Proton
PIC BASIC
Compiler

A Powerful BASIC Compiler for 8-bit 12F, 16F, and 18F PIC Devices

Written By Les Johnson

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The Proton compiler and documentation are written by Les Johnson.

If you should find any anomalies or omission in this document, please contact us, as we appreciate your assistance in improving our products and services.

8-bit Proton Compiler Development Suite.

Introduction

The Proton BASIC compiler was written with simplicity and flexibility in mind. Using BASIC, which is almost certainly the easiest programming language around, you can now produce extremely powerful applications for your PICmicro™ without having to learn the relative complexity of assembler, or wade through the gibberish that can be C.

The Proton IDE provides a seamless development environment, which allows you to write, debug and compile your code within the same Windows environment, and by using a compatible programmer, just one key press allows you to program and verify the resulting code in the PICmicro™ of your choice!

The Proton compiler allows many devices without requiring a USB key. The supported **free** devices are:

Free 12-bit core Devices:
PIC10F200, PIC10F202, PIC10F204, PIC10F206, PIC10F222, PIC12F508, PIC12F508A, PIC12F509, PIC12F509A

Free Standard 14-bit core Devices:
PIC12F675, PIC12F683, PIC16F627, PIC16LF627, PIC16F627A, PIC16LF627A, PIC16F628, PIC16LF628, PIC16F628A, PIC16LF628A, PIC16F684, PIC16LF684, PIC16F685, PIC16LF685, PIC16F687, PIC16LF687, PIC16F688, PIC16LF688, PIC16F689, PIC16LF689, PIC16F84, PIC16F84A, PIC16F87, PIC16LF87, PIC16F88, PIC16LF88, PIC16F876, PIC16F876A, PIC16F877, PIC16F877A, PIC16F882, PIC16F883, PIC16F884, PIC16F886, PIC16F887

Free Enhanced 14-bit core Devices:
PIC12F1552, PIC12LF1552, PIC12F1572, PIC12LF1572, PIC16F1614, PIC16LF1614, PIC16F1826, PIC16LF1826, PIC16F1829, PIC16LF1829, PIC16F18323, PIC16LF18323, PIC16F1937, PIC16LF1937

Free 18F devices:
PIC18F13K50, PIC18LF13K50, PIC18F14K50, PIC18LF14K50, PIC18F252, PIC18LF252, PIC18F2550, PIC18LF2550, PIC18F25K20, PIC18LF25K20, PIC18F25K22, PIC18LF25K22, PIC18F26K20, PIC18LF26K20, PIC18F26K22, PIC18LF26K22, PIC18F452, PIC18LF452, PIC18F4550, PIC18LF4550, PIC18F45K20, PIC18LF45K20, PIC18F45K22, PIC18LF45K22, PIC18F46K20, PIC18LF46K20, PIC18F46K22, PIC18LF46K22

These will be increased in time, and the most popular devices on the market will be added as free devices. For other devices, the commercial compiler is available for a, relatively, small fee that allows the author to develop it further.

Contact Details

For your convenience we have set up a web site **www.picbasic.org**, where there is a section for users of the Proton compiler, to discuss the compiler, and provide self help with programs written for Proton BASIC, or download sample programs. The web site is well worth a visit now and then, either to learn a bit about how other peoples code works or to request help should you encounter any problems with programs that you have written.

Should you need to get in touch with us for any reason our details are as follows: -

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Compiler Overview

PICmicro™ Devices

The compiler supports 99% of the PICmicro™ range of devices, and takes full advantage of their various features e.g. A/D Converter, data memory eeprom area, hardware multiply etc.

This manual is not intended to give details about individual microcontroller devices, therefore, for further information visit the Microchip website at **www.microchip.com**, and download the multitude of datasheets and application notes available.

Limited 12-bit Device Compatibility.

The 12-bit core microcontrollers have been available for a long time, and are at the heart of many excellent, and complex projects. However, with their limited architecture, they were never intended to be used for high level languages such as BASIC. Some of these limits include only a two-level hardware stack and small amounts of general purpose RAM memory. The code page size is also small at 512 bytes. There is also a limitation that calls and computed jumps can only be made to the first half (256 words) of any code page. Therefore, these limitations have made it necessary to eliminate some compiler commands and modify the operation of others.

While many useful programs can be written for the 12-bit core devices using the compiler, there will be some applications that are not suited to them. Choosing a 14-bit core device with more resources will, in most instances, be the best solution, or better still, choose a suitable 18F device.

Some of the commands that are not supported for the 12-bit core devices are illustrated in the table below: -

Command	Reason for omission
Dwords	Memory limitations
Floats	Memory limitations
Signed Variables	Memory limitations
Adin	No internal ADCs
Cdata	No write modify feature
Cls	Limited stack size
Cread	No write modify feature
Cursor	Limited stack size
Cwrite	No write modify feature
DTMFout	Limited stack size
Edata	No on-board EEPROM
Eread	No on-board EEPROM
Ewrite	No on-board EEPROM
Freqout	Limited stack size
LCDread	No graphic LCD support
LCDwrite	No graphic LCD support
Hpwm	No 12-bit MSSP modules
Hrsin	No hardware serial port
Hrsout	No hardware serial port
Hserin	No hardware serial port
Hserout	No hardware serial port
Interrupts	No Interrupts
Pixel	No graphic LCD support
Plot	No graphic LCD support

Serout	Limited memory
Serin	Limited memory
Sound2	Limited resources
UnPlot	No graphic LCD support
USBin	No 12-bit USB devices
USBout	No 12-bit USB devices
Xin	Limited stack size
Xout	Limited stack size

Trying to use any of the above commands with 12-bit core devices will result in the compiler producing numerous Syntax errors. If any of these commands are a necessity, then choose a comparable standard or enhanced 14-bit core device.

The available commands that have had their operation modified are: -

   Print, Rsout, Busin, Busout

Most of the modifiers are not supported for these commands because of memory and stack size limitations, this includes the **At**, and the **Str** modifier. However, the **@**, **Dec** and **Dec3** modifiers are still available.

Programming Considerations for 12-bit core Devices.
Because of the limited architecture of the 12-bit core microcontrollers, programs compiled for them by the compiler will be larger and slower than programs compiled for the 14-bit core devices. The two main programming limitations that will most likely occur are running out of RAM memory for variables, and running past the first 256 word limit for the library routines.

Even though the compiler arranges its internal system variables more intuitively than previous versions, it still needs to create temporary variables for complex expressions etc. It also needs to allocate extra RAM for use as a Software-Stack so that the BASIC program is still able to nest **Gosub**s up to 4 levels deep.

Some of the older devices only have 25 bytes of RAM so there is very little space for user variables on those devices. Therefore, use variables sparingly, and always use the appropriately sized variable for a specific task. i.e. **Byte** variable if 0-255 is required, **Word** variable if 0-65535 required, **Bit** variables if a true or false situation is required. Try to alias any commonly used variables, such as loops or temporary stores etc.

As was mentioned earlier, 12-bit core microcontrollers can call only into the first half (256 words) of a code page. Since the compiler's library routines are all accessed by calls, they must reside entirely in the first 256 words of the code space. Many library routines, such as **Busin**, are quite large. It may only take a few routines to outgrow the first 256 words of code space. There is no work around for this, and if it is necessary to use more library routines that will fit into the first half of the first code page, it will be necessary to move to a 14-bit core device instead of the 12-bit core device.

No 32-bit or floating point variable support with 12-bit core devices.
Because of the profound lack of RAM space available on most 12-bit core devices, the Proton compiler does not allow 32-bit **Dword** type variables to be used. For 32-bit support, use one of the many 14-bit core, or 18F equivalent devices. Floating point variables are also not supported with 12-bit core devices.

Device Specific issues

Before venturing into your latest project, always read the datasheet for the specific device being used, because some devices have features that may interfere with expected pin operations.

An example of a potential problem is that bit-4 of PORTA (PORTA.4) exhibits unusual behaviour when used as an output. This is because the pin has an open drain output rather than the usual bipolar stage as in the rest of the output pins. This means it can pull to ground when set to 0 (low), but it will simply float when set to a 1 (high), instead of going high.

To make this pin act as expected, add a pull-up resistor between the pin and 5 Volts. A typical value resistor may be between 1KΩ and 33KΩ, depending on the device it is driving. If the pin is used as an input, it behaves the same as any other pin.

Most devices allow low-voltage programming. This function, generally, takes over one of the PORTB pins and can cause the device to act erratically if this pin is not pulled low. In normal use, It's best to make sure that low-voltage programming is disabled at the time the device is programmed. By default, the low voltage programming fuse is disabled, however, if the **Config** directive is used, then it may inadvertently be omitted.

All of the microcontroller's pins are set to inputs on power-up. If you need a pin to be an output, set it to an output before you use it, or use a BASIC command that does it for you. Once again, always read the PICmicro™ data sheets to become familiar with the particular part.

The name of the port pins on the 6-pin and 8-pin devices is GPIO. The name for the Tris register is TrisIO: -

```
GPIO.0 = 1            ' Set GPIO.0 high
TRISIO = %101010      ' Manipulate ins and outs
```

However, these are also mapped as PORTB, therefore any reference to PORTB on these devices will point to the relevant pin of GPIO.

Some of the more recent devices have PPS (Peripheral Pin Select), which allows the user to choose a pin to use. It does add some extra complexity to a program, but the compiler tries to help and any command that uses a peripheral will automatically adjust the PPS SFRs to suite. Such as **Hrsout**, **Hrsin**, **Hserout**, **Hserin**, **HPWM**, **Hbusin**, or **Hbusout**.

Identifiers

An identifier is a technical term for a name. Identifiers are used for line labels, variable names, and constant aliases. An identifier is any sequence of letters, digits, and underscores, although it must not start with a digit. Identifiers are not case sensitive, therefore label, LABEL, and Label are all treated as equivalent. And while labels might be any number of characters in length, only the first 32 are recognised.

Line Labels

In order to mark statements that the program may wish to reference with the **Goto**, **Call**, or **Gosub** commands, the compiler uses line labels. Unlike many older BASICs, the compiler does not allow or require line numbers and doesn't require that each line be labelled. Instead, any line may start with a line label, which is simply an identifier followed by a colon '**:**'.

```
Label:
    Print "Hello World"
    Goto Label
```

Variables

Variables are where temporary data is stored in a BASIC program. They are created using the **Dim** keyword. Because RAM space on 8-bit micrcontrollers is somewhat limited, choosing the right size variable for a specific task is important. Variables may be **Bits**, **Bytes**, **Words**, **Dwords** , **SBytes**, **SWords**, **SDwords** or **Floats**.

Space for each variable is automatically allocated in the microcontroller's RAM area. The format for creating a variable is as follows: -

Dim *Label* **as** *Size*

Label is any identifier, (excluding keywords). *Size* is **Bit**, **Byte, Word**, **Dword**, **SByte**, **SWord**, **SDword** or **Float**. Some examples of creating variables are: -

```
Dim Cat as Bit          ' Create a single bit variable (0 or 1)
Dim Dog as Byte         ' Create an 8-bit unsigned variable (0 to 255)
Dim Rat as Word         ' Create a 16-bit unsigned variable (0 to 65535)
Dim Lrg_Rat as Dword    ' Create a 32-bit unsigned variable (0 to 4294967295)

Dim sDog as SByte       ' Create an 8-bit signed variable (-128 to +127)
Dim sRat as SWord       ' Create a 16-bit signed variable (-32768 to +32767)
Dim sLrg_Rat as SDword  ' Create a 32-bit signed variable (-2147483648 to
                        ' +2147483647)

Dim Pointy_Rat as Float ' Create a 32-bit floating point variable
```

The number of variables available depends on the amount of RAM on a particular device and the size of the variables within the BASIC program. The compiler will reserve RAM for its own use and may also create additional temporary (System) variables for use when calculating equations, or more complex command structures. Especially if floating point calculations are carried out.

Intuitive Variable Handling.

The compiler handles its System variables intuitively, in that it only creates those that it requires. Each of the compiler's built in library subroutines i.e. **Print**, **Rsout** etc, require a certain amount of System RAM as internal variables. Previous versions of the compiler defaulted to 26 RAM spaces being created before a program had been compiled. However, with the 12-bit core device compatibility, 26 RAM slots is more than some devices possess.

Try the following program, and look at the RAM usage message on the bottom Status bar.

```
Dim MyWord as Word                    ' Create a Word variable i.e. 16-bits

Do                                    ' Create a loop
  High PORTB.0                        ' Set bit 0 of PORTB high
  For MyWord = 1 to 20000 : Next      ' Create a delay without using a library call
  Low PORTB.0                         ' Set bit 0 of PORTB high
  For MyWord = 1 to 20000 : Next      ' Create a delay without using a library call
Loop                                  ' Do it forever
```

Only two bytes of RAM were used, and those were the ones declared in the program as variable MyWord.

The compiler will increase its System RAM requirements as programs get larger, or more complex structures are used, such as complex expressions, inline commands used in conditions, Boolean logic used etc. However, with the limited RAM space available on some PICmicro™ devices, every byte counts.

There are certain reserved words that cannot be used as variable names, these are the system variables used by the compiler.

The following reserved words should not be used as variable names, as the compiler will create these names when required: -

```
PP0, PP0H, PP1, PP1H, PP2, PP2H, PP3, PP3H, PP4, PP4H, PP5, PP5H, PP6, PP6H,
PP7, PP7H, PP8, PP9H,GEN, GENH, GEN2, GEN2H, GEN3, GEN3H, GEN4, GEN4H, GPR,
BPF, BPFH.
```

RAM space required.
Each type of variable requires differing amounts of RAM memory for its allocation. The list below illustrates this.

Float	Requires 4 bytes of RAM.
Dword	Requires 4 bytes of RAM.
SDword	Requires 4 bytes of RAM.
Word	Requires 2 bytes of RAM.
SWord	Requires 2 bytes of RAM.
Byte	Requires 1 byte of RAM.
SByte	Requires 1 byte of RAM.
Bit	Requires 1 byte of RAM for every 8 Bit variables created.

Each type of variable may hold a different minimum and maximum value.

- **Bit** type variables may hold a 0 or a 1. These are created 8 at a time, therefore declaring a single **Bit** type variable in a program will not save RAM space, but it will save code space, as **Bit** type variables produce the most efficient use of code for comparisons etc.

- **Byte** type variables may hold an unsigned value from 0 to 255, and are the usual work horses of most programs. Code produced for **Byte** sized variables is very low compared to signed or unsigned **Word**, **DWord** or **Float** types, and should be chosen if the program requires faster, or more efficient operation.

- **SByte** type variables may hold a 2^{rs} complemented signed value from -128 to +127. Code produced for **SByte** sized variables is very low compared to **SWord**, **Float**, or **SDword** types, and should be chosen if the program requires faster, or more efficient operation. However, code produced is usually larger for signed variables than unsigned types.

- **Word** type variables may hold an unsigned value from 0 to 65535, which is usually large enough for most applications. It still uses more memory than an 8-bit byte variable, but not nearly as much as a **Dword** or **SDword** type.

- **SWord** type variables may hold a 2^{rs} complemented signed value from -32768 to +32767, which is usually large enough for most applications. **SWord** type variables will use more code space for expressions and comparisons, therefore, only use signed variables when required.

- **Dword** type variables may hold an unsigned value from 0 to 4294967295 making this the largest of the variable family types. This comes at a price however, as **Dword** calculations and comparisons will use more code space within the microcontroller Use this type of variable sparingly, and only when necessary.

- **SDword** type variables may hold a 2's complemented signed value from -2147483648 to +2147483647, also making this the largest of the variable family types. This comes at a price however, as **SDword** expressions and comparisons will use more code space than a regular **Dword** type. Use this type of variable sparingly, and only when necessary.

- **Float** type variables may theoretically hold a value from -1e37 to +1e38, but because of the 32-bit architecture of the compiler, a maximum and minimum value should be thought of as -2147483646.999 to +2147483646.999 making this the most varsatile of the variable family types. However, more so than **Dword** types, this comes at a price as floating point expressions and comparisons will use more code space within the PICmicro™. Use this type of variable sparingly, and only when strictly necessary. Smaller floating point values usually offer more accuracy.

See also :   Aliases, Arrays, Dim, Constants Symbol, Floating Point Math.

Floating Point Math

The Proton compiler can perform 32 x 32 bit IEEE 754 *'Compliant'* Floating Point calculations.

Declaring a variable as **Float** will enable floating point calculations on that variable.

```
Dim MyFloat as Float
```

To create a floating point constant, add a decimal point. Especially if the value is a whole number.

```
Symbol PI = 3.14    ' Create an obvious floating point constant

Symbol FlNum = 5.0 ' Create a floating point value of a whole number
```

Please note. Floating point arithmetic is not the ultimate in accuracy, it is merely a means of compressing a complex or large value into a small space (4 bytes in the compiler's case). Perfectly adequate results can usually be obtained from correct scaling of integer variables, with an increase in speed and a saving of RAM and code space. 32 bit floating point math is extremely microcontroller intensive since the PICmicro™ is only an 8 bit processor. It also consumes large amounts of RAM, and code space for its operation, therefore always use floating point sparingly, and only when strictly necessary. Floating point is not available on 12-bit core PICmicros because of memory restrictions, and is most efficient when used with 18F devices because of the more linear code and RAM specifications.

Floating Point Format

The Proton compiler uses the Microchip variation of IEEE 754 floating point format. The differences to standard IEEE 745 are minor, and well documented in Microchip application note AN575 (downloadable from *www.microchip.com*).

Floating point numbers are represented in a modified IEEE-754 format. This format allows the floating-point routines to take advantage of the PICmicro's architecture and reduce the amount of overhead required in the calculations. The representation is shown below compared to the IEEE-754 format: where *s* is the sign bit, *y* is the lsb of the exponent and *x* is a placeholder for the mantissa and exponent bits.

The two formats may be easily converted from one to the other by manipulation of the Exponent and Mantissa 0 bytes. The following assembly code shows an example of this operation.

Format	Exponent	Mantissa 0	Mantissa 1	Mantissa 2
IEEE-754	sxxx xxxx	yxxx xxxx	xxxx xxxx	xxxx xxxx
Microchip	xxxx xxxy	sxxx xxxx	xxxx xxxx	xxxx xxxx

IEEE-754 to Microchip
```
Rlf Mantissa0
Rlf Exponent
Rrf Mantissa0
```

Microchip to IEEE-754
```
Rlf Mantissa0
Rrf Exponent
Rrf Mantissa0
```

Variables Used by the Floating Point Libraries.

Several 8-bit RAM registers are used by the math routines to hold the operands for and results of floating point operations. Since there may be two operands required for a floating point operation (such as multiplication or division), there are two sets of exponent and mantissa registers reserved (A and B). For argument A, PBP_AARGHHH holds the exponent and PBP_AARGHH, PBP_AARGH and PBP_AARG hold the mantissa. For argument B, PBP_BARGHHH holds the exponent and PBP_BARGHH, PBP_BARGH and PBP_BARG hold the mantissa.

Floating Point Example Programs.

```
' Multiply two floating point values
   Device = 18F452
   Declare Xtal = 4
   Declare Hserial_Baud = 9600     ' Set the Baud rate for Hrsout

   Dim MyFloat as Float
   Symbol FlNum = 1.234 ' Create a floating point constant value

   MyFloat = FlNum * 10
   HrsoutLn Dec MyFloat
   Stop

' Add two floating point variables
   Device = 18F452
   Declare Xtal = 4
   Declare Hserial_Baud = 9600     ' Set the Baud rate for Hrsout

   Dim MyFloat as Float
   Dim Flt1 as Float
   Dim Flt2 as Float

   Flt1 = 1.23
   Flt2 = 1000.1
   MyFloat = Flt1 + Flt2
   HrsoutLn Dec MyFloat
   Stop

' A digital volt meter, using the on-board ADC
   Device = 16F1829
   Declare Xtal = 4
   Declare Hserial_Baud = 9600     ' Set the Baud rate for Hrsout

   Declare Adin_Res = 10           ' 10-bit result required
   Declare Adin_Tad = cFRC         ' RC OSC chosen for the ADC
   Declare Adin_Delay = 50         ' Allow 50us sample time

   Dim ADC_Raw as Word
   Dim Volts as Float
   Symbol Quanta = 5.0 / 1024      ' Calculate the quantising value

   ADCON1 = %10000000              ' Set analogue input on PORTA.0

   Do                              ' Create a loop
      ADC_Raw = Adin 0             ' Get an ADC reading
      Volts = ADC_Raw * Quanta     ' Convert it to a Voltage value
      HrsoutLn Dec2 Volts,"V"      ' Transmit the decimal volts to a serial terminal
      DelayMs 300
   Loop                            ' Do it forever
```

Notes.
Any expression that contains a floating point variable or constant will be calculated as a floating point. Even if the expression also contains integer constants or variables.

If the assignment variable is an integer variable, but the expression is of a floating point nature, then the floating point result will be converted into an integer.

```
Device = 16F1829
Dim MyDword as Dword
Dim MyFloat as Float
Symbol PI = 3.14

MyFloat = 10
MyDword = MyFloat + PI  ' Float calculation will be 13.14, reduced to 13
HrsoutLn Dec MyDword    ' Transmit the integer result 13
Stop
```

For a more in-depth explanation of floating point, download the Microchip application notes AN575, and AN660. These can be found at www.microchip.com.

Code space requirements.
As mentioned above, floating point accuracy comes at a price of speed, and code space. Both these issues are not a problem if an 18F device is used, however 14-bit core devices can pose a problem. The compiler attempts to load the floating point libraries into low memory, along with all the other library subroutines, but if it does not fit within the first 2048 bytes of code space, and the PICmicro™ has more than 2048 bytes of code available, the floating point libraries will be loaded into the top 1000 bytes of code memory. This is invisible to the user, however, the compiler will warn that this is occurring in case that part of memory is being used by your BASIC program.

Floating Point To Integer Rounding
Assigning a floating point variable to an integer type will be truncated to the nearest value by default. For example:

```
FloatVar = 3.9
DwordVar = FloatVar
```

The variable DwordVar will hold the value of 3.

If rounding to the nearest integer value is required, use the **fRound** command.

Floating Point Exception Flags

The floating point exception flags are accessible from within the BASIC program via the system variable _FP_FLAGS. This must be brought into the BASIC program for the code to recognise it:

```
Dim _FP_FLAGS as Byte System
```

The exceptions are:

```
_FP_FLAGS.1      ' Floating point overflow
_FP_FLAGS.2      ' Floating point underflow
_FP_FLAGS.3      ' Floating point divide by zero
_FP_FLAGS.5      ' Domain error exception
```

The exception bits can be aliased for more readability within the program:

```
Symbol FpOverflow   = _FP_FLAGS.1  ' Floating point overflow
Symbol FpUnderFlow  = _FP_FLAGS.2  ' Floating point underflow
Symbol FpDiv0       = _FP_FLAGS.3  ' Floating point divide by zero
Symbol FpDomainError = _FP_FLAGS.5  ' Domain error exception
```

After an exception is detected and handled in the program, the exception bit should be cleared so that new exceptions can be detected, however, exceptions can be ignored because new operations are not affected by old exceptions.

More Accurate Display or Conversion of Floating Point values.

By default, the compiler uses a relatively small routine for converting floating point values to decimal, ready for **Rsout**, **Print Str$** etc. However, because of its size, it does not perform any rounding of the value first, and is only capable of converting relatively small values. i.e. approx 6 digits of accuracy. In order to produce a more accurate result, the compiler needs to use a larger routine. This is implemented by using a **Declare**: -

```
Declare Float_Display_Type = Fast or Standard
```

Using the *Fast* model for the above declare will trigger the compiler into using the more accurate floating point to decimal routine. Note that even though the routine is larger than the standard converter, it operates much faster.

The compiler defaults to Standard if the **Declare** is not issued in the BASIC program.

See also :   Dim, Symbol, Aliases, Arrays, Constants .

Aliases

The **Symbol** directive is the primary method of creating an alias, however **Dim** can be used to create an alias to a variable. This is extremely useful for accessing the separate parts of a variable.

```
Dim Fido as Dog             ' Fido is another name for Dog
Dim Mouse as Rat.LowByte    ' Mouse is the first byte (low byte) of word Rat
Dim Tail as Rat.HighByte    ' Tail is the second byte(high byte) of word Rat
Dim Flea as Dog.0           ' Flea is bit-0 of Dog, which is aliased to Fido
```

There are modifiers that may also be used with variables. These are **HighByte**, **LowByte**, **Byte0**, **Byte1**, **Byte2**, **Byte3**, **Word0**, **Word1**, **SHighByte**, **SLowByte**, **SByte0**, **SByte1**, **SByte2**, **SByte3**, **SWord0**, and **SWord1**,

Word0, **Word1**, **Byte2**, **Byte3**, **SWord0**, **SWord1**, **SByte2**, and **SByte3** may only be used in conjunction with 32-bit **Dword** or **SDword** type variables.

HighByte and **Byte1** are one and the same thing, when used with a **Word** or **SWord** type variable, they refer to the unsigned High byte of a **Word** or **SWord** type variable: -

```
Dim Wrd as Word        ' Create an unsigned Word variable
Dim Wrd_Hi as Wrd.HighByte
' Wrd_Hi now represents the unsigned high byte of variable Wrd
```

Variable Wrd_Hi is now accessed as a **Byte** sized type, but any reference to it actually alters the high byte of Wrd.

SHighByte and **SByte1** are one and the same thing, when used with a **Word** or **SWord** type variable, they refer to the signed High byte of a **Word** or **SWord** type variable: -

```
Dim Wrd as SWord        ' Create a signed Word variable
Dim Wrd_Hi as Wrd.SHighByte
' Wrd_Hi now represents the signed high byte of variable Wrd
```

Variable Wrd_Hi is now accessed as an **SByte** sized type, but any reference to it actually alters the high byte of Wrd.

However, if **Byte1** is used in conjunction with a **Dword** type variable, it will extract the second byte. **HighByte** will still extract the high byte of the variable, as will **Byte3**. If **SByte1** is used in conjunction with an **SDword** type variable, it will extract the signed second byte. **SHighByte** will still extract the signed high byte of the variable, as will **SByte3**.

The same is true of **LowByte**, **Byte0**, **SLowByte** and **SByte0**, but they refer to the unsigned or signed Low Byte of a **Word** or **SWord** type variable: -

```
Dim Wrd as Word         ' Create an unsigned Word variable
Dim Wrd_Lo as Wrd.LowByte
' Wrd_Lo now represents the low byte of variable Wrd
```

Variable Wrd_Lo is now accessed as a **Byte** sized type, but any reference to it actually alters the low byte of Wrd.

The modifier **Byte2** will extract the 3rd unsigned byte from a 32-bit **Dword** or **SDword** type variable as an alias. Likewise **Byte3** will extract the unsigned high byte of a 32-bit variable.

```
Dim Dwd as Dword        ' Create a 32-bit unsigned variable named Dwd
Dim Part1 as Dwd.Byte0  ' Alias unsigned Part1 to the low byte of Dwd
Dim Part2 as Dwd.Byte1  ' Alias unsigned Part2 to the 2nd byte of Dwd
Dim Part3 as Dwd.Byte2  ' Alias unsigned Part3 to the 3rd byte of Dwd
Dim Part4 as Dwd.Byte3  ' Alias unsigned Part3 to the high (4th) byte of Dwd
```

The modifier **SByte2** will extract the 3rd signed byte from a 32-bit **Dword** or **SDword** type variable as an alias. Likewise **SByte3** will extract the signed high byte of a 32-bit variable.

```
Dim sDwd as SDword        ' Create a 32-bit signed variable named sDwd
Dim sPart1 as sDwd.SByte0 ' Alias signed Part1 to the low byte of sDwd
Dim sPart2 as sDwd.SByte1 ' Alias signed Part2 to the 2nd byte of sDwd
Dim sPart3 as sDwd.SByte2 ' Alias signed Part3 to the 3rd byte of sDwd
Dim sPart4 as sDwd.SByte3 ' Alias signed Part3 to the 4th byte of sDwd
```

The **Word0** and **Word1** modifiers extract the unsigned low word and high word of a **Dword** or **SDword** type variable, and is used the same as the **Byte***n* modifiers.

```
Dim Dwd as Dword        ' Create a 32-bit unsigned variable named Dwd
Dim Part1 as Dwd.Word0  ' Alias unsigned Part1 to the low word of Dwd
Dim Part2 as Dwd.Word1  ' Alias unsigned Part2 to the high word of Dwd
```

The **SWord0** and **SWord1** modifiers extract the signed low word and high word of a **Dword** or **SDword** type variable, and is used the same as the **SByte***n* modifiers.

```
Dim sDwd as SDword        ' Create a 32-bit signed variable named sDwd
Dim sPart1 as sDwd.SWord0 ' Alias Part1 to the low word of sDwd
Dim sPart2 as sDwd.SWord1 ' Alias Part2 to the high word of sDwd
```

RAM space for variables is allocated within the microcontroller in the order that they are placed in the BASIC code. For example: -

```
Dim Var1 as Byte
Dim Var2 as Byte
```

Places Var1 first, then Var2: -

```
Var1 equ n
Var2 equ n
```

This means that on a device with more than one RAM Bank, the first *n* variables will always be in Bank0 (the value of *n* depends on the specific PICmicro™ used).

Finer points for variable handling.

The position of the variable within Banks is usually of little importance if BASIC code is used, however, if assembler routines are being implemented, always assign any variables used within them first.

Problems may also arise if a **Word**, **SWord**, **Dword**, **SDword** or **Float** variable crosses a Bank boundary. If this happens, a warning message will be displayed in the error window. Most of the time, this will not cause any problems, however, to err on the side of caution, try and ensure that **Word**, **SWord**, **Dword**, **SDword** or **Float** type variables are fully inside a Bank. This is easily accomplished by placing a dummy **Byte** variable before the offending variable, or relocating the offending variable within the list of Dim statements.

Word and **SWord** type variables have a low byte and a high byte. The high byte may be accessed by simply adding the letter H to the end of the variable's name. For example: -

```
Dim Wrd as Word
```

Will produce the assembler code: -

```
Wrd equ n
WrdH equ n
```

To access the high byte of variable Wrd, use: -

```
WrdH = 1
```

This is especially useful when assembler routines are being implemented, such as: -

```
Movlw 1
Movwf WrdH      ' Load the high byte of Wrd with 1
```

Dword, **SDWord** and **Float** type variables have a low, mid1, mid2, and high byte. The high byte may be accessed by by using **Byte0**, **Byte1**, **Byte2**, or **Byte3**. For example: -

```
Dim MyDword as Dword
```

To access the high byte of variable MyDword, use: -

```
MyDword.Byte3 = 1
```

The same is true of all the alias modifiers such as SWord0, Word0 etc...

Casting a variable from signed to unsigned and vice-versa is also possible using the modifiers. For example:

```
Dim MyDword as SDword   ' Create a 32-bit signed variable

MyDword.Byte3 = 1       ' Load the unsigned high byte with the value 1
MyDword.SByte0 = -1     ' Load the signed low byte with the value -1
MyDword.SWord0 = 128    ' Load the signed low and mid1 bytes with the value 128
```

Constants

Named constants may be created in the same manner as variables. It can be more informative to use a constant name instead of a constant number. Once a constant is declared, it cannot be changed later, hence the name 'constant'.

Dim *Label* **as** *Constant expression*

```
Dim Mouse as 1
Dim Mice as Mouse * 400
Dim Mosue_PI as Mouse + 2.14
```

Although **Dim** can be uses to create constants, **Symbol** is more often used.

Symbols

The **Symbol** directive provides yet another method for aliasing variables and constants. Symbol cannot be used to create a variable. Constants declared using Symbol do not use any RAM within the PICmicro™.

```
Symbol Cat = 123
Symbol Tiger = Cat                ' Tiger now holds the value of Cat
Symbol Mouse = 1                  ' Same as Dim Mouse as 1
Symbol TigOuse = Tiger + Mouse    ' Add Tiger to Mouse to make Tigouse
```

Floating point constants may also be created using **Symbol** by simply adding a decimal point to a value.

```
Symbol PI = 3.14    ' Create a floating point constant named PI
Symbol FlNum = 5.0  ' Create a floating point constant holding the value 5
```

Floating point constant can also be created using expressions.

```
' Create a floating point constant holding the result of the expression
Symbol Quanta = 5.0 / 1024
```

If a variable or register's name is used in a constant expression then the variable's or register's address will be substituted, not the value held in the variable or register: -

```
Symbol Const = (PORTA + 1)' Const will hold the value 6 (5+1)
```

Symbol is also useful for aliasing Ports and Registers: -

```
Symbol LED = PORTA.1      ' LED now references bit-1 of PORTA
Symbol T0IF = INTCON.2    ' T0IF now references bit-2 of INTCON register
```

The equal sign between the constant's name and the alias value is optional: -

```
Symbol LED PORTA.1          ' Same as Symbol LED=PORTA.1
```

Numeric Representations

The compiler recognises several different numeric representations: -

Binary is prefixed by %. i.e. %0101
Hexadecimal is prefixed by $ or 0x. i.e. $0A or 0x0A
Character byte is surrounded by quotes. i.e. "a" represents a value of 97
Decimal values need no prefix.
Floating point is created by using a decimal point. i.e. 3.14

Quoted String of Characters

A Quoted String of Characters contains one or more characters (maximum 200) and is delimited by double quotes. Such as "Hello World"

The compiler also supports a subset of C language type formatters within a quoted string of characters. These are: -

\a	Bell (alert) character	$07
\b	Backspace character	$08
\f	Form feed character	$0C
\n	New line character	$0A
\r	Carriage return character	$0D
\t	Horizontal tab character	$09
\v	Vertical tab character	$0B
\\	Backslash	$5C
\"	Double quote character	$22

Example: -

```
Hrsout "Hello World\n\r"
```

Strings are usually treated as a list of individual character values, and are used by commands such as **Print**, **Rsout**, **Busout**, **Ewrite** etc. And of course, **String** variables.

Null Terminated

Null is a term used in computer languages for zero. So a null terminated String is a collection of characters followed by a zero in order to signify the end of characters. For example, the string of characters "Hello", would be stored as: -

```
"H", "e", "l", "l" ,"o", 0
```

Notice that the terminating null is the value 0 not the character "0".

Ports and other Registers

All of the PICmicro™ registers, including the ports, can be accessed just like any other byte-sized variable. This means that they can be read from, written to or used in equations directly.

```
PORTA = %01010101      ' Write value to PORTA

Var1 = Wrd * PORTA     ' Multiply variable Wrd with the contents of PORTA
```

The compiler can also combine16-bit registers such as TMR1 into a **Word** type variable. Which makes loading and reading these registers simple: -

```
' Combine TMR1L and TMR1H into unsigned Word variable wTimer1
  Dim wTimer1 as TMR1L.Word

  wTimer1 = 12345        ' Load TMR1L and TMR1H with the value 12345
or
  Wrd1 = wTimer1         ' Load Wrd1 with contents of TMR1
```

The **.Word** extension links registers TMR1L, and TMR1H, (which are assigned in the .ppi file associated with the relevant device used).

Any hardware register that can hold a 16-bit result can be assigned as a **Word** type variable: -

```
' Combine ADRESL and ADRESH into unsigned Word variable wADC_Result
'
  Dim wADC_Result as ADRESL.Word
'
' Combine PRODL and PRODH into unsigned Word variable wMul_PROD
'
  Dim wMul_PROD as PRODL.Word
```

General Format

The compiler is not case sensitive, except when processing string constants such as "hello".

Multiple instructions and labels can be combined on the same line by separating them with co-lons '**:**'.

The examples below show the same program as separate lines and as a single-line: -

Multiple-line version: -

```
  Output PORTB            ' Make all pins on PORTB outputs
  For Var1 = 0 to 100     ' Count from 0 to 100
    PORTB = Var1          ' Make PORTB = Var1
  Next                    ' Continue counting until 100 is reached
```

Single-line version: -

```
  Output PORTB : For Var1 = 0 to 100 : PORTB = Var1 : Next
```

A Typical basic Program Layout

The compiler is very flexible, and will allow most types of constant, declaration, or variable to be placed anywhere within the BASIC program. However, it may not produce the correct results, or an unexpected syntax error may occur due to a variable being declared after it is supposed to be used.

The recommended layout for a program is shown below.

```
   Device
{
   Declares
}
{
   Includes
}
{
   Constants and Variables
}

   GoTo Main                        ' Jump over the subroutines (if any)

{
   Subroutines go here
}
{
   Main:
   Main Program code goes here
}
```

For example:

```
   Device = 18F25K20
'---------------------------------------
   Declare Xtal = 20
   Declare Hserial_Baud = 9600
'---------------------------------------
' Load an ADC include file (if required)
   Include "ADC.inc"
'---------------------------------------
' Define Variables
   Dim WordVar as Word              ' Create a Word size variable
'---------------------------------------
' Define Constants and/or aliases
   Symbol Value = 10                ' Create a constant
'---------------------------------------
   GoTo Main                        ' Jump over the subroutine/s (if any)
'---------------------------------------
' Simple Subroutine
AddIt:
   WordVar = WordVar + Value        ' Add the constant to the variable
   Return                           ' Return from the subroutine
'---------------------------------------
' Main Program Code
Main:
   WordVar = 10                     ' Pre-load the variable
   GoSub AddIt                      ' Call the subroutine
   HrsoutLn Dec WordVar             ' Display the result on the serial terminal
```

Of course, it depends on what is within the include file as to where it should be placed within the program, but the above outline will usually suffice. Any include file that requires placing within a certain position within the code should be documented to state this fact.

Line Continuation Character '_'

Lines that are too long to display, may be split using the continuation character '_'. This will direct the continuation of a command to the next line. Its use is only permitted after a comma delimiter: -

```
Var1 = LookUp Var2,[1,2,3,_
                    4,5,6,7,8]
```

or

```
HrsoutLn "Hello World",_
         Dec Var1,_
         Hex Var2
```

Creating and using Arrays

The Proton compiler supports multi part **Byte**, **Word**, **Dword**, **SByte**, **Sword**, **SDword** and **Float** variables named arrays (**Dword**, **SDword** and **Float** arrays are only supported with 18F and enhanced 14-bit core devices). An array is a group of variables of the same size (8-bits, 16-bits or 32-bits wide), sharing a single name, but split into numbered cells, called elements.

An array is defined using the following syntax: -

    Dim Name**[** *length* **] as Byte**
    Dim Name**[** *length* **] as Word**
    Dim Name**[** *length* **] as Dword**
    Dim Name**[** *length* **] as SByte**
    Dim Name**[** *length* **] as SWord**
    Dim Name**[** *length* **] as Sdword**
    Dim Name**[** *length* **] as Float**

where *Name* is the variable's given name, and the new argument, [*length*], informs the compiler how many elements you want the array to contain. For example: -

```
Dim MyArray[10] as Byte      ' Create a 10 element unsigned byte array
Dim MyArray[10] as Word      ' Create a 10 element unsigned word array
Dim MyArray[10] as Dword     ' Create a 10 element unsigned dword array
Dim sMyArray[10] as SByte    ' Create a 10 element signed byte array
Dim sMyArray[10] as SWord    ' Create a 10 element signed word array
Dim sMyArray[10] as SDword   ' Create a 10 element signed dword array
Dim fMyArray[10] as Float    ' Create a 10 element floatin point array
```

On 18F or enhanced core devices, arrays may have as many elements as RAM permits, however, with 12-bit core and standard 14-bit core devices, arrays may contain a maximum of 256 elements, (128 for word arrays when using standard 14-bit core devices). Because of the rather complex way that some PICmicro's RAM cells are organised (i.e. Banks), there are a few rules that need to be observed when creating arrays with standard 14-bit core devices.

PICmicro™ Memory Map Complexities.

Some microcontrollers have more RAM available for variable storage, however, accessing the RAM on the standard 14-bit core devices is not as straightforward as one might expect. The RAM is organised in Banks, where each Bank is 128 bytes in length. Crossing these Banks requires bits 5 and 6 of the STATUS register to be manipulated. The larger devices such as the 16F877 have 512 RAM locations, but only 368 of these are available for variable storage, the rest are known as Special Function Registers (SFRs) and are used to control certain aspects of the microcontroller i.e. TRIS, IO ports, USART etc. The compiler attempts to make this complex system of RAM Bank switching as transparent to the user as possible, and succeeds where standard **Bit**, **Byte**, **Word**, and **Dword** variables are concerned. However, Array variables will inevitably need to cross the Banks in order to create arrays larger than 96 bytes, which is the largest section of RAM within Bank0. Coincidently, this is also the largest array size permissible by most other compilers at the time of writing this manual.

Large arrays (normally over 96 elements) require that their Starting address be located within the first 255 bytes of RAM (i.e. within Bank0 and Bank2), the array itself may cross this boundary. This is easily accomplished by declaring them at, or near the top of the list of variables. The compiler does not manipulate the variable declarations. If a variable is placed first in the list, it will be placed in the first available RAM slot within the microcontroller. This way, you, the programmer maintains finite control of the variable usage. For example, commonly used variables should be placed near the top of the list of declared variables. An example of declaring an array is illustrated below: -

```
Device 16F1829                   ' Choose a microcontroller with extra RAM
Dim Small_Array[20] as Byte      ' Create a small array of 20 elements
Dim Var1 as Byte                 ' Create a standard Byte variable
Dim Large_Array[256] as Byte     ' Create a Byte array of 256 elements
```
or
```
Dim Array1[120] as Byte          ' Create an array of 120 elements
Dim Array2[100] as Byte          ' Create another smaller array of 100 elements
```

If an array cannot be resolved, then a warning will be issued informing you of the offending line:
Warning Array 'array name' is declared at address 'array address'. Which is over the 255 RAM address limit, and crosses Bank3 boundary!

Ignoring this warning will spell certain failure of your program.

The following array declaration will produce a warning when compiled for a 16F877 device: -

```
Device 16F877            ' Choose a microcontroller with extra RAM
Dim Array1[200] as Byte  ' Create an array of 200 elements
Dim Array2[100] as Byte  ' Create another smaller array of 100 elements
```

Examining the assembler code produced, will reveal that Array1 starts at address 32 and finishes at address 295. This is acceptable and the compiler will not complain. Now look at Array2, its start address is at 296 which is over the 255 address limit, thus producing a warning message.

The above warning is easily remedied by re-arranging the variable declaration list: -

```
Dim Array2[100] as Byte   ' Create a small array of 100 elements
Dim Array1[200] as Byte   ' Create an array of 200 elements
```

Again, examining the asm code produced, now reveals that Array2 starts at address 32 and finishes at address 163. everything OK there then. And Array1 starts at address 164 and finishes at address 427, again, its starting address was within the 255 limit so everything's OK there as well, even though the array itself crossed several Banks. A simple re-arrangement of code meant the difference between a working and not working program.

Of course, the smaller microcontrollers do not have this limitation as they do not have 255 RAM cells anyway. Therefore, arrays may be located anywhere in the variable declaration list. The same goes for the 18F devices, as these can address any area of their RAM.

18F and enhanced 14-bit core device simplicity.

The 18F devices have no such complexities in their memory map as the standard 14-bit core devices do. The memory is still banked, but each bank is 256 bytes in length, and runs linearly from one to the other. Add to that, the ability to access all RAM areas using indirect addressing, makes arrays extremely easy to use. If many large arrays are required in a program, then the 18F devices are highly recommended.

Once an array is created, its elements may be accessed numerically. Numbering starts at 0 and ends at n-1. For example: -

```
MyArray[3] = 57
HrsoutLn "MyArray[3] = ", Dec MyArray[3]
```

The above example will access the fourth element in the **Byte** array and display "MyArray[3] = 57" on the serial terminal. The true flexibility of arrays is that the index value itself may be a variable. For example: -

```
Device 16F88                    ' We'll use a smaller device this time
Dim MyArray[10] as Byte         ' Create a 10-byte array.
Dim Index as Byte               ' Create a Byte variable.

For Index = 0 to 9              ' Repeat with Index= 0,1,2...9
  MyArray[Index] = Index * 10   ' Write Index*10 to each element of the array.
Next
For Index = 0 to 9              ' Repeat with Index= 0,1,2...9
  Print At 1, 1, Dec MyArray [Index] ' Show the contents of each element.
  DelayMs 500                   ' Wait long enough to view the values
Next
Stop
```

If the above program is run, 10 values will be displayed, counting from 0 to 90 i.e. Index * 10.

A word of caution regarding arrays: If you're familiar with other BASICs and have used their arrays, you may have run into the "subscript out of range" error. Subscript is simply another term for the index value. It is considered 'out-of range' when it exceeds the maximum value for the size of the array.

For example, in the example above, MyArray is a 10-element array. Allowable index values are 0 through 9. If your program exceeds this range, the compiler will not respond with an error message. Instead, it will access the next RAM location past the end of the array.

If you are not careful about this, it can cause all sorts of subtle anomalies, as previously loaded variables are overwritten. It's up to the programmer (you!) to help prevent this from happening.

Even more flexibility is allowed with arrays because the index value may also be an expression.

```
Device 16F88                    ' We'll use a smaller device
Dim MyArray[10] as Byte         ' Create a 10-byte array.
Dim Index as Byte               ' Create a Byte variable.

For Index = 0 to 8              ' Repeat with Index= 0,1,2...8
  MyArray[Index + 1] = Index * 10 ' Write Index*10 to each element of array
Next
For Index = 0 to 8              ' Repeat with Index= 0,1,2...8
  Print At 1, 1, Dec MyArray[Index + 1] ' Show the contents of elements
  DelayMs 500                   ' Wait long enough to view the values
Next
Stop
```

The expression within the square braces should be kept simple, and arrays are not allowed as part of the expression.

Using Arrays in Expressions.

Of course, arrays are allowed within expressions themselves. For example: -

```
Device = 16F88                  ' We'll use a smaller device
Device Xtal = 4
Declare Hserial_Baud = 9600

Dim MyArray[10] as Byte        ' Create a 10-byte array.
Dim Index as Byte              ' Create a Byte variable.
Dim Var1 as Byte              ' Create another Byte variable
Dim MyResult as Byte          ' Create a variable to hold result of expression

Index = 5                      ' And Index now holds the value 5
Var1 = 10                      ' Variable Var1 now holds the value 10
MyArray[Index] = 20           ' Load the 6th element of MyArray with value 20
MyResult = (Var1 * MyArray[Index]) / 20 ' Do a simple expression
HrsoutLn Dec MyResult          ' Display result of expression
Stop
```

The previous example will display 10 on the serial terminal, because the expression reads as: -

(10 * 20) / 20

Var1 holds a value of 10, MyArray[Index] holds a value of 20, these two variables are multiplied together which will yield 200, then they're divided by the constant 20 to produce a result of 10.

An index expression used within an array that is used within an expression itself is limited to two operands.

Arrays as Strings

Arrays may also be used as simple strings in certain commands, because after all, a string is simply a byte array used to store text.

For this, the **Str** modifier is used.

The commands that support the **Str** modifier are: -

Busout - **Busin**
Hbusout - **Hbusin**
Hrsout - **Hrsin**
Owrite - **Oread**
Rsout - **Rsin**
Serout - **Serin**
Shout - **Shin**
Print

The **Str** modifier works in two ways, it outputs data from a pre-declared array in commands that send data i.e. **Rsout**, **Print** etc, and loads data into an array, in commands that input informa-tion i.e. **Rsin**, **Serin** etc. The following examples illustrate the **Str** modifier in each compatible command.

Using **Str** with the **Busin** and **Busout** commands.

Refer to the sections explaining the **Busin** and **Busout** commands.

Using **Str** with the **Hbusin** and **Hbusout** commands.

Refer to the sections explaining the **Hbusin** and **Hbusout** commands.

Using **Str** with the **Rsin** command.

```
Dim Array1[10] as Byte      ' Create a 10-byte array named Array1
Rsin Str Array1             ' Load 10 bytes of data directly into Array1
```

Using **Str** with the **Rsout** command.

```
Dim Array1[10] as Byte      ' Create a 10-byte array named Array1
Rsout Str Array1            ' Send 10 bytes of data directly from Array1
```

Using **Str** with the **Hrsin** and **Hrsout** commands.

Refer to the sections explaining the **Hrsout** and **Hrsin** commands.

Using **Str** with the **Shout** command.

```
Symbol Data_Pin = PORTA.0    ' Alias the two lines for the Shout command
Symbol Clk_Pin = PORTA.1
Dim Array1[10] as Byte       ' Create a 10-byte array named Array1

' Send 10 bytes of data from Array1
Shout Data_Pin, Clk_Pin, MSBFirst, [Str Array1]
```

Using **Str** with the **Shin** command.

```
Symbol Data_Pin = PORTA.0    ' Alias the two lines for the Shin command
Symbol Clk_Pin = PORTA.1
Dim Array1[10] as Byte       ' Create a 10-byte array named Array1

' Load 10 bytes of data directly into Array1
Shin Data_Pin, Clk_Pin, MSBPre, [Str Array1]
```

Using **Str** with the **Print** command.

```
Dim Array1[10] as Byte       ' Create a 10-byte array named Array1
Print Str Array1             ' Send 10 bytes of data directly from Array1
```

Using **Str** with the **Serout** and **Serin** commands.

Refer to the sections explaining the **Serin** and **Serout** commands.

Using **Str** with the **Oread** and **Owrite** commands.

Refer to the sections explaining the **Oread** and **Owrite** commands.

The **Str** modifier has two forms for variable-width and fixed-width data, shown below: -

Str bytearray ASCII string from bytearray until byte = 0 (null terminated).

Or array length is reached.

Str bytearray\n ASCII string consisting of n bytes from bytearray.

null terminated means that a zero (null) is placed at the end of the string of ASCII characters to signal that the string has finished.

The example below is the variable-width form of the **Str** modifier: -

```
Dim MyArray[5] as Byte  ' Create a 5 element array
MyArray[0] = "A"        ' Fill the array with ASCII
MyArray[1] = "B"
MyArray[2] = "C"
MyArray[3] = "D"
MyArray[4] = 0          ' Add the null Terminator
Print Str MyArray        ' Display the string
```

The code above displays "ABCD" on the LCD. In this form, the **Str** formatter displays each character contained in the byte array until it finds a character that is equal to 0 (value 0, not ASCII "0"). Note: If the byte array does not end with 0 (null), the compiler will read and

output all RAM register contents until it cycles through all RAM locations for the declared length of the byte array.

For example, the same code as before without a null terminator is: -

```
Dim MyArray[4] as Byte  ' Create a 4 element array
MyArray[0] = "A"          ' Fill the array with ASCII
MyArray[1] = "B"
MyArray[2] = "C"
MyArray[3] = "D"
Print Str MyArray         ' Display the string
```

The code above will display the whole of the array, because the array was declared with only four elements, and each element was filled with an ASCII character i.e. "ABCD".

To specify a fixed-width format for the **Str** modifier, use the form **Str** MyArray\n; where MyArray is the byte array and n is the number of characters to display, or transmit. Changing the **Print** line in the examples above to: -

```
Print Str MyArray \ 2
```

would display "AB" on the LCD.

Str is not only used as a modifier, it is also a command, and is used for initially filling an array with data. The above examples may be re-written as: -

```
Dim MyArray[5] as Byte    ' Create a 5 element array
Str MyArray = "ABCD", 0   ' Fill array with ASCII, and null terminate it
Print Str MyArray         ' Display the string
```

Strings may also be copied into other strings: -

```
Dim String1[5] as Byte    ' Create a 5 element array
Dim String2[5] as Byte    ' Create another 5 element array
Str String1 = "ABCD", 0   ' Fill array with ASCII, and null terminate it
Str String2 = "EFGH", 0   ' Fill other array with ASCII, null terminate it
Str String1 = Str String2 ' Copy String2 into String1
Print Str String1         ' Display the string
```

The above example will display "EFGH", because String1 has been overwritten by String2.

Using the **Str** command with **Busout**, **Hbusout**, **Shout**, and **Owrite** differs from using it with commands **Serout**, **Print**, **Hrsout**, and **Rsout** in that, the latter commands are used more for dealing with text, or ASCII data, therefore these are null terminated.

The **Hbusout**, **Busout**, **Shout**, and **Owrite** commands are not commonly used for sending ASCII data, and are more inclined to send standard 8-bit bytes. Thus, a null terminator would cut short a string of byte data, if one of the values happened to be a 0. So these commands will output data until the length of the array is reached, or a fixed length terminator is used i.e. MyArray\n.

Creating and using Strings

The Proton compiler supports **String** variables, but only when targeting an 18F or enhanced 14-bit core device.

The syntax to create a string is : -

Dim *String Name* **as String** * *String Length*

String Name can be any valid variable name. See **Dim** .
String Length can be any value up to 255, allowing up to 255 characters to be stored.

The line of code below will create a **String** named MyString that can hold 20 characters: -

```
Dim MyString as String * 20
```

Two or more strings can be concatenated (linked together) by using the plus (**+**) operator: -

```
Device = 18F4520            ' A suitable device for Strings
' Create three strings capable of holding 20 characters
Dim DestString as String * 20
Dim SourceString1 as String * 20
Dim SourceString2 as String * 20

SourceString1 = "HELLO "     ' Load String SourceString1 with the text HELLO
'
' Load String SourceString2 with the text WORLD
SourceString2 = "WORLD"
' Add both Source Strings together. Place result into String DestString
'
DestString = SourceString1 + SourceString2
```

The String DestString now contains the text "HELLO WORLD", and can be transmitted serially or displayed on an LCD: -

```
Print DestString
```

The Destination String itself can be added to if it is placed as one of the variables in the addition expression. For example, the above code could be written as: -

```
Device = 18F452             ' A suitable device for Strings
'
' Create a String capable of holding 20 characters
'
Dim DestString as String * 20
'
' Create another String capable of holding 20 characters
'
Dim SourceString as String * 20

DestString = "HELLO "         ' Pre-load String DestString with the text HELLO
SourceString = "WORLD"        ' Load String SourceString with the text WORLD
' Concatenate DestString with SourceString
'
DestString = DestString + SourceString
Print DestString              ' Display the result which is "HELLO WORLD"
Stop
```

Note that Strings cannot be subtracted, multiplied or divided, and cannot be used as part of a regular expression otherwise a syntax error will be produced.

It's not only other strings that can be added to a string, the functions **Cstr**, **Estr**, **Mid$**, **Left$**, **Right$**, **Str$**, **ToUpper**, and **ToLower** can also be used as one of variables to concatenate.

A few examples of using these functions are shown below: -

Cstr Example

```
' Use Cstr function to place a code memory string into a RAM String variable

  Device = 18F4520                  ' A suitable device for Strings
' Create a String capable of holding 20 characters
  Dim DestString as String * 20
  Dim SourceString as String * 20   ' Create another String
  SourceString = "HELLO "           ' Load the string with characters
  DestString = SourceString + Cstr CodeStr' Concatenate the string
  Print DestString                  ' Display the result which is "HELLO WORLD"
  Stop
CodeStr:
  Cdata "WORLD",0
```

The above example is really only for demonstration because if a Label name is placed as one of the parameters in a string concatenation, an automatic (more efficient) **Cstr** operation will be carried out. Therefore the above example should be written as: -

More efficient Example of above code

```
' Place a code memory string into a String variable more efficiently than
' using Cstr

  Device = 18F4520                      ' A suitable device for Strings
' Create a String capable of holding 20 characters
  Dim DestString as String * 20
  Dim SourceString as String * 20       ' Create another String
  SourceString = "HELLO "               ' Load the string with characters
  DestString = SourceString + CodeStr   ' Concatenate the string
  Print DestString                      ' Display the result which is "HELLO WORLD"
  Stop
CodeStr:
  Cdata "WORLD",0
```

A null terminated string of characters held in Data (on-board eeprom) memory can also be loaded or concatenated to a string by using the **Estr** function: -

Estr Example

```
' Use the Estr function in order to place a
' Data memory string into a String variable
' Remember to place Edata before the main code
' so it's recognised as a constant value

  Device = 18F4520                  ' A suitable device for Strings
  Dim DestString as String * 20     ' Create a String for 20 characters
  Dim SourceString as String * 20   ' Create another String

Data_Str Edata "WORLD",0            ' Create a string in Data memory
  SourceString = "HELLO "           ' Load the string with characters
  DestString = SourceString + Estr Data_Str ' Concatenate the strings
  Print DestString                  ' Display the result which is "HELLO WORLD"
  Stop
```

Converting an integer or floating point value into a string is accomplished by using the **Str$** function: -

Str$ Example

```
' Use the Str$ function in order to concatenate
' an integer value into a String variable

  Device = 18F4520                  ' A suitable device for Strings
  Dim DestString as String * 30     ' Create a String for 30 characters
  Dim SourceString as String * 20   ' Create another String
  Dim Wrd1 as Word                  ' Create a Word variable

  Wrd1 = 1234                       ' Load the Word variable with a value
  SourceString = "Value = "         ' Load the string with characters
  DestString = SourceString + Str$(Dec Wrd1) ' Concatenate the string
  Print DestString                  ' Display the result which is "Value = 1234"
  Stop
```

Left$ Example

```
' Copy 5 characters from the left of SourceString
' and add to a quoted character string

  Device = 18F4520                  ' A suitable device for Strings
  Dim SourceString as String * 20   ' Create a String
  Dim DestString as String * 20     ' Create another String

  SourceString = "Hello World"      ' Load the source string with characters
  DestString = Left$(SourceString, 5) + " World"
  Print DestString                  ' Display the result which is "Hello World"
  Stop
```

Right$ Example

```
' Copy 5 characters from the right of SourceString
' and add to a quoted character string

  Device = 18F4520                  ' A suitable device for Strings
  Dim SourceString as String * 20   ' Create a String
  Dim DestString as String * 20     ' Create another String

  SourceString = "Hello World"      ' Load the source string with characters
  DestString = "Hello " + Right$(SourceString, 5)
  Print DestString                  ' Display the result which is "Hello World"
  Stop
```

Mid$ Example

```
' Copy 5 characters from position 4 of SourceString
' and add to quoted character strings

  Device = 18F4520                  ' A suitable device for Strings
  Dim SourceString as String * 20   ' Create a String
  Dim DestString as String * 20     ' Create another String

  SourceString = "Hello World"      ' Load the source string with characters
  DestString = "Hel" + Mid$(SourceString, 4, 5) + "rld"
  Print DestString                  ' Display the result which is "Hello World"
  Stop
```

Converting a string into uppercase or lowercase is accomplished by the functions **ToUpper** and **ToLower**: -

ToUpper Example
```
' Convert the characters in SourceString to upper case

    Device = 18F4520                ' A suitable device for Strings
    Dim SourceString as String * 20 ' Create a String
    Dim DestString as String * 20   ' Create another String

    SourceString = "hello world"    ' Load source with lowercase characters
    DestString = ToUpper(SourceString )
    Print DestString                ' Display the result which is "HELLO WORLD"
    Stop
```

ToLower Example
```
' Convert the characters in SourceString to lower case

    Device = 18F4520                ' A suitable device for Strings
    Dim SourceString as String * 20 ' Create a String
    Dim DestString as String * 20   ' Create another String

    SourceString = "HELLO WORLD"     ' Load the string with uppercase characters
    DestString = ToLower(SourceString )
    Print DestString                ' Display the result which is "hello world"
    Stop
```

Loading a String Indirectly
If the Source String is asigned or unsigned **Byte**, **Word**, **Float** or an **Array** variable, the value contained within the variable is used as a pointer to the start of the Source String's address in RAM.

Example
```
' Copy SourceString into DestString using a pointer to SourceString

    Device = 18F4520                ' A suitable device for Strings
    Dim SourceString as String * 20 ' Create a String
    Dim DestString as String * 20   ' Create another String
'
' Create a Word variable to hold the address of SourceString
'
    Dim StringAddr as Word

    SourceString = "Hello World"     ' Load the source string with characters
'
' Locate the start address of SourceString in RAM
'
    StringAddr = AddressOf(SourceString)
    DestString = StringAddr         ' Source string into the destination string
    Print DestString                ' Display the result, which will be "Hello"
    Stop
```

Slicing a String.

Each position within the string can be accessed the same as an unsigned **Byte Array** by using square braces: -

```
Device = 18F4520        ' A suitable device for Strings
Dim SourceString as String * 20   ' Create a String

SourceString[0] = "H"   ' Place letter "H" as first character in the string
SourceString[1] = "E"   ' Place the letter "E" as the second character
SourceString[2] = "L"   ' Place the letter "L" as the third character
SourceString[3] = "L"   ' Place the letter "L" as the fourth character
SourceString[4] = "O"   ' Place the letter "O" as the fifth character
SourceString[5] = 0     ' Add a null to terminate the string

Print SourceString      ' Display the string, which will be "HELLO"
Stop
```

The example above demonstrates the ability to place individual characters anywhere in the string. Of course, you wouldn't use the code above in an actual BASIC program.

A string can also be read character by character by using the same method as shown above: -

```
Device = 18F4520                    ' A suitable device for Strings
Dim SourceString as String * 20   ' Create a String
Dim Var1 as Byte

SourceString = "HELLO"              ' Load the source string with characters
'
' Copy character 1 from the source string and place it into Var1
'
Var1 = SourceString[1]
Print Var1     ' Display character extracted from string. Which will be "E"
Stop
```

When using the above method of reading and writing to a string variable, the first character in the string is referenced at 0 onwards, just like an unsigned **Byte Array**.

The example below shows a more practical String slicing demonstration.

```
' Display a string's text by examining each character individually
Device = 18F4520                    ' A suitable device for Strings
Dim SourceString as String * 20   ' Create a String
Dim Charpos as Byte                 ' Holds the position within the string

SourceString = "Hello World"        ' Load the source string with characters
Charpos = 0                         ' Start at position 0 within the string
Repeat                              ' Create a loop
   Print SourceString[Charpos]      ' Display character extracted from the string
   Inc Charpos                      ' Move to next position within the string
Until Charpos = Len(SourceString) ' Keep looping until the end of string is found
Stop
```

Notes

A word of caution regarding Strings: If you're familiar with interpreted BASICs and have used their String variables, you may have run into the "subscript out of range" error. This error occurs when the amount of characters placed in the string exceeds its maximum size.

For example, in the examples above, most of the strings are capable of holding 20 characters. If your program exceeds this range by trying to place 21 characters into a string only created for 20 characters, the compiler will not respond with an error message. Instead, it will access the next RAM location past the end of the String.

If you are not careful about this, it can cause all sorts of subtle anomalies as previously loaded variables are overwritten. It's up to the programmer (you!) to prevent this from happening by ensuring that the **String** in question is large enough to accommodate all the characters required, but not too large that it uses up too much precious RAM.

The compiler will help by giving a reminder message when appropriate, but this can be ignored if you are confident that the **String** is large enough.

See also :   **Creating and using Virtual Strings with Cdata**
                           Creating and using Virtual Strings with Edata
                           Cdata, Len, Left$, Mid$, Right$
                           String Comparisons, Str$, ToLower, ToUpper, AddressOf.

Creating and using Flash Memory Strings

Some devices have the ability to read and write to their own flash memory. And although writing to this memory too many times is unhealthy for the PICmicro™, reading this memory is both fast, and harmless. Which offers a unique form of data storage and retrieval, the **Cdata** command and the new **Dim as Code** directive proves this, as they uses the mechanism of reading and storing in the microcntroller's flash memory.

Combining the unique features of the 'self modifying devices ' with a string format, the compiler is capable of reducing the overhead of printing, or transmitting large amounts of text data. The **Cstr** modifier may be used in commands that deal with text processing i.e. **Print**, **Serout**, **Hrsout**, and **Rsout** .

The **Cstr** modifier is used in conjunction with the **Cdata** command. The **Cdata** command is used for initially creating the string of characters: -

```
String1: Cdata "HELLO WORLD", 0
```

The above line of code will create, in flash memory, the values that make up the ASCII text "HELLO WORLD", at address String1. Note the null terminator after the ASCII text.

 null terminated means that a zero (null) is placed at the end of the string of ASCII characters to signal that the string has finished.

To display, or transmit this string of characters, the following command structure could be used:

```
Print Cstr String1
```

The label that declared the address where the list of **Cdata** values resided, now becomes the string's name. In a large program with lots of text formatting, this type of structure can save quite literally hundreds of bytes of valuable code space.

Try both these small programs, and you'll see that using **Cstr** saves a few bytes of code: -

First the standard way of displaying text: -

```
Device = 18F4520
Cls
Print "HELLO WORLD"
Print "HOW ARE YOU?"
Print "I AM FINE!"
Stop
```

Now using the **Cstr** modifier: -

```
Cls
Print Cstr Text1
Print Cstr Text2
Print Cstr Text3
Stop

Text1: Cdata "HELLO WORLD", 0
Text2: Cdata "HOW ARE YOU?", 0
Text3: Cdata "I AM FINE!", 0
```

Again, note the null terminators after the ASCII text in the **Cdata** commands. Without these, the microcontroller will continue to transmit data in an endless loop.

The term 'virtual string' relates to the fact that a string formed from the **Cdata** command cannot (rather should not) be written too, but only read from.

Not only label names can be used with the **Cstr** modifier, constants, variables and expressions can also be used that will hold the address of the **Cdata** 's label (a pointer). For example, the program below uses a **Word** size variable to hold 2 pointers (address of a label, variable or array) to 2 individual null terminated text strings formed by **Cdata** .

Example 1
```
' Use the Proton development board for the example
  Include "Proton_4.Inc"
  Dim Address as Word      ' Pointer variable

  DelayMs 100               ' Wait for the LCD to stabilise
  Cls                       ' Clear the LCD

  Address = String1         ' Point address to string 1
  Print Cstr Address        ' Display string 1
  Address = String2         ' Point Address to string 2
  Print Cstr Address        ' Display string 2
  Stop

' Create the text to display in flash memory
String1:
  Cdata "Hello ", 0
String2:
  Cdata "World", 0
```

It is also possible to eliminate the **Cstr** modifier altogether and place the label's name directly. The compiler will see this as an implied **Cstr** and act accordingly. For example:

```
' Use the Proton development board for the example
  Include "Proton18_4.Inc"

  Dim CodeString1 as Code = "Hello ", 0
  Dim CodeString2 as Code = "World", 0

  Cls                        ' Clear the LCD

  Print CodeString1      ' Display CodeString1
  Print CodeString2      ' Display CodeString2
  Stop
```

Creating and using Eeprom Memory Strings with Edata

Some 14-bit core and most 18F microcontrollers have on-board eeprom memory, and although writing to this memory too many times is unhealthy for the device, reading this memory is both fast and harmless. Which offers a great place for text storage and retrieval.

Combining the eeprom memory of a device with a string format, the compiler is capable of reducing the overhead of printing, or transmitting large amounts of text data using a memory resource that is very often left unused and ignored. The **Estr** modifier may be used in commands that deal with text processing i.e. **Print**, **Serout**, **Hrsout**, and **Rsout** and **String** handling etc.

The **Estr** modifier is used in conjunction with the **Edata** command, which is used to initially create the string of characters: -

```
String1 Edata "HELLO WORLD", 0
```

The above line of code will create, in eeprom memory, the values that make up the ASCII text "HELLO WORLD", at address String1 in Data memory. Note the null terminator after the ASCII text.

To display, or transmit this string of characters, the following command structure could be used:

```
  Print Estr String1
```

The identifier that declared the address where the list of **Edata** values resided, now becomes the string's name. In a large program with lots of text formatting, this type of structure can save many bytes of valuable code space.

Try both these small programs, and you'll see that using **Estr** saves code space: -

First the standard way of displaying text: -

```
  Device 18F4520
  Cls
  Print "HELLO WORLD"
  Print "HOW ARE YOU?"
  Print "I AM FINE!"
  Stop
```

Now using the **Estr** modifier: -

```
Text1 Edata "HELLO WORLD", 0
Text2 Edata "HOW ARE YOU?", 0
Text3 Edata "I AM FINE!", 0

  Cls
  Print Estr Text1
  Print Estr Text2
  Print Estr Text3
  Stop
```

Again, note the null terminators after the ASCII text in the **Edata** commands. Without these, the microcontroller will continue to transmit data in an endless loop.

The term 'virtual string' relates to the fact that a string formed from the **Edata** command cannot (rather should not) be written to often, but can be read as many times as wished without causing harm to the device.

Not only identifiers can be used with the **Estr** modifier, constants, variables and expressions can also be used that will hold the address of the **Edata**'s identifier (a pointer). For example, the program below uses a **Byte** size variable to hold 2 pointers (address of a variable or array) to 2 individual null terminated text strings formed by **Edata** .

```
' Use the Proton development board for the example
  Include "Proton_4.Inc"

  Dim Address as Word      ' Pointer variable
'
' Create the text to display in eeprom memory
'
String1 Edata "HELLO ", 0
String2 Edata "WORLD", 0

  DelayMs 100              ' Wait for the LCD to stabilise
  Cls                     ' Clear the LCD
  Address = String1       ' Point address to string 1
  Print Estr Address      ' Display string 1
  Address = String2       ' Point Address to string 2
  Print Estr Address      ' Display string 2
  Stop
```

Notes

Note that the identifying text *must* be located on the same line as the **Edata** directive or a syntax error will be produced. It must also not contain a postfix colon as does a line label or it will be treat as a line label. Think of it as an alias name to a constant.

Any **Edata** directives *must* be placed at the head of the BASIC program as is done with Symbols, so that the name is recognised by the rest of the program as it is parsed. There is no need to jump over **Edata** directives as you have to with **Ldata** or **Cdata**, because they do not occupy code memory, but reside in high Data memory.

String Comparisons

Just like any other variable type, **String** variables can be used within comparisons such as **If-Then**, **Repeat-Until**, and **While-Wend** . In fact, it's an essential element of any programming language. However, there are a few rules to obey because of the PICmicro's architecture.

Equal (=) or Not Equal (<>) comparisons are the only type that apply to Strings, because one **String** can only ever be equal or not equal to another **String**. It would be unusual (unless your using the C language) to compare if one **String** was greater or less than another.

So a valid comparison could look something like the lines of code below: -

```
If String1 = String2 Then Print "Equal" : Else : Print "Not Equal"
```
or
```
If String1 <> String2 Then Print "Not Equal" : Else : Print "Equal"
```

But as you've found out if you read the *Creating Strings* section, there is more than one type of **String** in a PICmicro™. There is a **String** variable, a code memory string, and a quoted character string .

Note that pointers to **String** variables are not allowed in comparisons, and a syntax error will be produced if attempted.

Starting with the simplest of string comparisons, where one string variable is compared to another string variable. The line of code would look similar to either of the two lines above.

Example 1
```
' Simple string variable comparison

  Device = 18F452                ' A suitable device for Strings
' Create a String capable of holding 20 characters
  Dim String1 as String * 20
  Dim String2 as String * 20     ' Create another String

  Cls
  String1 = "EGGS"               ' Pre-load String String1 with the text EGGS
  String2 = "BACON"              ' Load String String2 with the text BACON

  If String1 = String2 Then      ' Is String1 equal to String2 ?
    Print At 1,1, " Equal "      ' Yes. So display Equal on line 1 of the LCD
  Else                           ' Otherwise
    Print At 1,1, "Not Equal "   ' Display Not Equal on line 1 of the LCD
  EndIf

  String2 = "EGGS"               ' Now make the strings the same as each other
  If String1 = String2 Then      ' Is String1 equal to String2 ?
    Print At 2,1, "Equal"        ' Yes. So display Equal on line 2 of the LCD
  Else                           ' Otherwise
    Print At 2,1, "Not Equal "   ' Display Not Equal on line 2 of the LCD
  EndIf
  Stop
```

The example above will display not Equal on line one of the LCD because String1 contains the text "EGGS" while String2 contains the text "BACON", so they are clearly not equal.

Line two of the LCD will show Equal because String2 is then loaded with the text "EGGS" which is the same as String1, therefore the comparison is equal.

A similar example to the previous one uses a quoted character string instead of one of the **String** variables.

Example 2

```
' String variable to Quoted character string comparison

  Device = 18F4520             ' A suitable device for Strings
  Declare Xtal = 16
  Declare Hserial_Baud = 9600

  Dim String1 as String * 20   ' Create a String for 20 characters

  String1 = "EGGS"             ' Pre-load String String1 with the text EGGS

  If String1 = "BACON" Then    ' Is String1 equal to "BACON" ?
    HrsoutLn "Equal"           ' Yes. So display equal
  Else                         ' Otherwise…
    HrsoutLn "Not Equal"       ' Display Not Equal
  EndIf

  If String1 = "EGGS" Then     ' Is String1 equal to "EGGS" ?
    HrsoutLn "Equal"           ' Yes. So display Equal
  Else                         ' Otherwise…
    HrsoutLn "Not Equal"       ' Display Not Equal
  EndIf
  Stop
```

The example above produces exactly the same results as example1 because the first comparison is clearly not equal, while the second comparison is equal.

Example 3

```
' Use a string comparison in a Repeat-Until loop

  Device = 18F4520                 ' A suitable device for Strings
  Declare Xtal = 16
  Declare Hserial_Baud = 9600

  Dim SourceString as String * 20  ' Create a String
  Dim DestString as String * 20    ' Create another String
  Dim Charpos as Byte              ' Character position within the strings

  Clear DestString                 ' Fill DestString with nulls
  SourceString = "Hello"           ' Load String SourceString with the text Hello

  Repeat                           ' Create a loop
    '
    ' Copy SourceString into DestString one character at a time
    '
    DestString[Charpos] = SourceString[Charpos]
    Inc Charpos                    ' Move to the next character in the strings
  Until DestString = "Hello"       ' Stop when DestString is equal to the text "Hello"
  HrsoutLn DestString              ' Display DestString
  Stop
```

Example 4

```
' Compare a string variable to a string held in flash memory
  Device = 18F4520              ' A suitable device for Strings
  Declare Xtal = 16
  Declare Hserial_Baud = 9600

  Dim String1 as String * 20    ' Create a String for 20 characters

  String1 = "BACON"             ' Pre-load String String1 with the text BACON
  If CodeString= "BACON" Then   ' Is CodeString equal to "BACON"?
    HrsoutLn " Equal"           ' Yes. So display Equal
  Else                          ' Otherwise…
    HrsoutLn "Not Equal"        ' Display Not Equal
  EndIf

  String1 = "EGGS"              ' Pre-load String String1 with the text EGGS
  If String1 = CodeString Then  ' Is String1 equal to CodeString?
    HrsoutLn " Equal"           ' Yes. So display Equal
  Else                          ' Otherwise…
    HrsoutLn "Not Equal"        ' Display Not Equal
  EndIf
  Stop

CodeString:
  Cdata "EGGS", 0
```

Example 5

```
' String comparisons using Select-Case
  Device = 18F4520              ' A suitable device for Strings
  Declare Xtal = 16
  Declare Hserial_Baud = 9600

  Dim String1 as String * 20    ' Create a String for 20 characters

  String1 = "EGGS"             ' Pre-load String String1 with the text EGGS
  Select String1                ' Start comparing the string
    Case "EGGS"                 ' Is String1 equal to EGGS?
      HrsoutLn "Found EGGS"     ' Yes. So display it
    Case "BACON"                ' Is String1 equal to BACON?
      HrsoutLn "Found BACON"    ' Yes. So display it
    Case "COFFEE"               ' Is String1 equal to COFFEE?
      HrsoutLn "Found COFFEE"   ' Yes. So display it
    Case Else                   ' Default to...
      HrsoutLn "No Match"       ' Displaying no match
  EndSelect
  Stop
```

See also :   Creating and using Strings
Creating and using Virtual Strings with Cdata
Cdata, If-Then-Else-EndIf, Repeat-Until
Select-Case, While-Wend, Do-Loop.

Relational Operators

Relational operators are used to compare two values. The result can be used to make a decision regarding program flow.

The list below shows the valid relational operators accepted by the compiler:

Operator	Relation	Expression Type
=	Equality	X = Y
==	Equality	X == Y (Same as above Equality)
<>	Inequality	X <> Y
<	Less than	X < Y
>	Greater than	X > Y
<=	Less than or Equal to	X <= Y
>=	Greater than or Equal to	X >= Y

See also : **If-Then-Else-EndIf, Repeat-Until, Select-Case, While-Wend.**

Boolean Logic Operators

The **If-Then-Else-EndIf**, **While-Wend**, and **Repeat-Until** conditions now support the logical operators **and** and **or**.

The operators **and** and **or** join the results of two conditions to produce a single true/false result. **and** and **or** work the same as they do in everyday speech. Run the example below once with **and** (as shown) and again, substituting **or** for **and**: -

```
    Dim Var1 as Byte
    Dim Var2 as Byte

    Cls
    Var1 = 5
    Var2 = 9
    If Var1 = 5 and Var2 = 10 Then Result_True
    Stop

Result_True:
    Print "Result Is True."
    Stop
```

The condition "Var1 = 5 **and** Var2 = 10" is not true. Although Var1 is 5, Var2 is not 10. **and** works just as it does in plain English, both conditions must be true for the statement to be true. **or** also works in a familiar way; if one or the other or both conditions are true, then the statement is true. **xor** (short for exclusive-or) may not be familiar, but it does have an English counterpart: If one condition or the other (but not both) is true, then the statement is true.

Parenthesis (or rather the lack of it!).

Every compiler has its quirky rules, and the Proton compiler is no exception. One of its quirks means that parenthesis is not supported in a Boolean condition, or indeed with any of the **If-Then-Else-EndIf**, **While-Wend**, and **Repeat-Until** conditions. Parenthesis in an expression within a condition is allowed however. So, for example, the expression: -

```
    If (Var1 + 3) = 10 Then do something.      Is allowed.
```
but: -
```
    If( (Var1 + 3) = 10) Then do something.    Is not allowed.
```

The boolean operands do have a precedence within a condition. The **and** operand has the highest priority, then the **or**, then the **xor**. This means that a condition such as: -

```
    If Var1 = 2 and Var2 = 3 or Var3 = 4 Then do something
```

Will compare Var1 and Var2 to see if the **and** condition is true. It will then see if the **or** condition is true, based on the result of the **and** condition.

Then operand always required.

The Proton compiler relies heavily on the **Then** part. Therefore, if the **Then** part of a condition is left out of the code listing, a *Syntax Error* will be produced.

Math Operators

The Proton compiler performs all math operations in full hierarchal order. Which means that there is precedence to the operators. For example, multiplies and divides are performed before adds and subtracts. To ensure the operations are carried out in the correct order use parenthesis to group the operations: -

A = ((B - C) * (D + E)) / F

All math operations are signed or unsigned depending on the variable type used, and performed with 16, or 32-bit or floating point precision, again, depending on the variable types and constant values used within the expression. The operators supported are: -

Standard operators

Addition '+'	Adds variables and/or constants.
Subtraction '-'	Subtracts variables and/or constants.
Multiply '*'	Multiplies variables and/or constants.
Multiply High ''**	Returns the high 16 bits of an unsigned 16-bit integer multiply.
Multiply Middle '*/'	Returns the middle 16 bits of an unsigned 16-bit integer multiply.
Divide '/'	Divides variables and/or constants.
Modulus '//'.	Returns the remainder after dividing one integer value by another.

Logical operators

Bitwise and '&'	Returns the logical **AND** of two values.
Bitwise or '|'	Returns the logical **OR** of two values.
Bitwise xor '^'	Returns the logical **XOR** of two values.
Bitwise Shift Left '<<'	Shifts the bits of a value left a specified number of places.
Bitwise Shift Right '>>'	Shifts the bits of a value right a specified number of places.
Bitwise Complement '~'	Reverses the bits in a variable.
Bitwise Reverse '@'	Reverses the order of the lowest bits in a value.

Proton operators

Abs.	Returns the absolute value of a signed number.
Dcd.	2 n -power decoder of a four-bit value.
Decimal Digit Extract '?'	Returns the specified decimal digit of a positive value.
Div32.	15-bit x 31 bit unsigned divide. (For PBP compatibility only)
Exp	Return the exponential function of a floating point value.
Isqr	Returns the Square Root of an integer value.
Ncd.	Priority encoder of a 16-bit value.
Pow	Computes a variable to the power of another.
Sqr	Returns the Square Root of a floating point value.

Trigonometry functions

Acos	Returns the Arc Cosine of a floating point value in radians.
Asin	Returns the Arc Sine of a floating point value in radians.
Atan	Returns the Arc Tangent of a floating point value in radians.
Cos	Returns the Cosine of a floating point value in radians.
ISin	Returns the Sine of an integer value in radians.
ICos	Returns the Cosine of an integer value in radians.
Log	Returns the Natural Log of a floating point value.
Log10	Returns the Log of a floating point value.
Sin	Returns the Sine of a floating point value in radians.
Tan	Returns the Tangent of a floating point value in radians.

Add '+'

Syntax
*Assignment Variable = Variable **+** Variable*

Overview
Adds variables and/or constants, returning an unsigned or signed 8, 16, 32-bit or floating point result.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Addition works exactly as you would expect with signed and unsigned integers as well as floating point.

```
    Dim Value1 as Word
    Dim Value2 as Word

    Value1 = 1575
    Value2 = 976
    Value1 = Value1 + Value2        ' Add the numbers.
    HrsoutLn Dec Value1             ' Display the result

' 32-bit addition
    Dim Value1 as Word
    Dim Value2 as Dword

    Value1 = 1575
    Value2 = 9763647
    Value2 = Value2 + Value1        ' Add the numbers.
    HrsoutLn Dec Value1             ' Display the result
```

Subtract '-'

Syntax
*Assignment Variable = Variable **-** Variable*

Overview
Subtracts variables and/or constants, returning an unsigned or signed 8, 16, 32-bit or floating point result.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Subtract works exactly as you would expect with signed and unsigned integers as well as floating point.

```
    Dim Value1 as Word
    Dim Value2 as Word

    Value1 = 1000
    Value2 = 999
    Value1 = Value1 - Value2        ' Subtract the numbers.
    HrsoutLn Dec Value1             ' Display the result
```

```
' 32-bit subtraction
  Dim Value1 as Word
  Dim Value2 as Dword

  Value1 = 1575
  Value2 = 9763647
  Value2 = Value2 - Value1     ' Subtract the numbers.
  HrsoutLn Dec Value1          ' Display the result


' 32-bit signed subtraction
  Dim Value1 as SDword
  Dim Value2 as SDword

  Value1 = 1575
  Value2 = 9763647
  Value1 = Value1 - Value2     ' Subtract the numbers.
  HrsoutLn SDec Value1         ' Display the result
```

Multiply '*'

Syntax
*Assignment Variable = Variable * Variable*

Overview
Multiplies variables and/or constants, returning an unsigned or signed 8, 16, 32-bit or floating point result.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Multiply works exactly as you would expect with signed or unsigned integers from -2147483648 to +2147483647 as well as floating point. If the result of multiplication is larger than 2147483647 when using 32-bit variables, the excess bit will be lost.

```
  Dim Value1 as Word
  Dim Value2 as Word

  Value1 = 1000
  Value2 = 19
  Value1 = Value1 * Value2     ' Multiply Value1 by Value2.
  HrsoutLn Dec Value1          ' Display the result


' 32-bit multiplication
  Dim Value1 as Word
  Dim Value2 as Dword

  Value1 = 100
  Value2 = 10000
  Value2 = Value2 * Value1     ' Multiply the numbers.
  HrsoutLn Dec Value1          ' Display the result
```

Multiply High '**'

Syntax
*Assignment Variable = Variable ** Variable*

Overview
Multiplies 8 or 16-bit unsigned variables and/or constants, returning the high 16 bits of the result.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

When multiplying two 16-bit values, the result can be as large as 32 bits. Since the largest variable supported by the compiler is 16-bits, the highest 16 bits of a 32-bit multiplication result are normally lost. The ** (double-star) operand produces these upper 16 bits.

For example, suppose 65000 ($FDE8) is multiplied by itself. The result is 4,225,000,000 or $FBD46240. The * (star, or normal multiplication) instruction would return the lower 16 bits, $6240. The ** instruction returns $FBD4.

```
Dim Value1 as Word
Dim Value2 as Word

Value1 = $FDE8
Value2 = Value1 ** Value1        ' Multiply $FDE8 by itself
HrsoutLn Hex Value2              ' Display the high 16 bits.
```

Notes.
This operand enables compatibility with BASIC STAMP code, and melab's compiler code, but is rather obsolete considering the 32-bit capabilities of the Proton compiler.

Multiply Middle '*/'

Syntax
*Assignment Variable = Variable */ Variable*

Overview
Multiplies unsigned variables and/or constants, returning the middle 16 bits of the 32-bit result.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

The Multiply Middle operator (*/) has the effect of multiplying a value by a whole number and a fraction. The whole number is the upper byte of the multiplier (0 to 255 whole units) and the fraction is the lower byte of the multiplier (0 to 255 units of 1/256 each). The */ operand allows a workaround for the compiler's integer-only math.

Suppose we are required to multiply a value by 1.5. The whole number, and therefore the upper byte of the multiplier, would be 1, and the lower byte (fractional part) would be 128, since 128/256 = 0.5. It may be clearer to express the */ multiplier in Hex as $0180, since hex keeps the contents of the upper and lower bytes separate. Here's an example: -

```
Dim Value1 as Word
Value1 = 100
Value1 = Value1 */ $0180        ' Multiply by 1.5 [1 + (128/256)]
HrsoutLn Dec Value1             ' Display result (150).
```

To calculate constants for use with the */ instruction, put the whole number portion in the upper byte, then use the following formula for the value of the lower byte: -

    int(fraction * 256)

For example, take Pi (3.14159). The upper byte would be $03 (the whole number), and the lower would be int(0.14159 * 256) = 36 ($24). So the constant Pi for use with */ would be $0324. This isn't a perfect match for Pi, but the error is only about 0.1%.

Notes.
This operand enables compatibility with BASIC STAMP code, and melab's compiler code, but is rather obsolete considering the 32-bit capabilities of the Proton compiler.

Divide '/'

Syntax
Assignment Variable = Variable / Variable

Overview
Divides variables and/or constants, returning an unsigned or signed 8, 16, 32-bit or floating point result.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

The Divide operator (/) works exactly as you would expect with signed or unsigned integers from -2147483648 to +2147483647 as well as floating point.

```
Dim Value1 as Word
Dim Value2 as Word

Value1 = 1000
Value2 = 5
Value1 = Value1 / Value2        ' Divide the numbers.
HrsoutLn Dec Value1             ' Display the result (200).

' 32-bit division
Dim Value1 as Word
Dim Value2 as Dword

Value1 = 100
Value2 = 10000
Value2 = Value2 / Value1        ' Divide the numbers.
HrsoutLn Dec Value1             ' Display the result
```

Integer Modulus '//'

Syntax
Assignment Variable = Variable // Variable

Overview
Return the remainder left after dividing one unsigned or signed value by another.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Some division problems don't have a whole-number result; they return a whole number and a fraction. For example, 1000/6 = 166.667. Integer math doesn't allow the fractional portion of the result, so 1000/6 = 166. However, 166 is an approximate answer, because 166*6 = 996. The division operation left a remainder of 4. The // returns the remainder of a given division operation. Numbers that divide evenly, such as 1000/5, produce a remainder of 0: -

```
Dim Value1 as Word
Dim Value2 as Word
Value1 = 1000
Value2 = 6
Value1 = Value1 // Value2      ' Get remainder of Value1 / Value2.
HrsoutLn Dec Value1            ' Display the result (4).

' 32-bit modulus
Dim Value1 as Word
Dim Value2 as Dword
Value1 = 100
Value2 = 99999
Value2 = Value2 // Value1      ' Mod the numbers.
HrsoutLn Dec Value1            ' Display the result
```

The modulus operator does not operate with floating point values or variables.

Logical and '&'

The And operator (&) returns the bitwise and of two values. Each bit of the values is subject to the following logic: -

    0 and 0 = 0
    0 and 1 = 0
    1 and 0 = 0
    1 and 1 = 1

The result returned by & will contain 1s in only those bit positions in which both input values contain 1s: -

```
Dim Value1 as Byte
Dim Value2 as Byte
Dim MyResult as Byte

Value1 = %00001111
Value2 = %10101101
MyResult = Value1 & Value2
HrsoutLn Bin MyResult                   ' Display and result (%00001101)
```

or

```
HrsoutLn Bin ( %00001111 & %10101101 )  ' Display and result (%00001101)
```

Bitwise operations are not permissible with floating point values or variables.

Logical or '|'

The Or operator (|) returns the bitwise or of two values. Each bit of the values is subject to the following logic: -

    0 or 0 = 0
    0 or 1 = 1
    1 or 0 = 1
    1 or 1 = 1

The result returned by | will contain 1s in any bit positions in which one or the other (or both) input values contain 1s: -

```
Dim Value1 as Byte
Dim Value2 as Byte
Dim MyResult as Byte

Value1 = %00001111
Value2 = %10101001
MyResult = Value1 | Value2
HrsoutLn Bin MyResult                   ' Display or result (%10101111)
```

or

```
HrsoutLn Bin ( %00001111 | %10101001 )  ' Display or result (%10101111)
```

Bitwise operations are not permissible with floating point values or variables.

Logical Xor '^'

The Xor operator (^) returns the bitwise xor of two values. Each bit of the values is subject to the following logic: -

```
0 xor 0 = 0
0 xor 1 = 1
1 xor 0 = 1
1 xor 1 = 0
```

The result returned by ^ will contain 1s in any bit positions in which one or the other (but not both) input values contain 1s: -

```
Dim Value1 as Byte
Dim Value2 as Byte
Dim MyResult as Byte

Value1 = %00001111
Value2 = %10101001
MyResult = Value1 ^ Value2
HrsoutLn Bin MyResult                    ' Display xor result (%10100110)
```

or

```
HrsoutLn Bin ( %00001111 ^ %10101001 )  ' Display xor result (%10100110)
```

Bitwise operations are not permissible with floating point values or variables.

Bitwise Shift Left '<<'

Shifts the bits of a value to the left a specified number of places. Bits shifted off the left end of a number are lost; bits shifted into the right end of the number are 0s. Shifting the bits of a value left *n* number of times also has the effect of multiplying that number by two to the *nth* power.

For example 100 << 3 (shift the bits of the decimal number 100 left three places) is equivalent to 100 * 2^3.

```
Dim Value1 as Word
Dim MyLoop as Byte

Value1 = %1111111111111111
For MyLoop = 1 to 16                 ' Repeat with MyLoop = 1 to 16.
   HrsoutLn Bin Value1 << MyLoop     ' Shift Value1 left MyLoop places.
Next
```

Bitwise operations are not permissible with floating point values or variables. All bit shifts are unsigned, regardless of the variable type used.

Bitwise Shift Right '>>'

Shifts the bits of a variable to the right a specified number of places. Bits shifted off the right end of a number are lost; bits shifted into the left end of the number are 0s. Shifting the bits of a value right *n* number of times also has the effect of dividing that number by two to the *nth* power.

For example 100 >> 3 (shift the bits of the decimal number 100 right three places) is equivalent to 100 / 2^3.

```
Dim Value1 as Word
Dim MyLoop as Byte

Value1 = %1111111111111111
For MyLoop = 1 to 16          ' Repeat with MyLoop = 1 to 16.
   HrsoutLn Bin Value1 >> MyLoop  ' Shift Value1 right MyLoop places.
Next
```

Complement '~'

The Complement operator (~) inverts the bits of a value. Each bit that contains a 1 is changed to 0 and each bit containing 0 is changed to 1. This process is also known as a "bitwise not".

```
Dim Value1 as Word
Dim Value2 as Word

Value2 = %1111000011110000
Value1 = ~Value2             ' Complement Value2.
Print Bin16 Value1           ' Display the result
```

Complementing can be carried out with all variable types except **Float**s. Attempting to complement a floating point variable will produce a syntax error. All bit shifts are unsigned, regardless of the variable type used.

Bitwise Reverse '@'

Reverses the order of the lowest bits in a value. The number of bits to be reversed is from 1 to 32. Its syntax is: -

```
   MyVar = %10101100 @ 4   ' Sets MyVar to %10100011
```
or
```
   Dim MyDword as Dword
' Sets MyDword to %10101010000000001111111110100011
   MyDword = %10101010000000001111111110101100 @ 4
```

Decimal Digit extract '?'

In this form, the ? operator is compatible with the BASIC Stamp, and the melab's PicBASIC Pro compiler. It returns the specified decimal digit of a 16-bit positive value. Digits are numbered from 0 (the rightmost digit) to 4 (the leftmost digit of a 16- bit number; 0 to 65535). Example: -

```
   MyWord = 9742
   HrsoutLn MyWord ? 2            ' Display digit 2 (7)
   For MyLoop = 0 to 4
      HrsoutLn MyWord ? MyLoop    ' Display digits 0 through 4 of 9742.
   Next
```

Note

Decimal Digit Extract does not support **Float** type variables.

Abs

Syntax
Assignment Variable = **Abs(***Variable***)**

Overview
Return the absolute value of a constant, variable or expression.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

32-bit Example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600  ' Choose the Baud rate for HrsoutLn

Dim Dwd1 as Dword            ' Create an unsigned Dword variable
Dim Dwd2 as Dword            ' Create an unsigned Dword variable

Dwd1 = -1234567              ' Load Dwd1 with value -1234567
Dwd2 = Abs(Dwd1)             ' Extract the absolute value from Dwd1
HrsoutLn Dec Dwd2            ' Display the result, which is 1234567
Stop
```

Floating Point example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600  ' Choose the Baud rate for HrsoutLn

Dim Flp1 as Float            ' Create a Float variable
Dim Flp2 as Float            ' Create a Float variable

Flp1 = -1234567              ' Load Flp1 with value -1234567
Flp2 = Abs(Flp1)             ' Extract the absolute value from Flp1
HrsoutLn Dec Flp2            ' Display the result, which is 1234567
Stop
```

Note
When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Abs(MyVar1)) + MyVar2
```

fAbs

Syntax
*Assignment Variable = **fAbs(**Variable**)**

Overview
Return the absolute value of a constant, variable or expression as floating point.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Floating Point example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Flp1 as Float            ' Create a Float variable
Dim Flp2 as Float            ' Create a Float variable

Flp1 = -1234567             ' Load Flp1 with value -1234567
Flp2 = fAbs(Flp1)           ' Extract the absolute value from Flp1
HrsoutLn Dec Flp2           ' Display the result, which is 1234567
Stop
```

Note
When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (fAbs(MyVar1)) + MyVar2
```

Acos

Syntax
Assignment Variable = **Acos(***Variable***)**

Overview
Deduce the Arc Cosine of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Arc Cosine (Inverse Cosine) extracted. The value expected and returned by the floating point **Acos** is in radians. The value must be in the range of -1 to +1

Example
```
Device = 18F25K22          ' Choose the device
Declare Xtal = 16          ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float        ' Holds the value to Acos
Dim Floatout as Float       ' Holds the result of the Acos

Floatin = 0.8               ' Load the variable
Floatout = Acos(Floatin)    ' Extract the Acos of the value
HrsoutLn Dec Floatout       ' Display the result
Stop
```

Notes
Acos is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point Arc Cosine is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Acos(MyVar1)) + MyVar2
```

Asin

Syntax
Assignment Variable = **Asin(***Variable***)**

Overview
Deduce the Arc Sine of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Arc Sine (Inverse Sine) extracted. The value expected and returned by **Asin** is in radians. The value must be in the range of -1 to +1

Example
```
Device = 18F25K22         ' Choose the device
Declare Xtal = 16         ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float      ' Holds the value to Asin
Dim Floatout as Float     ' Holds the result of the Asin

Floatin = 0.8             ' Load the variable
Floatout = Asin(Floatin)  ' Extract the Asin of the value
HrsoutLn Dec Floatout     ' Display the result
Stop
```

Notes
Asin is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point Arc Sine is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Asin(MyVar1)) + MyVar2
```

Atan

Syntax
Assignment Variable = **Atan(***Variable***)**

Overview
Deduce the Arc Tangent of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Arc Tangent (Inverse Tangent) extracted. The value expected and returned by the floating point **Atan** is in radians.

Example
```
Device = 18F25K22          ' Choose the device
Declare Xtal = 16          ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float       ' Holds the value to Atan
Dim Floatout as Float      ' Holds the result of the Atan

Floatin = 1                ' Load the variable
Floatout = Atan(Floatin)   ' Extract the Atan of the value
HrsoutLn Dec Floatout      ' Display the result
Stop
```

Notes
Atan is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point Arc Tangent is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Atan(MyVar1)) + MyVar2
```

Cos

Syntax
Assignment Variable = **Cos(***Variable***)**

Overview
Deduce the Cosine of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Cosine extracted. The value expected and returned by **Cos** is in radians.

Example
```
Device = 18F25K22          ' Choose the device
Declare Xtal = 16          ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float       ' Holds the value to Cos with
Dim Floatout as Float      ' Holds the result of the Cos

Floatin = 123              ' Load the variable
Floatout = Cos(Floatin)    ' Extract the Cos of the value
HrsoutLn Dec Floatout      ' Display the result
Stop
```

Notes
With 12, and 14-bit core devices, **Cos** returns the 8-bit cosine of a value, compatible with the BASIC Stamp syntax. The result is in two's complement form (i.e. -127 to 127). **Cos** starts with a value in binary radians, 0 to 255, instead of the customary 0 to 359 degrees.

However, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point Cosine is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Cos(MyVar1)) + MyVar2
```

Dcd

2 n -power decoder of a four-bit value. **Dcd** accepts a value from 0 to 15, and returns a 16-bit number with that bit number set to 1. For example: -

```
Wrd1= Dcd 12          ' Set bit-12.
HrsoutLn Bin16 Wrd1   ' Display result (%0001000000000000)
```

Dcd does not support **Dword**, or **Float** type variables. Therefore the highest value obtainable is 65535.

Exp

Syntax
Assignment Variable = **Exp(** *Variable* **)**

Overview
Deduce the exponential function of a floating point value. This is *e* to the power of *value* where
e is the base of natural logarithms. **Exp** 1 is 2.7182818.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Example
```
Device = 18F25K22          ' Choose the device
Declare Xtal = 16          ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float       ' Holds the value to Exp with
Dim Floatout as Float      ' Holds the result of the Exp

Floatin = 1                ' Load the variable
Floatout = Exp(Floatin)    ' Extract the Exp of the value
HrsoutLn Dec Floatout      ' Display the result
Stop
```

Notes
Exp is not implemented with 12, or 14-bit core devices, however, with the extra functionality,
and more linear memory offered by the 18F devices, full 32-bit floating point exponentials are
implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk
of the microcontroller's code memory is used with a single operator. This also means that float-
ing point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap
them in parenthesis, otherwise the parser may consider the extra operands as part of the trigo-
nometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Exp(MyVar1)) + MyVar2
```

fRound

Syntax
*Assignment Variable = **fRound(***Variable***)**

Overview
Round a value, variable or expression to the nearest integer.

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.

Example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600  ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float         ' Holds the value to round
Dim Dwordout as Dword        ' Holds the result of fRound

Floatin = 1.9                ' Load the variable
Dwordout = fRound(Floatin)   ' Round to the nearest integer value
HrsoutLn Dec Dwordout        ' Display the integer result
Stop
```

Notes
Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (fRound(MyVar1)) + MyVar2
```

ISin

Syntax
*Assignment Variable = **ISin(***Variable*)

Overview
Deduce the integer Sine of an integer value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Sine extracted. The value expected and returned by **ISin** is in decimal radians (0 to 255).

Example
```
Device = 18F25K22          ' Choose the device
Declare Xtal = 16          ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim ByteIn as Byte         ' Holds the value to ISin
Dim ByteOut as Byte        ' Holds the result of the ISin

ByteIn = 123               ' Load the variable
ByteOut = ISin(ByteIn)     ' Extract the integer Sin of the value
HrsoutLn Dec ByteOut       ' Display the result
Stop
```

Note
When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (ISin(MyVar1)) + MyVar2
```

ICos

Syntax
Assignment Variable = **ICos(***Variable***)**

Overview
Deduce the integer Cosine of an integer value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Cosine extracted. The value expected and returned by **ICos** is in decimal radians (0 to 255).

Example
```
Device = 18F25K22              ' Choose the device
Declare Xtal = 16              ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600   ' Choose the Baud rate for HrsoutLn

Dim ByteIn as Byte             ' Holds the value to ICos
Dim ByteOut as Byte            ' Holds the result of the Icos

ByteIn = 123                   ' Load the variable
ByteOut = ICos(ByteIn)         ' Extract the integer Cosine of the value
HrsoutLn Dec ByteOut           ' Display the result
Stop
```

Note
When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (ICos(MyVar1)) + MyVar2
```

Isqr

Syntax
Assignment Variable = **ISqr(***Variable***)**

Overview
Deduce the integer Square Root of an integer value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Square Root extracted.

Example
```
Device = 18F25K22             ' Choose the device
Declare Xtal = 16             ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600   ' Choose the Baud rate for HrsoutLn

Dim ByteIn as Byte            ' Holds the value to ISqr
Dim ByteOut as Byte           ' Holds the result of the Isqr

ByteIn = 123                  ' Load the variable
ByteOut = ISqr(ByteIn)        ' Extract the integer square root of the value
HrsoutLn Dec ByteOut          ' Display the result
Stop
```

Note
When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigo-nometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Isqr(MyVar1)) + MyVar2
```

Log

Syntax
Assignment Variable = **Log(***Variable***)**

Overview
Deduce the Natural Logarithm a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the natural logarithm extracted.

Example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float         ' Holds the value to Log with
Dim Floatout as Float        ' Holds the result of the Log

Floatin = 1                  ' Load the variable
Floatout = Log(Floatin)      ' Extract the Log of the value
HrsoutLn Dec Floatout        ' Display the result
Stop
```

Notes
Log is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point Natural Logarithms are implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Log(MyVar1)) + MyVar2
```

Log10

Syntax
Assignment Variable = **Log10(***Variable***)**

Overview
Deduce the Logarithm a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Logarithm extracted.

Example
```
Device = 18F25K22             ' Choose the device
Declare Xtal = 16             ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600   ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float          ' Holds the value to Log10 with
Dim Floatout as Float         ' Holds the result of the Log10

Floatin = 1                   ' Load the variable
Floatout = Log10(Floatin)     ' Extract the Log10 of the value
HrsoutLn Dec Floatout         ' Display the result
Stop
```

Notes
Log10 is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point logarithms are implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Log10(MyVar1)) + MyVar2
```

Ncd

Priority encoder of a 16-bit value. Ncd takes a 16-bit value, finds the highest bit containing a 1 and returns the bit position plus one (1 through 16). If no bit is set, the input value is 0. Ncd returns 0. Ncd is a fast way to get an answer to the question "what is the largest power of two that this value is greater than or equal to?" The answer that Ncd returns will be that power, plus one. Example: -

```
Wrd1= %1101              ' Highest bit set is bit-3.
HrsoutLn Dec Ncd Wrd1    ' Display the Ncd of Wrd1(4).
```

Ncd does not support **Dword**, or **Float** type variables.

Pow

Syntax
*Assignment Variable = **Pow(***Variable, Pow Variable***)**

Overview
Computes *Variable* to the power of *Pow Variable.*

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression.
Pow Variable can be a constant, variable or expression.

Example
```
Device = 18F25K22              ' Choose the device
Declare Xtal = 16              ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600   ' Choose the Baud rate for HrsoutLn

Dim PowOf as Float
Dim Floatin as Float          ' Holds the value to Pow with
Dim Floatout as Float         ' Holds the result of the Pow

PowOf= 10
Floatin = 2                   ' Load the variable
Floatout = Pow(Floatin,PowOf) ' Extract the Pow of the value
HrsoutLn Dec Floatout         ' Display the result
Stop
```

Notes
Pow is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point power of is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Pow(MyVar1, MyVar2)) + MyVar3
```

Sin

Syntax
Assignment Variable = **Sin(***Variable***)**

Overview
Deduce the Sine of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Sine extracted. The value expected and returned by **Sin** is in radians.

Example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600  ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float         ' Holds the value to Sin
Dim Floatout as Float        ' Holds the result of the Sin

Floatin = 123                ' Load the variable
Floatout = Sin(Floatin)      ' Extract the Sin of the value
HrsoutLn Dec Floatout        ' Display the result
Stop
```

Notes
With 12, and 14-bit core devices, **Sin** returns the 8-bit sine of a value, compatible with the BASIC Stamp syntax. The result is in two's complement form (i.e. -127 to 127). **Sin** starts with a value in binary radians, 0 to 255, instead of the customary 0 to 359 degrees.

However, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point Sine is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Sin(MyVar1)) + MyVar2
```

Sqr

Syntax
Assignment Variable = **Sqr(***Variable***)**

Overview
Deduce the Square Root of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Squrare Root extracted.

Notes
With 12 and 14-bit core devices, **Sqr** returns an integer square root of a value, compatible with the BASIC Stamp syntax. Remember that most square roots have a fractional part that the compiler discards in doing its integer-only math. Therefore it computes the square root of 100 as 10 (correct), but the square root of 99 as 9 (the actual is close to 9.95). Example: -

```
Var1 = Sqr Var2
```

or

```
HrsoutLn Sqr 100        ' Display square root of 100 (10).
HrsoutLn Sqr 99         ' Display of square root of 99 (9 due to truncation)
```

However, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point **Sqr** is implemented.

Example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600  ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float         ' Holds the value to Sqr
Dim Floatout as Float        ' Holds the result of the Sqr

Floatin = 600                ' Load the variable
Floatout = Sqr(Floatin)      ' Extract the Sqr of the value
HrsoutLn Dec Floatout        ' Display the result
Stop
```

Notes
Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Sqr(MyVar1)) + MyVar2
```

Tan

Syntax
Assignment Variable = **Tan(***Variable***)**

Overview
Deduce the Tangent of a floating point value

Operands
Assignment Variable can be any valid variable type.
Variable can be a constant, variable or expression that requires the Tangent extracted. The value expected and returned by the floating point **Tan** is in radians.

Example
```
Device = 18F25K22            ' Choose the device
Declare Xtal = 16            ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600  ' Choose the Baud rate for HrsoutLn

Dim Floatin as Float         ' Holds the value to Tan
Dim Floatout as Float        ' Holds the result of the Tan

Floatin = 1                  ' Load the variable
Floatout = Tan(Floatin)      ' Extract the Tan of the value
HrsoutLn Dec Floatout        ' Display the result
Stop
```

Notes
Tan is not implemented with 12, or 14-bit core devices, however, with the extra functionality, and more linear memory offered by the 18F devices, full 32-bit floating point tangent is implemented.

Floating point trigonometry is extremely memory hungry, so do not be surprised if a large chunk of the microcontroller's code memory is used with a single operator. This also means that floating point trigonometry is comparatively slow to operate.

When implementing trigonometry, or other built in, functions within an expression, always wrap them in parenthesis, otherwise the parser may consider the extra operands as part of the trigonometry parameter and produce an incorrect result. For example:

```
MyAssignment = (Tan(MyVar1)) + MyVar2
```

Div32

In order to make the Proton compiler more compatible with code produced for the melab's PicBASIC Pro compiler, the **Div32** operator has been added. The melab's compiler's multiply operand operates as a 16-bit x 16-bit multiply, thus producing a 32-bit result. However, since the compiler only supports a maximum variable size of 16 bits (**Word**), access to the result had to happen in 2 stages: -

`Var = Var1 * Var2` returns the lower 16 bits of the multiply

while…

`Var = Var1 ** Var2` returns the upper 16 bits of the multiply

There was no way to access the 32-bit result as a valid single value.

In many cases it is desirable to be able to divide the entire 32-bit result of the multiply by a 16-bit number for averaging, or scaling. **Div32** is actually limited to dividing a 31-bit unsigned integer (0 - 2147483647) by a 15-bit unsigned integer (0 - 32767). This ought to be sufficient in most situations.

Because the melab's compiler only allows a maximum variable size of 16 bits (0 - 65535), **Div32** relies on the fact that a multiply was performed just prior to the **Div32** command, and that the internal compiler variables still contain the 32-bit result of the multiply. No other operation may occur between the multiply and the **Div32** or the internal variables may be altered, thus destroying the 32-bit multiplication result.

The following example demonstrates the operation of **Div32**:-

```
Device = 18F25K22           ' Choose the device
Declare Xtal = 16           ' Choose the oscillator frequency used
Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

Dim Wrd1 as Word
Dim Wrd2 as Word
Dim Wrd3 as Word
Dim Fake as Word            ' Must be a Word type variable for result

Wrd2 = 300
Wrd3 = 1000

Fake = Wrd2 * Wrd3          ' Operators ** or */ could also be used instead
Wrd1= Div32 100
HrsoutLn Dec Wrd1
```

The above program assigns Wrd2 the value 300 and Wrd3 the value 1000. When multiplied together, the result is 300000. However, this number exceeds the 16-bit word size of a variable (65535). Therefore, the dummy variable, Fake, contains only the lower 16 bits of the result. **Div32** uses the compiler's internal (System) variables as the operands.

Note.
This operand enables a certain compatibility with melab's compiler code, but is rather obsolete considering the 32-bit, and floating point capabilities of the Proton compiler.

Compiler Commands and Directives

Peripheral and Interfacing Commands

Command	Description
Adin	Read the on-board Analogue to Digital Converter peripheral.
Bstart	Send a Start condition to the I^2C bus.
Bstop	Send a Stop condition to the I^2C bus.
Brestart	Send a Restart condition to the I^2C bus.
BusAck	Send an Acknowledge condition to the I^2C bus.
BusNack	Send an Not Acknowledge condition to the I^2C bus.
Busin	Read bytes from an I^2C device.
Busout	Write bytes to an I^2C device.
Button	Detect and debounce a key press.
ClearPin	Clear a pin of a port using a variable as the pin number.
Counter	Count the number of pulses occurring on a pin.
DTMFout	Produce a DTMF Touch Tone note.
Freqout	Generate one or two tones, of differing or the same frequencies.
GetPin	Read a pin from a port using a variable as the index
HbStart	Send a Start condition to the I^2C bus using the MSSP module.
HbStop	Send a Stop condition to the I^2C bus using the MSSP module.
HbRestart	Send a Restart condition to the I^2C bus using the MSSP module.
HbusAck	Send an Ack condition to the I^2C bus using the MSSP module.
HbusNack	Send a Not Ack condition to the I2C bus using the MSSP module.
Hbusin	Read from an I^2C device using the MSSP module.
Hbusout	Write to an I^2C device using the MSSP module.
High	Make a pin or port high.
Hpwm	Generate Pwm signals using the device's CCP peripherals.
I2Cin	Read bytes from an I^2C device with user definable SDA\SCL lines.
I2Cout	Write bytes to an I^2C device with user definable SDA\SCL lines.
Inkey	Scan a matrix keypad.
Input	Make a pin or port an input.
Output	Make a pin or port an output.
Oread	Receive data from a device using the Dallas 1-wire protocol.
Owrite	Send data to a device using the Dallas 1-wire protocol.
Low	Make a pin or port low.
Pot	Read a potentiometer on specified pin using an RC method.
PulseIn	Measure the pulse width on a pin.
PulseOut	Generate a pulse from a pin.
Pwm	Output a pulse width modulated pulse train to pin.
RCin	Measure a pulse width on a pin.
Servo	Control a servo motor.
SetPin	Set a pin of a port using a variable as the pin number.
Shin	Synchronous serial input. i.e. SPI
Shout	Synchronous serial output. i.e. SPI
Sound	Generate a tone or white-noise from a specified pin.
Sound2	Generate 2 tones from 2 separate pins.
Toggle	Reverse the state of a port's bit.
USBinit	Initialise the USB on devices that contain a USB peripheral.
USBin	Receive data via a USB endpoint on devices that contain a USB peripheral.
USBout	Transmit data via a USB endpoint on devices that contain a USB peripheral.
Xin	Receive data using the X10 protocol.
Xout	Transmit data using the X10 protocol.

LCD Commands

Box	Draw a square on a graphic LCD.
Circle	Draw a circle on a graphic LCD.
Cls	Clear the LCD.
Cursor	Position the cursor on the LCD.
LCDread	Read a single byte from a Graphic LCD.
LCDwrite	Write bytes to a Graphic LCD.
Line	Draw a line in any direction on a graphic LCD.
LineTo	Draw a straight line in any direction on a graphic LCD, starting from the previous **Line** command's end position.
Pixel	Read a single pixel from a Graphic LCD.
Plot	Set a single pixel on a Graphic LCD.
Print	Display characters on an LCD.
Toshiba_Command	Send a command to a Toshiba T6963 graphic LCD.
Toshiba_UDG	Create User Defined Graphics for Toshiba T6963 graphic LCD.
UnPlot	Clear a single pixel on a Graphic LCD.

Async Serial Commands

Hrsin	Receive data from the serial port on devices that contain a USART.
Hrsout	Transmit data from the serial port on devices that contain a USART.
HrsoutLn	Transmit data from the serial port on devices that contain a USART and transmit a terminator value or values.
Hserin	Receive data from the serial port on devices that contain a USART.
Hserout	Transmit data from the serial port on devices that contain a USART.
HseroutLn	Transmit data from the serial port on devices that contain a USART and transmit a terminator value or values.
Hrsin2	Same as **Hrsin** but using a 2nd USART if available.
Hrsout2	Same as **Hrsout** but using a 2nd USART if available.
Hrsout2Ln	Same as **HrsoutLn** but using a 2nd USART if available.
Hserin2	Same as **Hserin** but using a 2nd USART if available.
Hserout2	Same as **Hserout** but using a 2nd USART if available.
Hserout2Ln	Same as **HseroutLn** but using a 2nd USART if available.
Hrsin3	Same as **Hrsin** but using a 3rd USART if available.
Hrsout3	Same as **Hrsout** but using a 3rd USART if available.
Hrsout3Ln	Same as **HrsoutLn** but using a 3rd USART if available.
Hserin3	Same as **Hserin** but using a 3rd USART if available.
Hserout3	Same as **Hserout** but using a 3rd USART if available.
Hserout3Ln	Same as **HseroutLn** but using a 3rd USART if available.
Hrsin4	Same as **Hrsin** but using a 4th USART if available.
Hrsout4	Same as **Hrsout** but using a 4th USART if available.
Hrsout4Ln	Same as **HrsoutLn** but using a 4th USART if available.
Hserin4	Same as **Hserin** but using a 4th USART if available.
Hserout4	Same as **Hserout** but using a 4th USART if available.
Hserout4Ln	Same as **HseroutLn** but using a 4th USART if available.
Rsin	Asynchronous serial input from a fixed pin and baud rate.
Rsout	Asynchronous serial output to a fixed pin and baud rate.
RsoutLn	Asynchronous serial output to a fixed pin and baud rate, and transmit a terminator value or values.
Serin	Receive asynchronous serial data (i.e. RS232 data).
Serout	Transmit asynchronous serial data (i.e. RS232 data).

Comparison and Loop Commands

Branch	Computed **Goto** (equiv. to **On..Goto**).
BranchL	Branch out of page (long **Branch**).
Break	Exit a loop prematurely.
Continue	Cause the next iteration of the enclosing loop to begin.
Do...Loop	Execute a block of instructions until a condition is true.
For…To…Next…Step	Repeatedly execute statements.
If..Then..ElseIf..Else..EndIf	Conditionally execute statements.
On Gosub	Call a Subroutine based on an Index value. For 18F devices only.
On Goto	Jump to an address in code memory based on an Index value. (Primarily for smaller devices)
On GotoL	Jump to an address in code memory based on an Index value. (Primarily for larger devices)
Repeat...Until	Execute a block of instructions until a condition is true.
Select..Case..EndSelect	Conditionally run blocks of code.
While…Wend	Execute statements while condition is true.

General BASIC Commands

AddressOf	Get the address of a variable or label.
Call	Call an assembly language subroutine.
Clear	Place a variable or bit in a low state, or clear all RAM area.
ClearBit	Clear a bit of a variable, using a variable index.
Dec	Decrement a variable.
DelayCs	Delay with a 1 instruction cycle resolution.
DelayMs	Delay milliseconds.
DelayUs	Delay microseconds.
Dig	Return the value of a decimal digit.
GetBit	Examine a bit of a variable, using a variable index.
Gosub	Call a BASIC subroutine at a specified label.
Goto	Continue execution at a specified label.
Inc	Increment a variable.
LoadBit	Set or Clear a bit of a variable, using a variable index.
Random	Generate a pseudo-random number.
Return	Continue at the statement following the last **Gosub**.
Rol	Rotate a variable left, with or without the microcontroller's Carry flag.
Ror	Rotate a variable right, with or without the microcontroller's Carry flag.
Seed	Seed the random number generator, to obtain a more random result.
Set	Place a variable or bit in a high state.
SetBit	Set a bit of a variable, using a variable index.
Sleep	Power down the processor for a period of time.
Snooze	Power down the processor for short period of time.
Stop	Stop program execution.
Swap	Exchange the values of two variables.

RAM String Variable Commands

Left$	Extract n amount of characters from the left of a String.
Mid$	Extract characters from a String beginning at n characters from the left.
Right$	Extract n amount of characters from the right of a String.
Str	Load a byte array with values.
Strn	Create a null terminated byte array.
Str$	Convert the contents of a variable to a null terminated String.
ToLower	Convert the characters in a String to lower case.
ToUpper	Convert the characters in a String to upper case.
Val	Convert a null terminated String to an integer value.

Non-Volatile Data (Flash memory) Commands

cPtr8, cPtr16, cPtr32	Indirectly read flash memory using a variable as the address.
Cdata	Place information into flash memory. For access by **Cread**.
Cread	Read data from flash memory.
Cread8, Cread16, Cread32	Read a single or multi-byte value from an **Cdata** table with more efficiency than **Cread**.
Cwrite	Write data to flash memory.
Edata	Define initial contents of on-board eeprom.
Eread	Read a value from on-board eeprom.
Ewrite	Write a value to on-board eeprom.
Ldata	Place information into flash memory. For access by **Lread**.
LookDown	Search a constant lookdown table for a value.
LookDownL	Search constant or variable lookdown table for a value.
LookUp	Fetch a constant value from a lookup table.
LookUpL	Fetch a constant or variable value from lookup table.
Lread	Read a value from an **Ldata** table.
Lread8, Lread16, Lread32	Read a single or multi-byte value from an **Ldata** table with more efficiency than **Lread**.

Directives

Asm-EndAsm	Insert assembly language code section.
Config	Set or Reset programming fuse configurations.
Declare	Adjust library routine parameters.
Device	Choose the type of PICmicro™ to compile for.
Dim	Create a variable.
Disable	Disable software interrupts previously Enabled.
Enable	Enable software interrupts previously Disabled.
End	Stop execution of the BASIC program.
Include	Load a file into the source code.
On Interrupt	Execute a subroutine using a Software interrupt (**On Interrupt is Legacy. Not Recommended**).
On_Hardware_Interrupt	Point to the subroutine that a hardware interrupt will jump too.
On_Low_Interrupt	Point to a subroutine for a Low Priority interrupt on an 18F device.
Org	Set Program Origin.
Resume	Re-enable software interrupts and return.
Set_OSCCAL	Calibrate the internal oscillator found on some PICmicro™ devices.
Sub-EndSub	Create a subroutine unit
Symbol	Create a constant.

ADin

Syntax
Variable **= ADin** *channel number*

Overview
Read the value from the on-board Analogue to Digital Converter.

Parameters
Variable is a user defined variable.
Channel number can be a constant or a variable expression.

Example
```
' Read the value from AN0 of the ADC and place in variable ADC_Result.
  Device = 18F25K20
  Declare Xtal = 16
  Declare Hserial_Baud = 9600   ' Set the Baud rate for HrsoutLn
  Declare Adin_Res = 10         ' 10-bit ADC result required
  Declare Adin_Tad = FRC        ' RC oscillator chosen for the ADC
  Declare Adin_Stime = 50       ' Allow 50us sample time

  Dim ADC_Result as Word        ' Create a word variable to hold the ADC value

  ADCON1 = %10000000            ' Set analogue input on PORTA.0
  ADC_Result = Adin 0           ' Place the conversion into variable ADC_Result
  HrsoutLn Dec ADC_Result       ' Transmit the decimal ADC value
```

ADin Declares
There are three **Declare** directives for use with **ADin.** These are: -

Declare Adin_Res 8, 10, or 12.
Sets the number of bits in the result.

If this **Declare** is not used, then the default is the resolution of the PICmicro™ type used. For example, the 16F87X range will result in a resolution of 10-bits, along with the 18F devices, while the standard PICmicro™ types will produce an 8-bit result. Using the above **Declare** allows an 8-bit result to be obtained from the 10-bit PICmicro™ types, but not 10-bits from the 8-bit types.

Declare Adin_Tad 2_FOSC, 8_FOSC, 32_FOSC, 64_FOSC, or FRC.
Sets the ADC's clock source.

All compatible PICs have four options for the clock source used by the ADC. 2_FOSC, 8_FOSC, 32_FOSC, and 64_FOSC are ratios of the external oscillator, while FRC is the PICmicro's internal RC oscillator. Instead of using the predefined names for the clock source, values from 0 to 3 may be used. These reflect the settings of bits 0-1 in register ADCON0.

Care must be used when issuing this **Declare**, as the wrong type of clock source may result in poor resolution, or no conversion at all. If in doubt use FRC which will produce a slight reduction in resolution and conversion speed, but is guaranteed to work first time, every time. FRC is the default setting if the **Declare** is not issued in the BASIC listing.

Declare Adin_Stime 0 to 65535 microseconds (us).
Allows the internal capacitors to fully charge before a sample is taken. This may be a value from 0 to 65535 microseconds (us).

A value too small may result in a reduction of resolution. While too large a value will result in poor conversion speeds without any extra resolution being attained.

A typical value for **Adin_Stime** is 50 to 100. This allows adequate charge time without loosing too much conversion speed. But experimentation will produce the right value for your particular requirement. The default value if the **Declare** is not used in the BASIC listing is 50.

Notes
Before the **Adin** command may be used, the appropriate **Tris** register must be manipulated to set the desired pin to an input. Also, the ADCON1 register must be set according to which pin is required as an analogue input, and in some cases, to configure the format of the conversion's result. See the numerous Microchip datasheets for more information on these registers and how to set them up correctly for the specific device used.

If multiple conversions are being implemented, then a small delay should be used after the **Adin** command. This allows the ADC's internal capacitors to discharge fully: -

```
Do
   ADC_Result = Adin 3   ' Place the conversion into variable ADC_Result
   DelayUs 2             ' Wait for 2us
Loop                     ' Read the ADC forever
```

The circuit below shows a typical setup for a simple ADC test.
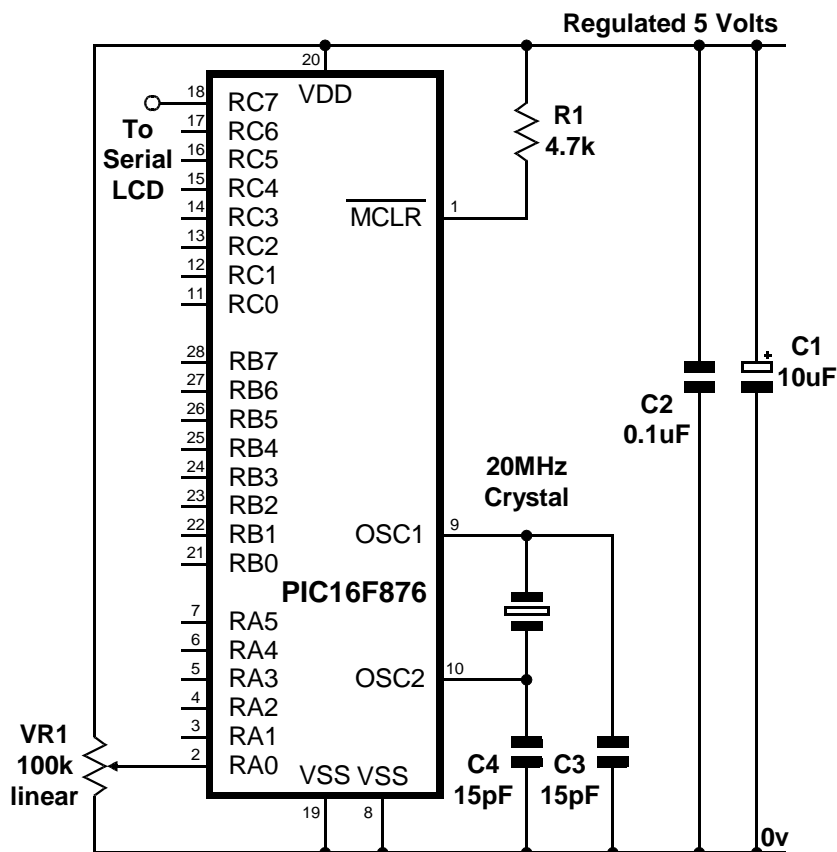
See also :   Rcin, Pot.

Asm..EndAsm

Syntax
Asm
assembler mnemonics
EndAsm

or

@ *assembler mnemonic*

Overview
Incorporate in-line assembler in the BASIC code. The mnemonics are passed directly to the assembler without the compiler interfering in any way. This allows a great deal of flexibility that cannot always be achieved using BASIC commands alone.

When the **Asm** directive is found within the BASIC program, the RAM banks are reset before the assembler code is operated upon. The same happens when the **EndAsm** directive is found, in that the RAM banks are reset upon leaving the assembly code. However, this may not always be required and can waste precious code memory.

Placing a dash after **Asm** or **EndAsm** will remove the RAM reset mnemonics.

```
Asm-
EndAsm
```

Only remove the RAM resets if you are confident enough to do so, as PICmicro™ devices have fragmented RAM.

The compiler also allows simple assembler mnemonics to be used within the BASIC program without wrapping them in **Asm**-**EndAsm**, however, the constants, labels, and variables used must be valid BASIC types:

```
Dim MyVar As Byte

Movlw 10
Movwf MyVar
```

Note. It is important to remember that mnemonics within the BASIC program will not manipulate RAM banks or Flash pages, as the high level commands do, so always us with caution, and understand the RAM and flash fragmentation of the device being used.

Box

Syntax
Box *Set_Clear*, *Xpos Start*, *Ypos Start*, *Size*

Overview
Draw a square on a graphic LCD.

Parameters
Set_Clear may be a constant or variable that determines if the square will set or clear the pixels. A value of 1 will set the pixels and draw a square, while a value of 0 will clear any pixels and erase a square .
Xpos Start may be a constant or variable that holds the X position for the centre of the square. Can be a value from 0 to 127.
Ypos Start may be a constant or variable that holds the Y position for the centre of the square. Can be a value from 0 to 63.
Size may be a constant or variable that holds the Size of the square (in pixels). Can be a value from 0 to 255.

Example
```
' Draw a square at position 63,32 with a size of 20 pixels
' on a KS0108 graphic LCD
'
  Include "Proton_G4.int"

  Dim Xpos as Byte
  Dim Ypos as Byte
  Dim Size as Byte
  Dim SetClr as Byte

  DelayMs 100          ' Wait for the LCD to stabilise
  Cls                  ' Clear the LCD
  Xpos = 63
  Ypos = 32
  Size = 20
  SetClr = 1
  Box SetClr, Xpos, Ypos, Radius
  Stop
```

Notes
Because of the aspect ratio of the pixels on the graphic LCD (approx 1.5 times higher than wide) the square will appear elongated.

See Also :   Circle, Line, LineTo, Plot, UnPlot.

Branch

Syntax
Branch *Index*, **[***Label1* {,...*Labeln* }**]**

Overview
Cause the program to jump to different locations based on a variable index. On a PICmicro™ device with only one page of memory.

Parameters
Index is a constant, variable, or expression, that specifies the address to branch to.
Label1*,...*Labeln are valid labels that specify where to branch to. A maximum of 255 labels may be placed between the square brackets, 256 if using an 18F device.

Example
```
  Device = 16F84
  Dim Index as Byte
Start:
  Index = 2              ' Assign Index a value of 2
  Branch Index,[Lab_0, Lab_1, Lab_2] ' Jump to Lab_2 because Index = 2
Lab_0:
  Index = 2              ' Index now equals 2
  Goto Start
Lab_1:
  Index = 0              ' Index now equals 0
  Goto Start
Lab_2:
  Index = 1              ' Index now equals 1
  Goto Start
```

The above example we first assign the index variable a value of 2, then we define our labels. Since the first position is considered 0 and the variable index equals 2 the **Branch** command will cause the program to jump to the third label in the brackets [Lab_2].

Notes
Branch operates the same as **On** x **Goto**. It's useful when you want to organise a structure such as: -

```
  If Var1 = 0 Then Goto Lab_0 ' Var1 =0: go to label "Lab_0"
  If Var1 = 1 Then Goto Lab_1 ' Var1 =1: go to label "Lab_1"
  If Var1 = 2 Then Goto Lab_2 ' Var1 =2: go to label "Lab_2"
```

You can use **Branch** to organise this into a single statement: -

```
  Branch Var1, [Lab_0, Lab_1, Lab_2]
```

This works exactly the same as the above **If**...**Then** example. If the value is not in range (in this case if Var1 is greater than 2), **Branch** does nothing. The program continues with the next instruction..

The **Branch** command is primarily for use with devices that have one page of memory (0-2047). If larger devices are used and you suspect that the branch label will be over a page boundary, use the **BranchL** command instead.

BranchL

Syntax
BranchL *Index*, **[***Label1* {,...*Labeln* }**]**

Overview
Cause the program to jump to different locations based on a variable index. On a PICmicro™ device with more than one page of memory.

Parameters
Index is a constant, variable, or expression, that specifies the address to branch to.
Label1,...*Labeln* are valid labels that specify where to branch to. A maximum of 127 labels may be placed between the square brackets, 256 if using an 18F device.

Example
```
  Device = 16F1829
  Dim Index as Byte

Start:
  Index = 2            ' Assign Index a value of 2
' Jump to label 2 (Label_2) because Index = 2
  BranchL Index,[Label_0, Label_1, Label_2]
Label_0:
  Index = 2            ' Index now equals 2
  Goto Start
Label_1:
  Index = 0            ' Index now equals 0
  Goto Start
Label_2:
  Index = 1            ' Index now equals 1
  Goto Start
```

The above example we first assign the index variable a value of 2, then we define our labels. Since the first position is considered 0 and the variable index equals 2 the **BranchL** command will cause the program to jump to the third label in the brackets [Label_2].

Notes
The **BranchL** command is mainly for use with PICmicro™ devices that have more than one page of memory (greater than 2048). It may also be used on any PICmicro™ device, but does produce code that is larger than **Branch**.

See also :   Branch

Break

Syntax
Break

Overview
Exit a **For**…**Next**, **While**…**Wend**, **Repeat**…**Until** or **Do**…**Loop** condition prematurely.

Example 1
```
' Break out of a For-Next loop when the count reaches 10

    Include "Proton_4.Inc"        ' Demo using Proton Dev board
    Dim Var1 as Byte

    DelayMs 100                   ' Wait for the LCD to stabilise
    Cls                           ' Clear the LCD
    For Var1 = 0 to 39            ' Create a loop of 40 revolutions
      Print At 1,1,Dec Var1       ' Print the revolutions on the LCD
      If Var1 = 10 Then Break     ' Break out of the loop when Var1 = 10
      DelayMs 200                 ' Delay so we can see what's happening
    Next                          ' Close the For-Next loop
    Print At 2,1,"Exited At ", Dec Var1 ' Display value when loop was broke
    Stop
```

Example 2
```
' Break out of a Repeat-Until loop when the count reaches 10

    Include "Proton_4.Inc"        ' Demo using Proton Dev board
    Dim Var1 as Byte

    DelayMs 100                   ' Wait for the LCD to stabilise
    Cls                           ' Clear the LCD
    Var1 = 0
    Repeat                        ' Create a loop
      Print At 1,1,Dec Var1       ' Print the revolutions on the LCD
      If Var1 = 10 Then Break     ' Break out of the loop when Var1 = 10
      DelayMs 200                 ' Delay so we can see what's happening
      Inc Var1
    Until Var1 > 39               ' Close the loop after 40 revolutions
    Print At 2,1,"Exited At ", Dec Var1 ' Display value when loop was broke
    Stop
```

Example 3

```
' Break out of a While-Wend loop when the count reaches 10

    Include "Proton_4.Inc"          ' Demo using Proton Dev board
    Dim Var1 as Byte
    DelayMs 100                     ' Wait for the LCD to stabilise
    Cls                             ' Clear the LCD
    Var1 = 0
    While Var1 < 40                 ' Create a loop of 40 revolutions
        Print At 1,1,Dec Var1       ' Print the revolutions on the LCD
        If Var1 = 10 Then Break     ' Break out of the loop when Var1 = 10
        DelayMs 200                 ' Delay so we can see what's happening
        Inc Var1
    Wend                            ' Close the loop
    Print At 2,1,"Exited At ", Dec Var1 ' Display value when loop was broke
    Stop
```

Notes

The **Break** command is similar to a **Goto** but operates internally. When the **Break** command is encountered, the compiler will force a jump to the loop's internal exit label.

If the **Break** command is used outside of **For**…**Next**, **Repeat**…**Until**, **While**…**Wend** or **Do**…**Loop**, an error will be produced.

If the **Break** command is used within a **Select...EndSelect** construct while this is itself inside a loop, only the **Select...EndSelect** will be exited, not the loop.

See also :   **Continue, For**…**Next, While**…**Wend, Repeat**…**Until.**

Bstart

Syntax
Bstart

Overview
Send a **Start** condition to the I^{2}C bus.

Notes
Because of the subtleties involved in interfacing to some I^{2}C devices, the compiler's standard **Busin**, and **Busout** commands were found lacking somewhat. Therefore, individual pieces of the I^{2}C protocol may be used in association with the new structure of **Busin**, and **Busout**. See relevant sections for more information.

Example
```
' Interface to a 24LC32 serial eeprom
  Device = 16F1829
  Dim MyLoop as Byte
  Dim Array[10] as Byte
'
' Transmit bytes to the I2C bus
'
  Bstart                    ' Send a Start condition
  Busout %10100000          ' Target an eeprom, and send a Write command
  Busout 0                  ' Send the High Byte of the address
  Busout 0                  ' Send the Low Byte of the address
  For MyLoop = 48 to 57     ' Create a loop containing ASCII 0 to 9
    Busout MyLoop           ' Send the value of MyLoop to the eeprom
  Next                      ' Close the loop
  Bstop                     ' Send a Stop condition
  DelayMs 10                ' Wait for the data to be entered into eeprom matrix
'
' Receive bytes from the I2C bus
'
  Bstart                       ' Send a Start condition
  Busout %10100000             ' Target an eeprom, and send a Write command
  Busout 0                     ' Send the High Byte of the address
  Busout 0                     ' Send the Low Byte of the address
  Brestart                     ' Send a Restart condition
  Busout %10100001             ' Target an eeprom, and send a Read command
  For MyLoop = 0 to 9          ' Create a loop
    Array[MyLoop] = Busin      ' Load an array with bytes received
    If MyLoop = 9 Then Bstop : Else : BusAck ' Ack or Stop ?
  Next                         ' Close the loop
  Print At 1,1, Str Array      ' Display the Array as a String
  Stop
```

See also: **Bstop, Brestart, BusAck, Busin, Busout, HbStart, HbRestart, HbusAck, Hbusin, Hbusout.**

Bstop

Syntax
Bstop

Overview
Send a **Stop** condition to the I^{2}C bus.

Brestart

Syntax
Brestart

Overview
Send a **Restart** condition to the I^{2}C bus.

BusAck

Syntax
BusAck

Overview
Send an **Acknowledge** condition to the I^{2}C bus.

BusNack

Syntax
BusNack

Overview
Send a **Not Acknowledge** condition to the I^{2}C bus.

See also: **Bstop, Bstart, Brestart, Busin, Busout, HbStart, HbRestart, HbusAck, Hbusin, Hbusout.**

Busin

Syntax
Variable = **Busin** *Control*, { *Address* }

or

Variable = **Busin**

or

Busin *Control*, { *Address* }, **[** *Variable* {, *Variable...*} **]**

or

Busin *Variable*

Overview
Receives a value from the I^{2}C bus, and places it into *variable/s*. If versions *two* or *four* (see above) are used, then No Acknowledge, or Stop is sent after the data. Versions *one* and *three* first send the *control* and optional *address.*

Parameters
Variable is a user defined variable or constant.
Control may be a constant value or a **Byte** sized variable expression.
Address may be a constant value or a variable expression.

The four variations of the **Busin** command may be used in the same BASIC program. The *second* and *fourth* types are useful for simply receiving a single byte from the bus, and must be used in conjunction with one of the low level commands. i.e. **Bstart**, **Brestart**, **BusAck**, or **Bstop**. The *first*, and *third* types may be used to receive several values and designate each to a separate variable, or variable type.

The **Busin** command operates as an I^{2}C master without using the microcontroller's MSSP peripheral, and may be used to interface with any device that complies with the 2-wire I^{2}C protocol.

The most significant 7-bits of *control* byte contain the control code and the slave address of the device being interfaced with. Bit-0 is the flag that indicates whether a read or write command is being implemented.

For example, if we were interfacing to an external eeprom such as the 24LC32, the control code would be %10100001 or $A1. The most significant 4-bits (1010) are the eeprom's unique slave address. Bits 1 to 3 reflect the three address pins of the eeprom. And bit-0 is set to signify that we wish to read from the eeprom. Note that this bit is automatically set by the **Busin** command, regardless of its initial setting.

Example
```
' Receive a byte from the I2C bus and place it into variable Var1.

  Dim Var1 as Byte            ' We'll only read 8-bits
  Dim Address as Word         ' 16-bit address required
  Symbol Control %10100001    ' Target an eeprom
```

```
Address = 20                    ' Read the value at address 20
Var1 = Busin Control, Address    ' Read the byte from the eeprom
```

or

```
Busin Control, Address, [ Var1 ] ' Read the byte from the eeprom
```

Address, is an optional parameter that may be an 8-bit or 16-bit value. If a variable is used in this position, the size of *address* is dictated by the size of the variable used (**Byte**, **Word**, or **Dword**). In the case of the previous eeprom interfacing, the 24LC32 eeprom requires a 16-bit address. While the smaller types require an 8-bit address. Make sure you assign the right size address for the device interfaced with, or you may not achieve the results you intended.

The value received from the bus depends on the size of the variables used, except for variation three, which only receives a **Byte** (8-bits). For example: -

```
Dim Wrd as Word          ' Create a Word size variable
Wrd = Busin Control, Address
```

Will receive a 16-bit value from the bus. While: -

```
Dim Var1 as Byte      ' Create a Byte size variable
Var1 = Busin Control, Address
```

Will receive an 8-bit value from the bus.

Using the *third* variation of the **Busin** command allows differing variable assignments. For example: -

```
Dim Var1 as Byte
Dim Wrd as Word
Busin Control, Address, [Var1, Wrd]
```

Will receive two values from the bus, the first being an 8-bit value dictated by the size of variable Var1 which has been declared as a byte. And a 16-bit value, this time dictated by the size of the variable Wrd which has been declared as a word. Of course, **Bit** type variables may also be used, but in most cases these are not of any practical use as they still take up a byte within the eeprom.

The *second* and *fourth* variations allow all the subtleties of the I^2C protocol to be exploited, as each operation may be broken down into its constituent parts. It is advisable to refer to the datasheet of the device being interfaced to fully understand its requirements. See section on **Bstart**, **Brestart**, **BusAck**, or **Bstop**, for example code.

Declares
See **Busout** for declare explanations.

Notes
When the **Busout** command is used, the appropriate SDA and SCL Port and Pin are automatically setup as inputs, and outputs.

Because the I^2C protocol calls for an *open-collector* interface, pull-up resistors are required on both the SDA and SCL lines. Values of 1KΩ to 4.7KΩ will suffice.

You may imagine that it's limiting having a fixed set of pins for the I²C interface, but you must remember that several different devices may be attached to a single bus, each having a unique slave address. Which means there is usually no need to use up more than two pins on the PICmicro™, in order to interface to many devices.

Str modifier with Busin

Using the **Str** modifier allows variations *three* and *four* of the **Busin** command to transfer the bytes received from the I²C bus directly into a byte array. If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. An example of each is shown below: -

```
  Dim Array[10] as Byte          ' Define an array of 10 bytes
  Dim Address as Byte            ' Create a word sized variable
  Busin %10100000, Address, [Str Array] ' Load data into all the array
'
' Load data into only the first 5 elements of the array
'
  Busin %10100000, Address, [Str Array\5]
  Bstart                         ' Send a Start condition
  Busout %10100000              ' Target an eeprom, and send a WRITE command
  Busout 0                       ' Send the HighByte of the address
  Busout 0                       ' Send the LowByte of the address
  Brestart                       ' Send a Restart condition
  Busout %10100001              ' Target an eeprom, and send a Read command
  Busin Str Array                ' Load all the array with bytes received
  Bstop                          ' Send a Stop condition
```

An alternative ending to the above example is: -

```
  Busin Str Array\5     ' Load data into only the first 5 elements of the array
  Bstop                 ' Send a Stop condition
```

See also :   BusAck, Bstart, Brestart, Bstop, Busout, HbStart, HbRestart, HbusAck, Hbusin, Hbusout.

Busout

Syntax
Busout *Control*, { *Address* }, **[** *Variable* {, *Variable*...} **]**

or

Busout *Variable*

Overview
Transmit a value to the I^{2}C bus, by first sending the *control* and optional *address* out of the clock pin (*SCL*), and data pin (*SDA*). Or alternatively, if only one operator is included after the **Busout** command, a single value will be transmitted, along with an Ack reception.

Parameters
Variable is a user defined variable or constant.
Control may be a constant value or a **Byte** sized variable expression.
Address may be a constant, variable, or expression.

The **Busout** command operates as an I^{2}C master using a bit-bashed (software only) method, and may be used to interface with any device that complies with the 2-wire I^{2}C protocol.

The most significant 7-bits of *control* byte contain the control code and the slave address of the device being interfaced with. Bit-0 is the flag that indicates whether a read or write command is being implemented.

For example, if we were interfacing to an external eeprom such as the 24LC32, the control code would be %10100000 or $A0. The most significant 4-bits (1010) are the eeprom's unique slave address. Bits 1 to 3 reflect the three address pins of the eeprom. And Bit-0 is clear to signify that we wish to write to the eeprom. Note that this bit is automatically cleared by the **Busout** command, regardless of its initial value.

Example
```
' Send a byte to the I2C bus.
  Dim Var1 as Byte                 ' We'll only read 8-bits
  Dim Address as Word              ' 16-bit address required
  Symbol Control = %10100000       ' Target an eeprom

  Address = 20                     ' Write to address 20
  Var1 = 200                       ' The value place into address 20
  Busout Control, Address, [Var1]  ' Send the byte to the eeprom
  DelayMs 10                       ' Allow time for allocation of byte
```

Address, is an optional parameter that may be an 8-bit or 16-bit value. If a variable is used in this position, the size of *address* is dictated by the size of the variable used (**Byte**, **Word** or **Dword**). In the case of the above eeprom interfacing, the 24LC32 eeprom requires a 16-bit address. While the smaller types require an 8-bit address. Make sure you assign the right size address for the device interfaced with, or you may not achieve the results you intended.

The value sent to the bus depends on the size of the variables used. For example: -

```
Dim Wrd as Word              ' Create a Word size variable
Busout Control, Address, [Wrd]
```

Will send a 16-bit value to the bus. While: -

```
Dim Var1 as Byte           ' Create a Byte size variable
Busout Control, Address, [Var1]
```

Will send an 8-bit value to the bus.

Using more than one variable within the brackets allows differing variable sizes to be sent. For example: -

```
Dim Var1 as Byte
Dim Wrd as Word
Busout Control, Address, [Var1, Wrd]
```

Will send two values to the bus, the first being an 8-bit value dictated by the size of variable Var1 which has been declared as a byte. And a 16-bit value, this time dictated by the size of the variable Wrd which has been declared as a word. Of course, **Bit** type variables may also be used, but in most cases these are not of any practical use as they still take up a byte within the eeprom.

A string of characters can also be transmitted, by enclosing them in quotes: -

```
Busout Control, Address, ["Hello World", Var1, Wrd]
```

Using the second variation of the **Busout** command, necessitates using the low level commands i.e. Bstart, Brestart, BusAck, or Bstop.

Using the **Busout** command with only one value after it, sends a byte of data to the I^2C bus, and returns holding the Acknowledge reception. This acknowledge indicates whether the data has been received by the slave device.

The Ack reception is returned in the PICmicro's Carry flag, which is STATUS.0, and also System variable PP4.0. A value of zero indicates that the data was received correctly, while a one indicates that the data was not received, or that the slave device has sent a NAck return. You must read and understand the datasheet for the device being interfacing to, before the Ack return can be used successfully. An code snippet is shown below: -

```
' Transmit a byte to a 24LC32 serial eeprom
  Dim PP4 as Byte System      ' Bring the system variable into the BASIC program
  Bstart                      ' Send a Start condition
  Busout %10100000            ' Target an eeprom, and send a Write command
  Busout 0                    ' Send the High Byte of the address
  Busout 0                    ' Send the Low Byte of the address
  Busout "A"                  ' Send the value 65 to the bus
  If PP4.0 = 1 Then Goto Not_Received ' Has Ack been received OK?
  Bstop                       ' Send a Stop condition
  DelayMs 10                  ' Wait for the data to be entered into eeprom
```

Str modifier with Busout.

The **Str** modifier is used for transmitting a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that sends four bytes from an array: -

```
Dim MyArray[10] as Byte          ' Create a 10-byte array.
MyArray [0] = "A"                ' Load the first 4 bytes of the array
MyArray [1] = "B"                ' With the data to send
MyArray [2] = "C"
MyArray [3] = "D"
Busout %10100000, Address, [Str MyArray\4] ' Send 4-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the program would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 4 bytes.

The above example may also be written as: -

```
Dim MyArray [10] as Byte    ' Create a 10-byte array.
Str MyArray = "ABCD"        ' Load the first 4 bytes of the array
Bstart                      ' Send a Start condition
Busout %10100000            ' Target an eeprom, and send a Write command
Busout 0                    ' Send the HighByte of the address
Busout 0                    ' Send the LowByte of the address
Busout Str MyArray\4        ' Send 4-byte string.
Bstop                       ' Send a Stop condition
```

The above example, has exactly the same function as the previous one. The only differences are that the string is now constructed using the **Str** as a command instead of a modifier, and the low-level Hbus commands have been used.

Declares

There are three **Declare** directives for use with **Busout**.
These are: -

Declare SDA_Pin Port . Pin

Declares the port and pin used for the data line (SDA). This may be any valid port on the PICmicro™. If this declare is not issued in the BASIC program, then the default Port and Pin is PORTA.0

Declare SCL_Pin Port . Pin

Declares the port and pin used for the clock line (SCL). This may be any valid port on the PICmicro™. If this declare is not issued in the BASIC program, then the default Port and Pin is PORTA.1

These declares, as is the case with all the Declares, may only be issued once in any single program, as they setup the I^2C library code at design time.

Declare Slow_Bus On - Off or 1 - 0
Slows the bus speed when using an oscillator higher than 4MHz.

The standard speed for the I^2C bus is 100KHz. Some devices use a higher bus speed of 400KHz. If you use an 8MHz or higher oscillator, the bus speed may exceed the devices specs, which will result in intermittent transactions, or in some cases, no transactions at all. Therefore, use this **Declare** if you are not sure of the device's spec. The datasheet for the device used will inform you of its bus speed.

Notes
When the **Busout** command is used, the appropriate SDA and SCL Port and Pin are automatically setup as inputs, and outputs.

Because the I^2C protocol calls for an *open-collector* interface, pull-up resistors are required on both the SDA and SCL lines. Values of 1KΩ to 4.7KΩ will suffice.

You may imagine that it's limiting having a fixed set of pins for the I^2C interface, but you must remember that several different devices may be attached to a single bus, each having a unique slave address. Which means there is usually no need to use up more than two pins on the PICmicro™, in order to interface to many devices.

A typical use for the I^2C commands is for interfacing with serial eeproms. Shown below is the connections to the I^2C bus of a 24LC32 serial eeprom.
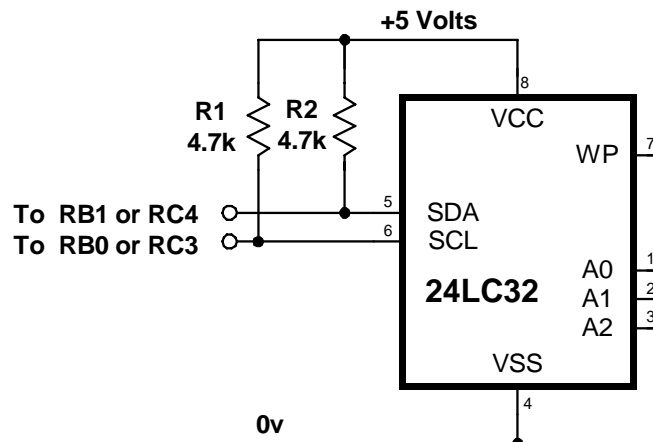
See also :   **BusAck, Bstart, Brestart, Bstop, Busin, HbStart, HbRestart, HbusAck, Hbusin, Hbusout.**

Button

Syntax
Button *Pin*, *DownState*, *Delay,* Rate, *Workspace*, *TargetState, Label*

Overview
Debounce button input, perform auto-repeat, and branch to address if button is in target state. Button circuits may be active-low or active-high.

Parameters
Pin is a Port.Bit, constant, or variable (0 - 15), that specifies the I/O pin to use. This pin will automatically be set to input.

DownState is a variable, constant, or expression (0 or 1) that specifies which logical state occurs when the button is pressed.

Delay is a variable, constant, or expression (0 - 255) that specifies how long the button must be pressed before auto-repeat starts. The delay is measured in cycles of the **Button** routine. Delay has two special settings: 0 and 255. If Delay is 0, **Button** performs no debounce or auto-repeat. If Delay is 255, **Button** performs debounce, but no auto-repeat.

Rate is a variable, constant, or expression (0 – 255) that specifies the number of cycles between auto-repeats. The rate is expressed in cycles of the **Button** routine.

Workspace is a byte variable used by **Button** for workspace. It must be cleared to 0 before being used by **Button** for the first time and should not be adjusted outside of the **Button** command.

TargetState is a variable, constant, or expression (0 or 1) that specifies which state the button should be in for a branch to occur. (0 = not pressed, 1 = pressed).

Label is a label that specifies where to branch if the button is in the target state.

Example
```
  Dim BtnVar as Byte          ' Workspace for Button instruction.
  Do                          ' Go to NoPress unless BtnVar = 0.
    Button 0, 0, 255, 250, BtnVar, 0, NoPress
    Print "* "
NoPress:
  Loop
```

Notes
When a button is pressed, the contacts make or break a connection. A short (1 to 20ms) burst of noise occurs as the contacts scrape and bounce against each other. **Button**'s debounce feature prevents this noise from being interpreted as more than one switch action.

Button also reacts to a button press the way a computer keyboard does to a key press. When a key is pressed, a character immediately appears on the screen. If the key is held down, there's a delay, then a rapid stream of characters appears on the screen. **Button**'s auto-repeat function can be set up to work much the same way.

Button is designed for use inside a program loop. Each time through the loop, **Button** checks the state of the specified pin. When it first matches *DownState,* the switch is debounced. Then, as dictated by *TargetState,* it either branches to *address* (TargetState = 1) or doesn't (Target-State = 0).

If the switch stays in *DownState,* **Button** counts the number of program loops that execute. When this count equals *Delay,* **Button** once again triggers the action specified by *TargetState* and *address.* Thereafter, if the switch remains in *DownState*, **Button** waits *Rate* number of cycles between actions. The *Workspace* variable is used by **Button** to keep track of how many cycles have occurred since the *pin* switched to *TargetState* or since the last auto-repeat.

Button does not stop program execution. In order for its delay and auto repeat functions to work properly, **Button** must be executed from within a program loop.

Two suitable circuits for use with **Button** are shown below.
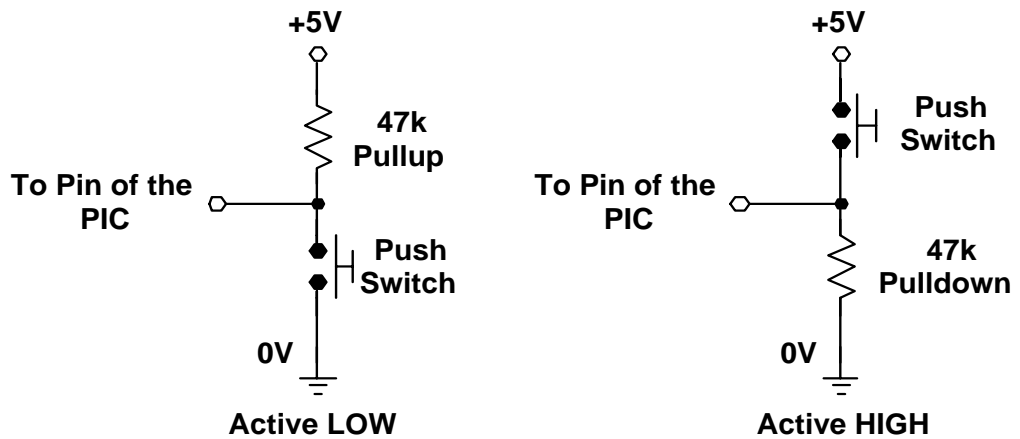
Call

Syntax
Call *Label*

Overview
Execute the assembly language subroutine named *label*.

Parameters
Label must be a valid label name.

Example
```
' Call an assembler routine
  Call Asm_Sub

  Asm
     Asm_Sub
     {mnemonics}
     Return
  EndAsm
```

Notes
The **Gosub** command is usually used to execute a BASIC subroutine. However, if your subroutine happens to be written in assembler, the **Call** command should be used. The main difference between **Gosub** and **Call** is that when **Call** is used, the *label's* existence is not checked until assembly time. Using **Call**, a *label* in an assembly language section can be accessed that would otherwise be inaccessible to **Gosub**. This also means that any errors produced will be assembler types.

The **Call** command adds Page and Bank switching instructions prior to actually calling the subroutine, however, if **Call** is used in an all assembler environment, the extra mnemonics preceding the command can interfere with carefully sculptured code such as bit tests etc. By wrapping the subroutine's name in parenthesis, the Bank and Page instructions are suppressed, and the **Call** command becomes the **Call** mnemonic.

```
  Call(Subroutine_Name)
```

Only use the mnemonic variation of **Call**, if you know that your destination is within the same Page as the section of code calling it. This is not an issue if using 18F devices, as they have a more linear memory organisation.

See also :   Gosub, Goto

Cdata

Syntax
Cdata { *alphanumeric data* }

Overview
Place information directly into flash memory for access by **Cread** and **Cwrite**.

Parameters
alphanumeric data can be any value, alphabetic character, or string enclosed in quotes (") or numeric data without quotes.

Example
```
  Device = 16F1829              ' A device with flash modifying features
  Dim MyChar as Byte
  Dim MyLoop as Byte

  For MyLoop = 0 to 10          ' Create a loop of 11
    MyChar = Cread Address + MyLoop ' Read memory location Address + MyLoop
    Print MyChar                 ' Display the value read
  Next
  Stop

Address:
  Cdata "Hello World"           ' Create a string of text in flash memory
```

The program above reads and displays 10 values from the address located by the Label accompanying the **Cdata** command. Resulting in "Hello World" being displayed.

Using the in-line command structure, the **Cread** and **Print** parts of the above program may be written as: -

```
' Read and display memory location Address + MyLoop
  Print Cread Address + MyLoop
```

The **Cwrite** command uses the same technique for writing to memory: -

```
Device = 16F1829                ' A device with code modifying features
Dim Dbyte as Byte
Dim MyLoop as Byte

Cwrite Address, ["HELLO WORLD"]  ' Write string to code memory at location Address
For MyLoop = 0 to 9             ' Create a loop of 10
    Print Cread Address + MyLoop  ' Read and display flash memory Address + MyLoop
Next
Stop
'
' Reserve 10 spaces in flash memory
'
Address:
Cdata 32, 32, 32, 32, 32, 32, 32, 32, 32, 32
```

Notice the string text now allowed in the Cwrite command. This allows the whole PICmicro™ to be used for data storage and retrieval if desired.

Important Note

Take care not to overwrite existing code when using the **Cwrite** command, and also remember that the all PICmicro™ devices have a finite amount of write cycles (approx 1000). A single program can easily exceed this limit, making that particular memory cell or cells inaccessible.

The configuration fuse setting WRTE must be enabled before **Cdata**, **Cread** and **Cwrite** may be used. This enables the self-modifying feature. If the **Config** directive is used, then the WRTE_ON fuse setting must be included in the list: -

```
Config WDT_ON, XT_OSC, WRTE_ON
```

Because the 14-bit core devices are only capable of holding 14 bits to a **Word**, values greater than 16383 ($3FFF) cannot be stored.

Formatting a Cdata table with an 18F device.

Sometimes it is necessary to create a data table with a known format for its values. For example all values will occupy 4 bytes of data space even though the value itself would only occupy 1 or 2 bytes. Formatters are not supported with 14-bit core devices, because they can only hold a maximum value of $3FFF (16383). i.e. 14-bits.

```
Cdata 100000, 10000, 1000, 100, 10, 1
```

The above line of code would produce an uneven code space usage, as each value requires a different amount of code space to hold the values. 100000 would require 4 bytes of code space, 10000 and 1000 would require 2 bytes, but 100, 10, and 1 would only require 1 byte.

Reading these values using **Cread** would cause problems because there is no way of knowing the amount of bytes to read in order to increment to the next valid value.

The answer is to use formatters to ensure that a value occupies a predetermined amount of bytes. These are: -

    Byte
    Word
    Dword
    Float

Placing one of these formatters before the value in question will force a given length.

```
Cdata  Dword 100000, Dword 10000, Dword 1000 ,_
       Dword 100, Dword 10, Dword 1
```

Byte will force the value to occupy one byte of code space, regardless of its value. Any values above 255 will be truncated to the least significant byte.

Word will force the value to occupy 2 bytes of code space, regardless of its value. Any values above 65535 will be truncated to the two least significant bytes. Any value below 255 will be padded to bring the memory count to 2 bytes.

Dword will force the value to occupy 4 bytes of code space, regardless of its value. Any value below 65535 will be padded to bring the memory count to 4 bytes. The line of code shown above uses the **Dword** formatter to ensure all the values in the **Cdata** table occupy 4 bytes of code space.

Float will force a value to its floating point equivalent, which always takes up 4 bytes of code space.

If all the values in an **Cdata** table are required to occupy the same amount of bytes, then a single formatter will ensure that this happens.

```
Cdata as Dword 100000, 10000, 1000, 100, 10, 1
```

The above line has the same effect as the formatter previous example using separate **Dword** formatters, in that all values will occupy 4 bytes, regardless of their value. All four formatters can be used with the **as** keyword.

The example below illustrates the formatters in use.

```
' Convert a Dword value into a string array
' Using only BASIC commands
' Similar principle to the Str$ command

  Include "Proton18_4.Inc"      ' Use an 18F device
  Dim P10 as Dword              ' Power of 10 variable
  Dim Cnt as Byte
  Dim J as Byte

  Dim Value as Dword            ' Value to convert
  Dim String1[11] as Byte       ' Holds the converted value
```

```
   Dim Ptr as Byte          ' Pointer within the Byte array

   DelayMs 100              ' Wait for the LCD to stabilise
   Cls                      ' Clear the LCD
   Clear                    ' Clear all RAM before we start
   Value = 1234576          ' Value to convert
   Gosub DwordToStr         ' Convert Value to string
   Print Str String1        ' Display the result
   Stop
' Convert a Dword value into a string array
' Value to convert is placed in 'Value'
' Byte array 'String1' is built up with the ASCII equivalent

DwordToStr:
   Ptr = 0
   J = 0
   Repeat
      P10 = Cread DwordTbl + (J * 4)
      Cnt = 0

      While Value >= P10
         Value = Value – P10
         Inc Cnt
      Wend

      If Cnt <> 0 Then
         String1[Ptr] = Cnt + "0"
         Inc Ptr
      EndIf
      Inc J
   Until J > 8

   String1[Ptr] = Value + "0"
   Inc Ptr
   String1[Ptr] = 0    ' Add the null to terminate the string
   Return

' Cdata table is formatted for all 32-bit values.
' Which means each value will require 4 bytes of code space
Dword_TBL:
   Cdata as Dword 1000000000, 100000000, 10000000, 1000000, 100000,_
                  10000, 1000, 100, 10
```

Label names as an Address.

If a label's name is used in the list of values in a **Cdata** table, the label's address will be used. This is useful for accessing other tables of data using their address from a lookup table. See the following example.

Note that this is not always permitted with standard 14-bit core devices, because they may not be able to hold the larger value in a 14-bit word.

```
' Display text from two Cdata tables
' Based on their address located in a separate table

   Include "Proton18_4.Inc"          ' Use an 18F device

   Dim Address as Word
   Dim DataByte as Byte

   DelayMs 100                        ' Wait for the LCD to stabilise
   Cls                                ' Clear the LCD
   Address = Cread AddrTable          ' Locate the address of the first string
   While                              ' Create an infinite loop
      DataByte = Cread Address        ' Read each character from the Cdata string
      If DataByte = 0 Then Break      ' Exit if null found
      Print DataByte                  ' Display the character
      Inc Address                     ' Next character
   Wend                               ' Close the loop

   Cursor 2,1                         ' Point to line 2 of the LCD
   Address = Cread AddrTable + 2      ' Locate the address of the second string
   While                              ' Create an infinite loop
      DataByte = Cread Address        ' Read each character from the Cdata string
      If DataByte = 0 Then Break      ' Exit if null found
      Print DataByte                  ' Display the character
      Inc Address                     ' Next character
   Wend                               ' Close the loop
   Stop

AddrTable:                            ' Table of address's
   Cdata Word String1,Word String2
String1:
   Cdata "HELLO",0
String2:
   Cdata "WORLD",0
```

See also :   Config, Cread, Cread8, Cread16, Cread32, Cwrite, Dim, Ldata, Lread, Lread8, Lread16, Lread32.

Circle

Syntax
Circle *Set_Clear*, *Xpos*, *Ypos*, *Radius*

Overview
Draw a circle on a graphic LCD.

Parameters
Set_Clear may be a constant or variable that determines if the circle will set or clear the pixels. A value of 1 will set the pixels and draw a circle, while a value of 0 will clear any pixels and erase a circle.
Xpos may be a constant or variable that holds the X position for the centre of the circle. Can be a value from 0 to the X resolution of the display.
Ypos may be a constant or variable that holds the Y position for the centre of the circle. Can be a value from 0 to the Y resolution of the display.
Radius may be a constant or variable that holds the Radius of the circle. Can be a value from 0 to 255.

Example
```
' Draw circle at pos 63,32 with radius of 20 pixels on a KS0108 LCD

  Include "Proton_G4.int"    ' Use a KS0108 LCD

  Dim Xpos as Byte
  Dim Ypos as Byte
  Dim Radius as Byte
  Dim SetClr as Byte

  DelayMs 100             ' Wait for the LCD to stabilise
  Cls                     ' Clear the LCD
  Xpos = 63
  Ypos = 32
  Radius = 20
  SetClr = 1
  Circle SetClr, Xpos, Ypos, Radius
  Stop
```

Notes
Because of the aspect ratio of the pixels on the graphic LCD (approx 1.5 times higher than wide) the circle will appear elongated.

See Also :   Box, Line, Pixel, Plot, UnPlot.

Clear

Syntax
Clear *Variable* or *Variable.Bit* or *Pin Number*

Clear

Overview
Place a variable or bit in a low state. For a variable, this means loading it with 0. For a bit this means setting it to 0.

Clear has another purpose. If no variable is present after the command, all user RAM within the device is cleared.

Parameters
Variable can be any variable or register.
Variable.Bit can be any variable and bit combination.
Pin Number can only be a constant that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example1
```
  Clear               ' Clear all RAM area
  Clear Var1.3        ' Clear bit 3 of Var1
  Clear Var1          ' Load Var1 with the value of 0
  Clear STATUS.0      ' Clear the carry flag high
  Clear Array         ' Clear all of an Array variable. i.e. reset to zero's
  Clear String1       ' Clear all of a String variable. i.e. reset to zero's
  Clear 0             ' Clear PORTA.0.
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
  Device = 18F25K20
  Declare Xtal = 16

  Dim MyPin as Byte

  Low PORTA
  Low PORTB
  For MyPin = 0 to 15       ' Create a loop for the pin to flash
    Set MyPin              ' Set the pin
    DelayMs 500            ' Delay so that it can be seen
    Clear MyPin            ' Clear the pin
    DelayMs 500            ' Delay so that it can be seen
  Next
```

Notes
There is a major difference between the **Clear** and **Low** command. **Clear** does not alter the TRIS register if a Port is targeted.

See Also :   Set, Low, High

ClearPin

Syntax
ClearPin *Pin Number*

Overview
Pull a Port's pin low using a variable as the pin's number, but does not set it as an output.

Operands
Pin Number can be a variable or constant or expression that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example
```
' Clear then Set each pin of PORTB
  Device = 16F1829
  Declare Xtal = 4
  Dim PinNumber as Byte

  High PORTB                        ' Make PORTB output high before we start
  Do                                ' Create a loop
    For PinNumber = 8 to 16         ' Create a loop for 8 pins
      ClearPin PinNumber            ' Clear each pin of PORTB
      DelayMs 100                   ' Slow things down to see what's happening
    Next                            ' Close the loop
    For PinNumber = 8 to 16         ' Create a loop for 8 pins
      SetPin PinNumber              ' Set each pin of PORTB
      DelayMs 100                   ' Slow things down to see what's happening
    Next                            ' Close the loop
  Loop                              ' Do it forever
```

Notes.
There are many ways to pull a pin of an I/O port low, however, each method requires a certain amount of manipulation, either with rotates, or alternatively, the use of indirect addressing. Each method has its merits, but requires a certain amount of knowledge to accomplish the task correctly. The **ClearPin** command makes this task extremely simple using a variable as the pin number, however, this is not necessarily the quickest method, or the smallest, but it is the easiest. For speed and size optimisation, there is no shortcut to experience.

To clear a known constant pin number of a port, access the pin directly using the **Low** command

```
      Low PORTA.1
```

Each pin number has a designated name. These are Pin_A0, Pin_A1, Pin_A2, Pin_B0…Pin_B7, Pin_C0…Pin_C7, Pin_D0…Pin_D7 to Pin_L7 etc… Each of the names has a relevant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber As Byte            ' Holds the pin number to set high and low

   Do                               ' Create an infinite loop
      PinNumber = Pin_B0            ' Give the pin number to flash (PORTB.0)
      Gosub FlashPin                ' Call the subroutine to flash the pin
      PinNumber = Pin_B1            ' Give the pin number to flash (PORTB.1)
      Gosub FlashPin                ' Call the subroutine to flash the pin
   Loop                             ' Do it forever
'
' Make a pin high then low for 500ms using a variable as the pin to adjust
'
FlashPin:
   Output PinNumber                 ' Make the pin an output
   SetPin PinNumber                 ' Bring the pin high
   DelayMs 500                      ' Wait for 500 milliseconds
   ClearPin PinNumber               ' Bring the pin low
   DelayMs 500                      ' Wait for 500 milliseconds
   Return
```

Example 2

```
' Clear then Set each pin of PORTC
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber as Byte

   High PORTC                       ' Make PORTC output high before we start
   Do                               ' Create a loop
      For PinNumber = Pin_C0 to Pin_C7 ' Create a loop for 8 pins
         ClearPin PinNumber         ' Clear each pin of PORTC
         DelayMs 100                ' Slow things down to see what's happening
      Next                          ' Close the loop
      For PinNumber = Pin_C0 to Pin_C7 ' Create a loop for 8 pins
         SetPin PinNumber           ' Set each pin of PORTC
         DelayMs 100                ' Slow things down to see what's happening
      Next                          ' Close the loop
   Loop                             ' Do it forever
```

See also :   SetPin, High, Low.

ClearBit

Syntax
ClearBit *Variable, Index*

Overview
Clear a bit of a variable or register using a variable index to the bit of interest.

Parameters
Variable is a user defined variable.
Index is a constant, variable, or expression that points to the bit within *Variable* that requires clearing.

Example
```
' Clear then Set each bit of variable ExVar
  Device = 16F1829
  Declare Xtal = 4
  Dim ExVar as Byte
  Dim Index as Byte
  Cls
  ExVar = %11111111

  While                              ' Create an infinite loop
    For Index = 0 to 7               ' Create a loop for 8 bits
      ClearBit ExVar,Index           ' Clear each bit of ExVar
      Print At 1,1,Bin8 ExVar        ' Display the binary result
      DelayMs 100                    ' Slow things down to see what's happening
    Next                             ' Close the loop
    For Index = 7 to 0 Step -1       ' Create a loop for 8 bits
      SetBit ExVar,Index             ' Set each bit of ExVar
      Print At 1,1,Bin8 ExVar        ' Display the binary result
      DelayMs 100                    ' Slow things down to see what's happening
    Next                             ' Close the loop
  Wend                               ' Do it forever
```

Notes
There are many ways to clear a bit within a variable, however, each method requires a certain amount of manipulation, either with rotates, or alternatively, the use of indirect addressing using the FSR, and INDF registers. Each method has its merits, but requires a certain amount of knowledge to accomplish the task correctly. The **ClearBit** command makes this task extremely simple using a register rotate method, however, this is not necessarily the quickest method, or the smallest, but it is the easiest. For speed and size optimisation, there is no shortcut to experience.

To Clear a known constant bit of a variable or register, then access the bit directly using Port.n.

```
  PORTA.1 = 0
```
or
```
  Var1.4 = 0
```

If a Port is targeted by **ClearBit**, the Tris register is **not** affected.

See also :   GetBit, LoadBit, SetBit.

Cls

Syntax
Cls

Or if using a Toshiba T6963 graphic LCD

Cls Text
Cls Graphic

Overview
Clears the alphanumeric or graphic LCD and places the cursor at the home position i.e. line 1, position 1 (line 0, position 0 for graphic LCDs).

Toshiba graphic LCDs based upon the T6963 chipset have separate RAM for text and graphics. Issuing the word **Text** after the **Cls** command will only clear the TEXT RAM, while issuing the word **Graphic** after the **Cls** command will only clear the Graphic RAM. Issuing the **Cls** command on its own will clear both areas of RAM.

Example 1
```
' Clear an alphanumeric or KS0108 graphic LCD
  Cls                   ' Clear the LCD
  Print "HELLO"         ' Display the word "HELLO" on the LCD
  Cursor 2, 1           ' Move the cursor to line 2, position 1
  Print "WORLD"         ' Display the word "WORLD" on the LCD
  Stop
```

In the above example, the LCD is cleared using the **Cls** command, which also places the cursor at the home position i.e. line 1, position 1. Next, the word HELLO is displayed in the top left corner. The cursor is then moved to line 2 position 1, and the word WORLD is displayed.

Example 2
```
' Clear a Toshiba T6963 graphic LCD.
  Cls                   ' Clear all RAM within the LCD
  Print "Hello"         ' Display the word "Hello" on the LCD
  Line 1,0,0,63,63      ' Draw a line on the LCD
  DelayMs 1000          ' Wait for 1 second
  Cls Text              ' Clear only the text RAM, leaving the line displayed
  DelayMs 1000          ' Wait for 1 second
  Cls Graphic           ' Now clear the line from the display
  Stop
```

Notes
The **Cls** command will also initialise any of the above LCDs. (set the ports to inputs/outputs etc), however, this is most important to Toshiba graphic LCDs, and the **Cls** command should always be placed at the head of the BASIC program, prior to issuing any command that interfaces with the LCD. i.e. **Print**, **Plot** etc.

See also :   Cursor, Print, Toshiba_Command.

Config

Syntax
Config { *configuration fuse settings* }

Overview
Enable or Disable particular fuse settings for the PICmicro™.

Parameters
configuration fuse settings vary from device to device, however, certain settings are standard to most PICmicro™ types. Refer to the microcontroller's datasheet for details.

Example
```
' Disable Watchdog timer and specify an HS_OSC etc, on a PIC16F877 device
   Config HS_OSC, WDT_OFF, PWRTE_ON, BODEN_OFF, LVP_OFF, _
          WRTE_ON, CP_OFF, DEBUG_OFF
```

18F Fuse Setting.
Because of the complexity that 18F devices require for adjusting their many fuses, the **Config** directive is not suitable. Instead a more intuitive approach is adopted using the **Config_Start** and **Config_End** directives: -

```
Config_Start
    OSC = HS              ' Oscillator Selection HS
    OSCS = Off            ' Osc. Switch Enable Disabled
    PWRT = On             ' Power-up Timer Enabled
    BOR = Off             ' Brown-out Reset Disabled
    BORV = 25             ' Brown-out Voltage 2.5V
    WDT = Off             ' Watchdog Timer Disabled
    WDTPS = 128           ' Watchdog Postscaler 1:128
    CCP2MUX = On          ' CCP2 MUX Enable (RC1)
    STVR = Off            ' Stack Overflow Reset Disabled
    LVP = Off             ' Low Voltage ICSP Disabled
    DEBUG = Off           ' Background Debugger Enable Disabled
    CP0 = Off             ' Code Protection Block 0 Disabled
    CP1 = Off             ' Code Protection Block 1 Disabled
    CP2 = Off             ' Code Protection Block 2 Disabled
    CP3 = Off             ' Code Protection Block 3 Disabled
    CPB = Off             ' Boot Block Code Protection Disabled
    CPD = Off             ' Data EEPROM Code Protection Disabled
    WRT0 = Off            ' Write Protection Block 0 Disabled
    WRT1 = Off            ' Write Protection Block 1Disabled
    WRT2 = Off            ' Write Protection Block 2 Disabled
    WRT3 = Off            ' Write Protection Block 3 Disabled
    WRTB = Off            ' Boot Block Write Protection Disabled
    WRTC = Off            ' Configuration Register Write Protection Disabled
    WRTD = Off            ' Data EEPROM Write Protection Disabled
    EBTR0 = Off           ' Table Read Protection Block 0 Disabled
    EBTR1 = Off           ' Table Read Protection Block 1 Disabled
    EBTR2 = Off           ' Table Read Protection Block 2 Disabled
    EBTR3 = Off           ' Table Read Protection Block 3 Disabled
    EBTRB = Off           ' Boot Block Table Read Protection Disabled
Config_End
```

The configs shown are for the 18F452 device and differ from device to device.

A complete list of Config fuse settings can be found in the "*hlpPIC18ConfigSet.chm*" file downloadable from www.microchip.com.

The fuse setting text between **Config_Start** and **Config_End** will have the preceding **Config** text added, then is passed directly to the assembler. Any errors in the fuse setting texts will result in Assembler errors being produced.

Notes
If the **Config** directive is not used within the BASIC program then default values are used. These may be found in the .ppi files within the "Includes\PPI" folder.

When using either of the **Config** directives, always use all the fuse settings for the particular PICmicro™ used. With 14-bit core (16F) devices, the compiler will always issue a reminder after the **Config** directive has been issued, however, this may be ignored if you are confident that you have assigned all the relevant fuse names.

Any fuse names that are omitted from the **Config** list will normally assume an Off or Disabled state. However, this is not always the case, and unpredictable results may occur, or the PICmicro™ may refuse to start up altogether.

Before programming the PICmicro™, always check the user configured fuse settings at programming time to ensure that the settings are correct.

Always read the datasheet for the particular PICmicro™ of interest, before using this directive.

Config1,Config2, Config3 and Config4
Some enhanced 14-bit core devices have more than one configuration area, therefore additional **Config** directives have been added. These are **Config1**, **Config2**, **Config3** and **Config4**. Their use is exactly the same as the **Config** directive, but the fuse names depend on the device used:

Example:
```
' Alter the fuse settings for a 16F886 device
Config1 HS_OSC, WDT_OFF, DEBUG_OFF, FCMEN_OFF, IESO_OFF,_
        BOR_OFF, CPD_OFF, CP_OFF, MCLRE_ON, PWRTE_ON
Config2 WRT_OFF, BOR21V
```

Note that at the time of writing, all enhanced 14-bit core devices have 2 or more config areas.

Continue

Syntax
Continue

Overview
Cause the next iteration of **For**…**Next**, **While**...**Wend** or **Repeat**...**Until** or **Do**…**Loop** conditions to occur. With a **For**…**Next** loop, **Continue** will jump to the **Next** part. With a **While**…**Wend** loop, **Continue** will jump to the **While** part. With a **Repeat**…**Until** loop, **Contnue** will jump to the **Until** part.

Example
```
' Create and display a For-Next loop's iterations, missing out number 10
  Device = 18F25K20
  Declare Xtal = 4

  Dim Index as Byte

  For Index = 0 to 19              ' Create a loop of 20 iterations
    If Index = 10 Then Continue    ' Miss out number 10
    HrsoutLn Dec Index             ' Display the counting loop
    DelayMs 100                    ' Slow things down to see what's happening
  Next                             ' Close the loop
```

See also :   Break, For…**Next, Repeat**…**Until, While**…**Wend.**

Context

Syntax
Context Save *{Variable,Variable}*
Context Restore

Overview
Save and restore important variables and device SFRs (Special Function Registers) while inside an interrupt. **Context Restore** will also exit the interrupt and hand control back to the main program.

Parameters
Variable is an optional list of user-defined variables or SFRs that will also be saved before entering the interrupt handling subroutine and restored after the interrupt has ended.

Example:
```
' Illustrate a typical use for Context Save and Context Restore
   Device = 18F4520
   Declare Xtal = 20

   On_Hardware_Interrupt Goto ISR_Handler ' Point to the interrupt handler
   Dim wTimer1 as TMR1L.Word       ' Create a 16-bit Word from registers TMR1L/H

   Goto Main                       ' Jump over any subroutines to main program

' ---------------------------------------
' A typical Interrupt handling subroutine
'
ISR_Handler:
   Context Save                    ' Save any variables used in the interrupt
   If PIR1bits_TMR1IF = 1 Then     ' Is it a Timer1 overflow interrupt?
      Toggle PORTB.0               ' Yes. So. Toggle PORTB.0
      PIR1bits_TMR1IF = 0          ' Clear the Timer1 Overflow flag
   EndIf                           '
   Context Restore                 ' Restore any variables and exit the interrupt

' ---------------------------------------
' The main program starts here
'
Main:
   Low PORTB                       ' Make all of PORTB output low
'
' Setup a Timer1 interrupt
   T1CONbits_RD16 = 1              ' Enable read/write of Timer1 in 16-bit mode
   T1CONbits_T1CKPS1 = 0           ' \ Timer1 Prescaler to 1:4
   T1CONbits_T1CKPS0 = 1           ' /
   T1CONbits_T1OSCEN = 0           ' Disable External Oscillator
   T1CONbits_TMR1CS = 0            ' Increment on the internal Clock
   wTimer1 = 0                     ' Clear Timer1
   T1CONbits_TMR1ON = 1            ' Enable Timer1
   PIE1bits_TMR1IE = 1             ' Enable the Timer1 overflow interrupt
   INTCON1bits_PEIE = 1            ' Enable all peripheral interrupts
   INTCON1bits_GIE = 1             ' Enable all interrupts

   While                           ' Create an infinite loop
      PORTB.1 = 1                  ' Set PORTB.1 high
      DelayMS 200                  ' Wait a while
      PORTB.1 = 0                  ' Pull PORTB.1 low
      DelayMs 200                  ' Wait a while
   Wend                            ' Do it forever
```

Notes.

When an interrupt occurs, it will immediately leave the main program and jump to the interrupt handling subroutine regardless of what the main program is doing. The main program generally has no idea that an interrupt has occurred and if it was using any of the device's resources or the compiler's system variables and the interrupt handler is doing the same, they will be altered when the main program continues, with disastrous results.

This is the reason for context saving and restoring of the compiler's internal system variables and the device's SFRs (Special Function Registers). Each compiler command generates variables for it to work upon, either for passing parameters or the actual working of the library routine. Some commands also make use of the device's SFRs, for example FSR or PRODL or PRODH etc…

Of course, we don't want to save every internal system variable or device SFR as this would take far too much RAM and slow down the entry and exit of the interrupt while each was saved and restored. What we want is to save and restore only the variables and SFRs that are used within the interrupt handler itself. This may be a lot or a little, or none, depending on the program within the interrupt handler subroutine.

The compiler examines the code between the **Context Save** and **Context Restore** commands and keeps a record of the internal compiler system variables and SFRs used. There are excepts to this rule concerning SFRs which we'll deal with later.

The **Context Save** command should always be at the beginning of the interrupt handling subroutine, and this will save any variables in a specially created byte array.

Exceptions to the Rule.

Each of the compiler's commands reports internally as to which compiler system variable and SFR they use. However, this is not the case for any SFRs used as an assignment variable. For example:

```
PRODL = ByteIn1 + ByteIn2
```

It is also not the case for any PORT or TRIS registers.

For these SFRs to be saved and restored they will need to be added to the list of parameters after the **Context Save** command:

```
Context Save PRODL, PORTB, TRISB
```

See also :   On_Hardware_Interrupt, On_Low_Interrupt.

Counter

Syntax
Variable **= Counter** *Pin*, *Period*

Overview
Count the number of pulses that appear on *pin* during *period*, and store the result in *variable*.

Parameters
Variable is a user-defined variable.
Pin is a Port.Pin constant declaration i.e. PORTA.0.
Period may be a constant, variable, or expression.

Example
```
' Count the pulses that occur on PORTA.0 within a 100ms period
' and displays the results.

  Dim Wrd as Word          ' Create a word size variable
  Symbol Pin = PORTA.0     ' Assign the input pin to PORTA.0
  Cls
MyLoop:
  Wrd = Counter Pin, 100   ' Variable Wrd now contains the Count
  Cursor 1, 1
  Print Dec Wrd, " "       ' Display the decimal result on the LCD
  Goto MyLoop              ' Do it indefinitely
```

Notes
The resolution of *period* is in milliseconds (ms). It obtains its scaling from the oscillator declaration, **Declare Xtal.**

Counter checks the state of the pin in a concise loop, and counts the rising edge of a transition (low to high).

With a 4MHz oscillator, the pin is checked every 20us, and every 4us with a 20MHz oscillator. From this we can determine that the highest frequency of pulses that may be counted is: -

   25KHz using a 4MHz oscillator.
   125KHz using a 20MHz oscillator.

See also :   PulseIn, Rcin.

cPtr8, cPtr16, cPtr32

Syntax
Variable **= cPtr8** *(Address)*
Variable **= cPtr16** *(Address)*
Variable **= cPtr32** *(Address)*

Overview
Indirectly read code memory using a variable to hold the 16-bit or 32-bit address. For enhanced 14-bit core devices and 18F devices only.

Operands
Variable is a user defined variable that holds the result of the indirectly addressed code memory area.
Address is a **Word** or **Dword** variable that holds the 16-bit or 32-bit address of the code memory area of interest.

Address can also post or pre increment or decrement:

- ● (MyAddress++)   Post increment MyAddress after retreiving it's RAM location.
- ● (MyAddress --)   Post decrement MyAddress after retreiving it's RAM location.
- ● (++MyAddress)   Pre increment MyAddress before retreiving it's RAM location.
- ● (--MyAddress)   Pre decrement MyAddress before retreiving it's RAM location.

cPtr8 will retrieve a value with an optional 8-bit post or pre increment or decrement.
cPtr16 will retrieve a value with an optional 16-bit post or pre increment or decrement.
cPtr32 will retrieve a value with an optional 32-bit post or pre increment or decrement.

8-bit Example.
```
'
' Read 8-bit values indirectly from code memory
'
  Device = 18F25K20                  ' Choose an 18F device
  Declare Xtal = 16

  Declare Hserial_Baud = 9600        ' Set baud rate to 9600
'
' Create an 8-bit code memory array
'
  Dim CodeArray As Code = as Byte 1, 2, 3, 4, 5, 6, 7, 8, 9, 0
  Dim MyByte As Byte                 ' Create a byte variable
  Dim bIndex As Byte
  Dim wAddress As Word               ' Create variable to hold 16-bit address
Main:
'
' Read from code memory
'
  wAddress = AddressOf(CodeArray)    ' Load wAddress with address of memory
  While                              ' Create a loop
    MyByte = cPtr8(wAddress++)       ' Retrieve from code with post increment
    If MyByte = 0 Then Break         ' Exit when a null(0) is read from code
    HRSOutLn Dec MyByte              ' Transmit the byte read from code
  Wend
```

16-bit Example.

```
'
' Read 16-bit values indirectly from code memory
'
  Device = 18F25K20                      ' Choose an 18F device
  Declare Xtal = 16

  Declare Hserial_Baud = 9600            ' Set baud rate to 9600
'
' Create a 16-bit code memory array
'
  Dim CodeArray As Code = as Word 100, 200, 300, 400, 500, 600, 700, 0
  Dim MyWord As Word                     ' Create a word variable
  Dim bIndex As Byte
  Dim wAddress As Word                   ' Create variable to hold 16-bit address

Main:
'
' Read from code memory
'
  wAddress = AddressOf(CodeArray)    ' Load wAddress with address of memory
  While                              ' Create a loop
    MyWord = cPtr16(wAddress++)      ' Retrieve from code with post increment
    If MyWord = 0 Then Break         ' Exit when a null(0) is read from code
    HRSOutLn Dec MyWord              ' Transmit the word read from code
  Wend
```

32-bit Example.

```
'
' Read 32-bit values indirectly from code memory
'
  Device = 18F25K20                      ' Choose an 18F device
  Declare Xtal = 16

  Declare Hserial_Baud = 9600            ' Set baud rate to 9600
'
' Create a 32-bit code memory array
'
  Dim CodeArray As Code = as Dword 100, 200, 300, 400, 500, 600, 700, 0
  Dim MyDword As Dword                   ' Create a dword variable
  Dim bIndex As Byte
  Dim wAddress As Word                   ' Create variable to hold 16-bit address

Main:
'
' Read from code memory
'
  wAddress = AddressOf(CodeArray)    ' Load wAddress with address of memory
  While                              ' Create a loop
    MyDword = cPtr32(wAddress++)     ' Retrieve from code with post increment
    If MyDword = 0 Then Break        ' Exit when a null(0) is read from code
    HRSOutLn Dec MyDword             ' Transmit the dword read from code
  Wend
```

See also: **AddressOf, Cread8, Cread16, Cread32.**

Cread

Syntax
Variable **= Cread** *Address*

Overview
Read data from anywhere in code memory.

Parameters
Variable is a user defined variable.
Address is a constant, variable, label, or expression that represents any valid address within code memory

Example
```
' Read code memory locations within the device

  Device = 16F1829
  Dim Var1 as Byte
  Dim Wrd as Word
  Dim Address as Word

  Address = 1000              ' Address now holds the base address
  Var1 = Cread 1000           ' Read 8-bit data at address 1000 into Var1
  Wrd = Cread Address + 10    ' Read data at address 1000+10
```

Notes
The **Cread** command takes advantage of the self-modifying feature that is available in the latest devices.

If a **Float** or **Dword** size variable is used as the assignment, then 32-bits will be read. If a **Word** size variable is used as the assignment, then 16-bits will be read. If a **Byte** sized variable is used as the assignment, then 8-bits will be read.

The configuration fuse setting WRTE must be enabled before **Cdata**, **Cread**, and **Cwrite** may be used, this is the default setting. This enables the self-modifying feature. If the **Config** directive is used, then the WRTE_ON fuse setting must be included in the list: -

```
 Config WDT_ON, XT_OSC, WRTE_ON
```

See also :   Cdata, Cread8, Cread16, Cread32, Config, Cwrite, Dim, Ldata, Lread, Lread8, Lread16, Lread32.

Cread8, Cread16, Cread32

Syntax
Variable **= Cread8** *Label* **[** *Offset Variable* **]**

or

Variable **= Cread16** *Label* **[** *Offset Variable* **]**

or

Variable **= Cread32** *Label* **[** *Offset Variable* **]**

Overview
Read an 8, 16, or 32-bit value from a **Cdata** table using an offset of *Offset Variable* and place into *Variable*, with more efficiency than using **Cread** . For device's that can access their own code memory.

Cread8 will access 8-bit values from an **Cdata** table.
Cread16 will access 16-bit values from an **Cdata** table.
Cread32 will access 32-bit values from an **Cdata** table, this also includes floating point values.

Parameters
Variable is a user defined variable or an **Array**.
Label is a label name preceding the **Cdata** statement of which values will be read from.
Offset Variable can be a constant value, variable, or expression that points to the location of interest within the **Cdata** table.

Cread8 Example
```
' Extract the second value from within an 8-bit Cdata table
  Device = 18F452
  Dim Offset as Byte        ' Create a Byte size variable for the offset
  Dim MyResult as Byte      ' Create a Byte size variable to hold the result
  ' Create a table containing only 8-bit values
  Dim Byte_Table as Code = as Byte 100, 200

  Cls                       ' Clear the LCD
  Offset = 1                ' Point to the second value in the Ldata table
' Read the 8-bit value pointed to by Offset
  MyResult = Cread8 Byte_Table[Offset]
  Print Dec MyResult        ' Display the decimal result on the LCD
  Stop
```

Cread16 Example

```
' Extract the second value from within a 16-bit Cdata table
   Device = 18F4520
   Dim Offset as Byte        ' Create a Byte size variable for the offset
   Dim MyResult as Word      ' Create a Word size variable to hold the result
   ' Create a table containing only 16-bit values
   Dim WordTable as Code = as Word 1234, 5678

   Cls                          ' Clear the LCD
   Offset = 1                   ' Point to the second value in the Ldata table
' Read the 16-bit value pointed to by Offset
   MyResult = Cread16 WordTable[Offset]
   Print Dec MyResult           ' Display the decimal result on the LCD
   Stop
```

Cread32 Example

```
' Extract the second value from within a 32-bit Cdata table
   Device = 18F4520
   Dim Offset as Byte        ' Create a Byte size variable for the offset
   Dim MyResult as Dword     ' Create a Dword size variable to hold the result

' Create a table containing only 32-bit values
   Dim DwordTable as Code = as Dword 12340, 56780

   Cls                          ' Clear the LCD
   Offset = 1                   ' Point to the second value in the Ldata table
' Read the 32-bit value pointed to by Offset
   MyResult = Cread32 DwordTable[Offset]
   Print Dec MyResult           ' Display the decimal result on the LCD
   Stop
```

Notes

Data storage in any program is of paramount importance, and although the standard **Cread** command can access multi-byte values from a flash memory data table, it was not originally intended as such, and is more suited to accessing character data or single 8-bit values. However, the **Cread8**, **Cread16**, and **Cread32** commands are specifically written in order to efficiently read data from an **Cdata** table, and use the least amount of code space in doing so, thus increasing the speed of operation. Which means that wherever possible, **Cread** should be replaced by **Cread8**, **Cread16**, or **Cread32**.

See also : **Cdata, Cread, Dim, Ldata, Lread, Lread8, Lread16, Lread32.**

Cursor

Syntax
Cursor *Line, Position*

Overview
Move the cursor position on an Alphanumeric or Graphic LCD to a specified line (ypos) and position (xpos).

Parameters
Line is a constant, variable, or expression that corresponds to the line (Ypos) number from 1 to maximum lines (0 to maximum lines if using a graphic LCD).
Position is a constant, variable, or expression that moves the position within the position (Xpos) chosen, from 1 to maximum position (0 to maximum position if using a graphic LCD).

Example 1
```
Dim Line as Byte
Dim Xpos as Byte

Line = 2
Xpos = 1
Cls                   ' Clear the LCD
Print "Hello"         ' Display the word "Hello" on the LCD
Cursor Line, Xpos     ' Move the cursor to line 2, position 1
Print "World"         ' Display the word "World" on the LCD
```

In the above example, the LCD is cleared using the **Cls** command, which also places the cursor at the home position i.e. line 1, position 1. Next, the word "Hello" is displayed in the top left corner. The cursor is then moved to line 2 position 1, and the word "World" is displayed.

Example 2
```
Dim Xpos as Byte
Dim Ypos as Byte
Again:
Ypos = 1                   ' Start on line 1
For Xpos = 1 to 16         ' Create a loop of 16
   Cls                     ' Clear the LCD
   Cursor Ypos, Xpos       ' Move the cursor to position Ypos,Xpos
   Print "*"               ' Display the character
   DelayMs 100
Next
Ypos = 2                   ' Move to line 2
For Xpos = 16 to 1 Step -1 ' Create another loop, this time reverse
   Cls                     ' Clear the LCD
   Cursor Ypos, Xpos       ' Move the cursor to position Ypos,Xpos
   Print "*"               ' Display the character
   DelayMs 100
Next
Goto Again                 ' Repeat forever
```

Example 2 displays an asterisk character moving around the perimeter of a 2-line by 16 character LCD.

See also : **Cls, Print**

Cwrite

Syntax
Cwrite *Address,* **[** *Variable* {*, Variable...*} **]**

Overview
Write data to anywhere in code memory on devices that support it.

Parameters
Variable can be a constant, variable, or expression.
Address is a constant, variable, label, or expression that represents any valid code memory address

Example
```
' Write to memory location 2000+ within the PICmicro

  Device = 16F877                  ' Choose the PICmicro
  Declare Xtal = 4

  Dim Var1 as Byte = 234
  Dim Wrd as Word = 1043
  Dim Address as Word = 2000       ' Address now holds the base address

  Cwrite Address, [10, Var1, Wrd]  ' Write to address 2000 +
  Org 2000
```

Notes
The **Cwrite** command takes advantage of the self-modifying feature that is available in most devices.

If a **Word** size variable is used as the assignment, then a 14-bit **Word** will be written. If a **Byte** sized variable is used as the assignment, then 8-bits will be written.

Because the 14-bit core devices are only capable of holding 14 bits to a **Word**, values greater than 16383 ($3FFF) cannot be written. However, the 18F devices may hold values up to 65535 ($FFFF).

The configuration fuse setting WRTE must be enabled before **Cdata**, **Cread**, and **Cwrite** may be used, this is the default setting. This enables the self-modifying feature. If the Config directive is used, then the WRTE_ON fuse setting must be included in the list: -

```
  Config WDT_ON, XT_OSC, WRTE_ON
```

See also :   Cdata, Config, Cread, Cread8, Cread16, Cread32, Dim.

Dec

Syntax
Dec *Variable*

Overview
Decrement a variable i.e. Var1 = Var1 - 1

Parameters
Variable is a user defined variable

Example
```
Device = 16F877              ' Choose the microcontroller
Declare Xtal = 4

Dim Var1 as Byte = 11

Repeat                       ' Create a loop
  Dec Var1                   ' Decrement the variable
  HrsoutLn Dec Var1          ' Transmit the decimal value serially
  DelayMs 200                ' A delay to see what's happening
Until Var1 = 0              ' Loop until the variable reaches 0
```

The above example shows the equivalent to the **For**-**Next** loop: -

```
For Var1 = 10 to 0 Step -1
Next
```

See also :   Inc.

Declare

Syntax
[Declare] *code modifying directive = modifying value*

Overview
Adjust certain aspects of the produced code at compile time, i.e. Crystal frequency, LCD port and pins, serial baud rate etc.

Parameters
code modifying directive is a set of pre-defined words. See list below.
modifying value is the value that corresponds to the action. See list below.

The **Declare** directive is an indispensable part of the compiler. It moulds the library subroutines, and passes essential user information to them.

Notes
The **Declare** directive usually alters the corresponding library subroutine at runtime. This means that once the **Declare** is added to the BASIC program, it usually cannot be Undeclared later, or changed in any way. However, there are some declares that alter the flow of code, and can be enabled and disabled throughout the BASIC listing.

Oscillator Frequency Declare.
12-bit core device XTAL values:
Declare Xtal 4, 8, 10, 12, 16, or 20.

Standard 14-bit core device XTAL values:
Declare Xtal 3, 4, 7, 8, 10, 12, 14, 16, 19, 20, 22, or 24.

Enhanced 14-bit core device XTAL values:
Declare Xtal 3, 4, 7, 8, 10, 12, 14, 16, 19, 20, 22, 24, 32, 48, or 64.

18F device XTAL values:
Declare Xtal 3, 4, 7, 8, 10, 12, 14, 16, 19, 20, 22, 24, 25, 29, 32, 33, 40, 48, 64, 80, or 88.

Inform the compiler what frequency oscillator is being used.

Some commands are very dependant on the oscillator frequency, **Rsin**, **Rsout**, **DelayMs**, and **DelayUs** being just a few. In order for the compiler to adjust the correct timing for these commands, it must know what frequency crystal is being used.

The **Xtal** frequencies 3, 7, 14, 19 and 22 are for 3.58MHz, 7.2MHz, 14.32MHz, 19.66MHz, 22.1184MHz and 29.2MHz respectively.

If the **Declare** is not used in the program, then the default frequency will be of an unknown state.

Misc Declares.

Declare WatchDog = On or Off, or True or False, or 1, 0
The **WatchDog Declare** directive enables or disables the watchdog timer. It also sets the PICmicro's Config fuses for no watchdog. In addition, it removes any **ClrWdt** mnemonics from the assembled code, thus producing slightly smaller programs. The default for the compiler is **WatchDog Off**, therefore, if the watchdog timer is required, then this **Declare** will need to be invoked.

The **WatchDog Declare** can be issued multiple times within the BASIC code, enabling and disabling the watchdog timer as and when required.

Declare BootLoader = On or Off, or True or False, or 1, 0
The **BootLoader Declare** directive enables or disables the special settings that a serial boot-loader requires at the start of code space. This directive is ignored if a PICmicro™ without boot-loading capabilities is targeted.

Disabling the bootloader will free a few bytes from the code produced. This doesn't seem a great deal, however, these few bytes may be the difference between a working or non-working program. The default for the compiler is **BootLoader** On

Declare Show_System_Variables = On or Off, or True or False, or 1, 0
When using the Proteus VSM to simulate BASIC code, it is sometimes beneficial to observe the behaviour of the compiler's System variables that are used for its library routines. The **Show_System_Variables Declare** enables or disables this option.

Declare Warnings = On or Off, or True or False, or 1, 0
The **Warnings Declare** directive enables or disables the compiler's warning messages. This can have disastrous results if a warning is missed or ignored, so use this directive sparingly, and at your own peril.

The **Warnings Declare** can be issued multiple times within the BASIC code, enabling and disabling the warning messages at key points in the code as and when required.

Declare Hints = On or Off, or True or False, or 1, 0
The **Hints Declare** directive enables or disables the compiler's hint messages. The compiler issues a hint for a reason, so use this directive sparingly, and at your own peril.

The **Hints Declare** can be issued multiple times within the BASIC code, enabling and disabling the hint messages at key points in the code as and when required.

Declare Label_Bank_Resets = On or Off, or True or False, or 1, 0
The compiler has very intuitive RAM bank handling, however, if you think that an anomaly is occurring due to misplaced or mishandled RAM bank settings, you can issue this **Declare** and it will reset the RAM bank on every BASIC label, which will force the compiler to re-calculate its bank settings. If nothing else, it will reassure you that bank handling is not the cause of the problem, and you can get on with finding the cause of the programming problem. However, if it does cure a problem then please let me know and I will make sure the anomaly is fixed as quickly as possible.

Using this **Declare** will increase the size of the code produced, as it will place **Bcf** mnemonics in the case of a 12 or 14-bit core device, and a **Movlb** mnemonic in the case of an 18F device.

The **Label_Bank_Resets Declare** can be issued multiple times within the BASIC code, enabling and disabling the bank resets at key points in the code as and when required. See Line Lables for more information.

Declare Float_Display_Type = Fast or Standard
By default, the compiler uses a relatively small routine for converting floating point values to decimal, ready for **Rsout**, **Print**, **Str$** etc. However, because of its size, it does not perform any rounding of the value first, and is only capable of converting relatively small values. i.e. approx 6 digits of accuracy. In order to produce a more accurate result, the compiler needs to use a larger routine. This is implemented by using the above **Declare**.

Using the Fast model for the above **Declare** will trigger the compiler into using the more accurate floating point to decimal routine. Note that even though the routine is larger than the standard converter, it actually operates much faster.

The compiler defaults to Standard if the **Declare** is not issued in the BASIC program.

Declare Create_Coff = On or Off, or True or False or 1, 0
When the **Create_Coff Declare** is set to **On**, the compiler produces a cof file (Common Object File). This is used for simulating the BASIC code within the MPLAB™ IDE environment or the ISIS simulator.

Declare **ICD_Req** = On or Off, or True or False, or 1, 0
When the **ICD_Req Declare** is set to **On**, the compiler configures itself so that the Microchip ICD2™ In-Circuit-Debugger, or PICkit2™ can be used. The ICD2™ and PICkit2™ are very invasive to the program, in so much that they require certain RAM areas for itself. This can be up to 26 bytes on some PICmicros. They also require 2 call-stack levels, so be careful when using a 14-bit core device or you may overflow the call-stack with disastrous results.

With a 14-bit core device, the top of Bank0 RAM is reserved for the ICD, for 18F devices, the RAM usage is not so noticeable because of its linear nature, but it still requires 12 bytes reserved at the end of RAM.

The list below highlights the requirements for the ICD2™ with some devices that support it.

Device	RAM Usage
P12F675	$54 - $5F
P12F629	$54 - $5F
P16F627A	$70 - $7F
P16F628A	$70 - $7F
P16F648A	$70 - $7F
P16F630	$54 - $5F
P16F676	$54 - $5F
P16F87	$70 - $7F
P16F88	$70 - $7F
P16F818	$65 - $7F
P16F819	$65 - $7F
P16F870	$70 - $7F, $B5 - $BF
P16F871	$70 - $7F, $B5 - $BF
P16F872	$70 - $7F, $B5 - $BF
P16F873/873A	$74 - $7F
P16F874/874A	$74 - $7F
P16F876/876A	$70 - $7F
P16F877/877A	$70 - $7F
P18F242/442	$02F4 - $02FF
P18F252/452	$05F4 - $05FF
P18F248/448	$02F4 - $02FF
P18F258/458	$05F4 - $05FF
P18F1220	$F4 - $FF
P18F1320	$F4 - $FF
P18F2220/4220	$01F4 - $01FF
P18F2320/4320	$01F4 - $01FF
P18F2331/4331	$02F4 - $02FF
P18F2431/4431	$02F4 - $02FF
P18F2680/4680	$0CF4 - $0CFF
P18F6520/8520	$0EF4 - $0EFF
P18F6620/8620	$0EF4 - $0EFF
P18F6720/8720	$0EF4 - $0EFF

Whenever ICD2™ or PICkit2™ or PICkit3™ compatibility is enabled, the compiler will automatically deduct the reserved RAM from the available RAM within the PICmicro™, therefore you must take this into account when declaring variables. Remember, there aren't as many variables available with the ICD enabled.

Adin Declares.

Declare Adin_Res 8, 10, or 12.
Sets the number of bits in the result.

If this **Declare** is not used, then the default is the resolution of the microcontroller used. Using the above **Declare** allows an 8-bit result to be obtained from 10-bit or 12-bit microcontrollers, but not 10-bits or 12-bits from the 8-bit types.

Declare Adin_Tad 2_FOSC, 8_FOSC, 32_FOSC, 64_FOSC or FRC.
Sets the ADC's clock source.

All compatible PICmicros have four options for the clock source used by the ADC; 2_FOSC, 8_FOSC, and 32_FOSC, are ratios of the external oscillator, while FRC is the PICmicro's internal RC oscillator. Instead of using the predefined names for the clock source, values from 0 to 3 may be used. These reflect the settings of bits 0-1 in register ADCON0.

Care must be used when issuing this **Declare**, as the wrong type of clock source may result in poor resolution, or no conversion at all. If in doubt use FRC which will produce a slight reduction in resolution and conversion speed, but is guaranteed to work first time, every time. FRC is the default setting if the **Declare** is not issued in the BASIC listing.

Declare Adin_Stime 0 to 65535 microseconds (us).
Allows the internal capacitors to fully charge before a sample is taken. This may be a value from 0 to 65535 microseconds (us).

A value too small may result in a reduction of resolution. While too large a value will result in poor conversion speeds without any extra resolution being attained.

A typical value for **Adin_Stime** is 50 to 100. This allows adequate charge time without loosing too much conversion speed.

But experimentation will produce the right value for your particular requirement. The default value if the **Declare** is not used in the BASIC listing is 50.

Busin - Busout Declares.

Declare SDA_Pin Port **.** Pin
Declares the port and pin used for the data line (SDA). This may be any valid port on the microcontroller. If this declare is not issued in the BASIC program, then the default Port and Pin is PORTA.0

Declare SCL_Pin Port **.** Pin
Declares the port and pin used for the clock line (SCL). This may be any valid port on the microcontroller. If this declare is not issued in the BASIC program, then the default Port and Pin is PORTA.1

Declare Slow_Bus On - Off or 1 - 0
Slows the bus speed when using an oscillator higher than 4MHz.

The standard speed for the I^{2}C bus is 100KHz. Some devices use a higher bus speed of 400KHz. If you use an 8MHz or higher oscillator, the bus speed may exceed the devices specs, which will result in intermittent writes or reads, or in some cases, none at all. Therefore, use this **Declare** if you are not sure of the device's spec. The datasheet for the device used will inform you of its bus speed.

Declare Bus_SCL On - Off, 1 - 0 or True - False
Eliminates the necessity for a pull-up resistor on the SCL line.

The I^{2}C protocol dictates that a pull-up resistor is required on both the SCL and SDA lines, however, this is not always possible due to circuit restrictions etc, so once the **Bus_SCL On Declare** is issued at the top of the program, the resistor on the SCL line can be omitted from the circuit. The default for the compiler if the **Bus_SCL Declare** is not issued, is that a pull-up resistor is required.

Hbusin - Hbusout Declares.
Declare Hbus_Bitrate Constant 100, 400, 1000 etc.
The standard speed for the I^{2}C bus is 100KHz. Some devices use a higher bus speed of 400KHz. The above **Declare** allows the I^{2}C bus speed to be increased or decreased. Use this **Declare** with caution, as too high a bit rate may exceed the device's specs, which will result in intermittent transactions, or in some cases, no transactions at all. The datasheet for the device used will inform you of its bus speed. The default bit rate is the standard 100KHz.

Declare HSDA_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the data line (SDA) must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare HSCL_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the clock line (SCL) must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

USART1 Declares for use with Hrsin, Hserin, Hrsout and Hserout.

Declare Hserout_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the TX line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserin_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the RX line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial_Baud Constant value
Sets the Baud rate that will be used to receive a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program. The compiler will assign the best values to the SFRs for the Baud rate required. Within the asm file listing are the Baud rate achieved and the error percentage. Once compiled, press the F2 button and view the asm listing.

Declare Hserial_RCSTA Constant value (0 to 255)
Hserial_RCSTA, is an *optional* declare that sets the respective microcontroller hardware register RCSTA, to the value in the **Declare**. See the device's data sheet for more information regarding this register.

Declare Hserial_TXSTA Constant value (0 to 255)
Hserial_TXSTA, is an *optional* declare that sets the respective hardware register, TXSTA, to the value in the **Declare**. See the device's data sheet for more information regarding this register. The TXSTA register's BRGH bit controls the high speed mode for the baud rate generator. Certain Baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial_TXSTA** to a value of $24 instead of the default $20.

Declare Hserial_Parity Odd or Even
Enables/Disables parity on the serial port. For **Hrsin**, **Hrsout**, **Hserin** and **Hserout**. The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial_Parity** declare.

```
Declare Hserial_Parity = Even    ' Use if even parity desired
Declare Hserial_Parity = Odd     ' Use if odd parity desired
```

Declare Hserial_Clear On or Off
Clear the overflow error bit before commencing a read.

Because the hardware serial port only has a 2-byte input buffer, it can easily overflow is characters are not read from it often enough. When this occurs, the USART stops accepting any new characters, and requires resetting. This overflow error can be reset by strobing the CREN bit within the RCSTA register. Example: -

```
    RCSTAbits_CREN = 0
    RCSTAbits_CREN = 1
or
    Clear RCSTAbits_CREN
    Set RCSTAbits_CREN
```

Alternatively, the **Hserial_Clear** declare can be used to automatically clear this error, even if no error occurred. However, the program will not know if an error occurred while reading, therefore some characters may be lost.

```
    Declare Hserial_Clear = On
```

USART2 Declares for use with Hrsin2, Hserin2, Hrsout2 and Hserout2.

Declare Hserout2_Pin Port . Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the TX2 line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserin2_Pin Port . Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the RX2 line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial2_Baud Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program. The compiler will assign the best values to the SFRs for the Baud rate required. Within the asm file listing are the Baud rate achieved and the error percentage. Once compiled, press the F2 button and view the asm listing.

Declare Hserial2_RCSTA Constant value (0 to 255)
Hserial2_RCSTA, is an *optional* declare that sets the respective hardware register RCSTA2, to the value in the **Declare**. See the device's data sheet for more information regarding this register.

Declare Hserial2_TXSTA Constant value (0 to 255)
Hserial2_TXSTA, is an *optional* declare that sets the respective hardware register, TXSTA2, to the value in the **Declare**. See the device's data sheet for more information regarding this register. The TXSTA2 register's BRGH2 bit controls the high speed mode for the baud rate generator. Certain baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial2_TXSTA** to a value of $24 instead of the default $20.

Declare Hserial2_Parity Odd or Even
Enables/Disables parity on the serial port. For **Hrsout2**, **Hrsin2**, **Hserout2** and **Hserin2**. The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial2_Parity** declare.

```
Declare Hserial2_Parity = Even   ' Use if even parity desired
Declare Hserial2_Parity = Odd    ' Use if odd parity desired
```

Declare Hserial2_Clear On or Off
Clear the overflow error bit before commencing a read.

Because the hardware serial port only has a 2-byte input buffer, it can easily overflow is characters are not read from it often enough. When this occurs, the USART stops accepting any new characters, and requires resetting. This overflow error can be reset by strobing the CREN bit within the RCSTA2 register. Example: -

```
RCSTA2bits_CREN = 0
RCSTA2bits_CREN = 1
```
or
```
Clear RCSTA2bits_CREN
Set RCSTA2bits_CREN
```

Alternatively, the **Hserial2_Clear** declare can be used to automatically clear this error, even if no error occurred. However, the program will not know if an error occurred while reading, therefore some characters may be lost.

```
Declare Hserial2_Clear = On
```

USART3 Declares for use with Hrsin3, Hserin3, Hrsout3 and Hserout3.

Declare Hserout3_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the TX3 line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserin3_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the RX3 line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial3_Baud Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program. The compiler will assign the best values to the SFRs for the Baud rate required. Within the asm file listing are the Baud rate achieved and the error percentage. Once compiled, press the F2 button and view the asm listing.

Declare Hserial3_RCSTA Constant value (0 to 255)
Hserial2_RCSTA, is an ***optional*** declare that sets the respective hardware register RCSTA3, to the value in the **Declare**. See the device's data sheet for more information regarding this register.

Declare Hserial3_TXSTA Constant value (0 to 255)
Hserial3_TXSTA, is an *optional* declare that sets the respective hardware register, TXSTA3, to the value in the **Declare**. See the device's data sheet for more information regarding this register. The TXSTA3 register's BRGH bit controls the high speed mode for the baud rate generator. Certain Baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial3_TXSTA** to a value of $24 instead of the default $20.

Declare Hserial3_Parity Odd or Even
Enables/Disables parity on the serial port. For **Hrsout3**, **Hrsin3**, **Hserout3** and **Hserin3**. The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial2_Parity** declare.

```
Declare Hserial3_Parity = Even    ' Use if even parity desired
Declare Hserial3_Parity = Odd     ' Use if odd parity desired
```

Declare Hserial3_Clear On or Off
Clear the overflow error bit before commencing a read.

Because the hardware serial port only has a 2-byte input buffer, it can easily overflow is characters are not read from it often enough. When this occurs, the USART stops accepting any new characters, and requires resetting. This overflow error can be reset by strobing the CREN bit within the RCSTA3 register. Example: -

```
RCSTA3bits_CREN = 0
RCSTA3bits_CREN = 1
```
or
```
Clear RCSTA3bits_CREN
Set RCSTA3bits_CREN
```

Alternatively, the **Hserial3_Clear** declare can be used to automatically clear this error, even if no error occurred. However, the program will not know if an error occurred while reading, therefore some characters may be lost.

```
Declare Hserial3_Clear = On
```

USART4 Declares for use with Hrsin4, Hserin4, Hrsout4 and Hserout4.

Declare Hserout4_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the TX4 line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserin4_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the RX4 line must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial4_Baud Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program. The compiler will assign the best values to the SFRs for the Baud rate required. Within the asm file listing are the Baud rate achieved and the error percentage. Once compiled, press the F2 button and view the asm listing.

Declare Hserial4_RCSTA Constant value (0 to 255)
Hserial4_RCSTA, is an *optional* declare that sets the respective hardware register RCSTA4, to the value in the **Declare**. See the device's data sheet for more information regarding this register.

Declare Hserial4_TXSTA Constant value (0 to 255)
Hserial4_TXSTA, is an *optional* declare that sets the respective hardware register, TXSTA4, to the value in the **Declare**. See the device's data sheet for more information regarding this register. The TXSTA4 register's BRGH bit controls the high speed mode for the Baud rate generator. Certain Baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial4_TXSTA** to a value of $24 instead of the default $20.

Declare Hserial4_Parity Odd or Even
Enables/Disables parity on the serial port. For **Hrsout4**, **Hrsin4**, **Hserout4** and **Hserin4**. The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial4_Parity** declare.

```
Declare Hserial4_Parity = Even    ' Use if even parity desired
Declare Hserial4_Parity = Odd     ' Use if odd parity desired
```

Declare Hserial4_Clear On or Off
Clear the overflow error bit before commencing a read.

Because the hardware serial port only has a 2-byte input buffer, it can easily overflow if bytes are not read from it often enough. When this occurs, the USART stops accepting any new characters, and requires resetting. This overflow error can be reset by strobing the CREN bit within the RCSTA4 register. Example: -

```
RCSTA4bits_CREN = 0
RCSTA4bits_CREN = 1
```
or
```
Clear RCSTA4bits_CREN
Set RCSTA4bits_CREN
```

Alternatively, the **Hserial4_Clear** declare can be used to automatically clear this error, even if no error occurred. However, the program will not know if an error occurred while reading, therefore some characters may be lost.

```
Declare Hserial4_Clear = On
```

Hpwm Declares.

Some devices have alternate pins that may be used for **Hpwm**. The following **Declares** allow the use of different pins: -

```
Declare CCP1_Pin Port.Pin ' Select Hpwm port and bit for CCP1 module (ch 1)
Declare CCP2_Pin Port.Pin ' Select Hpwm port and bit for CCP2 module (ch 2)
Declare CCP3_Pin Port.Pin ' Select Hpwm port and bit for CCP3 module (ch 3)
Declare CCP4_Pin Port.Pin ' Select Hpwm port and bit for CCP4 module (ch 4)
Declare CCP5_Pin Port.Pin ' Select Hpwm port and bit for CCP5 module (ch 5)
Declare CCP6_Pin Port.Pin ' Select Hpwm port and bit for CCP6 module (ch 6)
```

Or

```
Declare HPWM1_Pin Port.Pin ' Select Hpwm port and bit for PWM1 module (ch 1)
Declare HPWM2_Pin Port.Pin ' Select Hpwm port and bit for PWM 2 module (ch 2)
Declare HPWM3_Pin Port.Pin ' Select Hpwm port and bit for PWM 3 module (ch 3)
Declare HPWM4_Pin Port.Pin ' Select Hpwm port and bit for PWM 4 module (ch 4)
Declare HPWM5_Pin Port.Pin ' Select Hpwm port and bit for PWM 5 module (ch 5)
Declare HPWM6_Pin Port.Pin ' Select Hpwm port and bit for PWM 6 module (ch 6)
```

Both texts after the declare; HPWMx_Pin or CCPx_Pin are valid for all devices that contain, either CCP peripherals or PWM peripherals.

For devices that have PPS (Peripheral Pin Select), the compiler will manipulate the appropriate SFRs before the program starts, so that the PWM signal is produced correctly.

Alphanumeric (Hitachi HD44780) LCD Print Declares.
Declare LCD_DTPin Port **.** Pin
Assigns the Port and Pins that the LCD's DT lines will attach to.

The LCD may be connected to the microcontroller using either a 4-bit bus or an 8-bit bus. If an 8-bit bus is used, all 8 bits must be on one port. If a 4-bit bus is used, it must be connected to either the bottom 4 or top 4 bits of one port. For example: -

```
Declare LCD_DTPin PORTB.4    ' Used for 4-line interface.
Declare LCD_DTPin PORTB.0    ' Used for 8-line interface.
```

In the above examples, PORTB is only a personal preference. The LCD's DT lines can be attached to any valid port on the microcontroller. If the **Declare** is not used in the program, then the default Port and Pin is PORTB.4, which assumes a 4-line interface.

Declare LCD_DataX_Pin Port . Pin
Assigns the individual Ports and Pins that the HD4470 LCD's DT lines will attach to.

Unlike the above **LCD_DTPin** declares, the LCD's data pins can also be attached to any seperate port and pin. For example:-

```
Declare LCD_Data0_Pin PORTA.0  ' Connect PORTA.0 to the LCD's D0 line
Declare LCD_Data1_Pin PORTA.2  ' Connect PORTA.2 to the LCD's D1 line
Declare LCD_Data2_Pin PORTA.4  ' Connect PORTA.4 to the LCD's D2 line
Declare LCD_Data3_Pin PORTB.0  ' Connect PORTB.0 to the LCD's D3 line
Declare LCD_Data4_Pin PORTB.1  ' Connect PORTB.1 to the LCD's D4 line
Declare LCD_Data5_Pin PORTB.5  ' Connect PORTB.5 to the LCD's D5 line
Declare LCD_Data6_Pin PORTC.0  ' Connect PORTC.0 to the LCD's D6 line
Declare LCD_Data7_Pin PORTC.1  ' Connect PORTC.1 to the LCD's D7 line
```

There are no default settings for these **Declares** and they must be used within the BASIC program if required.

Declare LCD_ENPin Port **.** Pin
Assigns the Port and Pin that the LCD's EN line will attach to. This also assigns the graphic LCD's EN pin, however, the default value remains the same as for the alphanumeric type, so this will require changing.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.2.

Declare LCD_RSPin Port **.** Pin
Assigns the Port and Pins that the LCD's RS line will attach to. This also assigns the graphic LCD's RS pin, however, the default value remains the same as for the alphanumeric type, so this will require changing.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.3.

Declare LCD_Interface 4 or 8
Inform the compiler as to whether a 4-line or 8-line interface is required by the LCD.

If the **Declare** is not used in the program, then the default interface is a 4-line type.

Declare LCD_Lines 1, 2, or 4
Inform the compiler as to how many lines the LCD has.

LCD's come in a range of sizes, the most popular being the 2 line by 16 character types. However, there are 4-line types as well. Simply place the number of lines that the particular LCD has into the declare.

If the **Declare** is not used in the program, then the default number of lines is 2.

Declare LCD_CommandUS 1 to 65535
Time to wait (in microseconds) between commands sent to the LCD.

If the **Declare** is not used in the program, then the default delay is 2000us (2ms).

Declare LCD_DataUs 1 to 255
Time to wait (in microseconds) between data sent to the LCD.

If the **Declare** is not used in the program, then the default delay is 50us.

Graphic LCD Declares.

Declare LCD_Type 0 or 1 or 2, **Alpha** or **Graphic** or **KS0108** or **Toshiba** or **T6963**

Inform the compiler as to the type of LCD that the **Print** command will output to. If **Graphic, KS0108** or 1 is chosen then any output by the **Print** command will be directed to a graphic LCD based on the KS0108 chipset. A value of 2, or the text **Toshiba**, or **T6963** will direct the output to a graphic LCD based on the Toshiba T6963 chipset. A value of 0 or **Alpha**, or if the **Declare** is not issued, will target the standard Hitachi HD44780 alphanumeric LCD type

Targeting the graphic LCD will also enable commands such as **Plot**, **UnPlot**, **LCDread**, **LCDwrite**, **Pixel**, **Box**, **Circle** and **Line**.

KS0108 Graphic LCD specific Declares.

Declare LCD_DTPort Port

Assign the port that will output the 8-bit data to the graphic LCD.

If the **Declare** is not used, then the default port is PORTB.

Declare LCD_RWPin Port **.** Pin

Assigns the Port and Pin that the graphic LCD's RW line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTC.0.

Declare LCD_CS1Pin Port **.** Pin

Assigns the Port and Pin that the graphic LCD's CS1 line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTC.0.

Declare LCD_CS2Pin Port **.** Pin

Assigns the Port and Pin that the graphic LCD's CS2 line will attach to.

If the Declare is not used in the program, then the default Port and Pin is PORTC.0.

Declare Internal_Font On - Off, 1 or 0

The graphic LCD's that are compatible with Proton are non-intelligent types, therefore, a separate character set is required. This may be in one of two places, either externally, in an I^2C eeprom, or internally in a **Cdata** table.

If an external font is chosen, the I^2C eeprom must be connected to the specified SDA and SCL pins (as dictated by **Declare SDA_Pin** and **Declare SCL_Pin**).

If an internal font is chosen, it must be on a PICmicro™ device that has self modifying code features, such as the 16F87X, or 18F range.

The **Cdata** table that contains the font must have a label, named Font_Table: preceding it. For example: -

```
Font_Table:     Cdata $7E, $11, $11, $11, $7E, $0,_   ' Chr "A"
                      $7F, $49, $49, $49, $36, $0     ' Chr "B"
                { rest of font table }
```

The font table may be anywhere in memory, however, it is best placed after the main program code.

If the **Declare** is omitted from the program, then an external font is the default setting.

Declare Font_Addr 0 to 7
Set the slave address for the I^{2}C eeprom that contains the font.

When an external source for the font is chosen, it may be on any one of 8 eeproms attached to the I^{2}C bus. So as not to interfere with any other eeproms attached, the slave address of the eeprom carrying the font code may be chosen.

If the **Declare** is omitted from the program, then address 0 is the default slave address of the font eeprom.

Declare GLCD_CS_Invert On - Off, 1 or 0
Some graphic LCD types have inverters on their CS lines. Which means that the LCD displays left hand data on the right side, and vice-versa. The **GLCD_CS_Invert Declare**, adjusts the library LCD handling library subroutines to take this into account.

Declare GLCD_Strobe_Delay 0 to 65535 us (microseconds).
Create a delay of n microseconds between strobing the EN line of the graphic LCD. This can help noisy, or badly decoupled circuits overcome random bits appearing on the LCD. The default if the **Declare** is not used in the BASIC program is a delay of 0.

Toshiba T6963 Graphic LCD specific Declares.
Declare LCD_DTPort Port
Assign the port that will output the 8-bit data to the graphic LCD.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_WRPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's WR line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_RDPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's RD line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_CEPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's CE line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_CDPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's CD line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_RSTPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's RST line will attach to.

The LCD's RST (Reset) **Declare** is optional and if omitted from the BASIC code the compiler will not manipulate it. However, if not used as part of the interface, you must set the LCD's RST pin high for normal operation.

Declare LCD_X_Res 0 to 255
LCD displays using the T6963 chipset come in varied screen sizes (resolutions). The compiler must know how many horizontal pixels the display consists of before it can build its library sub-routines.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_Y_Res 0 to 255
LCD displays using the T6963 chipset come in varied screen sizes (resolutions). The compiler must know how many vertical pixels the display consists of before it can build its library subrou-tines.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_Font_Width 6 or 8
The Toshiba T6963 graphic LCDs have two internal font sizes, 6 pixels wide by eight high, or 8 pixels wide by 8 high. The particular font size is chosen by the LCD's FS pin. Leaving the FS pin floating or bringing it high will choose the 6 pixel font, while pulling the FS pin low will choose the 8 pixel font. The compiler must know what size font is required so that it can calcu-late screen and RAM boundaries.

Note that the compiler does not control the FS pin and it is down to the circuit layout whether or not it is pulled high or low. There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_RAM_Size 1024 to 65535
Toshiba graphic LCDs contain internal RAM used for Text, Graphic or Character Generation. The amount of RAM is usually dictated by the display's resolution. The larger the display, the more RAM is normally present. Standard displays with a resolution of 128x64 typically contain 4096 bytes of RAM, while larger types such as 240x64 or 190x128 typically contain 8192 bytes or RAM. The display's datasheet will inform you of the amount of RAM present.

If this **Declare** is not issued within the BASIC program, the default setting is 8192 bytes.

Declare LCD_Text_Pages 1 to n
As mentioned above, Toshiba graphic LCDs contain RAM that is set aside for text, graphics or characters generation. In normal use, only one page of text is all that is required, however, the compiler can re-arrange its library subroutines to allow several pages of text that is continuous. The amount of pages obtainable is directly proportional to the RAM available within the LCD itself. Larger displays require more RAM per page, therefore always limit the amount of pages to only the amount actually required or unexpected results may be observed as text, graphic and character generator RAM areas merge.

This **Declare** is purely optional and is usually not required. The default is 3 text pages if this **Declare** is not issued within the BASIC program.

Declare LCD_Graphic_Pages 1 to n
Just as with text, the Toshiba graphic LCDs contain RAM that is set aside for graphics. In normal use, only one page of graphics is all that is required, however, the compiler can re-arrange its library subroutines to allow several pages of graphics that is continuous. The amount of pages obtainable is directly proportional to the RAM available within the LCD itself. Larger displays require more RAM per page, therefore always limit the amount of pages to only the amount actually required or unexpected results may be observed as text, graphic and character generator RAM areas merge.

This **Declare** is purely optional and is usually not required. The default is 1 graphics page if this **Declare** is not issued within the BASIC program.

Declare LCD_Text_Home_Address 0 to n
The RAM within a Toshiba graphic LCD is split into three distinct uses, text, graphics and character generation. Each area of RAM must not overlap or corruption will appear on the display as one uses the other's assigned space. The compiler's library subroutines calculate each area of RAM based upon where the text RAM starts. Normally the text RAM starts at address 0, however, there may be occasions when it needs to be set a little higher in RAM. The order of RAM is; Text, Graphic, then Character Generation.

This **Declare** is purely optional and is usually not required. The default is the text RAM staring at address 0 if this **Declare** is not issued within the BASIC program.

Keypad Declare.
Declare Keypad_Port Port
Assigns the Port that the keypad is attached to.

The keypad routine requires pull-up resistors, therefore, the best Port for this device is PORTB which, sometimes, comes equipped with internal pull-ups. If the **Declare** is not used in the program, then PORTB is the default Port.

Rsin - Rsout Declares.

Declare Rsout_Pin Port **.** Pin
Assigns the Port and Pin that will be used to output serial data from the **Rsout** command. This may be any valid port on the microcontroller.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.0.

Declare Rsin_Pin Port **.** Pin
Assigns the Port and Pin that will be used to input serial data by the **Rsin** command. This may be any valid port on the microcontroller.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.1.

Declare Rsout_Mode True or Inverted or 1, 0
Sets the serial mode for the data transmitted by **Rsout**. This may be inverted or true. Alternatively, a value of 1 may be substituted to represent inverted, and 0 for true.

If the **Declare** is not used in the program, then the default mode is inverted.

Declare Rsin_Mode True or Inverted or 1, 0
Sets the serial mode for the data received by **Rsin**. This may be inverted or true. Alternatively, a value of 1 may be substituted to represent inverted, and 0 for true.

If the **Declare** is not used in the program, then the default mode is inverted.

Declare Serial_Baud 0 to 65535 bps (baud)
Informs the **Rsin** and **Rsout** routines as to what Baud rate to receive and transmit data.

Virtually any baud rate may be transmitted and received (within reason), but there are standard bauds, namely: -

300, 600, 1200, 2400, 4800, 9600, and 19200.

When using a 4MHz crystal, the highest baud rate that is reliably achievable is 9600. However, an increase in the oscillator speed allows higher baud rates to be achieved, including 38400 baud.

If the **Declare** is not used in the program, then the default baud is 9600.

Declare Rsout_Pace 0 to 65535 microseconds (us)
Implements a delay between characters transmitted by the **Rsout** command.

On occasion, the characters transmitted serially are in a stream that is too fast for the receiver to catch, this results in missed characters. To alleviate this, a delay may be implemented between each individual character transmitted by **Rsout**.

If the **Declare** is not used in the program, then the default is no delay between characters.

Declare Rsin_Timeout 0 to 65535 milliseconds (ms)
Sets the time, in ms, that **Rsin** will wait for a start bit to occur.

Rsin waits in a tight loop for the presence of a start bit. If no timeout parameter is issued, then it will wait forever.

The Rsin command has the option of jumping out of the loop if no start bit is detected within the time allocated by timeout.

If the **Declare** is not used in the program, then the default timeout value is 10000ms which is 10 seconds.

Serin - Serout Declare.

If communications are with existing software or hardware, its speed and mode will determine the choice of baud rate and mode. In general, 7-bit/even-parity (7E) mode is used for text, and 8-bit/no-parity (8N) for byte-oriented data. Note: the most common mode is 8-bit/no-parity, even when the data transmitted is just text. Most devices that use a 7-bit data mode do so in order to take advantage of the parity feature. Parity can detect some communication errors, but to use it you lose one data bit. This means that incoming data bytes transferred in 7E (even-parity) mode can only represent values from 0 to 127, rather than the 0 to 255 of 8N (no-parity) mode.

The compiler's serial commands **Serin** and **Serout** have the option of still using a parity bit with 4 to 8 data bits. This is through the use of a **Declare**: -

With parity disabled (the default setting): -

```
Declare Serial_Data 4 ' Set Serin and Serout data bits to 4
Declare Serial_Data 5 ' Set Serin and Serout data bits to 5
Declare Serial_Data 6 ' Set Serin and Serout data bits to 6
Declare Serial_Data 7 ' Set Serin and Serout data bits to 7
Declare Serial_Data 8 ' Set Serin and Serout data bits to 8 (default)
```

With parity enabled: -

```
Declare Serial_Data 5 ' Set Serin and Serout data bits to 4
Declare Serial_Data 6 ' Set Serin and Serout data bits to 5
Declare Serial_Data 7 ' Set Serin and Serout data bits to 6
Declare Serial_Data 8 ' Set Serin and Serout data bits to 7 (default)
Declare Serial_Data 9 ' Set Serin and Serout data bits to 8
```

Serial_Data data bits may range from 4 bits to 8 (the default if no **Declare** is issued). Enabling parity uses one of the number of bits specified.

Declaring **Serial_Data** as 9 allows 8 bits to be read and written along with a 9th parity bit.

Parity is a simple error-checking feature. When a serial sender is set for even parity (the mode the compiler supports) it counts the number of 1s in an outgoing byte and uses the parity bit to make that number even. For example, if it is sending the 7-bit value: %0011010, it sets the parity bit to 1 in order to make an even number of 1s (four).

The receiver also counts the data bits to calculate what the parity bit should be. If it matches the parity bit received, the serial receiver assumes that the data was received correctly. Of course, this is not necessarily true, since two incorrectly received bits could make parity seem correct when the data was wrong, or the parity bit itself could be bad when the rest of the data was correct.

Many systems that work exclusively with text use 7-bit/ even-parity mode. For example, to receive one data byte through bit-0 of PORTA at 9600 baud, 7E, inverted:

Shin - Shout Declare.
Declare Shift_DelayUs 0 - 65535 microseconds (us)
Extend the active state of the shift clock.

The clock used by **Shin** and **Shout** runs at approximately 45KHz dependent on the oscillator. The active state is held for a minimum of 2 microseconds. By placing this declare in the program, the active state of the clock is extended by an additional number of microseconds up to 65535 (65.535 milliseconds) to slow down the clock rate.

If the **Declare** is not used in the program, then the default is a very small clock delay.

DelayCs

Syntax
DelayCs Length

Overview
Delay execution for an amount of instruction cycles.

Parameters
Length can only be a constant with a value from 1 to 1000.

Example
```
DelayCs 100              ' Delay for 100 cycles
```

Notes
DelayCs is oscillator independent, as long as you inform the compiler of the crystal frequency to use, using the **Declare** directive.

The length of a given instruction cycle is determined by the oscillator frequency. For example, running the microcontroller at it's default speed of 64MHz will result in an instruction cycle of 62.5ns (nano seconds).

Because of code memory paging overheads, **DelayCs** is only available when using enhanced 14-bit core or 18F devices.

See also : **DelayUs**, **DelayMs**, **Sleep**, **Snooze**.

DelayMs

Syntax
DelayMs *Length*

Overview
Delay execution for *length* x milliseconds (ms). Delays may be up to 65535ms (65.535 seconds) long.

Parameters
Length can be a constant, variable, or expression.

Example
```
Device = 18F25K20
Declare Xtal = 16

Dim MyByte as Byte = 50
Dim MyWord as Word = 1000

DelayMs 100              ' Delay for 100ms
DelayMs MyByte           ' Delay for 50ms
DelayMs MyWord           ' Delay for 1000ms
DelayMs MyWord + 10      ' Delay for 1010ms
```

Notes
DelayMs is oscillator independent, as long as you inform the compiler of the crystal frequency to use, using the Declare directive.

See also :   DelayUs, Sleep, Snooze.

DelayUs

Syntax
DelayUs *Length*

Overview
Delay execution for *length* x microseconds (us). Delays may be up to 65535us (65.535 milli-seconds) long.

Parameters
Length can be a constant, variable, or expression.

Example
```
Device = 18F25K20
Declare Xtal = 16

Dim MyByte as Byte = 50
Dim MyWord as Word = 1000

DelayUs 1                ' Delay for 1us
DelayUs 100              ' Delay for 100us
DelayUs MyByte           ' Delay for 50us
DelayUs MyWord           ' Delay for 1000us
DelayUs MyWord + 10      ' Delay for 1010us
```

Notes
DelayUs is oscillator independent, as long as you inform the compiler of the crystal frequency to use, using the **Xtal** directive.

If a constant is used as *length*, then delays down to 1us can be achieved, however, if a variable is used as *length*, then there's a minimum delay time depending on the frequency of the crystal used: -

Crystal Freq	Minimum Delay
4MHz	24us
8MHz	12us
10MHz	8us
16MHz	5us
20MHz	2us
24MHz	2us
25MHz	2us
32MHz	2us
33MHz	2us
40MHz	2us
48MHz	2us
64MHz	2us

See also : **Declare, DelayMs, DelayCs, Sleep, Snooze**

Device

Syntax
Device *Device number*

Overview
Inform the compiler which microcontroller is being used.

Parameters
Device number can be a 12-bit, 14-bit, enhanced 14-bit or 18F device. If a PIC24 or dsPIC device is chosen, the compiler will automatically use the Proton24.

Example

```
Device = 16F1829      ' Produce code for a 16F1829 device
```

 or

```
Device = 16F684       ' Produce code for a 16F684 device
```

or

```
Device = 12F508       ' Produce code for a 12-bit core 12F508 device
```

or

```
Device = 18F4520      ' Produce code for a 18F4520 device
```

Device should be the first command placed in the program.

If the **Device** directive is not used in the BASIC program, the code produced will default to the **PIC18F25K20** device.

For an up-to-date list of compatible devices refer to the compiler's PPI directory.

Dig

Syntax
Variable **= Dig** *Value, Digit number*

Overview
Returns the value of a decimal digit.

Parameters
Value is an unsigned constant, 8-bit, 16-bit, 32-bit variable or expression, from which the *digit number* is to be extracted.
Digit number is a constant, variable, or expression, that represents the digit to extract from *value*. (0 - 4 with 0 being the rightmost digit).

Example
```
Device = 18F25K20
Declare Xtal = 16

Dim MyValue as Byte
Dim MyDigit as Byte

MyValue = 124
MyDigit = Dig MyValue, 1  ' Extract the second digit's value
HrsoutLn Dec MyDigit      ' Transmit the value, which is 2
```

Dim

Syntax
Dim *Variable* **as** *Size*

or

Dim Label **as Code** = *comma delimited data*

Overview
Declare a variable or alias or code memory table.

Parameters
Variable can be any alphanumeric character or string.
Size is the physical size of the variable, it may be **Bit**, **Byte**, **Word**, **Dword**, **SByte**, **SWord**, **SDword**, **Float**, or **String**.
Label is a valid label name that will be associated with a code memory table.

Example
```
' Declare different sized variables
  Dim Var1 as Byte            ' Create an unsigned 8-bit Byte variable
  Dim Wrd1 as Word            ' Create an unsigned 16-bit Word variable
  Dim Dwrd1 as Dword          ' Create an unsigned 32-bit Dword variable

  Dim sVar1 as SByte          ' Create a signed 8-bit SByte variable
  Dim sWrd1 as SWord          ' Create a signed 16-bit SWord variable
  Dim sDwrd1 as SDword        ' Create a signed 32-bit SDword variable

  Dim BitVar as Bit           ' Create a 1-bit Bit variable
  Dim MyFloat as Float        ' Create a 32-bit floating point variable
  Dim StrnG as String*20      ' Create a 20 character string variable
  Dim MyCode as Code = 1,2,3,4,5,6,7 ' Place 7 bytes in code memory
```

Notes
Any variable that is declared without the '**as**' text after it, will assume an 8-bit **Byte** type.

Dim should be placed near the beginning of the program. Any references to variables not declared or before they are declared may, in some cases, produce errors.

Variable names, as in the case or labels, may freely mix numeric content and underscores.

```
  Dim MyVar as Byte
```
or
```
  Dim MY_Var as Word
```
or
```
  Dim My_Var2 as Bit
```

Variable names may start with an underscore, but must not start with a number. They can be no more than 32 characters long. Any characters after this limit will cause a syntax error.

```
  Dim 2MyVar
```
   is **not** allowed.

Variable names are not case sensitive, which means that the variable: -

```
Dim MYVar
```

Is the same as…

```
Dim MYVar
```

Dim can also be used to create Alias's to other variables: -

```
Dim MyByte as Byte          ' Create a Byte sized variable
Dim Var_Bit as MyByte.1     ' Var_Bit now represents Bit-1 of MyByte
```

Alias's, as in the case of constants, do not require any RAM space, because they point to a variable, or part of a variable that has already been declared.

RAM space required.

Each type of variable requires differing amounts of RAM memory for its allocation. The list below illustrates this.

- **String**   Requires the specified length of characters + 1.
- **Float**   Requires 4 bytes of RAM.
- **Dword**   Requires 4 bytes of RAM.
- **SDword**   Requires 4 bytes of RAM.
- **Word**   Requires 2 bytes of RAM.
- **SWord**   Requires 2 bytes of RAM.
- **Byte**   Requires 1 byte of RAM.
- **SByte**   Requires 1 byte of RAM.
- **Bit**   Requires 1 byte of RAM for every 8 Bit variables used.

Each type of variable may hold a different minimum and maximum value.

- **String** type variables are only useable with 18F and enhanced 14-bit core devices, and can hold a maximum of 255 characters.

- **Bit** type variables may hold a 0 or a 1. These are created 8 at a time, therefore declaring a single **Bit** type variable in a program will not save RAM space, but it will save code space, as **Bit** type variables produce the most efficient use of code for comparisons etc.

- **Byte** type variables may hold an unsigned value from 0 to 255, and are the usual work horses of most programs. Code produced for **Byte** sized variables is very low compared to signed or unsigned **Word**, **DWord** or **Float** types, and should be chosen if the program requires faster, or more efficient operation.

- **SByte** type variables may hold a $2^{'s}$ complemented signed value from -128 to +127. Code produced for **SByte** sized variables is very low compared to **SWord**, **Float**, or **SDword** types, and should be chosen if the program requires faster, or more efficient operation. However, code produced is usually larger for signed variables than unsigned types.

- **Word** type variables may hold an unsigned value from 0 to 65535, which is usually large enough for most applications. It still uses more memory than an 8-bit byte variable, but not nearly as much as a **Dword** or **SDword** type.

- **SWord** type variables may hold a $2^{\text{'s}}$ complemented signed value from -32768 to +32767, which is usually large enough for most applications. **SWord** type variables will use more code space for expressions and comparisons, therefore, only use signed variables when required.

- **Dword** type variables may hold an unsigned value from 0 to 4294967295 making this the largest of the variable family types. This comes at a price however, as **Dword** calculations and comparisons will use more code space within the microcontroller Use this type of variable sparingly, and only when necessary.

- **SDword** type variables may hold a $2^{\text{'s}}$ complemented signed value from -2147483648 to +2147483647, also making this the largest of the variable family types. This comes at a price however, as **SDword** expressions and comparisons will use more code space than a regular **Dword** type. Use this type of variable sparingly, and only when necessary.

- **Float** type variables may theoretically hold a value from -1e37 to +1e38, but because of the 32-bit architecture of the compiler, a maximum and minimum value should be thought of as -2147483646.999 to +2147483646.999 making this the most varsatile of the variable family types. However, more so than **Dword** types, this comes at a price as floating point expressions and comparisons will use more code space within the microcontroller. Use this type of variable sparingly, and only when strictly necessary. Smaller floating point values usually offer more accuracy.

There are modifiers that may also be used with variables. These are **HighByte**, **LowByte**, **Byte0**, **Byte1**, **Byte2**, **Byte3**, **Word0**, **Word1**, **SHighByte**, **SLowByte**, **SByte0**, **SByte1**, **SByte2**, **SByte3**, **SWord0**, and **SWord1**,

Word0, **Word1**, **Byte2**, **Byte3**, **SWord0**, **SWord1**, **SByte2**, and **SByte3** may only be used in conjunction with 32-bit **Dword** or **SDword** type variables.

HighByte and **Byte1** are one and the same thing, when used with a **Word** or **SWord** type variable, they refer to the unsigned High byte of a **Word** or **SWord** type variable: -

```
  Dim Wrd as Word          ' Create an unsigned Word variable
  Dim Wrd_Hi as Wrd.HighByte
' Wrd_Hi now represents the unsigned high byte of variable Wrd
```

Variable Wrd_Hi is now accessed as a **Byte** sized type, but any reference to it actually alters the high byte of Wrd.

SHighByte and **SByte1** are one and the same thing, when used with a **Word** or **SWord** type variable, they refer to the signed High byte of a **Word** or **SWord** type variable: -

```
  Dim Wrd as SWord         ' Create a signed Word variable
  Dim Wrd_Hi as Wrd.SHighByte
' Wrd_Hi now represents the signed high byte of variable Wrd
```

Variable Wrd_Hi is now accessed as an **SByte** sized type, but any reference to it actually alters the high byte of Wrd.

However, if **Byte1** is used in conjunction with a **Dword** type variable, it will extract the second byte. **HighByte** will still extract the high byte of the variable, as will **Byte3**. If **SByte1** is used in conjunction with an **SDword** type variable, it will extract the signed second byte. **SHighByte** will still extract the signed high byte of the variable, as will **SByte3**.

The same is true of **LowByte**, **Byte0**, **SLowByte** and **SByte0**, but they refer to the unsigned or signed Low Byte of a **Word** or **SWord** type variable: -

```
  Dim Wrd as Word          ' Create an unsigned Word variable
  Dim Wrd_Lo as Wrd.LowByte
' Wrd_Lo now represents the low byte of variable Wrd
```

Variable Wrd_Lo is now accessed as a **Byte** sized type, but any reference to it actually alters the low byte of Wrd.

The modifier **Byte2** will extract the 3rd unsigned byte from a 32-bit **Dword** or **SDword** type variable as an alias. Likewise **Byte3** will extract the unsigned high byte of a 32-bit variable.

```
  Dim Dwd as Dword        ' Create a 32-bit unsigned variable named Dwd
  Dim Part1 as Dwd.Byte0  ' Alias unsigned Part1 to the low byte of Dwd
  Dim Part2 as Dwd.Byte1  ' Alias unsigned Part2 to the 2nd byte of Dwd
  Dim Part3 as Dwd.Byte2  ' Alias unsigned Part3 to the 3rd byte of Dwd
  Dim Part4 as Dwd.Byte3  ' Alias unsigned Part3 to the high (4th) byte of Dwd
```

The modifier **SByte2** will extract the 3rd signed byte from a 32-bit **Dword** or **SDword** type variable as an alias. Likewise **SByte3** will extract the signed high byte of a 32-bit variable.

```
  Dim sDwd as SDword         ' Create a 32-bit signed variable named sDwd
  Dim sPart1 as sDwd.SByte0  ' Alias signed Part1 to the low byte of sDwd
  Dim sPart2 as sDwd.SByte1  ' Alias signed Part2 to the 2nd byte of sDwd
  Dim sPart3 as sDwd.SByte2  ' Alias signed Part3 to the 3rd byte of sDwd
  Dim sPart4 as sDwd.SByte3  ' Alias signed Part3 to the 4th byte of sDwd
```

The **Word0** and **Word1** modifiers extract the unsigned low word and high word of a **Dword** or **SDword** type variable, and is used the same as the **Byte**n modifiers.

```
  Dim Dwd as Dword        ' Create a 32-bit unsigned variable named Dwd
  Dim Part1 as Dwd.Word0  ' Alias unsigned Part1 to the low word of Dwd
  Dim Part2 as Dwd.Word1  ' Alias unsigned Part2 to the high word of Dwd
```

The **SWord0** and **SWord1** modifiers extract the signed low word and high word of a **Dword** or **SDword** type variable, and is used the same as the **SByte**n modifiers.

```
  Dim sDwd as SDword       ' Create a 32-bit signed variable named sDwd
  Dim sPart1 as sDwd.SWord0  ' Alias Part1 to the low word of sDwd
  Dim sPart2 as sDwd.SWord1  ' Alias Part2 to the high word of sDwd
```

RAM space for variables is allocated within the microcontroller in the order that they are placed in the BASIC code. For example: -

```
Dim Var1 as Byte
Dim Var2 as Byte
```

Places Var1 first, then Var2: -

```
Var1 equ n
Var2 equ n
```

This means that on a device with more than one RAM Bank, the first *n* variables will always be in Bank0 (the value of *n* depends on the specific PICmicro™ used).

The position of the variable within Banks is usually of little importance if BASIC code is used, however, if assembler routines are being implemented, always assign any variables used within them first.

Problems may also arise if a **Word**, **Dword** or **Float** variable crosses a RAM bank boundary. If this happens, a warning message will be displayed in the error window. Most of the time, this will not cause any problems, however, to err on the side of caution, try and ensure that **Word**, **Dword** or **Float** type variables are fully inside a Bank. This is easily accomplished by placing a dummy **Byte** variable before the offending **Word**, **Dword** or **Float** type variable, or relocating the offending variable within the list of **Dim** statements.

See Also :   **Aliases, Declaring Arrays, Floating Point Math, Symbol, Creating and using Strings .**

Disable

Disable software interrupt processing that was previously Enabled following this instruction.

Disable and **Enable**, and **Resume** are not actually commands in the truest sense of the word, but flags that the compiler uses internally. They do not produce any code.

```
    Device = 16F877
    Declare Xtal = 4

    Symbol LED = PORTD.0

    OPTION_REG = %00000111
    INTCON = %00100000

'
' Enable software interrupts, and point to interrupt handler
'
    On Interrupt Goto My_Software_Int

    Stop

    Disable               ' Disable interrupts in the handler
My_Software_Int:
    Toggle LED            ' Toggle an LED when interrupted
    Resume                ' Return to main program
    Enable                ' Enable interrupts after the handler
```

Note.
Software interrupts are a remnant from earlier compiler versions and are not recommended for new applications. See **Managed Hardware Interrupts** for a better method of interrupt handling.

See also :   Software Interrupts in BASIC, Enable, Resume.

Do...Loop

Syntax
Do
 Instructions
Loop

or

Do
  Instructions
Loop Until *Condition*

or

Do
  Instructions
Loop While *Condition*

Overview
Execute a block of instructions until a condition is true, or while a condition is false, or create an infinite loop.

Example 1
```
Device = 18F25K22
Declare Xtal = 4

Dim MyWord as Word
MyWord = 1
Do                           ' Create a loop
  HrsoutLn Dec MyWord
  DelayMs 200
  Inc MyWord
Loop Until MyWord > 10       ' Loop until MyWord is greater than 10
```

Example 2
```
Device = 18F25K22
Declare Xtal = 4

Dim MyWord as Word
MyWord = 1
Do                           ' Create a loop
  HrsoutLn Dec MyWord
  DelayMs 200
  Inc MyWord
Loop While MyWord < 11       ' Loop while MyWord is less than 11
```

Example 3
```
Device = 18F25K22
Declare Xtal = 4

Dim MyWord as Word
MyWord = 1
Do                              ' Create a loop
   HrsoutLn Dec MyWord
   DelayMs 200
   Inc MyWord
Loop                            ' Loop forever
```

Notes.
Do-Loop differs from the **While-Wend** type in that, the **Do** loop will carry out the instructions within the loop at least once like a **Repeat-Until** type, then continuously until the condition is true, but the **While** loop only carries out the instructions if the condition is true.

Do-Loop is an ideal replacement to a **For-Next** loop, and can actually take less code space, thus performing the loop faster.

The above example 2 and example 3 show the equivalent to the **For-Next** loop: -

```
For MyWord = 1 to 10 : Next
```

See also :   While...Wend, For...Next...Step.

DTMFout

Syntax
DTMFout *Pin*, { *OnTime* }, { *OffTime*, } **[** *Tone* {, *Tone…*} **]**

Overview
Produce a DTMF Touch Tone sequence on *Pin.*

Parameters
Pin is a Port.Bit constant that specifies the I/O pin to use. This pin will be set to output during generation of tones and set to input after the command is finished.
OnTime is an optional variable, constant, or expression (0 - 65535) specifying the duration, in ms, of the tone. If the *OnTime* parameter is not used, then the default time is 200ms
OffTime is an optional variable, constant, or expression (0 - 65535) specifying the length of silent delay, in ms, after a tone (or between tones, if multiple tones are specified). If the *OffTime* parameter is not used, then the default time is 50ms
Tone may be a variable, constant, or expression (0 - 15) specifying the DTMF tone to generate. Tones 0 through 11 correspond to the standard layout of the telephone keypad, while 12 through 15 are the fourth-column tones used by phone test equipment and in some radio applications.

Example
```
DTMFout PORTA.0, [ 7, 5, 7, 9, 4, 0 ]    ' Call a number.
```

If the PICmicro™ was connected to the phone line correctly, the above command would dial 666-709. If you wanted to slow down the dialling in order to break through a noisy phone line or radio link, you could use the optional *OnTime* and *OffTime* values: -

```
'Set the OnTime to 500ms and OffTime to 100ms
DTMFout PORTA.0, 500, 100, [5, 4, 5, 9, 2, 0] ' Call Slowly.
```

Notes DTMF tones are used to dial a telephone, or remotely control pieces of radio equipment. The PICmicro™ can generate these tones digitally using the **DTMFout** command. However, to achieve the best quality tones, a higher crystal frequency is required. A 4MHz type will work but the quality of the sound produced will suffer. The circuits illustrate how to connect a speaker or audio amplifier to hear the tones produced.

The PICmicro™ is a digital device, however, DTMF tones are analogue waveforms, consisting of a mixture of two sine waves at different audio frequencies. So how can a digital device generate an analogue output? The PICmicro™ creates and mixes two sine waves mathematically, then uses the resulting stream of numbers to control the duty cycle of an extremely fast pulse-width modulation (Pwm) routine. Therefore, what's actually being produced from the I/O pin is a rapid stream of pulses. The purpose of the filtering arrangements illustrated above is to smooth out the high-frequency Pwm, leaving behind only the lower frequency audio. You should keep this in mind if you wish to interface the PICmicro's DTMF output to radios and other equipment that could be adversely affected by the presence of high-frequency noise on the input. Make sure to filter the DTMF output scrupulously. The circuits above are only a foundation; you may want to use an active low-pass filter with a cut-off frequency of approximately 2KHz.

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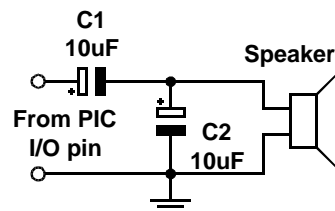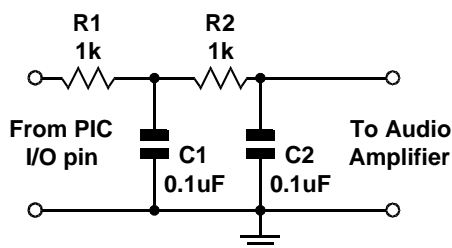
Edata

Syntax
Edata *Constant1 { ,...Constantn etc }*

Overview
Places constants or strings directly into the on-board eeprom memory of compatible PICmicro's

Parameters
Constant1,Constantn are values that will be stored in the on-board eeprom. When using an **Edata** statement, all the values specified will be placed in the eeprom starting at location 0. The **Edata** statement does not allow you to specify an eeprom address other than the beginning location at 0. To specify a location to write or read data from the eeprom other than 0 refer to the **Eread**, **Ewrite** commands.

Example
```
' Stores the values 1000,20,255,15, and the ASCII values for
' H','e','l','l','o' in the eeprom starting at memory position 0.

  Edata 1000, 20, $FF, %00001111, "Hello"
```

Notes
16-bit, 32-bit and floating point values may also be placed into eeprom memory. These are placed LSB first (Lowest Significant Byte). For example, if 1000 is placed into an **Edata** statement, then the order is: -

```
  Edata 1000
```

In eeprom it looks like 232, 03

Alias's to constants may also be used in an **Edata** statement: -

```
  Symbol Alias = 200

  Edata Alias, 120, 254, "Hello World"
```

Addressing an Edata table.
Eeprom data starts at address 0 and works up towards the maximum amount that the PICmicro™ will allow. However, it is rarely the case that the information stored in eeprom memory is one continuous piece of data. Eeprom memory is normally used for storage of several values or strings of text, so a method of accessing each piece of data is essential. Consider the following piece of code: -

```
  Edata "Hello"
  Edata "World"
```

Now we know that eeprom memory starts at 0, so the text "Hello" must be located at address 0, and we also know that the text "Hello" is built from 5 characters with each character occupying a byte of eeprom memory, so the text "World" must start at address 5 and also contains 5 characters, so the next available piece of eeprom memory is located at address 10. To access the two separate text strings we would need to keep a record of the start and end address's of each character placed in the tables.

Counting the amount of eeprom memory used by each piece of data is acceptable if only a few **Edata** tables are used in the program, but it can become tedious if multiple values and strings are needing to be stored, and can lead to program glitches if the count is wrong.

Placing an identifying name before the **Edata** table will allow the compiler to do the byte counting for you. The compiler will store the eeprom address associated with the table in the identifying name as a constant value. For example: -

```
Hello_Text Edata "Hello"
World_Text  Edata "World"
```

The name Hello_Text is now recognised as a constant with the value of 0, referring to address 0 that the text string "Hello" starts at. The World_Text is a constant holding the value 5, which refers to the address that the text string "World" starts at.

Note that the identifying text *must* be located on the same line as the **Edata** directive or a syntax error will be produced. It must also not contain a postfix colon as does a line label or it will be treat as a line label. Think of it as an alias name to a constant.

Any **Edata** directives *must* be placed at the head of the BASIC program as is done with Symbols, so that the name is recognised by the rest of the program as it is parsed. There is no need to jump over **Edata** directives as you have to with **Ldata** or **Cdata**, because they do not occupy code memory, but reside in high *Data* memory.

The example program below illustrates the use of eeprom addressing.

```
' Display two text strings held in eeprom memory

  Include "Proton_4.Inc"      ' Demo on a Proton development board
  Dim Char as Byte            ' Holds the character read from eeprom
  Dim Charpos as Byte         ' Holds the address within eeprom memory
'
' Create a string of text in eeprom memory. null terminated
Hello  Edata "HELLO ",0
'
' Create another string of text in eeprom memory. null terminated
World  Edata "WORLD",0

  DelayMs 100                 ' Wait for the LCD to stabilise
  Cls                         ' Clear the LCD
  Charpos = Hello             ' Point Charpos to the start of text "Hello"
  Gosub DisplayText           ' Display the text "Hello"
  Charpos = World             ' Point Charpos to the start of text "World"
  Gosub DisplayText           ' Display the text "World"
  Stop                        ' We're all done
'
' Subroutine to read and display the text held at the address in Charpos
'
DisplayText:
  Do                          ' Create an infinite loop
    Char = Eread Charpos      ' Read the eeprom data
    If Char = 0 Then Break    ' Exit when null found
    Print Char                ' Display the character
    Inc Charpos               ' Move up to the next address
  Loop                        ' Close the loop
  Return                      ' Exit the subroutine
```

Formatting an Edata table.

Sometimes it is necessary to create a data table with a known format for its values. For example all values will occupy 4 bytes of data space even though the value itself would only occupy 1 or 2 bytes.

```
Edata 100000, 10000, 1000, 100, 10, 1
```

The above line of code would produce an uneven data space usage, as each value requires a different amount of data space to hold the values. 100000 would require 4 bytes of eeprom space, 10000 and 1000 would require 2 bytes, but 100, 10, and 1 would only require 1 byte.

Reading these values using **Eread** would cause problems because there is no way of knowing the amount of bytes to read in order to increment to the next valid value.

The answer is to use formatters to ensure that a value occupies a predetermined amount of bytes.

These are: -

   Byte
   Word
   Dword
   Float

Placing one of these formatters before the value in question will force a given length.

```
Edata  Dword 100000, Dword 10000 ,_
       Dword 1000, Dword 100, Dword 10, Dword 1
```

Byte will force the value to occupy one byte of eeprom space, regardless of its value. Any values above 255 will be truncated to the least significant byte.

Word will force the value to occupy 2 bytes of eeprom space, regardless of its value. Any values above 65535 will be truncated to the two least significant bytes. Any value below 255 will be padded to bring the memory count to 2 bytes.

Dword will force the value to occupy 4 bytes of eeprom space, regardless of its value. Any value below 65535 will be padded to bring the memory count to 4 bytes. The line of code shown above uses the **Dword** formatter to ensure all the values in the **Edata** table occupy 4 bytes of eeprom space.

Float will force a value to its floating point equivalent, which always takes up 4 bytes of eeprom space.

If all the values in an **Edata** table are required to occupy the same amount of bytes, then a single formatter will ensure that this happens.

```
Edata as Dword 100000, 10000, 1000, 100, 10, 1
```

The above line has the same effect as the formatter previous example using separate **Dword** formatters, in that all values will occupy 4 bytes, regardless of their value. All four formatters can be used with the **as** keyword.

The example below illustrates the formatters in use.

```
' Convert a Dword value into a string array
' Using only BASIC commands
' Similar principle to the Str$ command

    Include "Proton_4.Inc"
    Dim P10 as Dword        ' Power of 10 variable
    Dim Cnt as Byte
    Dim J as Byte

    Dim Value as Dword      ' Value to convert
    Dim MyString[11] as Byte  ' Holds the converted value
    Dim Ptr as Byte         ' Pointer within the Byte array

    DelayMs 100             ' Wait for the LCD to stabilise
    Cls                     ' Clear the LCD
    Clear                   ' Clear all RAM before we start
    Value = 1234576         ' Value to convert
    Gosub DwordToStr        ' Convert Value to string
    Print Str MyString      ' Display the result
    Stop
'-------------------------
' Convert a Dword value into a string array
' Value to convert is placed in 'Value'
' Byte array 'MyString' is built up with the ASCII equivalent

DwordToStr:
    Ptr = 0
    J = 0
    Repeat
       P10 = Eread J * 4
       Cnt = 0

       While Value >= P10
          Value = Value - P10
          Inc Cnt
       Wend
       If Cnt <> 0 Then
          MyString[Ptr] = Cnt + "0"
          Inc Ptr
       EndIf
       Inc J
    Until J > 8
    MyString[Ptr] = Value + "0"
    Inc Ptr
    MyString[Ptr] = 0            ' Add the null to terminate the string
    Return

' Edata table is formatted for all 32 bit values.
' Which means each value will require 4 bytes of eeprom space
Edata as Dword 1000000000, 100000000, 10000000, 1000000,100000,_
               10000, 1000, 100, 10
```

Label names as pointers in an Edata table.

If a label's name is used in the list of values in an **Edata** table, the labels address will be used. This is useful for accessing other tables of data using their address from a lookup table. See example below.

```
' Display text from two Cdata tables
' Based on their address located in a separate table
  Include "Proton_4.Inc"    ' Use a 14-bit core device

  Dim Address as Word
  Dim DataByte as Byte

  DelayMs 100                ' Wait for the LCD to stabilise
  Cls                        ' Clear the LCD
  Address = Eread 0          ' Locate the address of the first string
  Do                         ' Create an infinite loop
    DataByte = Cread Address ' Read each character from the Cdata string
    If DataByte = 0 Then Break' Exit if null found
    Print DataByte           ' Display the character
    Inc Address              ' Next character
  Loop                       ' Close the loop

  Cursor 2,1                 ' Point to line 2 of the LCD
  Address = Eread 2          ' Locate the address of the second string
  Do                         ' Create an infinite loop
    DataByte = Cread Address ' Read each character from the Cdata string
    If DataByte = 0 Then Break' Exit if null found
    Print DataByte           ' Display the character
    Inc Address              ' Next character
  Loop                       ' Close the loop
  Stop
'
' Table of address's located in eeprom memory
'
  Edata as Word String1, String2
String1:
  Cdata "Hello",0
String2:
  Cdata "World",0
```

See also :   Eread, Ewrite.

Enable

Enable software interrupt processing that was previously Disabled following this instruction.

Disable and **Enable**, and **Resume** are not actually commands in the truest sense of the word, but flags that the compiler uses internally. They do not produce any code.

```
Device = 16F877
Declare Xtal = 4
Symbol LED = PORTD.0

OPTION_REG = %00000111
INTCON = %00100000

'
' Enable software interrupts, and point to interrupt handler
'
On Interrupt Goto My_Software_Int

Stop

Disable                  ' Disable interrupts in the handler
My_Software_Int:
Toggle LED               ' Toggle an LED when interrupted
Resume                   ' Return to main program
Enable                   ' Enable interrupts after the handler
```

Note.

Software interrupts are a remnant from earlier compiler versions and are not recommended for new applications. See **Managed Hardware Interrupts** for a better method of interrupt handling.

See also :   Software Interrupts in BASIC, Disable, Resume.

Software Interrupts in BASIC

Although the most efficient method of using an interrupt is in assembler, hardware interrupts and BASIC are poor bedfellows. By far the easiest way to write an interrupt handler is to write it in BASIC, in combination with the **On Interrupt** statement. This is not the same as the compiler's **On_Interrupt** statement, which initiates a Hardware interrupt. **On Interrupt** (two separate words.. *On Interrupt*) informs the compiler to activate its internal interrupt handling and to jump to the BASIC interrupt handler as soon as it's capable, after receiving an interrupt. However, there's no such thing as a free lunch, and there are some penalties to pay for the ease of use that this method brings.

The statement **On_Hardware_Interrupt** are also recognised by the compiler in order to clarify which type of interrupt is being implemented.

When **On Interrupt** is used, the compiler simply flags that the interrupt has happened and immediately goes back to what it was doing, before it was rudely interrupted. Unlike a hardware interrupt, it does not immediately jump to the interrupt handler. And since the compiler's commands are non re-entrant, there could be a considerable delay before the interrupt is actually handled.

For example, if the program has just started to execute a **DelayMs** 2000 command when an interrupt occurs, the compiler will flag the interrupt and continue with the delay. It could be as much as 2 seconds later before the interrupt handler is executed. Any time critical routines dependant on the interrupt occurring regularly will be ruined. For example, multiplexing seven segment display.

To minimise the above problem, use only statements that don't take long to execute. For example, instead of **DelayMs** 2000, use **DelayMs** 1 in a **For..Next**, or **Repeat..Until** loop. This will allow the compiler to complete each command more quickly and handle any awaiting interrupts: -

```
For Var1 = 0 to 199 : DelayMs 1 : Next   ' Delay for 200ms
```

If interrupt processing needs to occur more regularly, then there is no choice but to use a hardware interrupt, with all its quirks.

Exactly what happens when **On Interrupt** is used is this: A short interrupt handler is placed at location 4 in the PICmicro™. This interrupt handler is simply a **Return**. What this does is send the program back to what it was doing before the interrupt occurred. It does not require any processor context saving. What it doesn't do is re-enable Global Interrupts as happens when using a **Retfie** instruction.

A Call to a short subroutine is placed before each command in the BASIC program once an **On Interrupt** statement is encountered. This short subroutine checks the state of the Global Interrupt Enable bit (GIE). If it's off, an interrupt is awaiting so it vectors to the users interrupt handler. Which is essentially a BASIC subroutine.

If it is still set, the program continues with the next BASIC statement, after which, the GIE bit is checked again, and so forth.

Note.
Software interrupts are a remnant from earlier compiler versions and are not recommended for new applications. See **Managed Hardware Interrupts** for a better method of interrupt handling.

See also : Enable, Disable, Resume.

End

Syntax
End

Overview
The **End** statement stops compilation of source, and creates an infinite loop.

Notes
End stops the PICmicro™ processing by placing it into a continuous loop. The port pins remain the same and the device is placed in low power mode.

See also :   Stop, Sleep, Snooze.

Eread

Syntax
Variable **= Eread** *Address*

Overview
Read information from the on-board eeprom available on some PICmicro™ types.

Parameters
Variable is a user defined variable.
Address is a constant, variable, or expression, that contains the address of interest within eeprom memory.

Example
```
Device = 16F877                ' A device with on-board eeprom
Dim Var1 as Byte
Dim Wrd1 as Word
Dim Dwrd1 as Dword

Edata 10, 354, 123456789       ' Place some data into the eeprom
Var1 = Eread 0                 ' Read the 8-bit value from address 0
Wrd1= Eread 1                  ' Read the 16-bit value from address 1
Dwrd1 = Eread 3                ' Read the 32-bit value from address 3
```

Notes
If a **Float**, or **Dword** type variable is used as the assignment variable, then 4-bytes will be read from the eeprom. Similarly, if a **Word** type variable is used as the assignment variable, then a 16-bit value (2-bytes)will be read from eeprom, and if a **Byte** type variable is used, then 8-bits will be read. To read an 8-bit value while using a **Word** sized variable, use the **LowByte** modifier: -

```
Wrd1.LowByte = Eread 0  ' Read an 8-bit value
Wrd1.HighByte = 0           ' Clear the high byte of Wrd
```

If a 16-bit (**Word**) size value is read from the eeprom, the address must be incremented by two for the next read. Also, if a **Float** or **Dword** type variable is read, then the address must be incremented by 4.

Most of the Flash PICmicro™ types have a portion of memory set aside for storage of information. The amount of memory is specific to the individual PICmicro™ type, some, such as the 16F84, has 64 bytes, the 16F877 device has 256 bytes, and some of the 18F devices have upwards of 512 bytes.

Eeprom memory is non-volatile, and is an excellent place for storage of long-term information, or tables of values.

Reading data with the **Eread** command is almost instantaneous, but writing data to the eeprom can take up to 10ms per byte.

See also :   Edata, Ewrite

Ewrite

Syntax
Ewrite *Address*, **[** *Variable* {, *Variable*…etc } **]**

Overview
Write information to the on-board eeprom available on some PICmicro™ types.

Parameters
Address is a constant, variable, or expression, that contains the address of interest within eeprom memory.
Variable is a user defined variable.

Example

```
Device = 16F628             ' A device with on-board eeprom
Dim Var1 as Byte
Dim Wrd1 as Word
Dim Address as Byte

Var1 = 200
Wrd1= 2456
Address = 0                 ' Point to address 0 within the eeprom
Ewrite Address, [Wrd, Var1]  ' Write a 16-bit then an 8-bit value
```

Notes
If a **Dword** type variable is used, then a 32-bit value (4-bytes) will be written to the eeprom. Similarly, if a **Word** type variable is used, then a 16-bit value (2-bytes) will be written to eeprom, and if a **Byte** type variable is used, then 8-bits will be written. To write an 8-bit value while using a **Word** sized variable, use the **LowByte** modifier: -

```
Ewrite Address, [ Wrd.LowByte, Var1 ]
```

If a 16-bit (**Word**) size value is written to the eeprom, the address must be incremented by two before the next write: -

```
For Address = 0 to 64 Step 2
   Ewrite Address, [Wrd]
Next
```

Most of the Flash PICmicro™ types have a portion of memory set aside for storage of information. The amount of memory is specific to the individual PICmicro™ type, some, such as the 16F84, has 64 bytes, while the 16F877, and 18FXXX devices have 256 bytes.

Eeprom memory is non-volatile, and is an excellent place for storage of long-term information, or tables of values.

Writing data with the **Ewrite** command can take up to 10ms per byte, but reading data from the eeprom is almost instantaneous,.

See also :   Edata, Eread

For...Next...Step

Syntax
For *Variable* **=** *Startcount* **to** *Endcount* **[Step** { *Stepval* } **]**
{*code body*}
Next

Overview
The **For…Next** loop is used to execute a statement, or series of statements a predetermined amount of times.

Parameters
Variable refers to an index variable used for the sake of the loop. This index variable can itself be used in the code body but beware of altering its value within the loop as this can cause many problems.
Startcount is the start number of the loop, which will initially be assigned to the *variable*. This does not have to be an actual number - it could be the contents of another variable.
Endcount is the number on which the loop will finish. This does not have to be an actual number, it could be the contents of another variable, or an expression.
Stepval is an optional constant or variable by which the *variable* increases or decreases with each trip through the For-Next loop. If *startcount* is larger than *endcount*, then a minus sign must precede *stepval*.

Example 1
```
' Display in decimal, all the values of Wrd within an upward loop
  Dim Wrd as Word

  For Wrd = 0 to 2000 Step 2        ' Perform an upward loop
    Print Dec Wrd ," "              ' Display the value of Wrd
  Next                             ' Close the loop
```

Example 2
```
' Display in decimal, all the values of Wrd within a downward loop
  Dim Wrd as Word

  For Wrd = 2000 to 0 Step -2       ' Perform a downward loop
    Print Dec Wrd ," "              ' Display the value of Wrd
  Next                             ' Close the loop
```

Example 3
```
' Display in decimal, all the values of Dwrd within a downward loop
  Dim Dwrd as Dword

  For Dwrd = 200000 to 0 Step -200   ' Perform a downward loop
    Print Dec Dwrd ,"        "       ' Display the value of Dwrd
  Next                             ' Close the loop
```

Example 4
```
' Display all of Wrd1 using a expressions as parts of the For-Next construct

  Dim Wrd1 as Word
  Dim Wrd2 as Word

  Wrd2 = 1000

  For Wrd1= Wrd2 + 10 to Wrd2 + 1000  ' Perform a loop
    Print Dec Wrd1," "                 ' Display the value of Wrd1
  Next                                 ' Close the loop
```

Notes
You may have noticed from the above examples, that no variable is present after the **Next** command. A variable after **Next** is purely optional.

For-Next loops may be nested as deeply as the memory on the PICmicro™ will allow. To break out of a loop you may use the **Goto** command without any ill effects, which is exactly what the **Break** command does: -

```
  For Var1 = 0 to 20              ' Create a loop of 21
    If Var1 = 10 Then Goto BreakOut ' Break out of loop when Var1 is 10
  Next                            ' Close the loop

BreakOut:
  Stop
```

See also :   While...Wend, Repeat...Until.

Freqout

Syntax
Freqout *Pin, Period, Freq1 {, Freq2}*

Overview
Generate one or two sine-wave tones, of differing or the same frequencies, for a specified period.

Parameters
Pin is a Port-Bit combination that specifies which I/O pin to use.
Period may be a variable, constant, or expression (0 - 65535) specifying the amount of time to generate the tone(s).
Freq1 may be a variable, constant, or expression (0 - 32767) specifying frequency of the first tone.
Freq2 may be a variable, constant, or expression (0 - 32767) specifying frequency of the second tone. When specified, two frequencies will be mixed together on the same I/O pin.

Example
```
' Generate a 2500Hz (2.5KHz) tone for 1 second (1000 ms) on bit 0 of PORTA.
  Freqout PORTA.0, 1000, 2500

' Play two tones at once for 1000ms. One at 2.5KHz, the other at 3KHz.
  Freqout PORTA.0, 1000, 2500, 30000
```

Notes
Freqout generates one or two sine waves using a pulse-width modulation algorithm. **Freqout** will work with a 4MHz crystal, however, it is best used with higher frequency crystals, and operates accurately with a 20MHz crystal. The raw output from **Freqout** requires filtering, to eliminate most of the switching noise. The circuits shown below will filter the signal in order to play the tones through a speaker or audio amplifier.
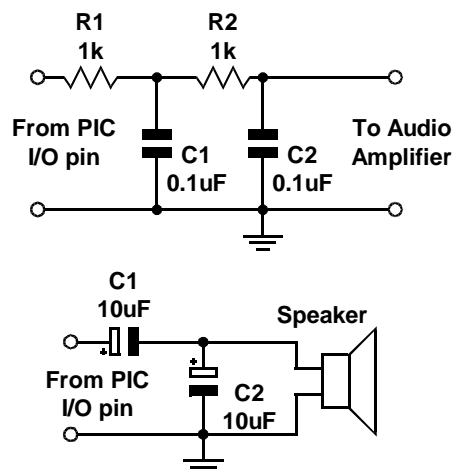
The two circuits shown above, work by filtering out the high-frequency Pwm used to generate the sine waves. **Freqout** works over a very wide range of frequencies (0 to 32767KHz) so at the upper end of its range, the Pwm filters will also filter out most of the desired frequency. You may need to reduce the values of the parallel capacitors shown in the circuit, or to create an active filter for your application.

Example 2
```
' Play a tune using Freqout to generate the notes

    Device = 16F1829
    Declare Xtal = 20

    Dim MyLoop as Byte          ' Counter for notes.
    Dim Freq1 as Word           ' Frequency1.
    Dim Freq2 as Word           ' Frequency2

    Symbol C = 2092             ' C note
    Symbol D = 2348             ' D note
    Symbol E = 2636             ' E note
    Symbol G = 3136             ' G note
    Symbol R = 0                ' Silent pause.
    Symbol Pin = PORTA.0        ' Sound output pin

    ADCON1 = 7                  ' Set PORTA and PORTE to all digital
    MyLoop = 0
    Repeat                      ' Create a loop for 29 notes within the LookUpL table.
       Freq1 = LookUpL MyLoop,[E,D,C,D,E,E,E,R,D,D,D,_
                              R,E,G,G,R,E,D,C,D,E,E,E,E,D,D,E,D,C]
       If Freq1 = 0 Then
         Freq2 = 0
       Else
         Freq2 = Freq1 - 8
       EndIf
       Freqout Pin, 225, Freq1, Freq2
       Inc MyLoop
    Until MyLoop > 28
```

See also :   DTMFout, Sound, Sound2.

GetBit

Syntax
Variable **= GetBit** *Variable*, *Index*

Overview
Examine a bit of a variable, or register.

Parameters
Variable is a user defined variable.
Index is a constant, variable, or expression that points to the bit within *Variable* that requires examining.

Example
```
' Examine and display each bit of variable ExVar
  Device = 16F1829
  Declare Xtal = 4

  Dim ExVar as Byte
  Dim Index as Byte
  Dim Var1 as Byte

  ExVar = %10110111

  Do
    Cls
    Print At 1,1,Bin8 ExVar          ' Display the original variable
    Cursor 2,1                       ' Position the cursor at line 2
    For Index = 7 to 0 Step -1       ' Create a loop for 8 bits
      Var1 = GetBit ExVar,Index      ' Examine each bit of ExVar
      Print Dec1 Var1                ' Display the binary result
      DelayMs 100                    ' Slow things down to see what's happening
    Next                             ' Close the loop
  Loop                               ' Do it forever
```

See also :   ClearBit, LoadBit, SetBit.

GetPin

Syntax
Variable **= GetPin** *Pin Number*

Overview
Read a pin of a port.

Parameters
Variable is a user defined variable.
Pin Number is a constant, variable, or expression that points to the pin of a port that requires reading. A value of 0 will read PORTA.0, a value of 1 will read PORTA.1, a value of 8 will read PORTB.0 etc… The pin will be made an input before reading commences.

Example
```
' Examine and display each pin of PORTB
  Device = 16F1829
  Declare Xtal = 4

  Dim PinNumber as Byte
  Dim Var1 as Byte

  Do
    For PinNumber = 8 to 15          ' Create a loop for 8 pins
      Var1 = GetPin PinNumber        ' Examine each pin of PORTB
      Print Dec1 Var1                ' Display the binary result
      DelayMs 100                    ' Slow things down to see what's happening
    Next                             ' Close the loop
  Loop                               ' Do it forever
```

Gosub

Syntax
Gosub *Label*

or

Gosub *Label* **[***Variable***,** {*Variable*, *Variable*... etc}**]**, *Receipt Variable*

Overview
Gosub jumps the program to a defined label and continues execution from there. Once the program hits a **Return** command the program returns to the instruction following the **Gosub** that called it and continues execution from that point.

If using an 18F device, parameters can be pushed onto a software stack before the call is made, and a variable can be popped from the stack before continuing execution of the next commands. Only the 18F devices have this mechanism, because they contain an FSR2 register that is used as a stack pointer. The other 16F devices do not contain this SFR.

Parameters
Label is a user-defined label placed at the beginning of a line which must have a colon '**:**' directly after it.
Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float**, **String**, **Array** or **Constant** value, that will be pushed onto the stack before the call to a subroutine is performed.
Receipt Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float**, **String** or **Array** that will hold a value popped from the stack after the subroutine has returned.

Example 1
```
' Implement a standard subroutine call
   Goto Start       ' Jump over the subroutines
SubA:  { subroutine A code
   ……
   ……
   }
   Return

SubB:  { subroutine B code
   ……
   ……
   }
   Return

' Actual start of the main program
Start:
   Gosub SubA
   Gosub SubB
   Stop
```

See also :   Sub-EndSub

Example 2
```
' Call a subroutine with parameters
  Device = 18F25K20                  ' Stack only suitable for 18F devices
  Declare Stack_Size = 20            ' Create a small stack capable of holding 20 bytes

  Dim Wrd1 as Word                   ' Create a Word variable
  Dim Wrd2 as Word                   ' Create another Word variable
  Dim Receipt as Word                ' Create a variable to hold result

  Wrd1 = 1234                        ' Load the Word variable with a value
  Wrd2 = 567                         ' Load the other Word variable with a value
' Call the subroutine and return a value
  Gosub AddThem [Wrd1, Wrd2], Receipt
  Print Dec Receipt                  ' Display the result as decimal
  Stop

' Subroutine starts here. Add two parameters passed and return the result
AddThem:
  Dim AddWrd1 as Word                ' Create two uniquely named variables
  Dim AddWrd2 as Word

  Pop AddWrd2                        ' Pop the last variable pushed
  Pop AddWrd1                        ' Pop the first variable pushed
  AddWrd1 = AddWrd1 + AddWrd2        ' Add the values together
  Return AddWrd1                     ' Return the result of the addition
```

In reality, what's happening with the **Gosub** in the above program is simple, if we break it into its constituent events: -

```
  Push Wrd1
  Push Wrd2
  Gosub AddThem
  Pop Receipt
```

Notes
Only one parameter can be returned from the subroutine, any others will be ignored.

If a parameter is to be returned from a subroutine but no parameters passed to the subroutine, simply issue a pair of empty square braces: -

```
  Gosub Label [ ], Receipt
```

The same rules apply for the parameters as they do for **Push**, which is after all, what is happening.

Proton allows any amount of **Gosub**s in a program, but the 14-bit PICmicro™ architecture only has an 8-level return address stack, which only allows 8 **Gosub**s to be nested. The compiler only ever uses a maximum of 4-levels for its library subroutines, therefore do not use more than 4 **Gosub**s within subroutines. The 18F devices however, have a 28-level return address stack which allows any combination of up to 28 **GosubS** to occur.

A subroutine must always end with a **Return** command.

What is a Stack?

All microprocessors and most microcontrollers have access to a Stack, which is an area of RAM allocated for temporary data storage. But this is sadly lacking on a PICmicro™ device. However, the 18F devices have an architecture and low-level mnemonics that allow a Stack to be created and used very efficiently.

A stack is first created in high memory by issuing the **Stack_Size Declare**.

```
Declare Stack_Size = 40
```

The above line of code will reserve 40 bytes at the top of RAM that cannot be touched by any BASIC command, other than **Push** and **Pop**. This means that it is a safe place for temporary variable storage.

Taking the above line of code as an example, we can examine what happens when a variable is pushed on to the 40 byte stack, and then popped off again.

First the RAM is allocated. For this explanation we will assume that a 18F452 PICmicro™ device is being used. The 18F452 has 1536 bytes of RAM that stretches linearly from address 0 to 1535. Reserving a stack of 40 bytes will reduce the top of memory so that the compiler will only see 1495 bytes (1535 - 40). This will ensure that it will not inadvertently try and use it for normal variable storage.

Pushing.

When a **Word** variable is pushed onto the stack, the memory map would look like the diagram below: -

```
Top of Memory  |..............Empty RAM.............. | Address 1535
                        ~               ~
                        ~               ~
               |..............Empty RAM.............. | Address 1502
               |..............Empty RAM.............. | Address 1501
               |   Low Byte address of Word variable  | Address 1496
Start of Stack |   High Byte address of Word variable | Address 1495
```
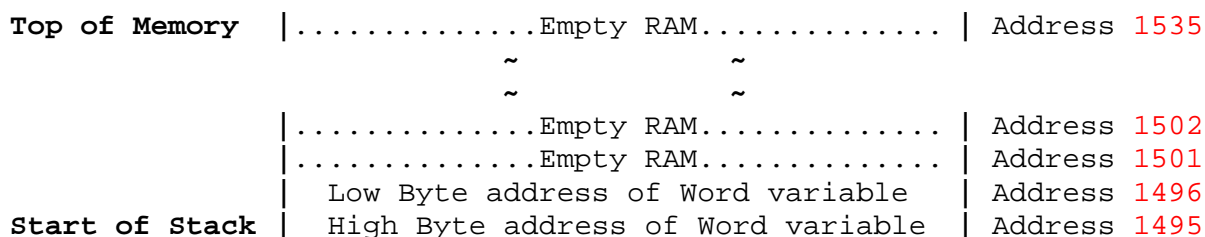
The high byte of the variable is first pushed on to the stack, then the low byte. And as you can see, the stack grows in an upward direction whenever a **Push** is implemented, which means it shrinks back down whenever a **Pop** is implemented.

If we were to **Push** a **Dword** variable on to the stack as well as the **Word** variable, the stack memory would look like: -

```
Top of Memory  |................Empty RAM.............| Address 1535
                        ~               ~
                        ~               ~
               |................Empty RAM.............| Address 1502
               |................Empty RAM.............| Address 1501
               |   Low Byte address of Dword variable  | Address 1500
               |   Mid1 Byte address of Dword variable | Address 1499
               |   Mid2 Byte address of Dword variable | Address 1498
               |   High Byte address of Dword variable | Address 1497
               |   Low Byte address of Word variable   | Address 1496
Start of Stack |   High Byte address of Word variable  | Address 1495
```

Popping.

When using the **Pop** command, the same variable type that was pushed last must be popped first, or the stack will become out of phase and any variables that are subsequently popped will contain invalid data. For example, using the above analogy, we need to **Pop** a **Dword** variable first. The **Dword** variable will be popped Low Byte first, then MID1 Byte, then MID2 Byte, then lastly the High Byte. This will ensure that the same value pushed will be reconstructed correctly when placed into its recipient variable. After the **Pop**, the stack memory map will look like: -

```
Top of Memory  |..............Empty RAM.............. | Address 1535
                            ~            ~
                            ~            ~
               |..............Empty RAM.............. | Address 1502
               |..............Empty RAM.............. | Address 1501
               |   Low Byte address of Word variable  | Address 1496
Start of Stack |   High Byte address of Word variable | Address 1495
```

If a **Word** variable was then popped, the stack will be empty, however, what if we popped a **Byte** variable instead? the stack would contain the remnants of the **Word** variable previously pushed. Now what if we popped a **Dword** variable instead of the required **Word** variable? the stack would underflow by two bytes and corrupt any variables using those address's . The compiler cannot warn you of this occurring, so it is up to you, the programmer, to ensure that proper stack management is carried out. The same is true if the stack overflows. i.e. goes beyond the top of RAM. The compiler cannot give a warning.

Technical Details of Stack implementation.

The stack implemented by the compiler is known as an ***Incrementing Last-In First-Out*** Stack. *Incrementing* because it grows upwards in memory. *Last-In First-Out* because the last variable pushed, will be the first variable popped.

The stack is not circular in operation, so that a stack overflow will rollover into the PICmicro's hardware register, and an underflow will simply overwrite RAM immediately below the Start of Stack memory. If a circular operating stack is required, it will need to be coded in the main BASIC program, by examination and manipulation of the stack pointer (see below).

Indirect register pair FSR2L and FSR2H are used as a 16-bit stack pointer, and are incremented for every **Byte** pushed, and decremented for every **Byte** popped. Therefore checking the FSR2 registers in the BASIC program will give an indication of the stack's condition if required. This also means that the BASIC program cannot use the FSR2 register pair as part of its code, unless for manipulating the stack. Note that none of the compiler's commands, other than **Push** and **Pop**, use FSR2.

Whenever a variable is popped from the stack, the stack's memory is not actually cleared, only the stack pointer is moved. Therefore, the above diagrams are not quite true when they show empty RAM, but unless you have use of the remnants of the variable, it should be considered as empty, and will be overwritten by the next **Push** command.

See also :   Call, Goto, Push, Pop.

Goto

Syntax
Goto *Label*

Overview
Jump to a defined label and continue execution from there.

Parameters
Label is a user-defined label placed at the beginning of a line which must have a colon '**:**' directly after it.

Example
```
  If Var1 = 3 Then Goto Jumpover
  {
  code here executed only if Var1<>3
  ……
  ……
  }
JumpOver:
  {continue code execution}
```

In this example, if Var1=3 then the program jumps over all the code below it until it reaches the *label* JumpOver where program execution continues as normal.

See also :   Call, Gosub.

HbStart

Syntax
HbStart

Overview
Send a **Start** condition to the I^{2}C bus using the microcontroller's MSSP module.

Notes
Because of the subtleties involved in interfacing to some I^{2}C devices, the compiler's standard Hbusin, and Hbusout commands were found lacking. Therefore, individual pieces of the I^{2}C protocol may be used in association with the new structure of Hbusin, and Hbusout. See relevant sections for more information.

Example
```
' Interface to a 24LC32 serial eeprom
'
  Device = 16F1829          ' Use a device with an MSSP module
  Dim MyLoop as Byte
  Dim Array[10] as Byte
'
' Transmit bytes to the I2C bus
'
  HbStart                   ' Send a Start condition
  Hbusout %10100000         ' Target an eeprom, and send a Write command
  Hbusout 0                 ' Send the HighByte of the address
  Hbusout 0                 ' Send the LowByte of the address
  For MyLoop = 48 to 57     ' Create a loop containing ASCII 0 to 9
    Hbusout MyLoop          ' Send the value of MyLoop to the eeprom
  Next                      ' Close the loop
  HbStop                    ' Send a Stop condition
  DelayMs 10                ' Wait for the data to be entered into eeprom matrix
'
' Receive bytes from the I2C bus
'
  HbStart                   ' Send a Start condition
  Hbusout %10100000         ' Target an eeprom, and send a Write command
  Hbusout 0                 ' Send the HighByte of the address
  Hbusout 0                 ' Send the LowByte of the address
  HbRestart                 ' Send a Restart condition
  Hbusout %10100001         ' Target an eeprom, and send a Read command
  For MyLoop = 0 to 9       ' Create a loop
    Array[MyLoop] = Hbusin  ' Load an array with bytes received
    If MyLoop = 9 Then HbStop : Else : HbusAck ' Ack or Stop ?
  Next                      ' Close the loop
  Print At 1,1, Str Array   ' Display the Array as a String
```

See also :   HbusAck, HbRestart, HbStop, Hbusin, Hbusout.

HbStop

Syntax
HbStop

Overview
Send a **Stop** condition to the I^{2}C bus using the microcontroller's MSSP module.

HbRestart

Syntax
HbRestart

Overview
Send a **Restart** condition to the I^{2}C bus using the microcontroller's MSSP module.

HbusAck

Syntax
HbusAck

Overview
Send an **Acknowledge** condition to the I^{2}C bus using the microcontroller's MSSP module.

HbusNack

Syntax
HbusNack

Overview
Send a **Not Acknowledge** condition to the I^{2}C bus using the microcontroller's MSSP module..

See also :   HbStart, HbRestart, HbStop, Hbusin, Hbusout.

Hbusin

Syntax
Variable = **Hbusin** *Control*, { *Address* }

or

Variable = **Hbusin**

or

Hbusin *Control*, { *Address* }, **[** *Variable* {, *Variable*…} **]**

or

Hbusin *Variable*

Overview
Receives a value from the I^{2}C bus using the MSSP module, and places it into *variable/s*. If variations *two* or *four* (see above) are used, then No Acknowledge, or Stop is sent after the data. Variations *one* and *three* first send the *control* and optional *address*.

Parameters
Variable is a user defined variable or constant.
Control may be a constant value or a **Byte** sized variable expression.
Address may be a constant value or a variable expression.

The four variations of the **Hbusin** command may be used in the same BASIC program. The *second* and *fourth* types (see ablve) are useful for simply receiving a single byte from the bus, and must be used in conjunction with one of the low level commands. i.e. **HbStart**, **HbRestart**, **HbusAck**, or **HbStop**. The *first*, and *third* types may be used to receive several values and designate each to a separate variable, or variable type.

The **Hbusin** command operates as an I^{2}C master, using the microcontroller's MSSP module, and may be used to interface with any device that complies with the 2-wire I^{2}C protocol.

The most significant 7-bits of *control* byte contain the control code and the slave address of the device being interfaced with. Bit-0 is the flag that indicates whether a read or write command is being implemented.

For example, if we were interfacing to an external eeprom such as the 24LC32, the control code would be %10100001 or $A1. The most significant 4-bits (1010) are the eeprom's unique slave address. Bits 2 to 3 reflect the three address pins of the eeprom. And bit-0 is set to signify that we wish to read from the eeprom. Note that this bit is automatically set by the **Hbusin** command, regardless of its initial setting.

Example
```
' Receive a byte from the I2C bus and place it into variable Var1.

  Dim Var1 as Byte              ' We'll only read 8-bits
  Dim Address as Word           ' 16-bit address required
  Symbol Control %10100001      ' Target an eeprom

  Address = 20                  ' Read the value at address 20
  Var1 = Hbusin Control, Address ' Read the byte from the eeprom
```

or

```
  Hbusin Control, Address, [Var1]   ' Read the byte from the eeprom
```

Address, is an optional parameter that may be an 8-bit or 16-bit value. If a variable is used in this position, the size of *address* is dictated by the size of the variable used (**Byte** or **Word**). In the case of the previous eeprom interfacing, the 24LC32 eeprom requires a 16-bit address. While the smaller types require an 8-bit address. Make sure you assign the right size address for the device interfaced with, or you may not achieve the results you intended.

The value received from the bus depends on the size of the variables used, except for variation three, which only receives a **Byte** (8-bits). For example: -

```
  Dim Wrd as Word          ' Create a Word size variable
  Wrd = Hbusin Control, Address
```

Will receive a 16-bit value from the bus. While: -

```
  Dim Var1 as Byte         ' Create a Byte size variable
  Var1 = Hbusin Control, Address
```

Will receive an 8-bit value from the bus.

Using the *third* variation of the **Hbusin** command allows differing variable assignments. For example: -

```
  Dim Var1 as Byte
  Dim Wrd as Word
  Hbusin Control, Address, [Var1, Wrd]
```

Will receive two values from the bus, the first being an 8-bit value dictated by the size of variable Var1 which has been declared as a byte. And a 16-bit value, this time dictated by the size of the variable Wrd which has been declared as a word. Of course, bit type variables may also be used, but in most cases these are not of any practical use as they still take up a byte within the eeprom.

The *second* and *fourth* variations allow all the subtleties of the I^{2}C protocol to be exploited, as each operation may be broken down into its constituent parts. It is advisable to refer to the datasheet of the device being interfaced to fully understand its requirements. See section on **HbStart**, **HbRestart**, **HbusAck**, or **HbStop**, for example code.

Hbusin Declares
Declare Hbus_Bitrate Constant 100, 400, 1000

The standard speed for the I^{2}C bus is 100KHz. Some devices use a higher bus speed of 400KHz. The above Declare allows the I^{2}C bus speed to be increased or decreased. Use this Declare with caution, as too high a bit rate may exceed the device's specs, which will result in intermittent transactions, or in some cases, no transactions at all. The datasheet for the device used will inform you of its bus speed. The default bit rate is the standard 100KHz.

Declare HSDA_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the data line (SDA) must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare HSCL_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the clock line (SCL) must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Notes
Not all PICmicro^{TM} devices contain an MSSP module, some only contain an SSP type, which only allows I^{2}C slave operations. These types of devices may not be used with any of the HBUS commands. Therefore, always read and understand the datasheet for the PICmicro^{TM} device used.

When the **Hbusin** command is used, the appropriate SDA and SCL Port and Pin are automatically setup as inputs. On devices without PPS (Peripheral Pin Select), the SDA, and SCL lines are predetermined as hardware pins on the PICmicro^{TM} , however, on devices with PPS, the compiler sets up the appropriate SFRs using the HSDA_Pin and HSCL_Pin declares.

Because the I^{2}C protocol calls for an *open-collector* interface, pull-up resistors are required on both the SDA and SCL lines. Values of 1KΩ to 4.7KΩ will suffice.

Str modifier with Hbusin

Using the **Str** modifier allows variations *three* and *four* of the **Hbusin** command to transfer the bytes received from the I^{2}C bus directly into a byte array. If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. An example of each is shown below: -

```
    Dim Array[10] as Byte       ' Create an array of 10 bytes
    Dim Address as Byte         ' Create a word sized variable

    Hbusin %10100000, Address, [Str Array]  ' Load data into all the array
'
' Load data into only the first 5 elements of the array
'
    Hbusin %10100000, Address, [Str Array\5]
    HbStart                     ' Send a Start condition
    Hbusout %10100000           ' Target an eeprom, and send a WRITE command
    Hbusout 0                   ' Send the HighByte of the address
    Hbusout 0                   ' Send the LowByte of the address
    HbRestart                   ' Send a Restart condition
    Hbusout %10100001           ' Target an eeprom, and send a Read command
    Hbusin Str Array            ' Load all the array with bytes received
    HbStop                      ' Send a Stop condition
```

An alternative ending to the above example is: -

```
    Hbusin Str Array\5          ' Load data into only the first 5 elements of the array
    HbStop                      ' Send a Stop condition
```

See also :   HbusAck, HbRestart, HbStop, HbStart, Hbusout.

Hbusout

Syntax
Hbusout *Control*, { *Address* }, **[** *Variable* {, *Variable*…} **]**

or

Hbusout *Variable*

Overview
Transmit a value to the I^{2}C bus using the microcontroller's on-board MSSP module, by first sending the *control* and optional *address* out of the clock pin (*SCL*), and data pin (*SDA*). Or alternatively, if only one operator is included after the **Hbusout** command, a single value will be transmitted, along with an Ack reception.

Parameters
Variable is a user defined variable or constant.
Control may be a constant value or a **Byte** sized variable expression.
Address may be a constant, variable, or expression.

The **Hbusout** command operates as an I^{2}C master and may be used to interface with any device that complies with the 2-wire I^{2}C protocol.

The most significant 7-bits of *control* byte contain the control code and the slave address of the device being interfaced with. Bit-0 is the flag that indicates whether a read or write command is being implemented.

For example, if we were interfacing to an external eeprom such as the 24LC32, the control code would be %10100000 or $A0. The most significant 4-bits (1010) are the eeprom's unique slave address. Bits 2 to 3 reflect the three address pins of the eeprom. And Bit-0 is clear to signify that we wish to write to the eeprom. Note that this bit is automatically cleared by the **Hbusout** command, regardless of its initial value.

Example
```
' Send a byte to the I2C bus.

  Dim Var1 as Byte              ' We'll only read 8-bits
  Dim Address as Word           ' 16-bit address required
  Symbol Control = %10100000    ' Target an eeprom

  Address = 20                  ' Write to address 20
  Var1 = 200                    ' The value place into address 20
  Hbusout Control, Address, [Var1] ' Send the byte to the eeprom
  DelayMs 10                    ' Allow time for allocation of byte
```

Address, is an optional parameter that may be an 8-bit or 16-bit value. If a variable is used in this position, the size of *address* is dictated by the size of the variable used (**Byte** or **Word**). In the case of the above eeprom interfacing, the 24LC32 eeprom requires a 16-bit address. While the smaller types require an 8-bit address. Make sure you assign the right size address for the device interfaced with, or you may not achieve the results you intended.

The value sent to the bus depends on the size of the variables used. For example: -

```
Dim Wrd as Word          ' Create a Word size variable
Hbusout Control, Address, [Wrd]
```

Will send a 16-bit value to the bus. While: -

```
Dim Var1 as Byte         ' Create a Byte size variable
Hbusout Control, Address, [Var1]
```

Will send an 8-bit value to the bus.

Using more than one variable within the brackets allows differing variable sizes to be sent. For example: -

```
Dim Var1 as Byte
Dim Wrd as Word
Hbusout Control, Address, [Var1, Wrd]
```

Will send two values to the bus, the first being an 8-bit value dictated by the size of variable Var1 which has been declared as a byte. And a 16-bit value, this time dictated by the size of the variable Wrd which has been declared as a word. Of course, **Bit** type variables may also be used, but in most cases these are not of any practical use as they still take up a byte within the eeprom.

A string of characters can also be transmitted, by enclosing them in quotes: -

```
Hbusout Control, Address, [ "Hello World", Var1, Wrd ]
```

Using the second variation of the **Hbusout** command, necessitates using the low level commands i.e. **HbStart**, **HbRestart**, **HbusAck**, or **HbStop**.

Using the **Hbusout** command with only one value after it, sends a byte of data to the I^{2}C bus, and returns holding the Acknowledge reception. This acknowledge indicates whether the data has been received by the slave device.

The Ack reception is returned in the PICmicro's CARRY flag, which is STATUS.0, and also System variable PP4.0. A value of zero indicates that the data was received correctly, while a one indicates that the data was not received, or that the slave device has sent a NAck return. You must read and understand the datasheet for the device being interfacing to, before the Ack return can be used successfully. An code snippet is shown below: -

```
' Transmit a byte to a 24LC32 serial eeprom
  Dim PP4 as Byte System
  HbStart                   ' Send a Start condition
  Hbusout %10100000         ' Target an eeprom, and send a Write command
  Hbusout 0                 ' Send the HighByte of the address
  Hbusout 0                 ' Send the LowByte of the address
  Hbusout "A"               ' Send the value 65 to the bus
  If PP4.0 = 1 Then Goto Not_Received ' Has Ack been received OK ?
  HbStop                    ' Send a Stop condition
  DelayMs 10                ' Wait for the data to be entered into eeprom matrix
```

Str modifier with Hbusout.

The **Str** modifier is used for transmitting a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that sends four bytes from an array: -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
MyArray [0] = "A"              ' Load the first 4 bytes of the array
MyArray [1] = "B"              ' With the data to send
MyArray [2] = "C"
MyArray [3] = "D"
Hbusout %10100000, Address, [Str MyArray \4]    ' Send 4-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the program would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 4 bytes.

The above example may also be written as: -

```
Dim MyArray [10] as Byte        ' Create a 10-byte array.
Str MyArray = "ABCD"            ' Load the first 4 bytes of the array
HbStart                         ' Send a Start condition
Hbusout %10100000              ' Target an eeprom, and send a Write command
Hbusout 0                      ' Send the HighByte of the address
Hbusout 0                      ' Send the LowByte of the address
Hbusout Str MyArray\4          ' Send 4-byte string.
HbStop                         ' Send a Stop condition
```

The above example, has exactly the same function as the previous one. The only differences are that the string is now constructed using the **Str** as a command instead of a modifier, and the low-level Hbus commands have been used.

Notes

Not all PICmicro[TM] devices contain an MSSP module, some only contain an SSP type, which only allows I^2C slave operations. These types of devices may not be used with any of the Hbus commands. Therefore, always read and understand the datasheet for the PICmicro[TM] device used.

Hbusout Declares
Declare Hbus_Bitrate Constant 100, 400, 1000

The standard speed for the I^2C bus is 100KHz. Some devices use a higher bus speed of 400KHz. The above Declare allows the I^2C bus speed to be increased or decreased. Use this Declare with caution, as too high a bit rate may exceed the device's specs, which will result in intermittent transactions, or in some cases, no transactions at all. The datasheet for the device used will inform you of its bus speed. The default bit rate is the standard 100KHz.

Declare HSDA_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the data line (SDA) must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare HSCL_Pin Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the clock line (SCL) must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Notes
Not all PICmicro™ devices contain an MSSP module, some only contain an SSP type, which only allows I^2C slave operations. These types of devices may not be used with any of the HBUS commands. Therefore, always read and understand the datasheet for the PICmicro™ device used.

When the **Hbusout** command is used, the appropriate SDA and SCL Port and Pin are automatically setup as inputs. On devices without PPS (Peripheral Pin Select), the SDA, and SCL lines are predetermined as hardware pins on the PICmicro™ , however, on devices with PPS, the compiler sets up the appropriate SFRs using the HSDA_Pin and HSCL_Pin declares.

See also :   HbusAck, HbRestart, HbStop, Hbusin, HbStart.

High

Syntax
High *Port* or *Port.Bit* or *Pin Number*

Overview
Place a Port or Port.Pin in a high output state. For a Port, this means setting it as an output and filling it with 1's.

Parameters
Port can be any valid port.
Port.Bit can be any valid port and bit combination, i.e. PORTA.1
Pin Number can be a variable or constant that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example 1
```
Symbol LED = PORTB.4
High LED
High 1                          ' Set Pin PORTA.1 high
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
    Device = 18F25K20
    Declare Xtal = 16

    Dim MyPin as Byte

    For MyPin = 0 to 15         ' Create a loop for the pin to flash
        High MyPin             ' Set the pin high
        DelayMs 500            ' Delay so that it can be seen
        Low MyPin             ' Pull the pin low
        DelayMs 500            ' Delay so that it can be seen
    Next
```

Notes.

Each pin numberhas a designated name. These are Pin_A0, Pin_A1, Pin_A2, Pin_B0...Pin_B7, Pin_C0...Pin_C7, Pin_D0...Pin_D7 to Pin_L7 etc... Each of the names has a relevant constant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
    Device = 18F25K20
    Declare Xtal = 16

    Dim PinNumber As Byte           ' Holds the pin number to set high and low

    Do                              ' Create an infinite loop
       PinNumber = Pin_B0           ' Give the pin number to flash (PORTB.0)
       Gosub FlashPin               ' Call the subroutine to flash the pin
       PinNumber = Pin_B1           ' Give the pin number to flash (PORTB.1)
       Gosub FlashPin               ' Call the subroutine to flash the pin
    Loop                            ' Do it forever
'
' Set a pin high then low for 500ms using a value as the pin to adjust
'
FlashPin:
    High PinNumber                  ' Set the pin output high
    DelayMs 500                     ' Wait for 500 milliseconds
    Low PinNumber                   ' Pull the pin low
    DelayMs 500                     ' Wait for 500 milliseconds
    Return
```

Example 2

```
' Clear then Set each pin of PORTC
    Device = 18F25K20
    Declare Xtal = 16

    Dim PinNumber as Byte

    Low PORTC                           ' Make PORTC output low before we start
    Do                                  ' Create a loop
      For PinNumber = Pin_C0 to Pin_C7  ' Create a loop for 8 pins
        Low PinNumber                   ' Clear each pin of PORTC
        DelayMs 100                     ' Slow things down to see what's happening
      Next                              ' Close the loop
      For PinNumber = Pin_C0 to Pin_C7  ' Create a loop for 8 pins
        High PinNumber                  ' Set each pin of PORTC
        DelayMs 100                     ' Slow things down to see what's happening
      Next                              ' Close the loop
    Loop                                ' Do it forever
```

See also :   Clear, ClearPin, Dim, Low, Set, SetPin, Symbol, GetPin.

Hpwm

Syntax
Hpwm *Channel, Dutycycle, Frequency*

Overview
Output a pulse width modulated pulse train using the CCP modules Pwm hardware, available on some PICmicros. The Pwm pulses produced can run continuously in the background while the program is executing other instructions.

Parameters
Channel is a constant value that specifies which hardware Pwm channel to use. Some devices have 1, 2 or 3 Pwm channels. On devices with 2 channels, the Frequency must be the same on both channels. It must be noted, that this is a limitation of the PICmicro™ not the compiler. The data sheet for the particular device used shows the fixed hardware pin for each Channel. For example, for a PIC16F877, Channel 1 is CCP1 which is pin PORTC.2. Channel 2 is CCP2 which is pin PORTC.1.
Dutycycle is a variable, constant (0-255), or expression that specifies the on/off (high/low) ratio of the signal. It ranges from 0 to 255, where 0 is off (low all the time) and 255 is on (high) all the time. A value of 127 gives a 50% duty cycle (square wave).
Frequency is a variable, constant (0-32767), or expression that specifies the desired frequency of the Pwm signal. Not all frequencies are available at all oscillator settings. The highest frequency at any oscillator speed is 32767Hz. The lowest usable **Hpwm** *Frequency* at each oscillator setting is shown in the table below: -

Xtal frequency	Lowest useable Pwm frequency
4MHz	145Hz
8MHz	489Hz
10MHz	611Hz
12MHz	733Hz
16MHz	977Hz
20MHz	1221Hz
24MHz	1465Hz
33MHz	2015Hz
40MHz	2442Hz

Example
```
Device = 16F1829
Declare Xtal = 20

Hpwm 1,127,1000        ' Send a 50% duty cycle Pwm signal at 1KHz
DelayMs 500
Hpwm 1,64,2000         ' Send a 25% duty cycle Pwm signal at 2KHz
Stop
```

Notes
Some devices, such as the PIC16F62x, and PIC18F4xx, have alternate pins that may be used for **Hpwm**. The following **Declares** allow the use of different pins: -

```
Declare CCP1_Pin Port.Pin    ' Select Hpwm port and bit for CCP1 module.
Declare CCP2_Pin Port.Pin    ' Select Hpwm port and bit for CCP2 module.
Declare CCP3_Pin Port.Pin    ' Select Hpwm port and bit for CCP3 module.
Declare CCP4_Pin Port.Pin    ' Select Hpwm port and bit for CCP4 module.
```

See also :   Pwm, Pulseout, Servo.

Hrsin, Hrsin2, Hrsin3, Hrsin4

Syntax
Variable = **Hrsin**, **{** *Timeout*, *Timeout Label* **}**

or

Hrsin { ** *Timeout*, *Timeout Label* **}, { *Parity Error Label* **}**, *Modifiers, Variable* {, *Variable...* }

Overview
Receive one or more values from the serial port on devices that contain a USART peripheral. If **Hrsin2**, **Hrsin3**, or **Hrsout4** are used, the device must contain more than 1 USART.

Parameters
Timeout is an *optional* value for the length of time the **Hrsin** command will wait before jumping to label *Timeout Label*. *Timeout* is specified in 1 millisecond units and has a maximum of 16-bits.

Timeout Label is an *optional* valid BASIC label where **Hrsin** will jump to in the event that a character has not been received within the time specified by *Timeout*.

Parity Error Label is an *optional* valid BASIC label where **Hrsin** will jump to in the event that a Parity error is received. Parity is set using **Declares**. Parity Error detecting is not supported in the inline version of **Hrsin** (first syntax example above).

Modifier is one of the many formatting modifiers, explained below.

Variable is a **Bit**, **Byte**, **Word**, or **Dword** variable, that will be loaded by **Hrsin**.

Example
```
' Receive values serially and timeout if no reception after 1 second
  Device 16F1829
  Declare Xtal = 4

  Declare Hserial_Baud = 9600      ' Set baud rate to 9600
  Declare Hserial_Clear = On       ' Clear the buffer before receiving
  Dim Var1 as Byte

  Do
    Var1 = Hrsin, {1000, Timeout}  ' Receive a byte serially into Var1
    HrsoutLn Dec Var1              ' Display the byte received
  Loop                            ' Loop forever

Timeout:
  HrsoutLn "Timed Out"            ' Display an error if Hrsin timed out
  Stop
```

Hrsin Modifiers.
As we already know, **Rsin** will wait for and receive a single byte of data, and store it in a variable . If the PICmicro™ were connected to a PC running a terminal program and the user pressed the "A" key on the keyboard, after the **Hrsin** command executed, the variable would contain 65, which is the ASCII code for the letter "A"

What would happen if the user pressed the "1" key? The result would be that the variable would contain the value 49 (the ASCII code for the character "1"). This is an important point to remember: every time you press a character on the keyboard, the computer receives the ASCII value of that character. It is up to the receiving side to interpret the values as necessary.

In this case, perhaps we actually wanted the variable to end up with the value 1, rather than the ASCII code 49.

The **Hrsin** command provides a modifier, called the decimal modifier, which will interpret this for us. Look at the following code: -

```
Dim SerData as Byte
Hrsin Dec SerData
```

Notice the decimal modifier in the **Hrsin** command that appears just to the left of the SerData variable. This tells **Hrsin** to convert incoming text representing decimal numbers into true decimal form and store the result in SerData. If the user running the terminal software pressed the "1", "2" and then "3" keys followed by a space or other non-numeric text, the value 123 will be stored in the variable SerData, allowing the rest of the program to perform any numeric operation on the variable.

Without the decimal modifier, however, you would have been forced to receive each character ("1", "2" and "3") separately, and then would still have to do some manual conversion to arrive at the number 123 (one hundred twenty three) before you can do the desired calculations on it.

The decimal modifier is designed to seek out text that represents decimal numbers. The characters that represent decimal numbers are the characters "0" through "9". Once the **Hrsin** command is asked to use the decimal modifier for a particular variable, it monitors the incoming serial data, looking for the first decimal character. Once it finds the first decimal character, it will continue looking for more (accumulating the entire multi-digit number) until is finds a non-decimal numeric character. Remember that it will not finish until it finds at least one decimal character followed by at least one non-decimal character.

To illustrate this further, examine the following examples (assuming we're using the same code example as above): -

Serial input: "ABC"
Result: The program halts at the **Hrsin** command, continuously waiting for decimal text.

Serial input: "123" (with no characters following it)
Result: The program halts at the **Hrsin** command. It recognises the characters "1", "2" and "3" as the number one hundred twenty three, but since no characters follow the "3", it waits continuously, since there's no way to tell whether 123 is the entire number or not.

Serial input: "123" (followed by a space character)
Result: Similar to the above example, except once the space character is received, the program knows the entire number is 123, and stores this value in SerData. The **Hrsin** command then ends, allowing the next line of code to run.

Serial input: "123A"
Result: Same as the example above. The "A" character, just like the space character, is the first non-decimal text after the number 123, indicating to the program that it has received the entire number.

Serial input: "ABCD123EFGH"
Result: Similar to examples 3 and 4 above. The characters "ABCD" are ignored (since they're not decimal text), the characters "123" are evaluated to be the number 123 and the following character, "E", indicates to the program that it has received the entire number.

The final result of the **Dec** modifier is limited to 16 bits (up to the value 65535). If a value larger than this is received by the decimal modifier, the end result will be incorrect because the result rolled-over the maximum 16-bit value. Therefore, **Hrsin** modifiers may not (at this time) be used to load **Dword** (32-bit) variables.

The decimal modifier is only one of a family of conversion modifiers available with **Hrsin** See below for a list of available conversion modifiers. All of the conversion modifiers work similar to the decimal modifier (as described above). The modifiers receive bytes of data, waiting for the first byte that falls within the range of characters they accept (e.g., "0" or "1" for binary, "0" to "9" for decimal, "0" to "9" and "A" to "F" for hex. Once they receive a numeric character, they keep accepting input until a non-numeric character arrives, or in the case of the fixed length modifiers, the maximum specified number of digits arrives.

While very effective at filtering and converting input text, the modifiers aren't completely fool-proof. As mentioned before, many conversion modifiers will keep accepting text until the first non-numeric text arrives, even if the resulting value exceeds the size of the variable. After **Hrsin**, a **Byte** variable will contain the lowest 8 bits of the value entered and a **Word** (16-bits) would contain the lowest 16 bits. You can control this to some degree by using a modifier that specifies the number of digits, such as **Dec2**, which would accept values only in the range of 0 to 99.

Conversion Modifier	Type of Number Numeric	Characters Accepted
Dec{0..10}	Decimal, optionally limited to 0 - 10 digits	0 through 9
Hex{1..8}	Hexadecimal, optionally limited to 1 - 8 digits	0 through 9, A through F
Bin{1..32}	Binary, optionally limited to 1 - 32 digits	0, 1

A variable preceded by **Bin** will receive the ASCII representation of its binary value.
For example, if **Bin** Var1 is specified and "1000" is received, Var1 will be set to 8.

A variable preceded by **Dec** will receive the ASCII representation of its decimal value.
For example, if **Dec** Var1 is specified and "123" is received, Var1 will be set to 123.

A variable preceded by **Hex** will receive the ASCII representation of its hexadecimal value.
For example, if **Hex** Var1 is specified and "FE" is received, Var1 will be set to 254.

SKIP followed by a count will skip that many characters in the input stream.
For example, **SKIP** 4 will skip 4 characters.

The **Hrsin** command can be configured to wait for a specified sequence of characters before it retrieves any additional input. For example, suppose a device attached to the PICmicro™ is known to send many different sequences of data, but the only data you wish to observe happens to appear right after the unique characters, "XYZ". A modifier named **Wait** can be used for this purpose: -

```
Hrsin Wait("XYZ"), SerData
```

The above code waits for the characters "X", "Y" and "Z" to be received, in that order, then it receives the next data byte and places it into variable SerData.

Str modifier.
The **Hrsin** command also has a modifier for handling a string of characters, named **Str**.

The **Str** modifier is used for receiving a string of characters into a byte array variable.

A string is a set of characters that are arranged or accessed in a certain order. The characters "ABC" would be stored in a string with the "A" first, followed by the "B" then followed by the "C". A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string "ABC" would be stored in a byte array containing three bytes (elements).

Below is an example that receives ten bytes and stores them in the 10-byte array, SERString: -

```
Dim SerString[10] as Byte      ' Create a 10-byte array.
Hrsin Str SerString            ' Fill the array with received data.
Print Str SerString            ' Display the string.
```

If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. For example: -

```
Dim SerString[10] as Byte      ' Create a 10-byte array.
Hrsin Str SerString\5          ' Fill the first 5-bytes of the array
Print Str SerString\5          ' Display the 5-character string.
```

The example above illustrates how to fill only the first *n* bytes of an array, and then how to display only the first *n* bytes of the array. *n* refers to the value placed after the backslash.

Because of its complexity, serial communication can be rather difficult to work with at times. Using the guidelines below when developing a project using the **Hrsin** and **Hrsout** commands may help to eliminate some obvious errors: -

Always build your project in steps.
Start with small, manageable pieces of code, (that deal with serial communication) and test them, one individually.
Add more and more small pieces, testing them each time, as you go.
Never write a large portion of code that works with serial communication without testing its smallest workable pieces first.

Pay attention to timing.
Be careful to calculate and overestimate the amount of time, operations should take within the PICmicro™ for a given oscillator frequency. Misunderstanding the timing constraints is the source of most problems with code that communicate serially. If the serial communication in your project is bi-directional, the above statement is even more critical.

Pay attention to wiring.
Take extra time to study and verify serial communication wiring diagrams. A mistake in wiring can cause strange problems in communication, or no communication at all. Make sure to connect the ground pins (Vss) between the devices that are communicating serially.

Verify port setting on the PC and in the Hrsin / Hrsout commands.
Unmatched settings on the sender and receiver side will cause garbled data transfers or no data transfers. This is never more critical than when a line transceiver is used(i.e. MAX232). Always remember that a line transceiver inverts the serial polarity.
If the serial data received is unreadable, it is most likely caused by a baud rate setting error, or a polarity error.

If receiving data from another device that is not a PICmicro™, try to use baud rates of 9600 and below, or alternatively, use a higher frequency crystal.

Because of additional overheads in the PICmicro™, and the fact that the **Hrsin** command only offers a 2 level receive buffer for serial communication, received data may sometimes be missed or garbled. If this occurs, try lowering the baud rate, or increasing the crystal frequency. Using simple variables (not arrays) will also increase the chance that the PICmicro™ will receive the data properly.

Declares

There are six Declare directives for use with **Hrsin**. These are: -

Declare Hrsin_Pin, **Hrsin2_Pin**, **Hrsin3_Pin**, or **Hrsin4_Pin** Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the RX lines must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial_Baud, **Hserial2_Baud**, **Hserial3_Baud**, or **Hserial4_Baud** Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program.

Declare Hserial_RCSTA, **Hserial2_RCSTA**, **Hserial3_RCSTA**, or **Hserial4_RCSTA** Constant value (0 to 255)
Sets the respective PICmicro™ hardware register RCSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register.

Declare Hserial_TXSTA, **Hserial2_TXSTA**, **Hserial3_TXSTA**, or **Hserial4_TXSTA** Constant value (0 to 255)
Sets the respective PICmicro™ hardware register, TXSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register. The TXSTA register BRGH bit (bit-2) controls the high speed mode for the baud rate generator. Certain baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial_TXSTA** to a value of $24 instead of the normal $20.

Declare Hserial_Parity, **Hserial2_Parity**, **Hserial3_Parity**, or **Hserial4_Parity Odd** or **Even**
Enables/Disables parity on the serial port. For both **Hserout** and **Hserin** The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial_Parity** declare.

```
Declare Hserial_Parity = Even    ' Use if even parity desired
Declare Hserial_Parity = Odd     ' Use if odd parity desired
```

Declare Hserial_Clear, **Hserial2_Clear**, **Hserial3_Clear**, or **Hserial4_Clear** On or Off
Clear the overflow error bit before commencing a read.

Because the hardware serial port only has a 2-byte input buffer, it can easily overflow if bytes are not read from it often enough. When this occurs, the USART stops accepting any new bytes, and requires resetting. This overflow error can be reset by strobing the CREN bit within the RCSTA register.

Example: -
```
RCSTA.4 = 0
RCSTA.4 = 1
```
or
```
Clear RCSTA.4
Set RCSTA.4
```

Alternatively, the **Hserial_Clear** declare can be used to automatically clear this error, even if no error occurred. However, the program will not know if an error occurred while reading, therefore some characters may be lost.

```
Declare Hserial_Clear = On
```

Notes

Hrsin can only be used with devices that contain a hardware USART. See the specific device's data sheet for further information concerning the serial input pin as well as other relevant parameters.

Since the serial transmission is done in hardware, it is not possible to set the levels to an inverted state to eliminate an RS232 driver. Therefore a suitable driver should be used with **Hrsin**. Just such a circuit using a MAX232 is shown below.
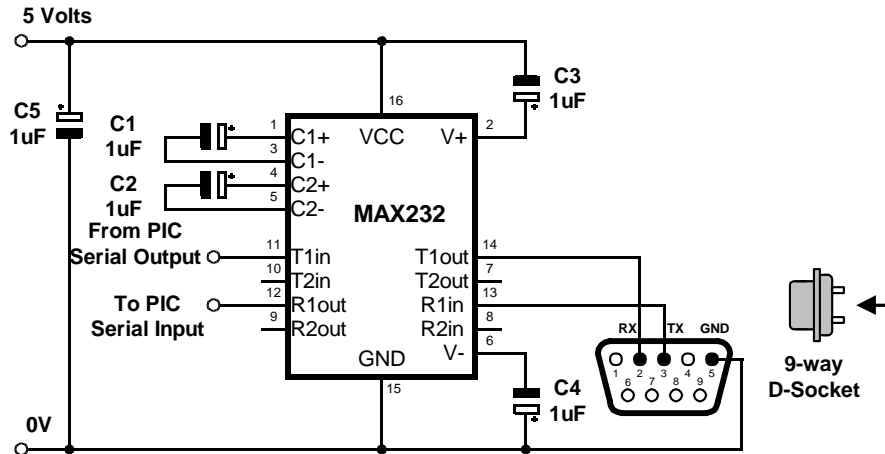
A simpler, and somewhat more elegant transceiver circuit using only 5 discrete components is shown in the diagram below.
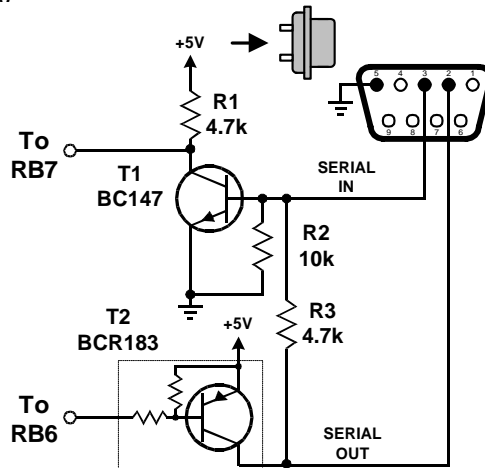
See also : Declare, Rsin, Rsout, Serin, Serout, Hrsout, Hserin, Hserout.

Hrsout, Hrsout2, Hrsout3, Hrsout4

Syntax
Hrsout *Item* {, *Item...* }

Overview
Transmit one or more *Item*s from the hardware serial port on devices that contain a USART peripheral. If **Hrsout2**, **Hrsout3**, or **Hrsout4** are used, the device must contain more than 1 USART.

Parameters
Item may be a constant, variable, expression, string list, or inline command.
There are no operators as such, instead there are *modifiers*.

The modifiers are listed below: -

Modifier	Operation
At ypos,xpos	Position the cursor on a serial LCD
Cls	Clear a serial LCD (also creates a 30ms delay)
Bin{1..32}	Send binary digits
Dec{0..10}	Send decimal digits (amount of digits after decimal point with floating point)
Hex{1..8}	Send hexadecimal digits
Sbin{1..32}	Send signed binary digits
Sdec{0..10}	Send signed decimal digits
Shex{1..8}	Send signed hexadecimal digits
Ibin{1..32}	Send binary digits with a preceding '%' identifier
Idec{0..10}	Send decimal digits with a preceding '#' identifier
Ihex{1..8}	Send hexadecimal digits with a preceding '$' identifier
ISbin{1..32}	Send signed binary digits with a preceding '%' identifier
ISdec{0..10}	Send signed decimal digits with a preceding '#' identifier
IShex{1..8}	Send signed hexadecimal digits with a preceding '$' identifier
Rep c\n	Send character c repeated n times
Str array\n	Send all or part of an array
Cstr cdata	Send string data defined in a Cdata statement.

The numbers after the **Bin**, **Dec**, and **Hex** modifiers are optional. If they are omitted, then the default is all the digits that make up the value will be displayed.

If a floating point variable is to be displayed, then the digits after the **Dec** modifier determine how many remainder digits are send. i.e. numbers after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.145
Hrsout Dec2 MyFloat      ' Send 2 digits after the decimal point
```

The above program will transmit the ASCII characters "3.14"

If the digit after the **Dec** modifier is omitted, then 3 digits will be displayed after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.1456
Hrsout Dec MyFloat    ' Send 3 digits after the decimal point
```

The above program will transmit the ASCII characters "3.145"

There is no need to use the **Sdec** modifier for signed floating point values, as the compiler's **Dec** modifier will automatically display a minus result: -

```
Dim MyFloat as Float
MyFloat = -3.1456
Hrsout Dec MyFloat    ' Send 3 digits after the decimal point
```

The above program will transmit the ASCII characters "-3.145"

Hex or **Bin** modifiers cannot be used with floating point values or variables.

The Xpos and Ypos values in the **At** modifier both start at 1. For example, to place the text "Hello World" on line 1, position 1, the code would be: -

```
Hrsout At 1, 1, "Hello World"
```

Example 1
```
Dim Var1 as Byte
Dim Wrd as Word
Dim Dwd as Dword

Hrsout "Hello World"      ' Display the text "Hello World"
Hrsout "Var1= ", Dec Var1 ' Display the decimal value of Var1
Hrsout "Var1= ", Hex Var1 ' Display the hexadecimal value of Var1
Hrsout "Var1= ", Bin Var1 ' Display the binary value of Var1
Hrsout "Dwd= ", Hex6 Dwd  ' Display 6 hex characters of a Dword variable
```

Example 2
```
' Display a negative value on a serial LCD.
Symbol Negative = -200
Hrsout At 1, 1, Sdec Negative
```

Example 3
```
' Display a negative value on a serial LCD with a preceding identifier.
Hrsout At 1, 1, IShex -$1234
```

Example 3 will produce the text "$-1234" on the LCD.

Some microcontrollers have the ability to read and write to their own flash memory. And although writing to this memory too many times is unhealthy for the PICmicro™, reading this memory is both fast, and harmless. Which offers a unique form of data storage and retrieval, the **Cdata** command proves this, as it uses the mechanism of reading and storing in the device's flash memory.

The **Cstr** modifier may be used in commands that deal with text processing i.e. **Serout**, **Hserout**, and **Print** etc.

The **Cstr** modifier is used in conjunction with the **Cdata** command. The **Cdata** command is used for initially creating the string of characters: -

```
String1: Cdata "Hello World", 0
```

The above line of case will create, in flash memory, the values that make up the ASCII text "Hello World", at address String1. Note the null terminator after the ASCII text.

null terminated means that a zero (null) is placed at the end of the string of ASCII characters to signal that the string has finished.

To display, or transmit this string of characters, the following command structure could be used:

```
Hrsout Cstr String1
```

The label that declared the address where the list of **Cdata** values resided, now becomes the string's name. In a large program with lots of text formatting, this type of structure can save quite literally hundreds of bytes of valuable code space.

The **Str** modifier is used for sending a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that displays four bytes (from a byte array): -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
MyArray [0] = "H"                ' Load the first 5 bytes of the array
MyArray [1] = "e"                ' With the data to send
MyArray [2] = "l"
MyArray [3] = "l"
MyArray [4] = "o"
Hrsout Str MyArray\5           ' Display a 5-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the PICmicro™ would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 5 bytes.

The above example may also be written as: -

```
Dim MyArray [10] as Byte      ' Create a 10-byte array.
Str MyArray = "Hello"          ' Load the first 5 bytes of the array
Hrsout Str MyArray\5          ' Send 5-byte string.
```

The above example, has exactly the same function as the previous one. The only difference is that the string is now constructed using **Str** as a command instead of a modifier.

Declares

There are five **Declare** directives for use with **Hrsout**. These are: -

Declare Hrsout_Pin, **Hrsout2_Pin**, **Hrsout3_Pin**, or **Hrsout4_Pin** Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the TX lines must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial_Baud, **Hserial2_Baud**, **Hserial3_Baud**, or **Hserial4_Baud** Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program.

Declare Hserial_RCSTA, **Hserial2_RCSTA**, **Hserial3_RCSTA**, or **Hserial4_RCSTA** Constant value (0 to 255)
Sets the respective PICmicro™ hardware register RCSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register.

Declare Hserial_TXSTA, **Hserial2_TXSTA**, **Hserial3_TXSTA**, or **Hserial4_TXSTA** Constant value (0 to 255)
Sets the respective PICmicro™ hardware register, TXSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register. The TXSTA register BRGH bit (bit-2) controls the high speed mode for the baud rate generator. Certain baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial_TXSTA** to a value of $24 instead of the normal $20.

Declare Hserial_Parity, **Hserial2_Parity**, **Hserial3_Parity**, or **Hserial4_Parity Odd** or **Even**
Enables/Disables parity on the serial port. For both **Hserout** and **Hserin** The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial_Parity** declare.

```
Declare Hserial_Parity = Even      ' Use if even parity desired
Declare Hserial_Parity = Odd       ' Use if odd parity desired
```

Notes
Hrsout can only be used with devices that contain a hardware USART. See the specific device's data sheet for further information concerning the serial input pin as well as other relevant parameters.

Since the serial transmission is done in hardware, it is not possible to set the levels to an inverted state in order to eliminate an RS232 driver. Therefore a suitable driver should be used with **Hrsout**. See **Hrsin** for circuits.

See also : **Declare, Rsin, Rsout, Serin, Serout, Hrsin, Hserin, Hserout.**

HrsoutLn, Hrsout2Ln, Hrsout3Ln, Hrsout4Ln

Syntax
HrsoutLn *Item* {, *Item...* }
Hrsout2Ln *Item* {, *Item...* }
Hrsout3Ln *Item* {, *Item...* }
Hrsout4Ln *Item* {, *Item...* }

Overview
Transmit one or more *Ite*ms from the hardware serial port on devices that contain one or more USART peripherals and terminate with a Carriage Return(13) or Carriage Return(13) Line Feed(10) or Line Feed(10) Carriage Return(13). The syntax and operators are exactly the same as **Hrsout**, **Hrsout2**, **Hrsout3** and **Hrsout4**. If **Hrsout2Ln**, **Hrsout3Ln**, or **Hrsout4Ln** are used, the device must contain more than 1 USART.

Parameters
Item may be a constant, variable, expression, string list, or inline command.
There are no operators as such, instead there are *modifiers*. See the section for **Hrsout** for more details.

Declares
There are 4 declares for the HrsoutXLn commands. Each one is for the particular command.

```
Declare Hserial1_Terminator = CRLF or LFCR or CR
Declare Hserial2_Terminator = CRLF or LFCR or CR
Declare Hserial3_Terminator = CRLF or LFCR or CR
Declare Hserial4_Terminator = CRLF or LFCR or CR
```

The parameter **CR** will transmit a single value of 13 at the end of transmission.
The parameter **CRLF** will transmit a value of 13 then 10 at the end of transmission.
The parameter **LFCR** will transmit a value of 10 then 13 at the end of transmission.

See also : Declare, Rsin, Rsout, Serin, Serout, Hrsout, Hrsin, Hserin, Hserout.

Hserin, Hserin2, Hserin3, Hserin4

Syntax
Hserin *Timeout*, *Timeout Label*, *Parity Error Label*, **[***Modifiers, Variable* {, *Variable... *}**]**

Overview
Receive one or more values from the serial port on devices that contain a USART peripheral. If **Hserin2**, **Hserin3**, or **Hserin4** are used, the device must contain more than 1 USART.

Parameters
Timeout is an *optional* value for the length of time the **Hserin** command will wait before jumping to label ***Timeout Label***. ***Timeout*** is specified in 1 millisecond units and has a maximum of 16-bits.
Timeout Label is an optional valid BASIC label where **Hserin** will jump to in the event that a character has not been received within the time specified by ***Timeout***.
Parity Error Label is an optional valid BASIC label where **Hserin** will jump to in the event that a Parity error is received. Parity is set using **Declares**. Parity Error detecting is not supported in the inline version of **Hserin** (first syntax example above).
Modifier is one of the many formatting modifiers, explained below.
Variable is a **Bit**, **Byte**, **Word**, or **Dword** variable, that will be loaded by **Hserin**.

Example
```
' Receive values serially and timeout if no reception after 1 second
  Device 16F1829
  Declare Xtal = 4

  Declare Hserial_Baud = 9600       ' Set baud rate to 9600
  Declare Hserial_Clear = On        ' Clear the buffer before receiving
  Dim Var1 as Byte

  Do
    Hserin 1000, Timeout, [Var1]    ' Receive a byte serially into Var1
    HrsoutLn Dec Var1               ' Display the byte received
  Loop                              ' Loop forever

Timeout:
  HrsoutLn "Timed Out"              ' Display an error if Hserin timed out
  Stop
```

Hserin Modifiers.
As we already know, **Hserin** will wait for and receive a single byte of data, and store it in a variable . If the microcontroller was connected to a PC running a terminal program and the user pressed the "A" key on the keyboard, after the **Hserin** command executed, the variable would contain 65, which is the ASCII code for the letter "A"

What would happen if the user pressed the "1" key? The result would be that the variable would contain the value 49 (the ASCII code for the character "1"). This is an important point to remember: every time you press a character on the keyboard, the computer receives the ASCII value of that character. It is up to the receiving side to interpret the values as necessary. In this case, perhaps we actually wanted the variable to end up with the value 1, rather than the ASCII code 49.

The **Hserin** command provides a modifier, called the decimal modifier, which will interpret this for us. Look at the following code: -

```
Dim SerData as Byte
Hserin [Dec SerData]
```

Notice the decimal modifier in the **Hserin** command that appears just to the left of the SerData variable. This tells **Hserin** to convert incoming text representing decimal numbers into true decimal form and store the result in SerData. If the user running the terminal software pressed the "1", "2" and then "3" keys followed by a space or other non-numeric text, the value 123 will be stored in the variable SerData, allowing the rest of the program to perform any numeric operation on the variable.

Without the decimal modifier, however, you would have been forced to receive each character ("1", "2" and "3") separately, and then would still have to do some manual conversion to arrive at the number 123 (one hundred twenty three) before you can do the desired calculations on it.

The decimal modifier is designed to seek out text that represents decimal numbers. The characters that represent decimal numbers are the characters "0" through "9". Once the **Hserin** command is asked to use the decimal modifier for a particular variable, it monitors the incoming serial data, looking for the first decimal character. Once it finds the first decimal character, it will continue looking for more (accumulating the entire multi-digit number) until is finds a non-decimal numeric character. Remember that it will not finish until it finds at least one decimal character followed by at least one non-decimal character.

To illustrate this further, examine the following examples (assuming we're using the same code example as above): -

Serial input: "ABC"
Result: The program halts at the **Hserin** command, continuously waiting for decimal text.

Serial input: "123" (with no characters following it)
Result: The program halts at the **Hserin** command. It recognises the characters "1", "2" and "3" as the number one hundred twenty three, but since no characters follow the "3", it waits continuously, since there's no way to tell whether 123 is the entire number or not.

Serial input: "123" (followed by a space character)
Result: Similar to the above example, except once the space character is received, the program knows the entire number is 123, and stores this value in SerData. The **Hserin** command then ends, allowing the next line of code to run.

Serial input: "123A"
Result: Same as the example above. The "A" character, just like the space character, is the first non-decimal text after the number 123, indicating to the program that it has received the entire number.

Serial input: "ABCD123EFGH"
Result: Similar to examples 3 and 4 above. The characters "ABCD" are ignored (since they're not decimal text), the characters "123" are evaluated to be the number 123 and the following character, "E", indicates to the program that it has received the entire number.

The final result of the **Dec** modifier is limited to 16 bits (up to the value 65535). If a value larger than this is received by the decimal modifier, the end result will be incorrect because the

result rolled-over the maximum 16-bit value. Therefore, **Hserin** modifiers may not (at this time) be used to load **Dword** (32-bit) variables.

The decimal modifier is only one of a family of conversion modifiers available with **Hserin** See below for a list of available conversion modifiers. All of the conversion modifiers work similar to the decimal modifier (as described above). The modifiers receive bytes of data, waiting for the first byte that falls within the range of characters they accept (e.g., "0" or "1" for binary, "0" to "9" for decimal, "0" to "9" and "A" to "F" for hex. Once they receive a numeric character, they keep accepting input until a non-numeric character arrives, or in the case of the fixed length modifiers, the maximum specified number of digits arrives.

While very effective at filtering and converting input text, the modifiers aren't completely fool-proof. As mentioned before, many conversion modifiers will keep accepting text until the first non-numeric text arrives, even if the resulting value exceeds the size of the variable. After **Hserin,** a **Byte** variable will contain the lowest 8 bits of the value entered and a **Word** (16-bits) would contain the lowest 16 bits. You can control this to some degree by using a modifier that specifies the number of digits, such as **Dec2**, which would accept values only in the range of 0 to 99.

Conversion Modifier	Type of Number Numeric	Characters Accepted
Dec{0..10}	Decimal, optionally limited to 0 - 10 digits	0 through 9
Hex{1..8}	Hexadecimal, optionally limited to 1 - 8 digits	0 through 9, A through F
Bin{1..32}	Binary, optionally limited to 1 - 32 digits	0, 1

A variable preceded by **Bin** will receive the ASCII representation of its binary value.
For example, if **Bin** Var1 is specified and "1000" is received, Var1 will be set to 8.

A variable preceded by **Dec** will receive the ASCII representation of its decimal value.
For example, if **Dec** Var1 is specified and "123" is received, Var1 will be set to 123.

A variable preceded by **Hex** will receive the ASCII representation of its hexadecimal value.
For example, if **Hex** Var1 is specified and "FE" is received, Var1 will be set to 254.

Skip followed by a count will skip that many characters in the input stream.
For example, **Skip** 4 will skip 4 characters.

The **Hserin** command can be configured to wait for a specified sequence of characters before it retrieves any additional input. For example, suppose a device attached to the PICmicro™ is known to send many different sequences of data, but the only data you wish to observe happens to appear right after the unique characters, "XYZ". A modifier named **Wait** can be used for this purpose: -

```
Hserin [Wait("XYZ"), SerData]
```

The above code waits for the characters "X", "Y" and "Z" to be received, in that order, then it receives the next data byte and places it into variable SerData.

Str modifier.

The **Hserin** command also has a modifier for handling a string of characters, named **Str**.

The **Str** modifier is used for receiving a string of characters into a byte array variable.

A string is a set of characters that are arranged or accessed in a certain order. The characters "ABC" would be stored in a string with the "A" first, followed by the "B" then followed by the "C". A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string "ABC" would be stored in a byte array containing three bytes (elements).

Below is an example that receives ten bytes and stores them in the 10-byte array, SerString: -

```
Dim SerString[10] as Byte     ' Create a 10-byte array.
Hserin [Str SerString]          ' Fill the array with received data.
Print Str SerString             ' Display the string.
```

If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. For example: -

```
Dim SerString[10] as Byte     ' Create a 10-byte array.
Hserin [Str SerString\5]         ' Fill the first 5-bytes of the array
Print Str SerString\5            ' Display the 5-character string.
```

The example above illustrates how to fill only the first *n* bytes of an array, and then how to display only the first *n* bytes of the array. *n* refers to the value placed after the backslash.

Because of its complexity, serial communication can be rather difficult to work with at times. Using the guidelines below when developing a project using the **Hserin** and Hserout commands may help to eliminate some obvious errors: -

Always build your project in steps.
Start with small, manageable pieces of code, (that deal with serial communication) and test them, one individually.
Add more and more small pieces, testing them each time, as you go.
Never write a large portion of code that works with serial communication without testing its smallest workable pieces first.

Pay attention to timing.
Be careful to calculate and overestimate the amount of time, operations should take within the PICmicro™ for a given oscillator frequency. Misunderstanding the timing constraints is the source of most problems with code that communicate serially. If the serial communication in your project is bi-directional, the above statement is even more critical.

Pay attention to wiring.
Take extra time to study and verify serial communication wiring diagrams. A mistake in wiring can cause strange problems in communication, or no communication at all. Make sure to connect the ground pins (Vss) between the devices that are communicating serially.

Verify port setting on the PC and in the Hserin / Hserout commands.
Unmatched settings on the sender and receiver side will cause garbled data transfers or no data transfers. This is never more critical than when a line transceiver is used(i.e. MAX232). Always remember that a line transceiver inverts the serial polarity.
If the serial data received is unreadable, it is most likely caused by a baud rate setting error, or a polarity error.

If receiving data from another device that is not a PICmicro™, try to use baud rates of 9600 and below, or alternatively, use a higher frequency crystal.
Because of additional overheads in the PICmicro™, and the fact that the **Hserin** command offers a 2 level hardware receive buffer for serial communication, received data may sometimes be missed or garbled. If this occurs, try lowering the baud rate, or increasing the crystal frequency. Using simple variables (not arrays) will also increase the chance that the PICmicro™ will receive the data properly.

Declares
There are six Declare directives for use with **Hserin** . These are: -

Declare Hserin_Pin, **Hserin2_Pin**, **Hserin3_Pin**, or **Hserin4_Pin** Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the RX lines must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial_Baud, **Hserial2_Baud**, **Hserial3_Baud**, or **Hserial4_Baud** Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program.

Declare Hserial_RCSTA, **Hserial2_RCSTA**, **Hserial3_RCSTA**, or **Hserial4_RCSTA** Constant value (0 to 255)
Sets the respective PICmicro™ hardware register RCSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register.

Declare Hserial_TXSTA, **Hserial2_TXSTA**, **Hserial3_TXSTA**, or **Hserial4_TXSTA** Constant value (0 to 255)
Sets the respective PICmicro™ hardware register, TXSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register. The TXSTA register BRGH bit (bit-2) controls the high speed mode for the baud rate generator. Certain baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial_TXSTA** to a value of $24 instead of the normal $20.

Declare Hserial_Parity, **Hserial2_Parity**, **Hserial3_Parity**, or **Hserial4_Parity Odd** or **Even**
Enables/Disables parity on the serial port. For both **Hserout** and **Hserin** The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial_Parity** declare.

```
Declare Hserial_Parity = Even      ' Use if even parity desired
Declare Hserial_Parity = Odd       ' Use if odd parity desired
```

Declare Hserial_Clear, **Hserial2_Clear**, **Hserial3_Clear**, or **Hserial4_Clear** On or Off
Clear the overflow error bit before commencing a read.

Because the hardware serial port only has a 2-byte input buffer, it can easily overflow is characters are not read from it often enough. When this occurs, the USART stops accepting any new characters, and requires resetting. This overflow error can be reset by strobing the CREN bit within the RCSTA register.

Example: -
```
   RCSTA.4 = 0
   RCSTA.4 = 1
```
or
```
   Clear RCSTA.4
   Set RCSTA.4
```

Alternatively, the **Hserial_Clear** declare can be used to automatically clear this error, even if no error occurred. However, the program will not know if an error occurred while reading, therefore some characters may be lost.

```
   Declare Hserial_Clear = On
```

Notes
Hserin can only be used with devices that contain a hardware USART. See the specific device's data sheet for further information concerning the serial input pin as well as other relevant parameters.

Since the serial transmission is done in hardware, it is not possible to set the levels to an inverted state to eliminate an RS232 driver. Therefore a suitable driver should be used with **Hserin** . See **Hrsin** for suitable circuits.

See also : **Declare, Hserout, Hrsin, Hrsout, Rsin, Rsout, Serin, Serout.**

Hserout, Hserout2, Hserout3, Hserout4

Syntax
Hserout [*Item* {, *Item...* }**]**
Hserout2 [*Item* {, *Item...* }**]**
Hserout3 [*Item* {, *Item...* }**]**
Hserout4 [*Item* {, *Item...* }**]**

Overview
Transmit one or more *Item*s from the hardware serial port on devices that contains one or more USART peripherals. If **Hserout2**, **Hserout3**, or **Hserout4** are used, the device must contain more than 1 USART.

Parameters
Item may be a constant, variable, expression, string list, or inline command.
There are no operators as such, instead there are *modifiers*. For example, if an at sign'@' precedes an *Ite*m, the ASCII representation for each digit is transmitted.

The modifiers are listed below: -

Modifier	Operation
At ypos,xpos	Position the cursor on a serial LCD
Cls	Clear a serial LCD (also creates a 30ms delay)
Bin{1..32}	Send binary digits
Dec{0..10}	Send decimal digits (amount of digits after decimal point with floating point)
Hex{1..8}	Send hexadecimal digits
Sbin{1..32}	Send signed binary digits
Sdec{0..10}	Send signed decimal digits
Shex{1..8}	Send signed hexadecimal digits
Ibin{1..32}	Send binary digits with a preceding '%' identifier
Idec{0..10}	Send decimal digits with a preceding '#' identifier
Ihex{1..8}	Send hexadecimal digits with a preceding '$' identifier
ISbin{1..32}	Send signed binary digits with a preceding '%' identifier
ISdec{0..10}	Send signed decimal digits with a preceding '#' identifier
IShex{1..8}	Send signed hexadecimal digits with a preceding '$' identifier
Rep c\n	Send character c repeated n times
Str array\n	Send all or part of an array
Cstr cdata	Send string data defined in a Cdata statement.

The numbers after the **Bin**, **Dec**, and **Hex** modifiers are optional. If they are omitted, then the default is all the digits that make up the value will be displayed.

If a floating point variable is to be displayed, then the digits after the **Dec** modifier determine how many remainder digits are send. i.e. numbers after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.145
Hserout [Dec2 MyFloat]      ' Send 2 values after the decimal point
```

The above program will send 3.14

If the digit after the **Dec** modifier is omitted, then 3 values will be displayed after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.1456
Hserout [Dec MyFloat]   ' Send 3 values after the decimal point
```

The above program will send 3.145

There is no need to use the **SDec** modifier for signed floating point values, as the compiler's **Dec** modifier will automatically display a minus result: -

```
Dim MyFloat as Float
MyFloat = -3.1456
Hserout [Dec MyFloat]    ' Send 3 values after the decimal point
```

The above program will send -3.145

Hex or **Bin** modifiers cannot be used with floating point values or variables.

The Xpos and Ypos values in the **At** modifier both start at 1. For example, to place the text "HELLO WORLD" on line 1, position 1, the code would be: -

```
Hserout [At 1, 1, "HELLO WORLD"]
```

Example 1
```
Dim Var1 as Byte
Dim Wrd as Word
Dim Dwd as Dword

Hserout ["Hello World"]          ' Display the text "Hello World"
Hserout ["Var1= ", Dec Var1]    ' Display the decimal value of Var1
Hserout ["Var1= ", Hex Var1]    ' Display the hexadecimal value of Var1
Hserout ["Var1= ", Bin Var1]    ' Display the binary value of Var1
'
' Display 6 hex characters of a Dword type variable
'
Hserout ["Dwd= ", Hex6 Dwd]
```

Example 2
```
' Display a negative value on a serial LCD.
Symbol Negative = -200
Hserout [At 1, 1, Sdec Negative]
```

Example 3
```
' Display a negative value on a serial LCD with a preceding identifier.
Hserout [At 1, 1, IShex -$1234]
```

Example 3 will produce the text "$-1234" on the LCD.

Some PICmicros™ have the ability to read and write to their own flash memory. And although writing to this memory too many times is unhealthy for the PICmicro™, reading this memory is both fast, and harmless.

Which offers a unique form of data storage and retrieval, the Cdata command proves this, as it uses the mechanism of reading and storing in the PICmicro's™ flash memory.

Combining the unique features of the 'self modifying PICmicro's™' with a string format, the compiler is capable of reducing the overhead of printing, or transmitting large amounts of text data. The **Cstr** modifier may be used in commands that deal with text processing i.e. Serout, Hrsout, and Print etc.

The **Cstr** modifier is used in conjunction with the **Cdata** directive. The **Cdata** directive is used for initially creating the string of characters: -

```
String1: Cdata "HELLO WORLD", 0
```

The above line of case will create, in flash memory, the values that make up the ASCII text "HELLO WORLD", at address String1. Note the null terminator after the ASCII text.

"Null terminated" means that a zero (null) is placed at the end of the string of ASCII characters to signal that the string has finished.

To display, or transmit this string of characters, the following command structure could be used:

```
Hserout [Cstr String1]
```

The label that declared the address where the list of **Cdata** values resided, now becomes the string's name. In a large program with lots of text formatting, this type of structure can save quite literally hundreds of bytes of valuable code space.

Try both these small programs, and you'll see that using **Cstr** saves a few bytes of code: -

First the standard way of displaying text: -

```
Device = 16F1829
Hserout ["HELLO WORLD",13]
Hserout ["HOW ARE YOU?",13]
Hserout ["I AM FINE!",13]
Stop
```

Now using the **Cstr** modifier: -

```
Hserout [Cstr TEXT1]
Hserout [Cstr TEXT2]
Hserout [Cstr TEXT3]
Stop

TEXT1: Cdata "HELLO WORLD", 13, 0
TEXT2: Cdata "HOW ARE YOU?", 13, 0
TEXT3: Cdata "I AM FINE!", 13, 0
```

Again, note the null terminators after the ASCII text in the Cdata commands. Without these, the microcontroller will continue to transmit data in an endless loop.

The term 'virtual string' relates to the fact that a string formed from the **Cdata** command cannot be written too, but only read from.

The **Str** modifier is used for sending a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that displays four bytes (from a byte array): -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
MyArray [0] = "H"              ' Load the first 5 bytes of the array
MyArray [1] = "E"              ' With the data to send
MyArray [2] = "L"
MyArray [3] = "L"
MyArray [4] = "O"
Hserout [Str MyArray\5]        ' Display a 5-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the PICmicro™ would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 5 bytes.

The above example may also be written as: -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
Str MyArray = "HELLO"          ' Load the first 5 bytes of the array
Hserout [Str MyArray\5]        ' Send 5-byte string.
```

The above example, has exactly the same function as the previous one. The only difference is that the string is now constructed using **Str** as a command instead of a modifier.

Declares

There are five Declare directives for use with **Hserout**, **Hserout2**, **Hserout3**, and **Hserout4**. These are: -

Declare Hserout_Pin, **Hserout2_Pin**, **Hserout3_Pin**, or **Hserout4_Pin** Port **.** Pin
For devices that have PPS (Peripheral Pin Select), the port and pin used for the TX lines must be given, so that the compiler can seup the PPS SFRs before the program starts. This may be any valid port on the microcontroller, but check the datasheet to see if the Port is valid for the peripheral.

Declare Hserial_Baud, **Hserial2_Baud**, **Hserial3_Baud**, or **Hserial4_Baud** Constant value
Sets the Baud rate that will be used to transmit a value serially. The baud rate is calculated using the **Xtal** frequency declared in the program.

Declare Hserial_RCSTA, **Hserial2_RCSTA**, **Hserial3_RCSTA**, or **Hserial4_RCSTA** Constant value (0 to 255)
Hserial_RCSTA, sets the respective PICmicro™ hardware register RCSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register.

Declare Hserial_TXSTA, Hserial2_TXSTA, Hserial3_TXSTA, or **Hserial4_TXSTA** Constant value (0 to 255)

Hserial_TXSTA, sets the respective PICmicro™ hardware register, TXSTA, to the value in the **Declare**. See the Microchip data sheet for the device used for more information regarding this register. The TXSTA register BRGH bit (bit-2) controls the high speed mode for the baud rate generator. Certain baud rates at certain oscillator speeds require this bit to be set to operate properly. To do this, set **Hserial_TXSTA** to a value of $24 instead of the normal $20.

Declare Hserial_Parity, Hserial2_Parity, Hserial3_Parity, or Hserial4_Parity Odd or Even
Enables/Disables parity on the serial port. For both **Hserout** and **Hserin** The default serial data format is 8N1, 8 data bits, no parity bit and 1 stop bit. 7E1 (7 data bits, even parity, 1 stop bit) or 7O1 (7data bits, odd parity, 1 stop bit) may be enabled using the **Hserial_Parity** declare.

```
Declare Hserial_Parity = Even     ' Use if even parity desired
Declare Hserial_Parity = Odd      ' Use if odd parity desired
```

Notes
Hserout can only be used with devices that contain a hardware USART. See the specific device's data sheet for further information concerning the serial input pin as well as other relevant parameters.

Since the serial transmission is done in hardware, it is not possible to set the levels to an inverted state in order to eliminate an RS232 driver. Therefore a suitable driver should be used with **Hserout** . See **Hrsin** for circuit examples

See also :Declare, Rsin, Rsout, Serin, Serout, Hserin, Hserin2, Hserin3, Hserin4.

HseroutLn, Hserout2Ln, Hserout3Ln, Hserout4Ln

Syntax
HseroutLn [*Item* {, *Item...* }**]**
Hserout2Ln [*Item* {, *Item...* }**]**
Hserout3Ln [*Item* {, *Item...* }**]**
Hserout4Ln [*Item* {, *Item...* }**]**

Overview
Transmit one or more *Item*s from the hardware serial port on devices that contain one or more USART peripherals and terminate with a Carriage Return(13) or Carriage Return(13) Line Feed(10) or Line Feed(10) Carriage Return(13). The syntax and operators are exactly the same as **Hserout**, **Hserout2**, **Hserout3** and **Hserout4**. If **Hserout2Ln**, **Hserout3Ln**, or **HseroutLn** are used, the device must contain more than 1 USART.

Parameters
Item may be a constant, variable, expression, string list, modifier, or inline command. See the section on **Hserout** for more details.

Declares
There are 4 declares for the HseroutXLn commands. Each one is for the particular command.

```
Declare Hserial1_Terminator = CRLF or LFCR or CR
Declare Hserial2_Terminator = CRLF or LFCR or CR
Declare Hserial3_Terminator = CRLF or LFCR or CR
Declare Hserial4_Terminator = CRLF or LFCR or CR
```

The parameter **CR** will transmit a single value of 13 at the end of transmission.
The parameter **CRLF** will transmit a value of 13 then 10 at the end of transmission.
The parameter **LFCR** will transmit a value of 10 then 13 at the end of transmission.

See also : **Declare, Rsin, Rsout, Serin, Serout, Hrsout, HrsoutLn, Hrsin, Hserin, Hserout.**

HSerial1_ChangeBaud

Syntax
HSerial1_ChangeBaud *Baud Value,* { *Display Actual Baud* }

Overview
Changes the Baud rate of USART1 for the **HRsout**/**HRsin** and **HSerout**/**HSerin** commands.

Parameters
Baud Value is a constant value that signifies which Baud rate to set USART1 at.
Display Actual Baud is an optional constant of 0 or 1 that will produce a reminder message in the IDE that indicates what the actual Baud rate is, and its error ratio.

Example
```
Device = 18F25K20
Declare Xtal = 20
Declare HSerial_Baud = 9600        ' Set the Baud rate for USART1 to 9600

HRsoutLn "Hello World at 9600 Baud"
DelayMs 2000                       ' Wait for 2 seconds

HSerial1_ChangeBaud 115200         ' Change the Baud rate to 115200
HRsoutLn "Hello World at 115200 Baud"
Stop
```

HSerial2_ChangeBaud

Syntax
HSerial2_ChangeBaud *Baud Value,* { *Display Actual Baud* }

Overview
Changes the Baud rate of USART2 for the **HRsout2/HRsin2** and **HSerout2/HSerin2** commands.

Parameters
Baud Value is a constant value that signifies which Baud rate to set USART2 at.
Display Actual Baud is an optional constant of 0 or 1 that will produce a reminder message in the IDE that indicates what the actual Baud rate is, and its error ratio.

Example
```
Device = 18F25K20
Declare Xtal = 20
Declare HSerial2_Baud = 9600      ' Set the Baud rate for USART2 to 9600

Hrsout2Ln "Hello World at 9600 Baud"
DelayMs 2000                      ' Wait for 2 seconds

HSerial2_ChangeBaud 115200        ' Change the Baud rate to 115200
Hrsout2Ln "Hello World at 115200 Baud"
Stop
```

HSerial3_ChangeBaud

Syntax
HSerial3_ChangeBaud *Baud Value, { Display Actual Baud }*

Overview
Changes the Baud rate of USART3 for the **HRsout3**/**HRsin3** and **HSerout3**/**HSerin3** commands.

Parameters
Baud Value is a constant value that signifies which Baud rate to set USART3 at.
Display Actual Baud is an optional constant of 0 or 1 that will produce a reminder message in the IDE that indicates what the actual Baud rate is, and its error ratio.

Example
```
Device = 18F65J94                ' Use a device that has 4 USARTs
Declare Xtal = 20
Declare HSerial3_Baud = 9600     ' Set the Baud rate for USART3 to 9600

HRsout3Ln "Hello World at 9600 Baud"
DelayMs 2000                     ' Wait for 2 seconds

HSerial3_ChangeBaud 115200       ' Change the Baud rate to 115200
HRsoutLn "Hello World at 115200 Baud"
Stop
```

HSerial4_ChangeBaud

Syntax
HSerial4_ChangeBaud *Baud Value,* { *Display Actual Baud* }

Overview
Changes the Baud rate of USART4 for the **HRsout4**/**HRsin4** and **HSerout4**/**HSerin4** commands.

Parameters
Baud Value is a constant value that signifies which Baud rate to set USART4 at.
Display Actual Baud is an optional constant of 0 or 1 that will produce a reminder message in the IDE that indicates what the actual Baud rate is, and its error ratio.

Example
```
Device = 18F65J94                  ' Use a device that has 4 USARTs
Declare Xtal = 20
Declare HSerial4_Baud = 9600       ' Set the Baud rate for USART4 to 9600

HRsout4Ln "Hello World at 9600 Baud"
DelayMs 2000                       ' Wait for 2 seconds

HSerial4_ChangeBaud 115200   ' Change the Baud rate to 115200
Hrsout4Ln "Hello World at 115200 Baud"
Stop
```

I2Cin

Syntax
I2Cin *SDA_Pin, SCL_Pin, Control, { Address },* **[** *Variable {, Variable…}* **]**

Overview
Receives a value from the I^{2}C bus, and places it into *variable/s*.

Parameters
SDA_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the I^{2}C device's data line (SDA). This pin's I/O direction will be changed to input and will remain in that state after the instruction is completed.
SCL_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the I^{2}C device's clock line (SCL). This pin's I/O direction will be changed to output.
Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float**, **Array**.
Control is a constant value or a byte sized variable expression.
Address is an optional constant value or a variable expression.

The **I2Cin** command operates as an I^{2}C master, and may be used to interface with any device that complies with the 2-wire I^{2}C protocol. The most significant 7-bits of control byte contain the control code and the slave address of the device being interfaced with. Bit-0 is the flag that indicates whether a read or write command is being implemented.

For example, if we were interfacing to an external eeprom such as the 24LC32, the control code would be %10100001 or $A1. The most significant 4-bits (1010) are the eeprom's unique slave address. Bits 1 to 3 reflect the three address pins of the eeprom. And bit-0 is set to signify that we wish to read from the eeprom. Note that this bit is automatically set by the **I2Cin** command, regardless of its initial setting.

Example
```
' Receive a byte from the I2C bus and place it into variable Var1
'
  Dim Var1 as Byte            ' We'll only read 8-bits
  Dim Address as Word         ' 16-bit address required
  Symbol Control %10100001    ' Target an eeprom
  Symbol SDA = PORTC.3        ' Alias the SDA (Data) line
  Symbol SCL = PORTC.4        ' Alias the SSL (Clock) line

  Address = 20                ' Read the value at address 20
  I2Cin SDA, SCL, Control, Address, [Var1] ' Read the byte from the eeprom
```

Address is an optional parameter that may be an 8-bit or 16-bit value. If a variable is used in this position, the size of address is dictated by the size of the variable used (byte or word). In the case of the previous eeprom interfacing, the 24LC32 eeprom requires a 16-bit address. While the smaller types require an 8-bit address. Make sure you assign the right size address for the device interfaced with, or you may not achieve the results you intended.

The **I2Cin** command allows differing variable assignments. For example: -

```
Dim Var1 as Byte
Dim Wrd as Word
I2Cin SDA, SCL, Control, Address, [Var1, Wrd]
```

The above example will receive two values from the bus, the first being an 8-bit value dictated by the size of variable Var1 which has been declared as a byte. And a 16-bit value, this time dictated by the size of the variable Wrd which has been declared as a word. Of course, bit type variables may also be used, but in most cases these are not of any practical use as they still take up a byte within the eeprom.

Declares
See **I2Cout** for declare explanations.

Notes
When the **I2Cin** command is used, the appropriate SDA and SCL Port and Pin are automatically setup as inputs, and outputs. Because the I^2C protocol calls for an open-collector interface, pull-up resistors are required on both the SDA and SCL lines. Values of 4.7KΩ to 10KΩ will suffice.

Str modifier with I2Cin
Using the **Str** modifier allows the **I2Cin** command to transfer the bytes received from the I^2C bus directly into a byte array. If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. An example of each is shown below: -

```
  Dim Array[10] as Byte            ' Define an array of 10 bytes
  Dim Address as Byte              ' Create a word sized variable
'
' Load data into all the array
'
  I2Cin SDA, SCL, %10100000, Address, [Str Array]
'
' Load data into only the first 5 elements of the array
'
  I2Cin SDA, SCL, %10100000, Address, [Str Array\5]
```

See Also: BusAck, Bstart, Brestart, Bstop, Busout, HbStart, HbRestart HbusAck, Hbusin, Hbusout, I2Cout

I2Cout

Syntax
I2Cout *SDA_Pin*, *SCL_Pin*, *Control*, { *Address* }, **[** *OutputData* **]**

Overview
Transmit a value to the I²C bus, by first sending the *control* and optional *address* out of the clock pin (*SCL*), and data pin (*SDA*).

Parameters
SDA_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the I²C device's data line (SDA). This pin's I/O direction will be changed to input and will remain in that state after the instruction is completed.
SCL_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the I²C device's clock line (SCL). This pin's I/O direction will be changed to output.
 Control is a constant value or a byte sized variable expression.
 Address is an optional constant, variable, or expression.
 OutputData is a list of variables, constants, expressions and modifiers that informs I2Cout how to format outgoing data. **I2Cout** can transmit individual or repeating bytes, convert values into decimal, hex or binary text representations, or transmit strings of bytes from variable arrays.

These actions can be combined in any order in the OutputData list.

The **I2Cout** command operates as an I²C master and may be used to interface with any device that complies with the 2-wire I²C protocol. The most significant 7-bits of *control* byte contain the control code and the slave address of the device being interfaced with. Bit-0 is the flag that indicates whether a read or write command is being implemented.

For example, if we were interfacing to an external eeprom such as the 24LC32, the control code would be %10100000 or $A0. The most significant 4-bits (1010) are the eeprom's unique slave address. Bits 1 to 3 reflect the three address pins of the eeprom. And Bit-0 is clear to signify that we wish to write to the eeprom. Note that this bit is automatically cleared by the **I2Cout** command, regardless of its initial value.

Example
```
' Send a byte to the I2C bus.
  Dim Var1 as Byte                  ' We'll only read 8-bits
  Dim Address as Word               ' 16-bit address required
  Symbol Control = %10100000        ' Target an eeprom
  Symbol SDA = PORTC.3              ' Alias the SDA (Data) line
  Symbol SCL = PORTC.4              ' Alias the SSL (Clock) line

  Address = 20                      ' Write to address 20
  Var1 = 200                        ' The value place into address 20
  I2Cout SDA, SCL, Control, Address, [Var1] ' Send the byte to the eeprom
  DelayMs 10                        ' Allow time for allocation of byte
```

Address is an optional parameter that may be an 8-bit or 16-bit value. If a variable is used in this position, the size of *address* is dictated by the size of the variable used (byte or word). In the case of the above eeprom interfacing, the 24LC32 eeprom requires a 16-bit address. While the smaller types require an 8-bit address. Make sure you assign the right size address for the device interfaced with, or you may not achieve the results you intended.

The value sent to the bus depends on the size of the variables used. For example: -

```
Dim Wrd as Word            ' Create a Word size variable
I2Cout SDA, SCL, Control, Address, [Wrd]
```

Will send a 16-bit value to the bus. While: -

```
Dim Var1 as Byte           ' Create a Byte size variable
I2Cout SDA, SCL, Control, Address, [Var1]
```

Will send an 8-bit value to the bus. Using more than one variable within the brackets allows differing variable sizes to be sent. For example: -

```
Dim Var1 as Byte
Dim Wrd as Word
I2Cout SDA, SCL, Control, Address, [Var1, Wrd]
```

Will send two values to the bus, the first being an 8-bit value dictated by the size of variable Var1 which has been declared as a byte. And a 16-bit value, this time dictated by the size of the variable Wrd which has been declared as a word. Of course, bit type variables may also be used, but in most cases these are not of any practical use as they still take up a byte within the eeprom.

A string of characters can also be transmitted, by enclosing them in quotes: -

```
I2Cout SDA, SCL, Control, Address, ["Hello World", Var1, Wrd]
```

Str modifier with I2Cout

The **Str** modifier is used for transmitting a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements). Below is an example that sends four bytes from an array: -

```
Dim MyArray[10] as Byte       ' Create a 10-byte array.
MyArray [0] = "A"             ' Load the first 4 bytes of the array
MyArray [1] = "B"             ' With the data to send
MyArray [2] = "C"
MyArray [3] = "D"
'
' Send a 4-byte string
'
I2Cout SDA, SCL, %10100000, Address, [Str MyArray\4]
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the program would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 4 bytes.

Declares

There are two **Declare** directives for use with **I2Cout** and **I2Cin**. These are: -

Declare I2C_Slow_Bus On - **Off** or 1 – 0

Slows the bus speed when using an oscillator higher than 4MHz. The standard speed for the I^{2}C bus is 100KHz. Some devices use a higher bus speed of 400KHz. If you use an 8MHz or higher oscillator, the bus speed may exceed the devices specs, which will result in intermittent transactions, or in some cases, no transactions at all. Therefore, use this **Declare** if you are not sure of the device's spec. The datasheet for the device used will inform you of its bus speed.

Declare I2C_Bus_SCL On - **Off**, 1 - 0 or **True** - **False**

Eliminates the necessity for a pullup resistor on the SCL line.

The I^{2}C protocol dictates that a pullup resistor is required on both the SCL and SDA lines, however, this is not always possible due to circuit restrictions etc, so once the **I2C_Bus_SCL On Declare** is issued at the top of the program, the resistor on the SCL line can be omitted from the circuit. The default for the compiler if the **I2C_Bus_SCL Declare** is not issued, is that a pullup resistor is required.

Notes

When the **I2Cout** command is used, the appropriate SDA and SCL Port and Pin are automatically setup as inputs, and outputs. Because the I^{2}C protocol calls for an *open-collector* interface, pull-up resistors are required on both the SDA and SCL lines. Values of 4.7KΩ to 10KΩ will suffice.

You may imagine that it's limiting having a fixed set of pins for the I^{2}C interface, but you must remember that several different devices may be attached to a single bus, each having a unique slave address. Which means there is usually no need to use up more than two pins on the PICmicro™ in order to interface to many devices.

See Also: **BusAck, Bstart, Brestart, Bstop, Busin, HbStart, HbRestart HbusAck, Hbusin, Hbusout, I2Cin**

If..Then..ElseIf..Else..EndIf

Syntax
If *Comparison* **Then** *Instruction* **:** { *Instruction* }

Or, you can use the single line form syntax:

If *Comparison* **Then** *Instruction* **:** { *Instruction* } **:** **ElseIf** *Comparison* **Then** *Instruction* **:** **Else** *Instruction*

Or, you can use the block form syntax:

If *Comparison* **Then**
Instruction(s)
ElseIf *Comparison* **Then**
Instruction(s)
{
ElseIf *Comparison* **Then**
Instruction(s)
        }
Else
Instruction(s)
EndIf

The curly braces signify optional conditions.

Overview
Evaluates the *comparison* and, if it fulfils the criteria, executes *expression.* If *comparison* is not fulfilled the *instruction* is ignored, unless an **Else** directive is used, in which case the code after it is implemented until the **EndIf** is found.

When all the instruction are on the same line as the **If**-**Then** statement, all the instructions on the line are carried out if the condition is fulfilled.

Parameters
Comparison is composed of variables, numbers and comparators.
Instruction is the statement to be executed should the *comparison* fulfil the **If** criteria

Example 1
```
Symbol LED = PORTB.4
Var1 = 3
Low LED
If Var1 > 4 Then High LED : DelayMs 500 : Low LED
```

In the above example, Var1 is not greater than 4 so the **If** criteria isn't fulfilled. Consequently, the **High** LED statement is never executed leaving the state of port pin PORTB.4 low. However, if we change the value of variable Var1 to 5, then the LED will turn on for 500ms then off, because Var1 is now greater than 4, so fulfils the *comparison* criteria.

A second form of **If**, evaluates the expression and if it is true then the first block of instructions is executed. If it is false then the second block (after the **Else**) is executed.

The program continues after the **EndIf** instruction.

The **Else** is optional. If it is missed out then if the expression is false the program continues after the **EndIf** line.

Example 2
```
If X & 1 = 0 Then
   A = 0
   B = 1
Else
   A = 1
EndIf
If Z = 1 Then
   A = 0
   B = 0
EndIf
```

Example 3
```
If X = 10 Then
   High LED1
ElseIf X = 20 Then
   High LED2
Else
   High LED3
EndIf
```

A forth form of **If**, allows the **Else** or **ElseIf** to be placed on the same line as the **If**: -

```
If X = 10 Then High LED1 : ElseIf X = 20 Then High LED2 : Else : High LED3
```

Notice that there is no **EndIf** instruction. The comparison is automatically terminated by the end of line condition. So in the above example, if X is equal to 10 then LED1 will illuminate, if X equals 20 then LED will illuminate, otherwise, LED3 will illuminate.

The **If** statement allows any type of variable, register or constant to be compared. A common use for this is checking a Port bit: -

```
If PORTA.0 = 1 Then High LED : Else : Low LED
```

Any commands on the same line after **Then** will only be executed if the comparison if fulfilled: -

```
If Var1 = 1 Then High LED : DelayMs 500 : Low LED
```

Notes
A **Goto** command is optional after the **Then**: -

```
If PORTB.0 = 1 Then Label
```

Then operand always required.
The Proton compiler relies heavily on the **Then** part. Therefore, if the **Then** part of a construct is left out of the code listing, a Syntax Error will be produced.

See also :   Boolean Logic Operators, Select..Case..EndSelect.

Include

Syntax
Include "*Filename*"

Overview
Include another file at the current point in the compilation. All the lines in the new file are compiled as if they were in the current file at the point of the **Include** directive.

A common use for the include command is shown in the example below. Here a small master program is used to include a number of smaller library files which are all compiled together to make the overall program.

Parameter
Filename is any valid Proton file.

Example
```
' Main Program Includes sub files
  Include "StartCode.bas"
  Include "MainCode.bas"
  Include "EndCode.bas"
```

Notes
The file to be included into the BASIC listing may be in one of three places on the hard drive if a specific path is not chosen.

1… Within the BASIC program's directory.
2… Within the Compiler's current directory.
3… Within the Includes\Sources folder of the compiler's current directory.

The list above also shows the order in which they are searched for.

Using Include files to tidy up your code.
If the include file contains assembler subroutines then it must always be placed at the beginning of the program. This allows the subroutine/s to be placed within the first bank of memory (*0..2048*), thus avoiding any bank boundary errors. Placing the include file at the beginning of the program also allows all of the variables used by the routines held within it to be predeclared. This again makes for a tidier program, as a long list of variables is not present in the main program.

There are some considerations that must be taken into account when writing code for an include file, these are: -

1). Always jump over the subroutines.

When the include file is placed at the top of the program this is the first place that the compiler starts, therefore, it will run the subroutine/s first and the **Return** command will be pointing to a random place within the code. To overcome this, place a **Goto** statement just before the subroutine starts.

For example: -

```
  Goto Over_This_Subroutine ' Jump over the subroutine
' The subroutine is placed here

Over_This_Subroutine:        ' Jump to here first
```

2). Variable and Label names should be as meaningful as possible.

For example. Instead of naming a variable **MyLoop**, change it to **ISUB_MyLoop**. This will help eliminate any possible duplication errors, caused by the main program trying to use the same variable or label name. However, try not to make them too obscure as your code will be harder to read and understand, it might make sense at the time of writing, but come back to it after a few weeks and it will be meaningless.

3). Comment, Comment, and Comment some more.

This cannot be emphasised enough. Always place a plethora of remarks and comments. The purpose of the subroutine/s within the include file should be clearly explained at the top of the program, also, add comments after virtually every command line, and clearly explain the purpose of all variables and constants used. This will allow the subroutine to be used many weeks or months after its conception. A rule of thumb that I use is that I can understand what is going on within the code by reading only the comments to the right of the command lines.

Inc

Syntax
Inc *Variable*

Overview
Increment a variable i.e. Var1 = Var1 + 1

Parameters
Variable is a user defined variable

Example
```
Dim Var1 as Byte = 1

Repeat
  Print Dec Var1, " "
  DelayMs 200
  Inc Var1
Until Var1 > 10
```

The above example shows the equivalent to the For-Next loop: -

```
For Var1 = 1 to 10 : Next
```

See also :Dec.

Inkey

Syntax
Variable **= Inkey**

Overview
Scan a keypad and place the returned value into *variable*

Parameters
Variable is a user defined variable

Example
```
Dim Var1 as Byte
Var1 = Inkey            ' Scan the keypad
DelayMs 50             ' Debounce by waiting 50ms
Print Dec Var1, " "    ' Display the result on the LCD
```

Notes
Inkey will return a value between 0 and 16. If no key is pressed, the value returned is 16.

Using a **LookUp** command, the returned values can be re-arranged to correspond with the legends printed on the keypad: -

```
Var1 = Inkey
Key = LookUp Var1, [255,1,4,7,"*",2,5,8,0,3,6,9,"#",0,0,0]
```

The above example is only a demonstration, the values inside the **LookUp** command will need to be re-arranged for the type of keypad used, and its connection configuration.

Declare

Declare Keypad_Port Port
 Assigns the Port that the keypad is attached to.

The keypad routine requires pull-up resistors, therefore, the best Port for this device is PORTB, which comes equipped with internal pull-ups. If the Declare is not used in the program, then PORTB is the default Port.

The diagram illustrates a typical connection of a 12-button keypad to a PIC16F84. If a 16-button type is used, then COLUMN 4 will connect to PORTB.7 (*RB7*).
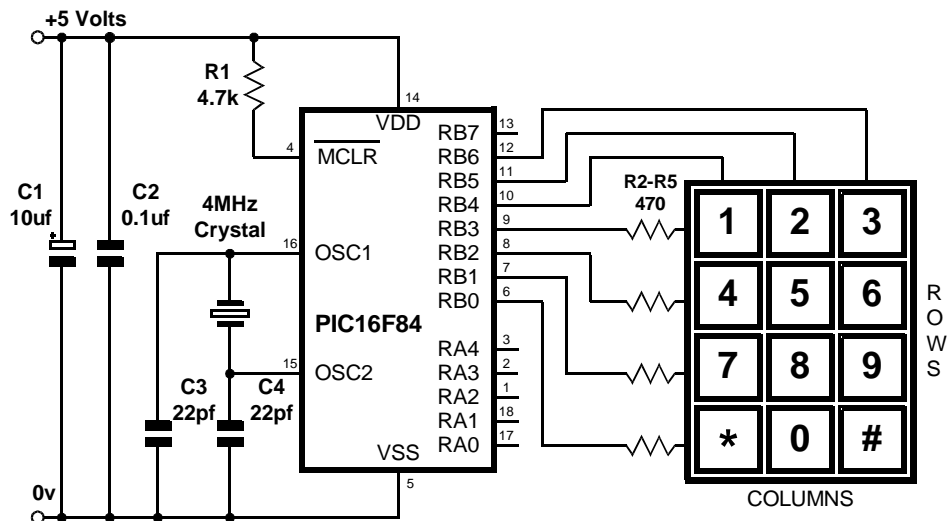
Input

Syntax
Input *Port . Pin* or *Pin Number*

Overview
Makes the specified *Port* or *Pin* an input.

Parameters
Port.Pin must be a Port, or Port.Pin constant declaration.
Pin Number can be any variable or constant holding 0 to the amount of I/O pins on the device.
A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example 1
```
Input PORTA.0       ' Make pin-0 of PORTA an input
Input PORTA         ' Make all of PORTA an input
Input 0             ' Make pin-0 of PORTA an input
Input 8             ' Make pin-0 of PORTB an input
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim MyPin as Byte

   High PORTA
   High PORTB
   For MyPin = 0 to 15       ' Create a loop for the pin to flash
     Output MyPin            ' Set the pin as an output
     DelayMs 500             ' Delay so that it can be seen
     Input MyPin             ' Set the pin as an input
     DelayMs 500             ' Delay so that it can be seen
   Next
```

Notes
An Alternative method for making a particular pin an input is by directly modifying the TRIS register: -

```
TRISB.0 = 1       ' Set PORTB, bit-0 to an input
```

All of the pins on a port may be set to inputs by setting the whole Tris register at once: -

```
TRISB = %11111111  ' Set all of PORTB to inputs
```

In the above examples, setting a TRIS bit to 1 makes the pin an input, and conversely, setting the bit to 0 makes the pin an output.

Each pin number has a designated name. These are Pin_A0, Pin_A1, Pin_A2, Pin_B0…Pin_B7, Pin_C0…Pin_C7, Pin_D0…Pin_D7 to Pin_L7 etc… Each of the names has a relevant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber As Byte          ' Holds the pin number to set high and low

   Do                             ' Create an infinite loop
     PinNumber = Pin_B0           ' Give the pin number to flash (PORTB.0)
     Gosub FlashPin               ' Call the subroutine to flash the pin
     PinNumber = Pin_B1           ' Give the pin number to flash (PORTB.1)
     Gosub FlashPin               ' Call the subroutine to flash the pin
   Loop                           ' Do it forever
'
' Set a pin high then an input for 500ms using a value as the pin to adjust
'
FlashPin:
   High PinNumber                 ' Set the pin output high
   DelayMs 500                    ' Wait for 500 milliseconds
   Input PinNumber                ' Make the pin an input
   DelayMs 500                    ' Wait for 500 milliseconds
   Return
```

See also : Output, ClearPin, SetPin, High, Low.

LCDread

Syntax
Variable **= LCDread** *Ypos, Xpos*

Or

Variable **= LCDread Text** *Ypos, Xpos*

Overview
Read a byte from a graphic LCD. Can also read Text RAM from a Toshiba T6963 LCD.

Parameters
Variable is a user defined variable.
Ypos :-
With a KS0108 graphic LCD this may be a constant, variable or expression within the range of 0 to 7 This corresponds to the line number of the LCD, with 0 being the top row.

With a Toshiba T6963 graphic LCD this may be a constant, variable or expression within the range of 0 to the Y resolution of the display. With 0 being the top line.
Xpos: -
With a KS0108 graphic LCD this may be a constant, variable or expression with a value of 0 to 127. This corresponds to the X position of the LCD, with 0 being the far left column.
With a Toshiba graphic LCD this may be a constant, variable or expression with a value of 0 to the X resolution of the display divided by the font width (LCD_X_Res / LCD_Font_Width). This corresponds to the X position of the LCD, with 0 being the far left column.

Example
```
' Read and display the top row of the KS0108 graphic LCD
  Device = 16F1829
  Declare LCD_Type = KS0108      ' Target a KS0108 graphic LCD

  Dim Var1 as Byte
  Dim Xpos as Byte
  Cls                            ' Clear the LCD
  Print "Testing 1 2 3"
  For Xpos = 0 to 127            ' Create a loop of 128
    Var1 = LCDread 0, Xpos       ' Read the LCD's top line
    Print At 1, 0, "Chr= ", Dec Var1," "
    DelayMs 100
  Next
  Stop
```

Notes
The graphic LCDs that are compatible with Proton are the KS0108, and the Toshiba T6963. The standard KS0108 display has a pixel resolution of 64 x 128. The 64 being the Y axis, made up of 8 lines each having 8-bits. The 128 being the X axis, made up of 128 positions. The Toshiba LCDs are available with differing resolutions.

As with **LCDwrite**, the graphic LCD must be targeted using the **LCD_Type Declare** directive before this command may be used.

The Toshiba T6963 graphic LCDs split their graphic and text information within internal RAM. This means that the **LCDread** command can also be used to read the textual information as well as the graphical information present on the LCD. Placing the word **Text** after the **LCDread** command will direct the reading process to Text RAM.

Example
```
' Read text from a Toshiba graphic LCD
  Device = 18F452
  Declare LCD_Type = Toshiba        ' Use a Toshiba T6963 graphic LCD
'
' LCD interface pin assignments
'
  Declare LCD_DTPort = PORTD      ' LCD's Data port
  Declare LCD_WRPin = PORTE.2     ' LCD's WR line
  Declare LCD_RDPin = PORTE.1     ' LCD's RD line
  Declare LCD_CEPin = PORTE.0     ' LCD's CE line
  Declare LCD_CDPin = PORTA.1     ' LCD's CD line
  Declare LCD_RSTPin = PORTA.0    ' LCD's RESet line (Optional)
'
' LCD characteristics
'
  Declare LCD_X_Res = 128         ' LCD's X Resolution
  Declare LCD_Y_Res = 64          ' LCD's Y Resolution
  Declare LCD_Font_Width = 8      ' The width of the LCD's font

  Dim Charpos as Byte             ' The X position of the read
  Dim Char as Byte                ' The byte read from the LCD

  DelayMs 100                     ' Wait for the LCD to stabilise
  ADCON1 = 7                      ' PORTA and PORTE to all digital mode
  Cls                             ' Clear the LCD
  Print At 0,0," This is for Copying" ' Display text on top line of LCD
  For Charpos = 0 to 20           ' Create a loop of 21 cycles
    Char = LCDread Text 0,Charpos ' Read the top line of the LCD
    Print At 1,Charpos,Char       ' Print the byte read on the second line
    DelayMs 100                   ' A small delay so we can see things happen
  Next                            ' Close the loop
```

See also : **LCDwrite for a description of the screen formats, Pixel, Plot, Toshiba_Command, Toshiba_UDG, UnPlot, see Print for LCD connections.**

LCDwrite

Syntax
LCDwrite *Ypos, Xpos,* **[** *Value* ,{ *Value etc…*} **]**

Overview
Write a byte to a graphic LCD.

Parameters
Ypos :-
With a KS0108 graphic LCD this may be a constant, variable or expression within the range of 0 to 7 This corresponds to the line number of the LCD, with 0 being the top row.

With a **Toshiba** T6963 graphic LCD this may be a constant, variable or expression within the range of 0 to the Y resolution of the display. With 0 being the top line.
Xpos: -
With a KS0108 graphic LCD this may be a constant, variable or expression with a value of 0 to 127. This corresponds to the X position of the LCD, with 0 being the far left column.
With a **Toshiba** graphic LCD this may be a constant, variable or expression with a value of 0 to the X resolution of the display divided by the font width (LCD_X_Res / LCD_Font_Width). This corresponds to the X position of the LCD, with 0 being the far left column.
Value may be a constant, variable, or expression, within the range of 0 to 255 (byte).

Example 1
```
' Display a line on the top row of a KS0108 graphic LCD
  Device = 16F1829
  Declare LCD_Type = KS0108          ' Target a KS0108 graphic LCD
  Dim Xpos as Byte

  Cls                                ' Clear the LCD
  For Xpos = 0 to 127                ' Create a loop of 128
    LCDwrite 0, Xpos, [%11111111]    ' Write to the LCD's top line
    DelayMs 100
  Next
  Stop
```

Example 2
```
' Display a line on the top row of a Toshiba 128x64 graphic LCD
  Device = 16F1829
  Declare LCD_Type = Toshiba         ' Target a Toshiba graphic LCD
  Dim Xpos as Byte

  Cls                                ' Clear the LCD
  For Xpos = 0 to 20                 ' Create a loop of 21
    LCDwrite 0, Xpos, [%00111111]    ' Write to the LCD's top line
    DelayMs 100
  Next
  Stop
```

Notes
The graphic LCDs that are compatible with Proton are the KS0108, and the Toshiba T6963. The KS0108 display has a pixel resolution of 64 x 128. The 64 being the Y axis, made up of 8 lines each having 8-bits. The 128 being the X axis, made up of 128 positions. The Toshiba LCDs are available with differing resolutions.

There are important differences between the KS0108 and Toshiba screen formats. The diagrams below show these in more detail: -

The diagram below illustrates the position of one byte at position 0,0 on a KS0108 LCD screen. The least significant bit is located at the top. The byte displayed has a value of 149 (10010101).
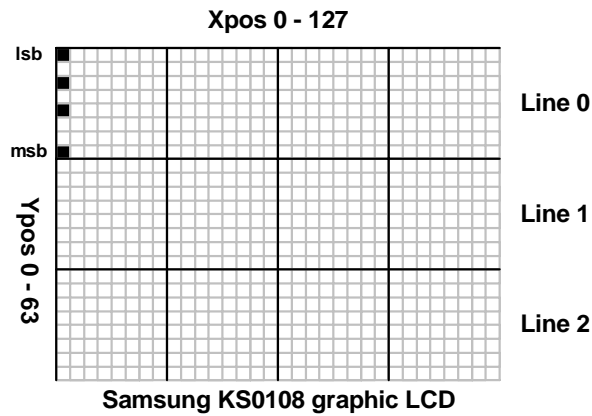
Samsung KS0108 graphic LCD

The diagram below illustrates the position of one byte at position 0,0 on a Toshiba T6963 LCD screen in 8-bit font mode. The least significant bit is located at the right of the screen byte. The byte displayed has a value of 149 (10010101).

Toshiba T6963 LCD. (8-bit Font mode)
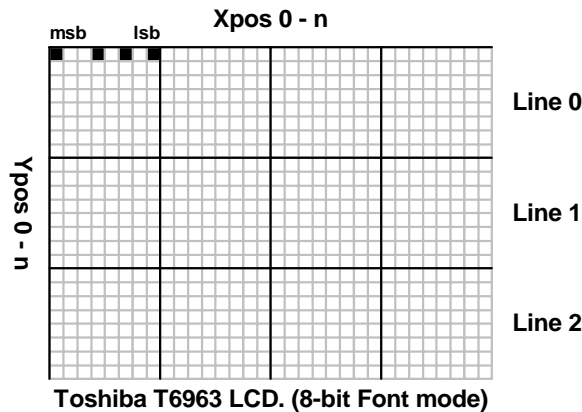
The diagram below illustrates the position of one byte at position 0,0 on a Toshiba T6963 LCD screen in 6-bit font mode. The least significant bit is located at the right of the screen byte. The byte displayed still has a value of 149 (10010101), however, only the first 6 bits are displayed (010101) and the other two are discarded.

Toshiba T6963 LCD. (6-bit Font mode)
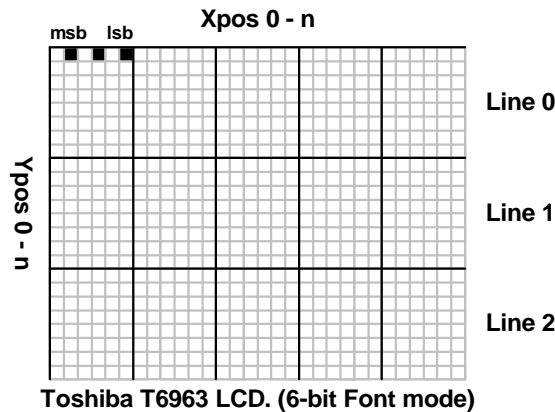
**See also :   LCDread, Plot, Toshiba_Command, Toshiba_UDG, UnPlot
            see Print for LCD connections.**

Ldata

Syntax
Ldata { *alphanumeric data* }

Overview
Place information into code memory using the Retlw instruction when used with a standard 14-bit core devices, and Flash (code) memory when using an 18F or enhanced 14-bit core device. For access by **Lread**, **Lread8**, **Lread16** or **Lread32**.

Parameters
alphanumeric data can be a 8,16, 32 bit value, or floating point values, or any alphabetic character or string enclosed in quotes.

Example
```
    Device = 16F1829

    Dim Char as Byte
    Dim MyLoop as Byte

    Cls
    For MyLoop = 0 to 9                    ' Create a loop of 10
       Char = Lread Label + MyLoop    ' Read memory location Label + MyLoop
       Print Char                     ' Display the value read
    Next
    Stop

Label: Ldata "HELLO WORLD"      ' Create a string of text in code memory
```

The program above reads and displays 10 values from the address located by the Label accompanying the **Ldata** command. Resulting in "HELLO WORL" being displayed.

Ldata is not simply used for character storage, it may also hold 8, 16, 32 bit, or floating point values. The example below illustrates this: -

```
    Device = 16F628
    Dim Var1 as Byte
    Dim Wrd1 as Word
    Dim Dwd1 as Dword
    Dim Flt1 as Float

    Cls
    Var1 = Lread Bit8_Val     ' Read the 8-bit value
    Print Dec Var1,"  "
    Wrd1= Lread Bit16_Val      ' Read the 16-bit value
    Print Dec Wrd1
    Dwd1 = Lread Bit32_Val     ' Read the 32-bit value
    Print At 2,1, Dec Dwd1,"  "
    Flt1 = Lread MyFloat_Val       ' Read the floating point value
    Print Dec Flt1
    Stop

Bit8_Val: Ldata 123
Bit16_Val: Ldata 1234
Bit32_Val: Ldata 123456
MyFloat_Val: Ldata 123.456
```

Floating point examples.
14-bit core example

```
' 14-bit read floating point data from a table and display the results
   Device = 16F1829
   Dim MyFloat as Float          ' Create a Floating Point variable
   Dim Fcount as Byte

   Cls                                ' Clear the LCD
   Fcount = 0                         ' Clear the table counter
   Repeat                             ' Create a loop
     MyFloat = Lread FlTable + Fcount ' Read the data from the Ldata table
     Print At 1, 1, Dec3 MyFloat  ' Display the data read
     Fcount = Fcount + 4              ' Point to next value, by adding 4 to counter
     DelayMs 1000                     ' Slow things down
   Until MyFloat = 0.005             ' Stop when 0.005 is read
   Stop

FlTable:
   Ldata as Float 3.14, 65535.123, 1234.5678, -1243.456, -3.14, 998999.12,_
                  0.005
```

18F device example

```
' 18F read floating point data from a table and display the results
   Device = 18F25K20
   Dim MyFloat as Float          ' Create a Floating Point variable
   Dim Fcount as Byte

   Cls                                ' Clear the LCD
   Fcount = 0                         ' Clear the table counter
   Repeat                             ' Create a loop
     MyFloat = Lread FlTable + Fcount ' Read the data from the Ldata table
     Print At 1, 1, Dec3 MyFloat  ' Display the data read
     Fcount = Fcount + 2              ' Point to next value, by adding 2 to counter
     DelayMs 1000                     ' Slow things down
   Until MyFloat = 0.005             ' Stop when 0.005 is read
   Stop

FlTable:
   Ldata as Float 3.14, 65535.123, 1234.5678, -1243.456, -3.14, 998999.12,_
                  0.005
```

Notes
Ldata tables should be placed at the end of the BASIC program. If an **Ldata** table is placed at the beginning of the program, then a **Goto** command must jump over the tables, to the main body of code.

```
   Goto OverDataTable

   Ldata 1,2,3,4,5,6

OverDataTable:

   { rest of code here}
```

With **14-bit** core devices, an 8-bit value (0 - 255) in an **Ldata** statement will occupy a single code space, however, 16-bit data (0 - 65535) will occupy two spaces, 32-bit and floating point values will occupy 4 spaces. This must be taken into account when using the Lread command. See 14-bit floating point example above.

With 18F devices, an 8, and 16-bit value in an **Ldata** statement will occupy a single code space, however, 32-bit and floating point values will occupy 2 spaces. This must be taken into account when using the **Lread** command. See 16-bit floating point example above.

18F device requirements.
The compiler uses a different method of holding information in an **Ldata** statement when using 18F devices. It uses the unique capability of these devices to read from their own code space, which offers optimisations when values larger than 8-bits are stored. However, because the 18F devices are **Byte** oriented, as opposed to the 14-bit types which are **Word** oriented. The **Ldata** tables should contain an even number of values, or corruption may occur on the last value read. For example: -

```
Even:   Ldata 1,2,3,"123"

Odd:    Ldata 1,2,3,"12"
```

An **Ldata** table containing an Odd amount of values will produce a compiler WARNING message.

Formatting an Ldata table.
Sometimes it is necessary to create a data table with an known format for its values. For example all values will occupy 4 bytes of code space even though the value itself would only occupy 1 or 2 bytes. I use the name Byte loosely, as 14-bit core devices use 14-bit Words, as opposed to 18F devices that do actually use Bytes.

```
Ldata 100000, 10000, 1000, 100, 10, 1
```

The above line of code would produce an uneven code space usage, as each value requires a different amount of code space to hold the values. 100000 would require 4 bytes of code space, 10000 and 1000 would require 2 bytes, but 100, 10, and 1 would only require 1 byte.

Reading these values using **Lread** would cause problems because there is no way of knowing the amount of bytes to read in order to increment to the next valid value.

The answer is to use formatters to ensure that a value occupies a predetermined amount of bytes. These are: -

Byte
Word
Dword
Float

Placing one of these formatters before the value in question will force a given length.

```
Ldata  Dword 100000, Dword 10000, Dword 1000 ,_
       Dword 100, Dword 10, Dword 1
```

Byte will force the value to occupy one byte of code space, regardless of its value. Any values above 255 will be truncated to the least significant byte.

Word will force the value to occupy 2 bytes of code space, regardless of its value. Any values above 65535 will be truncated to the two least significant bytes. Any value below 255 will be padded to bring the memory count to 2 bytes.

Dword will force the value to occupy 4 bytes of code space, regardless of its value. Any value below 65535 will be padded to bring the memory count to 4 bytes. The line of code shown above uses the **Dword** formatter to ensure all the values in the **Ldata** table occupy 4 bytes of code space.

Float will force a value to its floating point equivalent, which always takes up 4 bytes of code space.

If all the values in an **Ldata** table are required to occupy the same amount of bytes, then a single formatter will ensure that this happens.

```
Ldata as Dword 100000, 10000, 1000, 100, 10, 1
```

The above line has the same effect as the formatter previous example using separate **Dword** formatters, in that all values will occupy 4 bytes, regardless of their value. All four formatters can be used with the **as** keyword.

The example below illustrates the formatters in use.

```
' Convert a Dword value into a string array using only BASIC commands
' Similar principle to the Str$ command

  Include "Amicus18.Inc"

  Dim P10 as Dword          ' Power of 10 variable
  Dim Cnt as Byte
  Dim J as Byte
  Dim Value as Byte         ' Value to convert
  Dim String1[11] as Byte   ' Holds the converted value
  Dim Ptr as Byte           ' Pointer within the Byte array
  DelayMs 100               ' Wait for the LCD to stabilise
  Cls                       ' Clear the LCD
  Clear                     ' Clear all RAM before we start
  Value = 1234576           ' Value to convert
  Gosub DwordToStr          ' Convert Value to string
  Print Str String1         ' Display the result
  Stop
'-----------------------------------------------------------
' Convert a Dword value into a string array. Value to convert is placed in
' Value
' Byte array 'String1' is built up with the ASCII equivalent

DwordToStr:
  Ptr = 0
  J = 0
  Repeat
    P10 = Lread DwordTbl + (J * 4)
    Cnt = 0
    While Value >= P10
      Value = Value - P10
      Inc Cnt
    Wend
    If Cnt <> 0 Then
      String1[Ptr] = Cnt + "0"
      Inc Ptr
    EndIf
    Inc J
  Until J > 8
```

```
   String1[Ptr] = Value + "0"
   Inc Ptr
   String1[Ptr] = 0    ' Add the null to terminate the string
   Return
' Ldata table is formatted for all 32 bit values.
' Which means each value will require 4 bytes of code space
Dword_TBL:
   Ldata as Dword 1000000000, 100000000, 10000000, 1000000, 100000, 10000,_
                  1000, 100, 10
```

Label names as pointers.

If a label's name is used in the list of values in an **Ldata** table, the label's address will be used. This is useful for accessing other tables of data using their address from a lookup table. See example below.

```
' Display text from two Ldata tables
' Based on their address located in a separate table

   Include "Amicus18.Inc"
   Dim Address as Word
   Dim DataByte as Byte

   DelayMs 100                     ' Wait for the LCD to stabilise
   Cls                             ' Clear the LCD
   Address = Lread AddrTable       ' Locate the address of the first string
   While                           ' Create an infinite loop
   DataByte = Lread Address        ' Read each character from the Ldata string
      If DataByte = 0 Then Break   ' Exit if null found
      Print DataByte               ' Display the character
      Inc Address                  ' Next character
   Wend                            ' Close the loop

   Cursor 2,1                      ' Point to line 2 of the LCD
   Address = Lread AddrTable + 2   ' Locate the address of the second string
   While                           ' Create an infinite loop
      DataByte = Lread Address     ' Read each character from the Ldata string
    If DataByte = 0 Then Break     ' Exit if null found
    Print DataByte                 ' Display the character
    Inc Address                    ' Next character
   Wend                            ' Close the loop

   Stop

AddrTable:                         ' Table of address's
   Ldata as Word String1, String2
String1:
   Ldata "HELLO",0
String2:
   Ldata "WORLD",0
```

See also :   Cdata, Cread, Data, Edata, Lread, Read, Restore.

Len

Syntax
Variable **= Len(***Source String***)**

Overview
Find the length of a **String**. (not including the null terminator) .

Parameters
Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float** or **Array**.
Source String can be a **String** variable, or a Quoted String of Characters. The *Source String* can also be a **Byte**, **Word**, **Float** or **Array** variable, in which case the value contained within the variable is used as a pointer to the start of the Source String's address in RAM. A third possibility for *Source String* is a label name, in which case a null terminated Quoted String of Characters is read from a **Cdata** table.

Example 1
```
' Display the length of SourceString
  Device = 18F25K20                    ' A suitable device for Strings
  Declare Xtal = 20
  Dim SourceString as String * 20      ' Create a String capable of 20 characters
  Dim Length as Byte

  SourceString = "HELLO WORLD"         ' Load the source string with characters
  Length = Len(SourceString)           ' Find the length
  Print Dec Length                     ' Display the result, which will be 11
  Stop
```

Example 2
```
' Display the length of a Quoted Character String
  Device = 18F25K20                    ' A suitable device for Strings
  Declare Xtal = 20

  Dim Length as Byte

  Length = Len("HELLO WORLD")          ' Find the length
  Print Dec Length                     ' Display the result, which will be 11
  Stop
```

Example 3
```
' Display the length of SourceString using a pointer to SourceString
  Device = 18F25K20                    ' A suitable device for Strings
  Declare Xtal = 20

  Dim SourceString as String * 20      ' Create a String capable of 20 characters
  Dim Length as Byte                   ' Display the length of SourceString
  Dim SourceString as String * 20      ' Create a String capable of 20 characters
' Create a Word variable to hold the address of SourceString
  Dim StringAddr as Word

  SourceString = "HELLO WORLD"         ' Load the source string with characters
  ' Locate the start address of SourceString in RAM
  StringAddr = AddressOf(SourceString)
  Length = Len(StringAddr)             ' Find the length
  Print Dec Length                     ' Display the result, which will be 11
  Stop
```

Example 4
```
' Display the length of a Cdata string
  Device = 18F25K20            ' A suitable device for Strings
  Declare Xtal = 20

  Dim Length as Byte

  Length = Len(Source)        ' Find the length
  Print Dec Length            ' Display the result, which will be 11
  Stop
' Create a null terminated string of characters in code memory
Source:
  Cdata "HELLO WORLD", 0
```

See also :   Creating and using Strings, Creating and using Virtual Strings with Cdata, Cdata, Left$, Mid$, Right$, Str$, ToLower, ToUpper, AddressOf.

Left$

Syntax
Destination String = **Left$ (**Source String*, *Amount of characters***)**

Overview
Extract *n* amount of characters from the left of a source string and copy them into a destination string.

Parameters
Destination String can only be a **String** variable, and should be large enough to hold the correct amount of characters extracted from the *Source String*.
Source String can be a **String** variable, or a Quoted String of Characters. See below for more variable types that can be used for *Source String*.
Amount of characters can be any valid variable type, expression or constant value, that signifies the amount of characters to extract from the left of the *Source String*. Values start at 1 for the leftmost part of the string and should not exceed 255 which is the maximum allowable length of a String variable.

Example 1.
```
' Copy 5 characters from the left of SourceString into DestString

  Device = 18F452                   ' A suitable device for Strings
  Dim SourceString as String * 20   ' Create a String capable of 20 characters
  Dim DestString as String * 20     ' Create another String for 20 characters

  SourceString = "HELLO WORLD"       ' Load the source string with characters
' Copy 5 characters from the source string into the destination string
  DestString = Left$ (SourceString, 5)
  Print DestString                  ' Display the result, which will be "HELLO"
  Stop
```

Example 2.
```
' Copy 5 chars from the left of a Quoted Character String into DestString

  Device = 18F452                   ' A suitable device for Strings
  Dim DestString as String * 20     ' Create a String capable of 20 characters

' Copy 5 characters from the quoted string into the destination string
  DestString = Left$("HELLO WORLD", 5)
  Print DestString                  ' Display the result, which will be "HELLO"
  Stop
```

The *Source String* can also be a **Byte**, **Word**, **Dword**, **Float** or **Array** variable, in which case the value contained within the variable is used as a pointer to the start of the Source String's address in RAM.

Example 3.
```
' Copy 5 characters from the left of SourceString into DestString using a
' pointer to SourceString

  Device = 18F452                   ' A suitable device for Strings
  Dim SourceString as String * 20   ' Create a String capable of 20 characters
  Dim DestString as String * 20     ' Create another String for 20 characters
' Create a Word variable to hold the address of SourceString
  Dim StringAddr as Word

  SourceString = "HELLO WORLD"       ' Load the source string with characters
' Locate the start address of SourceString in RAM
  StringAddr = AddressOf(SourceString)
' Copy 5 characters from the source string into the destination string
  DestString = Left$(StringAddr, 5)
  Print DestString                  ' Display the result, which will be "HELLO"
  Stop
```

A third possibility for *Source String* is a label name, in which case a null terminated Quoted String of Characters is read from a **Cdata** table.

Example 4.
```
' Copy 5 characters from the left of a Cdata table into DestString

  Device = 18F452                   ' A suitable device for Strings
  Dim DestString as String * 20     ' Create a String capable of 20 characters

  ' Copy 5 characters from label Source into the destination string
  DestString = Left$(Source, 5)
  Print DestString                  ' Display the result, which will be "HELLO"
  Stop

' Create a null terminated string of characters in code memory
Source:
  Cdata "HELLO WORLD", 0
```

See also :   Creating and using Strings, Creating and using Virtual Strings with Cdata, Cdata, Len, Mid$, Right$, Str$, ToLower, ToUpper , AddressOf.

Line

Syntax
Line *Set_Clear*, *Xpos Start*, *Ypos Start*, *Xpos End*, *Ypos End*

Overview
Draw a straight line in any direction on a graphic LCD.

Parameters
Set_Clear may be a constant or variable that determines if the line will set or clear the pixels. A value of 1 will set the pixels and draw a line, while a value of 0 will clear any pixels and erase a line.
Xpos Start may be a constant or variable that holds the X position for the start of the line. Can be a value from 0 to 127.
Ypos Start may be a constant or variable that holds the Y position for the start of the line. Can be a value from 0 to 63.
Xpos End may be a constant or variable that holds the X position for the end of the line. Can be a value from 0 to 127.
Ypos End may be a constant or variable that holds the Y position for the end of the line. Can be a value from 0 to 63.

Example
```
' Draw a line from 0,0 to 120,34

  Include "Proton_G4.INT"

  Dim Xpos_Start as Byte
  Dim Xpos_End as Byte
  Dim Ypos_Start as Byte
  Dim Ypos_End as Byte
  Dim SetClr as Byte

  DelayMs 100            ' Wait for the LCD to stabilise
  Cls                    ' Clear the LCD
  Xpos_Start = 0
  Ypos_Start = 0
  Xpos_End = 120
  Ypos_End = 34
  SetClr = 1
  Line SetClr, Xpos_Start, Ypos_Start, Xpos_End, Ypos_End
  Stop
```

See Also :   Box, Circle.

LineTo

Syntax
LineTo *Set_Clear*, *Xpos End*, *Ypos End*

Overview
Draw a straight line in any direction on a graphic LCD, starting from the previous **Line** command's end position.

Parameters
Set_Clear may be a constant or variable that determines if the line will set or clear the pixels. A value of 1 will set the pixels and draw a line, while a value of 0 will clear any pixels and erase a line.
Xpos End may be a constant or variable that holds the X position for the end of the line. Can be a value from 0 to 127.
Ypos End may be a constant or variable that holds the Y position for the end of the line. Can be a value from 0 to 63.

Example
```
' Draw a line from 0,0 to 120,34. Then from 120,34 to 0,63

  Include "Proton_G4.INT"

  Dim Xpos_Start as Byte
  Dim Xpos_End as Byte
  Dim Ypos_Start as Byte
  Dim Ypos_End as Byte
  Dim SetClr as Byte

  DelayMs 100          ' Wait for the LCD to stabilise
  Cls                  ' Clear the LCD
  Xpos_Start = 0
  Ypos_Start = 0
  Xpos_End = 120
  Ypos_End = 34
  SetClr = 1
  Line SetClr, Xpos_Start, Ypos_Start, Xpos_End, Ypos_End
  Xpos_End = 0
  Ypos_End = 63
  LineTo SetClr, Xpos_End, Ypos_End
  Stop
```

Notes
The **LineTo** command uses the compiler's internal system variables to obtain the end position of a previous **Line** command. These X and Y coordinates are then used as the starting X and Y coordinates of the **LineTo** command.

See Also :   Line, Box, Circle.

LoadBit

Syntax
LoadBit *Variable, Index, Value*

Overview
Clear, or Set a bit of a variable or register using a variable index to point to the bit of interest.

Parameters
Variable is a user defined variable, of type **Byte**, **Word**, or **Dword**.
Index is a constant, variable, or expression that points to the bit within *Variable* that requires accessing.
Value is a constant, variable, or expression that will be placed into the bit of interest. Values greater than 1 will set the bit.

Example
```
' Copy variable ExVar bit by bit into variable PT_Var
  Device = 16F1829
  Declare Xtal = 4
  Dim ExVar as Word
  Dim Index as Byte
  Dim Value as Byte
  Dim PT_Var as Word

  Do
    PT_Var = %0000000000000000
    ExVar = %1011011000110111
    Cls
    For Index = 0 to 15              ' Create a loop for 16 bits
      Value = GetBit ExVar, Index    ' Examine each bit of variable ExVar
      LoadBit PT_Var, Index, Value   ' Set or Clear each bit of PT_Var
      Print At 1,1,Bin16 ExVar       ' Display the original variable
      Print At 2,1,Bin16 PT_Var      ' Display the copied variable
      DelayMs 100                    ' Slow things down to see what's happening
    Next                             ' Close the loop
  Loop                               ' Do it forever
```

Notes
There are many ways to clear or set a bit within a variable, however, each method requires a certain amount of manipulation, either with rotates, or alternatively, the use of indirect addressing using the FSR, and INDF registers. Each method has its merits, but requires a certain amount of knowledge to accomplish the task correctly. The **LoadBit** command makes this task extremely simple by taking advantage of the indirect method using FSR, and INDF, however, this is not necessarily the quickest method, or the smallest, but it is the easiest. For speed and size optimisation, there is no shortcut to experience.

To Clear a known constant bit of a variable or register, then access the bit directly using Port.n. i.e. PORTA**.**1 = 0

To Set a known constant bit of a variable or register, then access the bit directly using Port.n. i.e. PORTA**.**1 = 1

If a Port is targeted by **LoadBit**, the Tris register is **not** affected.

See also :   ClearBit, GetBit, SetBit.

LookDown

Syntax
Variable **= LookDown** *Index,* **[** *Constant* {, *Constant*…etc } **]**

Overview
Search *constants(s)* for *index* value. If *index* matches one of the *constants*, then store the matching *constant's* position (0-N) in *variable*. If no match is found, then the *variable* is unaffected.

Parameters
Variable is a user define variable that holds the result of the search.
Index is the variable/constant being sought.
Constant(s),... is a list of values. A maximum of 255 values may be placed between the square brackets, 256 if using an 18F device.

Example
```
Dim Value as Byte
Dim MyResult as Byte
Value = 177              ' The value to look for in the list
MyResult = 255          ' Default to value 255
MyResult = LookDown Value, [75,177,35,1,8,29,245]
Print "Value matches ", Dec MyResult, " in list"
```

In the above example, **Print** displays, "Value matches 1 in list" because Value (177) matches item 1 of [75,177,35,1,8,29,245]. Note that index numbers count up from 0, not 1; that is in the list [75,177,35,1,8,29,245], 75 is item 0.

If the value is not in the list, then MyResult is unchanged.

Notes
LookDown is similar to the index of a book. You search for a topic and the index gives you the page number. Lookdown searches for a value in a list, and stores the item number of the first match in a variable.

LookDown also supports text phrases, which are basically lists of byte values, so they are also eligible for Lookdown searches:

```
Dim Value as Byte
Dim MyResult as Byte

Value = 101             ' ASCII "e". the value to look for in the list
MyResult = 255          ' Default to value 255
MyResult = LookDown Value, ["Hello World"]
```

In the above example, MyResult will hold a value of 1, which is the position of character 'e'

See also :   **Cdata, Cread, Data, Edata, Eread, Ldata, LookDownL, LookUp, LookUpL, Lread, Read, Restore.**

LookDownL

Syntax
Variable **= LookDownL** *Index,* {*Operator*} **[** *Value* {, *Value…*etc } **]**

Overview
A comparison is made between *index* and *value*; if the result is true, 0 is written into *variable.* If that comparison was false, another comparison is made between *value* and *value*1; if the result is true, 1 is written into variable. This process continues until a true is yielded, at which time the *index* is written into *variabl*e, or until all entries are exhausted, in which case *variable* is unaffected.

Parameters
Variable is a user define variable that holds the result of the search.
Index is the variable/constant being sought.
Value(s) can be a mixture of 16-bit constants, string constants and variables. Expressions may not be used in the *Value* list, although they may be used as the *index* value. A maximum of 85 values may be placed between the square brackets, 256 if using an 18F device.
Operator is an optional comparison operator and may be one of the following: -

=	equal
<>	not equal
>	greater than
<	less than
>=	greater than or equal to
<=	less than or equal to

The optional operator can be used to perform a test for other than equal to ("=") while searching the list. For example, the list could be searched for the first *Value* greater than the *index* parameter by using ">" as the *operator*. If *operator* is left out, "=" is assumed.

Example
```
Var1 = LookDownL Wrd, [ 512, Wrd1, 1024 ]
Var1 = LookDownL Wrd, < [ 10, 100, 1000 ]
```

Notes
Because **LookDownL** is more versatile than the standard **LookDown** command, it generates larger code. Therefore, if the search list is made up only of 8-bit constants and strings, use **LookDown**.

See also :   **Cdata, Cread, Cread8, Cread16, Cread32, Edata, Eread, Ldata, LookDown, LookUp, LookUpL, Lread, Lread8, Lread16, Lread32.**

LookUp

Syntax
Variable **= LookUp** *Index,* **[** *Constant* {, *Constant*...etc } **]**

Overview
Look up the value specified by the index and store it in variable. If the index exceeds the highest index value of the items in the list, then variable remains unchanged.

Parameters
Variable may be a constant, variable, or expression. This is where the retrieved value will be stored.
Index may be a constant of variable. This is the item number of the value to be retrieved from the list.
Constant(s) may be any 8-bit value (0-255). A maximum of 255 values may be placed between the square brackets, 256 if using an 18F device.

Example
```
' Create an animation of a spinning line.
  Dim Index as Byte
  Dim Frame as Byte
  Cls                        ' Clear the LCD

  Do
    For Index = 0 to 3       ' Create a loop of 4
      Frame = LookUp Index, [ "|\-/" ] ' Table of animation characters
      Print At 1, 1, Frame ' Display the character
      DelayMs 200            ' So we can see the animation
    Next                     ' Close the loop
  Loop                       ' Repeat forever
```

Notes
index starts at value 0. For example, in the **LookUp** command below. If the first value (10) is required, then index will be loaded with 0, and 1 for the second value (20) etc.

```
  Var1 = LookUp Index, [10, 20, 30]
```

See also :   **Cdata, Cread, Cread8, Cread16, Cread32, Edata, Eread, Ldata, LookDown, LookDownL, LookUpL, Lread, Lread8, Lread8, Lread32.**

LookUpL

Syntax
Variable **= LookUpL** *Index,* **[** *Value* {, *Value*…etc } **]**

Overview
Look up the value specified by the index and store it in variable. If the index exceeds the highest index value of the items in the list, then variable remains unchanged. Works exactly the same as **LookUp**, but allows variable types or constants in the list of values.

Parameters
Variable may be a constant, variable, or expression. This is where the retrieved value will be stored.
Index may be a constant of variable. This is the item number of the value to be retrieved from the list.
Value(s) can be a mixture of 16-bit constants, string constants and variables. A maximum of 85 values may be placed between the square brackets, 256 if using an 18F device.

Example
```
Dim Var1 as Byte
Dim Wrd as Word
Dim Index as Byte
Dim Assign as Word

Var1 = 10
Wrd = 1234
Index = 0      ' Point to the first value in the list (Wrd)
Assign = LookUpL Index, [Wrd, Var1, 12345]
```

Notes
Expressions may not be used in the *Value* list, although they may be used as the *Index* value.

Because **LookUpL** is capable of processing any variable and constant type, the code produced is a lot larger than that of **LookUp**. Therefore, if only 8-bit constants are required in the list, use **LookUp** instead.

See also :   **Cdata, Cread, Cread8, Cread16, Cread32 Edata, Eread, Ldata, LookDown, LookDownL, LookUp, Lread, Lread8, Lread16, Lread32.**

Low

Syntax
Low *Port* or *Port.Bit* or *Pin Number*

Overview
Place a Port.Pin in a low output state. For a port, this means setting it as an output and filling it with 0's.

Parameters
Port can be any valid port.
Port.Bit can be any valid port and bit combination, i.e. PORTA.1
Pin Number can be a variable or constant that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example 1
```
Symbol LED = PORTB.4
Low LED
Low 1                    ' Pull Pin PORTA.1 low
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
    Device = 18F25K20
    Declare Xtal = 16

    Dim MyPin as Byte

    For MyPin = 0 to 15       ' Create a loop for the pin to flash
      High MyPin             ' Set the pin high
      DelayMs 500            ' Delay so that it can be seen
      Low MyPin              ' Pull the pin low
      DelayMs 500            ' Delay so that it can be seen
    Next
```

Notes.

Each pin number has a designated name. These are Pin_A0, Pin_A1, PinA2….Pin_B0, Pin_B7, Pin_C0, Pin_C7 to Pin_L7 etc… Each of the names has a relevant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber As Byte          ' Holds the pin number to set high and low

   Do                             ' Create an infinite loop
     PinNumber = Pin_B0           ' Give the pin number to flash (PORTB.0)
     Gosub FlashPin               ' Call the subroutine to flash the pin
     PinNumber = Pin_B1           ' Give the pin number to flash (PORTB.1)
     Gosub FlashPin               ' Call the subroutine to flash the pin
   Loop                           ' Do it forever
'
' Set a pin high then low for 500ms using a variable as the pin to adjust
'
FlashPin:
   High PinNumber                 ' Set the pin output high
   DelayMs 500                    ' Wait for 500 milliseconds
   Low PinNumber                  ' Pull the pin output low
   DelayMs 500                    ' Wait for 500 milliseconds
   Return
```

Example 2

```
' Clear then Set each pin of PORTC
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber as Byte

   Low PORTC                           ' Make PORTC output low before we start
   Do                                  ' Create a loop
     For PinNumber = Pin_C0 to Pin_C7  ' Create a loop for 8 pins
       Low PinNumber                   ' Clear each pin of PORTC
       DelayMs 100                     ' Slow things down to see what's happening
     Next                              ' Close the loop
     For PinNumber = Pin_C0 to Pin_C7  ' Create a loop for 8 pins
       High PinNumber                  ' Set each pin of PORTC
       DelayMs 100                     ' Slow things down to see what's happening
     Next                              ' Close the loop
   Loop                                ' Do it forever
```

See also :   Dim, High, Symbol, Clear, ClearPin, Set, SetPin, GetPin.

Lread

Syntax
Variable = **Lread** *Label*

Overview
Read a value from an **Ldata** table and place into *Variable*

Parameters
Variable is a user defined variable.
Label is a label name preceding the **Ldata** statement, or expression containing the *Label* name.

Example

```
  Device = 16F1829
  Dim Char as Byte
  Dim MyLoop as Byte
  Cls
  For MyLoop = 0 to 9              ' Create a loop of 10
     Char = Lread Label + MyLoop   ' Read memory location Label + MyLoop
      Print Char                   ' Display the value read
  Next
  Stop
Label: Ldata "HELLO WORLD"         ' Create a string of text in code memory
```

The program above reads and displays 10 values from the address located by the Label accompanying the **Ldata** command. Resulting in "HELLO WORL" being displayed.

Ldata is not simply used for character storage, it may also hold 8, 16, 32 bit, or floating point values. The example below illustrates this: -

```
  Device = 16F628
  Dim Var1 as Byte
  Dim Wrd1 as Word
  Dim Dwd1 as Dword
  Dim Flt1 as Float

  Cls
  Var1 = Lread Bit8_Val        ' Read the 8-bit value
  Print Dec Var1,"  "
  Wrd1= Lread Bit16_Val        ' Read the 16-bit value
  Print Dec Wrd1
  Dwd1 = Lread Bit32_Val       ' Read the 32-bit value
  Print At 2,1, Dec Dwd1,"  "
  Flt1 = Lread MyFloat_Val     ' Read the floating point value
  Print Dec Flt1
  Stop

Bit8_Val: Ldata 123
Bit16_Val: Ldata 1234
Bit32_Val: Ldata 123456
MyFloat_Val: Ldata 123.456
```

Floating point examples.
14-bit core example

```
' 14-bit read floating point data from a table and display the results
  Device = 16F1829
  Dim MyFloat as Float              ' Create a Floating Point variable
  Dim Fcount as Byte
  Cls                               ' Clear the LCD
  Fcount = 0                        ' Clear the table counter
  Repeat                            ' Create a loop
    MyFloat = Lread FlTable + Fcount ' Read the data from the Ldata table
    Print At 1, 1, Dec3 MyFloat     ' Display the data read
    Fcount = Fcount + 4             ' Point to next value, by adding 4 to counter
    DelayMs 1000                    ' Slow things down
  Until MyFloat = 0.005             ' Stop when 0.005 is read
  Stop
FlTable:
  Ldata as Float 3.14, 65535.123, 1234.5678, -1243.456, -3.14, 998999.12,_
                 0.005
```

18F device example

```
' Read floating point data from a table and display the results
  Device = 18F452
  Dim MyFloat as Float              ' Create a Floating Point variable
  Dim Fcount as Byte
  Cls                               ' Clear the LCD
  Fcount = 0                        ' Clear the table counter
  Repeat                            ' Create a loop
    MyFloat = Lread FlTable + Fcount ' Read the data from the Ldata table
    Print At 1, 1, Dec3 MyFloat     ' Display the data read
    Fcount = Fcount + 2             ' Point to next value, by adding 2 to counter
    DelayMs 1000                    ' Slow things down
  Until MyFloat = 0.005             ' Stop when 0.005 is read
  Stop
FlTable:
  Ldata as Float 3.14, 65535.123, 1234.5678, -1243.456, -3.14, 998999.12,_
                 0.005
```

Notes
Ldata tables should be placed at the end of the BASIC program. If an **Ldata** table is placed at the beginning of the program, then a **Goto** command must jump over the tables, to the main body of code.

```
  Goto OverDataTable
  Ldata 1,2,3,4,5,6
OverDataTable:

  { rest of code here}
```

With 14-bit core devices, an 8-bit value (0 - 255) in an **Ldata** statement will occupy a single code space, however, 16-bit data (0 - 65535) will occupy two spaces, 32-bit and floating point values will occupy 4 spaces. This must be taken into account when using the **Lread** command. See 14-bit floating point example above.

With **18F** devices, an 8, and 16-bit value in an **Ldata** statement will occupy a single code space, however, 32-bit and floating point values will occupy 2 spaces. This must be taken into account when using the **Lread** command. See previous 16-bit floating point example.

See also :   Cdata, Cread, Cread8, Cread16, Cread32, Ldata.

Lread8, Lread16, Lread32

Syntax
Variable **= Lread8** *Label* **[** *Offset Variable* **]**

or

Variable **= Lread16** *Label* **[** *Offset Variable* **]**

or

Variable **= Lread32** *Label* **[** *Offset Variable* **]**

Overview
Read an 8, 16, or 32-bit value from an **Ldata** table using an offset of *Offset Variable* and place into *Variable*, with more efficiency than using **Lread** . For PICmicro's that can access their own code memory, such as the 16F87x and all the 18F range.

Lread8 will access 8-bit values from an **Ldata** table.
Lread16 will access 16-bit values from an **Ldata** table.
Lread32 will access 32-bit values from an **Ldata** table, this also includes floating point values.

Parameters
Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float** or **Array**.
Label is a label name preceding the **Ldata** statement of which values will be read from.
Offset Variable can be a constant value, variable, or expression that points to the location of interest within the **Ldata** table.

Lread8 Example
```
' Extract the second value from within an 8-bit Ldata table
  Device = 16F1829
  Dim Offset as Byte           ' Create a Byte size variable for the offset
  Dim MyResult as Byte         ' Create a Byte size variable to hold the result

  Cls                          ' Clear the LCD
  Offset = 1                   ' Point to the second value in the Ldata table
' Read the 8-bit value pointed to by Offset
  MyResult = Lread8 Byte_Table[Offset]
  Print Dec MyResult           ' Display the decimal result on the LCD
  Stop

' Create a table containing only 8-bit values
Byte_Table: Ldata as Byte 100, 200
```

Lread16 Example

```
' Extract the second value from within a 16-bit Ldata table
   Device = 16F1829
   Dim Offset as Byte        ' Create a Byte size variable for the offset
   Dim MyResult as Word      ' Create a Word size variable to hold the result

   Cls                       ' Clear the LCD
   Offset = 1                ' Point to the second value in the Ldata table
' Read the 16-bit value pointed to by Offset
   MyResult = Lread16 WordTable[Offset]
   Print Dec MyResult        ' Display the decimal result on the LCD
   Stop


' Create a table containing only 16-bit values
WordTable: Ldata as Word 1234, 5678
```

Lread32 Example

```
' Extract the second value from within a 32-bit Ldata table
   Device = 16F1829
   Dim Offset as Byte        ' Create a Byte size variable for the offset
   Dim MyResult as Dword     ' Create a Dword size variable to hold the result

   Cls                       ' Clear the LCD
   Offset = 1                ' Point to the second value in the Ldata table
' Read the 32-bit value pointed to by Offset
   MyResult = Lread32 DwordTable[Offset]
   Print Dec MyResult        ' Display the decimal result on the LCD
   Stop


' Create a table containing only 32-bit values
DwordTable: Ldata as Dword 12340, 56780
```

Notes

Data storage in any program is of paramount importance, and although the standard **Lread** command can access multi-byte values from an **Ldata** table, it was not originally intended as such, and is more suited to accessing character data or single 8-bit values. However, the **Lread8**, **Lread16**, and **Lread32** commands are specifically written in order to efficiently read data from an **Ldata** table, and use the least amount of code space in doing so, thus increasing the speed of operation. Which means that wherever possible, **Lread** should be replaced by **Lread8**, **Lread16**, or **Lread32**.

See also :Cdata, Cread, Cread8, Cread16, Cread32, Ldata, Lread.

Mid$

Syntax
Destination String = **Mid$ (***Source String*, *Position within String*, *Amount of characters***)**

Overview
Extract *n* amount of characters from a source string beginning at *n* characters from the left, and copy them into a destination string.

Parameters
Destination String can only be a **String** variable, and should be large enough to hold the correct amount of characters extracted from the *Source String*.
Source String can be a **String** variable, or a **Quoted String of Characters**. See below for more variable types that can be used for *Source String*.
Position within String can be any valid variable type, expression or constant value, that signifies the position within the Source String from which to start extracting characters. Values start at 1 for the leftmost part of the string and should not exceed 255 which is the maximum allowable length of a String variable.
Amount of characters can be any valid variable type, expression or constant value, that signifies the amount of characters to extract from the left of the *Source String*. Values start at 1 and should not exceed 255 which is the maximum allowable length of a String variable.

Example 1
```
' Copy 5 characters from position 4 of SourceString into DestString
'
  Device = 18F452                    ' A suitable device for Strings
  Declare Hserial_Baud = 9600

  Dim SourceString as String * 20    ' Create a String of 20 characters
  Dim DestString as String * 20      ' Create another String

  SourceString = "Hello World"       ' Load the source string with characters
'
' Copy 5 characters from the source string into the destination string
'
  DestString = Mid$(SourceString, 4, 5)
  HrsoutLn DestString        ' Display the result, which will be "Lo Wo"
  Stop
```

Example 2
```
' Copy 5 chars from position 4 of a Quoted Character String into DestString
'
  Device = 18F452                    ' A suitable device for Strings
  Declare Hserial_Baud = 9600

  Dim DestString as String * 20      ' Create a String of 20 characters
'
' Copy 5 characters from the quoted string into the destination string
'
  DestString = Mid$("Hello World", 4, 5)
  HrsoutLn DestString        ' Display the result, which will be "Lo Wo"
  Stop
```

The *Source String* can also be a **Byte**, **Word**, **Dword**, **Float** or **Array** variable, in which case the value contained within the variable is used as a pointer to the start of the Source String's address in RAM.

Example 3
```
' Copy 5 chars from position 4 of SourceString to DestString with a pointer
' to SourceString
'
  Device = 18F452                       ' A suitable device for Strings
  Declare Hserial_Baud = 9600           ' Choose the Baud rate for HrsoutLn

  Dim SourceString as String * 20       ' Create a String of 20 characters
  Dim DestString as String * 20         ' Create another String
' Create a Word variable to hold the address of SourceString
  Dim StringAddr as Word

  SourceString = "Hello World"      ' Load the source string with characters
'
' Locate the start address of SourceString in RAM
'
  StringAddr = AddressOf(SourceString)
'
' Copy 5 characters from the source string into the destination string
'
  DestString = Mid$(StringAddr, 4, 5)
  HrsoutLn DestString          ' Display the result, which will be "Lo Wo"
  Stop
```

A third possibility for *Source String* is a Label name, in which case a null terminated Quoted String of Characters is read from a **Cdata** table.

Example 4
```
' Copy 5 characters from position 4 of a Cdata table into DestString
'
  Device = 18F452                       ' A suitable device for Strings
  Declare Hserial_Baud = 9600           ' Choose the Baud rate for HrsoutLn

  Dim DestString as String * 20         ' Create a String of 20 characters
'
' Copy 5 characters from label Source into the destination string
'
  DestString = Mid$(Source, 4, 5)
  HrsoutLn DestString                   ' Display the result, which will be "Lo Wo"
  Stop
'
' Create a null terminated string of characters in code memory
'
Source:
  Cdata "Hello World", 0
```

See also :   Creating and using Strings, Creating and using Virtual Strings with Cdata, Cdata, Len, Left$, Right$, Str$, ToLower, ToUpper, AddressOf.

On Goto

Syntax
On *Index Variable* **Goto** *Label1* {,...*Labeln* }

Overview
Cause the program to jump to different locations based on a variable index. On a PICmicro™ device with only one page of memory. Exactly the same functionality as **Branch**.

Parameters
Index Variable is a constant, variable, or expression, that specifies the label to jump to.
Label1...*Labeln* are valid labels that specify where to branch to. A maximum of 255 labels may be placed after the **Goto**, 256 if using an 18F device.

Example
```
  Device = 16F84
  Dim Index as Byte

  Cls                           ' Clear the LCD
  Index = 2                     ' Assign Index a value of 2
Start:                          ' Jump to label 2 (Label_2) because Index = 2
  On Index Goto Label_0, Label_1, Label_2

Label_0:
  Index = 2                     ' Index now equals 2
  Print At 1,1,"Label 0"        ' Display the Label name on the LCD
  DelayMs 500                   ' Wait 500ms
  Goto Start                    ' Jump back to Start
Label_1:
  Index = 0                     ' Index now equals 0
  Print At 1,1,"Label 1"        ' Display the Label name on the LCD
  DelayMs 500                   ' Wait 500ms
  Goto Start                    ' Jump back to Start
Label_2:
  Index = 1                     ' Index now equals 1
  Print At 1,1,"Label 2"        ' Display the Label name on the LCD
  DelayMs 500                   ' Wait 500ms
  Goto Start                    ' Jump back to Start
```

The above example we first assign the index variable a value of 2, then we define our labels. Since the first position is considered 0 and the variable Index equals 2 the **On Goto** command will cause the program to jump to the third label in the list, which is Label_2.

Notes

On Goto is useful when you want to organise a structure such as: -

```
If Var1 = 0 Then Goto Label_0  ' Var1 = 0: go to label "Label_0"
If Var1 = 1 Then Goto Label_1  ' Var1 = 1: go to label "Label_1"
If Var1 = 2 Then Goto Label_2  ' Var1 = 2: go to label "Label_2"
```

You can use **On Goto** to organise this into a single statement: -

```
On Var1 Goto Label_0, Label_1, Label_2
```

This works exactly the same as the above **If**...**Then** example. If the value is not in range (in this case if Var1 is greater than 2), **On Goto** does nothing. The program continues with the next instruction.

The **On Goto** command is primarily for use with PICmicro™ devices that have one page of memory (0-2047). If larger PICmicros are used and you suspect that the branch label will be over a page boundary, use the **On GotoL** command instead.

See also :   Branch, BranchL, On GotoL, On Gosub.

On GotoL

Syntax
On *Index Variable* **GotoL** *Label1* {,...*Labeln* }

Overview
Cause the program to jump to different locations based on a variable index. On a PICmicro™ device with more than one page of memory, or 18F devices. Exactly the same functionality as **BranchL**.

Parameters
Index Variable is a constant, variable, or expression, that specifies the label to jump to.
Label1...*Labeln* are valid labels that specify where to branch to. A maximum of 127 labels may be placed after the **GotoL**, 256 if using an 18F device.

Example
```
  Device = 16F1829            ' Use a larger PICmicro device
  Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

  Dim Index as Byte

  Index = 2                   ' Assign Index a value of 2
Start:                        ' Jump to label 2 (Label_2) because Index = 2

  On Index GotoL Label_0, Label_1, Label_2

Label_0:
  Index = 2                   ' Index now equals 2
  HrsoutLn "Label 0"          ' Display the Label name
  Goto Start                  ' Jump back to Start

Label_1:
  Index = 0                   ' Index now equals 0
  HrsoutLn "Label 1"          ' Display the Label name
  Goto Start                  ' Jump back to Start

Label_2:
  Index = 1                   ' Index now equals 1
  HrsoutLn "Label 2"          ' Display the Label name
  Goto Start                  ' Jump back to Start
```

The above example we first assign the index variable a value of 2, then we define our labels. Since the first position is considered 0 and the variable Index equals 2 the **On GotoL** command will cause the program to jump to the third label in the list, which is Label_2.

Notes
The **On GotoL** command is mainly for use with PICmicro™ devices that have more than one page of memory (greater than 2048). It may also be used on any PICmicro™ device, but does produce code that is larger than **On Goto**.

See also : Branch, BranchL, On Goto, On Gosub .

On Gosub

Syntax
On *Index Variable* **Gosub** *Label1* {,...*Labeln* }

Overview
Cause the program to Call a subroutine based on an index value. A subsequent **Return** will continue the program immediately following the **On Gosub** command.

Parameters
Index Variable is a constant, variable, or expression, that specifies the label to call.
Label1...*Labeln* are valid labels that specify where to call. A maximum of 256 labels may be placed after the **Gosub**.

Example
```
  Device = 18F452                ' Use an 18F PICmicro
  Declare Hserial_Baud = 9600 ' Choose the Baud rate for HrsoutLn

  Dim Index as Byte

  Do                             ' Create an infinite loop
    For Index = 0 to 2           ' Create a loop to call all the labels
      ' Call the label depending on the value of Index
      On Index Gosub Label_0, Label_1, Label_2
      DelayMs 500                ' Wait 500ms after the subroutine has returned
    Next
  Loop                           ' Do it forever

Label_0:
  HrsoutLn "Label 0"            ' Display the Label name
  Return
Label_1:
  HrsoutLn "Label 1"            ' Display the Label name
  Return
Label_2:
  HrsoutLn "Label 2"            ' Display the Label name
  Return
```

The above example, a loop is formed that will load the variable Index with values 0 to 2. The **On Gosub** command will then use that value to call each subroutine in turn. Each subroutine will **Return** to the **DelayMs** command, ready for the next scan of the loop.

Notes
On Gosub is useful when you want to organise a structure such as: -

```
If Var1 = 0 Then Gosub Label_0    ' Var1 = 0: call label "Label_0"
If Var1 = 1 Then Gosub Label_1    ' Var1 = 1: call label "Label_1"
If Var1 = 2 Then Gosub Label_2    ' Var1 = 2: call label "Label_2"
```

You can use **On Gosub** to organise this into a single statement: -

```
On Var1 Gosub Label_0, Label_1, Label_2
```

This works exactly the same as the above **If**...**Then** example. If the value is not in range (in this case if Var1 is greater than 2), **On Gosub** does nothing. The program continues with the next instruction..

On Gosub is only supported with 18F devices because they are the only PICmicro™ devices that allow code access to their return stack, which is required for the computed **Return** address.

See also : Branch, BranchL, On Goto, On GotoL.

On_Hardware_Interrupt

Syntax
On_Hardware_Interrupt *Label*

Overview
Point to the subroutine that will be called when a hardware interrupt occurs. High priority hardware interrupt if using an 18F device.

Parameters
Label is a valid identifier

Example
```
' Flash an LED on PORTB.0 at a different rate to the LED on PORTB.1
'
   Device = 16F1829
   Declare Xtal = 4
   On_Hardware_Interrupt Goto ISR_Flash

   Goto Main                  ' Jump over the interrupt subroutine
' -------------------------------------------------
' Timer0 overflow interrupt handler starts here
' Xor PORTB with 1, which will turn on the LED connected to PORTB.0
' with one interrupt and turn it off with the next interrupt
'
ISR_Flash:
   Context Save        ' Save any variables or SFRs before the interrupt starts
   If INTCONbits_T0IF = 1 Then ' Is it TMR0 that caused the interrupt?
      PORTB = PORTB ^ 1        ' Yes. So. Xor PORTB.0
      INTCONbits_T0IF = 0      ' Clear the TMR0 overflow flag
   EndIf
   Context Restore     ' Restore any variables or SFRs and exit the interrupt


' -------------------------------------------------
' The main program loop starts here
'
Main:
   Low PORTB = 0              ' Make PORTB all outputs and pull it low
'
' Initiate the interrupt
'
   OPTION_REG = %00101111     ' Setup Timer0
   TMR0 = 0                   ' Clear TMR0 initially
   INTCONbits_T0IE = 1        ' Enable a Timer0 overflow interrupt
   INTCONbits_GIE = 1         ' Enable global interrupts
   Do                         ' Create an infinite loop
      Clear PORTB.1           ' Extinguish the LED
      DelayMs 500             ' Wait a while
      Set PORTB.1             ' Illuminate the LED
      DelayMs 500             ' Wait a while
   Loop
```

Typical format of the interrupt handler with standard 14-bit core devices.

The interrupt handler subroutine must always follow a fixed pattern.

- First, the contents of the STATUS, PCLATH, and Working Register (WREG) must be saved, this is termed *context saving*, and is performed when the command **Context Save** is issued. Variable space is automatically allocated for these registers in the shared portion of memory located at the top of RAM Bank 0. The Context Save command also instructs the compiler to save any compiler system variables and device SFRs (Special Function Registers) used within the interrupt handler. Note that "within the interrupt handler" means code between **Context Save** and **Context Restore**. It will **not** track any **Goto** or **Gosub** commands.

- Because a standard 14-bit core device has a single interrupt vector, the cause of the interrupt must be ascertained by checking the appropriate flag. For example INTCON.T0IF for a Timer0 overflow interrupt, and only perform the relevant code for the relevant interrupt. This is accomplished by a simple **If-EndIf**. For example:

```
ISR_Handler:
  Context Save                       ' Save any variables or SFRs used
  If INTCONbits_T0IF = 1 Then        ' Is it Timer0 that caused the interrupt?
    Print "Hello World"              ' Yes. So do this code
    INTCONbits_T0IF = 0              ' Clear the Timer0 overflow flag
  EndIf
  Context Restore                    ' Restore any variables or SFRs used and exit
```

If more than one interrupt is enabled, multiple **If-Endif** conditions will be required within the single interrupt handling subroutine.

- The previously saved STATUS, PCLATH, and Working register (WREG) must be returned to their original conditions (*context restoring*) once the interrupt handler has performed its task. The **Context Restore** command is used for this. It also returns the program back to the main body code where the interrupt was called from. In other words it performs an assembler **Retfie** instruction.

The above code snippet will cause several compiler system variables and device SFRs to be saved and restored, thus causing little, or no, disturbance to the main body code.

Typical format of the interrupt handler with enhanced 14-bit core devices.

As with standard 14-bit core interrupts, the interrupt handler subroutine must follow a fixed pattern.

- First, the **Context Save** command should be issued, as this will save any compiler system variables and SFRs used. The microcontroller itself will save the contents of the STATUS, PCLATH, BSR, FSR0L\H, FSR1L\H and WREG registers.

- As with standard 14-bit core devices, enhanced 14-bit core devices have a single interrupt vector, therefore the same rules apply as outlined above concerning the establishment of the cause of the interrupt. Not forgetting to clear any interrupt flag that needs clearing before exiting the interrupt.

- The **Context Restore** command should be issued at the end of the interrupt handler, as long as its corresponding **Context Save** command was used previously. This will restore any compiler system variables and SFRs, then exit the interrupt using the **Retfie** mnemonic.

Note that the STATUS, PCLATH, BSR, FSR0L\H, FSR1L\H and WREG registers will automatically be restored by the microcontroller once the interrupt is exited.

As with standard 14-bit core devices, any compiler variable or device SFR that is used by a command will be saved and restored as long as they reside within the **Context Save** and **Context Restore** commands. This is termed Managed Interrupts.

Note that the **Context Save** and **Context Restore** commands are not required unless managed interrupts are implemented, in which case use the **Retfie** mnemonic to exit the interrupt handler. However, you must be certain that the interrupt handler is not disturbing any compiler system variables or SFRs, or your program will not run correctly.

Typical format of the interrupt handler with 18F devices.
As with both types of 14-bit core devices, the interrupt handler subroutine must also follow a fixed pattern.

- First, the **Context Save** command should be issued, as this will save any compiler system variables and SFRs used. The microcontroller itself will save the contents of the STATUS, BSR and WREG registers for a high priority interrupt.

- 18F devices have two interrupt vectors for high and low priority interrupts, see **On_Low_Interrupt**. However, both of these must follow the rules laid down for 14-bit core devices, in that the cause of the interrupt must be ascertained before the appropriate code is performed, and any interrupt flag that needs clearing must be cleared before exiting the interrupt.

- The **Context Restore** command should be issued at the end of the interrupt handler, as long as its corresponding **Context Save** command was used previously. This will restore any compiler system variables and SFRs, then exit the interrupt using the **Retfie** 1 mnemonic.

Note that the STATUS, BSR and WREG registers will automatically be restored by the microcontroller once the interrupt is exited from a high priority interrupt.

Upon exiting the interrupt, a simple **Retfie** 1 (Return From Interrupt Fast) mnemonic can be used, as long as the **Context Save** command is not issued and it is certain that the interrupt handling subroutine is not disturbing any compiler system variables or device SFRs.

Note.
On all devices, the code within the interrupt handler should be as quick and efficient as possible because while it's processing the code, the main program is halted. When inside an interrupt, care should be taken to ensure that the watchdog timer does not time-out, if it's enabled. Placing a **ClrWdt** mnemonic at the beginning of the interrupt handler will usually prevent this from happening. An alternative approach would be to disable the watchdog timer altogether at programming time, which is the default of the compiler.

On_Low_Interrupt

Syntax
On_Low_Interrupt *Label*

Overview
Point to the subroutine that will be called when a Low Priority Hardware interrupt occurs on an 18F device.

Parameters
Label is a valid identifier

Example
```
' Demonstrate the use of context saving of the compiler's System variables
' Creates low and high priority interrupts incrementing on Timer0 and Timer1
' Within the interrupts a value is displayed and incremented
' In the foreground another value is incremented and transmitted serially
'
  Include "Proton18_4.Inc"  ' Use the Proton Board with an 18F device
'
' Point to the High Priority interrupt handler to the subroutine
'
  On_Hardware_Interrupt Goto ISR_High
'
' Point to the Low Priority interrupt handler to the subroutine
'
  On_Low_Interrupt Goto ISR_Low
'
' Create some variables
'
  Dim HighCounter as Dword        ' Counter for the high interrupt routine
  Dim LowCounter as Dword         ' Counter for the low interrupt routine
  Dim ForeGroundCounter as Dword  ' Counter for the Foreground routine
  Dim wTimer0 as TMR0L.Word       ' Create a 16-bit Word from registers TMR0L/H
  Dim wTimer1 as TMR1L.Word       ' Create a 16-bit Word from registers TMR1L/H
' ----------------------------------------------------------------
  Goto Main                       ' Jump over any subroutines
'
' ----------------------------------------------------------------
' High Priority Hardware Interrupt Handler
' Interrupt's on a Timer1 Overflow. Display on the LCD and increment a value
'
ISR_High:
'
' Save the compiler's system variables used in the interrupt routine only
' Also save any SFRs used
'
  Context Save PORTD, TRISD
  If PIR1bits_TMR1IF = 1 Then     ' Is it a Timer1 overflow interrupt?
                                  ' Yes. So Display the value on the LCD
    Print at 1,1,"High Int ", Dec HighCounter
    Inc HighCounter               ' Increment the value
    PIR1bits_TMR1IF = 0           ' Clear the Timer1 Overflow flag
  EndIf
'
' Restore compiler's system variables used within the interrupt routine only
' and exit the interrupt
'
  Context Restore
```

```
' ----------------------------------------------------------------
' Low Priority Hardware Interrupt Handler
' Interrupt's on a Timer0 Overflow
' Display on the LCD and increment a value
'
ISR_Low:
' Save the compiler's system variables used in the interrupt routine only
' Also save any SFR's used.
'
    Context Save PORTD, TRISD
    If INTCON1bits_TMR0IF = 1 Then      ' Is it a Timer0 overflow interrupt?
      '
      ' Yes. So Disable Timer 1 High priority interrupt while we use the LCD
      '
      PIE1bits_TMR1IE = 0         ' Display the value on line 2 of the LCD
      Print at 2,1,"Low Int  ", Dec LowCounter,"  "
      Inc LowCounter             ' Increment the value
      PIE1bits_TMR1IE = 1         ' Re-Enable the Timer1 High priority interrupt
      INTCON1bits_TMR0IF = 0     ' Clear the Timer0 Overflow flag
    EndIf
'
' Restore the compiler's system variables used in the interrupt routine only ' and
exit the interrupt
'
    Context Restore
'
' ----------------------------------------------------------------
' The Main Program Loop Starts Here
'
Main:
    Delayms 100                 ' Wait for the LCD to stabilise
    INTCON1 = 0                 ' Disable Interrupts
    Low PORTD                   ' Set PORTD to Output Low
    HighCounter = 0
    LowCounter = 0
    ForeGroundCounter = 0
    Cls                         ' Clear the LCD
'
' Setup Timer0
'
    T0CONbits_T0PS2 = 0         ' \
    T0CONbits_T0PS1 = 0         ' | Timer0 Prescaler to 1:4
    T0CONbits_T0PS0 =  1        ' /
    T0CONbits_PSA = 0           ' Assign the prescaler
    T0CONbits_T0CS = 0          ' Increment on the internal Clk
    T0CONbits_T08Bit = 0        ' Timer0 is configured as a 16-bit counter
    wTimer0 = 0                 ' Clear Timer0
    T0CONbits_TMR0ON = 1        ' Enable Timer0
'
' Setup Timer1
'
    T1CONbits_RD16 = 1          ' Enable Timer1 in 16-bit operation
    T1CONbits_T1CKPS1 = 0       ' \ Timer1 Prescaler to 1:2
    T1CONbits_T1CKPS0 = 0       ' /
    T1CONbits_T1OSCEN = 0       ' Disable External Oscillator
    T1CONbits_TMR1CS = 0        ' Increment on the internal Clk
    wTimer1 = 0                 ' Clear Timer1
    T1CONbits_TMR1ON = 1        ' Enable Timer1
```

```
'
' Setup the High and Low priority interrupts
'
    INTCON1bits_TMR0IE  = 1          ' Enable the Timer0 overflow interrupt
    INTCON2bits_TMR0IP = 0           ' Timer0 Overflow Interrupt to Low priority
    INTCON1bits_TMR1IE = 1           ' Enable the Timer1 overflow interrupt
    IPR1bits_TMR1IP = 1              ' Timer1 Overflow Interrupt to High priority
    RCONbits_IPEN = 1                ' Enable priority levels on interrupts
    INTCON1bits_GIEL = 1             ' Enable low priority peripheral interrupts
    INTCON1bits_GIE = 1              ' Enable all high priority interrupts
'
' Display value in foreground while interrupts do their thing in background
'
    Do                               ' Create an infinite loop
        ' Display the  value on serial terminal
        Hrsout   "ForeGround ", Dec ForeGroundCounter, 13
        Inc ForeGroundCounter        ' Increment the value
        Delayms 200
    Loop                             ' Close the loop. i.e. do it forever
```

Output

Syntax
Output *Port or Port . Pin* or *Pin Number*

Overview
Makes the specified *Port* or *Port.Pin* an output.

Parameters
Port.Pin must be a Port.Pin constant declaration.
Pin Number can be any variable or constant holding 0 to the amount of I/O pins on the device.
A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example
```
Output PORTA.0        ' Make bit-0 of PORTA an output
Output PORTA          ' Make all of PORTA an output
Output 0              ' Make pin-0 of PORTA an output
Output 8              ' Make pin-0 of PORTB an output
Output Pin_B0         ' Make pin-0 of PORTB an output
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
  Device = 18F25K20
  Declare Xtal = 16

  Dim MyPin as Byte

  High PORTA                ' Make all of PORTA output high
  High PORTB                ' Make all of PORTB output high
  For MyPin = 0 to 15       ' Create a loop for the pin to flash
    Output MyPin            ' Set the pin as an output
    DelayMs 500             ' Delay so that it can be seen
    Input MyPin             ' Set the pin as an input
    DelayMs 500             ' Delay so that it can be seen
  Next
```

Notes
An Alternative method for making a particular pin an output is by directly modifying the Tris: -

```
  TRISB.0 = 0             ' Set PORTB, bit-0 to an output
```

All of the pins on a port may be set to output by setting the whole TRIS register at once: -

```
  TRISB = %00000000     ' Set all of PORTB to outputs
```

In the above examples, setting a TRIS bit to 0 makes the pin an output, and conversely, setting the bit to 1 makes the pin an input.

Each pin number has a designated name. These are Pin_A0, Pin_A1, Pin_A2, Pin_B0…Pin_B7, Pin_C0…Pin_C7, Pin_D0…Pin_D7 to Pin_L7 etc… Each of the names has a relevant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
  Device = 18F25K20
  Declare Xtal = 16

  Dim PinNumber As Byte          ' Holds the pin number to set high and low

  Do                             ' Create an infinite loop
     PinNumber = Pin_B0          ' Give the pin number to flash (PORTB.0)
     Gosub FlashPin              ' Call the subroutine to flash the pin
     PinNumber = Pin_B1          ' Give the pin number to flash (PORTB.1)
     Gosub FlashPin              ' Call the subroutine to flash the pin
  Loop                           ' Do it forever
'
' Make the pin an output then an input for 500ms using a value as the pin to adjust
'
FlashPin:
  SetPin PinNumber               ' Bring the pin high
  Output PinNumber               ' Make the pin an output
  DelayMs 500                    ' Wait for 500 milliseconds
  Input PinNumber                ' Make the pin an input
  DelayMs 500                    ' Wait for 500 milliseconds
  Return
```

See also :   Input, ClearPin, SetPin, High, Low.

Org

Syntax
Org *Value*

Overview
Set the program origin for subsequent code at the address defined in *Value*

Parameters
Value can be any constant value within the range of the particular microcontroller's memory.

Example
```
Device 16F1829

Org 2000                    ' Set the origin to address 2000
Cdata 120, 243, "Hello"     ' Place data starting at address 2000
```

or

```
Symbol Address = 2000

Org Address + 1             ' Set the origin to address 2001
Cdata 120, 243, "Hello"     ' Place data starting at address 2001
```

Notes
If more complex values are required after the **Org** directive, such as assembler variables etc.
Use : -

```
@ Org { assembler variables etc }
```

Oread

Syntax
Oread *Pin*, *Mode*, **[** *Inputdata* **]**

Overview
Receive data from a device using the Dallas Semiconductor 1-wire protocol. The 1-wire protocol is a form of asynchronous serial communication developed by Dallas Semiconductor. It requires only one I/O pin which may be shared between multiple 1-wire devices.

Parameters
Pin is a Port-Bit combination that specifies which I/O pin to use. 1-wire devices require only one I/O pin (normally called DQ) to communicate. This I/O pin will be toggled between output and input mode during the **Oread** command and will be set to input mode by the end of the **Oread** command.
Mode is a numeric constant (0 - 7) indicating the mode of data transfer. The Mode argument control's the placement of reset pulses and detection of presence pulses, as well as byte or bit input. See notes below.
Inputdata is a list of variables or arrays to store the incoming data into.

Example
```
Dim MyResult as Byte
Symbol DQ = PORTA.0
Oread DQ, 1, [MyResult]
```

The above example code will transmit a 'reset' pulse to a 1-wire device (connected to bit 0 of PORTA) and will then detect the device's 'presence' pulse and receive one byte and store it in the variable MyResult.

Notes
The Mode operator is used to control placement of reset pulses (and detection of presence pulses) and to designate byte or bit input. The table below shows the meaning of each of the 8 possible value combinations for Mode.

Mode Value	Effect
0	No Reset, Byte mode
1	Reset before data, Byte mode
2	Reset after data, Byte mode
3	Reset before and after data, Byte mode
4	No Reset, Bit mode
5	Reset before data, Bit mode
6	Reset after data, Bit mode
7	Reset before and after data, Bit mode

The correct value for Mode depends on the 1-wire device and the portion of the communication that is being dealt with. Consult the data sheet for the device in question to determine the correct value for Mode. In many cases, however, when using the **Oread** command, Mode should be set for either No Reset (to receive data from a transaction already started by an **Owrite**

command) or a Reset after data (to terminate the session after data is received). However, this may vary due to device and application requirements.

When using the Bit (rather than Byte) mode of data transfer, all variables in the InputData argument will only receive one bit. For example, the following code could be used to receive two bits using this mode: -

```
Dim BitVar1 as Bit
Dim BitVar2 as Bit
Oread PORTA.0, 6, [BitVar1, BitVar2]
```

In the example code shown, a value of 6 was chosen for Mode. This sets Bit transfer and Reset after data mode.

We could also have chosen to make the BitVar1 and BitVar2 variables each a Byte type, however, they would still only have received one bit each in the **Oread** command, due to the Mode that was chosen.

The compiler also has a modifier for handling a string of data, named **Str**.

The **Str** modifier is used for receiving data and placing it directly into a byte array variable.

A string is a set of bytes that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1 2 3 would be stored in a byte array containing three bytes (elements).

Below is an example that receives ten bytes through a 1-wire interface and stores them in the 10-byte array, MyArray: -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
Oread DQ, 1, [Str MyArray]
Print Dec Str MyArray          ' Display the values.
```

If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. For example: -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
Oread DQ, 1, [Str MyArray\5]   ' Fill the first 5-bytes of array with data.
Print Str MyArray \5           ' Display the 5-value string.
```

The example above illustrates how to fill only the first n bytes of an array, and then how to display only the first n bytes of the array. n refers to the value placed after the backslash.

Dallas 1-Wire Protocol.

The 1-wire protocol has a well defined standard for transaction sequences. Every transaction sequence consists of four parts: -

    Initialisation.
    ROM Function Command.
    Memory Function Command.
    Transaction / Data.

Additionally, the ROM Function Command and Memory Function Command are always 8 bits wide and are sent least-significant-bit first (LSB).

The Initialisation consists of a reset pulse (generated by the master) that is followed by a presence pulse (generated by all slave devices).

The reset pulse is controlled by the lowest two bits of the Mode argument in the Oread command. It can be made to appear before the ROM Function Command (Mode = 1), after the Transaction / Data portion (Mode = 2), before and after the entire transaction (Mode = 3) or not at all (Mode = 0).

Command	Value	Action
Read ROM	$33	Reads the 64-bit ID of the 1-wire device. This command can only be used if there is a single 1-wire device on the line.
Match ROM	$55	This command, followed by a 64-bit ID, allows the PICmicro to address a specific 1-wire device.
Skip ROM	$CC	Address a 1-wire device without its 64-bit ID. This command can only be used if there is a single 1-wire device on the line.
Search ROM	$F0	Reads the 64-bit IDs of all the 1-wire devices on the line. A process of elimination is used to distinguish each unique device.

Following the Initialisation, comes the ROM Function Command. The ROM Function Command is used to address the desired 1-wire device. The above table shows a few common ROM Function Commands. If only a single 1 wire device is connected, the Match ROM command can be used to address it. If more than one 1-wire device is attached, the PICmicro™ will ultimately have to address them individually using the Match ROM command.

The third part, the Memory Function Command, allows the PICmicro™ to address specific memory locations, or features, of the 1-wire device. Refer to the 1-wire device's data sheet for a list of the available Memory Function Commands.

Finally, the Transaction / Data section is used to read or write data to the 1-wire device. The **Oread** command will read data at this point in the transaction. A read is accomplished by generating a brief low-pulse and sampling the line within 15us of the falling edge of the pulse. This is called a 'Read Slot'.
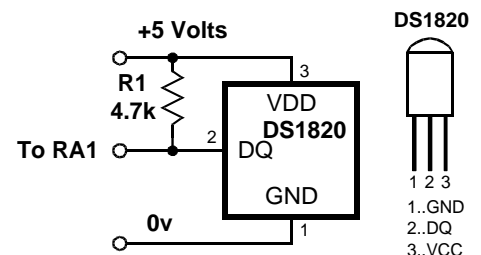
The following program demonstrates interfacing to a Dallas Semiconductor DS1820 1-wire digital thermometer device using the compiler's 1-wire commands, and connections as per the diagram to the right.

The code reads the Counts Remaining and Counts per Degree Centigrade registers within the DS1820 device in order to provide a more accurate temperature (down to 1/10th of a degree).

```
Device = 16F84
Declare Xtal = 4
Symbol DQ = PORTA.1           ' Place the DS1820 on bit-1 of PORTA
Dim Temp as Word             ' Holds the temperature value
Dim C as Byte                ' Holds the counts remaining value
Dim CPerD as Byte            ' Holds the Counts per degree C value

Cls                          ' Clear the LCD before we start
Do
   Owrite DQ, 1, [$CC, $44]  ' Send Calculate Temperature command
   Repeat
      DelayMs 25             ' Wait until conversion is complete
      Oread DQ, 4, [C]       ' Keep reading low pulses until
   Until C <> 0              ' the DS1820 is finished.
   Owrite DQ, 1, [$CC, $BE]  ' Send Read ScratchPad command
   Oread DQ, 2,[Temp.LowByte,Temp.HighByte, C, C, C, C, C, CPerD]
   '
   ' Calculate the temperature in degrees Centigrade
   '
   Temp = (((Temp >> 1) * 100) - 25) + (((CPerD - C) * 100) / CPerD)
   Print At 1,1, Dec Temp / 100, ".", Dec2 Temp," ", At 1,8,"C"
Loop
```

Note.
The equation used in the program above will not work correctly with negative temperatures. Also note that the 4.7kΩ pull-up resistor (R1) is required for correct operation.

Inline Oread Command.
The standard structure of the **Oread** command is: -

   Oread Pin, Mode, [Inputdata]

However, this did not allow it to be used in conditions such as **If-Then**, **While-Wend** etc. Therefore, there is now an additional structure to the **Oread** command: -

   Var = **Oread** Pin, Mode

Operands Pin and Mode have not changed their function, but the result from the 1-wire read is now placed directly into the assignment variable.

Oread - Owrite Presence Detection.

Another important feature to both the **Oread** and **Owrite** commands is the ability to jump to a section of the program if a presence is not detected on the 1-wire bus.

Owrite Pin, Mode, Label, [Outputdata]

Oread Pin, Mode, Label, [Inputdata]

Var = **Oread** Pin, Mode, Label

The Label parameter is an optional condition, but if used, it must reference a valid BASIC label.

```
' Skip ROM search & do temp conversion
  Owrite  DQ, 1, NoPresence, [$CC, $44]
  While Oread DQ, 4, NoPresence != 0 : Wend ' Read busy-bit,' Still busy..?
' Skip ROM search & read scratchpad memory
  Owrite  DQ, 1, NoPresence, [$CC, $BE]
  Oread  DQ, 2, NoPresence, [Temp.Lowbyte, Temp.Highbyte] ' Read two bytes
  Return

NoPresence:
  Print "No Presence"
  Stop
```

See also :   Owrite.

Owrite

Syntax
Owrite *Pin*, *Mode*, **[** *Outputdata* **]**

Overview
Send data to a device using the Dallas Semiconductor 1-wire protocol. The 1-wire protocol is a form of asynchronous serial communication developed by Dallas Semiconductor. It requires only one I/O pin which may be shared between multiple 1-wire d vices.

Parameters
Pin is a Port-Bit combination that specifies which I/O pin to use. 1-wire devices require only one I/O pin (normally called DQ) to communicate. This I/O pin will be toggled between output and input mode during the Owrite command and will be set to input mode by the end of the Owrite command.
Mode is a numeric constant (0 - 7) indicating the mode of data transfer. The Mode operator control's the placement of reset pulses and detection of presence pulses, as well as byte or bit input. See notes below.
Outputdata is a list of variables or arrays transmit individual or repeating bytes.

Example

```
Symbol DQ = PORTA.0
Owrite DQ, 1, [$4E]
```

The above example will transmit a 'reset' pulse to a 1-wire device (connected to bit 0 of PORTA) and will then detect the device's 'presence' pulse and transmit one byte (the value $4E).

Notes
The Mode operator is used to control placement of reset pulses (and detection of presence pulses) and to designate byte or bit input. The table below shows the meaning of each of the 8 possible value combinations for Mode.

Mode Value	Effect
0	No Reset, Byte mode
1	Reset before data, Byte mode
2	Reset after data, Byte mode
3	Reset before and after data, Byte mode
4	No Reset, Bit mode
5	Reset before data, Bit mode
6	Reset after data, Bit mode
7	Reset before and after data, Bit mode

The correct value for Mode depends on the 1-wire device and the portion of the communication you're dealing with. Consult the data sheet for the device in question to determine the correct value for Mode. In many cases, however, when using the **Owrite** command, Mode should be set for a Reset before data (to initialise the transaction). However, this may vary due to device and application requirements.

When using the Bit (rather than Byte) mode of data transfer, all variables in the InputData argument will only receive one bit. For example, the following code could be used to receive two bits using this mode: -

```
Dim BitVar1 as Bit
Dim BitVar2 as Bit
Owrite PORTA.0, 6, [BitVar1, BitVar2]
```

In the example code shown, a value of 6 was chosen for Mode. This sets Bit transfer and Reset after data mode. We could also have chosen to make the BitVar1 and BitVar2 variables each a Byte type, however, they would still only use their lowest bit (Bit0) as the value to transmit in the **Owrite** command, due to the Mode value chosen.

The Str Modifier

The **Str** modifier is used for transmitting a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that sends four bytes (from a byte array) through bit-0 of PORTA: -

```
Dim MyArray[10] as Byte         ' Create a 10-byte array.
MyArray [0] = $CC               ' Load the first 4 bytes of the array
MyArray [1] = $44               ' With the data to send
MyArray [2] = $CC
MyArray [3] = $4E
Owrite PORTA.0, 1, [Str MyArray\4] ' Send 4-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the PICmicro™ would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 4 bytes.

The above example may also be written as: -

```
Dim MyArray [10] as Byte            ' Create a 10-byte array.
Str MyArray = $CC,$44,$CC,$4E       ' Load the first 4 bytes of the array
Owrite PORTA.0, 1, [Str MyArray\4] ' Send 4-byte string.
```

The above example, has exactly the same function as the previous one. The only difference is that the string is now constructed using the **Str** as a command instead of a modifier.

See also :   Oread for example code, and 1-wire protocol.

Pixel

Syntax
Variable **= Pixel** *Ypos, Xpos*

Overview
Read the condition of an individual pixel from a graphic LCD. The returned value will be 1 if the pixel is set, and 0 if the pixel is clear.

Parameters
Variable is a user defined variable.
Xpos can be a constant, variable, or expression, pointing to the X-axis location of the pixel to examine. This must be a value of 0 to the X resolution of the LCD. Where 0 is the far left row of pixels.
Ypos can be a constant, variable, or expression, pointing to the Y-axis location of the pixel to examine. This must be a value of 0 to the Y resolution of the LCD. Where 0 is the top column of pixels.

Example
```
' Read a line of pixels from a KS0108 graphic LCD
  Device = 16F1829
  Declare LCD_Type = KS0108       ' Use a KS0108 Graphic LCD
  Declare Internal_Font = Off     ' Use an external chr set
  Declare Font_Addr = 0           ' Eeprom's address is 0
'
' Graphic LCD Pin Assignments
'
  Declare LCD_DTPort = PORTD
  Declare LCD_RSPin = PORTC.2
  Declare LCD_RWPin = PORTE.0
  Declare LCD_ENPin = PORTC.5
  Declare LCD_CS1Pin = PORTE.1
  Declare LCD_CS2Pin = PORTE.2
'
' Character set eeprom Pin Assignments
'
  Declare SDA_Pin = PORTC.4
  Declare SCL_Pin = PORTC.3

  Dim Xpos as Byte
  Dim Ypos as Byte
  Dim MyResult as Byte

  ADCON1 = 7        ' PORTA and PORTE to all digital mode
  Cls
  Print At 0, 0, "Testing 1-2-3"
'
' Read the top row and display the result
'
  For Xpos = 0 to 127
  MyResult = Pixel 0, Xpos       ' Read the top row
  Print At 1, 0, Dec MyResult
  DelayMs 400
  Next
  Stop
```

See also :   LCDread, LCDwrite, Plot, UnPlot. See Print for circuit.

Plot

Syntax
Plot *Ypos, Xpos*

Overview
Set an individual pixel on a graphic LCD.

Parameters
Xpos can be a constant, variable, or expression, pointing to the X-axis location of the pixel to set. This must be a value of 0 to the X resolution of the LCD. Where 0 is the far left row of pixels.
Ypos can be a constant, variable, or expression, pointing to the Y-axis location of the pixel to set. This must be a value of 0 to the Y resolution of the LCD. Where 0 is the top column of pixels.

Example
```
  Device = 16F1829
  Declare LCD_Type = KS0108      ' Use a KS0108 Graphic LCD
'
' Graphic LCD Pin Assignments
'
  Declare LCD_DTPort = PORTD
  Declare LCD_RSPin = PORTC.2
  Declare LCD_RWPin = PORTE.0
  Declare LCD_ENPin = PORTC.5
  Declare LCD_CS1Pin = PORTE.1
  Declare LCD_CS2Pin = PORTE.2

  Dim Xpos as Byte
'
' Draw a line across the LCD
'
  While                         ' Create an infinite loop
    For Xpos = 0 to 127
      Plot 20, Xpos
      DelayMs 10
    Next
    '
    ' Now erase the line
    '
    For Xpos = 0 to 127
      UnPlot 20, Xpos
      DelayMs 10
    Next
  Wend
```

 See also :   LCDread, LCDwrite, Pixel, UnPlot. See Print for circuit.

Graphic LCD pixel configuration for a 128x64 resolution display.
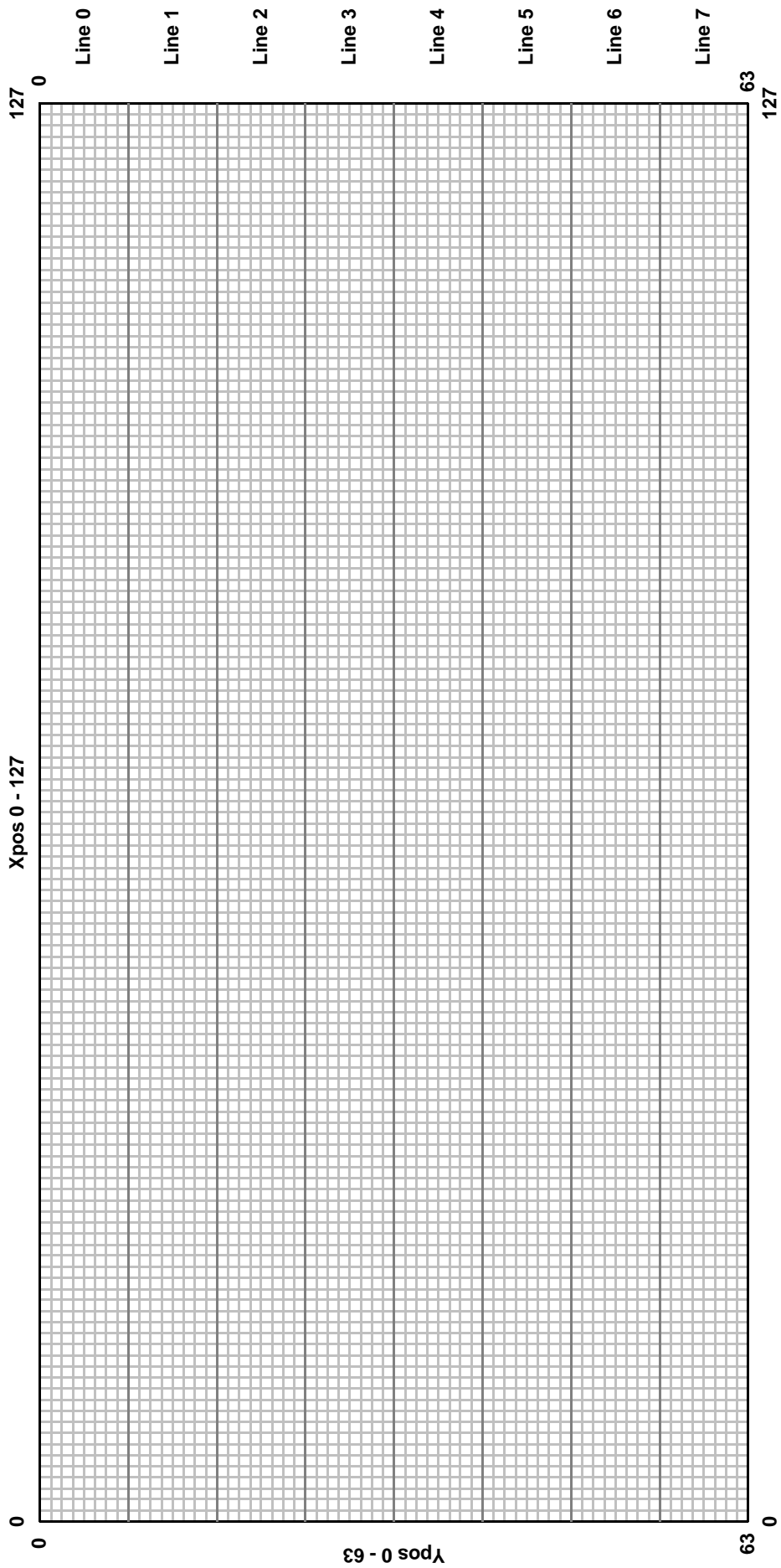
Pop

Syntax
Pop *Variable*, {*Variable*, *Variable* etc}

Overview
Pull a single variable or multiple variables from a software stack.
If the **Pop** command is issued without a following variable, it will implement the assembler mnemonic **Pop**, which manipulates the PICmicro's call stack.

Parameters
Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float**, **Array**, or **String**.

The amount of bytes pushed on to the stack varies with the variable type used. The list below shows how many bytes are pushed for a particular variable type, and their order.

Bit   1 Byte is popped containing the value of the bit pushed.
Byte   1 Byte is popped containing the value of the byte pushed.
Byte Array 1 Byte is popped containing the value of the byte pushed.
Word   2 Bytes are popped. Low Byte then High Byte containing
                  the value of the word pushed.
Word Array 2 Bytes are popped. Low Byte then High Byte containing
                  the value of the word pushed.
Dword Array 4 Bytes are popped. Low Byte, Mid1 Byte, Mid2 Byte then High Byte
                  containing the value of the dword pushed.
Dword   4 Bytes are popped. Low Byte, Mid1 Byte, Mid2 Byte then High Byte
                  containing the value of the dword pushed.
Float   4 Bytes are popped. Low Byte, Mid1 Byte, Mid2 Byte then High Byte
                  containing the value of the float pushed.
String   2 Bytes are popped. Low Byte then High Byte that point to the
                  start address of the string previously pushed.

Example 1
```
' Push two variables on to the stack then retrieve them

  Device = 18F452          ' Stack only suitable for 18F devices
  Declare Stack_Size = 20 ' Create a small stack capable of holding 20 bytes

  Dim Wrd as Word          ' Create a Word variable
  Dim Dwd as Dword         ' Create a Dword variable

  Wrd = 1234               ' Load the Word variable with a value
  Dwd = 567890             ' Load the Dword variable with a value
  Push Wrd, Dwd            ' Push the Word variable then the Dword variable

  Clear Wrd                ' Clear the Word variable
  Clear Dwd                ' Clear the Dword variable

  Pop Dwd, Wrd             ' Pop the Dword variable then the Word variable
  Print Dec Wrd, "  ", Dec Dwd   ' Display the variables as decimal
  Stop
```

Example 2
```
' Push a String on to the stack then retrieve it

    Device = 18F452                 ' Stack only suitable for 18F devices
    Declare Stack_Size = 10         ' Create a small stack capable of holding 10 bytes

    Dim SourceString as String * 20  ' Create a String variable
    Dim DestString as String * 20    ' Create another String variable

    SourceString = "Hello World"     ' Load the String variable with characters

    Push SourceString                ' Push the String variable's address

    Pop DestString      ' Pop the previously pushed String into DestString
    Print DestString    ' Display the string, which will be " Hello World "
    Stop
```

Example 3
```
' Push a Quoted character string on to the stack then retrieve it

    Device = 18F452                 ' Stack only suitable for 18F devices
    Declare Stack_Size = 10         ' Create a small stack capable of holding 10 bytes

    Dim DestString as String * 20    ' Create a String variable

    Push " Hello World "       ' Push the Quoted String of Characters on to the stack

    Pop DestString          ' Pop the previously pushed String into DestString
    Print DestString        ' Display the string, which will be "Hello World"
    Stop
```

See also :   Push, Gosub, Return, See Push for technical details of stack manipulation.

Pot

Syntax
Variable **= Pot** *Pin*, *Scale*

Overview
Read a potentiometer, thermistor, photocell, or other variable resistance.

Parameters
Variable is a user defined variable.
Pin is a Port.Pin constant that specifies the I/O pin to use.
Scale is a constant, variable, or expression, used to scale the instruction's internal 16-bit result. The 16- bit reading is multiplied by (scale/ 256), so a *scale* value of 128 would reduce the range by approximately 50%, a scale of 64 would reduce to 25%, and so on.

Example
```
Dim Var1 as Byte

Do
   Var1 = Pot PORTB.0, 100    ' Read potentiometer on pin 0 of PORTB.
   Print Dec Var1, " "        ' Display the potentiometer reading
Loop                          ' Repeat the process.
```

Notes
Internally, the **Pot** instruction calculates a 16-bit value, which is scaled down to an 8-bit value. The amount by which the internal value must be scaled varies with the size of the resistor being used.

The pin specified by **Pot** must be connected to one side of a resistor, whose other side is connected through a capacitor to ground. A resistance measurement is taken by timing how long it takes to discharge the capacitor through the resistor.
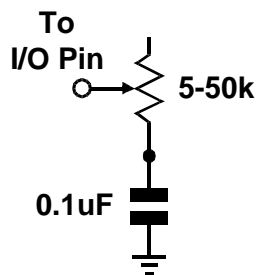
The value of *scale* must be determined by experimentation, however, this is easily accomplished as follows: -

Set the device under measure, the pot in this instance, to maximum resistance and read it with *scale* set to 255. The value returned in Var1 can now be used as *scale*: -

```
Var1 = Pot PORTB.0, 255
```

See also :   Adin, RCin.

Print

Syntax
Print *Item* {, *Item...* }

Overview
Send Text to an LCD module using the Hitachi HD44780 controller or a graphic LCD based on the KS0108, or Toshiba T6963 chipsets.

Parameters
Item may be a constant, variable, expression, modifier, or string list.
There are no operators as such, instead there are *modifiers*. For example, if an at sign'@' precedes an *Item*, the ASCII representation for each digit is sent to the LCD.

The modifiers are listed below: -

Modifier	Operation
At ypos (1 to n),xpos(1 to n)	Position the cursor on the LCD
Cls	Clear the LCD (also creates a 30ms delay)
Bin{1..32}	Display binary digits
Dec{0..10}	Display decimal digits
Hex{1..8}	Display hexadecimal digits
Sbin{1..32}	Display signed binary digits
Sdec{0..10}	Display signed decimal digits
Shex{1..8}	Display signed hexadecimal digits
Ibin{1..32}	Display binary digits with a preceding '%' identifier
Idec{0..10}	Display decimal digits with a preceding '#' identifier
Ihex{1..8}	Display hexadecimal digits with a preceding '$' identifier
ISbin{1..32}	Display signed binary digits with a preceding '%' identifier
ISdec{0..10}	Display signed decimal digits with a preceding '#' identifier
IShex{1..8}	Display signed hexadecimal digits with a preceding '$' identifier
Rep c\n	Display character c repeated n times
Str array\n	Display all or part of an array
Cstr cdata	Display string data defined in a Cdata statement.

The numbers after the **Bin**, **Dec**, and **Hex** modifiers are optional. If they are omitted, then the default is all the digits that make up the value will be displayed.

If a floating point variable is to be displayed, then the digits after the **Dec** modifier determine how many remainder digits are printed. i.e. numbers after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.145
Print Dec2 MyFloat    ' Display 2 values after the decimal point
```

The above program will display 3.14

If the digit after the **Dec** modifier is omitted, then 3 values will be displayed after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.1456
Print Dec MyFloat      ' Display 3 values after the decimal point
```

The above program will display 3.145

There is no need to use the **Sdec** modifier for signed floating point values, as the compiler's **Dec** modifier will automatically display a minus result: -

```
Dim MyFloat as Float
MyFloat = -3.1456
Print Dec MyFloat      ' Display 3 values after the decimal point
```

The above program will display -3.145

Hex or **Bin** modifiers cannot be used with floating point values or variables.

The Xpos and Ypos values in the **At** modifier both start at 1. For example, to place the text "HELLO WORLD" on line 1, position 1, the code would be: -

```
Print At 1, 1, "Hello World"
```

Example 1
```
Dim Var1 as Byte
Dim Wrd as Word
Dim Dwd as Dword

Print "Hello World"       ' Display the text "Hello World"
Print "Var1= ", Dec Var1  ' Display the decimal value of Var1
Print "Var1= ", Hex Var1  ' Display the hexadecimal value of Var1
Print "Var1= ", Bin Var1  ' Display the binary value of Var1
Print "Dwd= ", Hex6 Dwd   ' Display 6 hex characters of a Dword variable
```

Example 2
```
' Display a negative value on the LCD.
Symbol Negative = -200
Print At 1, 1, Sdec Negative
```

Example 3
```
' Display a negative value on the LCD with a preceding identifier.
Print At 1, 1, IShex -$1234
```

Example 3 will produce the text "$-1234" on the LCD.

Some PICmicros such as the 16F87x, and 18FXXX range have the ability to read and write to their own flash memory. And although writing to this memory too many times is unhealthy for the PICmicro™, reading this memory is both fast, and harmless. Which offers a unique form of data storage and retrieval, the **Cdata** command proves this, as it uses the mechanism of reading and storing in the PICmicro's flash memory.

Combining the unique features of the 'self modifying PICmicro's' with a string format, the compiler is capable of reducing the overhead of printing, or transmitting large amounts of text data. The **Cstr** modifier may be used in commands that deal with text processing i.e. **Serout**, **Hrsout**, and **RSOUT** etc.

The **Cstr** modifier is used in conjunction with the **Cdata** command. The **Cdata** command is used for initially creating the string of characters: -

```
String1: Cdata "HELLO WORLD", 0
```

The above line of case will create, in flash memory, the values that make up the ASCII text "HELLO WORLD", at address String1. Note the null terminator after the ASCII text.

null terminated means that a zero (null) is placed at the end of the string of ASCII characters to signal that the string has finished.

To display this string of characters, the following command structure could be used: -

```
    Print Cstr String1
```

The label that declared the address where the list of Cdata values resided, now becomes the string's name. In a large program with lots of text formatting, this type of structure can save quite literally hundreds of bytes of valuable code space.

Try both these small programs, and you'll see that using **Cstr** saves a few bytes of code: -

First the standard way of displaying text: -

```
    Device = 16F1829
    Cls
    Print "HELLO WORLD"
    Print "HOW ARE YOU?"
    Print "I AM FINE!"
    Stop
```

Now using the **Cstr** modifier: -

```
    Cls
    Print Cstr TEXT1
    Print Cstr TEXT2
    Print Cstr TEXT3
    Stop

TEXT1: Cdata "HELLO WORLD", 0
TEXT2: Cdata "HOW ARE YOU?", 0
TEXT3: Cdata "I AM FINE!", 0
```

Again, note the null terminators after the ASCII text in the **Cdata** commands. Without these, the PICmicro™ will continue to transmit data in an endless loop.

The term 'virtual string' relates to the fact that a string formed from the Cdata command cannot be written too, but only read from.

The **Str** modifier is used for sending a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order. The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that displays four bytes (from a byte array): -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
MyArray [0] = "H"              ' Load the first 5 bytes of the array
MyArray [1] = "E"              ' With the data to send
MyArray [2] = "L"
MyArray [3] = "L"
MyArray [4] = "O"
Print Str MyArray\5            ' Display a 5-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the PICmicro™ would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 5 bytes.

The above example may also be written as: -

```
Dim MyArray[10] as Byte        ' Create a 10-byte array.
Str MyArray = "HELLO"          ' Load the first 5 bytes of the array
Print Str MyArray\5            ' Send 5-byte string.
```

The above example, has exactly the same function as the previous one. The only difference is that the string is now constructed using **Str** as a command instead of a modifier.

Declares

There are several Declares for use with an alphanumeric LCD and **Print**: -

Declare LCD_Type 0 or 1 or 2, **Alpha** or **Graphic** or **KS0108** or **Toshiba** or T6963
Inform the compiler as to the type of LCD that the **Print** command will output to. If **Graphic, KS0108** or 1 is chosen then any output by the **Print** command will be directed to a graphic LCD based on the KS0108 chipset. A value of 2, or the text **Toshiba**, or **T6963**, will direct the output to a graphic LCD based on the Toshiba T6963 chipset. A value of 0 or **Alpha**, or if the **Declare** is not issued, will target the standard Hitachi HD44780 alphanumeric LCD type

Targeting the graphic LCD will also enable commands such as **Plot**, **UnPlot**, **LCDread**, **LCDwrite**, **Pixel**, **Box**, **Circle** and **Line**.

Declare LCD_DTPin Port **.** Pin
Assigns the Port and Pins that the LCD's DT (data) lines will attach to.
The LCD may be connected to the PICmicro™ using either a 4-bit bus or an 8-bit bus. If an 8-bit bus is used, all 8 bits must be on one port. If a 4-bit bus is used, it must be connected to either the bottom 4 or top 4 bits of one port. For example: -

```
Declare LCD_DTPin PORTB.4    ' Used for 4-line interface.

Declare LCD_DTPin PORTB.0    ' Used for 8-line interface.
```

In the previous examples, PORTB is only a personal preference. The LCD's DT lines may be attached to any valid port on the PICmicro™. If the **Declare** is not used in the program, then the default Port and Pin is PORTB.4, which assumes a 4-line interface.

Declare LCD_ENPin Port **.** Pin
Assigns the Port and Pin that the LCD's EN line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.2.

Declare LCD_RSPin Port **.** Pin
Assigns the Port and Pins that the LCD's RS line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.3.

Declare LCD_Interface 4 or 8
Inform the compiler as to whether a 4-line or 8-line interface is required by the LCD.

If the **Declare** is not used in the program, then the default interface is a 4-line type.

Declare LCD_Lines 1, 2, or 4
Inform the compiler as to how many lines the LCD has.

LCD's come in a range of sizes, the most popular being the 2 line by 16 character types. However, there are 4 line types as well. Simply place the number of lines that the particular LCD has, into the declare.

If the **Declare** is not used in the program, then the default number of lines is 2.

Notes
If no modifier precedes an item in a **Print** command, then the character's value is sent to the LCD. This is useful for sending control codes to the LCD. For example: -

```
Print $FE, 128
```

Will move the cursor to line 1, position 1 (HOME).

Below is a list of some useful control commands: -

Control Command	Operation
$FE, 1	Clear display
$FE, 2	Return home (beginning of first line)
$FE, $0C	Cursor off
$FE, $0E	Underline cursor on
$FE, $0F	Blinking cursor on
$FE, $10	Move cursor left one position
$FE, $14	Move cursor right one position
$FE, $C0	Move cursor to beginning of second line
$FE, $94	Move cursor to beginning of third line (if applicable)
$FE, $D4	Move cursor to beginning of fourth line (if applicable)

Note that if the command for clearing the LCD is used, then a small delay should follow it: -

```
Print $FE, 1 : DelayMs 30
```
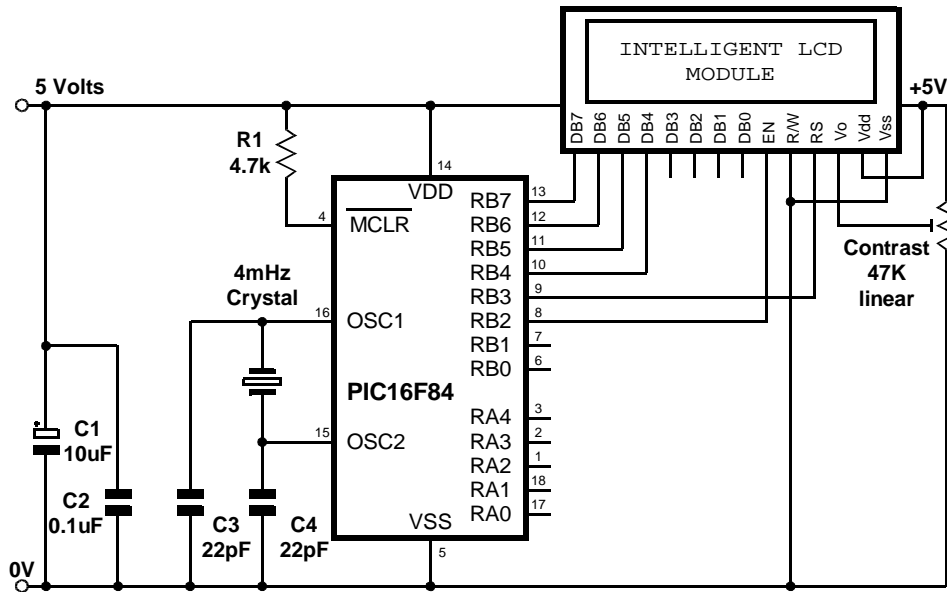

The above diagram shows the default connections for an alphanumeric LCD module. In this instance, connected to the 16F84 PICmicro™.

Using a KS0108 Graphic LCD

Once a KS0108 graphic LCD has been chosen using the **Declare LCD_Type** directive, all **Print** outputs will be directed to that LCD.

The standard modifiers used by an alphanumeric LCD may also be used with the graphics LCD. Most of the above modifiers still work in the expected manner, however, the **At** modifier now starts at Ypos 0 and Xpos 0, where values 0,0 will be the top left corner of the LCD.

There are also four new modifiers. These are: -

Font 0 to n	Choose the nth font, if available
Inverse 0-1	Invert the characters sent to the LCD
or 0-1	Or the new character with the original
Xor 0-1	Xor the new character with the original

Once one of the four new modifiers has been enabled, all future **Print** commands will use that particular feature until the modifier is disabled. For example: -

```
' Enable inverted characters from this point
  Print At 0, 0, Inverse 1, "Hello World"
  Print At 1, 0, "Still Inverted"
' Now use normal characters
  Print At 2, 0, Inverse 0, "Normal Characters"
```

If no modifiers are present, then the character's ASCII representation will be displayed: -

```
' Print characters A and B
  Print At 0, 0, 65, 66
```

Declares

There are nine declares associated with a KS0108 graphic LCD.

Declare LCD_DTPort Port

Assign the port that will output the 8-bit data to the graphic LCD.

If the **Declare** is not used, then the default port is PORTD.

Declare LCD_RWPin Port **.** Pin

Assigns the Port and Pin that the graphic LCD's RW line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTE.0.

Declare LCD_CS1Pin Port **.** Pin

Assigns the Port and Pin that the graphic LCD's CS1 line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTC.0.

Declare LCD_CS2Pin Port **.** Pin

Assigns the Port and Pin that the graphic LCD's CS2 line will attach to.

If the **Declare** is not used in the program, then the default Port and Pin is PORTC.2.

Note

Along with the new declares, two of the existing LCD declares must also be used. Namely, RS_Pin and EN_Pin.

Declare Internal_Font On - **Off**, 1 or 0

The graphic LCDs that are compatible with Proton are non-intelligent types, therefore, a separate character set is required. This may be in one of two places, either externally, in an I²C eeprom, or internally in a **Cdata** table.

If the **Declare** is omitted from the program, then an external font is the default setting.

If an external font is chosen, the I²C eeprom must be connected to the specified SDA and SCL pins (as dictated by **Declare** SDA and **Declare** SCL).

If an internal font is chosen, it must be on a PICmicro™ device that has self modifying code features, such as the 16F87X range.

The **Cdata** table that contains the font must have a label, named Font_Table: preceding it. For example: -

```
Font_Table:- '{ data for characters 0 to 64 }
    Cdata $7E, $11, $11, $11, $7E, $00,_  ' Chr 65 "A"
          $7F, $49, $49, $49, $36, $00    ' Chr 66 "B"
    { rest of font table }
```

Notice the dash after the font's label, this disables any bank switching code that may otherwise disturb the location in memory of the **Cdata** table.

The font table may be anywhere in memory, however, it is best placed after the main program code.

The font is built up of an 8x6 cell, with only 5 of the 6 rows, and 7 of the 8 columns being used for alphanumeric characters. See the diagram below.
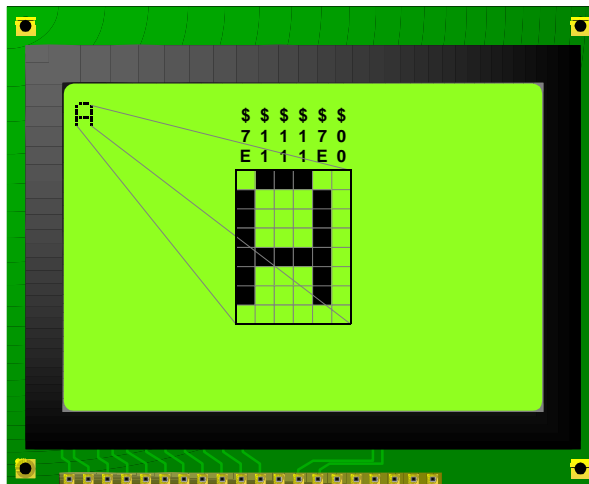
If a graphic character is chosen (chr 0 to 31), the whole of the 8x6 cell is used. In this way, large fonts and graphics may be easily constructed.
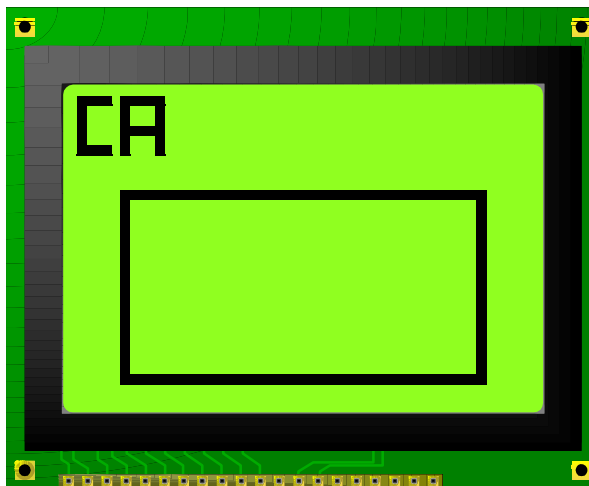
The character set itself is 128 characters long (0 -127). Which means that all the ASCII characters are present, including $, %, &, # etc.

There are two programs in the compiler's Samples directory, that are for use with internal and external fonts. **Int_Font.bas**, contains a **Cdata** table that may be cut and pasted into your own program if an internal font is chosen. **Ext_Font.bas**, writes the character set to a 24LC32 I^2C eeprom for use with an external font. Both programs are fully commented.

Declare Font_Addr 0 to 7
Set the slave address for the I^2C eeprom that contains the font.

When an external source for the font is used, it may be on any one of 8 eeproms attached to the I^2C bus. So as not to interfere with any other eeproms attached, the slave address of the eeprom carrying the font code may be chosen.

If the **Declare** is omitted from the program, then address 0 is the default slave address of the font eeprom.

Declare GLCD_CS_Invert On - **Off**, 1 or 0
Some graphic LCD types have inverters on the CS lines. Which means that the LCD displays left-hand data on the right side, and vice-versa. The **GLCD_CS_Invert Declare**, adjusts the library LCD handling subroutines to take this into account.

Declare GLCD_Strobe_Delay 0 to 65535 microseconds (us).
If a noisy circuit layout is unavoidable when using a graphic LCD, then the above **Declare** may be used. This will create a delay between the Enable line being strobed. This can ease random data being produced on the LCD's screen. See below for more details on circuit layout for graphic LCDs.

If the **Declare** is not used in the program, then no delay is created between strobes, and the LCD is accessed at full efficiency.

Declare GLCD_Read_Delay 0 to 65535 microseconds (us).
Create a delay of n microseconds between strobing the EN line of the graphic LCD, when reading from the GLCD. This can help noisy, or badly decoupled circuits overcome random bits being examined. The default if the **Declare** is not used in the BASIC program is a delay of 0.

Important
Because of the complexity involved with interfacing to the KS0108 graphic LCD, **six** of the eight stack levels available on the 14-bit core devices, are used when the **Print** command is issued with an external font. Therefore, be aware that if **Print** is used within a subroutine, you must limit the amount of subroutine nesting that may take place.

If an internal font is implemented on a KS0108 graphic LCD, then only **four** stack levels are used.

If any of the LCD's pins are attached to any of the microcontroller's analogue pins. i.e. PORTA or PORTE, then these pins must be set to digital by manipulating the appropriate SFRs (Special Function Registers)
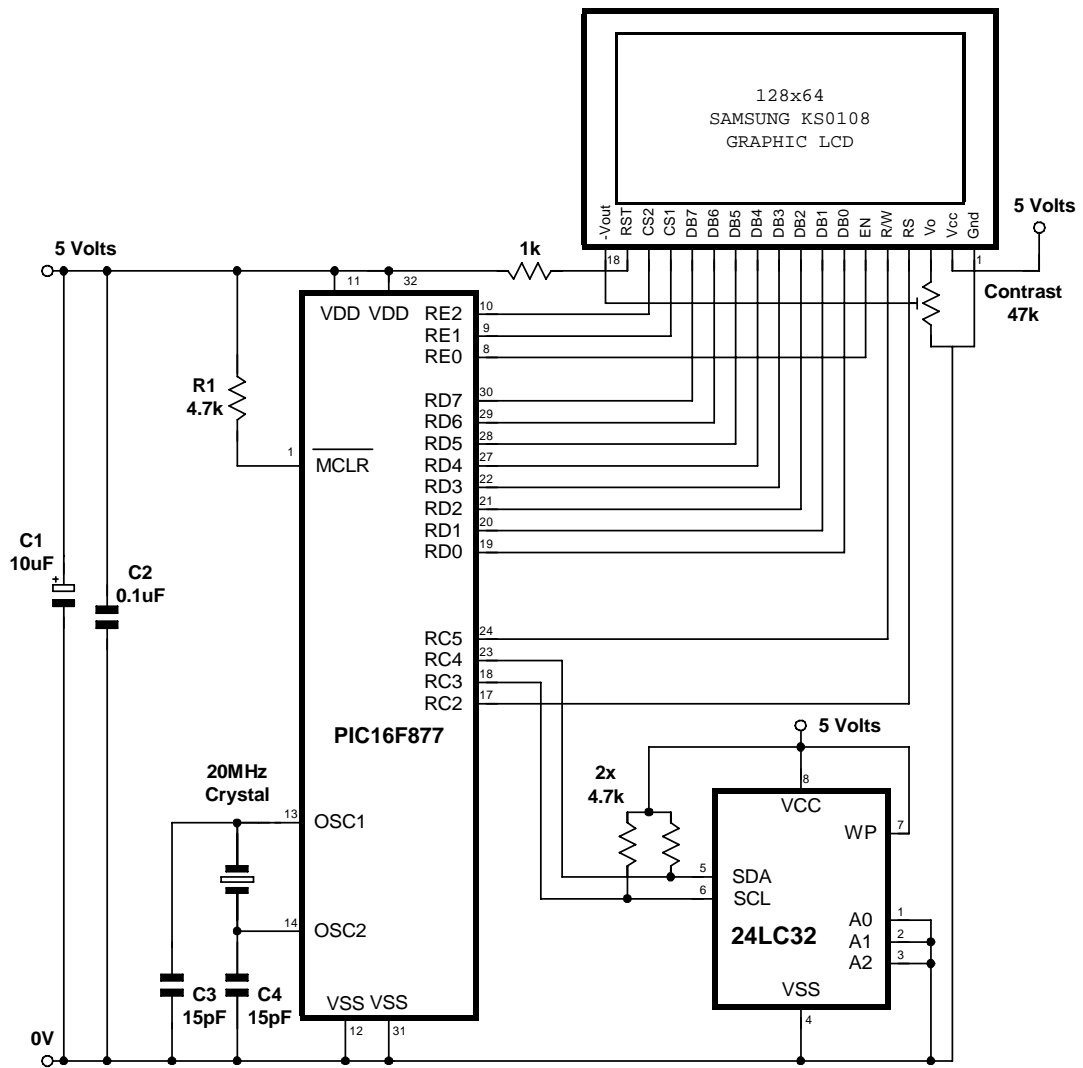
The diagram above shows a typical circuit arrangement for an external font with a KS0108 graphic LCD. The eeprom has a slave address of 0. If an internal font is used, then the eeprom may be omitted.

Using a Toshiba T6963 Graphic LCD

Once a Toshiba graphic LCD has been chosen using the **Declare LCD_Type** directive, all **Print** outputs will be directed to that LCD.

The standard modifiers used by an alphanumeric LCD may also be used with the graphics LCD. Most of the modifiers still work in the expected manner, however, the **At** modifier now starts at Ypos 0 and Xpos 0, where values 0,0 correspond to the top left corner of the LCD.

The KS0108 modifiers **Font**, **Inverse**, **Or**, and **Xor** are not supported because of the method Toshiba LCD's using the T6963 chipset implement text and graphics.

There are several **Declares** for use with a Toshiba graphic LCD, some optional and some mandatory.

Declare LCD_DTPort Port Port
Assign the port that will output the 8-bit data to the graphic LCD.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_WRPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's WR line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_RDPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's RD line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_CEPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's CE line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_CDPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's CD line will attach to.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_RSTPin Port **.** Pin
Assigns the Port and Pin that the graphic LCD's RST line will attach to.

The LCD's RST (Reset) **Declare** is optional and if omitted from the BASIC code the compiler will not manipulate it. However, if not used as part of the interface, you must set the LCD's RST pin high for normal operation.

Declare LCD_X_Res 0 to 255
LCD displays using the T6963 chipset come in varied screen sizes (resolutions). The compiler must know how many horizontal pixels the display consists of before it can build its library sub-routines.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_Y_Res 0 to 255
LCD displays using the T6963 chipset come in varied screen sizes (resolutions). The compiler must know how many vertical pixels the display consists of before it can build its library subroutines.

There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_Font_Width 6 or 8
The Toshiba T6963 graphic LCDs have two internal font sizes, 6 pixels wide by eight high, or 8 pixels wide by 8 high. The particular font size is chosen by the LCD's FS pin. Leaving the FS pin floating or bringing it high will choose the 6 pixel font, while pulling the FS pin low will choose the 8 pixel font. The compiler must know what size font is required so that it can calculate screen and RAM boundaries.

Note that the compiler does not control the FS pin and it is down to the circuit layout whether or not it is pulled high or low. There is no default setting for this **Declare** and it must be used within the BASIC program.

Declare LCD_RAM_Size 1024 to 65535
Toshiba graphic LCDs contain internal RAM used for Text, Graphic or Character Generation. The amount of RAM is usually dictated by the display's resolution. The larger the display, the more RAM is normally present. Standard displays with a resolution of 128x64 typically contain 4096 bytes of RAM, while larger types such as 240x64 or 190x128 typically contain 8192 bytes or RAM. The display's datasheet will inform you of the amount of RAM present.

If this **Declare** is not issued within the BASIC program, the default setting is 8192 bytes.

Declare LCD_Text_Pages 1 to n
As mentioned above, Toshiba graphic LCDs contain RAM that is set aside for text, graphics or characters generation. In normal use, only one page of text is all that is required, however, the compiler can re-arrange its library subroutines to allow several pages of text that is continuous. The amount of pages obtainable is directly proportional to the RAM available within the LCD itself. Larger displays require more RAM per page, therefore always limit the amount of pages to only the amount actually required or unexpected results may be observed as text, graphic and character generator RAM areas merge.

This **Declare** is purely optional and is usually not required. The default is 3 text pages if this **Declare** is not issued within the BASIC program.

Declare LCD_Graphic_Pages 1 to n
Just as with text, the Toshiba graphic LCDs contain RAM that is set aside for graphics. In normal use, only one page of graphics is all that is required, however, the compiler can re-arrange its library subroutines to allow several pages of graphics that is continuous. The amount of pages obtainable is directly proportional to the RAM available within the LCD itself. Larger displays require more RAM per page, therefore always limit the amount of pages to only the amount actually required or unexpected results may be observed as text, graphic and character generator RAM areas merge.

This **Declare** is purely optional and is usually not required. The default is 1 graphics page if this **Declare** is not issued within the BASIC program.

Declare LCD_Text_Home_Address 0 to n

The RAM within a Toshiba graphic LCD is split into three distinct uses, text, graphics and character generation. Each area of RAM must not overlap or corruption will appear on the display as one uses the other's assigned space. The compiler's library subroutines calculate each area of RAM based upon where the text RAM starts. Normally the text RAM starts at address 0, however, there may be occasions when it needs to be set a little higher in RAM. The order of RAM is; Text, Graphic, then Character Generation.

This **Declare** is purely optional and is usually not required. The default is the text RAM staring at address 0 if this **Declare** is not issued within the BASIC program.

Notes

Unlike interfacing to the KS0108 graphic LCD, only **four** of the eight stack levels available on the 14-bit core devices, are used when the **Print** command is issued.

If any of the LCD's pins are attached to any of the PICmicro's analogue pins. i.e. PORTA or PORTE, then these pins must be set to digital by manipulating the appropriate SFRs (Special Function Registers).

The diagram below shows a typical circuit for an interface with a Toshiba T6963 graphic LCD.
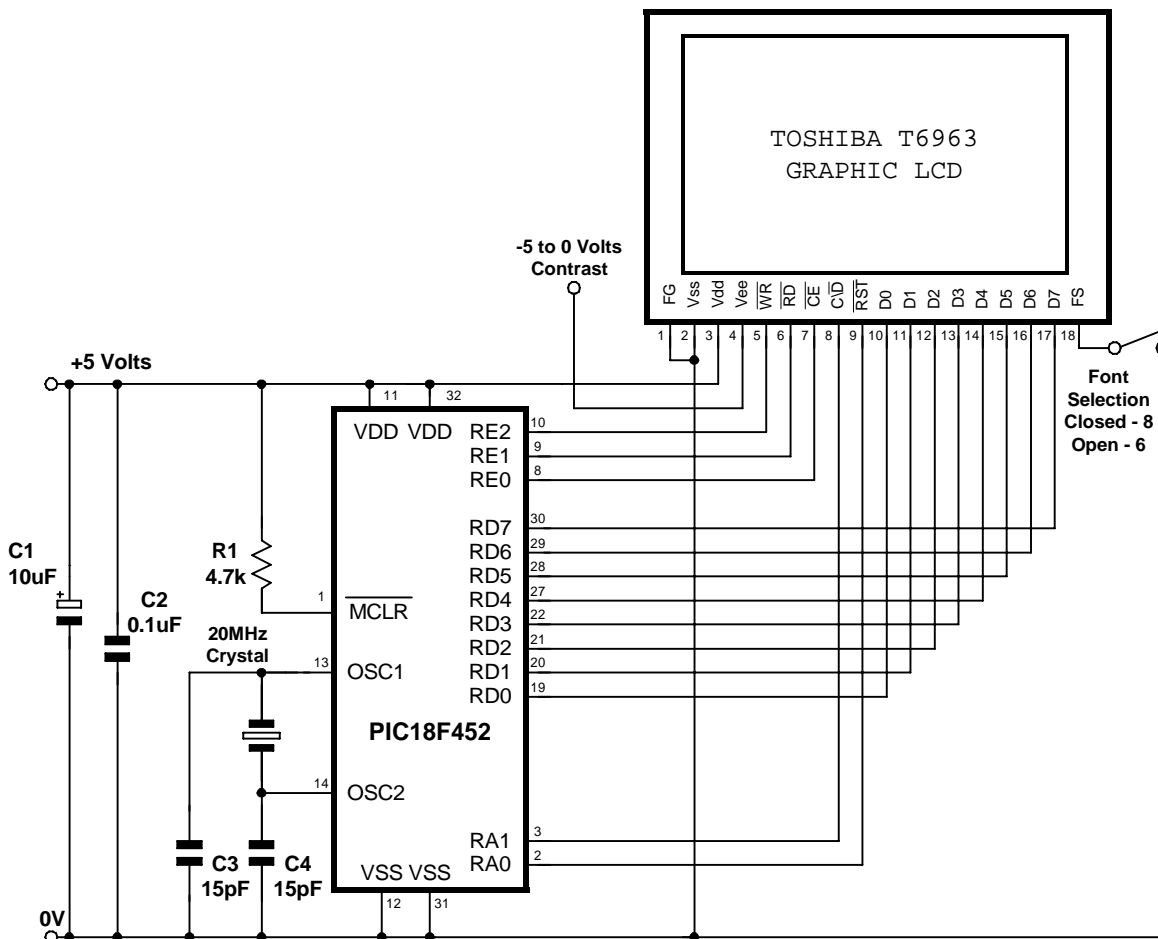
Ptr8, Ptr16, Ptr32

Syntax
Variable **= Ptr8** *(Address)*
Variable **= Ptr16** *(Address)*
Variable **= Ptr32** *(Address)*

or

Ptr8 *(Address) = Variable*
Ptr16 *(Address) = Variable*
Ptr32 *(Address) = Variable*

Overview
Indirectly address RAM for loading or retrieving using a variable to hold the 16-bit address on enhanced 14-bit core devices and 18F devices.

Operands
Variable is a user defined variable that holds the result of the indirectly address RAM area, or the variable to place into the indirectly addressed RAM area.
Address is a **Word** variable that holds the 16-bit address of the RAM area of interest.

Address can also post or pre increment or decrement:

- (MyAddress++)   Post increment MyAddress after retreiving it's RAM location.
- (MyAddress --)   Post decrement MyAddress after retreiving it's RAM location.
- (++MyAddress)   Pre increment MyAddress before retreiving it's RAM location.
- (--MyAddress)   Pre decrement MyAddress before retreiving it's RAM location.

Ptr8 will load or retrieve a value with an optional 8-bit post or pre increment or decrement.
Ptr16 will load or retrieve a value with an optional 16-bit post or pre increment or decrement.
Ptr32 will load or retrieve a value with an optional 32-bit post or pre increment or decrement.

8-bit Example.
```
' Load and Read 8-bit values indirectly from/to RAM
'
  Device = 18F25K20                   ' Choose an 18F device
  Declare Xtal = 16

  Declare Hserial_Baud = 9600       ' Set baud rate to 9600

  Dim MyByteArray[20] As Byte        ' Create a byte array
  Dim MyByte As Byte                 ' Create a byte variable
  Dim bIndex As Byte
  Dim wAddress as Word               ' Create a variable to hold address
```

```
Main:
'
' Load into RAM
'
   wAddress = AddressOf(MyByteArray)' Load wAddress with address of array
   For bIndex = 19 To 0 Step -1      ' Create a loop
      Ptr8(wAddress++) = bIndex          ' Load RAM with address post increment
   Next
'
' Read from RAM
'
   wAddress = AddressOf(MyByteArray)  ' Load wAddress with address of array
   While                             ' Create a loop
      MyByte = Ptr8(wAddress++)          ' Retrieve from RAM with post increment
      HRSOut Dec MyByte, 13             ' Transmit the byte read from RAM
      If MyByte = 0 Then Break          ' Exit when a null(0) is read from RAM
   Wend
```

16-bit Example.

```
' Load and Read 16-bit values indirectly from/to RAM
'
   Device = 18F25K20                 ' Choose an 18F device
   Declare Xtal = 16

   Declare Hserial_Baud = 9600       ' Set baud rate to 9600

   Dim MyWordArray[20] As Word       ' Create a word array
   Dim MyWord As Word                ' Create a word variable
   Dim bIndex As Byte
   Dim wAddress as Word              ' Create a variable to hold the address

Main:
'
' Load into RAM
'
   wAddress = AddressOf(MyWordArray)  ' Load wAddress with address of array
   For bIndex = 19 To 0 Step -1       ' Create a loop
      Ptr16(wAddress++) = bIndex         ' Load RAM with address post increment
   Next
'
' Read from RAM
'
   wAddress = AddressOf(MyWordArray)' Load wAddress with address of array
   While                             ' Create a loop
      MyWord = Ptr16(wAddress++)         ' Retrieve from RAM with post increment
      HRSOut Dec MyWord, 13             ' Transmit the word read from RAM
      If MyWord = 0 Then Break          ' Exit when a null(0) is read from RAM
   Wend
```

32-bit Example.

```
' Load and Read 32-bit values indirectly from RAM
'
  Device = 18F25K20                     ' Choose an 18F device
  Declare Xtal = 16

  Declare Hserial_Baud = 9600           ' Set baud rate to 9600

  Dim MyDwordArray[20] As Dword         ' Create a dword array
  Dim MyDword As Dword                  ' Create a dword variable
  Dim bIndex As Byte
  Dim wAddress as Word                  ' Create a variable to hold the address

Main:
'
' Load into RAM
'
  wAddress = AddressOf(MyDwordArray)    ' Load wAddress with address of array
  For bIndex = 19 To 0 Step -1          ' Create a loop
    Ptr32(wAddress++) = bIndex          ' Load RAM with address post increment
  Next
'
' Read from RAM
'
  wAddress = AddressOf(MyDwordArray)    ' Load wAddress with address of array
  While                                 ' Create a loop
    MyDword = Ptr32(wAddress++)         ' Retrieve from RAM with post increment
    HRSOut Dec MyDword, 13              ' Transmit the dword read from RAM
    If MyDword = 0 Then Break           ' Exit when a null(0) is read from RAM
  Wend
```

See also: AddressOf.

PulseIn

Syntax
Variable **= PulseIn** *Pin*, *State*

Overview
Change the specified pin to input and measure an input pulse.

Parameters
Variable is a user defined variable. This may be a word variable with a range of 1 to 65535, or a byte variable with a range of 1 to 255.
Pin is a Port.Pin constant that specifies the I/O pin to use.
State is a constant (0 or 1) or name **High** - **Low** that specifies which edge must occur before beginning the measurement.

Example
```
  Dim Var1 as Byte
MyLoop:
  Var1 = PulseIn PORTB.0, 1    ' Measure a pulse on pin 0 of PORTB.
  Print Dec Var1, " "          ' Display the reading
  Goto MyLoop                  ' Repeat the process.
```

Notes
PulseIn acts as a fast clock that is triggered by a change in state (0 or 1) on the specified pin. When the state on the pin changes to the state specified, the clock starts counting. When the state on the pin changes again, the clock stops. If the state of the pin doesn't change (even if it is already in the state specified in the **PulseIn** instruction), the clock won't trigger. **PulseIn** waits a maximum of 0.65535 seconds for a trigger, then returns with 0 in *variabl*e.

The variable can be either a **Word** or a **Byte** . If the variable is a word, the value returned by **PulseIn** can range from 1 to 65535 units.

The units are dependant on the frequency of the crystal used. If a 4MHz crystal is used, then each unit is 10us, while a 20MHz crystal produces a unit length of 2us.

If the variable is a byte and the crystal is 4MHz, the value returned can range from 1 to 255 units of 10µs. Internally, **PulseIn** always uses a 16-bit timer. When your program specifies a byte, **PulseIn** stores the lower 8 bits of the internal counter into it. Pulse widths longer than 2550µs will give false, low readings with a byte variable. For example, a 2560µs pulse returns a reading of 256 with a word variable and 0 with a byte variable.

See also :   Counter, PulseOut, RCin.

PulseOut

Syntax
PulseOut *Pi*n, *Period,* { *Initial State* }

Overview
Generate a pulse on *Pin* of specified *Period*. The pulse is generated by toggling the pin twice, thus the initial state of the pin determines the polarity of the pulse. Or alternatively, the initial state may be set by using High-Low or 1-0 after the *Period*. *Pin* is automatically made an output.

Parameters
Pin is a Port.Pin constant that specifies the I/O pin to use.
Period can be a constant of user defined variable. See notes.
State is an optional constant (0 or 1) or name **High** - **Low** that specifies the state of the outgoing pulse.

Example
```
' Send a high pulse 1ms long (at 4MHz) to PORTB.5
'
  Low PORTB.5
  PulseOut PORTB.5, 100
'
' Send a high pulse 1ms long (at 4MHz) to PORTB.5
'
  PulseOut PORTB.5, 100, High
```

Notes
The resolution of **PulseOut** is dependent upon the oscillator frequency. If a 4MHz oscillator is used, the *Period* of the generated pulse will be in 10us increments. If a 20MHz oscillator is used, *Period* will have a 2us resolution. Declaring an Xtal value has no effect on **PulseOut**. The resolution always changes with the actual oscillator speed.

See also :   Counter , PulseIn, RCin.

Push

Syntax
Push *Variable*, {*Variable*, *Variable* etc}

Overview
Place a single variable or multiple variables onto a software stack.
If the **Push** command is issued without a following variable, it will implement the assembler mnemonic **Push**, which manipulates the PICmicro's call stack.

Parameters
Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float**, **Array**, **String**, or **constant** value.

The amount of bytes pushed on to the stack varies with the variable type used. The list below shows how many bytes are pushed for a particular variable type, and their order.

Bit	1 Byte is pushed that holds the condition of the bit.
Byte	1 Byte is pushed.
Byte Array	1 Byte is pushed.
Word	2 Bytes are pushed. High Byte then Low Byte.
Word Array	2 Bytes are pushed. High Byte then Low Byte.
Dword Array	4 Bytes are pushed. High Byte then Low Byte.
Dword	4 Bytes are pushed. High Byte, Mid2 Byte, Mid1 Byte then Low Byte.
Float	4 Bytes are pushed. High Byte, Mid2 Byte, Mid1 Byte then Low Byte.
String	2 Bytes are pushed. High Byte then Low Byte that point to the start address of the string in memory.
Constant	Amount of bytes varies according to the value pushed. High Byte first.

Example 1
```
' Push two variables on to the stack then retrieve them

  Device = 18F452          ' Stack only suitable for 18F devices
  Declare Stack_Size = 20 ' Create a small stack capable of holding 20 bytes

  Dim Wrd as Word          ' Create a Word variable
  Dim Dwd as Dword         ' Create a Dword variable

  Wrd = 1234               ' Load the Word variable with a value
  Dwd = 567890             ' Load the Dword variable with a value
  Push Wrd, Dwd            ' Push the Word variable then the Dword variable

  Clear Wrd                ' Clear the Word variable
  Clear Dwd                ' Clear the Dword variable

  Pop Dwd, Wrd             ' Pop the Dword variable then the Word variable
  Print Dec Wrd, "  ", Dec Dwd' Display the variables as decimal
  Stop
```

Example 2
```
' Push a String on to the stack then retrieve it

    Device = 18F452              ' Stack only suitable for 18F devices
    Declare Stack_Size = 10      ' Create a small stack capable of holding 10 bytes

    Dim SourceString as String * 20  ' Create a String variable
    Dim DestString as String * 20    ' Create another String variable

    SourceString = "HELLO WORLD"      ' Load the String variable with characters

    Push SourceString                ' Push the String variable's address

    Pop DestString      ' Pop the previously pushed String into DestString
    Print DestString    ' Display the string, which will be "HELLO WORLD"
    Stop
```

Formatting a Push.

Each variable type, and more so, constant value, will push a different amount of bytes on to the stack. This can be a problem where values are concerned because it will not be known what size variable is required in order to **Pop** the required amount of bytes from the stack. For example, the code below will push a constant value of 200 on to the stack, which requires 1 byte.

```
    Push 200
```

All well and good, but what if the recipient popped variable is of a **Word** or **Dword** type.

```
    Pop Wrd
```

Popping from the stack into a **Word** variable will actually pull 2 bytes from the stack, however, the code above has only pushed on byte, so the stack will become out of phase with the values or variables previously pushed. This is not really a problem where variables are concerned, as each variable has a known byte count and the user knows if a **Word** is pushed, a **Word** should be popped.

The answer lies in using a formatter preceding the value or variable pushed, that will force the amount of bytes loaded on to the stack. The formatters are **Byte**, **Word**, **Dword** or **Float**.

The **Byte** formatter will force any variable or value following it to push only 1 byte to the stack.

```
    Push Byte 12345
```

The **Word** formatter will force any variable or value following it to push only 2 bytes to the stack:

```
    Push Word 123
```

The **Dword** formatter will force any variable or value following it to push only 4 bytes to the stack: -

```
    Push Dword 123
```

The **Float** formatter will force any variable or value following it to push only 4 bytes to the stack, and will convert a constant value into the 4-byte floating point format: -

```
Push Float 123
```

So for the **Push** of 200 code above, you would use: -

```
Push Word 200
```

In order for it to be popped back into a **Word** variable, because the push would be the high byte of 200, then the low byte.

If using the multiple variable **Push**, each parameter can have a different formatter preceding it.

```
Push Word 200, Dword 1234, Float 1234
```

Note that if a floating point value is pushed, 4 bytes will be placed on the stack because this is a known format.

What is a Stack?

All microprocessors and most microcontrollers have access to a Stack, which is an area of RAM allocated for temporary data storage. But this is sadly lacking on a PICmicro™ device. However, the 18F devices have an architecture and low-level mnemonics that allow a Stack to be created and used very efficiently.

A stack is first created in high memory by issuing the **Stack_Size Declare**.

```
Declare Stack_Size = 40
```

The above line of code will reserve 40 bytes at the top of RAM that cannot be touched by any BASIC command, other than **Push** and **Pop**. This means that it is a safe place for temporary variable storage.

Taking the above line of code as an example, we can examine what happens when a variable is pushed on to the 40 byte stack, and then popped off again.

First the RAM is allocated. For this explanation we will assume that a 18F452 PICmicro™ device is being used. The 18F452 has 1536 bytes of RAM that stretches linearly from address 0 to 1535. Reserving a stack of 40 bytes will reduce the top of memory so that the compiler will only see 1495 bytes (1535 - 40). This will ensure that it will not inadvertently try and use it for normal variable storage.

Pushing.

When a **Word** variable is pushed onto the stack, the memory map would look like the diagram below: -

Top of Memory	...................Empty RAM...................	Address 1535
	~ ~	
	~ ~	
	...................Empty RAM...................	Address 1502
	...................Empty RAM...................	Address 1501
	Low Byte Address of Word Variable	Address 1496
Start of Stack	High Byte Address of Word Variable	Address 1495

The high byte of the variable is first pushed on to the stack, then the low byte. And as you can see, the stack grows in an upward direction whenever a **Push** is implemented, which means it shrinks back down whenever a **Pop** is implemented.

If we were to **Push** a **Dword** variable on to the stack as well as the **Word** variable, the stack memory would look like: -

Top of Memory	...................Empty RAM...................	Address 1535
	~ ~	
	~ ~	
	...................Empty RAM...................	Address 1502
	...................Empty RAM...................	Address 1501
	Low Byte Address of Dword Variable	Address 1500
	Mid1 Byte Address of Dword Variable	Address 1499
	Mid2 Byte Address of Dword Variable	Address 1498
	High Byte Address of Dword Variable	Address 1497
	Low Byte Address of Word Variable	Address 1496
Start of Stack	High Byte Address of Word Variable	Address 1495

Popping.

When using the **Pop** command, the same variable type that was pushed last must be popped first, or the stack will become out of phase and any variables that are subsequently popped will contain invalid data. For example, using the above analogy, we need to **Pop** a **Dword** variable first. The **Dword** variable will be popped Low Byte first, then MID1 Byte, then MID2 Byte, then lastly the High Byte. This will ensure that the same value pushed will be reconstructed correctly when placed into its recipient variable. After the **Pop**, the stack memory map will look like: -

Top of Memory	...................Empty RAM...................	Address 1535
	~ ~	
	~ ~	
	...................Empty RAM...................	Address 1502
	...................Empty RAM...................	Address 1501
	Low Byte Address of Word Variable	Address 1496
Start of Stack	High Byte Address of Word Variable	Address 1495

If a **Word** variable was then popped, the stack will be empty, however, what if we popped a **Byte** variable instead? the stack would contain the remnants of the **Word** variable previously pushed. Now what if we popped a **Dword** variable instead of the required **Word** variable? the stack would underflow by two bytes and corrupt any variables using those address's . The compiler cannot warn you of this occurring, so it is up to you, the programmer, to ensure that proper stack management is carried out. The same is true if the stack overflows. i.e. goes beyond the top of RAM. The compiler cannot give a warning.

Technical Details of Stack implementation.
The stack implemented by the compiler is known as an ***Incrementing Last-In First-Out*** Stack. *Incrementing* because it grows upwards in memory. *Last-In First-Out* because the last variable pushed, will be the first variable popped.

The stack is not circular in operation, so that a stack overflow will rollover into the PICmicro's hardware register, and an underflow will simply overwrite RAM immediately below the Start of Stack memory. If a circular operating stack is required, it will need to be coded in the main BASIC program, by examination and manipulation of the stack pointer (see below).

Indirect register pair FSR2L and FSR2H are used as a 16-bit stack pointer, and are incremented for every **Byte** pushed, and decremented for every **Byte** popped. Therefore checking the FSR2 registers in the BASIC program will give an indication of the stack's condition if required. This also means that the BASIC program cannot use the FSR2 register pair as part of its code, unless for manipulating the stack. Note that none of the compiler's commands, other than **Push** and **Pop**, use FSR2.

Whenever a variable is popped from the stack, the stack's memory is not actually cleared, only the stack pointer is moved. Therefore, the above diagrams are not quite true when they show empty RAM, but unless you have use of the remnants of the variable, it should be considered as empty, and will be overwritten by the next **Push** command.

See also :   Pop, Gosub, Return .

Pwm

Syntax
Pwm *Pin, Duty*, *Cycles*

Overview
Output pulse-width-modulation on a pin, then return the pin to input state.

Parameters
Pin is a Port.Pin constant that specifies the I/O pin to use.
Duty is a variable, constant (0-255), or expression, which specifies the analogue level desired (0-5 volts).
Cycles is a variable or constant (0-255) which specifies the number of cycles to output. Larger capacitors require multiple cycles to fully charge. Cycle time is dependant on Xtal frequency. If a 4MHz crystal is used, then *cycle* takes approx 5 ms. If a 20MHz crystal is used, then *cycle* takes approx 1 ms.

Notes
Pwm can be used to generate analogue voltages (0-5V) through a pin connected to a resistor and capacitor to ground; the resistor-capacitor junction is the analogue output (see circuit). Since the capacitor gradually discharges, **Pwm** should be executed periodically to refresh the analogue voltage.

Pwm emits a burst of 1s and 0s whose ratio is proportional to the *duty* value you specify. If *duty* is 0, then the pin is continuously low (0); if *duty* is 255, then the pin is continuously high. For values in between, the proportion is *duty*/255. For example, if *duty* is 100, the ratio of 1s to 0s is 100/255 = 0.392, approximately 39 percent.
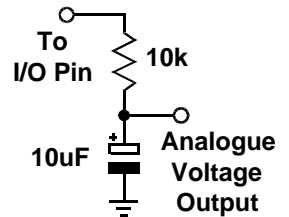
When such a burst is used to charge a capacitor arranged, the voltage across the capacitor is equal to:-

   (duty / 255) * 5.

So if *duty* is 100, the capacitor voltage is

   (100 / 255) * 5 = 1.96 volts.
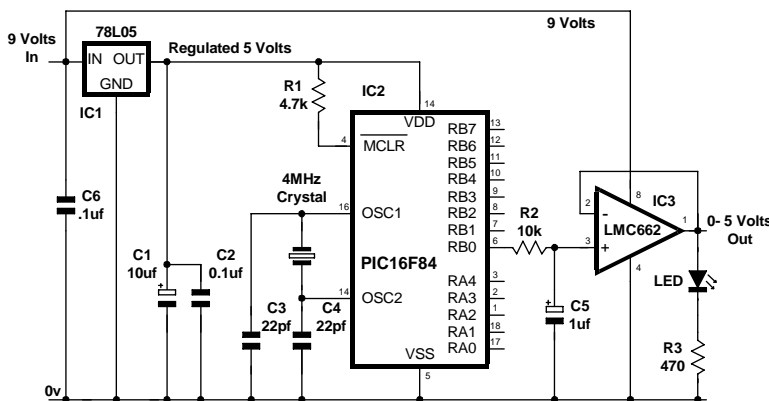
This voltage will drop as the capacitor discharges through whatever load it is driving. The rate of discharge is proportional to the current drawn by the load; more current = faster discharge. You can reduce this effect in software by refreshing the capacitor's charge with frequent use of the **Pwm** command, or you can buffer the output using an op-amp to greatly reduce the need for frequent **Pwm** cycles.

See also :   Hpwm, Pulseout, Servo.

Random

Syntax
Variable **= Random**

or

Random *Variable*

Overview
Generate a pseudo-randomised value.

Parameters
Variable is a user defined variable that will hold the pseudo-random value. The pseudo-random algorithm used has a working length of 1 to 65535 (only zero is not produced).

Example

```
Var1 = Random  ' Get a random number into Var1
Random Var1    ' Get a random number into Var1
```

See also: Seed.

RC5in

Syntax
Variable **= RC5in**

Overview
Receive Philips RC5 infrared data from a predetermined pin. The pin is automatically made an input.

Parameters
Variable can be a bit, byte, word, dword, or float variable, that will be loaded by **RC5in**. The return data from the **RC5in** command consists of two bytes, the System byte containing the type of remote used. i.e. TV, Video etc, and the Command byte containing the actual button value. The order of the bytes is Command (low byte) then System (high byte). If a byte variable is used to receive data from the infrared sensor then only the Command byte will be received.

Example
```
' Receive Philips RC5 data from an infrared sensor attached to PORTC.0
  Device = 16F1829
  Declare RC5in_Pin = PORTC.0 ' Choose port.pin for infrared sensor

  Dim RC5_Word as Word        ' Create a Word variable to receive the data
'
' Alias the Command byte to RC5_Word low byte
'
  Dim RC5_Command as RC5_Word.Lowbyte
'
' Alias the System byte to RC5_Word high byte
'
  Dim RC5_System as RC5_Word.Highbyte

  Cls                        ' Clear the LCD
  While                      ' Create an infinite loop
    Repeat
      RC5_Word = RC5In       ' Receive a signal from the infrared sensor
    Until RC5_Command <> 255 ' Keep looking until a valid header found
     Print at 1,1,"System  ",Dec RC5_System," "  ' Display the System value
    Print at 2,1,"Command ",Dec RC5_Command," " ' Display the Command value
  Wend
```

There is a single Declare for use with **RC5in**: -

Declare RC5in_Pin Port **.** Pin
Assigns the Port and Pin that will be used to input infrared data by the **RC5in** command. This may be any valid port on the PICmicro™.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.0.

Notes
The **RC5in** command will return with both Command and System bytes containing 255 if a valid header was not received. The CARRY (STATUS.0) flag will also be set if an invalid header was received. This is an ideal method of determining if the signal received is of the correct type.

RC5in is oscillator independent as long as the crystal frequency is declared at the top of the program. If no Xtal **Declare** is used, then **RC5in** defaults to a 4MHz crystal frequency for its timing.

RCin

Syntax
*Variable = **RCin** Pin, State*

Overview
Count time while pin remains in *state*, usually used to measure the charge/ discharge time of resistor/capacitor (RC) circuit.

Parameters
Pin is a Port.Pin constant that specifies the I/O pin to use. This pin will be placed into input mode and left in that state when the instruction finishes.
State is a variable or constant (1 or 0) that will end the Rcin period. Text, High or Low may also be used instead of 1 or 0.
Variable is a variable in which the time measurement will be stored.

Example
```
Dim MyResult as Word           ' Word variable to hold result.
High PORTB.0                    ' Discharge the cap
DelayMs 1                       ' Wait for 1 ms.
MyResult = RCin PORTB.0, High   ' Measure RC charge time.
Print Dec MyResult, " "         ' Display the value on an LCD.
```

Notes
The resolution of **RCin** is dependent upon the oscillator frequency. If a 4MHz oscillator is used, the time in state is returned in 10us increments. If a 20MHz oscillator is used, the time in state will have a 2us resolution. Declaring an Xtal value has no effect on **RCin**. The resolution always changes with the actual oscillator speed. If the pin never changes state 0 is returned.

When **RCin** executes, it starts a counter. The counter stops as soon as the specified pin is no longer in *State* (0 or 1). If *pin* is not in *State* when the instruction executes, **RCin** will return 1 in *Variable*, since the instruction requires one timing cycle to discover this fact. If pin remains in *State* longer than 65535 timing cycles **RCin** returns 0.
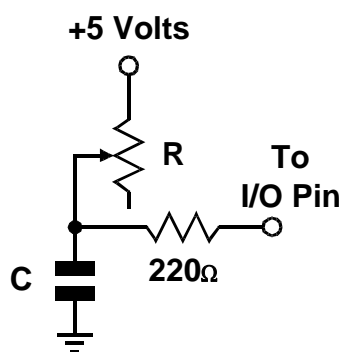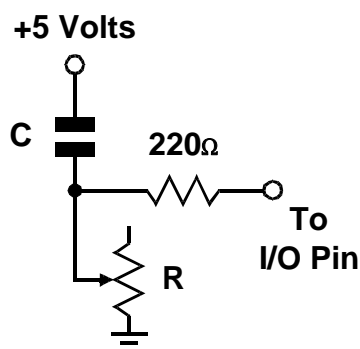
Figure A   Figure B

The diagrams above show two suitable RC circuits for use with **RCin**. The circuit in figure B is preferred, because the PICmicro's logic threshold is approximately 1.5 volts. This means that the voltage seen by the pin will start at 5V then fall to 1.5V (a span of 3.5V) before **RCin** stops. With the circuit in figure A, the voltage will start at 0V and rise to 1.5V (spanning only 1.5V) before **RCin** stops.

For the same combination of R and C, the circuit shown in figure A will produce a higher result, and therefore more resolution than figure B.

Before **RCin** executes, the capacitor must be put into the state specified in the **RCin** command. For example, with figure B, the capacitor must be discharged until both plates (sides of the capacitor) are at 5V. It may seem strange that discharging the capacitor makes the input high, but you must remember that a capacitor is charged when there is a voltage difference between its plates. When both sides are at +5 Volts, the capacitor is considered discharged. Below is a typical sequence of instructions for the circuit in figure A.

```
Dim MyResult as Word           ' Word variable to hold result.
High PORTB.0                    ' Discharge the cap
DelayMs 1                       ' Wait for 1 ms.
MyResult = RCin PORTB.0, High   ' Measure RC charge time.
Print Dec MyResult, "  "        ' Display the value on an LCD.
```

Using **RCin** is very straightforward, except for one detail: For a given R and C, what value will **RCin** return? It's actually rather easy to calculate, based on a value called the RC time constant, or tau (τ) for short. Tau represents the time required for a given RC combination to charge or discharge by 63 percent of the total change in voltage that they will undergo. More importantly, the value τ is used in the generalized RC timing calculation. Tau's formula is just R multiplied by C: -

$$\tau = R \times C$$

The general RC timing formula uses τ to tell us the time required for an RC circuit to change from one voltage to another: -

$$time = -\tau * (\ln (V_{final} / V_{initial}))$$

In this formula ln is the natural logarithm. Assume we're interested in a 10kΩ resistor and 0.1µF cap. Calculate τ: -

$$\tau = (10 \times 10^3) \times (0.1 \times 10^{-6}) = 1 \times 10^{-3}$$

The RC time constant is 1×10^{-3} or 1 millisecond. Now calculate the time required for this RC circuit to go from 5V to 1.5V (as in figure B):

$$Time = -1 \times 10^{-3} * (\ln(5.0v / 1.5v)) = 1.204 \times 10^{-3}$$

Using a 20MHz crystal, the unit of time is 2µs, that time (1.204×10^{-3}) works out to 602 units. With a 10kΩ resistor and 0.1µF capacitor, **RCin** would return a value of approximately 600. Since $V_{initial}$ and V_{final} don't change, we can use a simplified rule of thumb to estimate **RCin** results for circuits similar to figure A: -

RCin units = 600 x R (in kΩ) x C (in µF)

Another useful rule of thumb can help calculate how long to charge/discharge the capacitor before **RCin**. In the example shown, that's the purpose of the **High** and **DelayMs** commands. A given RC charges or discharges 98 percent of the way in 4 time constants (4 x R x C).

In both circuits, the charge/discharge current passes through a 220Ω series resistor and the capacitor. So if the capacitor were 0.1µF, the minimum charge/discharge time should be: -

Charge time = 4 x 220 x (0.1 x 10^{-6}) = 88 x 10^{-6}

So it takes only 88µs for the cap to charge/discharge, which means that the 1ms charge/discharge time of the example is more than adequate.

You may be wondering why the 220Ω resistor is necessary at all. Consider what would happen if resistor R in figure A were a pot, and was adjusted to 0Ω. When the I/O pin went high to discharge the cap, it would see a short direct to ground. The 220Ω series resistor would limit the short circuit current to 5V/220Ω = 23mA and protect the PICmicro™ from any possible damage.

See also :   Adin, Counter, Pot, PulseIn.

Repeat...Until

Syntax
Repeat *Condition*
Instructions
Instructions
Until *Condition*

or

Repeat { *Instructions : *} **Until** *Condition*

Overview
Execute a block of instructions until a condition is true.

Example
```
Var1 = 1
Repeat
  Print Dec Var1, " "
  DelayMs 200
  Inc Var1
Until Var1 > 10
```

or

```
Repeat High LED : Until PORTA.0 = 1 ' Wait for a Port change
```

Notes
The **Repeat-Until** loop differs from the **While-Wend** type in that, the **Repeat** loop will carry out the instructions within the loop at least once, then continuously until the condition is true, but the **While** loop only carries out the instructions if the condition is true.

The **Repeat-Until** loop is an ideal replacement to a **For-Next** loop, and actually takes less code space, thus performing the loop faster.

Two commands have been added especially for a **Repeat** loop, these are **Inc** and **Dec**.

   Inc. Increment a variable i.e. `Var1 = Var1 + 1`

   Dec. Decrement a variable i.e. `Var1 = Var1 - 1`

The above example shows the equivalent to the **For-Next** loop: -

```
For Var1 = 1 to 10 : Next
```

See also :   While...Wend, For...Next...Step.

Resume

When the **Resume** statement is encountered at the end of the BASIC interrupt handler, it sets the GIE bit to re-enable interrupts and returns to where the program was before the interrupt occurred. Disable stops the compiler from inserting the Call to the interrupt checker before each command. This allows sections of code to execute without the possibility of being interrupted. Enable allows the insertion to continue.

A Disable should be placed before the interrupt handler so that it will not be restarted every time the GIE bit is checked. If it is desired to turn off interrupts for some reason after **On Interrupt** is encountered, you must not turn off the GIE bit. Turning off this bit informs the compiler an interrupt has happened and it will execute the interrupt handler forever.

Instead use: -

```
INTCON = $80
```

This disables all the individual interrupts but leaves the Global Interrupt Enable bit set.

A final note about interrupts in BASIC is if the program uses the command structure: -

```
Fin:
   Goto Fin
```

You must remember the interrupt flag is checked before each instruction. It immediately jumps to label Fin with no interrupt check. Other commands must be placed in the loop for the interrupt check to happen: -

```
Fin:
   DelayMs 1
   Goto Fin
```

Note.
Software interrupts are a remnant from earlier compiler versions and are not recommended for new applications. See **Managed Hardware Interrupts** for a better method of interrupt handling.

See also :   Software Interrupts in BASIC, Disable, Enable.

Return

Syntax
Return

or

Return *Variable*

Availability
All devices. But a parameter return is only supported with 18F devices.

Overview
Return from a subroutine.

If using an 18F device, a parameter can be pushed onto a software stack before the return mnemonic is implemented.

Variable is a user defined variable of type **Bit**, **Byte**, **Word**, **Dword**, **Float**, **Array**, **String**, or **Constant** value, that will be pushed onto the stack before the subroutine is exited.

Example
```
' Call a subroutine with parameters
'
  Device = 18F452          ' Stack only suitable for 18F devices
  Declare Stack_Size = 20 ' Create a small stack capable of holding 20 bytes

  Dim Wrd1 as Word         ' Create a Word variable
  Dim Wrd2 as Word         ' Create another Word variable
  Dim Receipt as Word      ' Create a variable to hold result

  Wrd1 = 1234              ' Load the Word variable with a value
  Wrd2 = 567              ' Load the other Word variable with a value
'
' Call the subroutine and return a value
'
  Gosub AddThem [Wrd1, Wrd2], Receipt
  Print Dec Receipt        ' Display the result as decimal
  Stop
'
' Subroutine starts here. Add two parameters passed and return the result
'
AddThem:
  Dim AddWrd1 as Word      ' Create two uniquely named variables
  Dim AddWrd2 as Word

  Pop AddWrd2              ' Pop the last variable pushed
  Pop AddWrd1              ' Pop the first variable pushed
  AddWrd1 = AddWrd1 + AddWrd2    ' Add the values together
  Return AddWrd1          ' Return the result of the addition
```

In reality, what's happening with the **Return** in the above program is simple, if we break it into its constituent events: -

```
Push AddWrd1
Return
```

Notes
The same rules apply for the variable returned as they do for **Pop**, which is after all, what is happening when a variable is returned.

Return resumes execution at the statement following the **Gosub** which called the subroutine.

See also :   Call, Gosub, Push, Pop .

Right$

Syntax
Destination String = **Right$ (***Source String*, *Amount of characters***)**

Overview
Extract *n* amount of characters from the right of a source string and copy them into a destination string.

Overview
Destination String can only be a **String** variable, and should be large enough to hold the correct amount of characters extracted from the *Source String*.
Source String can be a **String** variable, or a **Quoted String of Characters**. See below for more variable types that can be used for *Source String*.
Amount of characters can be any valid variable type, expression or constant value, that signifies the amount of characters to extract from the right of the *Source String*. Values start at 1 for the rightmost part of the string and should not exceed 255 which is the maximum allowable length of a String variable.

Example 1
```
' Copy 5 characters from the right of SourceString into DestString
'
  Device = 18F452                    ' A suitable device for Strings
  Dim SourceString as String * 20    ' Create a String of 20 characters
  Dim DestString as String * 20      ' Create another String

  SourceString = "HELLO WORLD"       ' Load the source string with characters
'
' Copy 5 characters from the source string into the destination string
'
  DestString = Right$(SourceString, 5)
  Print DestString        ' Display the result, which will be "WORLD"
  Stop
```

Example 2
```
' Copy 5 characters from right of a Quoted Character String to DestString
'
  Device = 18F452                    ' A suitable device for Strings
  Dim DestString as String * 20      ' Create a String of 20 characters
'
' Copy 5 characters from the quoted string into the destination string
'
  DestString = Right$("HELLO WORLD", 5)
  Print DestString       ' Display the result, which will be "WORLD"
  Stop
```

The *Source String* can also be a **Byte**, **Word**, **Dword**, **Float** or **Array**, variable, in which case the value contained within the variable is used as a pointer to the start of the Source String's address in RAM.

Example 3
```
' Copy 5 characters from the right of SourceString into DestString using a
' pointer to SourceString

  Device = 18F452                     ' A suitable device for Strings
  Dim SourceString as String * 20   ' Create a String of 20 characters
  Dim DestString as String * 20     ' Create another String
' Create a Word variable to hold the address of SourceString
  Dim StringAddr as Word

  SourceString = "HELLO WORLD"    ' Load the source string with characters
' Locate the start address of SourceString in RAM
  StringAddr = AddressOf(SourceString)
' Copy 5 characters from the source string into the destination string
  DestString = Right$(StringAddr, 5)
  Print DestString               ' Display the result, which will be "WORLD"
  Stop
```

A third possibility for *Source String* is a Label name, in which case a null terminated Quoted String of Characters is read from a **Cdata** table.

Example 4
```
' Copy 5 characters from the right of a Cdata table into DestString

  Device = 18F452                     ' A suitable device for Strings
  Dim DestString as String * 20     ' Create a String of 20 characters

' Copy 5 characters from label Source into the destination string
  DestString = Right$(Source, 5)
  Print DestString               ' Display the result, which will be "WORLD"
  Stop

' Create a null terminated string of characters in code memory
Source:
  Cdata "Hello World", 0
```

See also :   Creating and using Strings, Creating and using Virtual Strings with Cdata, Cdata, Len, Left$, Mid$, Str$, ToLower, ToUpper, AddressOf.

Rol

Syntax
Rol *Variable {,Set or Clear}*

Overview
Bitwise rotate a variable left, with or without the microcontroller's Carry flag.

Parameters
Variable may be any standard variable type, but not an array or expression.
Set or ***Clear*** are optional parameters that will clear or set the Carry flag before the rotate.
If no parameter is placed after *Variable*, the current Carry flag state will be rotated into the LSB (Least Significant Bit) of *Variable*.

Example.
```
' Demonstrate the Rol Command
'
  Device = 18F25K22
  Declare Xtal = 16
  Declare Hserial_Baud = 9600        ' HrsoutLn Baud rate

  Dim Index As Byte
  Dim MyByte As Byte = %10000000
  Dim Byteout As Byte
'
' Rotate the carry flag through MyByte
  Rol MyByte
  Rol MyByte
  Rol MyByte
  Rol MyByte
  Rol MyByte
  Rol MyByte
  Rol MyByte
  Rol MyByte
'
' Set each bit of MyByte with every rotate
  MyByte = %00000000
  For Index  = 0 To 7              ' Create a loop of 8 iterations
    Rol MyByte, Set               ' Rotate MyByte and set the Least Significant Bit
    HRSOutLn Bin8 MyByte
  Next
  HRSOutLn "----------"
'
' Clear each bit of MyByte with every rotate
  MyByte = %11111111
  For Index = 0 To 7              ' Create a loop of 8 iterations
    Rol MyByte, Clear             ' Rotate MyByte and clear the Least Significant Bit
    HRSOutLn Bin8 MyByte
  Next
  HRSOutLn "----------"
'
' Transfer the value of MyByte to Byteout, but reversed
  MyByte = %10000000
  Byteout = %00000000
  For Index = 0 To 7              ' Create a loop of 8 iterations
    Rol MyByte                    ' Rotate MyByte into the Carry bit of STATUS
    Ror Byteout                   ' Rotate the Carry bit into Byteout
    HRSOutLn Bin8 Byteout
  Next
```

See also: Ror.

Ror

Syntax
Ror *Variable {,Set or Clear}*

Overview
Bitwise rotate a variable right, with or without the microcontroller's Carry flag.

Parameters
Variable may be any standard variable type, but not an array or expression.
Set or ***Clear*** are optional parameters that will clear or set the Carry flag before the rotate.
If no parameter is placed after *Variable*, the current Carry flag state will be rotated into the MSB
(Most Significant Bit) of *Variable*.

Example.
```
' Demonstrate the Ror Command
'
  Device = 18F25K22
  Declare Xtal = 16
  Declare Hserial_Baud = 9600        ' HrsoutLn Baud rate

  Dim Index As Byte
  Dim MyByte As Byte = %00000001
  Dim Byteout As Byte
'
' Rotate the carry through MyByte
  Ror MyByte
  Ror MyByte
  Ror MyByte
  Ror MyByte
  Ror MyByte
  Ror MyByte
  Ror MyByte
  Ror MyByte
'
' Set each bit of MyByte with every rotate
  MyByte = %00000000
  For Index  = 0 To 7          ' Create a loop of 8 iterations
    Ror MyByte, Set            ' Rotate MyByte and set the Most Significant Bit
    HRSOutLn Bin8 MyByte
  Next
  HRSOutLn "----------"
'
' Clear each bit of MyByte with every rotate
  MyByte = %11111111
  For Index = 0 To 7           ' Create a loop of 8 iterations
    Ror MyByte, Clear          ' Rotate MyByte and clear the Most Significant Bit
    HRSOutLn Bin8 MyByte
  Next
  HRSOutLn "----------"
'
' Transfer the value of MyByte to Byteout, but reversed
  MyByte = %00000001
  Byteout = %00000000
  For Index = 0 To 7           ' Create a loop of 8 iterations
    Ror MyByte                 ' Rotate MyByte into the Carry bit of STATUS
    Rol Byteout                ' Rotate the Carry bit into Byteout
    HRSOutLn Bin8 Byteout
  Next
```

See also: Rol.

Rsin

Syntax
Variable **= Rsin, {** *Timeout Label* **}**

 or

Rsin { *Timeout Label* **}**, *Modifier..Variable* {, *Modifier.. Variable*...}

Overview
Receive one or more bytes from a predetermined pin at a predetermined baud rate in standard asynchronous format using 8 data bits, no parity and 1 stop bit (8N1). The pin is automatically made an input.

Parameters
Modifiers may be one of the serial data modifiers explained below.
Variable can be any user defined variable.
An optional *Timeout Label* may be included to allow the program to continue if a character is not received within a certain amount of time. *Timeout* is specified in units of 1 millisecond and is specified by using a **Declare** directive.

Example
```
Declare Rsin_Timeout = 2000        ' Timeout after 2 seconds
Dim Var1 as Byte
Dim Wrd as Word
Var1 = Rsin, {Label}
Rsin Var1, Wrd
Rsin { Label }, Var1, Wrd

Label: { do something when timed out }
```

Declares
There are four **Declares** for use with **Rsin**. These are : -

Declare Rsin_Pin Port **.** Pin
Assigns the Port and Pin that will be used to input serial data by the **Rsin** command. This may be any valid port on the PICmicro™.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.1.

Declare Rsin_Mode Inverted or True or 1, 0
Sets the serial mode for the data received by **Rsin**. This may be inverted or true. Alternatively, a value of 1 may be substituted to represent inverted, and 0 for true.

If the **Declare** is not used in the program, then the default mode is Inverted.

Declare Serial_Baud 0 to 65535 bps (baud)
Informs the **Rsin** and **Rsout** routines as to what baud rate to receive and transmit data.

Virtually any baud rate may be transmitted and received, but there are standard bauds: -

  300, 600, 1200, 2400, 4800, 9600, and 19200.

When using a 4MHz crystal, the highest baud rate that is reliably achievable is 9600. However, an increase in the oscillator speed allows higher baud rates to be achieved, including 38400 baud.

If the **Declare** is not used in the program, then the default baud is 9600.

Declare Rsin_Timeout 0 to 65535 milliseconds (ms)
Sets the time, in milliseconds, that **Rsin** will wait for a start bit to occur.

Rsin waits in a tight loop for the presence of a start bit. If no timeout value is used, then it will wait forever. The **Rsin** command has the option of jumping out of the loop if no start bit is detected within the time allocated by timeout.

If the **Declare** is not used in the program, then the default timeout value is 10000ms or 10 seconds.

Rsin Modifiers.

As we already know, **Rsin** will wait for and receive a single byte of data, and store it in a variable . If the PICmicro™ were connected to a PC running a terminal program and the user pressed the "A" key on the keyboard, after the **Rsin** command executed, the variable would contain 65, which is the ASCII code for the letter "A"

What would happen if the user pressed the "1" key? The result would be that the variable would contain the value 49 (the ASCII code for the character "1"). This is an important point to remember: every time you press a character on the keyboard, the computer receives the ASCII value of that character. It is up to the receiving side to interpret the values as necessary. In this case, perhaps we actually wanted the variable to end up with the value 1, rather than the ASCII code 49.

The **Rsin** command provides a modifier, called the decimal modifier, which will interpret this for us. Look at the following code: -

```
Dim SerData as Byte
Rsin Dec SerData
```

Notice the decimal modifier in the **Rsin** command that appears just to the left of the SerData variable. This tells **Rsin** to convert incoming text representing decimal numbers into true decimal form and store the result in SerData. If the user running the terminal software pressed the "1", "2" and then "3" keys followed by a space or other non-numeric text, the value 123 will be stored in the variable SerData, allowing the rest of the program to perform any numeric operation on the variable.

Without the decimal modifier, however, you would have been forced to receive each character ("1", "2" and "3") separately, and then would still have to do some manual conversion to arrive at the number 123 (one hundred twenty three) before you can do the desired calculations on it.

The decimal modifier is designed to seek out text that represents decimal numbers. The characters that represent decimal numbers are the characters "0" through "9". Once the **Rsin** command is asked to use the decimal modifier for a particular variable, it monitors the incoming serial data, looking for the first decimal character. Once it finds the first decimal character, it will continue looking for more (accumulating the entire multi-digit number) until is finds a non-decimal numeric character. Remember that it will not finish until it finds at least one decimal character followed by at least one non-decimal character.

To illustrate this further, examine the following examples (assuming we're using the same code example as above): -

Serial input: "ABC"
Result: The program halts at the **Rsin** command, continuously waiting for decimal text.

Serial input: "123" (with no characters following it)
Result: The program halts at the **Rsin** command. It recognises the characters "1", "2" and "3" as the number one hundred twenty three, but since no characters follow the "3", it waits continuously, since there's no way to tell whether 123 is the entire number or not.

Serial input: "123" (followed by a space character)
Result: Similar to the above example, except once the space character is received, the program knows the entire number is 123, and stores this value in SerData. The **Rsin** command then ends, allowing the next line of code to run.

Serial input: "123A"
Result: Same as the example above. The "A" character, just like the space character, is the first non-decimal text after the number 123, indicating to the program that it has received the entire number.

Serial input: "ABCD123EFGH"
Result: Similar to examples 3 and 4 above. The characters "ABCD" are ignored (since they're not decimal text), the characters "123" are evaluated to be the number 123 and the following character, "E", indicates to the program that it has received the entire number.

The final result of the **Dec** modifier is limited to 16 bits (up to the value 65535). If a value larger than this is received by the decimal modifier, the end result will be incorrect because the result rolled-over the maximum 16-bit value. Therefore, **Rsin** modifiers may not (at this time) be used to load **Dword** (32-bit) variables.

The decimal modifier is only one of a family of conversion modifiers available with **Rsin** See below for a list of available conversion modifiers. All of the conversion modifiers work similar to the decimal modifier (as described above). The modifiers receive bytes of data, waiting for the first byte that falls within the range of characters they accept (e.g., "0" or "1" for binary, "0" to "9" for decimal, "0" to "9" and "A" to "F" for hex. Once they receive a numeric character, they keep accepting input until a non-numeric character arrives, or in the case of the fixed length modifiers, the maximum specified number of digits arrives.

While very effective at filtering and converting input text, the modifiers aren't completely foolproof. As mentioned before, many conversion modifiers will keep accepting text until the first non-numeric text arrives, even if the resulting value exceeds the size of the variable. After **Rsin**, a **Byte** variable will contain the lowest 8 bits of the value entered and a **Word** (16-bits) would contain the lowest 16 bits. You can control this to some degree by using a modifier that specifies the number of digits, such as **Dec2**, which would accept values only in the range of 0 to 99.

Conversion Modifier	Type of Number Numeric	Characters Accepted
Dec{1..10}	Decimal, optionally limited to 1 - 10 digits	0 through 9
Hex{1..8}	Hexadecimal, optionally limited to 1 - 8 digits	0 through 9, A through F
Bin{1..32}	Binary, optionally limited	0, 1 to 1 - 32 digits

A variable preceded by **Bin** will receive the ASCII representation of its binary value.
For example, if **Bin** Var1 is specified and "1000" is received, Var1 will be set to 8.

A variable preceded by **Dec** will receive the ASCII representation of its decimal value.
For example, if **Dec** Var1 is specified and "123" is received, Var1 will be set to 123.

A variable preceded by **Hex** will receive the ASCII representation of its hexadecimal value.
For example, if **Hex** Var1 is specified and "FE" is received, Var1 will be set to 254.

SKIP followed by a count will skip that many characters in the input stream.
For example, **SKIP** 4 will skip 4 characters.

The **Rsin** command can be configured to wait for a specified sequence of characters before it retrieves any additional input. For example, suppose a device attached to the PICmicro™ is known to send many different sequences of data, but the only data you wish to observe happens to appear right after the unique characters, "XYZ". A modifier named **Wait** can be used for this purpose: -

```
Rsin Wait("XYZ"), SerData
```

The above code waits for the characters "X", "Y" and "Z" to be received, in that order, then it receives the next data byte and places it into variable SerData.

Str modifier.
The **Rsin** command also has a modifier for handling a string of characters, named **Str**.

The **Str** modifier is used for receiving a string of characters into a byte array variable.

A string is a set of characters that are arranged or accessed in a certain order. The characters "ABC" would be stored in a string with the "A" first, followed by the "B" then followed by the "C". A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string "ABC" would be stored in a byte array containing three bytes (elements).

Below is an example that receives ten bytes and stores them in the 10-byte array, SerString: -

```
Dim SerString[10] as Byte    ' Create a 10-byte array.
Rsin Str SerString           ' Fill the array with received data.
Print Str SerString          ' Display the string.
```

If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. For example: -

```
Dim SerString[10] as Byte    ' Create a 10-byte array.
Rsin Str SerString\5         ' Fill the first 5-bytes of the array
Print Str SerString\5        ' Display the 5-character string.
```

The example above illustrates how to fill only the first *n* bytes of an array, and then how to display only the first *n* bytes of the array. *n* refers to the value placed after the backslash.

Because of its complexity, serial communication can be rather difficult to work with at times. Using the guidelines below when developing a project using the **Rsin** and Rsout commands may help to eliminate some obvious errors: -

Always build your project in steps.
Start with small, manageable pieces of code, (that deal with serial communication) and test them, one individually.
Add more and more small pieces, testing them each time, as you go.
Never write a large portion of code that works with serial communication without testing its smallest workable pieces first.

Pay attention to timing.
Be careful to calculate and overestimate the amount of time, operations should take within the PICmicro™ for a given oscillator frequency. Misunderstanding the timing constraints is the source of most problems with code that communicate serially. If the serial communication in your project is bi-directional, the above statement is even more critical.

Pay attention to wiring.
Take extra time to study and verify serial communication wiring diagrams. A mistake in wiring can cause strange problems in communication, or no communication at all. Make sure to connect the ground pins (Vss) between the devices that are communicating serially.

Verify port setting on the PC and in the Rsin / Rsout commands.
Unmatched settings on the sender and receiver side will cause garbled data transfers or no data transfers. This is never more critical than when a line transceiver is used(i.e. MAX232). Always remember that a line transceiver inverts the serial polarity.
If the serial data received is unreadable, it is most likely caused by a baud rate setting error, or a polarity error.

If receiving data from another device that is not a PICmicro™, try to use baud rates of 9600 and below, or alternatively, use a higher frequency crystal.

Because of additional overheads in the PICmicro™, and the fact that the **Rsin** command offers no hardware receive buffer for serial communication, received data may sometimes be missed or garbled. If this occurs, try lowering the baud rate, or increasing the crystal frequency. Using simple variables (not arrays) will also increase the chance that the PICmicro™ will receive the data properly.

Notes
Rsin is oscillator independent as long as the crystal frequency is declared at the top of the program. If no Xtal **Declare** is used, then **Rsin** defaults to a 4MHz crystal frequency for its bit timing.

See also :   Declare, Rsout, Serin, Serout, Hrsin, Hrsout, Hserin, Hserout.

Rsout

Syntax
Rsout *Item* {, *Item...* }

Overview
Send one or more *Items* to a predetermined pin at a predetermined baud rate in standard asynchronous format using 8 data bits, no parity and 1 stop bit (8N1). The pin is automatically made an output.

Parameters
Item may be a constant, variable, expression, or string list.
There are no operators as such, instead there are *modifiers*. For example, if an at sign '@' precedes an *Item*, the ASCII representation for each digit is transmitted.

The modifiers are listed below: -

Modifier	Operation
At ypos,xpos	Position the cursor on a serial LCD
Cls	Clear a serial LCD (also creates a 30ms delay)
Bin{1..32}	Send binary digits
Dec{0..10}	Send decimal digits (amount of digits after decimal point with floating point)
Hex{1..8}	Send hexadecimal digits
Sbin{1..32}	Send signed binary digits
Sdec{0..10}	Send signed decimal digits
Shex{1..8}	Send signed hexadecimal digits
Ibin{1..32}	Send binary digits with a preceding '%' identifier
Idec{0..10}	Send decimal digits with a preceding '#' identifier
Ihex{1..8}	Send hexadecimal digits with a preceding '$' identifier
ISbin{1..32}	Send signed binary digits with a preceding '%' identifier
ISdec{0..10}	Send signed decimal digits with a preceding '#' identifier
IShex{1..8}	Send signed hexadecimal digits with a preceding '$' identifier
Rep c\n	Send character c repeated n times
Str array\n	Send all or part of an array
Cstr cdata	Send string data defined in a Cdata statement.

The numbers after the **Bin**, **Dec**, and **Hex** modifiers are optional. If they are omitted, then the default is all the digits that make up the value will be displayed.

If a floating point variable is to be displayed, then the digits after the **Dec** modifier determine how many remainder digits are send. i.e. numbers after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.145
Rsout Dec2 MyFloat    ' Send 2 values after the decimal point
```

The above program will send 3.14

If the digit after the **Dec** modifier is omitted, then 3 values will be displayed after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.1456
Rsout Dec MyFloat        ' Send 3 values after the decimal point
```

The above program will send 3.145

There is no need to use the **Sdec** modifier for signed floating point values, as the compiler's **Dec** modifier will automatically display a minus result: -

```
Dim MyFloat as Float
MyFloat = -3.1456
Rsout Dec MyFloat        ' Send 3 values after the decimal point
```

The above program will send -3.145

Hex or **Bin** modifiers cannot be used with floating point values or variables.

The Xpos and Ypos values in the **At** modifier both start at 1. For example, to place the text "HELLO WORLD" on line 1, position 1, the code would be: -

```
Rsout At 1, 1, "HELLO WORLD"
```

Example 1
```
Dim Var1 as Byte
Dim Wrd as Word
Dim Dwd as Dword

Rsout "Hello World"         ' Display the text "Hello World"
Rsout "Var1= ", Dec Var1   ' Display the decimal value of Var1
Rsout "Var1= ", Hex Var1   ' Display the hexadecimal value of Var1
Rsout "Var1= ", Bin Var1   ' Display the binary value of Var1
Rsout "Dwd= ", Hex6 Dwd    ' Display 6 hex characters of a Dword variable
```

Example 2
```
' Display a negative value on a serial LCD.
Symbol Negative = -200
Rsout At 1, 1, Sdec Negative
```

Example 3
```
' Display a negative value on a serial LCD with a preceding identifier.
Rsout At 1, 1, IShex -$1234
```

Example 3 will produce the text "$-1234" on the LCD.

Some PICmicros such as the 16F87x, and 18FXXX range have the ability to read and write to their own flash memory. And although writing to this memory too many times is unhealthy for the PICmicro™, reading this memory is both fast, and harmless. Which offers a unique form of data storage and retrieval, the **Cdata** command proves this, as it uses the mechanism of reading and storing in the PICmicro's flash memory.

Combining the unique features of the 'self modifying PICmicro's' with a string format, the compiler is capable of reducing the overhead of printing, or transmitting large amounts of text data.

The **Cstr** modifier may be used in commands that deal with text processing i.e. **Serout**, **Hrsout**, and **Print** etc.

The **Cstr** modifier is used in conjunction with the **Cdata** command. The **Cdata** command is used for initially creating the string of characters: -

```
String1: Cdata "HELLO WORLD", 0
```

The above line of case will create, in flash memory, the values that make up the ASCII text "HELLO WORLD", at address String1. Note the null terminator after the ASCII text.

null terminated means that a zero (null) is placed at the end of the string of ASCII characters to signal that the string has finished.

To display, or transmit this string of characters, the following command structure could be used:

```
Rsout Cstr String1
```

The label that declared the address where the list of Cdata values resided, now becomes the string's name. In a large program with lots of text formatting, this type of structure can save quite literally hundreds of bytes of valuable code space.

Try both these small programs, and you'll see that using **Cstr** saves a few bytes of code: -

First the standard way of displaying text: -

```
Device = 16F1829

Rsout "HELLO WORLD"
Rsout "HOW ARE YOU?"
Rsout "I AM FINE!"
Stop
```

Now using the **Cstr** modifier: -

```
Rsout Cstr TEXT1
Rsout Cstr TEXT2
Rsout Cstr TEXT3
Stop

TEXT1: Cdata "HELLO WORLD", 13, 0
TEXT2: Cdata "HOW ARE YOU?", 13, 0
TEXT3: Cdata "I AM FINE!", 13, 0
```

Again, note the null terminators after the ASCII text in the Cdata commands. Without these, the PICmicro™ will continue to transmit data in an endless loop.

The term 'virtual string' relates to the fact that a string formed from the Cdata command cannot be written too, but only read from.

The **Str** modifier is used for sending a string of bytes from a byte array variable. A string is a set of bytes sized values that are arranged or accessed in a certain order.

The values 1, 2, 3 would be stored in a string with the value 1 first, followed by 2 then followed by the value 3. A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string 1,2,3 would be stored in a byte array containing three bytes (elements).

Below is an example that displays four bytes (from a byte array): -

```
Dim MyArray[10] as Byte    ' Create a 10-byte array.
MyArray [0] = "H"          ' Load the first 5 bytes of the array
MyArray [1] = "E"          ' With the data to send
MyArray [2] = "L"
MyArray [3] = "L"
MyArray [4] = "O"
Rsout Str MyArray\5        ' Display a 5-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the PICmicro™ would try to keep sending characters until all 10 bytes of the array were transmitted. Since we do not wish all 10 bytes to be transmitted, we chose to tell it explicitly to only send the first 5 bytes.

The above example may also be written as: -

```
Dim MyArray[10] as Byte    ' Create a 10-byte array.
Str MyArray = "HELLO"      ' Load the first 5 bytes of the array
Rsout Str MyArray\5        ' Send 5-byte string.
```

The above example, has exactly the same function as the previous one. The only difference is that the string is now constructed using **Str** as a command instead of a modifier.

Declares
There are four **Declares** for use with **Rsout**. These are : -

Declare Rsout_Pin Port **.** Pin
Assigns the Port and Pin that will be used to output serial data from the **Rsout** command. This may be any valid port on the PICmicro™.

If the **Declare** is not used in the program, then the default Port and Pin is PORTB.0.

Declare Rsout_Mode Inverted or True/False or 1, 0
Sets the serial mode for the data transmitted by **Rsout**. This may be inverted or true. Alternatively, a value of 1 may be substituted to represent inverted, and 0 for true.

If the **Declare** is not used in the program, then the default mode is INVERTED.

Declare Serial_Baud 0 to 65535 bps (baud)
Informs the **Rsin** and **Rsout** routines as to what baud rate to receive and transmit data.

Virtually any baud rate may be transmitted and received, but there are standard bauds: -

300, 600, 1200, 2400, 4800, 9600, and 19200.

When using a 4MHz crystal, the highest baud rate that is reliably achievable is 9600. However, an increase in the oscillator speed allows higher baud rates to be achieved, including 38400 baud.

If the **Declare** is not used in the program, then the default baud is 9600.

Declare Rsout_Pace 0 to 65535 microseconds (us)
Implements a delay between characters transmitted by the **Rsout** command.

On occasion, the characters transmitted serially are in a stream that is too fast for the receiver to catch, this results in missed characters. To alleviate this, a delay may be implemented between each individual character transmitted by **Rsout**.

If the **Declare** is not used in the program, then the default is no delay between characters.

Notes
Rsout is oscillator independent as long as the crystal frequency is declared at the top of the program. If no declare is used, then **Rsout** defaults to a 4MHz crystal frequency for its bit timing.

The **At** and **Cls** modifiers are primarily intended for use with serial LCD modules. Using the following command sequence will first clear the LCD, then display text at position 5 of line 2: -

```
Rsout Cls, At 2, 5, "HELLO WORLD"
```

The values after the **At** modifier may also be variables.

See also : Declare, Rsin , Serin, Serout, Hrsin, Hrsout, Hserin, Hserout.

RsoutLn

Syntax
RsoutLn *Item* {, *Item...* }

Overview
Transmit one or more *Items* to a predetermined pin at a predetermined baud rate in standard asynchronous format using 8 data bits, no parity and 1 stop bit (8N1), and terminate with a Carriage Return(13) or Carriage Return(13) Line Feed(10) or Line Feed(10) Carriage Return(13)..
The pin is automatically made an output.

Parameters
Item may be a constant, variable, expression, string list, modifier, or inline command. See the-section for **Rsout** for more details.

Declare

There is a declare for the **RsoutLn** command that dictates what values are used as the terminator.

```
Declare Serial_Terminator = CRLF or LFCR or CR
```

The parameter **CR** will transmit a single value of 13 at the end of transmission.
The parameter **CRLF** will transmit a value of 13 then 10 at the end of transmission.
The parameter **LFCR** will transmit a value of 10 then 13 at the end of transmission.

See also : Declare, Rsin , Serin, Serout, Hrsin, Hrsout, HrsoutLn, Hserin, Hserout.

Seed

Syntax
Seed *Value*

Overview
Seed the random number generator, in order to obtain a more random result.

Parameters
Value can be a variable, constant or expression, with a value from 1 to 65535. A value of $0345 is a good starting point.

Example
```
' Create and display a Random number
  Device = 16F1829
  Declare Xtal = 4

  Dim MyRandom as Word

  Seed $0345
  Cls

  Do
    MyRandom = Random
    HrsoutLn Dec MyRandom
    DelayMs 500
  Loop
```

See also: Random.

Select..Case..EndSelect

Syntax
Select *Expression*

    Case C*ondition(s)*
       Instructions
    {
    Case C*ondition(s)*
       Instructions

    Case Else
       Statement(s)
          }
EndSelect

The curly braces signify optional conditions.

Overview
Evaluate an *Expression* then continually execute a block of BASIC code based upon compari-sons to *Condition(s).* After executing a block of code, the program continues at the line follow-ing the **EndSelect**. If no conditions are found to be True and a **Case Else** block is included, the code after the **Case Else** leading to the **EndSelect** will be executed.

Parameters
Expression can be any valid variable, constant, expression or inline command that will be compared to the *Conditions*.
Condition(s) is a statement that can evaluate as True or False. The Condition can be a simple or complex relationship, as described below. Multiple conditions within the same **Case** can be separated by commas.
Instructions can be any valid BASIC command that will be operated on if the **Case** condition produces a True result.

Example
```
' Load variable MyResult according to the contents of variable Var1
' MyResult will return a value of 255 if no valid condition was met
  Include "Proton_4.Inc"  ' Use the Proton development board for the demo
  Dim Var1 as Byte
  Dim MyResult as Byte

  DelayMs 100             ' Wait for the LCD to stabilise
  Cls                     ' Clear the LCD
  MyResult = 0            ' Clear the MyResult variable before we start
  Var1 = 1               ' Variable to base the conditions upon
  Select Var1
    Case 1               ' Is Var1 equal to 1 ?
      MyResult = 1       ' Load MyResult with 1 if yes
    Case 2               ' Is Var1 equal to 2 ?
      MyResult = 2       ' Load MyResult with 2 if yes
    Case 3               ' Is Var1 equal to 3 ?
      MyResult = 3       ' Load MyResult with 3 if yes
    Case Else            ' Otherwise...
      MyResult = 255     ' Load MyResult with 255
  EndSelect
  Print Dec MyResult     ' Display the MyResult
  Stop
```

Notes
Select..Case is simply an advanced form of the **If..Then..ElseIf..Else** construct, in which multiple **ElseIf** statements are executed by the use of the **Case** command.

Taking a closer look at the **Case** command: -

  Case *Conditional_Op Expression*

Where *Conditional_Op* can be an = operator (which is implied if absent), or one of the standard comparison operators <>, <, >, >= or <=. Multiple conditions within the same **Case** can be separated by commas. If, for example, you wanted to run a **Case** block based on a value being less than one or greater than nine, the syntax would look like: -

```
Case < 1, > 9
```

Another way to implement Case is: -

```
Case value1 to value2
```

In this form, the valid range is from *Value1* to *Value2*, inclusive. So if you wished to run a Case block on a value being between the values 1 and 9 inclusive, the syntax would look like: -

```
Case 1 to 9
```

For those of you that are familiar with C or Java, you will know that in those languages the statements in a **Case** block fall through to the next **Case** block unless the keyword break is encountered. In BASIC however, the code under an executed **Case** block jumps to the code immediately after **EndSelect**.

Shown below is a typical **Select...Case** structure with its corresponding If..Then equivalent code alongside.

```
Select Var1
  Case 6, 9, 99, 66
  ' If Var1 = 6 or Var1 = 9 or Var1 = 99 or Var1 = 66 Then
    Print "or ValueS"
  Case 110 to 200
  ' ElseIf Var1 >= 110 and Var1 <= 200 Then
    Print "and ValueS"
  Case 100
  ' ElseIf Var1 = 100 Then
    Print "EQUAL Value"
  Case > 300
  ' ElseIf Var1 > 300 Then
    Print "GREATER Value"
  Case Else
  ' Else
    Print "DEFAULT Value"
EndSelect
' EndIf
```

See also :   If..Then..ElseIf..Else..EndIf.

Serin

Syntax
Serin *Rpin* { **** *Fpin* }, *Baudmode*, { *Plabel*, } { *Timeout, Tlabel,* } **[** InputData **]**

Overview
Receive asynchronous serial data (i.e. RS232 data).

Parameters
Rpin is a Port.Bit constant that specifies the I/O pin through which the serial data will be received. This pin will be set to input mode.
Fpin is an optional Port.Bit constant that specifies the I/O pin to indicate flow control status on. This pin will be set to output mode.
Baudmode may be a variable, constant, or expression (0 - 65535) that specifies serial timing and configuration.
Plabel is an optional label indicating where the program should jump to in the event of a parity error. This argument should only be provided if *Baudmode* indicates that parity is required.
Timeout is an optional constant (0 - 65535) that informs **Serin** how long to wait for incoming data. If data does not arrive in time, the program will jump to the address specified by *Tlable*.
Tlabel is an optional label that must be provided along with *Timeout*, indicating where the program should go in the event that data does not arrive within the period specified by *Timeout*.
InputData is list of variables and modifiers that informs **Serin** what to do with incoming data. **Serin** may store data in a variable, array, or an array string using the **Str** modifier.

Notes
One of the most popular forms of communication between electronic devices is serial communication. There are two major types of serial communication; asynchronous and synchronous. The **Rsin**, **Rsout**, **Serin** and **Serout** commands are all used to send and receive asynchronous serial data. While the **Shin** and **Shout** commands are for use with synchronous communications.

The term asynchronous means 'no clock.' More specifically, 'asynchronous serial communication' means data is transmitted and received without the use of a separate 'clock' line. Data can be sent using as few as two wires; one for data and one for ground. The PC's serial ports (also called COM ports or RS232 ports) use asynchronous serial communication. Note: the other kind of serial communication, synchronous, uses at least three wires; one for clock, one for data and one for ground.

RS232 is the electrical specification for the signals that PC serial ports use. Unlike standard TTL logic, where 5 volts is a logic 1 and 0 volts is logic 0, RS232 uses -12 volts for logic 1 and +12 volts for logic 0. This specification allows communication over longer wire lengths without amplification.

Most circuits that work with RS232 use a line driver / receiver (transceiver). This component does two things: -

Convert the ±12 volts of RS-232 to TTL compatible 0 to 5 volt levels.
Invert the voltage levels, so that 5 volts = logic 1 and 0 volts = logic 0.

By far, the most common line driver device is the MAX232 from Maxim semiconductor. With the addition of a few capacitors, a complete 2-way level converter is realised. Figure 1 shows a typical circuit for one of these devices. The MAX232 is not the only device available, there are

other types that do not require any external capacitors at all. Visit Maxim's excellent web site at **www.maxim.com**, and download one of their many detailed datasheets.
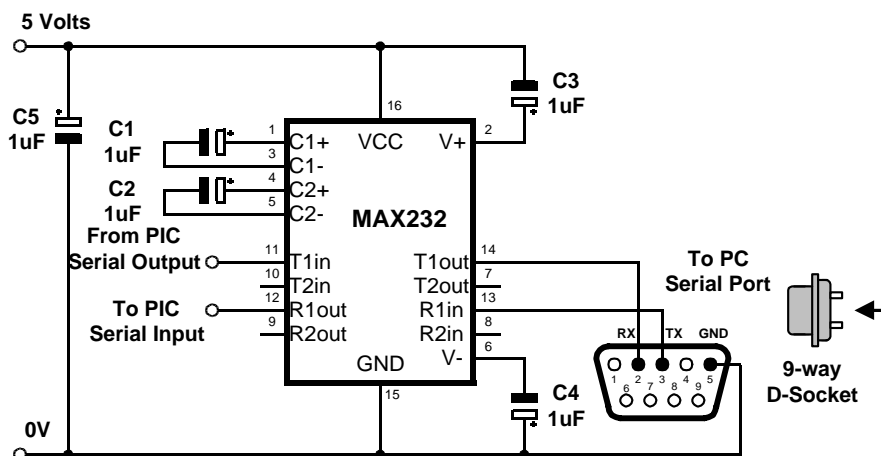
Typical MAX232 RS232 line-transceiver circuit.

Because of the excellent IO capabilities of the PICmicro™ range of devices, and the adoption of TTL levels on most modern PC serial ports, a line driver is often unnecessary unless long distances are involved between the transmitter and the receiver. Instead a simple current limiting resistor is all that's required. As shown below: -
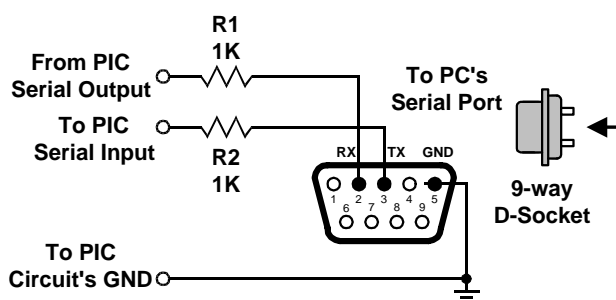
Directly connected RS232 circuit.

You should remember that when using a line transceiver such as the MAX232, the serial mode (polarity) is inverted in the process of converting the signal levels, however, if using the direct connection, the mode is untouched. This is the single most common cause of errors when connecting serial devices, therefore you must make allowances for this within your software.

Asynchronous serial communication relies on precise timing. Both the sender and receiver must be set for identical timing, this is commonly expressed in bits per second (bps) called baud. **Serin** requires a value called *Baudmode* that informs it of the relevant characteristics of the incoming serial data; the bit period, number of data and parity bits, and polarity.

The *Baudmode* argument for **Serin** accepts a 16-bit value that determines its characteristics: 1-stop bit, 8-data bits/no-parity or 7-data bits/even-parity and most speeds from as low as 300 baud to 38400 baud (depending on the crystal frequency used). The following table shows how *Baudmode* is calculated, while table 1 shows some common *baudmodes* for standard serial baud rates.

Step 1.	Determine the bit period. (bits 0 – 11)	(1,000,000 / baud rate) – 20
Step 2.	data bits and parity. (bit 13)	8-bit/no-parity = step 1 + 0 7-bit/even-parity = step 1 + 8192
Step 3.	Select polarity. (bit 14)	True (noninverted) = step 2 + 0 Inverted = step 2 + 16384

Baudmode calculation.

Add the results of steps 1, 2 3, and 3 to determine the correct value for the *Baudmode* operator.

BaudRate	8-bit no-parity inverted	8-bit no-parity true	7-bit even-parity inverted	7-bit even-parity true
300	19697	3313	27889	11505
600	18030	1646	26222	9838
1200	17197	813	25389	9005
2400	16780	396	24972	8588
4800	16572	188	24764	8380
9600	16468	84	24660	8276

Table 1. Common baud rates and corresponding *Baudmode*s.

If communications are with existing software or hardware, its speed and mode will determine the choice of baud rate and mode. In general, 7-bit/even-parity (7E) mode is used for text, and 8-bit/no-parity (8N) for byte-oriented data. Note: the most common mode is 8-bit/no-parity, even when the data transmitted is just text. Most devices that use a 7-bit data mode do so in order to take advantage of the parity feature. Parity can detect some communication errors, but to use it you lose one data bit. This means that incoming data bytes transferred in 7E (even-parity) mode can only represent values from 0 to 127, rather than the 0 to 255 of 8N (no-parity) mode.

The compiler's serial commands **Serin** and **Serout**, have the option of still using a parity bit with 4 to 8 data bits. This is through the use of a **Declare**: -

With parity disabled (the default setting): -

```
Declare Serial_Data 4  ' Set Serin and Serout data bits to 4
Declare Serial_Data 5  ' Set Serin and Serout data bits to 5
Declare Serial_Data 6  ' Set Serin and Serout data bits to 6
Declare Serial_Data 7  ' Set Serin and Serout data bits to 7
Declare Serial_Data 8  ' Set Serin and Serout data bits to 8 (default)
```

With parity enabled: -

```
Declare Serial_Data 5  ' Set Serin and Serout data bits to 4
Declare Serial_Data 6  ' Set Serin and Serout data bits to 5
Declare Serial_Data 7  ' Set Serin and Serout data bits to 6
Declare Serial_Data 8  ' Set Serin and Serout data bits to 7 (default)
Declare Serial_Data 9  ' Set Serin and Serout data bits to 8
```

Serial_Data data bits may range from 4 bits to 8 (the default if no Declare is issued). Enabling parity uses one of the number of bits specified.

Declaring **Serial_Data** as 9 allows 8 bits to be read and written along with a 9th parity bit.

Parity is a simple error-checking feature. When a serial sender is set for even parity (the mode the compiler supports) it counts the number of 1s in an outgoing byte and uses the parity bit to make that number even. For example, if it is sending the 7-bit value: %0011010, it sets the parity bit to 1 in order to make an even number of 1s (four).

The receiver also counts the data bits to calculate what the parity bit should be. If it matches the parity bit received, the serial receiver assumes that the data was received correctly. Of course, this is not necessarily true, since two incorrectly received bits could make parity seem correct when the data was wrong, or the parity bit itself could be bad when the rest of the data was correct.

Many systems that work exclusively with text use 7-bit/ even-parity mode. For example, to receive one data byte through bit-0 of PORTA at 9600 baud, 7E, inverted:

```
Serin PORTA.0, 24660, [SerData]
```

The above example will work correctly, however it doesn't inform the program what to do in the event of a parity error.

Below, is an improved version that uses the optional *Plabel* argument:

```
Serin PORTA.0, 24660, ParityError, [SerData]
Print Dec SerData
Stop
ParityError:
Print "Parity Error"
Stop
```

If the parity matches, the program continues at the **Print** instruction after **Serin**. If the parity doesn't match, the program jumps to the label P_ERROR. Note that a parity error takes precedence over other *InputData* specifications (as soon as an error is detected, **Serin** aborts and jumps to the *Plabel* routine).

In the examples above, the only way to end the **Serin** instruction (other than RESet or power-off) is to give **Serin** the serial data it needs. If no serial data arrives, the program is stuck in an endless loop. However, you can force **Serin** to abort if it doesn't receive data within a specified number of milliseconds.

For example, to receive a value through bit-0 of PORTA at 9600 baud, 8N, inverted and abort **Serin** after 2 seconds (2000 ms) if no data arrives: -

```
Serin PORTA.0, 16468, 2000, TimeoutError, [SerData]
Print Cls, Dec MyResult
Stop
TimeoutError:
Print Cls, "Timed Out"
Stop
```

If no serial data arrives within 2 seconds, **Serin** aborts and continues at the label to_ERROR.

Both Parity and Serial Timeouts may be combined. Below is an example to receive a value through bit-0 of PORTA at 2400 baud, 7E, inverted with a 10-second timeout: -

```
    Dim SerData as Byte
Again:
    Serin PORTA.0, 24660, ParityError, 10000, TimeoutError, [SerData]
    Print Cls, Dec SerData
    Goto Again
TimeoutError:
    Print Cls, "Timed Out"
    Goto Again
ParityError:
    Print Cls, "Parity Error"
    Goto Again
```

When designing an application that requires serial communication between PICs, you should remember to work within these limitations: -

When the PICmicro™ is sending or receiving data, it cannot execute other instructions.
When the PICmicro™ is executing other instructions, it cannot send or receive data.
The compiler does not offer a serial buffer as there is in PCs. At lower crystal frequencies, and higher serial rates, the PICmicro™ cannot receive data via **Serin**, process it, and execute another **Serin** in time to catch the next chunk of data, unless there are significant pauses between data transmissions.

These limitations can sometimes be addressed by using flow control; the *Fpin* option for **Serin** and **Serout**. Through *Fpin*, **Serin** can inform another PICmicro™ sender when it is ready to receive data. (*Fpin* flow control follows the rules of other serial handshaking schemes, however most computers other than the PICmicro™ cannot start and stop serial transmission on a byte-by-byte basis. That is why this discussion is limited to communication between PICmicros.)

Below is an example using flow control with data through bit-0 of PORTA, and flow control through bit-1 of PORTA, 9600 baud, N8, noninverted: -

```
    Serin PORTA.0\PORTA.1, 84, [SerData]
```

When **Serin** executes, bit-0 of PORTA *(Rpin)* is made an input in preparation for incoming data, and bit-1 of PORTA *(Fpin)* is made an output low, to signal "go" to the sender. After **Serin** finishes receiving data, bit-1 of PORTA is brought high to notify the sender to stop. If an inverted *BaudMode* had been specified, the *Fpin's* responses would have been reversed. The table below illustrates the relationship of serial polarity to *Fpin* states.

Serial Polarity	Ready to Receive ("Go")	Not Ready to Receive ("Stop")
Inverted	*Fpin* is High (1)	*Fpin* is Low (0)
Non-inverted	*Fpin* is Low (0)	*Fpin* is High (1)

See the following circuit for a flow control example using two 16F84 devices. In the demonstration program example, the sender transmits the whole word "HELLO!" in approx 6 ms. The receiver catches the first byte at most; by the time it got back from the first 1-second delay (**DelayMs** 1000), the rest of the data would be long gone. With flow control, communication is flawless since the sender waits for the receiver to catch up.

In the circuit below, the flow control pin (PORTA.1) is pulled to ground through a 10kΩ resistor. This is to ensure that the sender sees a stop signal (0 for inverted communications) when the receiver is first powered up.
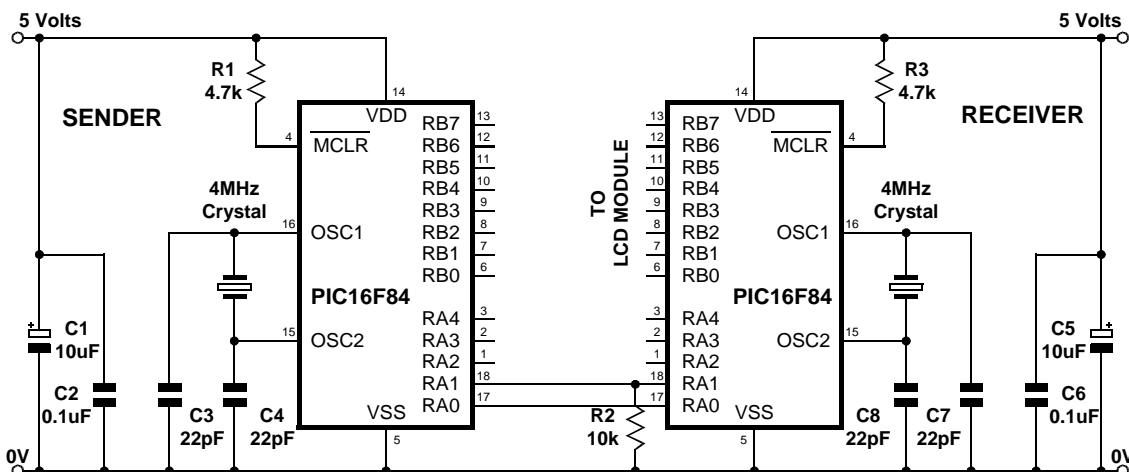
Communicating Communication between two PICs using flow control.

```
' Sender Code. Program into the Sender device.
   Do
      Serout PORTA.0\PORTA.1, 16468, ["HELLO!"]  ' Send the message.
      DelayMs 2500                               ' Delay for 2.5 seconds
   Loop                                          ' Repeat the message forever

' Receiver Code. Program into the Receiver device.
   Dim Message as Byte
   Do
      Serin PORTA.0\PORTA.1, 16468, [Message]    ' Get 1 byte.
      Print Message                              ' Display the byte on LCD.
      DelayMs 1000                               ' Delay for 1 second.
   Loop Again                                    ' Repeat forever
```

Serin Modifiers.

The **Serin** command can be configured to wait for a specified sequence of characters before it retrieves any additional input. For example, suppose a device attached to the PICmicro™ is known to send many different sequences of data, but the only data you wish to observe happens to appear right after the unique characters, "XYZ". A modifier named **Wait** can be used for this purpose: -

```
   Serin PORTA.0, 16468, [Wait("XYZ"), SerData]
```

The above code waits for the characters "X", "Y" and "Z" to be received, in that order, then it receives the next data byte and p[laces it into variable SerData.

The compiler also has a modifier for handling a string of characters, named **Str**.

The **Str** modifier is used for receiving a string of characters into a byte array variable.

A string is a set of characters that are arranged or accessed in a certain order. The characters "ABC" would be stored in a string with the "A" first, followed by the "B" then followed by the "C". A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string "ABC" would be stored in a byte array containing three bytes (elements).

Below is an example that receives ten bytes through bit-0 of PORTA at 9600 bps, N81/inverted, and stores them in the 10-byte array, SerString: -

```
Dim SerString[10] as Byte              ' Create a 10-byte array.
Serin PORTA.0, 16468, [Str SerString]  ' Fill the array with data.
Print Str SerString                    ' Display the string.
```

If the amount of received characters is not enough to fill the entire array, then a formatter may be placed after the array's name, which will only receive characters until the specified length is reached. For example: -

```
Dim SerString[10] as Byte                ' Create a 10-byte array.
Serin PORTA.0, 16468, [Str SerString\5]  ' Fill first 5-bytes of array
Print Str SerString\5                     ' Display the 5-character string.
```

The example above illustrates how to fill only the first *n* bytes of an array, and then how to display only the first *n* bytes of the array. *n* refers to the value placed after the backslash.

Because of its complexity, serial communication can be rather difficult to work with at times. Using the guidelines below when developing a project using the **Serin** and **Serout** commands may help to eliminate some obvious errors: -

Always build your project in steps.
Start with small, manageable pieces of code, (that deal with serial communication) and test them, one individually.
Add more and more small pieces, testing them each time, as you go.
Never write a large portion of code that works with serial communication without testing its smallest workable pieces first.
Pay attention to timing.
Be careful to calculate and overestimate the amount of time, operations should take within the microcontroller for a given oscillator frequency. Misunderstanding the timing constraints is the source of most problems with code that communicate serially. If the serial communication in your project is bi-directional, the above statement is even more critical.
Pay attention to wiring.
Take extra time to study and verify serial communication wiring diagrams. A mistake in wiring can cause strange problems in communication, or no communication at all. Make sure to connect the ground pins (Vss) between the devices that are communicating serially.
Verify port setting on the PC and in the Serin / Serout commands.
Unmatched settings on the sender and receiver side will cause garbled data transfers or no data transfers. This is never more critical than when a line transceiver is used(i.e. MAX232). Always remember that a line transceiver inverts the serial polarity.

If the serial data received is unreadable, it is most likely caused by a baud rate setting error, or a polarity error. If receiving data from another device that is not a PICmicro™, try to use baud rates of 9600 and below, or alternatively, use a higher frequency crystal.

Because of additional overheads in the microcontroller, and the fact that the **Serin** command offers no hardware receive buffer for serial communication, received data may sometimes be missed or garbled. If this occurs, try lowering the baud rate, or increasing the crystal frequency. Using simple variables (not arrays) will also increase the chance that the device will receive the data properly.

See also :   Hrsin, Hrsout, Hserin, Hserout, Rsin, Rsout.

Serout

Syntax
Serout *Tpin* { **** *Fpin* }, *Baudmode*, { *Pace*, } { *Timeout, Tlabel*, } **[** OutputData **]**

Overview
Transmit asynchronous serial data (i.e. RS232 data).

Parameters
Tpin is a Port.Bit constant that specifies the I/O pin through which the serial data will be transmitted. This pin will be set to output mode while operating. The state of this pin when finished is determined by the driver bit in *Baudmode*.

Fpin is an optional Port.Bit constant that specifies the I/O pin to monitor for flow control status. This pin will be set to input mode. Note: *Fpin* must be specified in order to use the optional *Timeout* and *Tlabel* operators in the **Serout** command.

Baudmode may be a variable, constant, or expression (0 - 65535) that specifies serial timing and configuration.

Pace is an optional variable, constant, or expression (0 - 65535) that determines the length of the delay between transmitted bytes. Note: *Pace* cannot be used simultaneously with *Timeout*.

Timeout is an optional variable or constant (0 - 65535) that informs **Serout** how long to wait for *Fpin* permission to send. If permission does not arrive in time, the program will jump to the address specified by *Tlable*. Note: *Fpin* must be specified in order to use the optional *Timeout* and *Tlabel* operators in the **Serout** command.

Tlabel is an optional label that must be provided along with *Timeout. Tlabel* indicates where the program should jump to in the event that permission to send data is not granted within the period specified by *Timeout*.

OutputData is list of variables, constants, expressions and modifiers that informs **Serout** how to format outgoing data. **Serout** can transmit individual or repeating bytes, convert values into decimal, hex or binary text representations, or transmit strings of bytes from variable arrays, and **Cdata** constructs. These actions can be combined in any order in the *OutputData* list.

Notes
One of the most popular forms of communication between electronic devices is serial communication. There are two major types of serial communication; asynchronous and synchronous. The **Rsin**, **Rsout**, **Serin** and **Serout** commands are all used to send and receive asynchronous serial data. While the **Shin** and **Shout** commands are for use with synchronous communications.

The term asynchronous means 'no clock.' More specifically, 'asynchronous serial communication' means data is transmitted and received without the use of a separate 'clock' line. Data can be sent using as few as two wires; one for data and one for ground. The PC's serial ports (also called COM ports or RS232 ports) use asynchronous serial communication. Note: the other kind of serial communication, synchronous, uses at least three wires; one for clock, one for data and one for ground.

RS232 is the electrical specification for the signals that PC serial ports use. Unlike standard TTL logic, where 5 volts is a logic 1 and 0 volts is logic 0, RS232 uses -12 volts for logic 1 and +12 volts for logic 0. This specification allows communication over longer wire lengths without amplification.

Most circuits that work with RS232 use a line driver / receiver (transceiver). This component does two things: -

   Convert the ±12 volts of RS-232 to TTL compatible 0 to 5 volt levels.
   Invert the voltage levels, so that 5 volts = logic 1 and 0 volts = logic 0.

By far, the most common line driver device is the MAX232 from MAXIM semiconductor. With the addition of a few capacitors, a complete 2-way level converter is realised (see **Serin** for circuit).

The MAX232 is not the only device available, there are other types that do not require any external capacitors at all. Visit Maxim's excellent web site at **www.maxim.com <http://www.maxim.com>**, and download one of their many detailed datasheets.

Because of the excellent IO capabilities of the PICmicro™ range of devices, and the adoption of TTL levels on most modern PC serial ports, a line driver is often unnecessary unless long distances are involved between the transmitter and the receiver. Instead a simple current limiting resistor is all that's required (see **Serin** for circuit).

You should remember that when using a line transceiver such as the MAX232, the serial mode (polarity) is inverted in the process of converting the signal levels, however, if using the direct connection, the mode is untouched. This is the single most common cause of errors when connecting serial devices, therefore you must make allowances for this within your software.

Asynchronous serial communication relies on precise timing. Both the sender and receiver must be set for identical timing, this is commonly expressed in bits per second (bps) called baud. **Serout** requires a value called *Baudmode* that informs it of the relevant characteristics of the incoming serial data; the bit period, number of data and parity bits, and polarity.

The *Baudmode* argument for **Serout** accepts a 16-bit value that determines its characteristics: 1-stop bit, 8-data bits/no-parity or 7-data bits/even-parity and virtually any speed from as low as 300 baud to 38400 baud (depending on the crystal frequency used). Table 2 below shows how *Baudmode* is calculated, while table 3 shows some common *baudmodes* for standard serial baud rates.

Step 1.	Determine the bit period. (bits 0 – 11)	(1,000,000 / baud rate) – 20
Step 2.	data bits and parity. (bit 13)	8-bit/no-parity = step 1 + 0 7-bit/even-parity = step 1 + 8192
Step 3.	Select polarity. (bit 14)	True (noninverted) = step 2 + 0 Inverted = step 2 + 16384

Baudmode calculation.

Add the results of steps 1, 2 3, and 3 to determine the correct value for the *Baudmode* operator

BaudRate	8-bit no-parity inverted	8-bit no-parity true	7-bit even-parity inverted	7-bit even-parity true
300	19697	3313	27889	11505
600	18030	1646	26222	9838
1200	17197	813	25389	9005
2400	16780	396	24972	8588
4800	16572	188	24764	8380
9600	16468	84	24660	8276

Note

For 'open' baudmodes used in networking, add 32768 to the values from the previous table.

If communications are with existing software or hardware, its speed and mode will determine the choice of baud rate and mode. In general, 7-bit/even-parity (7E) mode is used for text, and 8-bit/no-parity (8N) for byte-oriented data. Note: the most common mode is 8-bit/no-parity, even when the data transmitted is just text. Most devices that use a 7-bit data mode do so in order to take advantage of the parity feature. Parity can detect some communication errors, but to use it you lose one data bit. This means that incoming data bytes transferred in 7E (even-parity) mode can only represent values from 0 to 127, rather than the 0 to 255 of 8N (no-parity) mode.

The compiler's serial commands **Serout** and **Serin**, have the option of still using a parity bit with 4 to 8 data bits. This is through the use of a **Declare**: -

With parity disabled (the default setting): -

```
Declare Serial_Data 4   ' Set Serout and Serin data bits to 4
Declare Serial_Data 5   ' Set Serout and Serin data bits to 5
Declare Serial_Data 6   ' Set Serout and Serin data bits to 6
Declare Serial_Data 7   ' Set Serout and Serin data bits to 7
Declare Serial_Data 8   ' Set Serout and Serin data bits to 8 (default)
```

With parity enabled: -

```
Declare Serial_Data 5   ' Set Serout and Serin data bits to 4
Declare Serial_Data 6   ' Set Serout and Serin data bits to 5
Declare Serial_Data 7   ' Set Serout and Serin data bits to 6
Declare Serial_Data 8   ' Set Serout and Serin data bits to 7 (default)
Declare Serial_Data 9   ' Set Serout and Serin data bits to 8
```

Serial_Data data bits may range from 4 bits to 8 (the default if no **Declare** is issued). Enabling parity uses one of the number of bits specified.

Declaring **Serial_Data** as 9 allows 8 bits to be read and written along with a 9th parity bit.

Parity is a simple error-checking feature. When the **Serout** command's *Baudmode* is set for even parity (compiler default) it counts the number of 1s in the outgoing byte and uses the parity bit to make that number even. For example, if it is sending the 7-bit value: %0011010, it sets the parity bit to 1 in order to make an even number of 1s (four).

The receiver also counts the data bits to calculate what the parity bit should be. If it matches the parity bit received, the serial receiver assumes that the data was received correctly. Of course, this is not necessarily true, since two incorrectly received bits could make parity seem correct when the data was wrong, or the parity bit itself could be bad when the rest of the data was correct. Parity errors are only detected on the receiver side.

Normally, the receiver determines how to handle an error. In a more robust application, the receiver and transmitter might be set up in such that the receiver can request a re-send of data that was received with a parity error.

Serout Modifiers.

The example below will transmit a single byte through bit-0 of PORTA at 2400 baud, 8N1, inverted: -

```
Serout PORTA.0, 16780, [65]
```

In the above example, **Serout** will transmit a byte equal to 65 (the ASCII value of the character "A") through PORTA.0. If the PICmicro™ was connected to a PC running a terminal program such as HyperTerminal set to the same baud rate, the character "A" would appear on the screen. Always remembering that the polarity will differ if a line transceiver such as the MAX232 is used.

What if you wanted the value 65 to appear on the PC's screen? As was stated earlier, it is up to the receiving side (in serial communication) to interpret the values. In this case, the PC is interpreting the byte-sized value to be the ASCII code for the character "A". Unless you're also writing the software for the PC, you cannot change how the PC interprets the incoming serial data, therefore to solve this problem, the data needs to be translated before it is sent.

The **Serout** command provides a modifier which will translate the value 65 into two ASCII codes for the characters "6" and "5" and then transmit them: -

```
Serout PORTA.0, 16780, [@ 65]
```

or

```
Serout PORTA.0, 16780, [Dec 65]
```

Notice that the decimal modifier in the **Serout** command is the character @ or word **Dec**, both these modifiers do the same thing, which is to inform **Serout** to convert the number into separate ASCII characters which represent the value in decimal form. If the value 65 in the code were changed to 123, the **Serout** command would send three bytes (49, 50 and 51) corresponding to the characters "1", "2" and "3".

This is exactly the same modifier that is used in the **Rsout** and **Print** commands.

As well as the **Dec** modifier, **Serout** may use **Hex**, or **Bin** modifiers, again, these are the same as used in the **Rsout** and **Print** commands. Therefore, please refer to the **Rsout** or **Print** command descriptions for an explanation of these. The **Serout** command sends quoted text exactly as it appears in the *OutputData* list:

```
Serout PORTA.0, 16780, ["HELLO WORLD", 13]
Serout PORTA.0, 16780, ["Num = ", Dec 100]
```

The above code will display "HELLO WORLD" on one line and "Num = 100" on the next line. Notice that you can combine data to output in one **Serout** command, separated by commas. In the example above, we could have written it as one line of code: -

```
Serout PORTA.0, 16780, ["HELLO WORLD", 13, "Num = ", Dec 100]
```

Serout also has some other modifiers. These are listed below: -

Modifier	Operation
At ypos,xpos	Position the cursor on a serial LCD
Cls	Clear a serial LCD (also creates a 30ms delay)
Bin{1..32}	Send binary digits
Dec{0..10}	Send decimal digits (amount of digits after decimal point with floating point)
Hex{1..8}	Send hexadecimal digits
Sbin{1..32}	Send signed binary digits
Sdec{0..10}	Send signed decimal digits
Shex{1..8}	Send signed hexadecimal digits
Ibin{1..32}	Send binary digits with a preceding '%' identifier
Idec{0..10}	Send decimal digits with a preceding '#' identifier
Ihex{1..8}	Send hexadecimal digits with a preceding '$' identifier
ISbin{1..32}	Send signed binary digits with a preceding '%' identifier
ISdec{0..10}	Send signed decimal digits with a preceding '#' identifier
IShex{1..8}	Send signed hexadecimal digits with a preceding '$' identifier
Rep c\n	Send character c repeated n times

If a floating point variable is to be displayed, then the digits after the **Dec** modifier determine how many remainder digits are printed. i.e. numbers after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.145
Serout PORTA.0, 16780, [Dec2 MyFloat]' Send 2 values after decimal point
```

The above program will send 3.14

If the digit after the **Dec** modifier is omitted, then 3 values will be displayed after the decimal point.

```
Dim MyFloat as Float
MyFloat = 3.1456
Serout PORTA.0, 16780, [Dec MyFloat]     ' Send 3 values after decimal point
```

The above program will send 3.145

There is no need to use the **Sdec** modifier for signed floating point values, as the compiler's **Dec** modifier will automatically display a minus result: -

```
Dim MyFloat as Float
MyFloat = -3.1456
Serout PORTA.0, 16780, [Dec MyFloat]     ' Send 3 values after decimal point
```

The above program will send -3.145

Hex or **Bin** modifiers cannot be used with floating point values or variables.

Using Strings with Serout.

The **Str** modifier is used for transmitting a string of characters from a byte array variable. A string is a set of characters that are arranged or accessed in a certain order. The characters "ABC" would be stored in a string with the "A" first, followed by the "B" then followed by the "C". A byte array is a similar concept to a string; it contains data that is arranged in a certain order. Each of the elements in an array is the same size. The string "ABC" would be stored in a byte array containing three bytes (elements).

Below is an example that transmits five bytes (from a byte array) through bit-0 of PORTA at 9600 bps, N81/inverted: -

```
Dim SerString[10] as Byte        ' Create a 10-byte array.
SerString[0] = "H"               ' Load the first 5 bytes of the array
SerString[1] = "E"               ' With the word "HELLO"
SerString[2] = "L"
SerString[3] = "L"
SerString[4] = "O"
Serout PORTA.0, 16468, [Str SerString\5]   ' Send 5-byte string.
```

Note that we use the optional \n argument of **Str**. If we didn't specify this, the PICmicro™ would try to keep sending characters until all 10 bytes of the array were transmitted, or it found a byte equal to 0 (a null terminator). Since we didn't specify a last byte of 0 in the array, and we do not wish the last five bytes to be transmitted, we chose to tell it explicitly to only send the first 5 characters.

The above example may also be written as: -

```
Dim SerString[10] as Byte                ' Create a 10-byte array.
Str SerString = "HELLO", 0               ' Load the first 6 bytes of the array
Serout PORTA.0, 16468, [Str SerString]   ' Send first 5-bytes of string.
```

In the above example, we specifically added a null terminator to the end of the string (a zero). Therefore, the **Str** modifier within the **Serout** command will output data until this is reached. An alternative to this would be to create the array exactly the size of the text. In our example, the array would have been 5 elements in length.

Another form of string is used by the **Cstr** modifier. Note: Because this uses the **Cdata** command to create the individual elements it is only for use with PICs that support self-modifying features, such as the 16F87X, and 18XXXX range of devices.

Below is an example of using the **Cstr** modifier. Its function is the same as the above examples, however, no RAM is used for creating arrays.

```
Serout PORTA.0, 16468, [Cstr SerString]
```

```
SerString: Cdata "HELLO", 0
```

The **Cstr** modifier will always be terminated by a null (i.e. zero at the end of the text or data). If the null is omitted, then the **Serout** command will continue transmitting characters forever.

The **Serout** command can also be configured to pause between transmitted bytes. This is the purpose of the optional *Pace* operator. For example (9600 baud N8, inverted): -

```
Serout PORTA.0, 16468, 1000, ["Send this message Slowly"]
```

Here, the PICmicro™ transmits the message "Send this message Slowly" with a 1 second delay between each character.

A good reason to use the *Pace* feature is to support devices that require more than one stop bit. Normally, the PICmicro™ sends data as fast as it can (with a minimum of 1 stop bit between bytes). Since a stop bit is really just a resting state in the line (no data transmitted), using the *Pace* option will effectively add multiple stop bits. Since the requirement for 2 or more stop bits (on some devices) is really just a minimum requirement, the receiving side should receive this data correctly.

Serout Flow Control.

When designing an application that requires serial communication between PICs, you need to work within these limitations: -

When the PICmicro™ is sending or receiving data, it cannot execute other instructions.
When the PICmicro™ is executing other instructions, it cannot send or receive data.
The compiler does not offer a serial buffer as there is in PCs. At lower crystal frequencies, and higher serial rates, the PICmicro™ cannot receive data via **Serin**, process it, and execute another **Serin** in time to catch the next chunk of data, unless there are significant pauses between data transmissions.

These limitations can sometimes be addressed by using flow control; the *Fpin* option for **Serout** and **Serin**. Through *Fpin*, **Serin** can inform another PICmicro™ sender when it is ready to receive data and **Serout** (on the sender) will wait for permission to send. *Fpin* flow control follows the rules of other serial handshaking schemes, however most computers other than the PICmicro™ cannot start and stop serial transmission on a byte-by-byte basis. That is why this discussion is limited to communication between PICmicros.

Below is an example using flow control with data through bit-0 of PORTA, and flow control through bit-1 of PORTA, 9600 baud, N8, noninverted: -

```
Serout PORTA.0\PORTA.1, 84, [SerData]
```

When Serin executes, bit-0 of PORTA *(Tpin)* is made an output in preparation for sending data, and bit-1 of PORTA *(Fpin)* is made an input, to wait for the "go" signal from the receiver. The table below illustrates the relationship of serial polarity to *Fpin* states.

Serial Polarity	Ready to Receive ("Go")	Not Ready to Receive ("Stop")
Inverted	*Fpin* is High (1)	*Fpin* is Low (0)
Non-inverted	*Fpin* is Low (0)	*Fpin* is High (1)

See **Serin** for a flow control circuit.

The **Serout** command supports open-drain and open-source output, which makes it possible to network multiple PICs on a single pair of wires. These 'open baudmodes' only actively drive the *Tpin* in one state (for the other state, they simply disconnect the pin; setting it to an input mode). If two PICs in a network had their **Serout** lines connected together (while a third device listened on that line) and the PICs were using always-driven baudmodes, they could simultaneously output two opposite states (i.e. +5 volts and ground). This would create a short circuit. The heavy current flow would likely damage the I/O pins or the PICs themselves.

Since the open baudmodes only drive in one state and float in the other, there's no chance of this kind of short happening.

The polarity selected for **Serout** determines which state is driven and which is open as shown in the table below.

Serial Polarity	State(0)	State(1)	Resistor Pulled to:
Inverted	Open	Driven	Gnd (Vss)
Non-inverted	Driven	Open	+5V (Vdd)

Since open baudmodes only drive to one state, they need a resistor to pull the networked line into the opposite state, as shown in the above table and in the circuits below. Open baudmodes allow the PICmicro™ to share a line, however it is up to your program to resolve other networking issues such as who talks when, and how to detect, prevent and fix data errors.

See also :   Rsin, Rsout, Hrsin, Hrsout, Hserin, Hserout, Serin.

Servo

Syntax
Servo *Pin*, *Rotation Value*

Overview
Control a remote control type servo motor.

Parameters
Pin is a Port.Pin constant that specifies the I/O pin for the attachment of the motor's control terminal.
Rotation Value is a 16-bit (0-65535) constant or **Word** variable that dictates the position of the motor. A value of approx 500 being a rotation to the farthest position in a direction and approx 2500 being the farthest rotation in the opposite direction. A value of 1500 would normally centre the servo but this depends on the motor type.

Example

```
' Control a servo motor attached to pin 3 of PORTA

  Device = 16F628               ' We'll use a 14-bit core device
  Declare Xtal = 20

  Dim Pos as Word               ' Servo Position
  Symbol Pin = PORTA.3          ' Alias the servo pin

  Cls                           ' Clear the LCD
  Pos = 1500                    ' Centre the servo
  PORTA = 0                     ' PORTA lines low to read buttons
  TRISA = %00000111             ' Enable the button pins as inputs
'
' Check any button pressed to move servo
'
  Do
    If PORTA.0 = 0 And Pos < 3000 Then Pos = Pos + 1  ' Move servo left
    If PORTA.1 = 0 Then Pos = 1500                    ' Centre servo
    If PORTA.2 = 0 And Pos > 0 Then Pos = Pos – 1     ' Move servo right
    Servo Pin, Pos
    DelayMs 5                                         ' Servo update rate
    Print At 1, 1, "Position=", Dec Pos, " "
  Loop
```

Notes
Servos of the sort used in radio-controlled models are finding increasing applications in this robotics age we live in. They simplify the job of moving objects in the real world by eliminating much of the mechanical design. For a given signal input, you get a predictable amount of motion as an output.

To enable a servo to move it must be connected to a 5 Volt power supply capable of delivering an ampere or more of peak current. It then needs to be supplied with a positioning signal. The signal is normally a 5 Volt, positive-going pulse between 1 and 2 milliseconds (ms) long, repeated approximately 50 times per second.

The width of the pulse determines the position of the servo. Since a servo's travel can vary from model to model, there is not a definite correspondence between a given pulse width and a particular servo angle, however most servos will move to the centre of their travel when receiving 1.5ms pulses.

Servos are closed-loop devices. This means that they are constantly comparing their commanded position (proportional to the pulse width) to their actual position (proportional to the resistance of an internal potentiometer mechanically linked to the shaft). If there is more than a small difference between the two, the servo's electronics will turn on the motor to eliminate the error. In addition to moving in response to changing input signals, this active error correction means that servos will resist mechanical forces that try to move them away from a commanded position. When the servo is unpowered or not receiving positioning pulses, the output shaft may be easily turned by hand. However, when the servo is powered and receiving signals, it won't move from its position.

Driving servos with Proton is extremely easy. The **Servo** command generates a pulse in 1microsecond (µs) units, so the following code would command a servo to its centred position and hold it there: -

```
Do
   Servo PORTA.0, 1500
   DelayMs 20
Loop
```

The 20ms delay ensures that the program sends the pulse at the standard 50 pulse-per-second rate. However, this may be lengthened or shortened depending on individual motor characteristics.

The **Servo** command is oscillator independent and will always produce 1us pulses regardless of the crystal frequency used.

See also :   Pulseout.

SetBit

Syntax
SetBit *Variable, Index*

Overview
Set a bit of a variable or register using a variable index to the bit of interest.

Parameters
Variable is a user defined variable, of type **Byte**, **Word**, or **Dword**.
Index is a constant, variable, or expression that points to the bit within *Variable* that requires setting.

Example
```
' Clear then Set each bit of variable ExVar
  Device = 16F1829
  Declare Xtal = 4
  Dim ExVar as Byte
  Dim Index as Byte

  Cls
  ExVar = %11111111
  Do
    For Index = 0 to 7              ' Create a loop for 8 bits
      ClearBit ExVar,Index         ' Clear each bit of ExVar
      Print At 1,1,Bin8 ExVar      ' Display the binary result
      DelayMs 100                  ' Slow things down to see what's happening
    Next                           ' Close the loop
    For Index = 7 to 0 Step -1     ' Create a loop for 8 bits
      SetBit ExVar,Index           ' Set each bit of ExVar
      Print At 1,1,Bin8 ExVar      ' Display the binary result
      DelayMs 100                  ' Slow things down to see what's happening
    Next                           ' Close the loop
  Loop                             ' Do it forever
```

Notes
There are many ways to set a bit within a variable, however, each method requires a certain amount of manipulation, either with rotates, or alternatively, the use of indirect addressing using the FSR, and INDF registers. Each method has its merits, but requires a certain amount of knowledge to accomplish the task correctly. The **SetBit** command makes this task extremely simple using a register rotate method, however, this is not necessarily the quickest method, or the smallest, but it is the easiest. For speed and size optimisation, there is no shortcut to experience.

To Set a known constant bit of a variable or register, then access the bit directly using Port.n.

```
      PORTA.1 = 1
```
or
```
      Var1.4 = 1
```

If a Port is targeted by **SetBit**, the Tris register is **not** affected.

See also : ClearBit, GetBit, LoadBit.

SetPin

Syntax
SetPin *Pin Number*

Overview
Sets a Port's pin high using a variable as the pin's number, but does not make it an output.

Operands
Pin Number can be a variable or constant or expression that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example
```
' Clear then Set each pin of PORTB
  Device = 18F25K20
  Declare Xtal = 16

  Dim PinNumber as Byte

  High PORTB                      ' Make PORTB output high before we start
  Do                              ' Create a loop
    For PinNumber = 8 to 15       ' Create a loop for 8 pins
      ClearPin PinNumber          ' Clear each pin of PORTB
      DelayMs 100                 ' Slow things down to see what's happening
    Next                          ' Close the loop
    For PinNumber = 8 to 15       ' Create a loop for 8 pins
      SetPin PinNumber            ' Set each pin of PORTB
      DelayMs 100                 ' Slow things down to see what's happening
    Next                          ' Close the loop
  Loop                            ' Do it forever
```

Notes.
There are many ways to set a pin of an I/O port, however, each method requires a certain amount of manipulation, either with rotates, or alternatively, the use of indirect addressing. Each method has its merits, but requires a certain amount of knowledge to accomplish the task correctly. The **SetPin** command makes this task extremely simple using a variable as the pin number, however, this is not necessarily the quickest method, or the smallest, but it is the easiest. For speed and size optimisation, there is no shortcut to experience.

To set a known constant pin number of a port, access the pin directly using the **High** command

```
  High PORTA.1
```

Each pin number has a designated name. These are Pin_A0, Pin_A1, Pin_A2, Pin_B0…Pin_B7, Pin_C0…Pin_C7, Pin_D0…Pin_D7 to Pin_L7 etc… Each of the names has a relevant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber As Byte            ' Holds the pin number to set high and low

   Do                               ' Create an infinite loop
      PinNumber = Pin_B0            ' Give the pin number to flash (PORTB.0)
      Gosub FlashPin                ' Call the subroutine to flash the pin
      PinNumber = Pin_B1            ' Give the pin number to flash (PORTB.1)
      Gosub FlashPin                ' Call the subroutine to flash the pin
   Loop                             ' Do it forever
'
' Make a pin high then low for 500ms using a variable as the pin to adjust
'
FlashPin:
   Output PinNumber                 ' Make the pin an output
   SetPin PinNumber                 ' Bring the pin high
   DelayMs 500                      ' Wait for 500 milliseconds
   ClearPin PinNumber               ' Bring the pin low
   DelayMs 500                      ' Wait for 500 milliseconds
   Return
```

Example 2

```
' Clear then Set each pin of PORTC
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber as Byte

   High PORTC                          ' Make PORTC output high before we start
   Do                                  ' Create a loop
      For PinNumber = Pin_C0 to Pin_C7 ' Create a loop for 8 pins
         ClearPin PinNumber            ' Clear each pin of PORTC
         DelayMs 100                   ' Slow things down to see what's happening
      Next                             ' Close the loop
      For PinNumber = Pin_C0 to Pin_C7 ' Create a loop for 8 pins
         SetPin PinNumber              ' Set each pin of PORTC
         DelayMs 100                   ' Slow things down to see what's happening
      Next                             ' Close the loop
   Loop                                ' Do it forever
```

See also :   ClearPin, Low, High.

Set_OSCCAL

Syntax
Set_OSCCAL

Overview
Calibrate the on-chip oscillator found on some PICmicro™ devices.

Notes
Some devices, such as the PIC12C67x or 16F62x range, have on-chip RC oscillators. These devices contain an oscillator calibration factor in the last location of code space. The on-chip oscillator may be fine-tuned by reading the data from this location and moving it into the OSC-CAL register. The command **Set_OSCCAL** has been specially created to perform this task automatically each time the program starts: -

```
Device = 12C671
Set_OSCCAL     ' Set OSCCAL for 1K device 12C671
```

Add this command near the beginning of the program to perform the setting of OSCCAL.

If a UV erasable (windowed) device has been erased, the value cannot be read from memory. To set the OSCCAL register on an erased part, add the following line near the beginning of the program: -

```
OSCCAL = $C0   ' Set OSCCAL register to $C0
```

The value $C0 is only an example. The part would need to be read before it is erased to obtain the actual OSCCAL value for that particular device.

Always refer to the device's data sheet for more information on OSCCAL.

Set

Syntax
Set *Variable* or *Variable.Bit* or *Pin Number*

Overview
Place a variable or bit in a high state. For a variable, this means setting all the bits to 1. For a bit this means setting it to 1.

Parameters
Variable can be any variable or register.
Variable.Bit can be any variable and bit combination.
Pin Number can be a variable or constant that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example 1
```
Set Var1.3        ' Set bit 3 of Var1
Set Var1          ' Load Var1 with the value of 255
Set STATUS.0      ' Set the carry flag high
Set Array         ' Set all of an Array variable. i.e. set to 255 or 65535
Set String1       ' Set all of a String variable. i.e. set to spaces (ASCII 32)
Set               ' Load all RAM with 255
Set 0             ' Set PORTA.0.
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim MyPin as Byte

   Low PORTA
   Low PORTB
   For MyPin = 0 to 15       ' Create a loop for the pin to flash
     Set MyPin               ' Set the pin
     DelayMs 500             ' Delay so that it can be seen
     Clear MyPin             ' Clear the pin
     DelayMs 500             ' Delay so that it can be seen
   Next
```

Notes
Set does not alter the TRIS register if a Port is targeted.
If no variable follows the **Set** command then all user RAM will be loaded with the value 255.

See also :   Clear, High, Low.

Shin

Syntax
Shin *Data_Pin, Clk_Pin*, *mode,* **[** *result { \bits } { ,result { \bits }...}* **]**

or

Var = **Shin** *Data_Pin, Clk_Pin*, *mode, shifts*

Overview
Shift data in from a synchronous-serial device. i.e. SPI.

Parameters
Data_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the synchro-nous-serial device's data output. This pin's I/O direction will be changed to input and will remain in that state after the instruction is completed.
Clk_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the synchronous-serial device's clock input. This pin's I/O direction will be changed to output.
Mode is a constant that tells **Shin** the order in which data bits are to be arranged and the rela-tionship of clock pulses to valid data. Below are the symbols, values, and their meanings: -

Symbol	Value	Description
MsbPre MsbPre_L	0	Shift data in highest bit first. Read data before sending clock. Clock idles low
LsbPre LsbPre_L	1	Shift data in lowest bit first. Read data before sending clock. Clock idles low
MsbPost MsbPost_L	2	Shift data in highest bit first. Read data after sending clock. Clock idles low
LsbPost LsbPost_L	3	Shift data in highest bit first. Read data after sending clock. Clock idles low
MsbPre_H	4	Shift data in highest bit first. Read data before sending clock. Clock idles high
LsbPre_H	5	Shift data in lowest bit first. Read data before sending clock. Clock idles high
MsbPost_H	6	Shift data in highest bit first. Read data after sending clock. Clock idles high
LsbPost_H	7	Shift data in lowest bit first. Read data after sending clock. Clock idles high

Result is a bit, byte, or word variable in which incoming data bits will be stored.
Bits is an optional constant specifying how many bits (1-16) are to be input by **Shin**. If no *bits* entry is given, **Shin** defaults to 8 bits.
Shifts informs the **Shin** command as to how many bit to shift in to the assignment variable, when used in the inline format.

Notes
Shin provides a method of acquiring data from synchronous-serial devices, without resorting to the hardware SPI modules resident on some PICmicro™ types. Data bits may be valid after the rising or falling edge of the clock line. This kind of serial protocol is commonly used by control-ler peripherals such as ADCs, DACs, clocks, memory devices, etc.

The **Shin** instruction causes the following sequence of events to occur: -

Makes the clock pin (cpin) output low.
Makes the data pin (dpin) an input.
Copies the state of the data bit into the msb (lsb-modes) or lsb (msb modes) either before (-pre modes) or after (-post modes) the clock pulse.
Pulses the clock pin high.
Shifts the bits of the result left (msb- modes) or right (lsb-modes).
Repeats the appropriate sequence of getting data bits, pulsing the clock pin, and shifting the result until the specified number of bits is shifted into the variable.

Making **Shin** work with a particular device is a matter of matching the mode and number of bits to that device's protocol. Most manufacturers use a timing diagram to illustrate the relationship of clock and data.

```
Symbol CLK = PORTB.0
Symbol DTA = PORTB.1
Shin DTA, CLK, MsbPre, [Var1]     ' Shift in msb-first, pre-clock.
```

In the above example, both **Shin** instructions are set up for msb-first operation, so the first bit they acquire ends up in the msb (leftmost bit) of the variable.

The post-clock Shift in, acquires its bits after each clock pulse. The initial pulse changes the data line from 1 to 0, so the post-clock Shiftin returns %01010101.

By default, **Shin** acquires eight bits, but you can set it to shift any number of bits from 1 to 16 with an optional entry following the variable name. In the example above, substitute this for the first **Shin** instruction: -

```
Shin DTA, CLK, MsbPre, [Var1\4] ' Shift in 4 bits.
```

Some devices return more than 16 bits. For example, most 8-bit shift registers can be daisy-chained together to form any multiple of 8 bits; 16, 24, 32, 40... You can use a single **Shin** instruction with multiple variables.
Each variable can be assigned a particular number of bits with the
backslash (\) option. Modify the previous example: -

```
' 5 bits into Var1; 8 bits into Var2.
   Shin DTA, CLK, MsbPre, [Var1\5, Var2]
   Print "1st variable: ", Bin8 Var1
   Print "2nd variable: ", Bin8 Var2
```

Inline Shin Command.
The structure of the inline **Shin** command is: -

Var = **Shin** *dpin, cpin, mode, shifts*

DPin, *CPin*, and *Mode* have not changed in any way, however, the INLINE structure has a new operand, namely *Shifts*. This informs the **Shin** command as to how many bit to shift in to the assignment variable. For example, to shift in an 8-bit value from a serial device, we would use:

```
Var1 = Shin DTA, CLK, MsbPre, 8
```

To shift 16-bits into a **Word** variable: -

```
Wrd = Shin DTA, CLK, MsbPre, 16
```

Shout

Syntax
Shout *Data_Pin, Clk_Pin*, *Mode*, **[***OutputData* {*Bits*} {,*OutputData* {*Bits*}..} **]**

Overview
Shift data out to a synchronous serial device. i.e. SPI.

Parameters
Data_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the synchronous serial device's data input. This pin will be set to output mode.
Clk_Pin is a Port.Pin value that specifies the I/O pin that will be connected to the synchronous serial device's clock input. This pin will be set to output mode.
Mode is a constant that tells **Shout** the order in which data bits are to be arranged. Below are the symbols, values, and their meanings: -

Symbol	Value	Description
LsbFirst **LsbFirst _L**	0	Shift data out lowest bit first. Clock idles low
MsbFirst **MsbFirst_L**	1	Shift data out highest bit first. Clock idles low
LsbFirst _H	4	Shift data out lowest bit first. Clock idles high
MsbFirst_H	5	Shift data out highest bit first. Clock idles high

OutputData is a variable, constant, or expression containing the data to be sent.
Bits is an optional constant specifying how many bits are to be output by **Shout**. If no *Bits* entry is given, **Shout** defaults to 8 bits.

Notes
Shin and **Shout** provide a method of acquiring data from synchronous serial devices. Data bits may be valid after the rising or falling edge of the clock line. This kind of serial protocol is commonly used by controller peripherals like ADCs, DACs, clocks, memory devices, etc.

At their heart, synchronous-serial devices are essentially shift-registers; trains of flip flops that receive data bits in a bucket brigade fashion from a single data input pin. Another bit is input each time the appropriate edge (rising or falling, depending on the device) appears on the clock line.

The **Shout** instruction first causes the clock pin to output low and the data pin to switch to output mode. Then, **Shout** sets the data pin to the next bit state to be output and generates a clock pulse. **Shout** continues to generate clock pulses and places the next data bit on the data pin for as many data bits as are required for transmission.

Making **Shout** work with a particular device is a matter of matching the mode and number of bits to that device's protocol. Most manufacturers use a timing diagram to illustrate the relationship of clock and data. One of the most important items to look for is which bit of the data should be transmitted first; most significant bit (MSB) or least significant bit (LSB).

Example

```
Shout DTA, CLK, MsbFirst, [250]
```

In the above example, the **Shout** command will write to I/O pin DTA (the *Dpi*n) and will generate a clock signal on I/O CLK (the *Cpi*n). The **Shout** command will generate eight clock pulses while writing each bit (of the 8-bit value 250) onto the data pin *(Dpi*n). In this case, it will start with the most significant bit first as indicated by the *Mode* value of **MsbFirst**.

By default, **Shout** transmits eight bits, but you can set it to shift any number of bits from 1 to 16 with the *Bits* argument. For example: -

```
Shout DTA, CLK, MsbFirst, [250\4]
```

Will only output the lowest 4 bits (%0000 in this case). Some devices require more than 16 bits. To solve this, you can use a single **Shout** command with multiple values. Each value can be assigned a particular number of bits with the *Bits* argument. As in: -

```
Shout DTA, CLK, MsbFirst, [250\4, 1045\16]
```

The above code will first shift out four bits of the number 250 (%1111) and then 16 bits of the number 1045 (%0000010000010101). The two values together make up a 20 bit value.

See also :   Shin.

Snooze

Syntax
Snooze *Period*

Overview
Enter sleep mode for a short period. Power consumption is reduced to a few µA assuming no loads are being driven.

Parameters
Period is a variable or constant that determines the duration of the reduced power nap. The duration is (2^period) * 18 ms. (Read as "2 raised to the power of 'period', times 18 ms.") Period can range from 0 to 7, resulting in the following snooze lengths: -

Period	Length of Snooze (approx)
0 - 1	18ms
1 - 2	36ms
2 - 4	72ms
3 - 8	144ms
4 - 16	288ms
5 - 32	576ms
6 - 64	1152ms (1.152 seconds)
7 - 128	2304ms (2.304 seconds)

Example

```
Snooze 6     ' Low power mode for approx 1.152 seconds
```

Notes
Snooze intervals are directly controlled by the watchdog timer without compensation. Variations in temperature, supply voltage, and manufacturing tolerance of the device you are using can cause the actual timing to vary by as much as -50% to +100%

See also : **Sleep.**

Sleep

Syntax
Sleep { *Length* }

Overview
Places the microcontroller into low power mode for approx *n* seconds. i.e. power down but leaves the port pins in their previous states.

Parameters
Length is an optional variable or constant (1-65535) that specifies the duration of sleep in seconds. If length is omitted, then the Sleep command is assumed to be the assembler mnemonic, which means the microcontroller will sleep continuously, or until the Watchdog timer wakes it up.

Example
```
Symbol LED = PORTA.0

Do
   High LED          ' Turn LED on.
   DelayMs 1000      ' Wait 1 second.
   Low LED           ' Turn LED off.
   Sleep 60          ' Sleep for 1 minute.
Loop
```

Notes
Sleep will place the device into a low power mode for the specified period of seconds. Period is 16 bits, so delays of up to 65,535 seconds are the limit (a little over 18 hours) **Sleep** uses the Watchdog Timer so it is independent of the oscillator frequency. The smallest units is about 2.3 seconds and may vary depending on specific environmental conditions and the device used.

The **Sleep** command is used to put the microcontroller in a low power mode without resetting the registers. Allowing continual program execution upon waking up from the **Sleep** period.

Waking a 14-bit core dedvice from Sleep
All the PICmicro™ range have the ability to be placed into a low power mode, consuming micro Amps of current.

The command for doing this is **Sleep**. The compiler's **Sleep** command or the assembler's **Sleep** instruction may be used. The compiler's **Sleep** command differs somewhat to the assembler's in that the compiler's version will place the device into low power mode for approx *n* seconds (*where n is a value from 0 to 65535*). The assembler's version still places the device into low power mode, however, it does this forever, or until an internal or external source wakes it. This same source also wakes the device when using the compiler's command.

Many things can wake the device from its sleep, the WatchDog Timer is the main cause and is what the compiler's **Sleep** command uses.

Another method of waking the PICmicro™ is an external one, a change on one of the port pins. We will examine more closely the use of an external source. There are several ways of waking the microcontroller using an external source. One is a change on bits 4..7 of PORTB.

Another is a change on bit-0 of PORTB. We shall first look at the wake up on change of PORTB,bits-4..7.

As its name suggests, any change on these pins either high to low or low to high will wake the device. However, to setup this mode of operation several bits within registers INTCON and OPTION_REG need to be manipulated. One of the first things required is to enable the weak PORTB pull-up resistors. This is accomplished by clearing the RBPU bit of OPTION_REG (*OPTION_REG.7*). If this was not done, then the pins would be floating and random input states would occur waking the microcontroller up prematurely. Although technically we are enabling a form of interrupt, we are not interested in actually running an interrupt handler. Therefore, we must make sure that Global interrupts are disabled, or the device will jump to an interrupt handler every time a change occurs on PORTB. This is done by clearing the GIE bit of INTCON (*INTCON.7*).

The interrupt we are concerned with is the RB port change type. This is enabled by setting the RBIE bit of the INTCON register (*INTCON.3*). All this will do is set a flag whenever a change occurs (*and of course wake up the PICmicro*™). The flag in question is RBIF, which is bit-0 of the INTCON register. For now we are not particularly interested in this flag, however, if global interrupts were enabled, this flag could be examined to see if it was the cause of the interrupt. The RBIF flag is not cleared by hardware so before entering Sleep it should be cleared. It must also be cleared before an interrupt handler is exited.

The **Sleep** command itself is then used. Upon a change of PORTB, bits 4..7 the device will wake up and perform the next instruction (*or command*) after the **Sleep** command was issued. A second external source for waking the device is a pulse applied to PORTB.0. This interrupt is triggered by the edge of the pulse, high to low or low to high. The INTEDG bit of OPTION_REG (*OPTION_REG.6*) determines what type of pulse will trigger the interrupt. If it is set, then a low to high pulse will trigger it, and if it is cleared then a high to low pulse will trigger it.

To allow the PORTB.0 interrupt to wake the PICmicro™ the INTE bit must be set, this is bit-4 of the INTCON register. This will allow the flag INTF (*INTCON.1*) to be set when a pulse with the right edge is sensed. This flag is only of any importance when determining what caused the interrupt. However, it is not cleared by hardware and should be cleared before the Sleep command is used (*or the interrupt handler is exited*). The program below will wake the microcontroller when a change occurs on PORTB, bits 4-7.

```
   Symbol LED = PORTB.0          ' Assign the LED's pin
   Symbol RBIF = INTCON.0        ' PORTB[4..7] Change Interrupt Flag
   Symbol RBIE = INTCON.3        ' PORTB[4..7] Change Interrupt Enable
   Symbol RBPU = OPTION_REG.7    ' PORTB pull-ups
   Symbol GIE = INTCON.7         ' Global interrupt enable/disable

Main:
   GIE = 0                       ' Turn Off global interrupts
   TRISB.4 = 1                   ' Set PORTB.4 as an Input
   RBPU = 0                      ' Enable PORTB Pull-up Resistors
   RBIE = 1                      ' Enable PORTB[4..7] interrupt
Again:
   DelayMs 100
   Low LED                       ' Turn off the LED
   RBIF = 0                      ' Clear the PORTB[4..7] interrupt flag
   Sleep                         ' Put the PICmicro to sleep
   DelayMs 100                   ' When it wakes up, delay for 100ms
   High LED                      ' Then light the LED
   Goto Again                    ' Do it forever
```

SonyIn

Syntax
Variable **= SonyIn**

Overview
Receive Sony SIRC (Sony Infrared Remote Control) data from a predetermined pin. The pin is automatically made an input.

Parameters
Variable - a bit, byte, word, dword, or float variable, that will be loaded by **SonyIn**. The return data from the **SonyIn** command consists of two bytes, the System byte containing the type of remote used. i.e. TV, Video etc, and the Command byte containing the actual button value. The order of the bytes is Command (low byte) then System (high byte). If a byte variable is used to receive data from the infrared sensor then only the Command byte will be received.

Example
```
' Receive Sony SIRC data from an infrared sensor attached to PORTC.0
  Device = 16F1829
  Declare SonyIn_Pin = PORTC.0 ' Choose port.pin for infrared sensor

  Dim SonyIn_Word as Word      ' Create a Word variable to receive the SIRC data
'
' Alias the Command byte to SonyIn_Word low byte
'
  Dim SonyCommand as SonyIn_Word.Lowbyte
'
' Alias the System byte to SonyIn_Word high byte
'
  Dim SonySystem as SonyIn_Word.Highbyte

  Cls                               ' Clear the LCD
  While                             ' Create an infinite loop
    Repeat
      SonyIn_Word = SonyIn          ' Receive a signal from the infrared sensor
    Until SonyCommand <> 255        ' Keep looking until a valid header found
    Print at 1,1,"System  ",Dec SonySystem," "  ' Display the System value
    Print at 2,1,"Command ",Dec SonyCommand," " ' Display the Command value
  Wend
```

There is a single Declare for use with **SonyIn**: -

Declare SonyIn_Pin Port **.** Pin
Assigns the Port and Pin that will be used to input infrared data by the **SonyIn** command. This may be any valid port on the device.

If the Declare is not used in the program, then the default Port and Pin is PORTB.0.

Notes
The **SonyIn** command will return with both Command and System bytes containing 255 if a valid header was not received. The CARRY (STATUS.0) flag will also be set if an invalid header was received. This is an ideal method of determining if the signal received is of the correct type.

SonyIn is oscillator independent as long as the crystal frequency is declared at the top of the program. If no Xtal Declare is used, then **SonyIn** defaults to a 4MHz crystal frequency for its timing.

Sound

Syntax
Sound *Pin*, **[** *Note*,*Duration* {,*Note*,*Duration*...} **]**

Overview
Generates tone and/or white noise on the specified *Pin*. *Pin* is automatically made an output.

Parameters
Pin is a Port.Pin constant that specifies the output pin on the device.
Note can be an 8-bit variable or constant. 0 is silence. *Notes* 1-127 are tones. *Notes* 128-255 are white noise. Tones and white noises are in ascending order (i.e. 1 and 128 are the lowest frequencies, 127 and 255 are the highest). *Note* 1 is approx 78.74Hz and *Note* 127 is approx 10,000Hz.
Duration can be an 8-bit variable or constant that determines how long the *Note* is played in approx 10ms increments.

Example
```
' Star Trek The Next Generation...Theme and ship take-off
  Device = 16F1829
  Declare Xtal = 4

  Dim MyLoop as Byte
  Symbol Pin = PORTB.0

  Do
    Sound Pin,[50,60,70,20,85,120,83,40,70,20,50,20,70,20,90,120,90,20,98,160]
    DelayMs 500
    For MyLoop = 128 to 255     ' Ascending white noises
      Sound Pin, [MyLoop,2]     ' For warp drive sound
    Next
    Sound Pin, [43,80,63,20,77,20,71,80,51,20,_
                90,20,85,140,77,20,80,20,85,20,_
                90,20,80,20,85,60,90,60,92,60,87,_
                60,96,70,0,10,96,10,0,10,96,10,0,_
                10,96,30,0,10,92,30,0,10,87,30,0,_
                10,96,40,0,20,63,10,0,10,63,10,0,_
                10,63,10,0,10,63,20]
    DelayMs 10000
  Loop
```

Notes
With the excellent I/O characteristics of the PICmicro™, a speaker can be driven through a capacitor directly from the pin of the microcontroller. The value of the capacitor should be determined based on the frequencies of interest and the speaker load. Piezo speakers can be driven directly.

See also :   Freqout, DTMFout, Sound2.

Sound2

Syntax
Sound2 *Pin2*, *Pin2*, **[** *Note1\Note2\Duration {,Note1,Note2\Duration...}* **]**

Overview
Generate specific notes on each of the two defined pins. With the **Sound2** command more complex notes can be played by the microcontroller.

Parameters
Pin1 and Pin2 are Port.Pin constants that specify the output pins on the PICmicro™.
Note is a variable or constant specifying frequency in Hertz (Hz, 0 to 16000) of the tones.
Duration can be a variable or constant that determines how long the *Notes* are played. In approx 1ms increments (0 to 65535).

Example 1
```
' Generate a 2500Hz tone and a 3500Hz tone for 1 second.
' The 2500Hz note is played from the first pin specified (PORTB.0),
' and the 3500Hz note is played from the second pin specified (PORTB.1).
  Device = 16F1829
  Declare Xtal = 20
  Symbol Pin1 = PORTB.0
  Symbol Pin2 = PORTB.1
  Sound2 Pin1, Pin2, [2500\3500\1000]
  Stop
```

Example 2
```
' Play two sets of notes 2500Hz and 3500Hz for 1 second
' and the second two notes, 2500Hz and 3500Hz for 2 seconds.
  Device = 16F1829
  Declare Xtal = 20
  Symbol Pin1 = PORTB.0
  Symbol Pin2 = PORTB.1
  Sound2 Pin1, Pin2, [2500\3500 1000, 2500\3500\2000]
  Stop
```

Notes
Sound2 generates two pulses at the required frequency one on each pin specified. The **Sound2** command can be used to play tones through a speaker or audio amplifier. **Sound2** can also be used to play more complicated notes. By generating two frequencies on separate pins, a more defined sound can be produced. **Sound2** is somewhat dependent on the crystal frequency used for its note frequency, and duration.

Sound2 does not require any filtering on the output, and produces a cleaner note than **Freqout**. However, unlike **Freqout**, the note is not a SINE wave. See diagram: -
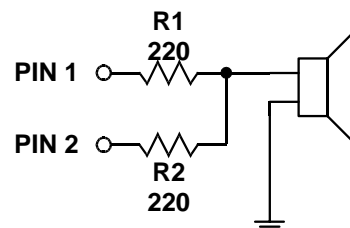
See also :   Freqout, DTMFout, Sound.

Stop

Syntax
Stop

Overview
Stop halts program execution by sending the microcontroller into an infinite loop.

Example
```
If A > 12 Then Stop
{ code data }
```

If variable A contains a value greater than 12 then stop program execution. *code data* will not be executed.

Notes
Although **Stop** halts the microcontroller in its tracks it does not prevent any code listed in the BASIC source after it from being compiled.

See also :   End, Sleep, Snooze.

Strn

Syntax
Strn *Byte Array = Item*

Overview
Load a **Byte Array** with null terminated data, which can be likened to creating a pseudo String variable.

Parameters
Byte Array is the variable that will be loaded with values.
Item can be another **Strn** command, a **Str** command, **Str$** command, or a quoted character string

Example
```
' Load the Byte Array String1 with null terminated characters

  Include "Proton_4.Inc"     ' Demonstration based on the Proton dev board
  Dim String1[21] as Byte    ' Create a Byte array with 21 elements

  DelayMs 100                ' Wait for the LCD to stabilise
  Cls                        ' Clear the LCD
  Strn String1 = "HELLO WORLD"
  ' Load String1 with characters and null terminate it
  Print Str String1          ' Display the string
  Stop
```

See also: Arrays as Strings, Str$.

Str$

Syntax
  Str *Byte Array* **= Str$ (***Modifier Variable***)**
or
  String = Str$ (*Modifier Variable***)**

Overview
Convert a Decimal, Hex, Binary, or Floating Point value or variable into a null terminated string held in a **Byte array**, or a **String** variable. For use only with the **Str** and **Strn** commands, and real String variables.

Parameters
Modifier is one of the standard modifiers used with **Print**, **Rsout, Hserout** etc. See list below.
Variable is a variable that holds the value to convert. This may be a **Bit**, **Byte**, **Word**, **Dword**, or **Float**.
Byte Array must be of sufficient size to hold the resulting conversion and a terminating null character (0).
String must be of sufficient size to hold the resulting conversion.

Notice that there is no comma separating the Modifier from the Variable. This is because the compiler borrows the format and subroutines used in **Print**. Which is why the modifiers are the same: -

Bin{1..32}	Convert to binary digits
Dec{1..10}	Convert to decimal digits
Hex{1..8}	Convert to hexadecimal digits
Sbin{1..32}	Convert to signed binary digits
Sdec{1..10}	Convert to signed decimal digits
Shex{1..8}	Convert to signed hexadecimal digits
Ibin{1..32}	Convert to binary digits with a preceding '%' identifier
Idec{1..10}	Convert to decimal digits with a preceding '#' identifier
Ihex{1..8}	Convert to hexadecimal digits with a preceding '$' identifier
ISbin{1..32}	Convert to signed binary digits with a preceding '%' identifier
ISdec{1..10}	Convert to signed decimal digits with a preceding '#' identifier
IShex{1..8}	Convert to signed hexadecimal digits with a preceding '$' identifier

Example 1
```
' Convert a Word variable to a String of characters in a Byte array.
  Include "Proton_4.Inc"          ' Use the Proton board for the demo
'
' Create a byte array to hold converted value, and null terminator
'
  Dim String1[11] as Byte
  Dim Wrd1 as Word

  DelayMs 100                     ' Wait for the LCD to stabilise
  Cls                             ' Clear the LCD
  Wrd1 = 1234                     ' Load the variable with a value
  Strn String1 = Str$(Dec Wrd1)   ' Convert the Integer to a String
  Print Str String1               ' Display the string
  Stop
```

Example 2

```
' Convert a Dword variable to a String of characters in a Byte array.
  Include "Proton_4.Inc"    ' Use the Proton board for the demo
'
' Create a byte array to hold converted value, and null terminator
'
  Dim String1[11] as Byte
  Dim Dwd1 as Dword

  DelayMs 100                ' Wait for the LCD to stabilise
  Cls                        ' Clear the LCD
  Dwd1 = 1234                ' Load the variable with a value
  Strn String1 = Str$(Dec Dwd1)  ' Convert the Integer to a String
  Print Str String1          ' Display the string
  Stop
```

Example 3

```
' Convert a Float variable to a String of characters in a Byte array.
  Include "Proton_4.Inc"     ' Use the Proton board for the demo
' Create a byte array to hold converted value, and null terminator
  Dim String1[11] as Byte
  Dim Flt1 as Float

  DelayMs 100                ' Wait for the LCD to stabilise
  Cls                        ' Clear the LCD
  Flt1 = 3.14                ' Load the variable with a value
  Strn String1 = Str$(Dec Flt1 ) ' Convert the Float to a String
  Print Str String1          ' Display the string
  Stop
```

Example 4

```
' Convert a Word variable to a Binary String of characters in an array.
  Include "Proton_4.Inc"     ' Use the Proton board for the demo
' Create a byte array to hold converted value, and null terminator
  Dim String1[34] as Byte
  Dim Wrd1 as Word

  DelayMs 100                ' Wait for the LCD to stabilise
  Cls                        ' Clear the LCD
  Wrd1 = 1234                ' Load the variable with a value
  Strn String1 = Str$(Bin Wrd1 ) ' Convert the Integer to a String
  Print Str String1          ' Display the string
  Stop
```

If we examine the resulting string (Byte Array) converted with example 2, it will contain: -

character 1, character 2, character 3, character 4, 0

The zero is not character zero, but value zero. This is a null terminated string.

Notes

The **Byte Array** created to hold the resulting conversion, must be large enough to accommo-date all the resulting digits, including a possible minus sign and preceding identifying character. %, $, or # if the **I** version modifiers are used. The compiler will try and warn you if it thinks the array may not be large enough, but this is a rough guide, and you as the programmer must de-cide whether it is correct or not. If the size is not correct, any adjacent variables will be overwrit-ten, with potentially catastrophic results.

See also :   Creating and using Strings, Strn, Arrays as Strings.

Sub-EndSub

Syntax
Sub *Label Name*()
 BASIC commands inside the Sub
EndSub

Overview
Create a subroutine.

Parameters
Label Name is the name of the subroutine.

Example
```
' Create a subroutine to flash an LED 10 times
  Device = 16F1829
  Declare Xtal = 20

  Dim FlashAmount as Byte     ' Create a variable for the amount of LED flashes
  Symbol LED = PORTB.0        ' Create a name for the LED's Port and Pin

  Do                          ' Create a loop
    FlashLED()                ' Call the subroutine
    DelayMs 1000              ' Delay for 1 second
  Loop                        ' Loop forever

' Create a subroutine that will flash an LED
'
  Sub FlashLED()
    For FlashAmount = 1 to 10 ' A loop for the amount of flashes
      High LED                ' Illuminate the LED
      DelayMs 500             ' Wait for half a second
      Low LED                 ' Extinguish the LED
      DelayMs 500             ' Wait for half a second
    Next                      ' Close the loop
  EndSub                      ' End the subroutine and return from it
```

The **EndSub** directive will produce a **Return** command and exit the subroutine as normal.
There is also an **ExitSub** command that will create a **Return** command and return from the
subroutine.

```
' Create a subroutine that will flash an LED and exit when required
'
  Sub FlashLED()
    For FlashAmount = 1 to 100' A loop for the amount of flashes
      High LED                ' Illuminate the LED
      DelayMs 500             ' Wait for half a second
      Low LED                 ' Extinguish the LED
      DelayMs 500             ' Wait for half a second
      If FlashAmount >= 10 Then ExitSub  ' Exit the subroutine after 10 flashes
    Next                      ' Close the loop
  EndSub                      ' End the subroutine and return from it
```

Calling a sub only requires the name, and a pair of parenthasis after it. This makes a program
easier to read:

MySub()   *' Call the subroutine named MySub*

See also :   Gosub.

Swap

Syntax
Swap *Variable, Variable*

Overview
Swap any two variable's values with each other.

Parameters
Variable is the variable to be swapped

Example
```
' If Dog = 2 and Cat = 10 then by using the swap command
' Dog will now equal 10 and Cat will equal 2.

  Var1 = 10          ' Var1 equals 10
  Var2 = 20          ' Var2 equals 20
  Swap Var1, Var2    ' Var2 now equals 20 and Var1 now equals 10
```

Symbol

Syntax
Symbol *Name* { = } *Value*

Overview
Assign an alias to a register, variable, or constant value

Parameters
Name can be any valid identifier.
Value can be any previously declared variable, system register, or a Register.Bit combination.
The equals '**=**' symbol is optional, and may be omitted if desired.

When creating a program it can be beneficial to use identifiers for certain values that don't change: -

```
Symbol Meter = 1
Symbol Centimetre = 100
Symbol Millimetre = 1000
```

This way you can keep your program very readable and if for some reason a constant changes later, you only have to make one change to the program to change all the values. Another good use of the constant is when you have values that are based on other values.

```
Symbol Meter = 1
Symbol Centimetre = Meter / 100
Symbol Millimetre = Centimetre / 10
```

In the example above you can see how the centimetre and millimetre were derived from the Meter.

Another use of the **Symbol** command is for assigning Port.Bit constants: -

```
Symbol LED = PORTA.0
High LED
```

In the above example, whenever the text LED is encountered, Bit-0 of PORTA is actually referenced.

Floating point constants may also be created using **Symbol** by simply adding a decimal point to a value.

```
Symbol PI = 3.14      ' Create a floating point constant named PI
Symbol FlNum = 5.0    ' Create a floating point constant with the value 5
```

Floating point constant can also be created using expressions.

```
' Create a floating point constant holding the result of the expression
Symbol Quanta = 5.0 / 1024
```

Notes
Symbol cannot create new variables, it simply aliases an identifier to a previously assigned variable, or assigns a constant to an identifier.

Toggle

Syntax
Toggle *Port.Bit* or *Pin Number*

Overview
Sets a pin to output mode and reverses the output state of the pin, changing 0 to 1 and 1 to 0.

Parameters
Port.Bit can be any valid Port and Bit combination.
Pin Number can be a variable or constant that holds a value from 0 to the amount of I/O pins on the device. A value of 0 will be PORTA.0, if present, 1 will be PORTA.1, 8 will be PORTB.0 etc…

Example 1
```
  Do                    ' Create a loop
    Toggle PORTB.0      ' Now reverse the pin
    DelayMs 500         ' Wait for half a second
  Loop                  ' Do it forever
```

Example 2
```
' Flash each of the pins on PORTA and PORTB
'
  Device = 18F25K20
  Declare Xtal = 16

  Dim MyPin as Byte

  For MyPin = 0 to 15       ' Create a loop for the pin to flash
    Toggle MyPin           ' Toggle the pin
    DelayMs 500            ' Delay so that it can be seen
    Toggle MyPin           ' Toggle the pin
    DelayMs 500            ' Delay so that it can be seen
  Next
```

Notes.

Each pin number has a designated name. These are Pin_A0, Pin_A1, PinA2....Pin_B0, Pin_B7, Pin_C0, Pin_C7 to Pin_L7 etc... Each of the names has a relevant value, for example, Pin_A0 has the value 0, Pin_B0 has the value 8, up to Pin_L7, which has the value 87.

These can be used to pass a relevant pin number to a subroutine. For example:

```
'
' Flash an LED attached to PORTB.0 via a subroutine
' Then flash an LED attached to PORTB.1 via the same subroutine
'
   Device = 18F25K20
   Declare Xtal = 16

   Dim PinNumber As Byte          ' Holds the pin number to set high and low

   Do                             ' Create an infinite loop
     PinNumber = Pin_B0           ' Give the pin number to flash (PORTB.0)
     Gosub FlashPin               ' Call the subroutine to flash the pin
     PinNumber = Pin_B1           ' Give the pin number to flash (PORTB.1)
     Gosub FlashPin               ' Call the subroutine to flash the pin
   Loop                           ' Do it forever
'
' Set a pin high then low for 500ms using a variable as the pin to adjust
'
FlashPin:
   Toggle PinNumber               ' Toggle the pin
   DelayMs 500                    ' Wait for 500 milliseconds
   Toggle PinNumber               ' Toggle the pin
   DelayMs 500                    ' Wait for 500 milliseconds
   Return
```

See also :   High, Low.

ToLower

Syntax
Destination String = **ToLower (***Source String***)**

Overview
Convert the characters from a source string to lower case.

Overview
Destination String can only be a **String** variable, and should be large enough to hold the correct amount of characters extracted from the *Source String*.
Source String can be a **String** variable, or a Quoted String of Characters. The *Source String* can also be a **Byte**, **Word**, **Dword**, **Float** or **Array**, variable, in which case the value contained within the variable is used as a pointer to the start of the Source String's address in RAM. A third possibility for *Source String* is a Label name, in which case a null terminated Quoted String of Characters is read from a **Cdata** table.

Example 1
```
' Convert the characters from SourceString to lowercase into DestString
'
  Device = 18F452                 ' A suitable device for Strings
  Dim SourceString as String * 20    ' Create a String of 20 characters
  Dim DestString as String * 20      ' Create another String

  SourceString = "HELLO WORLD"       ' Load the source string with characters
  DestString = ToLower (SourceString)' Convert to lowercase
  Print DestString      ' Display the result, which will be "hello world"
  Stop
```

Example 2
```
' Convert the characters from a Quoted Character String to lowercase
' into DestString
'
  Device = 18F452                 ' A suitable device for Strings
  Dim DestString as String * 20      ' Create a String of 20 characters

  DestString = ToLower ("HELLO WORLD")  ' Convert to lowercase
  Print DestString      ' Display the result, which will be "hello world"
  Stop
```

Example 3
```
' Convert to lowercase from SourceString into DestString using a pointer to
' SourceString
'
  Device = 18F452                 ' A suitable device for Strings
  Dim SourceString as String * 20    ' Create a String of 20 characters
  Dim DestString as String * 20      ' Create another String
'
' Create a Word variable to hold the address of SourceString
'
  Dim StringAddr as Word
  SourceString = "HELLO WORLD"          ' Load the source string with characters
  ' Locate the start address of SourceString in RAM
  StringAddr = AddressOf(SourceString)
  DestString = ToLower(StringAddr)    ' Convert to lowercase
  Print DestString      ' Display the result, which will be "hello world"
  Stop
```

Example 4

```
' Convert chars from a Cdata table to lowercase and place into DestString
'
    Device = 18F452                    ' A suitable device for Strings
    Dim DestString as String * 20      ' Create a String of 20 characters

    DestString = ToLower (Source)      ' Convert to lowercase
    Print DestString        ' Display the result, which will be "hello world"
    Stop
'
' Create a null terminated string of characters in code memory
'
Source:
    Cdata "HELLO WORLD", 0
```

See also :   **Creating and using Strings, Creating and using Virtual Strings with Cdata, Cdata, Len, Left\$, Mid\$, Right\$, Str\$, ToUpper, AddressOf.**

ToUpper

Syntax
Destination String = **ToUpper (***Source String***)**

Overview
Convert the characters from a source string to UPPER case.

Overview
Destination String can only be a **String** variable, and should be large enough to hold the correct amount of characters extracted from the *Source String*.
Source String can be a **String** variable, or a Quoted String of Characters . The *Source String* can also be a **Byte**, **Word**, **Dword**, **Float** or **Array**, variable, in which case the value contained within the variable is used as a pointer to the start of the Source String's address in RAM. A third possibility for *Source String* is a Label name, in which case a null terminated Quoted String of Characters is read from a **Cdata** table.

Example 1
```
' Convert the characters from SourceString to UpperCase and place into
' DestString
'
  Device = 18F452                     ' A suitable device for Strings
  Dim SourceString as String * 20     ' Create a String of 20 characters
  Dim DestString as String * 20       ' Create another String

  SourceString = "hello world"        ' Load the source string with characters
  DestString = ToUpper(SourceString)  ' Convert to uppercase
  Print DestString   ' Display the result, which will be "HELLO WORLD"
  Stop
```

Example 2
```
' Convert the chars from a Quoted Character String to UpperCase
' and place into DestString
'
  Device = 18F452                     ' A suitable device for Strings
  Dim DestString as String * 20       ' Create a String of 20 characters

  DestString = ToUpper("hello world") ' Convert to uppercase
  Print DestString        ' Display the result, which will be "HELLO WORLD"
  Stop
```

Example 3
```
' Convert to UpperCase from SourceString into DestString using a pointer to
' SourceString
'
  Device = 18F452                     ' A suitable device for Strings
  Dim SourceString as String * 20     ' Create a String of 20 characters
  Dim DestString as String * 20       ' Create another String
'
' Create a Word variable to hold the address of SourceString
'
  Dim StringAddr as Word
  ' Load the source string with characters
  SourceString = "hello world"
  ' Locate the start address of SourceString in RAM
  StringAddr = AddressOf(SourceString)
  DestString = ToUpper(StringAddr)    ' Convert to uppercase
  Print DestString   ' Display the result, which will be "HELLO WORLD"
  Stop
```

Example 4
```
' Convert chars from Cdata table to uppercase and place into DestString
'
  Device = 18F452                  ' A suitable device for Strings
  Dim DestString as String * 20    ' Create a String of 20 characters

  DestString = ToUpper(Source)     ' Convert to uppercase
  Print DestString   ' Display the result, which will be "HELLO WORLD"
  Stop
'
' Create a null terminated string of characters in code memory
Source:
  Cdata "hello world", 0
```

See also : **Creating and using Strings, Creating and using Virtual Strings with Cdata, Cdata, Len, Left$, Mid$, Right$, Str$, ToLower, AddressOf .**

Toshiba_Command

Syntax
Toshiba_Command *Command, Value*

Overview
Send a command with or without parameters to a Toshiba T6963 graphic LCD.

Parameters
Command can be a constant, variable, or expression, that contains the command to send to the LCD. This will always be an 8-bit value.

Value can be a constant, variable, or expression, that contains an 8-bit or 16-bit parameter associated with the command. An 8-bit value will be sent as a single parameter, while a 16-bit value will be sent as two parameters. Parameters are optional as some commands do not require any. Therefore if no parameters are included, only a command is sent to the LCD.

Because the size of the parameter is vital to the correct operation of specific commands, you can force the size of the parameter sent by issuing either the text "**Byte**" or "**Word**" prior to the parameter's value.

```
Toshiba_Command $C0, Byte $FF01   ' Send the low byte of the 16-bit value.
Toshiba_Command $C0, Word $01     ' Send a 16-bit value regardless.
```

The explanation of each command is too lengthy for this document, however they can be found in the Toshiba T6963 datasheet. The example program shown below contains a condensed list of commands.

Example
```
' Pan two pages of text left and right on a 128x64 Toshiba T6963 graphic LCD
  Device = 18F452
  Declare LCD_Type = Toshiba          ' Use a Toshiba T6963 graphic LCD
'
' LCD interface pin assignments
'
  Declare LCD_DTPort = PORTD          ' LCD's Data port
  Declare LCD_WRPin = PORTE.2         ' LCD's WR line
  Declare LCD_RDPin = PORTE.1         ' LCD's RD line
  Declare LCD_CEPin = PORTE.0         ' LCD's CE line
  Declare LCD_CDPin = PORTA.1         ' LCD's CD line
  Declare LCD_RSTPin = PORTA.0        ' LCD's RESet line (Optional)
'
' LCD characteristics
'
  Declare LCD_Text_Pages = 2          ' Choose two text pages
  Declare LCD_RAM_Size = 8192         ' Amount of RAM the LCD contains
  Declare LCD_X_Res = 128             ' LCD's X Resolution
  Declare LCD_Y_Res = 64              ' LCD's Y Resolution
  Declare LCD_Font_Width = 6          ' The width of the LCD's font
  Declare LCD_Text_Home_Address = 0   ' Text RAM starts at address 0
```

```
' LCD Display Constants: -
' Register set commands:
   Symbol T_Cursor_POINTER_Set = $21   ' Cursor Pointer Set
' Offset Register Set (CGRAM start address offset)
   Symbol T_OFFset_REG_Set  = $22
   Symbol T_Addr_POINTER_Set = $24      ' Address Pointer Set
' Control Word Set commands:
   Symbol T_Text_Home_Set = $40         ' Text Home Address Set
   Symbol T_Text_AREA_Set = $41         ' Text Area Set
   Symbol T_GRAPH_Home_Set = $42        ' Graphics Home address Set
   Symbol T_GRAPH_AREA_Set = $43        ' Graphics Area Set
' Mode Set commands:
   Symbol T_or_MODE = $80               ' or mode
   Symbol T_xor_MODE = $81              ' xor mode
   Symbol T_and_MODE = $83              ' and mode
   Symbol T_Text_ATTR_MODE = $84        ' Text Attribute mode
   Symbol T_INT_CG_MODE = $80           ' Internal CG ROM mode
   Symbol T_EXT_CG_MODE = $88           ' External CG RAM mode
' Display Mode commands (or together required bits):
   Symbol T_DISPLAY_OFF = $90           ' Display off
   Symbol T_BLINK_ON = $91              ' Cursor Blink on
   Symbol T_Cursor_ON = $92             ' Cursor on
   Symbol T_Text_ON = $94               ' Text mode on
   Symbol T_Graphic_ON = $98            ' Graphic mode on
   Symbol T_Text_and_GRAPH_ON = $9C     ' Text and graphic mode on
' Cursor Pattern Select:
   Symbol T_Cursor_1LINE = $A0          ' 1 line cursor
   Symbol T_Cursor_2LINE = $A1          ' 2 line cursor
   Symbol T_Cursor_3LINE = $A2          ' 3 line cursor
   Symbol T_Cursor_4LINE = $A3          ' 4 line cursor
   Symbol T_Cursor_5LINE = $A4          ' 5 line cursor
   Symbol T_Cursor_6LINE = $A5          ' 6 line cursor
   Symbol T_Cursor_7LINE = $A6          ' 7 line cursor
   Symbol T_Cursor_8LINE = $A7          ' 8 line cursor
' Data Auto Read/Write:
   Symbol T_Data_AUTO_WR = $B0          ' Data write with auto increment of address
   Symbol T_Data_AUTO_RD = $B1          ' Data read with auto increment of address
   Symbol T_AUTO_Data_Reset = $B2       ' Disable auto read/write
' Data Read/Write:
   Symbol T_Data_WR_Inc = $C0           ' Data write and increment address
   Symbol T_Data_RD_Inc = $C1           ' Data read and increment address
   Symbol T_Data_WR_Dec = $C2           ' Data write and decrement address
   Symbol T_Data_RD_Dec = $C3           ' Data read and decrement address
   Symbol T_Data_WR = $C4               ' Data write with no address change
   Symbol T_Data_RD = $C5               ' Data read with no address change
' Screen Peek:
   Symbol T_SCREEN_Peek = $E0           ' Read the display
' Screen Copy:
   Symbol T_SCREEN_COPY = $E8           ' Copy a line of the display
' Bit Set/Reset (or with bit number 0-7):
   Symbol T_Bit_Reset = $F0             ' Pixel clear
   Symbol T_Bit_Set = $F8               ' Pixel set
```

```
' Create two variables for the demonstration
  Dim Pan_Loop as Byte        ' Holds the amount of pans to perform
  Dim Ypos as Byte            ' Holds the Y position of the displayed text
'
' The Main program loop starts here
'
  DelayMs 100                 ' Wait for the LCD to stabilise
  Cls                         ' Clear and initialise the LCD
'
' Place text on two screen pages
'
  For Ypos = 1 to 6
    Print At Ypos, 0, "  THIS IS PAGE ONE     THIS IS PAGE TWO"
  Next
'
' Draw a box around the display
'
  Line 1, 0, 0, 127, 0        ' Top line
  LineTo 1, 127, 63           ' Right line
  LineTo 1, 0, 63             ' Bottom line
  LineTo 1, 0, 0              ' Left line
'
' Pan from one screen to the next then back
'
  While                       ' Create an infinite loop
    For Pan_Loop = 0 to 22
      '
      ' Increment the Text home address
      '
      Toshiba_Command T_Text_Home_Set, Word Pan_Loop
      DelayMs 200
    Next
    DelayMs 200
    For PAN_Loop = 22 to 0 Step -1
      '
      ' Decrement the Text home address
      '
      Toshiba_Command T_Text_Home_Set, Word Pan_Loop
      DelayMs 200
    Next
    DelayMs 200
  Wend                        ' Do it forever
```

Notes

When the Toshiba LCD's **Declares** are issued within the BASIC program, several internal variables and constants are automatically created that contain the Port and Bits used by the actual interface and also some constant values holding valuable information concerning the LCD's RAM boundaries and setup. These variables and constants can be used within the BASIC or Assembler environment. The internal variables and constants are: -

Variables.

__LCD_DTPort	The Port where the LCD's data lines are attached.
__LCD_WRPort	The Port where the LCD's WR pin is attached.
__LCD_RDPort	The Port where the LCD's RD pin is attached.
__LCD_CEPort	The Port where the LCD's CE pin is attached.
__LCD_CDPort	The Port where the LCD's CD pin is attached.
__LCD_RSTPort	The Port where the LCD's RST pin is attached.

Constants.

__**LCD_Type**	The type of LCD targeted. 0 = Alphanumeric, 1 = KS0108, 2 = Toshiba.
__**LCD_WRPin**	The Pin where the LCD's WR line is attached.
__**LCD_RDPin**	The Pin where the LCD's RD line is attached.
__**LCD_CEPin**	The Pin where the LCD's CE line is attached.
__**LCD_CDPin**	The Pin where the LCD's CD line is attached.
__**LCD_RSTPin**	The Pin where the LCD's RST line is attached.
__**LCD_Text_Pages**	The amount of TEXT pages chosen.
__**LCD_Graphic_Pages**	The amount of Graphic pages chosen.
__**LCD_RAM_Size**	The amount of RAM that the LCD contains.
__**LCD_X_Res**	The X resolution of the LCD. i.e. Horizontal pixels.
__**LCD_Y_Res**	The Y resolution of the LCD. i.e. Vertical pixels.
__**LCD_Font_Width**	The width of the font. i.e. 6 or 8.
__**LCD_Text_AREA**	The amount of characters on a single line of TEXT RAM.
__**LCD_Graphic_AREA**	The amount of characters on a single line of Graphic RAM.
__**LCD_Text_Home_Address**	The Starting address of the TEXT RAM.
__**LCD_Graphic_Home_Address**	The Starting address of the Graphic RAM.
__**LCD_CGRAM_Home_Address**	The Starting address of the CG RAM.
__**LCD_End_OF_Graphic_RAM**	The Ending address of Graphic RAM.
__**LCD_CGRAM_OFFset**	The Offset value for use with CG RAM.

Notice that each name has TWO underscores preceding it. This should ensure that duplicate names are not defined within the BASIC environment.

It may not be apparent straight away why the variables and constants are required, however, the Toshiba LCDs are capable of many tricks such as panning, page flipping, text manipulation etc, and all these require some knowledge of RAM boundaries and specific values relating to the resolution of the LCD used.

See also :   LCDRead, LCDWrite, Pixel, Plot, Toshiba_UDG,UnPlot.
See Print for circuit.

Toshiba_UDG

Syntax
Toshiba_UDG *Character,* **[***Value {, Values* **}** **]**

Overview
Create **U**ser **D**efined **G**raphics for a Toshiba T6963 graphic LCD.

Parameters
Character can be a constant, variable, or expression, that contains the character to define. User defined characters start from 160 to 255.
Value\s is a list of constants, variables, or expressions, that contain the information to build the User Defined character. There are also some modifiers that can be used in order to access UDG data from various tables.

Example
```
' Create four User Defined Characters using four different methods
  Device = 18F452
  Declare Xtal = 20

  Declare LCD_Type = T6963        ' Use a Toshiba T6963 graphic LCD
'
' LCD interface pin assignments
'
  Declare LCD_DTPort = PORTD      ' LCD's Data port
  Declare LCD_WRPin = PORTE.2     ' LCD's WR line
  Declare LCD_RDPin = PORTE.1     ' LCD's RD line
  Declare LCD_CEPin = PORTE.0     ' LCD's CE line
  Declare LCD_CDPin = PORTA.1     ' LCD's CD line
  Declare LCD_RSTPin = PORTA.0    ' LCD's RESet line (Optional)
'
' LCD characteristics
'
  Declare LCD_X_Res = 128         ' LCD's X Resolution
  Declare LCD_Y_Res = 64          ' LCD's Y Resolution
  Declare LCD_Font_Width = 8      ' The width of the LCD's font
  Dim UDG_3[8] as Byte            ' Create a byte array to hold UDG data
  Dim DemoChar as Byte            ' Create a variable for the demo loop
' Create some User Defined Graphic data in eeprom memory
UDG_1 Edata $18, $18, $3C, $7E, $DB, $99, $18, $18
'
' The main demo loop starts here
  DelayMs 100                     ' Wait for the LCD to stabilise
  Cls                             ' Clear both text and graphics of the LCD
' Load the array with UDG data
  Str UDG_3 = $18, $18, $99, $DB, $7E, $3C, $18, $18
'
' Print user defined graphic chars 160, 161, 162, and 162 on the LCD
'
  Print At 1, 0, "Char 160 = ", 160
  Print At 2, 0, "Char 161 = ", 161
  Print At 3, 0, "Char 162 = ", 162
  Print At 4, 0, "Char 163 = ", 163
```

```
Toshiba_UDG 160, [Estr UDG_1]         ' Place UDG edata into character 160
Toshiba_UDG 161, [UDG_2]              ' Place UDG cdata into character 161
Toshiba_UDG 162, [Str UDG_3\8]       ' Place UDG array into character 162
' Place values into character 163
Toshiba_UDG 163, $0C, $18, $30, $FF, $FF, $30, $18, $0C]
While                                ' Create an infinite loop
  For DemoChar = 160 to 163          ' Cycle through characters 160 to 163
    Print At 0, 0, DemoChar          ' Display the character
    DelayMs 200                      ' A small delay
  Next                               ' Close the loop
Wend                                 ' Do it forever
'
' Create some User Defined Graphic data in code memory
UDG_2: Cdata $30, $18, $0C, $FF, $FF, $0C, $18, $30
```

Notes

User Defined Graphic values can be stored in on-board eeprom memory by the use of **Edata** tables, and retrieved by the use of the **Estr** modifier. Eight, and only Eight, values will be read with a single **Estr**:

```
UDG_1 Edata $18, $18, $3C, $7E, $DB, $99, $18, $18
  Toshiba_UDG 160, [Estr UDG_1]
```

User Defined Graphic values can also be stored in code memory, on devices that can access their own code memory, and retrieved by the use of a label name associated with a **Cdata** table. Eight, and only Eight, values will be read with a single label name:

```
  Toshiba_UDG 161, [UDG_2]
UDG_2:
  Cdata $30, $18, $0C, $FF, $FF, $0C, $18, $30
```

The use of the **Str** modifier will retrieve values stored in an array, however, this is not recommended as it will waste precious RAM.

The Toshiba LCD's font is designed in an 8x8 grid or a 6x8 grid depending on the font size chosen. The diagram below shows a designed character and its associated values.


```
msb              lsb
%00000000 = $18
%00011000 = $18
%00111100 = $3C
%01111110 = $7E
%11011011 = $DB
%10011001 = $99
%00011000 = $18
%00000000 = $18
```
←— 6 x 8 Font —→
←——— 8 x 8 Font ———→
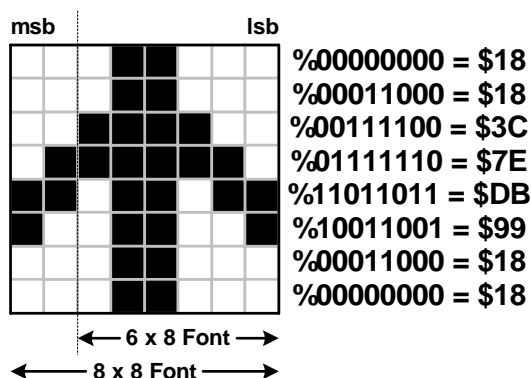
See also :   LCDRead, LCDWrite, Pixel, Plot, Toshiba_Command, UnPlot.
                See Print for circuit.

UnPlot

Syntax
UnPlot *Ypos, Xpos*

Overview
Clear an individual pixel on a graphic LCD.

Parameters
Xpos can be a constant, variable, or expression, pointing to the X-axis location of the pixel to clear. This must be a value of 0 to the X resolution of the LCD. Where 0 is the far left row of pixels.
Ypos can be a constant, variable, or expression, pointing to the Y-axis location of the pixel to clear. This must be a value of 0 to the Y resolution of the LCD. Where 0 is the top column of pixels.

Example
```
  Device = 16F1829
  Declare Xtal = 4

  Declare LCD_Type = KS0108  ' Use a KS0108 Graphic LCD
'
' Graphic LCD Pin Assignments
'
  Declare LCD_DTPort = PORTD
  Declare LCD_RSPin = PORTC.2
  Declare LCD_RWPin = PORTE.0
  Declare LCD_ENPin = PORTC.5
  Declare LCD_CS1Pin = PORTE.1
  Declare LCD_CS2Pin = PORTE.2

  Dim Xpos as Byte
  Cls                                ' Clear the LCD
'
' Draw a line across the LCD
'
  While                              ' Create an infinite loop
    For Xpos = 0 to 127
      Plot 20, Xpos
      DelayMs 10
    Next
    '
    ' Now erase the line
    '
    For Xpos = 0 to 127
      UnPlot 20, Xpos
      DelayMs 10
    Next
  Wend
```

See also :   LCDRead, LCDWrite, Pixel, Plot. See Print for circuit.

USBinit

Syntax
USBinit

Overview
Initialise the USB peripheral and wait until the USB bus is configured and enabled.

Notes.
USBinit is optional within the BASIC program itself. If it is not used in the program, the compiler will initialise the USB peripheral itself before the program starts.

If the device contains the OSCTUNE register, it will set bit PLLEN and enable the x4 PLL.

The benefit of adding **USBinit** within the BASIC program is that you will have the opportunity to set or clear this bit as required.

See also :   USBout, USBin, USBpoll, Config_Start…Config_End.

USBin

Syntax
USBin *Endpoint*, *Buffer*, *Countvar*, *Label*

Overview
Receive USB data from the host computer and place it into *Buffer*.

Parameters
Endpoint is a constant value (0 - 15) that indicates which EndPoint to receive data from.
Buffer is a Byte array or String that will contain the bytes received. This may be up to 128 bytes in length if using CDC and 64 bytes for HID.
Countvar is a constant, variable or expression that indicates how many bytes are transferred from the *Buffer*. The text **Auto** may be placed instead of the *Countvar* parameter. This will con-figure the receiving bus to it's maximum, which is 128 bytes for CDC and 64 bytes for HID.
Label is an optional valid BASIC label, that **USBin** will jump to in the event that no data is available.

Example 1
```
' USB interface
  Dim Buffer[8] as Byte
Try_Again:
  USBin 1, Buffer, 4, Try_Again
```

Example 2
```
' USB demo program for CDC virtual serial emulation
' Wait for a byte from USB and transmit several characters
'
  Declare Reminders = Off
  Device = 18F26J50
  Declare Xtal = 48
  Declare Optimiser_Level = 1

  Include "CDC_Descriptor.inc"            ' Include the CDC descriptors

  Dim Byteout As Byte = $41
  Dim Wordout As Word = $4142
  Dim DWordout As Dword = $41424344
  Dim RxBuffer[16] As Byte
  Dim TxBuffer As String * 16 = "Hello World\r"
  Dim CodeText As Code = "Hello World\r"

  OSCTUNE.6 = 1                           ' Enable PLL for 18F87J50 family
  DelayMS 10
  USBInit                                 ' Initialise USB

  While
IdleLoop:
    USBIn 3, RxBuffer, 16, IdleLoop       ' Wait for USB input
' Transmit to a serial terminal
OutLoop1:
    USBOut 3, CodeText, Auto, OutLoop1
OutLoop2:
    USBOut 3, TxBuffer, Auto, OutLoop2
OutLoop3:
    USBOut 3, Byteout, 1, OutLoop3
```

```
OutLoop4:
    USBOut 3, Wordout, 2, OutLoop4
OutLoop5:
    USBOut 3, DWordout, 4, OutLoop5
  Wend                         ' Wait for next buffer
' Configure the 18F26J50 for 48MHz operation using a 12MHz crystal
Config_Start
  CPUDIV = OSC1               ' No CPU System clock divide
  PLLDIV = 3                  ' Divide by 3 (12 MHz oscillator input)
  OSC = HSPLL                 ' HS PLL oscillator x 4
  CP0 = OFF                   ' Program memory is not code-protected
  WDTEN = OFF                 ' Watchdog disabled
  DEBUG = OFF                 ' Hardware Debug disabled
  XINST = OFF                 ' Extended Instruction Set: Disabled
  T1DIG = OFF                 ' Secondary Oscillator clock source may not be selected
  LPT1OSC = ON                ' Timer1 Oscillator: Low-power operation
  FCMEN = OFF                 ' Fail-Safe Clock Monitor: Disabled
  IESO = OFF                  ' Internal External Oscillator Switch Over Mode: Disable
  WDTPS = 128                 ' Watchdog Postscaler: 1:128
  DSWDTOSC = INTOSCREF        ' DSWDT uses INTRC
  RTCOSC = INTOSCREF          ' RTCC Clock Select: RTCC uses INTRC
  DSBOREN = OFF               ' Deep Sleep BOR Disabled
  DSWDTEN = OFF               ' Deep Sleep Watchdog Timer: Disabled
  DSWDTPS = 128               ' Deep Sleep Watchdog Postscaler 1:128 (132 ms)
  IOL1WAY = OFF               ' The IOLOCK bit can be set and cleared as needed
  MSSP7B_EN = MSK5            ' 5 Bit address masking mode
  WPCFG = OFF                 ' Configuration Words page not erase/write-protected
  WPDIS = OFF                 ' WPFP<5:0>/WPEND region ignored
Config_End
```

Two USB interface types have been implemented within the compiler; HID (Human Interface Device) and CDC (Communication Device Class). These are chosen by the type of descriptor used. For example, the **CDC_Descriptor.Inc** descriptor file will use the CDC interface, while **HID_Descriptor.Inc** will use the HID interface. Both these files can be found within the compiler's Includes\Sources folder.

The **USBin** command polls the USB interface before continuing, therefore there is not always a need to use the **USBpoll** command.

The *Label* part of the **USBin** command is optional and can be omitted if required. Instead, the Carry flag (STATUS.0) can be checked to see if the microcontroller or USB transceiver has control of the Dual Port RAM buffer. The Carry will return clear if the microcontroller has control of the buffer and is able to receive some data.

Upon exiting the **USBin** command, register PRODL will contain the amount of bytes received.

Notes.
The method used for USB is polled, meaning that no interrupt is working in the background. However, this does mean that either a **USBpoll**, **USBin**, or **USBout** command needs to be executed approximately every 10ms or the USB interface connection will be lost.

USB must work at an oscillator speed of 48MHz. Achieving this frequency is accomplished by the use of the device's divide and multiply configuration fuse settings. See the relevant datasheet for more information concerning these.

See also :   USBinit, USBout, USBpoll, Config_Start…Config_End.

USBout

Syntax
USBout *Endpoint*, *Buffer*, *Countvar*, *Label*

Overview
Take **Countvar** number of bytes from **Buffer** and send them to the USB **Endpoint**.

Parameters
Endpoint is a constant value (0 - 15) that indicates which EndPoint to transmit data from.
Buffer can be any of the compiler's variable or constant types, and contains the bytes to transmit. This may be up to 128 bytes in length if using CDC and 64 bytes for HID.
Countvar is a constant, variable or expression that indicates how many bytes are transferred from the *Buffer*. The text **Auto** may be placed instead of the *Countvar* value, which will transmit data until a null is found, or until the correct amount of bytes are transmitted for the variable size.
Label is an optional valid BASIC label, that **USBout** will jump to in the event that no data is available.

Example
```
  Dim Buffer[8] as Byte
Try_Again:
  USBout 1, Buffer, 4, Try_Again
```

Notes.
The *Label* used for buffer control may be omitted and the microcontroller's Carry flag (STATUS.0) monitored instead:-

```
  Repeat
    USBout 3, USB_BUFFER, 4    ' Transmit 4 bytes from USB_BUFFER
  Until STATUS.0 = 0            ' Wait for control over the buffer RAM
```

The *CountVar* parameter can also be replaced with the text **Auto**, in which case a string of characters terminated by a null (0) will be transmitted, or the amount of bytes that a particular variable type used will be transmitted. The Countvar parameter can be omitted, in which case **Auto** is implied: -

```
  USBout 3, "Hello Wordl\n\r"
```

The buffer itself can take the form of any variable type of the compiler, and even the internal USB buffer itself. The internal USB buffer is brought into the BASIC code named __USBout_Buffer (note the two preceding underscores).

In the event that **Auto** has been used for the *Countvar* parameter, a **Bit** or **Byte** variable will transmit 1 byte of data, a **Word** will transmit 2 bytes (lowest byte first), a **Dword** and **Float** will transmit 4 bytes of data (lowest byte first).

The method used for USB is polled, meaning that no interrupt is working in the background. However, this does mean that either a **USBpoll**, **USBin**, or **USBout** command needs to be executed approximately every 10ms for HID and 5ms for CDC or the USB interface connection will be lost.

The USB library subroutines require the use of the DP (Dual Port) RAM starting at address $0200 or $0400 depending on the device used. This leaves the RAM underneath DP RAM available for the BASIC program. However, the DP USB buffers can also be accessed directly from BASIC. __USBOUT_BUFFER, and __USBIN_BUFFER are declared automatically as **String** type variables within the USB_Mem.inc file, located within the compiler Inclcudes\Sources folder.

USB must work at an oscillator speed of 48MHz. Achieving this frequency is accomplished by the use of the device's divide and multiply configuration fuse settings. See the relevant data-sheet for more information concerning these.

Typical circuit for self powered USB interface.
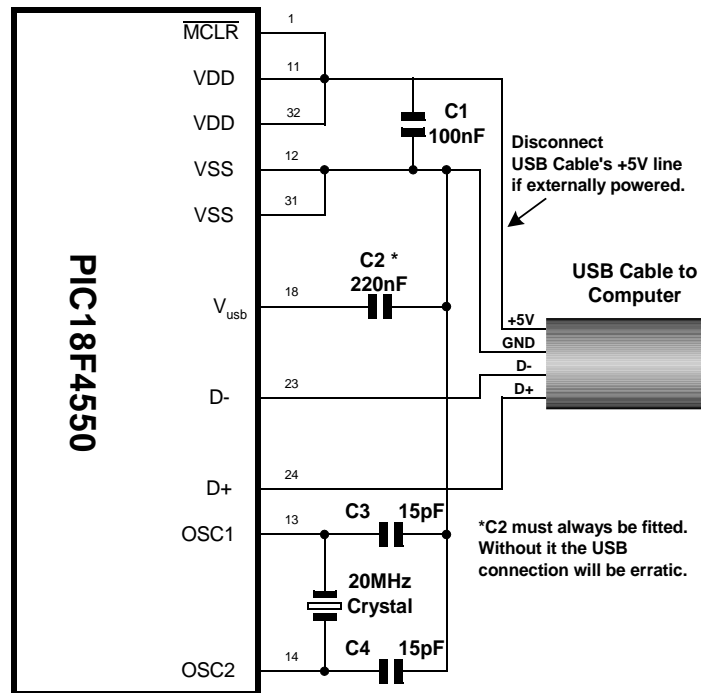
The **USBout** command polls the USB interface before transferring its data to the bus, and returns with the Carry flag (STATUS.0) clear if it has control over the Dual Port buffer.

```
Repeat
   USBout 3, __USBout_BUFFER, Auto
Until STATUS.0 = 0
```

Two USB interface types have been implemented within the compiler; HID (Human Interface Device) and CDC (Communication Device Class). These are chosen by the type of descriptor used. For example, the **CDC_Descriptor.Inc** descriptor file will use the CDC interface, while **HID_Descriptor.Inc** will use the HID interface. Both these files can be found within the compiler's Includes\Sources folder.

Example.

```
' Demonstrate a HID (Human Interface Device) interface
' When connected to the PC, the mouse pointer will rotate in a small square

    Device = 18F4550                    ' Choose a device with on-board full speed USB
    Declare Xtal = 48                   ' Inform the compiler we're operating at 48MHz


    Include "HID_Descriptor.inc"    ' Include the HID descriptors


    Dim Buffer[4] As Byte
    Dim Loop_Count As Byte
    Dim Position As Byte
' High if microcontroller does not have control over the DP Buffer
    Symbol Carry_Flag = STATUS.0


'-----------------------------------------------------------------------
' The main program loop starts here
    DelayMS 10                          ' Wait for things to stabilise
    Clear Buffer                        ' Clear the array before we start

    Repeat
        USBPoll                         '    Wait for USB to become attached
    Until USB_tConnected = 1 Or USB_tConfigured = 1
        While
            For Position = 0 To 3       ' Move through each position
                For Loop_Count = 0 To 31    ' 32 steps in each direction
                    Select Position
                        Case 0                  ' Move Up?
                            Buffer#1 = 0
                            Buffer#2 = -2
                        Case 1                  ' Move Right?
                            Buffer#1 = 2
                            Buffer#2 = 0
                        Case 2                  ' Move Down?
                            Buffer#1 = 0
                            Buffer#2 = 2
                        Case 3                  ' Move Left?
                            Buffer#1 = -2
                            Buffer#2 = 0
                    EndSelect
                    Repeat
                        USBOut 1, Buffer, 4    ' Send the Buffer to endpoint 1
                    Until Carry_Flag = 0    ' Keep trying if we don't have control
                Next
            Next
        Wend
'-----------------------------------------------------------------------
' Configure the 18F4550 for 48MHz operation using a 12MHz crystal
Config_Start
    PLLDIV = 3              ' Divide by 3 (12 MHz oscillator input)
    CPUDIV = OSC1_PLL2     ' [OSC1/OSC2 Src: /1][96 MHz PLL Src: /2]
    USBDIV = 1              ' USB clock source comes directly from the primary osc
    FOSC = HSPLL_HS         ' HS oscillator, PLL enabled
    FCMEN = OFF             ' Fail-Safe Clock Monitor disabled
    IESO = OFF              ' Oscillator Switchover mode disabled
```

```
PWRT = ON       ' PWRT enabled
BOR = ON        ' Brown-out Reset enabled in hardware only
BORV = 3        ' Brown-out Voltage bits: Minimum setting
VREGEN = ON     ' USB voltage regulator enabled
WDT = OFF       ' Watchdog Timer  Disabled - SW Controlled
WDTPS = 128     ' Watchdog Timer Postscale Select bits: 1:128
MCLRE = ON      ' MCLR pin enabled, RE3 input pin disabled
LPT1OSC = ON    ' Timer1 configured for low-power operation
PBADEN = OFF    ' PORTB<4:0> pins are configured as digital I/O on Reset
CCP2MX = ON     ' CCP2 input/output is multiplexed with RC1
STVREN = OFF    ' Stack full/underflow will not cause Reset
LVP = OFF       ' Single-Supply ICSP disabled
XINST = OFF     ' Instruction set extension disabled
DEBUG = OFF     ' Background debugger disabled
CP0 = OFF       ' Block 0 (000800-001FFFh) not code-protected
CP1 = OFF       ' Block 1 (002000-003FFFh) not code-protected
CP2 = OFF       ' Block 2 (004000-005FFFh) not code-protected
CP3 = OFF       ' Block 3 (006000-007FFFh) not code-protected
CPB = OFF       ' Boot block (000000-0007FFh) not code-protected
CPD = OFF       ' Data EEPROM not code-protected
WRT0 = OFF      ' Block 0 (000800-001FFFh) not write-protected
WRT1 = OFF      ' Block 1 (002000-003FFFh) not write-protected
WRT2 = OFF      ' Block 2 (004000-005FFFh) not write-protected
WRT3 = OFF      ' Block 3 (006000-007FFFh) not write-protected
WRTB = OFF      ' Boot block (000000-0007FFh) not write-protected
WRTC = OFF      ' Config registers (300000-3000FFh) not write-protected
WRTD = OFF      ' Data eeprom not write-protected
EBTR0 = OFF     ' Block 0 not protected from table reads
EBTR1 = OFF     ' Block 1 not protected
EBTR2 = OFF     ' Block 2 not protected
EBTR3 = OFF     ' Block 3 not protected
EBTRB = OFF     ' Boot block not protected
Config_End
```

See also : USBinit, USBin, USBpoll, Config_Start…Config_End.

USBpoll

Syntax
USBpoll

Overview
Poll the USB interface in order to keep it attached to the bus.

Notes
If the commands **USBin** or **USBout** are not used within a program loop, the interface will drop off the bus, therefore issue the **USBpoll** command to stop this happening. This command should be issued at least every 10ms if using a HID interface and at least once every 5ms for a CDC interface.

Upon exiting the **USBpoll** command, the state of the bus can be checked via the USB variable __USB_bDeviceState. This variable resides in a higher RAM bank of the PICmicro™ (as do all of the USB variables), which means that bank switching will take place whenever it is accessed. For this reason, the **USBpoll** subroutine loads this variable into a variable within Access RAM. The variable it uses is named USB_bStatus.

Several states are declared within the USB_Dev.Inc file located within the compiler's Includes folder. These are: -

DETACHED_STATE	0
ATTACHED_STATE	1
POWERED_STATE	2
DEFAULT_STATE	4
ADDRESS_PENDING_STATE	8
ADDRESS_STATE	16
CONFIGURED_STATE	32

Within the USB_Mem.inc file, there are several bits pre-declared for each of the above states. The relevant ones are:

```
  USB_tConnected       ' Set if the USB is connected
  USB_tConfigured       ' Set if the USB is Configured
```

Example
```
' Wait the for USB interface to be recognised and attached
  Repeat
    USBpoll
  Until USB_tConnected = 1 Or USB_tConfigured = 1
```

With newer devices, testing the USB_tConnected bit is all that is required, however, for older types such as the 18F4550, the USB_tConfigured bit has to be tested. For good measure, it may be prudent to test both of them.

See also :   USBinit, USBout, USBin, Config_Start…Config_End.

Val

Syntax
Variable = **Val (***Array Variable*, *Modifier***)**

Overview
Convert a Byte Array or String containing Decimal, Hex, or Binary numeric text into its integer equivalent.

Parameters
Array Variable is a byte array or string containing the alphanumeric digits to convert and terminated by a null (i.e. value 0).
Modifier can be Hex, Dec, or Bin. To convert a Hex string, use the Hex modifier, for Binary, use the Bin modifier, for Decimal use the Dec modifier.
Variable is a variable that will contain the converted value. Floating point characters and variables cannot be converted, and will be rounded down to the nearest integer value.

Example 1
```
' Convert a string of hexadecimal characters to an integer
  Include "Proton_4.Inc"        ' Use the Proton board for the demo
  Dim String1[10] as Byte       ' Create a byte array as a String
  Dim Wrd1 as Word              ' Create a variable to hold result
  DelayMs 100                   ' Wait for the LCD to stabilise
  Cls                           ' Clear the LCD
  Str String1 = "12AF",0        ' Load the String with Hex digits
  Wrd1 = Val(String1,Hex)       ' Convert the String into an integer
  Print Hex Wrd1                ' Display the integer as Hex
  Stop
```

Example 2
```
' Convert a string of decimal characters to an integer
  Include "Proton_4.Inc"        ' Use the Proton board for the demo
  Dim String1[10] as Byte       ' Create a byte array as a String
  Dim Wrd1 as Word              ' Create a variable to hold result
  DelayMs 100                   ' Wait for the LCD to stabilise
  Cls                           ' Clear the LCD
  Str String1 = "1234",0        ' Load the String with Decimal digits
  Wrd1 = Val(String1,Dec)       ' Convert the String into an integer
  Print Dec Wrd1                ' Display the integer as Decimal
  Stop
```

Example 3
```
' Convert a string of binary characters to an integer
  Include "Proton_4.Inc"        ' Use the Proton board for the demo
  Dim String1[17] as Byte       ' Create a byte array as a String
  Dim Wrd1 as Word              ' Create a variable to hold result
  DelayMs 100                   ' Wait for the LCD to stabilise
  Cls                           ' Clear the LCD
  Str String1 = "1010101010000000",0 ' Load the String with Binary
  Wrd1 = Val(String1,Bin)       ' Convert the String into an integer
  Print Bin Wrd1                ' Display the integer as Binary
  Stop
```

Notes
There are limitations with the **Val** command when used on a 14-bit core device, in that the array must fit into a single RAM bank. But this is not really a problem, just a little thought when placing the variables will suffice. The compiler will inform you if the array is not fully located inside a Bank, and therefore not suitable for use with the **Val** command.

This is not a problem with 18F devices, as they are able to access all their memory very easily.

The **Val** command is not recommended inside an expression, as the results are not predictable. However, the **Val** command can be used within an **If-Then**, **While-Wend**, or **Repeat-Until** construct, but the code produced is not as efficient as using it outside a construct, because the compiler must assume a worst case scenario, and use **Dword** comparisons.

```
Include "Proton_4.Inc"          ' Use the Proton board for the demo
Dim String1[10] as Byte         ' Create a byte array as a String

DelayMs 100                     ' Wait for the LCD to stabilise
  Cls                           ' Clear the LCD
Str String1 = "123",0           ' Load the String with Dec digits
If Val(String1,Hex) = 123 Then  ' Compare the result
  Print At 1,1,Dec Val (String1,Hex)
Else
  Print At 1,1,"not Equal"
EndIf
Stop
```

See also: **Str, Strn, Str$.**

AddressOf or VarPtr

Syntax
Assignment Variable = **VarPtr (** *Variable* **)**
or
Assignment Variable = **AddressOf (** *Variable* **)**

Overview
Returns the address of the variable in RAM, or a label in code memory. Commonly known as a pointer.

Parameters
Assignment Variable can be any of the compiler's variable types, and will receive the pointer to the *variable's* address.
Variable can be any variable name used in the BASIC program.

Notes
Be careful if using **AddressOf** to locate the starting address of an array when using a standard 14-bit device, as arrays can cross bank boundaries, and the finishing address of the array may be in a different bank to its start address. The compiler can track bank changes internally when accessing arrays, but BASIC code generally cannot. For example, the most common use for **AddressOf** is when implementing indirect addressing using the microcontroller's FSR and INDF registers.

This is not the case with 18F devices, as the FSR0, 1, and 2 registers can access all memory areas linearly.

When using **AddressOf** with an enhanced 14-bit core device it will return the address of a variable or label plus the offsets required to make them linearly accessible. i.e. $2000 for RAM and $8000 for code memory.

While...Wend

Syntax
While *Condition*
Instructions
Instructions
Wend

or

While *Condition* { *Instructions :* } **Wend**

Overview
Execute a block of instructions while a condition is true.

Example
```
Var1 = 1
While Var1 <= 10
  Print Dec Var1, " "
  Var1 = Var1 + 1
Wend
```

or

```
While PORTA.0 = 1: Wend    ' Wait for a change on the Port
```

Notes
While-Wend, repeatedly executes *Instructions* **While** *Condition* is true. When the *Condition* is no longer true, execution continues at the statement following the **Wend**. *Condition* may be any comparison expression.

See also :   If-Then, Repeat-Until, For-Next.

Xin

Syntax
Xin *DataPin, ZeroPin, {Timeout, Timeout Label}*, **[***Variable{,...}***]**

Overview
Receive X-10 data and store the House Code and Key Code in a variable.

Parameters
DataPin is a constant (0 - 15), Port.Bit, or variable, that receives the data from an X-10 inter-face. This pin is automatically made an input to receive data, and should be pulled up to 5 Volts with a 4.7KΩ resistor.

ZeroPin is a constant (0 - 15), Port.Bit, or variable, that is used to synchronise to a zero-cross event. This pin is automatically made an input to received the zero crossing timing, and should also be pulled up to 5 Volts with a 4.7KΩ resistor.

Timeout is an optional value that allows program continuation if X-10 data is not received within a certain length of time. Timeout is specified in AC power line half-cycles (approximately 8.33 milliseconds).

Timeout Label is where the program will jump to upon a timeout.

Example
```
  Dim HouseKey as Word
  Cls
MyLoop:
' Receive X-10 data, go to NoData if none
  Xin PORTA.2, PORTA.0, 10, NoData, [HouseKey]
' Display X-10 data on an LCD
  Print At 1, 1, "House=", Dec HouseKey.Byte1,"Key=", Dec HouseKey.Byte0
  Goto MyLoop                    ' Do it forever
NoData:
  Print "No Data"
  Stop
```

Xout and Xin Declares
In order to make the **Xin** command's results more in keeping with the BASIC Stamp interpreter, two declares have been included for both **Xin** and Xout These are.

```
  Declare Xout_Translate = On/Off, True/False or 1/0
```

and

```
  Declare Xin_Translate = On/Off, True/False or 1/0
```

Notes
Xin processes data at each zero crossing of the AC power line as received on ***ZeroPin***. If there are no transitions on this line, **Xin** will effectively wait forever.

Xin is used to receive information from X-10 devices that can transmit the appropriate data. X-10 modules are available from a wide variety of sources under several trade names. An inter-face is required to connect the microcontroller to the AC power line. The TW-523 for two-way X-10 communications is required by **Xin**. This device contains the power line interface and iso-lates the microcontroller from the AC line.

If *Variable* is a **Word** sized variable, then each House Code received will be stored in the upper 8-bits of the **Word** And each received Key Code will be stored in the lower 8-bits of the **Word** variable. If *Variable* is a **Byte** sized variable, then only the Key Code will be stored.

The House Code is a number between 0 and 15 that corresponds to the House Code set on the X-10 module A through P.

The Key Code can be either the number of a specific X-10 module or the function that is to be performed by a module. In normal operation, a command is first sent, specifying the X-10 module number, followed by a command specifying the desired function. Some functions operate on all modules at once so the module number is unnecessary. Key Code numbers 0-15 correspond to module numbers 1-16.

Warning. Under no circumstances should the microcontroller be connected directly to the AC power line. Voltage potentials carried by the power line will not only instantly destroy the microcontroller, but could also pose a serious health hazard.

See also :   Xout.

Xout

Syntax
Xout *DataPin, ZeroPin,* **[***HouseCode\KeyCode {\Repeat}* {, ...}**]**

Overview
Transmit a HouseCode followed by a KeyCode in X-10 format.

Parameters
DataPin is a constant (0 - 15), Port.Bit, or variable, that transmits the data to an X-10 interface. This pin is automatically made an output.

ZeroPin is a constant (0 - 15), Port.Bit, or variable, that is used to synchronise to a zero-cross event. This pin is automatically made an input to received the zero crossing timing, and should also be pulled up to 5 Volts with a 4.7KΩ resistor.

HouseCode is a number between 0 and 15 that corresponds to the House Code set on the X-10 module A through P. The proper HouseCode must be sent as part of each command.

KeyCode can be either the number of a specific X-10 module, or the function that is to be performed by a module. In normal use, a command is first sent specifying the X-10 module number, followed by a command specifying the function required. Some functions operate on all modules at once so the module number is unnecessary. KeyCode numbers 0-15 correspond to module numbers 1-16.

Repeat is an optional operator, and if it is not included, then a repeat of 2 times (the minimum) is assumed. ***Repeat*** is normally reserved for use with the X-10 Bright and Dim commands.

Example
```
  Dim House as Byte
  Dim Unit as Byte
' Create some aliases of the keycodes
  Symbol UnitOn = %10010       ' Turn module on
  Symbol UnitOff = %11010      ' Turn module off
  Symbol UnitsOff = %11100     ' Turn all modules off
  Symbol LightsOn = %10100     ' Turn all light modules on
  Symbol LightsOff = %10000    ' Turn all light modules off
  Symbol Bright = %10110       ' Brighten light module
  Symbol DimIt = %11110        ' Dim light module
' Create aliases for the pins used
  Symbol DataPin = PORTA.1
  Symbol ZeroC = PORTA.0
  House = 0                    ' Set house to 0 (A)
  Unit = 8                     ' Set unit to 8 (9)
' Turn on unit 8 in house 0
  Xout DataPin ,ZeroC,[House \ Unit,House \ UnitOn ]
' Turn off all the lights in house 0
  Xout DataPin ,ZeroC,[House \ LightsOff ]
  Xout DataPin ,ZeroC,[House \ 0]
' Blink light 0 on and off every 10 seconds
MyLoop:
  Xout DataPin ,ZeroC,[House \ UnitOn ]
  DelayMs 10000                ' Wait 10 seconds
  Xout DataPin ,ZeroC,[House \ UnitOff ]
  DelayMs 10000                ' Wait 10 seconds
  Goto MyLoop
```

Xout and Xin Declares

In order to make the **Xout** command's results more in keeping with the BASIC Stamp interpreter, two declares have been included for both Xin and **Xout**. These are.

```
Declare Xout_Translate = On/Off, True/False or 1/0
```
and
```
Declare Xin_Translate = On/Off, True/False or 1/0
```

Notes

Xout only transmits data at each zero crossing of the AC power line, as received on *ZeroPin*. If there are no transitions on this line, **Xout** will effectively wait forever.

Xout is used to transmit information from X-10 devices that can receive the appropriate data. X-10 modules are available from a wide variety of sources under several trade names. An interface is required to connect the microcontroller to the AC power line. Either the PL-513 for send only, or the TW-523 for two-way X-10 communications are required. These devices contain the power line interface and isolate the PICmicro™ from the AC line.

The KeyCode numbers and their corresponding operations are listed below: -

```
KeyCode        KeyCode No.     Operation
UnitOn         %10010          Turn module on
UnitOff        %11010          Turn module off
UnitsOff       %11100          Turn all modules off
LightsOn       %10100          Turn all light modules on
LightsOff      %10000          Turn all light modules off
Bright         %10110          Brighten light module
Dim            %11110          Dim light module
```

Wiring to the X-10 interfaces requires 4 connections. Output from the X-10 interface (zero crossing and receive data) are open-collector, which is the reason for the pull-up resistors on the microcontroller.

Wiring for each type of interface is shown below: -

```
PL-513 Wiring
  Wire No.    Wire Colour    Connection
  1           Black          Zero crossing output
  2           Red            Zero crossing common
  3           Green          X-10 transmit common
  4           Yellow         X-10 transmit input
TW-523 Wiring
  Wire No.    Wire Colour    Connection
  1           Black          Zero crossing output
  2           Red            Common
  3           Green          X-10 receive output
  4           Yellow         X-10 transmit input
```

Warning. Under no circumstances should the microcontroller be connected directly to the AC power line. Voltage potentials carried by the power line will not only instantly destroy the microcontroller, but could also pose a serious health hazard.

See also :   Xin.

Using the Optimiser

The underlying assembler code produced by the compiler is the single most important element to a good language, because compact assembler not only means more can be squeezed into the tight confines of the microcontroller, but also the code runs faster which allows more complex operations to be performed. This is why the compiler now has a "dead code removal" pass as standard which will remove redundant mnemonics, and replace certain combinations of mnemonics with a single mnemonic. WREG tracking is also implemented as standard which helps eliminate unnecessary loading of a constant value into the WREG.

And even though the compiler already produces good underlying assembler mnemonics, there is always room for improvement, and that improvement is achieved by a separate optimising pass.

The optimiser is enabled by issuing the **Declare**: -

```
    Declare Optimiser_Level = n
```

Where n is the level of optimisation required.

The **Declare** should be placed at the top of the BASIC program, but anywhere in the code is actually acceptable because once the optimiser is enabled it cannot be disabled later in the same program.

As of version 3.3.3.0 of the compiler, the optimiser has 3 levels, 4 if you include Off as a level.

Level 0 disables the optimiser.

Level 1 Chooses the appropriate branching mnemonics when using an 18F device, and actively chooses the appropriate page switching mnemonics when using a 14-bit core (16F) device.

This is the single most important optimising pass for larger microcontrollers. For 18F types it will replace **Call** with **RCall** and **Goto** with **Bra** whenever appropriate, saving 1 byte of code space every time.

Level 2 Further re-arranging of branching operations.

Level 3 18F devices only. Re-arranges conditional branching operations. This is an important optimising pass because a single program can implement many decision making mnemonics.

You must be aware that optimising code, especially paged code found in the larger standard 14-bit core (16F) devices can, in some circumstances, have a detrimental effect on a program if it misses a page boundary, this is true of all optimisation on all compilers and is something that you should take into account. This is why the 14-bit core optimiser is not an official part of the compiler, and has been left in place because of current user requests.

Always try to write and test your program without the optimiser pass. Then once it's working as expected, enable the optimiser a level at a time. However, this is not always possible with larger programs that will not fit within the microcontroller without optimisation. In this circumstance, choose level 1 optimisation whenever the code is reaching the limits of the microcontroller, testing the code as you go along.

Caveats

Of course there's no such thing as a free lunch, and there are some features that cannot be used when implementing the optimiser.

The main one is that the optimiser is not supported with 12-bit core devices.

Also, the **Org** directive is not allowed with 14-bit core (16F) devices when using the optimiser, but can be used with 18F devices.

When using 18F devices, do not use the **Movfw** macro as this will cause problems withing the Asm listing, use the correct mnemonic of **Movf** Var,**w**.

On all devices, do not use the assembler **LIST** and **NOLIST** directives, as the optimiser uses these to sculpt the final Asm used.

```
Declare Dead_Code_Remove = On/Off
```

The above declare removes some redundant op-codes from the underlying Asm code.

Removal of redundant Bank Switching mnemonics.
Removal of redundant **Movwf** mnemonics if preceded by a **Movf** Var,w mnemonic.
Removal of reduntant **Movf** Var,W mnemonics if preceded by a **Movwf** mnemonic.
Removal of reduntant **Andlw** mnemomics if preceded by another **Andlw** mnemonic.
Replaced a **Call**-**Return** mnemonic pair with a single **Goto** mnemonic.

Note that the Optimiser for standard 14-bit core devices is no longer officially supported, and only remains because of user requests.

Using the Preprocessor

A preprocessor directive is a non executable statement that informs the compiler how to compile. For example, some microcontroller have certain hardware features that others don't. A pre-processor directive can be used to inform the compiler to add or remove source code, based on that particular devices ability to support that hardware.

It's important to note that the preprocessor works with directives on a line by line basis. It is therefore important to ensure that each directive is on a line of its own. Don't place directives and source code on the same line.

It's also important not to mistake the compiler's preprocessor with the assembler's preprocessor. Any directive that starts with a dollar "$" is the compiler's preprocessor, and any directive that starts with a hash "#" is the assembler's preprocessor. They cannot be mixed, as each has no knowledge of the other.

Preprocessor directives can be nested in the same way as source code statements. For example:

```
$ifdef MyValue
   $if MyValue = 10
      Symbol CodeConst = 10
   $else
      Symbol CodeConst = 0
   $endif
$endif
```

Preprocessor directives are lines included in the code of the program that are not BASIC language statements but directives for the preprocessor itself. The preprocessor is actually a seperate entity to the compiler, and, as the name suggests, preprocesses the BASIC code before the actual compiler sees it. Preprocessor directives are always preceded by a dollar sign "$".

Preprocessor Directives

To define preprocessor macros the directive **$define** is used. Its format is:-

$define *identifier replacement*

When the preprocessor encounters this directive, it replaces any occurrence of *identifier* in the rest of the code by *replacement*. This replacement can be an expression, a statement, a block, or simply anything. The preprocessor does not understand BASIC, it simply replaces any occurrence of *identifier* by *replacement*.

```
$define TableSize 100
Dim Table1[TableSize] as Byte
Dim Table2[TableSize] as Byte
```

After the preprocessor has replaced TableSize, the code becomes equivalent to:-

```
Dim Table1[100] as Byte
Dim Table2[100] as Byte
```

The use of **$define** as a constant definer is only one aspect of the preprocessor, and **$define** can also work with parameters to define psuedo function macros. The syntax then is:-

$define *identifier* **(***parameter list***)** *replacement*

A simple example of a function-like macro is:-

```
$define RadToDeg(x) ((x) * 57.29578)
```

This defines a radians to degrees conversion which can be used as:-

```
Var1 = RadToDeg(34)
```

This is expanded in-place, so the caller does not need to clutter copies of the multiplication constant througout the code.

Precedence

Note that the example macro `RadToDeg(x)` given above uses normally unnecessary parentheses both around the argument and around the entire expression. Omitting either of these can lead to unexpected results. For example:-

Macro defined as:
```
$define RadToDeg(x) (x * 57.29578)
```
will expand
```
RadToDeg(a + b)
```
to
```
(a + b * 57.29578)
```

Macro defined as
```
$define RadToDeg(x) (x) * 57.29578
```
will expand
```
1 / RadToDeg(a)
```
to
```
1 / (a) * 57.29578
```

neither of which give the intended result.

Not all replacement tokens can be passed back to an assignment using the equals operator. If this is the case, the code needs to be similar to BASIC Stamp syntax, where the assignment variable is the last parameter:-

```
$define GetMax(x,y,z) If x > y Then z = x : Else : z = y
```

This would replace any occurrence of GetMax followed by three parameter (argument) by the replacement expression, but also replacing each parameter by its identifier, exactly as would be expected of a function.

```
Dim Var1 as Byte
Dim Var2 as Byte
Dim Var3 as Byte

Var1 = 100
Var2 = 99
GetMax(Var1, Var2, Var3)
```

The previous would be placed within the BASIC program as:-

```
Dim Var1 as Byte
Dim Var2 as Byte
Dim Var3 as Byte

Var1 = 100
Var2 = 99
If Var1 > Var2 Then Var3 = Var1 : Else : Var3 = Var2
```

Notice that the third parameter "Var3" is loaded with the result.

A macro lasts until it is undefined with the **$undef** preprocessor directive:-

```
$define TableSize 100
Dim Table1[TableSize] as Byte
$undef TableSize
$define TableSize 200
Dim Table2[TableSize] as Byte
```

This would generate the same code as:-

```
Dim Table1[100] as Byte
Dim Table2[200] as Byte
```

Because preprocessor replacements happen before any BASIC syntax check, macro definitions can be a tricky feature, so be careful. Code that relies heavily on complicated macros may be difficult to understand, since the syntax they expect is, on many occasions, different from the regular expressions programmers expect in Proton BASIC.

Preprocessor directives only extend across a single line of code. As soon as a newline character is found (end of line), the preprocessor directive is considered to end. The only way a preprocessor directive can extend through more than one line is by preceding the newline character at the end of the line by a comment character (') followed by a new line. No comment text can follow the comment character. For example:-

```
$define GetMax(x,y,z) If x > y Then    '
                          z = x        '
                      Else             '
                          z = y        '
                      EndIf
```

```
GetMax(Var1, Var2, Var3)
```

The compiler will see:-

```
If Var1 > Var2 Then
   Var3 = Var1
Else
   Var3 = Var2
EndIf
```

Note that parenthasis is always required around the **$define** declaration and its use within the program.

If the *replacement* argument is not included within the **$define** directive, the *identifier* argument will output nothing. However, it can be used as an identifier for conditional code:-

```
$define DoThis

$ifdef DoThis
   {Rest of Code here}
$endif
```

$undef *identifier*
This removes any existing definition of the user macro *identifier*.

$eval *expression*
In normal operation, the **$define** directive simply replaces text, however, using the **$eval** directive allows constant value expressions to be evaluated before replacement within the BASIC code. For example:-

```
$define Expression(Prm1) $eval Prm1 << 1
```

The above will evaluate the constant parameter Prm1, shifting it left one position.

```
Var1 = Expression(1)
```

Will be added to the BASIC code as:-

```
Var1 = 2
```

Because 1 shifted left one position is 2.

Several operators are available for use with an expression. These are +, -, *, -, ~, <<, >>, =, >, <, >=, <=, <>, And, Or, Xor.

Conditional Directives ($ifdef, $ifndef, $if, $endif, $else and $elseif)
Conditional directives allow parts of the code to be included or discarded if a certain condition is met.

$ifdef allows a section of a program to be compiled only if the macro that is specified as the parameter has been defined, no matter what its value is. For example:-

```
$ifdef TableSize
   Dim Table[TableSize] as Byte
$endif
```

In the above condition, the line of code *Dim Table[TableSize] as Byte* is only compiled if TableSize was previously defined with **$define**, independent of its value. If it was not defined, the line will not be included in the program compilation.

$ifndef serves for the exact opposite: the code between **$ifndef** and **$endif** directives is only compiled if the specified identifier has not been previously defined. For example:-

```
$ifndef TableSize
   $define TableSize 100
$endif
Dim Table[TableSize] as Byte
```

In the previous code, when arriving at this piece of code, the TableSize directive has not been defined yet. If it already existed it would keep its previous value since the **$define** directive would not be executed.

A valuable use for $ifdef is that of a code guard with include files. This allows multiple insertions of a file, but only the first will be used.

A typical code guard looks like:

```
$ifndef IncludeFileName
   $define IncludeFileName
   { BASIC Code goes Here }
$endif
```

The logic of the above snippet is that if the include file has not previously been loaded into the program, the **$define** *IncludeFileName* will not have been created, thus allowing the inclusion of the code between **$ifndef** and **$endif**. However, if the include file has been previously loaded, the **$define** will have already been created, and the condition will be false, thus not allowing the code to be used.

IncludeFileName must be unique to each file. Therefore, it is recommended that a derivative of the Include File's name is used.

$if *expression*
This directive invokes the arithmetic evaluator and compares the result in order to begin a conditional block. In particular, note that the logical value of *expression* is always true when it cannot be evaluated to a number.

The **$if** directive as well as the **$elseif** directive can use quite complex logic. For example:-

```
$if _device = _18F452 or _device = _18F4520 and _core = 16
   { BASIC Code Here }
$endif
```

There are several built in user defines that will help separate blocks of code. These are:-

- **_device**. This holds the PICmicro™ device name, as a string. i.e. _18F452, _12F508, _16F684 etc. Notice the preceding underscore
- **_core**.   This holds the device's core. i.e. 12 for 12-bit core devices, 14 for 14-bit core (16F) devices, and 16 for 18F devices.
- **_ecore**   This is valid if the device is an enhanced 14-bit core type
- **_ram**.   This holds the amount of RAM contained in the device (in bytes).
- **_code**.   This holds the amount of flash memory in the device. In *words* for 12 and 14-bit core devices, and *bytes* for 18F devices.
- **_eeprom**.   This holds the amount of eeprom memory the device contains.
- **_ports**.   This holds the amount of I/O ports that the device has.
- **_adc**.   This holds the amount of ADC channels the device has.
- **_adcres**.This holds the resolution of the device's ADC. i.e. 8, 10, or 12.
- **_uart**.   This holds the amount of UARTs or USARTS the device has. i.e. 0, 1, or 2
- **_usb**.   This holds the amount of USB peripherals the device has. i.e. 0 or 1
- **_flash**.   This informs of the ability for the device to access it's own code memory. 0 = no access, 1 = read and write, and 2 = read only

The values for the user defines are taken from the compiler's PPI files, and are only available if the compiler's **Device** directive is included within the BASIC program.

$else
This toggles the logical value of the current conditional block. What follows is evaluated if and only if the preceding input was commented out.

$endif
This ends a conditional block started by the **$if** directive.

$elseif *expression*
This directive can be used to avoid nested **$if** conditions. **$if..$elseif..$endif** is equivalent to **$if..$else $if ..$endif $endif**.

The **$if**, **$else** and **$elseif** directives serve to specify some condition to be met in order for the portion of code they surround to be compiled. The condition that follows **$if** or **$elseif** can only evaluate constant expressions, including macro expressions. For example:-

```
$if TableSize > 200
   $undef TableSize
   $define TableSize 200

$elseif TableSize < 50
   $undef TableSize
   $define TableSize 50

$else
   $undef TableSize
   $define TableSize 100
$endif

Dim Table[TableSize] as Byte
```

Notice how the whole structure of **$if**, **$elseif** and **$else** chained directives ends with **$endif**.

The behavior of **$ifdef** and **$ifndef** can also be achieved by using the special built-in user directive _**defined** and **!** _**defined** respectively, in any **$if** or **$elseif** condition. These allow more flexability than **$ifdef** and **$ifndef**. For example:-

```
$if _defined (MyDefine) and _defined (AnotherDefine)
   { BASIC Code Here }
$endif
```

The argument for the _**defined** user directive must be surrounded by parenthasis. The preceding character "!" means "not".

$error *message*
This directive causes an error message with the current filename and line number. Subsequent processing of the code is then aborted.

```
$error Error Message Here
```

Proton IDE Overview

Proton IDE is a professional and powerful Integrated Development Environment (IDE) designed specifically for the Proton compiler. Proton IDE is designed to accelerate product development in a comfortable user friendly environment without compromising performance, flexibility or control.

Code Explorer

Possibly the most advanced code explorer for PICmicro™ based development on the market. Quickly navigate your program code and device Special Function Registers (SFRs).

Compiler Results

Provides information about the device used, the amount of code and data used, the version number of the project and also date and time. You can also use the results window to jump to compilation errors.

Programmer Integration

The Proton IDE enables you to start your preferred programming software from within the development environment . This enables you to compile and then program your microcontroller with just a few mouse clicks (or keyboard strokes, if you prefer).

Integrated Bootloader

Quickly download a program into your microcontroller without the need of a hardware programmer. Bootloading can be performed in-circuit via a serial cable connected to your PC.

Real Time Simulation Support

Proteus Virtual System Modelling (VSM) combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. For the first time ever, it is possible to develop and test such designs before a physical prototype is constructed.

Serial Communicator

A simple to use utility which enables you to transmit and receive data via a serial cable connected to your PC and development board. The easy to use configuration window allows you to select port number, baudrate, parity, byte size and number of stop bits. Alternatively, you can use Serial Communicator favourites to quickly load pre-configured connection settings.

Online Updating

Online updates enable you to keep right up to date with the latest IDE features and fixes.

Plugin Architecture

The Proton IDE has been designed with flexibility in mind with support for IDE plugins.

Supported Operating Systems

Windows XP or Windows 7 or Windows 8 or Windows 10

Minimum Hardware Requirements

1 GHz Processor
1 GB RAM
40 GB hard drive space
16 bit graphics card.

Menu Bar

File Menu

- **New** - Creates a new document. A header is automatically generated, showing information such as author, copyright and date. To toggle this feature on or off, or edit the header properties, you should select editor options.

- **Open** - Displays a open dialog box, enabling you to load a document into the Proton IDE. If the document is already open, then the document is made the active editor page.

- **Save** - Saves a document to disk. This button is normally disabled unless the document has been changed. If the document is 'untitled', a save as dialog is invoked. A save as dialog is also invoked if the document you are trying to save is marked as read only.

- **Save As** - Displays a save as dialog, enabling you to name and save a document to disk.

- **Close** - Closes the currently active document.

- **Close All** - Closes all editor documents and then creates a new editor document.

- **Reopen** - Displays a list of Most Recently Used (MRU) documents.

- **Print Setup** - Displays a print setup dialog.

- **Print Preview** - Displays a print preview window.

- **Print** - Prints the currently active editor page.

- **Exit** - Enables you to exit the Proton IDE.

Edit Menu

- **Undo** - Cancels any changes made to the currently active document page.

- **Redo** - Reverse an undo command.

- **Cut** - Cuts any selected text from the active document page and places it into the clipboard. This option is disabled if no text has been selected. Clipboard data is placed as both plain text and RTF.

- **Copy** - Copies any selected text from the active document page and places it into the clipboard. This option is disabled if no text has been selected. Clipboard data is placed as both plain text and RTF.

- **Paste** - Paste the contents of the clipboard into the active document page. This option is disabled if the clipboard does not contain any suitable text.

- **Delete** - Deletes any selected text. This option is disabled if no text has been selected.

- **Select All** - Selects the entire text in the active document page.

- **Change Case** - Allows you to change the case of a selected block of text.

- **Find** - Displays a find dialog.

- **Replace** - Displays a find and replace dialog.

- **Find Next** - Automatically searches for the next occurrence of a word. If no search word has been selected, then the word at the current cursor position is used. You can also select a whole phrase to be used as a search term. If the editor is still unable to identify a search word, a find dialog is displayed.

View Menu

- **Results** - Display or hide the results window.

- **Code Explorer** - Display or hide the code explorer window.

- **Loader** - Displays the MicroCode Loader application.

- **Loader Options** - Displays the MicroCode Loader options dialog.

- **Compile and Program Options** - Displays the compile and program options dialog.

- **Editor Options** - Displays the application editor options dialog.

- **Toolbars** - Display or hide the main, edit and compile and program toolbars. You can also toggle the toolbar icon size.

- **Plugin** - Display a drop down list of available IDE plugins.

Help Menu

- **Help Topics** - Displays the helpfile section for the toolbar.

- **Online Forum** - Opens your default web browser and connects to the online Proton Plus developer forum.

- **About** - Display about dialog, giving both the Proton IDE and Proton compiler version numbers.

Main Toolbar

New

Creates a new document. A header is automatically generated, showing information such as author, copyright and date. To toggle this feature on or off, or edit the header properties, you should select the editor options dialog from the main menu.

Open

Displays a open dialog box, enabling you to load a document into the Proton IDE. If the document is already open, then the document is made the active editor page.

Save

Saves a document to disk. This button is normally disabled unless the document has been changed. If the document is 'untitled', a save as dialog is invoked. A save as dialog is also invoked if the document you are trying to save is marked as read only.

Cut

Cuts any selected text from the active document page and places it into the clipboard. This option is disabled if no text has been selected. Clipboard data is placed as both plain text and RTF.

Copy

Copies any selected text from the active document page and places it into the clipboard. This option is disabled if no text has been selected. Clipboard data is placed as both plain text and RTF.

Paste

Paste the contents of the clipboard into the active document page. This option is disabled if the clipboard does not contain any suitable text.

Undo

Cancels any changes made to the currently active document page.

Redo

Reverse an undo command.

Print

Prints the currently active editor page.

Edit Toolbar

Find

Displays a find dialog.

Find and Replace

Displays a find and replace dialog.

Indent

Shifts all selected lines to the next tab stop. If multiple lines are not selected, a single line is moved from the current cursor position. All lines in the selection (or cursor position) are moved the same number of spaces to retain the same relative indentation within the selected block. You can change the tab width from the editor options dialog.

Outdent

Shifts all selected lines to the previous tab stop. If multiple lines are not selected, a single line is moved from the current cursor position. All lines in the selection (or cursor position) are moved the same number of spaces to retain the same relative indentation within the selected block. You can change the tab width from the editor options dialog.

Block Comment
Adds the comment character to each line of a selected block of text. If multiple lines are not selected, a single comment is added to the start of the line containing the cursor.

Block Uncomment
Removes the comment character from each line of a selected block of text. If multiple lines are not selected, a single comment is removed from the start of the line containing the cursor.

Compile and Program Toolbar

Compile
Pressing this button, or F9, will compile the currently active editor page. The compile button will generate a *.hex file, which you then have to manually program into your microcontroller. Pressing the compile button will automatically save all open files to disk. This is to ensure that the compiler is passed an up to date copy of the file(s) your are editing.

Compile and Program
Pressing this button, or F10, will compile the currently active editor page. Pressing the compile and program button will automatically save all open files to disk. This is to ensure that the compiler is passed an up to date copy of the file(s) your are editing.

Unlike the compile button, the Proton IDE will then automatically invoke a user selectable application and pass the compiler output to it. The target application is normally a device programmer, for example, MicroCode Loader. This enables you to program the generated *.hex file into your MCU. Alternatively, the compiler output can be sent to an IDE Plugin. For example, the Labcenter Electronics Proteus VSM simulator. You can select a different programmer or Plugin by pressing the small down arrow, located to the right of the compile and program button...

```
  Install New Programmer...
  _____
  ✓  MicroCode Loader
     microEngineering Labs Serial Programmer
  _____
  Labcenter Electronics PROTEUS VSM...
```
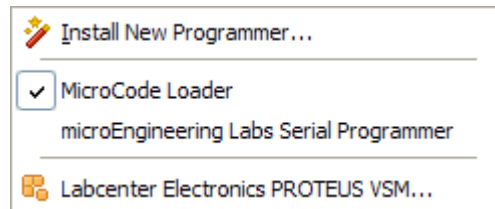
In the above example, MicroCode Loader has been selected as the default device programmer. The compile and program drop down menu also enables you to install new programming software. Just select the 'Install New Programmer...' option to invoke the programmer configuration wizard. Once a program has been compiled, you can use F11 to automatically start your programming software or plugin. You do not have to re-compile, unless of course your program has been changed.

Loader Verify
This button will verify a *.hex file (if one is available) against the program resident on the microcontroller. The loader verify button is only enabled if MicroCode Loader is the currently selected programmer.

Loader Read

This button will upload the code and data contents of a microcontroller to MicroCode Loader. The loader read button is only enabled if MicroCode Loader is the currently selected programmer.

Loader Erase

This button will erase program memory for the 18Fxxx(x) series of microcontroller. The loader erase button is only enabled if MicroCode Loader is the currently selected programmer.

Loader Information

This button will display the microcontroller loader firmware version. The loader information button is only enabled if MicroCode Loader is the currently selected programmer.

Code Explorer

The code explorer enables you to easily navigate your program code. The code explorer tree displays your currently selected processor, include files, declares, constants, variables, alias and modifiers, labels, macros and data labels.

Device Node

The device node is the first node in the explorer tree. It displays your currently selected processor type. For example, if you program has the declaration: -

```
Device = 16F1829
```

then the name of the device node will be 16F1829. You don't need to explicitly give the device name in your program for it to be displayed in the explorer. For example, you may have an include file with the device type already declared. The code explorer looks at all include files to determine the device type. The last device declaration encountered is the one used in the explorer window. If you expand the device node, then all Special Function Registers (SFRs) belonging to the selected device are displayed in the explorer tree.

Include File Node

When you click on an include file, the IDE will automatically open that file for viewing and editing. Alternatively, you can just explorer the contents of the include file without having to open it. To do this, just click on the ⊞ icon and expand the node. For example: -
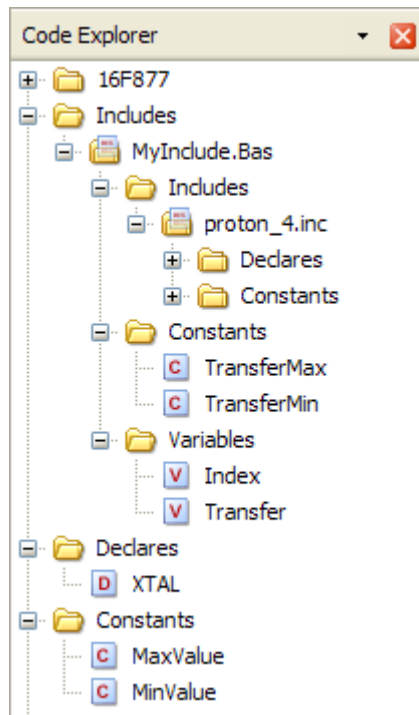
In the above example, clicking on the ⊞ icon for MyInclude.bas has expanded the node to reveal its contents. You can now see that MyInclude.bas has two constant declarations called TransferMax and TransferMin and also two variables called Index and Transfer. The include file also contains another include file called proton_4.inc. Again, by clicking the ⊞ icon, the contents of proton_4.inc can be seen, without opening the file. Clicking on a declaration name will open the include file and automatically jump to the line number. For example, if you were to click on TransferMax, the include file MyInclude.bas would be opened and the declaration TransferMax would be marked in the IDE editor window.

When using the code explorer with include files, you can use the explorer history buttons to go backwards or forwards. The explorer history buttons are normally located to the left of the main editors file select tabs,

History back button
History forward button

Additional Nodes
Declares, constants, variables, alias and modifiers, labels, macros and data label explorer nodes work in much the same way. Clicking on any of these nodes will take you to its declaration. If you want to find the next occurrence of a declaration, you should enable automatically select variable on code explorer click from *View...Editor Options*.

Selecting this option will load the search name into the 'find dialog' search buffer. You then just need to press F3 to search for the next occurrence of the declaration in your program. To sort the explorer nodes, right click on the code explorer and check the Sort Nodes option.

Explorer Warnings and Errors
The code explorer can identify duplicate declarations. If a declaration duplicate is found, the explorer node icon changes from its default state to a . For example,

```
Dim MyVar as Byte
Dim MyVar as Byte
```

The above example is rather simplistic. It is more likely you see the duplicate declaration error in you program without an obvious duplicate partner. That is, only one single duplicate error symbol is being displayed in the code explorer. In this case, the declaration will have a duplicate contained in an include file. For example,
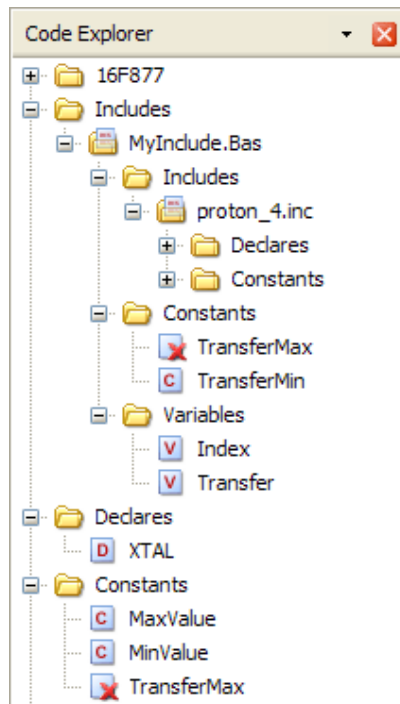
The declaration TransferMax has been made in the main program and marked as a duplicate. By exploring your include files, the problem can be identified. In this example, TransferMax has already been declared in the include file MyInclude.bas

Some features of the compiler of not available for some MCU types. For example, you cannot have a string declaration when using a 14 core part (for example, the 16F1829). If you try to do this, the explorer node icon changes from its default state and displays a ⌵. You will also see this icon displayed if the SFR View feature for a device is not available.

Notes
The code explorer uses an optimised parse and pattern match strategy in order to update the tree in real time. The explorer process is threaded so as not to interfere or slow down other IDE tasks, such as typing in new code. However, if you run computationally expensive background tasks on your machine (for example, circuit simulation) you will notice a drop in update performance, due to the threaded nature of the code explorer.

Results View

The results view performs two main tasks. These are (a) display a list of error messages, should either compilation or assembly fail and (b) provide a summary on compilation success.

Compilation Success View
By default, a successful compile will display the results success view. This provides information about the device used, the amount of code and data used, the version number of the project and also date and time.
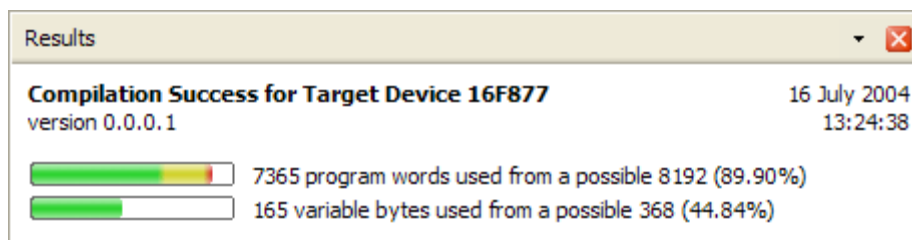
If you don't want to see full summary information after a successful compile, select *View...Editor Options* from the IDE main menu and uncheck display full summary after successful compile. The number of program words (or bytes used, if its a 16 core device) and the number of data bytes used will still be displayed in the IDE status bar.

Version Numbers
The version number is automatically incremented after a successful build. Version numbers are displayed as major, minor, release and build. Each number will rollover if it reaches 256. For example, if your version number is 1.0.0.255 and you compile again, the number displayed will be 1.0.1.0. You might want to start you version information at a particular number. For example 1.0.0.0. To do this, click on the version number in the results window to invoke the version information dialog. You can then set the version number to any start value. Automatic incrementing will then start from the number you have specified. To disable version numbering, click on the version number in the results window to invoke the version information dialog and then uncheck enable version information.

Date and Time
Date and time information is extracted from the generated *.hex file and is always displayed in the results view.

Success - With Warnings!
A compile is considered successful if it generates a *.hex file. However, you may have generated a number of warning messages during compilation. Because you should not normally ignore warning messages, the IDE will always display the error view, rather than the success view, if warnings have been generated.

To toggle between these different views, you can do one of the following click anywhere on the IDE status bar right click on the results window and select the Toggle View option.

Compilation Error View
If your program generates warning or error messages, the error view is always displayed.

```
Results                                                        ▾  ✕
  ⊗ ERROR [Line 19] : Variable ' A ' not found! (includeroot.bas)
  ⊗ ERROR [Line 20] : Variable ' LABEL ' not found! (includeroot.bas)
```
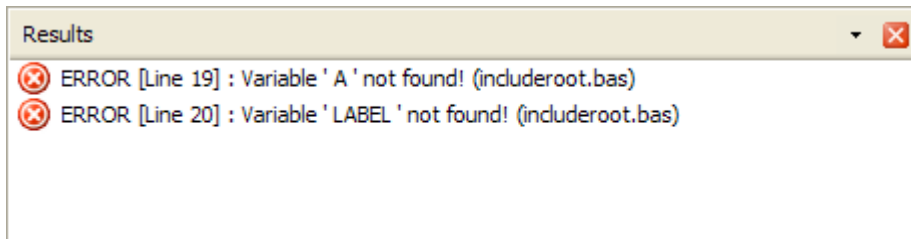
Clicking on each error or warning message will automatically highlight the offending line in the main editor window. If the error or warning has occurred in an include file, the file will be opened and the line highlighted. By default, the IDE will automatically highlight the first error line found. To disable this feature, select *View...Editor Options* from the IDE main menu and uncheck automatically jump to first compilation error. At the time of writing, some compiler errors do not have line numbers bound to them. Under these circumstances, Proton IDE will be unable to automatically jump to the selected line.

Occasionally, the compiler will generate a valid Asm file but warnings or errors are generated during assembly. Proton IDE will display all assembler warnings or error messages in the error view, but you will be unable to automatically jump to a selected line.

Editor Options
The editor options dialog enables you to configure and control many of the Proton IDE features. The window is composed of four main areas, which are accessed by selecting the General, Highlighter, Program Header and Online Updating tabs.

Show Line Numbers in Left Gutter
Display line numbers in the editors left hand side gutter. If enabled, the gutter width is increased in size to accommodate a five digit line number.

Show Right Gutter
Displays a line to the right of the main editor. You can also set the distance from the left margin (in characters). This feature can be useful for aligning your program comments.

Use Smart Tabs
Normally, pressing the tab key will advance the cursor by a set number of characters. With smart tabs enabled, the cursor will move to a position along the current line which depends on the text on the previous line. Can be useful for aligning code blocks.

Convert Tabs to Spaces
When the tab key is pressed, the editor will normally insert a tab control character, whose size will depend on the value shown in the width edit box (the default is four spaces). If you then press the backspace key, the whole tab is deleted (that is, the cursor will move back four spaces). If convert tabs to spaces is enabled, the tab control character is replaced by the space control character (multiplied by the number shown in the width edit box). Pressing the backspace key will therefore only move the cursor back by one space. Please note that internally, the editor does not use hard tabs, even if convert tabs to spaces is unchecked.

Automatically Indent

When the carriage return key is pressed in the editor window, automatically indent will advance the cursor to a position just below the first word occurrence of the previous line. When this feature is unchecked, the cursor just moves to the beginning of the next line.

Show Parameter Hints

If this option is enabled, small prompts are displayed in the main editor window when a particular compiler keyword is recognised. For example,

DELAYMS

DELAYMS *Value or Variable or Expression*

Parameter hints are automatically hidden when the first parameter character is typed. To view the hint again, press F1. If you want to view more detailed context sensitive help, press F1 again.

Open Last File(s) When Application Starts

When checked, the documents that were open when Proton IDE was closed are automatically loaded again when the application is restarted.

Display Full Filename Path in Application Title Bar

By default, Proton IDE only displays the document filename in the main application title bar (that is, no path information is includes). Check display full pathname if you would like to display additional path information in the main title bar.

Prompt if File Reload Needed

Proton IDE automatically checks to see if a file time stamp has changed. If it has (for example, and external program has modified the source code) then a dialog box is displayed asking if the file should be reloaded. If prompt on file reload is unchecked, the file is automatically reloaded without any prompting.

Automatically Select Variable on Code Explorer Click

By default, clicking on a link in the code explorer window will take you to the part of your program where a declaration has been made. Selecting this option will load the search name into the 'find dialog' search buffer. You then just need to press F3 to search for the next occurrence of the declaration in your program.

Automatically Jump to First Compilation Error

When this is enabled, Proton IDE will automatically jump to the first error line, assuming any errors are generated during compilation.

Automatically Change Identifiers to Match Declaration

When checked, this option will automatically change the identifier being typed to match that of the actual declaration. For example, if you have the following declaration,

Dim MyIndex **as Byte**

and you type 'myindex' in the editor window, Proton IDE will automatically change 'myindex' to 'MyIndex'. Identifiers are automatically changed to match the declaration even if the declaration is made in an include file.

Please note that the actual text is not physically changed, it just changes the way it is displayed in the editor window. For example, if you save the above example and load it into wordpad or another text editor, it will still show as 'myindex'. If you print the document, the identifier will be shown as 'MyIndex'. If you copy and paste into another document, the identifier will be shown as 'MyIndex', if the target application supports formatted text (for example Microsoft Word). In short, this feature is very useful for printing, copying and making you programs look consistent throughout.

Clear Undo History After Successful Compile
If checked, a successful compilation will clear the undo history buffer. A history buffer takes up system resources, especially if many documents are open at the same time. It's a good idea to have this feature enabled if you plan to work on many documents at the same time.

Display Full Summary After Successful Compile
If checked, a successful compilation will display a full summary in the results window. Disabling this option will still give a short summary in the IDE status bar, but the results window will not be   displayed.

Default Source Folder
Proton IDE will automatically go to this folder when you invoke the file open or save as dialogs. To disable this feature, uncheck the 'Enabled' option, shown directly below the default source folder.

Highlighter Options

Item Properties
The syntax highlighter tab lets you change the colour and attributes (for example, bold and italic) of the following items: -

Comment
Device Name
Identifier
Keyword (Asm)
Keyword (Declare)
Keyword (Important)
Keyword (Macro Parameter)
Keyword (Proton)
Keyword (User)
Number
Number (Binary)
Number (Hex)
SFR
SFR (Bitname)
String
Symbol
Preprocessor

The point size is ranged between 6pt to 16pt and is global. That is, you cannot have different point sizes for individual items.

Reserved Word Formatting

This option enables you to set how Proton IDE displays keywords. Options include: -

Database Default - the IDE will display the keyword as declared in the applications keyword database.

Uppercase - the IDE will display the keyword in uppercase.

Lowercase - the IDE will display the keyword in lowercase.

As Typed - the IDE will display the keyword as you have typed it.

Please note that the actual keyword text is not physically changed, it just changes the way it is displayed in the editor window. For example, if you save your document and load it into word-pad or another text editor, the keyword text will be displayed as you typed it. If you print the document, the keyword will be formatted. If you copy and paste into another document, the keyword will be formatted, if the target application supports formatted text (for example Microsoft Word).

Header options allows you to change the author and copyright name that is placed in a header when a new document is created. For example: -

```
    '***************************************************************
    '* Name    : Untitled.bas                                      *
    '* Author  : J.R Hartley                                       *
    '* Notice  : Copyright (c) 2016 MyCompany                      *
    '*         : All Rights Reserved                               *
    '* Date    : 06/03/16                                          *
    '* Version : 1.0                                               *
    '* Notes   :                                                   *
    '*         :                                                   *
    '***************************************************************
```

If you do not want to use this feature, simply deselect the enable check box.

Compile and Program Options

Compiler Tab
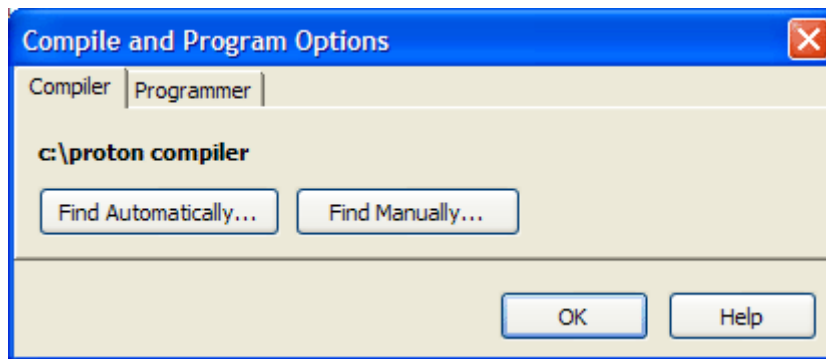
You can get the Proton IDE to locate a compiler directory automatically by clicking on the find automatically button. The auto-search feature will stop when a compiler is found.

Alternatively, you can select the directory manually by selecting the find manually button. The auto-search feature will search for a compiler and if one is found, the search is stopped and the path pointing to the compiler is updated. If you have multiple versions of a compiler installed on your system, use the find manually button. This ensures the correct compiler is used by the IDE.

Programmer Tab
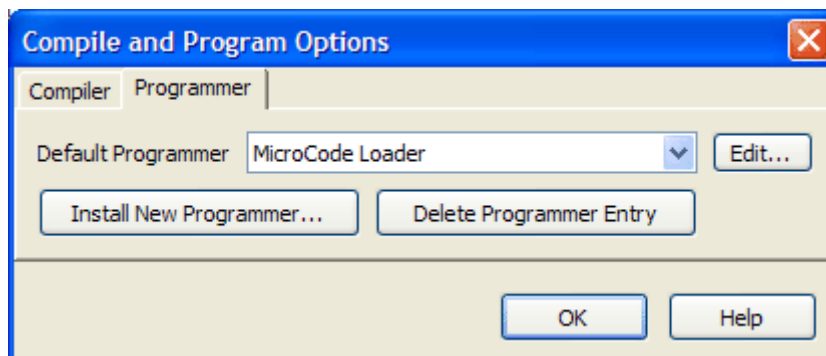
Use the programmer tab to install a new programmer, delete a programmer entry or edit the currently selected programmer. Pressing the Install New Programmer button will invoke the install new programmer wizard. The Edit button will invoke the install new programmer wizard in custom configuration mode.

Installing a Programmer

The Proton IDE enables you to start your preferred programming software from within the development environment . This enables you to compile and then program your microcontroller with just a few mouse clicks (or keyboard strokes, if you prefer). The first thing you need to do is tell Proton IDE which programmer you are using. Select View...Options from the main menu bar, then select the Programmer tab. Next, select the Add New Programmer button. This will open the install new programmer wizard.
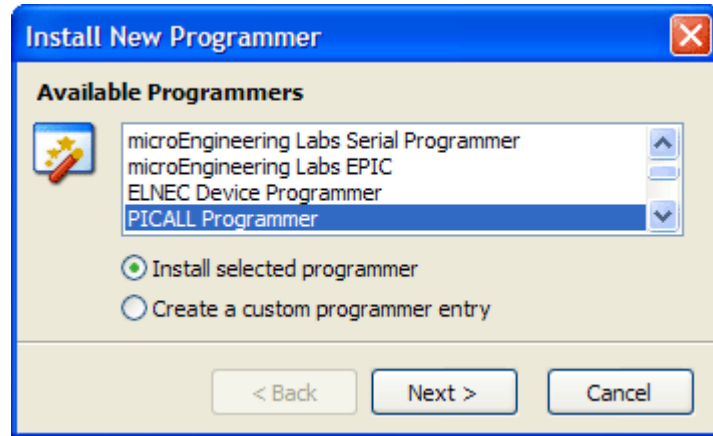
Select the programmer you want Proton IDE to use, then choose the Next button. Proton IDE will now search your computer until it locates the required executable. If your programmer is not in the list, you will need to create a custom programmer entry.

Your programmer is now ready for use. When you press the Compile and Program button on the main toolbar, you program is compiled and the programmer software started. The *.hex filename and target device is automatically set in the programming software (if this feature is supported), ready for you to program your microcontroller.

You can select a different programmer, or install another programmer, by pressing the small down arrow, located to the right of the compile and program button, as shown below
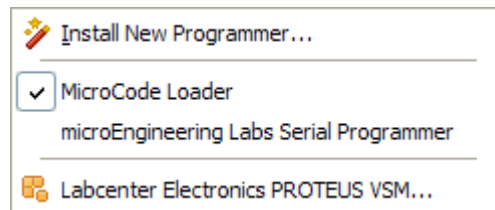
Creating a custom Programmer Entry

In most cases, Proton IDE has a set of pre-configured programmers available for use. However, if you use a programmer not included in this list, you will need to add a custom programmer entry. Select View...Options from the main menu bar, then select the Programmer tab. Next, select the Add New Programmer button. This will open the install new programmer wizard. You then need to select 'create a custom programmer entry', as shown below
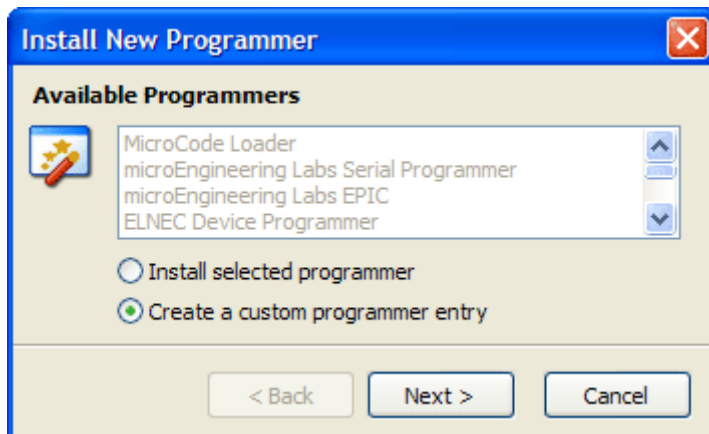
Select Display Name

The next screen asks you to enter the display name. This is the name that will be displayed in any programmer related drop down boxes. Proton IDE enables you to add and configure multiple programmers. You can easily switch from different types of programmer from the compile and program button, located on the main editor toolbar. The multiple programmer feature means you do not have to keep reconfiguring your system when you switch programmers. Proton IDE will remember the settings for you. In the example below, the display name will be 'My New Programmer'.
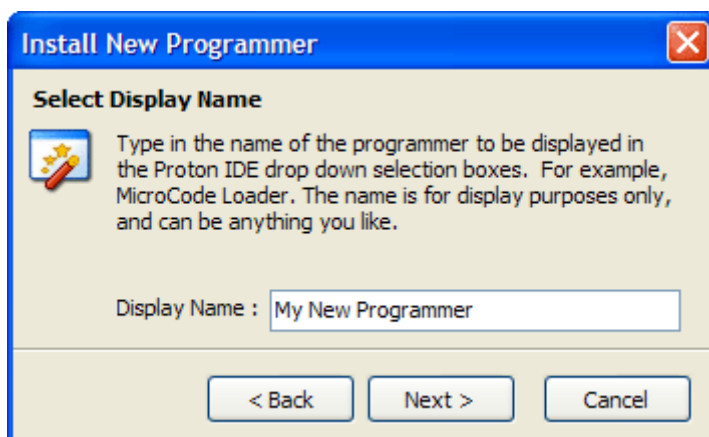
Select Programmer Executable

The next screen asks for the programmer executable name. You do not have to give the full path, just the name of the executable name will do.
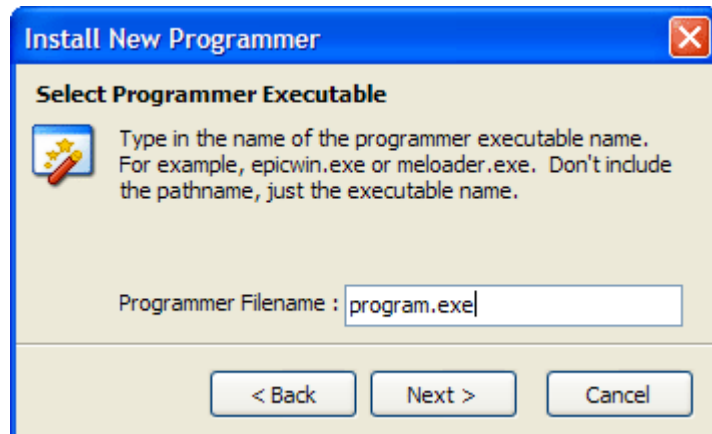
Select Programmer Path

The next screen is the path to the programmer executable. You can let Proton IDE find it automatically, or you can select it manually.
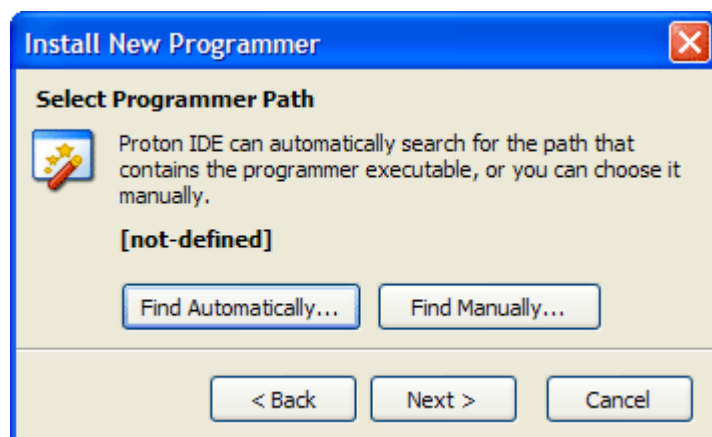
Select Parameters

The final screen is used to set the parameters that will be passed to your programmer. Some programmers, for example, EPICWin™ allows you to pass the device name and hex filename. Proton IDE enables you to 'bind' the currently selected device and *.hex file you are working on.
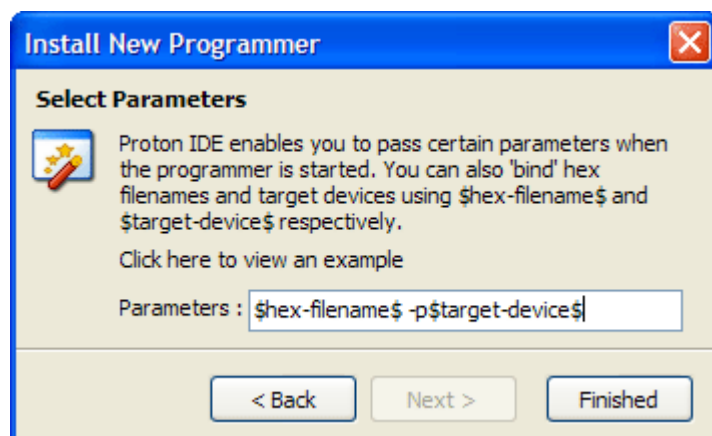
For example, if you are compiling 'blink.bas' in the Proton IDE using a 16F628, you would want to pass the 'blink.hex' file to the programmer and also the name of the microcontroller you intend to program. Here is the EPICWin™ example: -

    -pPIC$target-device$ $hex-filename$

When EPICWin™ is started, the device name and hex filename are 'bound' to $target-device$ and $hex-filename$ respectively. In the 'blink.bas' example, the actual parameter passed to the programmer would be: -

-pPIC16F628 blink.hex

Parameter Summary

Parameter	Description
$target-device$	Microcontroller name
$hex-filename$	Hex filename and path, DOS 8.3 format
$long-hex-filename$	Hex filename and path
$asm-filename$	Asm filename and path, DOS 8.3 format
$long-asm-filename$	Asm filename and path

Microcode Loader

Most of the modern PICmicros have the ability to write to their own program memory, without the need of a hardware programmer. A small piece of software called a bootloader resides on the target microcontroller, which allows user code and eeprom data to be transmitted over a serial cable and written to the device. The MicroCode Loader application is the software which resides on the computer. Together, these two components enable a user to program, verify and read their program and eeprom data all in circuit.

When power is first applied to the microcontroller (or it is reset), the bootloader first checks to see if the MicroCode Loader application has something for it to do (for example, program your code into the target device). If it does, the bootloader gives control to MicroCode Loader until it is told to exit. However, if the bootloader does not receive any instructions with the first few hundred milliseconds of starting, the bootloader will exit and the code previously written to the target device will start to execute.

The bootloader software resides in the upper 256 words of program memory (336 words for 18Fxxx devices), with the rest of the microcontroller code space being available for your program. All eeprom data memory and microcontroller registers are available for use by your program. Please note that only the program code space and eeprom data space may be programmed, verified and read by MicroCode Loader. The microcontroller ID location and configuration fuses are not available to the loader process. Configuration fuses must therefore be set at the time the bootloader software is programmed into the target microcontroller.

Hardware Requirements

MicroCode Loader communicates with the target microcontroller using its hardware Universal Synchronous Asynchronous Receiver Transmitter (USART). You will therefore need a development board that supports RS232 serial communication in order to use the loader. There are many boards available which support RS232.

Whatever board you have, if the board has a 9 pin serial connector on it, the chances are it will have a MAX232 or equivalent located on the board. This is ideal for MicroCode Loader to communicate with the target device using a serial cable connected to your computer. Alternatively, you can use the following circuit and build your own.
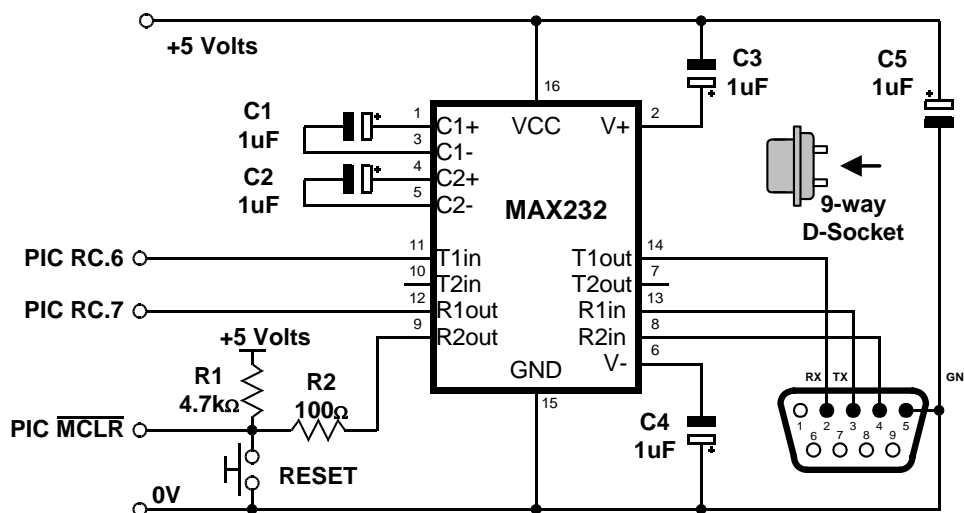
Note: Components R1, R2, and the Reset switch are optional, and serve to reset the microcontroller automatically. If these components are not used, the connections to R2in and R2out of the MAX232 may be omitted.

MicroCode Loader supports a host of devices capable of using a bootloader and the support will grow as new devices devices become available.

MicroCode Loader comes with a number of pre-compiled *.hex files, ready for programming into the target microcontroller. If you require a bootloader file with a different configuration, please contact Mecanique.

Using the Bootloader is very easy. Before using this guide make sure that your target microcontroller is supported by the loader and that you also have suitable hardware.

Programming the Loader Firmware
Before using the Bootloader, you need to ensure that the bootloader firmware has been programmed onto the target microcontroller using a hardware programmer. This is a one off operation, after which you can start programming your target device over an RS232 serial connection. You need to make sure that the bootloader *.hex file matches the clock speed of your target microcontroller. For example, if you are using a 16F877 on a development board running at 20MHz, then you need to use the firmware file called 16F877_20.hex. If you don't do this, the Bootloader will be unable to communicate with the target microcontroller. The Compiler comes with a number of pre-compiled *.hex files, ready for programming into the target microcontroller. The loader firmware files can be found in the MCLoader folder, located in your main IDE installation folder. Default fuse settings are embedded in the firmware *.hex file. You should not normally change these default settings. You should certainly never select the code protect fuse. If the code protect fuse is set the Bootloader will be unable to program your *.hex file.

Configuring the Loader

Assuming you now have the firmware installed on your microcontroller, you now just need to tell MicroCode Loader which COM port you are going to use. To do this, select View...Loader from the MicroCode IDE main menu. Select the COM port from the MicroCode Loader main toolbar. Finally, make sure that MicroCode Loader is set as your default programmer.

Click on the down arrow, to the right of the Compile and Program button. Check the MicroCode Loader option, like this: -

```
🪄  Install New Programmer...

 ✓  MicroCode Loader

     microEngineering Labs Serial Programmer

🔳  Labcenter Electronics PROTEUS VSM...
```
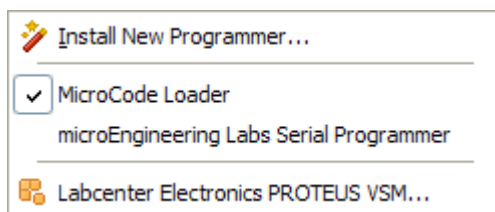
Using MicroCode Loader

Connect a serial cable between your computer and development board. Apply power to the board.

Press 'Compile and Program' or F10 to compile your program. If there are no compilation errors, the MicroCode Loader application will start. It may ask you to reset the development board in order to establish communications with the resident microcontroller bootloader. This is perfectly normal for development boards that do not implement a software reset circuit. If required, press reset to establish communications and program you microcontroller.

Loader Options

Loader options can be set by selecting the Options menu item, located on the main menu bar.

Program Code

Optionally program user code when writing to the target microcontroller. Uncheck this option to prevent user code from being programmed. The default is On.

Program Data

Optionally program Eeprom data when writing to the target microcontroller. Uncheck this option to prevent Eeprom data from being programmed. The default is On.

Verify Code When Programming

Optionally verify a code write operation when programming. Uncheck this option to prevent user code from being verified when programming. The default is On.

Verify Data When Programming

Optionally verify a data write operation when programming. Uncheck this option to prevent user data from being verified when programming. The default is On.

Verify Code

Optionally verify user code when verifying the loaded *.hex file. Uncheck this option to prevent user code from being verified. The default is On.

Verify Data

Optionally verify Eeprom data when verifying the loaded *.hex file. Uncheck this option to prevent Eeprom data from being verified. The default is On.

Verify After Programming
Performs an additional verification operation immediately after the target microcontroller has been programmed. The default is Off.

Run User Code After Programming
Exit the bootloader process immediately after programming and then start running the target user code. The default is On.

Load File Before Programming
Optionally load the latest version of the *.hex file immediately before programming the target microcontroller. The default is Off.

Baud Rate
Select the speed at which the computer communicates with the target microcontroller. By default, the Auto Detect option is enabled. This feature enables MicroCode Loader to determine the speed of the target microcontroller and set the best communication speed for that device.

If you select one of the baud rates manually, it must match the baud rate of the loader software programmed onto the target microcontroller. For devices running at less that 20MHz, this is 19200 baud. For devices running at 20MHz, you can select either 19200 or 115200 baud.

Loader Main Toolbar

Open Hex File
The open button loads a *.hex file ready for programming.

Program
The program button will program the loaded hex file code and eeprom data into the target microcontroller. When programming the target device, a verification is normally done to ensure the integrity of the programmed user code and eeprom data. You can override this feature by un-checking either Verify Code When Programming or Verify Data When Programming. You can also optionally verify the complete *.hex file after programming by selecting the Verify After Programming option.

Pressing the program button will normally program the currently loaded *.hex file. However, you can load the latest version of the *.hex file immediately before programming by checking Load File Before Programming option. You can also set the loader to start running the user code immediately after programming by checking the Run User Code After Programming option. When programming the target device, both user code and eeprom data are programmed by default (recommended). However, you may want to just program code or eeprom data. To change the default configuration, use the Program Code and Program Data options.

Should any problems arise when programming the target device, a dialog window will be displayed giving additional details. If no problems are encountered when programming the device, the status window will close at the end of the write sequence.

Read
The read button will read the current code and eeprom data from the target microcontroller.
Should any problems arise when reading the target device, a dialog window will be displayed giving additional details. If no problems are encountered when reading the device, the status window will close at the end of the read sequence.

Verify

The verify button will compare the currently loaded *.hex file code and eeprom data with the code and eeprom data located on the target microcontroller. When verifying the target device, both user code and eeprom data are verified by default. However, you may want to just verify code or eeprom data. To change the default configuration, use the Verify Code and Verify Data options.

Should any problems arise when verifying the target device, a dialog window will be displayed giving additional details. If no problems are encountered when verifying the device, the status window will close at the end of the verification sequence.

Erase

The erase button will erase all of the code memory on a PIC16F8x and PIC18Fxxx(x) micro-controller.

Run User Code

The run user code button will cause the bootloader process to exit and then start running the program loaded on the target microcontroller.

Loader Information

The loader information button displays the loader firmware version and the name of the target microcontroller, for example PIC16F877.
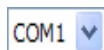
Loader Serial Port

The loader serial port drop down box allows you to select the com port used to communicate with the target microcontroller.

IDE Plugins

The Proton IDE has been designed with flexibility in mind. Plugins enable the functionality of the IDE to be extended by through additional third party software, which can be integrated into the development environment. Proton IDE comes with a default set of plugins which you can use straight away. These are: -

ASCII Table
Assembler
Hex View
Serial Communicator
Labcenter Electronics Proteus VSM
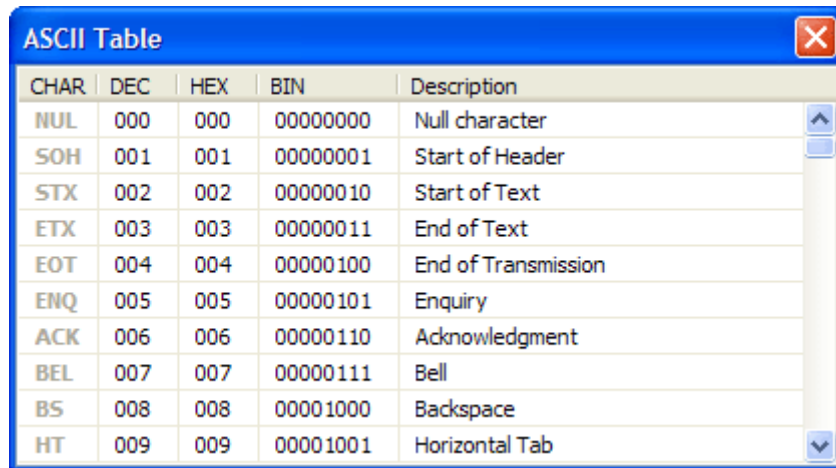
To access a plugin, select the plugin icon just above the main editor window. A drop down list of available plugins will then be displayed. Plugins can also be selected from the main menu, or by right clicking on the main editor window.

Plugin Developer Notes

The plugin architecture has been designed to make writing third party plugins very easy, using the development environment of your choice (for example Visual BASIC, C++ or Borland Del-phi). This architecture is currently evolving and is therefore publicly undocumented until all of the protocols have been finalised. As soon as the protocol details have been finalised, this documentation will be made public. For more information, please feel free to contact us.

ASCII Table

The American Standard Code for Information Interchange (ASCII) is a set of numerical codes, with each code representing a single character, for example, 'a' or '$'.

The ASCII table plugin enables you to view these codes in either decimal, hexadecimal or binary. The first 32 codes (0..31) are often referred to as non-printing characters, and are displayed as grey text.

Hex View

The Hex view plugin enables you to view program code and EEPROM data for 14 and 16 core devices.
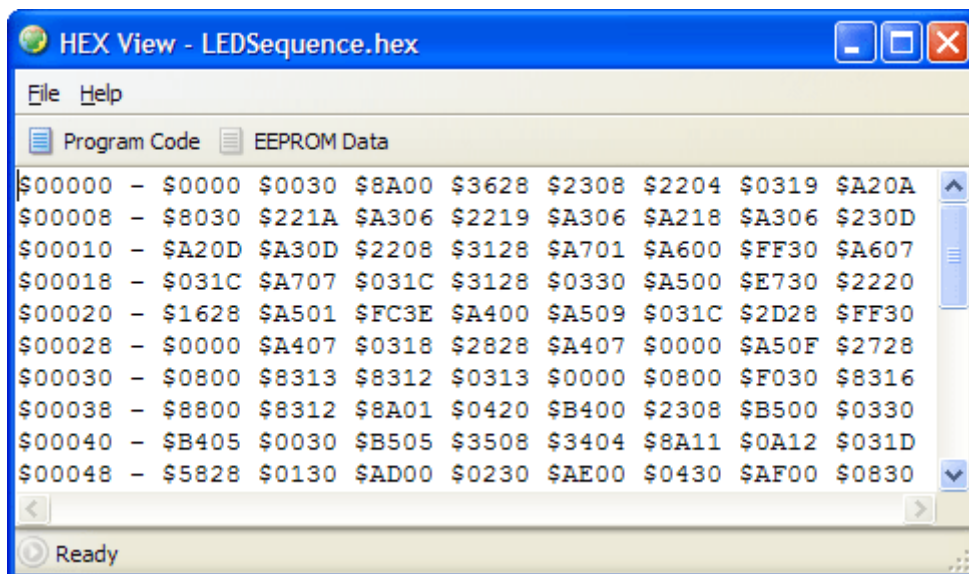
The Hex View window is automatically updated after a successful compile, or if you switch program tabs in the IDE. By default, the Hex view window remains on top of the main IDE window. To disable this feature, right click on the Hex View window and uncheck the Stay on Top option.

Assembler Window

The Assembler plugin allows you to view and modify the *.asm file generated by the compiler. Using the Assembler window to modify the generated *.asm file is not really recommended, unless you have some experience using assembler.

Assembler Menu Bar

File Menu

New - Creates a new document. A header is automatically generated, showing information such as author, copyright and date.

- **Open** - Displays a open dialog box, enabling you to load a document into the Assembler plugin. If the document is already open, then the document is made the active editor page.

- **Save** - Saves a document to disk. This button is normally disabled unless the document has been changed. If the document is 'untitled', a save as dialog is invoked. A save as dialog is also invoked if the document you are trying to save is marked as read only.

- **Save As** - Displays a save as dialog, enabling you to name and save a document to disk.

- **Close** - Closes the currently active document.

- **Close All** - Closes all editor documents and then creates a new editor document.

- **Reopen** - Displays a list of Most Recently Used (MRU) documents.

- **Print Setup** - Displays a print setup dialog.

- **Print** - Prints the currently active editor page.

- **Exit** - Enables you to exit the Assembler plugin.

Edit Menu
- **Undo** - Cancels any changes made to the currently active document page.

- **Redo** - Reverse an undo command.

- **Cut** - Cuts any selected text from the active document page and places it into the clipboard.

- **Copy** - Copies any selected text from the active document page and places it into the clipboard.

- **Paste** - Paste the contents of the clipboard into the active document page. This option is disabled if the clipboard does not contain any suitable text.

- **Delete** - Deletes any selected text. This option is disabled if no text has been selected.

- **Select All** - Selects the entire text in the active document ament page.

- **Find** - Displays a find dialog.

- **Replace** - Displays a find and replace dialog.

- **Find Next** - Automatically searches for the next occurrence of a word. If no search word has been selected, then the word at the current cursor position is used. You can also select a whole phrase to be used as a search term. If the editor is still unable to identify a search word, a find dialog is displayed.

View Menu
- **Options** - Displays the application editor options dialog.

- **Toolbars** - Display or hide the main and assemble and program toolbars. You can also toggle the toolbar icon size.

Help Menu
- **Help Topics** - Displays the IDE help file.

- **About** - Display about dialog, giving the Assembler plugin version number.

Assembler Main Toolbar

New

Creates a new document. A header is automatically generated, showing information such as author, copyright and date.

Open

Displays a open dialog box, enabling you to load a document into the Assembler plugin. If the document is already open, then the document is made the active editor page.

Save

Saves a document to disk. This button is normally disabled unless the document has been changed. If the document is 'untitled', a save as dialog is invoked. A save as dialog is also invoked if the document you are trying to save is marked as read only.

Cut

Cuts any selected text from the active document page and places it into the clipboard. This option is disabled if no text has been selected.

Copy

Copies any selected text from the active document page and places it into the clipboard. This option is disabled if no text has been selected.

Paste

Paste the contents of the clipboard into the active document page. This option is disabled if the clipboard does not contain any suitable text.

Undo

Cancels any changes made to the currently active document page.

Redo
Reverse an undo command.

Assembler Editor Options

Show Line Numbers in Left Gutter
Display line numbers in the editors left hand side gutter. If enabled, the gutter width is increased in size to accommodate a five digit line number.

Show Right Gutter
Displays a line to the right of the main editor. You can also set the distance from the left margin (in characters). This feature can be useful for aligning your program comments.

Use Smart Tabs
Normally, pressing the tab key will advance the cursor by a set number of characters. With smart tabs enabled, the cursor will move to a position along the current line which depends on the text on the previous line. Can be useful for aligning code blocks.

Convert Tabs to Spaces
When the tab key is pressed, the editor will normally insert a tab control character, whose size will depend on the value shown in the width edit box (the default is four spaces). If you then press the backspace key, the whole tab is deleted (that is, the cursor will move back four spaces). If convert tabs to spaces is enabled, the tab control character is replaced by the space control character (multiplied by the number shown in the width edit box). Pressing the backspace key will therefore only move the cursor back by one space. Please note that internally, the editor does not use hard tabs, even if convert tabs to spaces is unchecked.

Automatically Indent
When the carriage return key is pressed in the editor window, automatically indent will advance the cursor to a position just below the first word occurrence of the previous line. When this feature is unchecked, the cursor just moves to the beginning of the next line.

Show Parameter Hints
If this option is enabled, small prompts are displayed in the main editor window when a particular compiler keyword is recognised.

Open Last File(s) When Application Starts
When checked, the documents that were open when the Assembler plugin was closed are automatically loaded again when the application is restarted.

Display Full Filename Path in Application Title Bar
By default, the Assembler plugin only displays the document filename in the main application title bar (that is, no path information is included). Check display full pathname if you would like to display additional path information in the main title bar.

Prompt if File Reload Needed
The Assembler plugin automatically checks to see if a file time stamp has changed. If it has (for example, and external program has modified the source code) then a dialog box is displayed asking if the file should be reloaded. If prompt on file reload is unchecked, the file is automatically reloaded without any prompting.

Automatically Jump to First Compilation Error
When this is enabled, the Assembler plugin will automatically jump to the first error line, assuming any errors are generated during compilation.

Clear Undo History After Successful Compile
If checked, a successful compilation will clear the undo history buffer. A history buffer takes up system resources, especially if many documents are open at the same time. It's a good idea to have this feature enabled if you plan to work on many documents at the same time.

Default Source Folder
The Assembler plugin will automatically go to this folder when you invoke the file open or save as dialogs. To disable this feature, uncheck the 'Enabled' option, shown directly below the default source folder.

Serial Communicator

The Serial Communicator plugin is a simple to use utility which enables you to transmit and receive data via a serial cable connected to your PC and development board. The easy to use configuration window allows you to select port number, baudrate, parity, byte size and number of stop bits. Alternatively, you can use Serial Communicator favourites to quickly load pre-configured connection settings.

Menu options

File Menu
- **Clear** - Clears the contents of either the transmit or receive window.

- **Open** - Displays a open dialog box, enabling you to load data into the transmit window.

- **Save As** - Displays a save as dialog, enabling you to name and save the contents of the receive window.

- **Exit** - Enables you to exit the Serial Communicator software.

Edit Menu
- **Undo** - Cancels any changes made to either the transmit or receive window.

- **Cut** - Cuts any selected text from either the transmit or receive window.

- **Copy** - Copies any selected text from either the transmit or receive window.

- **Paste** - Paste the contents of the clipboard into either the transmit or receive window. This option is disabled if the clipboard does not contain any suitable text.

- **Delete** - Deletes any selected text. This option is disabled if no text has been selected.

View Menu
- **Configuration Window** - Display or hide the configuration window.

- **Toolbars** - Display small or large toolbar icons.

Help Menu
- **Help Topics** - Displays the serial communicator help file.

- **About** - Display about dialog, giving software version information.

Serial Communicator Main Toolbar

Clear
Clears the contents of either the transmit or receive window.

Open
Displays a open dialog box, enabling you to load data into the transmit window.

Save As
Displays a save as dialog, enabling you to name and save the contents of the receive window.

Cut
Cuts any selected text from either the transmit or receive window.

Copy
Copies any selected text from either the transmit or receive window.

Paste
Paste the contents of the clipboard into either the transmit or receive window. This option is disabled if the clipboard does not contain any suitable text.

Connect
Connects the Serial Communicator software to an available serial port. Before connecting, you should ensure that your communication options have been configured correctly using the configuration window.

Disconnect
Disconnect the Serial Communicator from a serial port.

Configuration
The configuration window is used to select the COM port you want to connect to and also set the correct communications protocols.
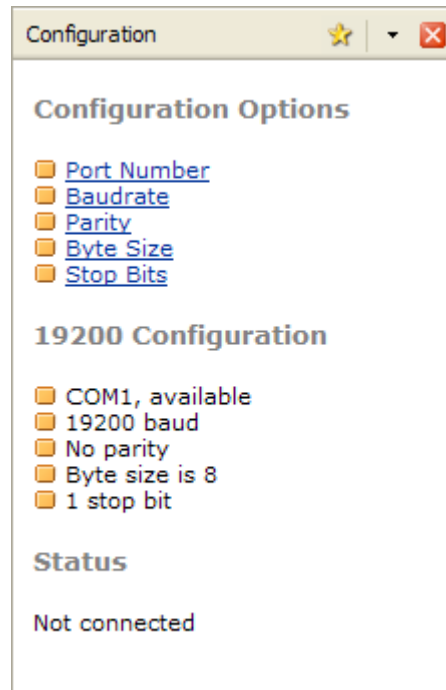
Clicking on a configuration link will display a drop down menu, listing available options. A summary of selected options is shown below the configuration links. For example, in the image above, summary information is displayed under the heading 19200 Configuration.

Favourites
Pressing the favourite icon will display a number of options allowing you to add, manage or load configuration favourites.
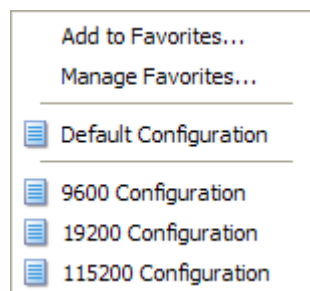
Add to Favourites
Select this option if you wish to save your current configuration. You can give your configuration a unique name, which will be displayed in the favourite drop down menu. For example, 9600 Configuration or 115200 Configuration

Manage Favourites
Select this option to remove a previously saved configuration favourite.

Notes
After pressing the connect icon on the main toolbar, the configuration window is automatically closed and opened again when disconnect is pressed. If you don't want the configuration window to automatically close, right click on the configuration window and un-check the Auto-Hide option.

Transmit Window

The transmit window enables you to send serial data to an external device connected to a PC serial port. In addition to textual data, the send window also enables you to send control characters. To display a list of transmit options, right click on the transmit window.

```
        Clear
        ────────────────────────────
        Word Wrap
        Auto Clear After Transmit
    ✓   Transmit on Carriage Return

        Line Terminator            ▶

        Parse Control Characters
```
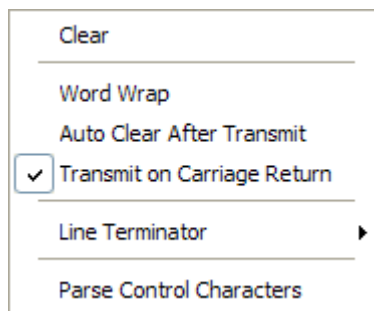
Clear

Clear the contents of the transmit window.

Word Wrap

This option allows you to wrap the text displayed in the transmit window.

Auto Clear After Transmit

Enabling this option will automatically clear the contents of the transmit window when data is sent.

Transmit on Carriage Return

This option will automatically transmit data when the carriage return key is pressed. If this option is disabled, you will need to manually press the send button or press F4 to transmit.

Line Terminator

You can append your data with a number of line terminations characters. These include CR, CR and LF, LF and CR, null and No Terminator.

Parse Control Characters

When enabled, the parse control characters option enables you to send control characters in your message, using either a decimal or hexadecimal notation. For example, if you want to send hello world followed by a carriage return and line feed character, you would use hello world#13#10 for decimal, or hello world$D$A for hex. Only numbers in the range 0 to 255 will be converted. For example, sending the message letter #9712345 will be interpreted as letter a12345.

If the sequence of characters does not form a legal number, the sequence is interpreted as normal characters. For example, hello world#here I am. If you don't want characters to be interpreted as a control sequence, but rather send it as normal characters, then all you need to do is use the tilde symbol (~). For example, letter ~#9712345 would be sent as letter #9712345.

Receive Window

The receive window is used to capture data sent from an external device (for example, a PIC MCU) to your PC. To display a list of transmit options, right click on the receive window.
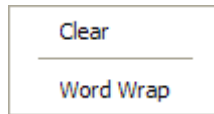
Clear
Word Wrap

Clear

Clear the contents of the receive window.

Word Wrap

When enabled, incoming data is automatically word wrapped.

Notes

In order to advance the cursor to the next line in the receive window, you must transmit either a CR ($D) or a CR LF pair ($D $A) from your external device.

Labcenter Electronics Proteus VSM

Proteus Virtual System Modelling (VSM) combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. For the first time ever, it is possible to develop and test such designs before a physical prototype is constructed.

The Proton Plus Development Suite comes shipped with a free demonstration version of the Proteus simulation environment and also a number of pre-configured Virtual Hardware Boards (VHB). Unlike the professional version of Proteus, you are unable to make any changes to the pre-configured boards or create your own boards.
If you already have a full version of Proteus VSM installed on your system (6.5.0.5 or higher), then this is the version that will be used by the IDE. If you don't have the full version, the IDE will default to using the demonstration installation.

System Requirements

Windows XP or Vista
512MB RAM (1 GB or higher recommended)
500 MHz Processor

Further Information

You can find out more about the simulator supplied with the Proton Development Suite from Labcenter Electronics

ISIS Simulator Quick Start Guide

This brief tutorial aims to outline the steps you need to take in order to use Labcenter Electronics Proteus Virtual System Modelling (VSM) with the Proton IDE. The first thing you need to do is load or create a program to simulate. In this worked example, we will keep things simple and use a classic flashing LED program. In the IDE, press the New toolbar button and type in the following: -

```
Device = 16F1829
Declare Xtal = 20
Symbol LED = PORTD.0
MainProgram:
High LED
```

```
Delayms 500
Low LED
Delayms 500
Goto MainProgram
```

You now need to make sure that the output of the compile and program process is re-directed to the simulator. Normally, pressing compile and program will create a *.hex file which is then sent to your chosen programmer. However, we want the output to be sent to the simulator, not a device programmer. To do this, press the small down arrow to the right of the compile and program toolbar icon and check the Labcenter Electronics Proteus VSM option, as shown below: -
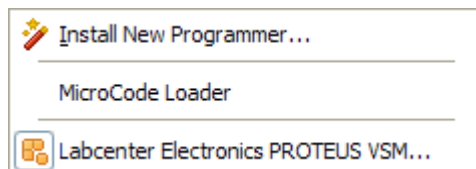
After selecting the above option, save your program and then press the compile and program toolbar button to build your project. This will then start the Virtual Hardware Board (VHB) Explorer, as shown below: -
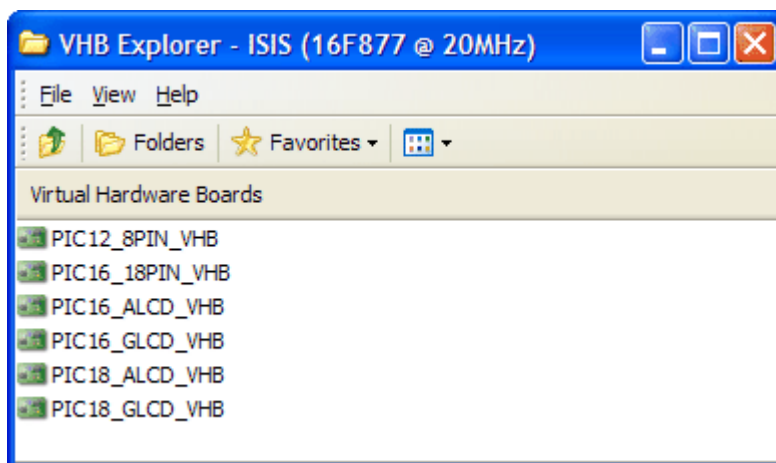
VHB Explorer is the IDE plugin that co-ordinates activity between the IDE and the simulator. Its primary purpose is to bind a Virtual Hardware Board to your program. In this example, the program has been built for the 16F877 MCU which flashes an LED connected to PORTD.0. To run the simulation for this program, just double click on the PIC16_ALCD_VHB hardware board item. This will invoke the Proteus simulator which will then automatically start executing your program using the selected board.

Additional Integration Tips

If you followed the Proteus VSM quick start guide, you will know how easy it is to load you program into the simulation environment with the Virtual Hardware Board (VHB) Explorer. However, one thing you might have noticed is that each time you press compile and program the VHB Explorer is always displayed. If you are using the same simulation board over and over again, manually having to select the board using VHB Explorer can become a little tiresome.

Virtual Hardware Boards Favourites
The good news is that every time you select a board using VHB Explorer, it is saved as a VHB Explorer favourite. You can access VHB Explorer favourites from within Proton IDE by right clicking on the main editor window and selecting the Virtual Hardware Boards option, as shown below : -
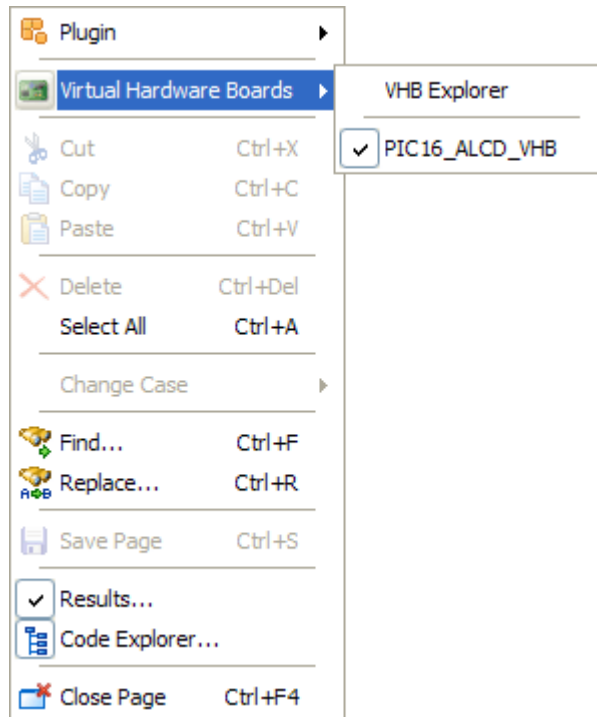
In the quick start guide, the program was bound to a simulation board called PIC16_ALCD_VHB. If we check this favourite and then press compile and program, VHB Explorer is not displayed. Instead, you project is loaded immediately into the Proteus simulation environment. You can have more than one board bound to your project, allowing you to quickly switch between target simulation boards during project development.

To add additional boards to your project, manually start VHB Explorer by selecting the plugin icon 🔳 and clicking on the Labcenter Electronics Proteus VSM... option. When VHB Explorer starts, just double click on the board you want to be bound to your current project. Your new board selection will be displayed next time you right click on the main editor window and select Virtual Hardware Boards. You can delete a favourite board by manually starting VHB Explorer and pressing the Favourites toolbar icon. Choose the Manage Favourites option to remove the virtual hardware board from the favourites list.

Proton
Amicus18
Hardware Overview
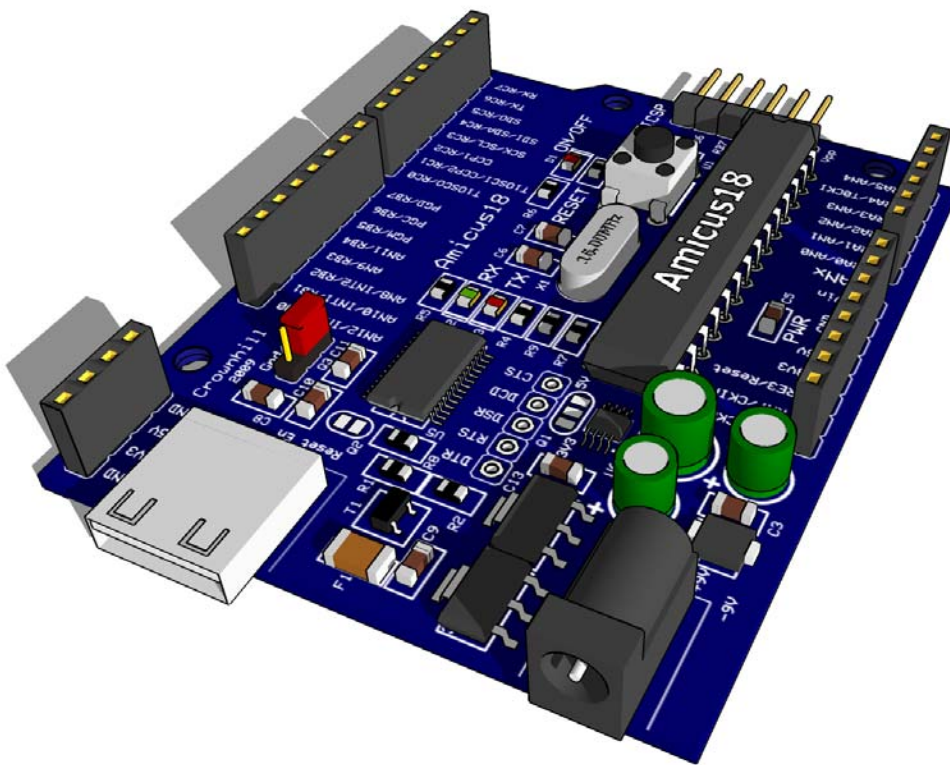
Amicus18 Hardware Overview

The Amicus18 hardware is based upon the Arduino board, however, the Amicus18 board uses a Microchip PIC® microcontroller instead of an Atmel AVR type. The preferred language for the Amicsu18 board is the Proton BASIC compiler, and the devie used within the Amicus18 board is freely avalable within the Proton compiler.
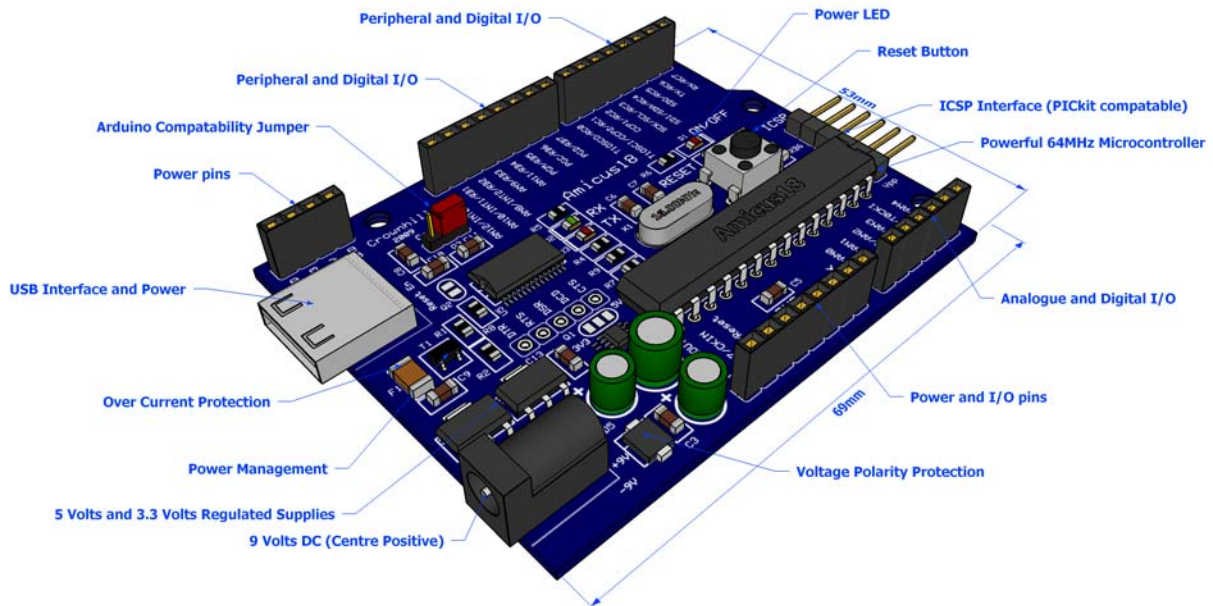
It has exactly the same dimensions as the Arduino, and all Arduino shields will physically fit on the Amicus18 board.

The microcontroller used on the Amicus18 is the Microchip PIC18F25K20, or the PIC18F25K22 which each have 32768 bytes of flash memory, 1536 bytes of RAM, and operate at 64MHz, which equates to 16 MIPS (Million Instructions per Second).

There are up to eleven 10-bit ADC (Analogue to Digital Converter) inputs, and two 10-bit PWM (Pulse Width Modulation) outputs, as well as comparators, USARTs (Universal Synchronous Asynchronous Receiver Transmitter), SPI (Serial Peripheral Interface), I^{2}C (Inter-Integrated Circuit), and up to six timers, each with various internal operations attached to them.

Each of the microcontroller's I/O lines are brought out for use with external devices such as LEDs, Servos, Potentiometers, LCDs etc…

Communication with the Amicus18 board is through a USB interface, which presents itself as a standard serial port on the PC. The microcontroller can be programmed directly through this port so there is no need for a dedicated device programmer, however, if the need arises, there is an ICSP (In Circuit Serial Programming) interface suitable for all programmers, but tailored for the Microchip PICkit2™ programmer.

Power can be supplied to the board either via the USB port, or an external 9 Volt DC source. When powered from the USB port, a maximum of 500mA (milliAmp) may be drawn, and the USB port is protected by a resetable fuse. When powered via a 9V source, a maximum of 800mA may be drawn.

The PIC18F25K20 microcontroller is a 3.3 volts type, while the PIC18F25K22 will operate with both 3.3 volts and 5 volts.

The Amicus18 board is extremely easy to use, in fact, no previous microcontroller experience is required in order to get your first project up and running, as you'll find out later.

Amicus18 Sockets

As mentioned earlier, each of the microcontroller's I/O lines is brought to the outside world via 2.54mm (0.1") SIL sockets on the Amicus18 board. The operation of each block of pins is outlined below:

The 8-pin Power header socket:
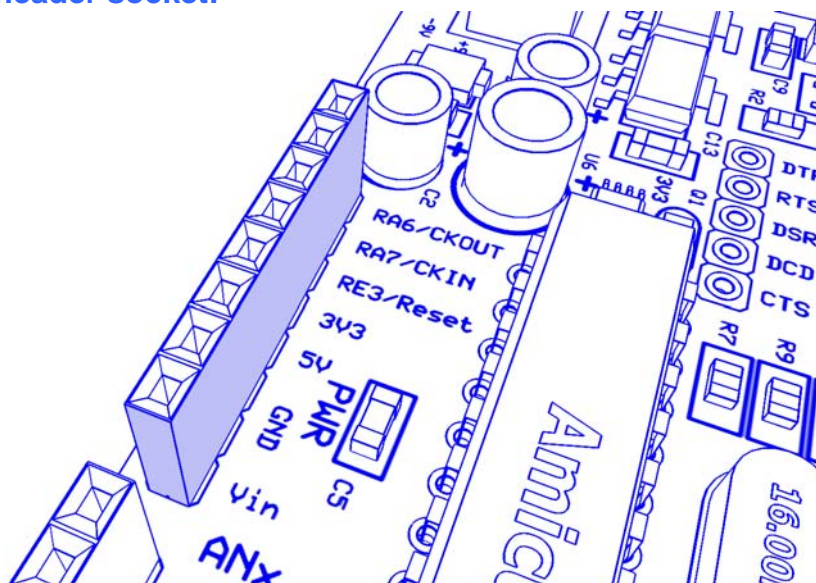
- RA6 which is bit-6 of PORTA. This pin defaults to the Clock Output Pin where the crystal is connected. It may be used as an I/O pin only when an internal oscillator setting is chosen.

- RA7 which is bit-7 of PORTA. This pin defaults to the Clock Input Pin where the crystal is connected. It may be used as an I/O pin only when an internal oscillator setting is chosen.

- Microcontroller's reset line, which also acts as bit-3 of PORTE (RE3), and is also the voltage input for a device programmer such as the PICkit2™ or the PICkit3™.

- 3.3 Volts output. 500mA when powered via USB, or 800mA when powered by an external 9 Volts source.

- 5 Volts output. 500mA when powered via USB, or 800mA when powered by an external 9 Volts source.

- Ground (0 Volts).

- DC 9 Volts input. This may be used to power the board.

The 4-pin Power header socket:

- Ground (0 Volts)

- 3.3 Volts output. 500mA when powered via USB, or 800mA when powered by an external 9 Volts source.

- 5 Volts output. 500mA when powered via USB, or 800mA when powered by an external 9 Volts source.
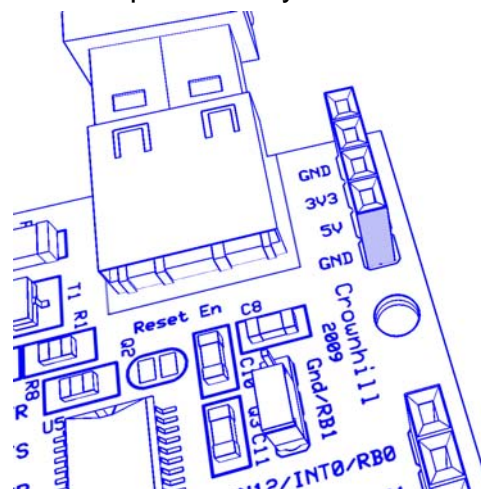
The PORTA (ANx) socket:
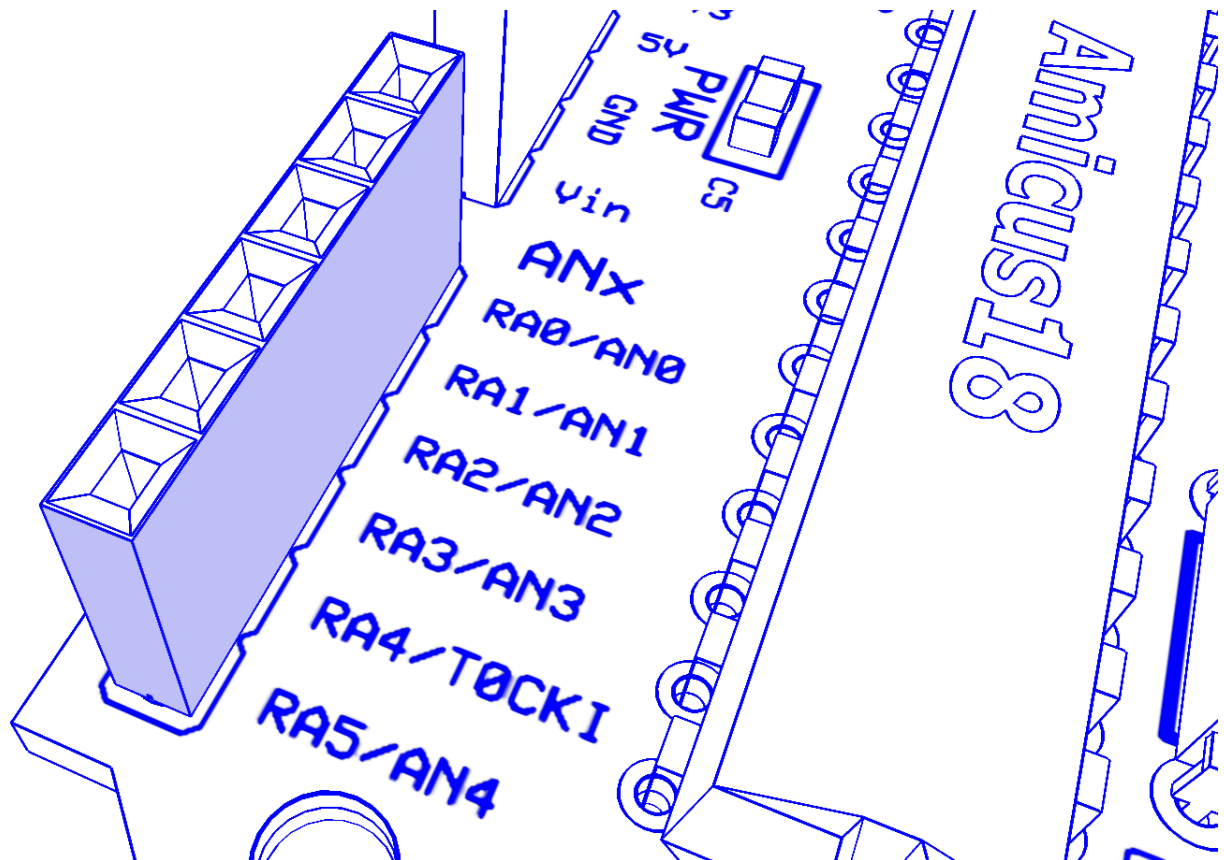
- RA0 which is bit-0 of digital PORTA. This pin can also be configured as Input 0 (AN0) of the 10-bit ADC (*Analogue to Digital Converter*). It can also be configured as the negative (-) input pin to either Comparator 1 or 2.

- RA1 which is bit-1 of digital PORTA. This pin can also be configured as Input 1 (AN1) of the 10-bit ADC (*Analogue to Digital Converter*). It can also be configured as the negative (-) input pin to either Comparator 1 or 2.

- RA2 which is bit-2 of digital PORTA. This pin can also be configured as Input 2 (AN2) of the 10-bit ADC (*Analogue to Digital Converter*). It can also be configured as the positive (+) input pin to Comparator 2, or the output for the internal voltage reference.

- RA3 which is bit-3 of digital PORTA. This pin can also be configured as Input 3 (AN3) of the 10-bit ADC (*Analogue to Digital Converter*). It can also be configured as the positive (+) input pin to Comparator 1.

- RA4 which is bit-4 of digital PORTA. This pin can also be configured as the input trigger for Timer 0. It can also be configured as the output pin of Comparator 1.

- RA5 which is bit-5 of digital PORTA. This pin can also be configured as Input 4 (AN4) of the 10-bit ADC (*Analogue to Digital Converter*). It can also be configured as the output pin of Comparator 2.

The PORTC socket:
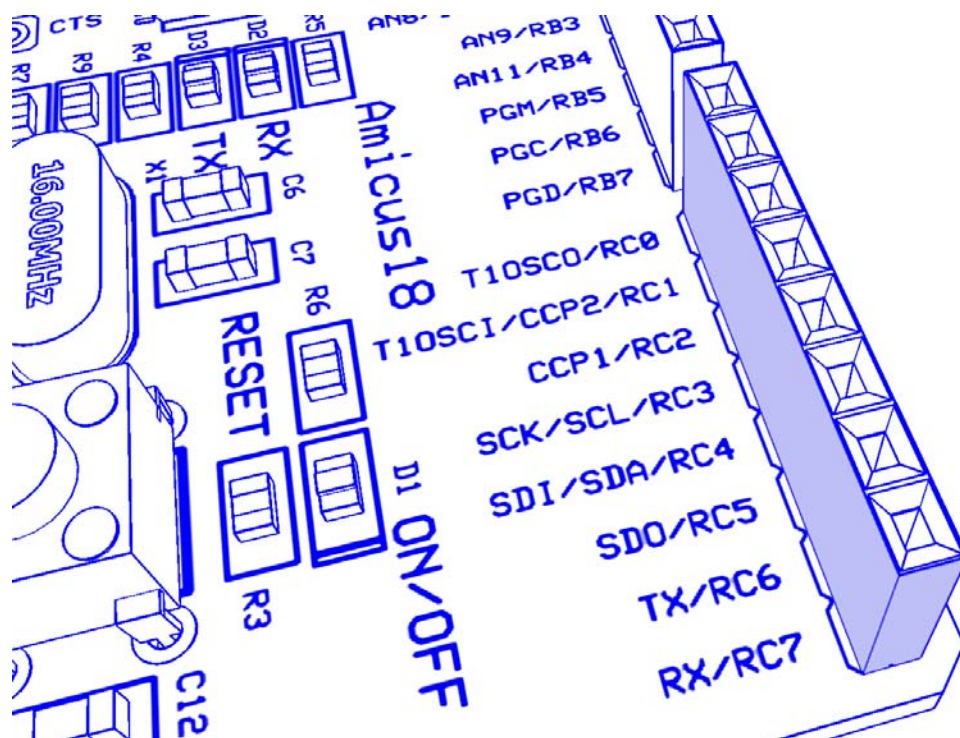
- RC0 which is bit-0 of digital PORTC. This pin can also be configured as the input for Timer 1.

- RC1 which is bit-1 of digital PORTC. This pin can also be configured as the input for Timer 1, or a PWM (*Pulse Width Modulation*) output.

- RC2 which is bit-2 of digital PORTC. This pin can also act as a PWM (*Pulse Width Modulation*) output.

- RC3 which is bit-3 of digital PORTC. This pin can also be configured as the clock source for I^{2}C (*Inter-Integrated Circuit*) or SPI (*Serial Peripheral Interface*) communications.

- RC4 which is bit-4 of digital PORTC. This pin can also be configured as the data source for I^{2}C (*Inter-Integrated Circuit*) or the data output for SPI (*Serial Peripheral Interface*) communications.

- RC5 which is bit-5 of digital PORTC. This pin can also be configured as the data input for SPI (*Serial Peripheral Interface*) communications.

- RC6 which is bit-6 of digital PORTC. This pin can also be configured as the USART (*Universal Synchronous Asynchronous Receiver Transmitter*) output for serial communications.

- RC7 which is bit-7 of digital PORTC. This pin can also be configured as the USART (*Universal Synchronous Asynchronous Receiver Transmitter*) input for serial communications.

The PORTB socket:
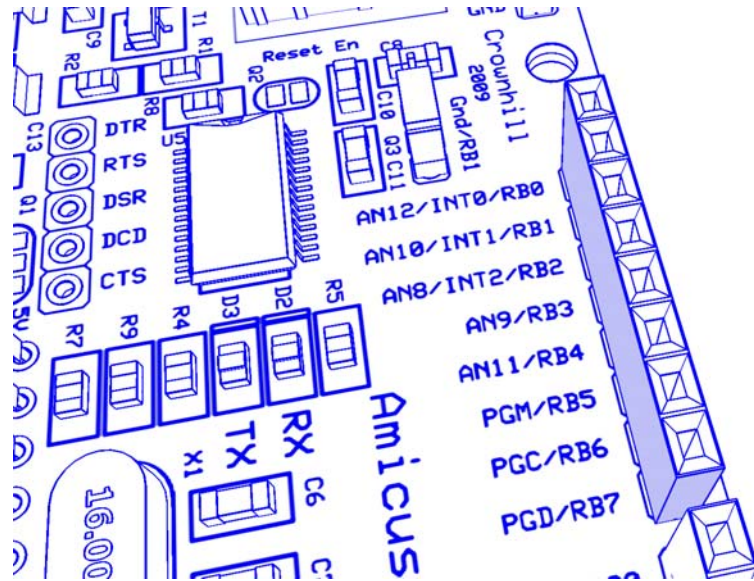
- RB0 which is bit-0 of digital PORTB. This pin can also be configured as input 12 (AN12) of the 10-bit ADC, or an external interrupt trigger.

- RB1 which is bit-1 of digital PORTB. This pin can also be configured as input 10 (AN10) of the 10-bit ADC, or an external interrupt trigger.

- RB2 which is bit-2 of digital PORTB. This pin can also be configured as input 8 (AN8) of the 10-bit ADC, or an external interrupt trigger.

- RB3 which is bit-3 of digital PORTB. This pin can also be configured as input 9 (AN9) of the10-bit ADC, or an alternative PWM (*Pulse Width Modulation*) output.

- RB4 which is bit-4 of digital PORTB. This pin can also be configured as input 11 (AN11) of the 10-bit ADC, or an external interrupt trigger.

- RB5 which is bit-5 of digital PORTB. This pin can also be configured as an external interrupt trigger.

- RB6 which is bit-6 of digital PORTB. This pin can also be configured as an external interrupt trigger, and is also the clock line for a device programmer such as the PICkit2™ or the PICkit3™.

- RB7 which is bit-7 of digital PORTB. This pin can also be configured as an external interrupt trigger, and is also the data line for a device programmer such as the PICkit2™ or the PICkit3™.

Each pin of the microcontroller is capable of sourcing or sinking 25mA, with a maximum of 100mA per port.

The microcontroller's architecture is very versatile, allowing several internal peripherals to share the same pin, thus maximising the flexibility, but keeping the size of the device small. Each internal peripheral can be enabled, disabled and configured very easily from within the free Proton BASIC compiler environment.

Although the PIC18F25K20 microcontroller has a 3.3 Volts operating voltage, some I/O pins are 5 Volt tolerant. Alternatively, use a PIC18F25K22 device for full 5 Volt operation.

Device Programming Header

The Amicus18 board has the ability to be programmed in circuit. This bypasses the built in bootloader, and indeed, will overwrite it.

The header has been designed for a PICkit2™ or PICkit3™ programmer to fit straight onto it, however, any other device programmer may be used with a suitable adapter. It must be remembered that the microcontroller is a 3.3 Volt PIC18F25K20 type, therefore if a programmer other than a PICkit2™ or a PICkit3™ is used, ensure that it supports this device, as a 5 Volt only programmer will damage the microcontroller.

The programming header's location is shown below:
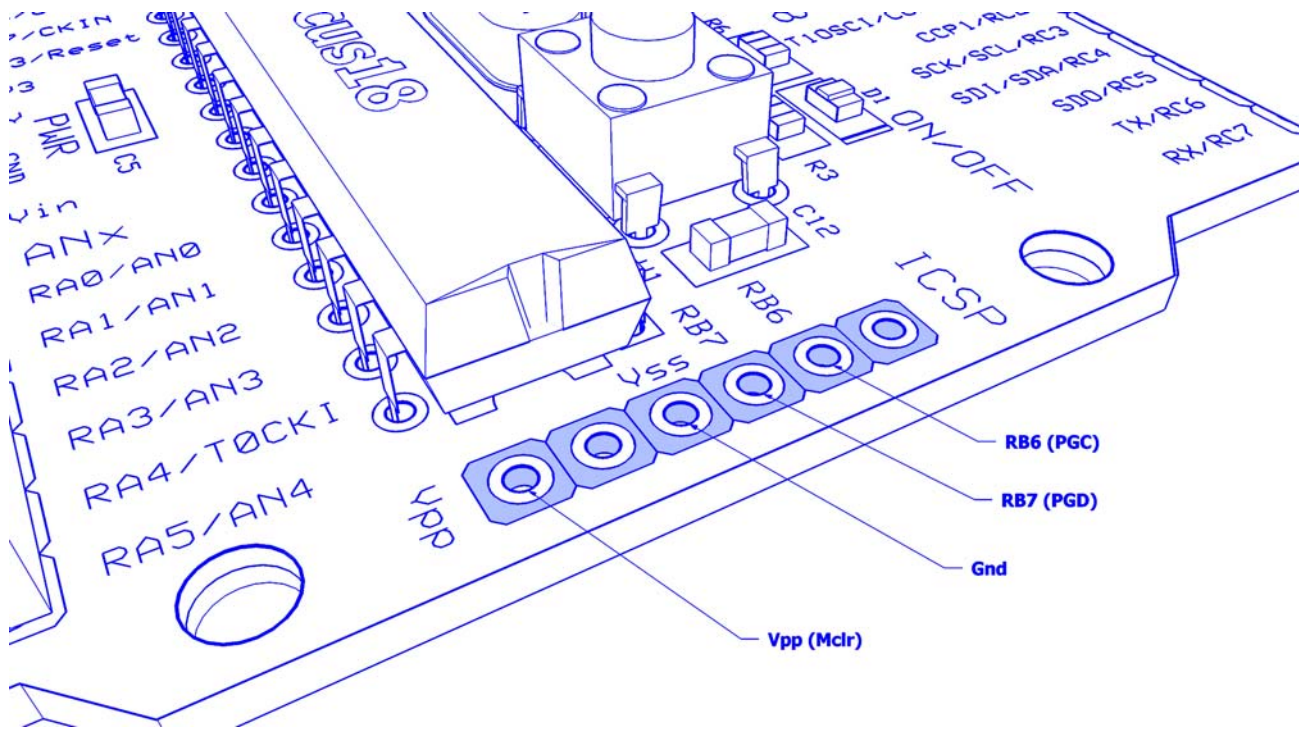
Jumper and Pad Settings

The Amicus18 board has a jumper and two pads that can alter it's characteristics.

Pad Q1

This allows a 5 Volts type microcontroller to be used with the board instead of the supplied 3.3 Volt type. For example, a PIC18F25K22.
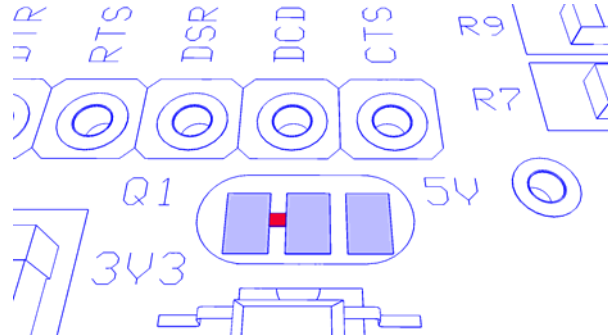
Pad Q2

This allows disconnection of the internal Reset for the microcontroller from the USB bootloader.
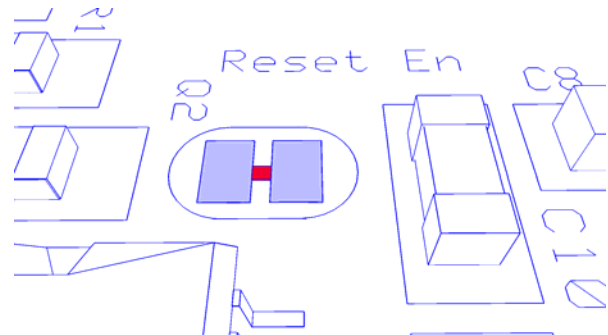
Jumper Q3

This allows maximum compatibility with existing Arduino shields. The PIC18F25K20 and PIC25K22 microcontrollers have more I/O lines than that of an Atmel, therefore, two of the pins on the PortB socket operate differently on the Amicus18. RB1 is a Ground pin on the Arduino board, but this would waste a valuable I/O pin if it were simply grounded. Instead, Jumper Q3 can be configured for RB1 or Ground.
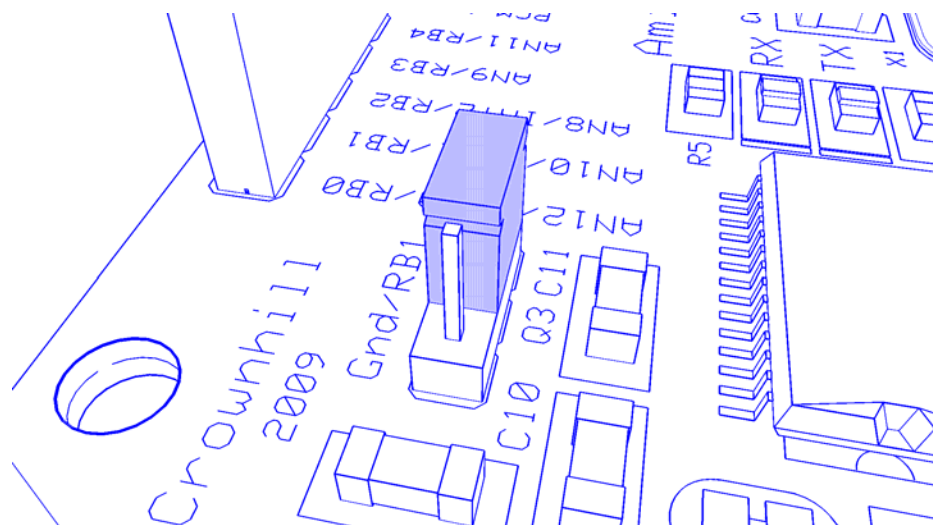
Serial Handshake Connections

The USB to serial device also emulates the handshaking lines of a conventional serial port. These are shown below:
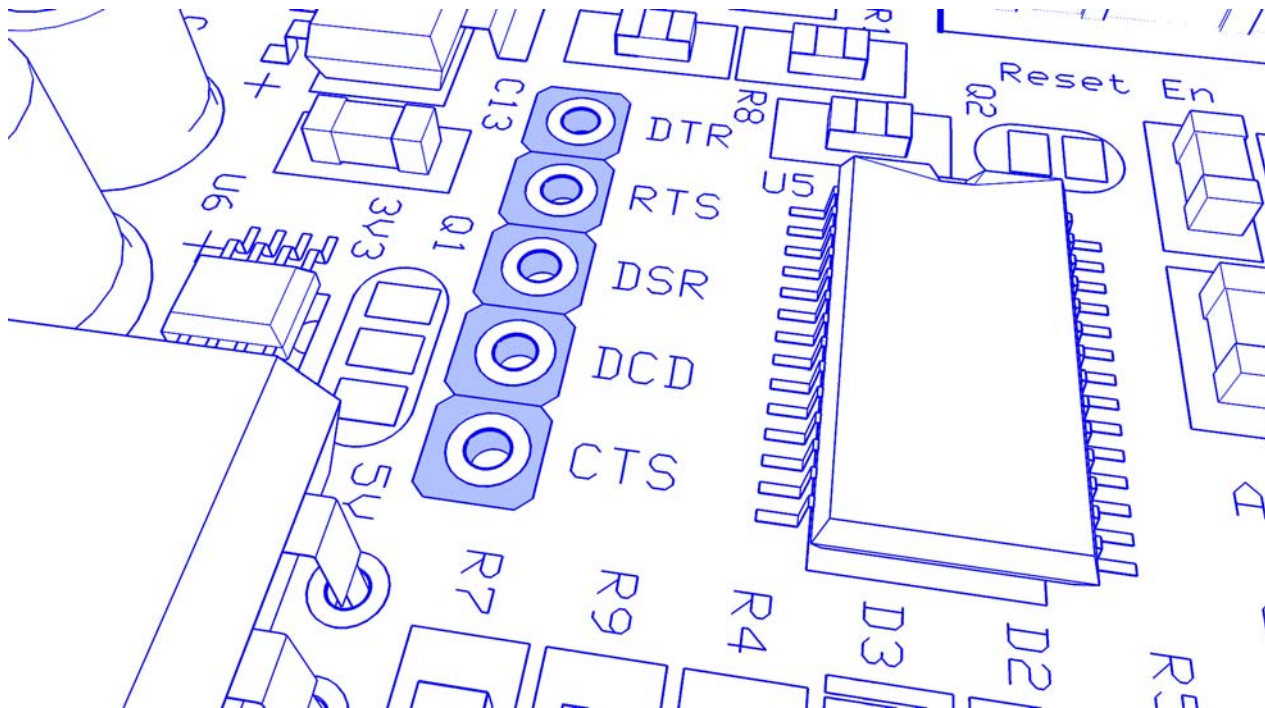
The Amicus18 board uses the DTR line in-order to reset the microcontroller, however, the other lines are available to use. The direction of each line is shown below:

- DTR   This is an output from the PC to the Amicus18 board.
- RTS   This is an output from the PC to the Amicus18 board.
- DSR   This is an input to the PC from the Amicus18 board.
- DCD   This is an input to the PC from the Amicus18 board.
- CTS   This is an input to the PC from the Amicus18 board.

Using the Proton Compiler with the Amicus18 board

Configuring the Proton compiler to work with the Amicus18 board is simplicity itself, as all the applications required are installed along with the compiler.

The Amicus18 board's microcontroller has a built-in bootloader, so first we'll choose the correct bootloader from within the Proton IDE. On the toolbar, Click the small arrow on the Program button:
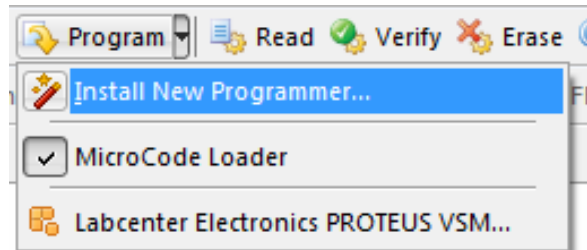
Choose the option "Install New Programmer" and a window will open:
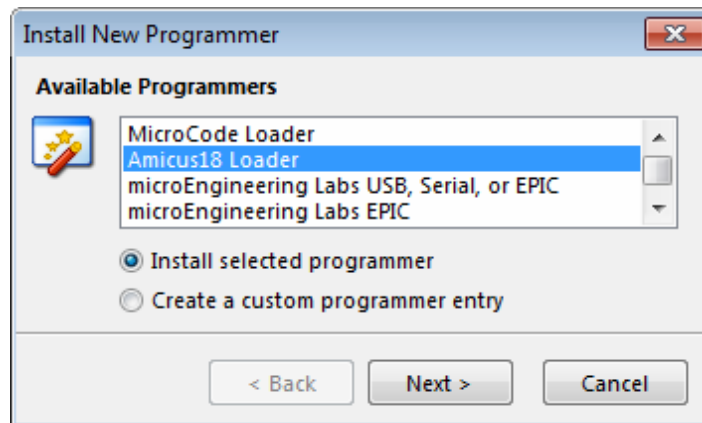
Choose the Amicus18 Loader option and click Next.

The bootloader's executable will then be searched for:
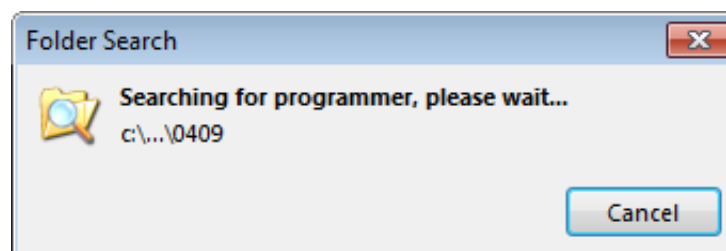
Once it has been found the window will disappear and the job is done. In order to verify that the Amicus18 bootloader has been allocated correctly, click the downward arrow on the program button again:
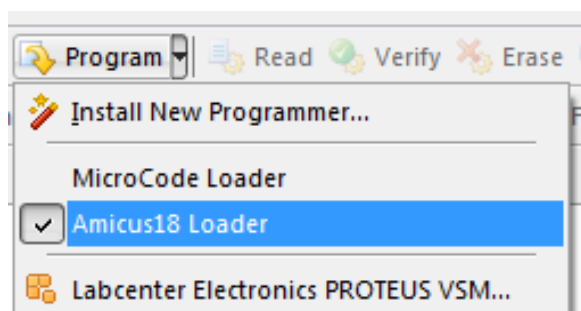
Writing your first Amicus18 program using the Proton compiler

Here's a very small sample of the Proton BASIC language:

```
' Flash an LED connected to RB0
  Include "Amicus18.inc"  ' Configure the compiler to use the Amicus18 board

  Do                         ' Create an infinite loop
    High PORTB.0             ' Bring the LED pin high (illuminate the LED)
    DelayMs 500             ' Wait 500ms (half a second)
    Low PORTB.0             ' Pull the LED pin low (extinguish the LED)
    DelayMs 500             ' Wait 500ms (half a second)
  Loop                       ' Close the loop
```

As can be seen, the language is very simple to understand, but has a powerful command set, and produces true assembler code that talks to the microcontroller directly.

Click the toolbar button ***Compile and Program***, and watch as the compiler takes over automatically. The program will be compiled and if there are no syntax errors, the bootloader will be invoked, which will automatically locate the Amicus18 board connected to USB and program its microcontroller:

```
colour_organ.hex

       Writing Program to Amicus18
   [■                              ]
                  6%

        Write            Close
```
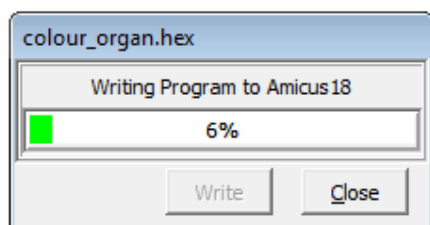
Here's a slightly more complex program:

```
'
' Pulse two LEDs, one decreases brightness, while the other increases brightness
'
  Include "Amicus18.inc"        ' Configure the compiler to use the Amicus18 board
  Include "Amicus18_Hpwm10.inc"  ' Load the Amicus18 10-bit PWM macros into program

  Dim wDutyCycle As Word                 ' Holds the duty cycle of the PWM pulses

  Do                                     ' Create an infinite loop
    '
    ' Increase LED1 illumination, while decreasing LED2 illumination
    '
    For wDutyCycle = 0 To 1023           ' Cycle the full range of 10-bits
      WriteAnalog1(wDutyCycle)          ' PWM on CCP1 (Bit-2 of PortC) (0 to 1023)
      WriteAnalog2(1023 - wDutyCycle)   ' PWM on CCP2 (Bit-1 of PortC) (1023 to 0)
      DelayMS 5                         ' A small delay between duty cycle changes
    Next                                 ' Close the loop
    DelayMS 5
    '
    ' Decrease LED1 illumination, while increasing LED2 illumination
    '
    For wDutyCycle = 1023 To 0 Step -1 ' Cycle the full 10-bit range (reversed)
      WriteAnalog1(wDutyCycle)          ' PWM on CCP1 (Bit-2 of PortC) (1023 to 0)
      WriteAnalog2(1023 - wDutyCycle)   ' PWM on CCP2 (Bit-1 of PortC) (0 to 1023)
      DelayMS 5                         ' A small delay between duty cycle changes
    Next                                 ' Close the loop
  Loop                                   ' Do it forever
```

The Amicus18 has its own serial terminal application that has some features specially developed for it.

This can be located by clicking on the IDE's View->Plugin menu option:
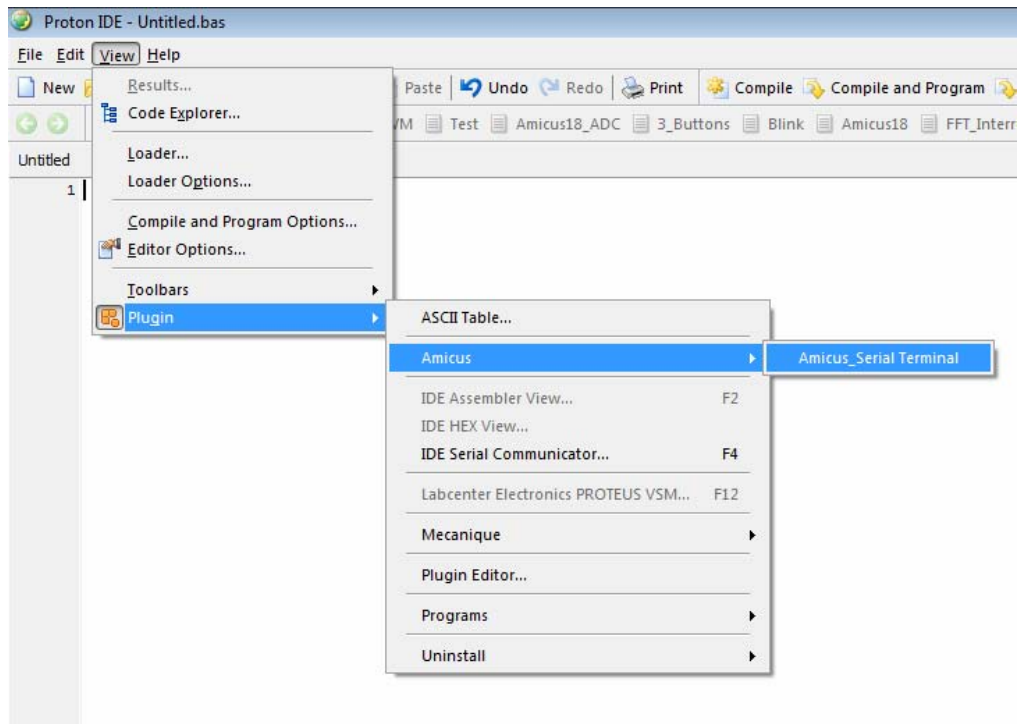
Amicus18 Circuit Diagram
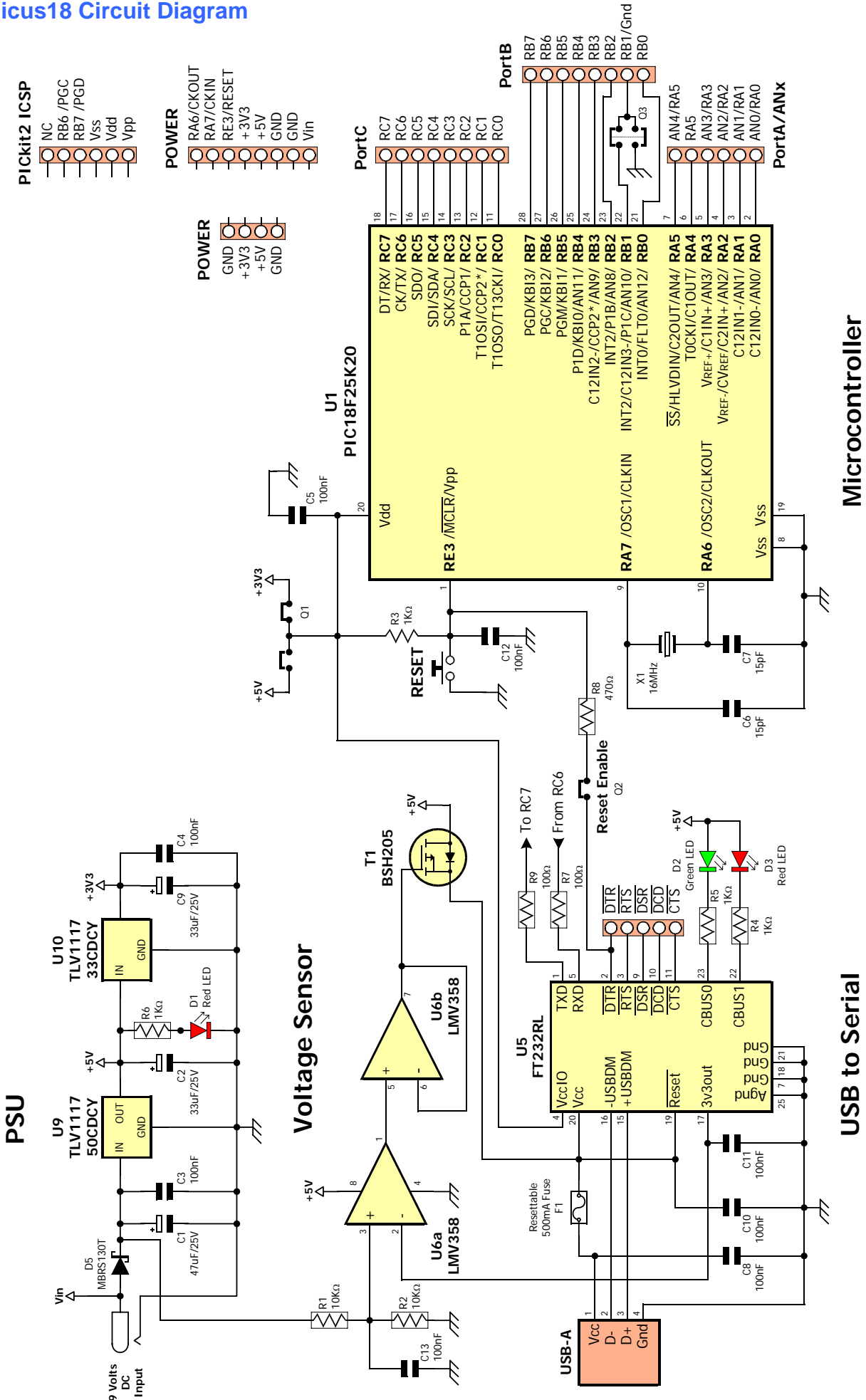
Amicus18 PCB Layout
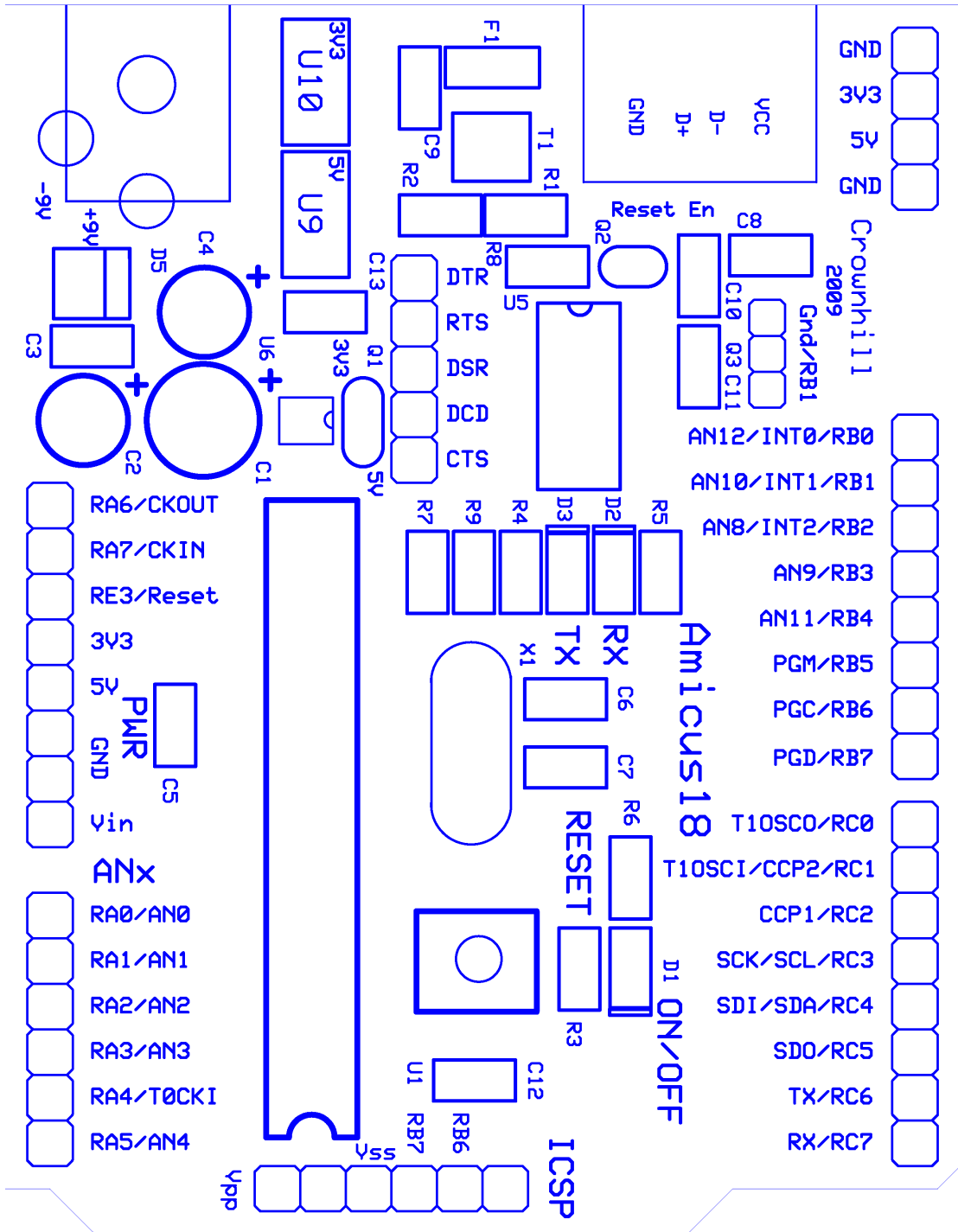
Installing the Amicus18 USB Driver

The Amicus18 board uses an FTDI serial to USB device, which presents itself as a standard com port on the PC. However, this requires USB drivers to be installed the first time the Amicus18 board is connected to your computer. This is a simple process and a step by step guide is outlined below for a Windows XP system. Note that Vista systems use the same principle, only windows and dialogues will change:

Plug the USB cable into a free USB port on the PC, and then into the Amicus18's USB port.

Note. Make sure you plug the Amicus18 board into a powered USB HUB or direct to the PC's USB port, as un-powered HUBs can only supply 100mA of power, instead of 500mA for powered HUBs.

The first window will inform you that a new device has been found on the USB port:

Choose the option *"Install from a list or specific location"* and click *Next*:
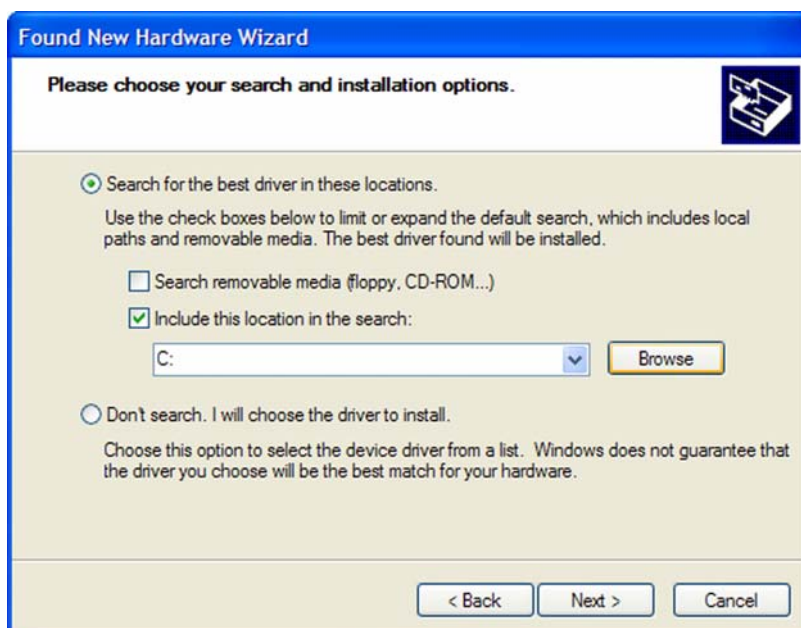
Make sure the options are ticked as in the previous window and click on the *Browse* button:
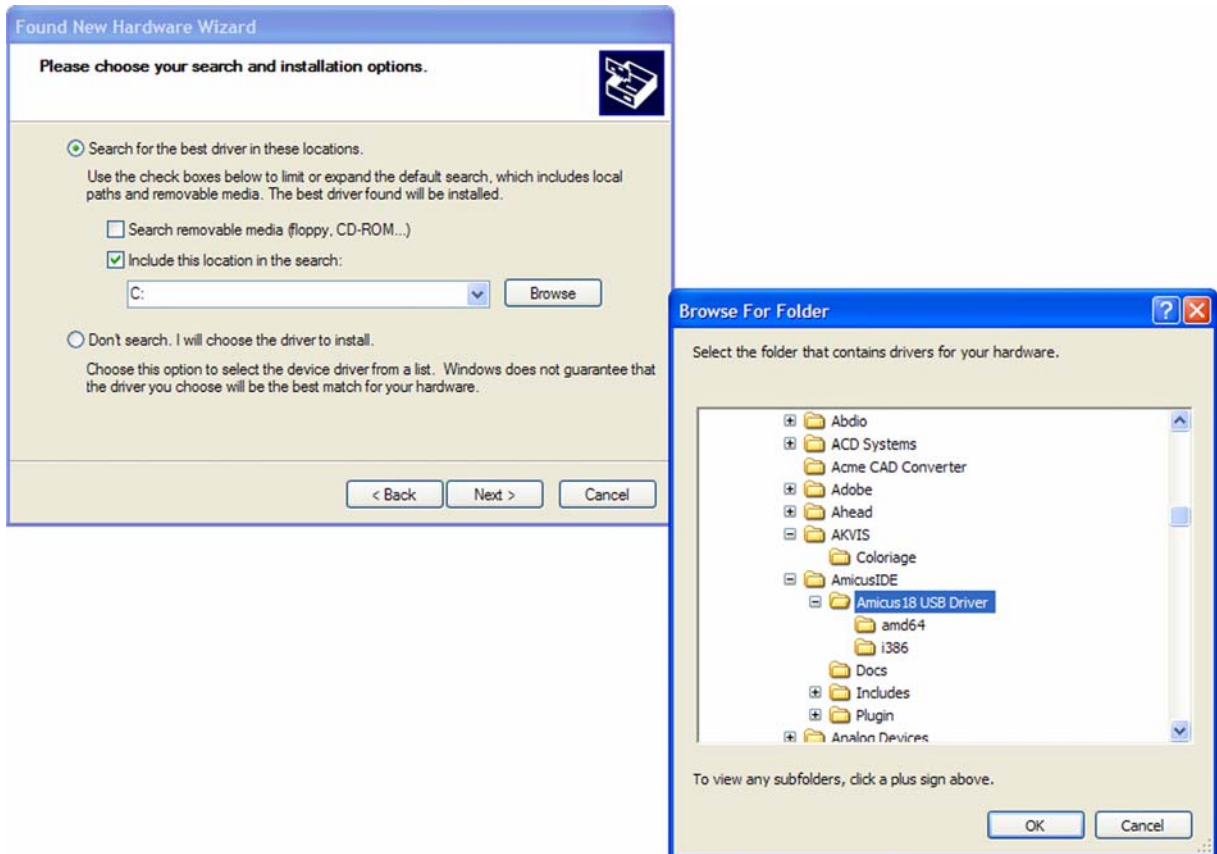
Navigate to the compiler's install path which it defaults to "**C:\Program Files\ProtonIDE**" , **"C:\Program Files (x86)\ProtonIDE"** for Windows7 64-bit, and choose the "**Amicus18 USB Driver**" folder. Click **OK**:

The windows should look like the image below:

Click the **Next** button and the driver will begin to install.

You will see a windows message stating that the drivers have not been certified by Microsoft. This is quite normal and nothing to be worried about, just click the **Continue Anyway** button:
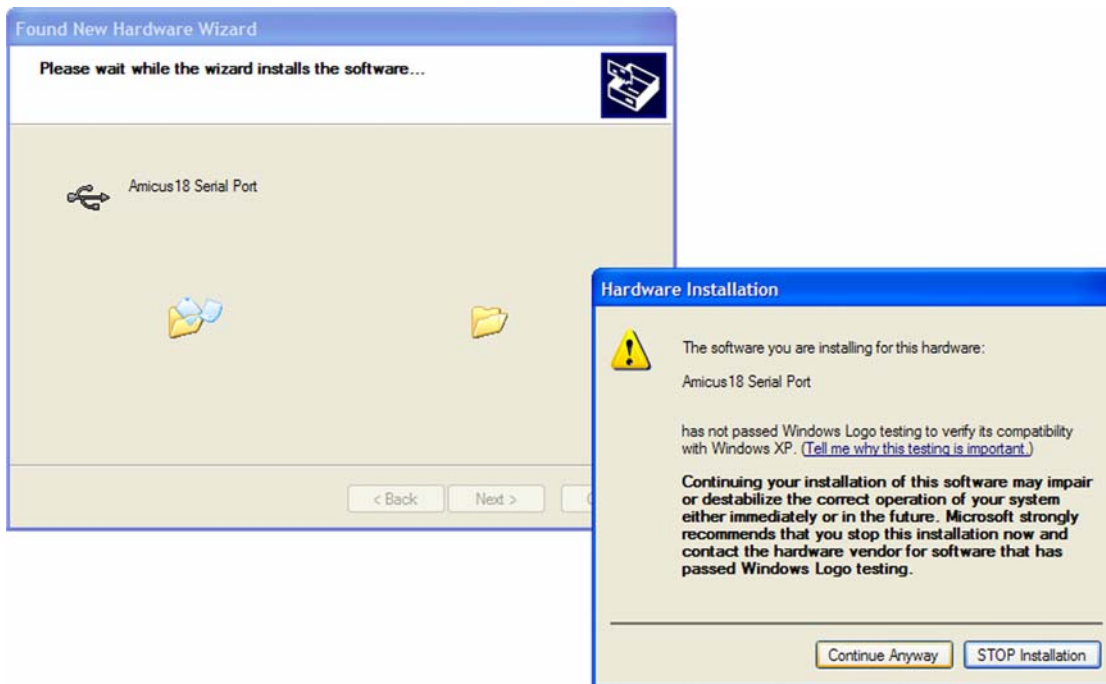
The driver will continue to install:
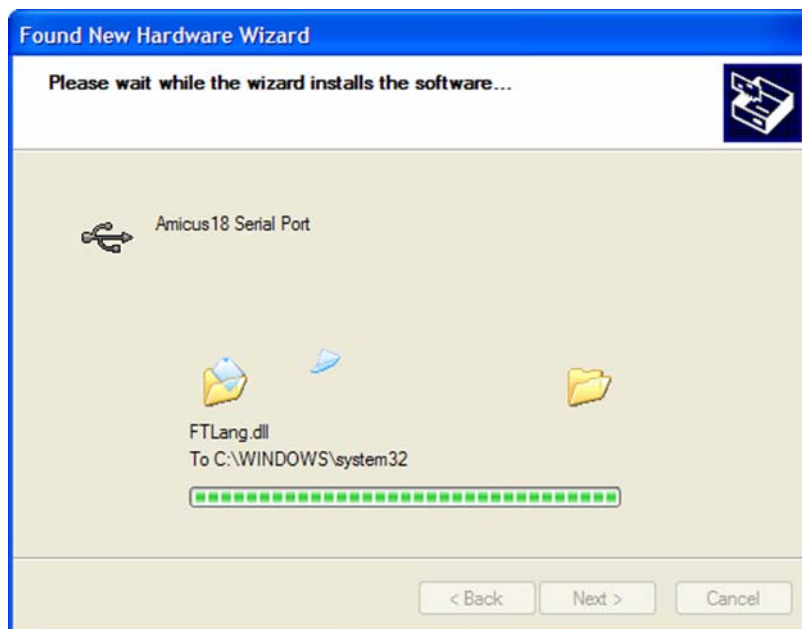
Once the driver is complete it will show the window below:

Click on the *Finish* button.

Note that the above procedure will need to be carried out twice for the driver to be fully in-stalled, however, the second time, the files will have already been located on the hard drive, so it may not be necessary to navigate to the driver folder:
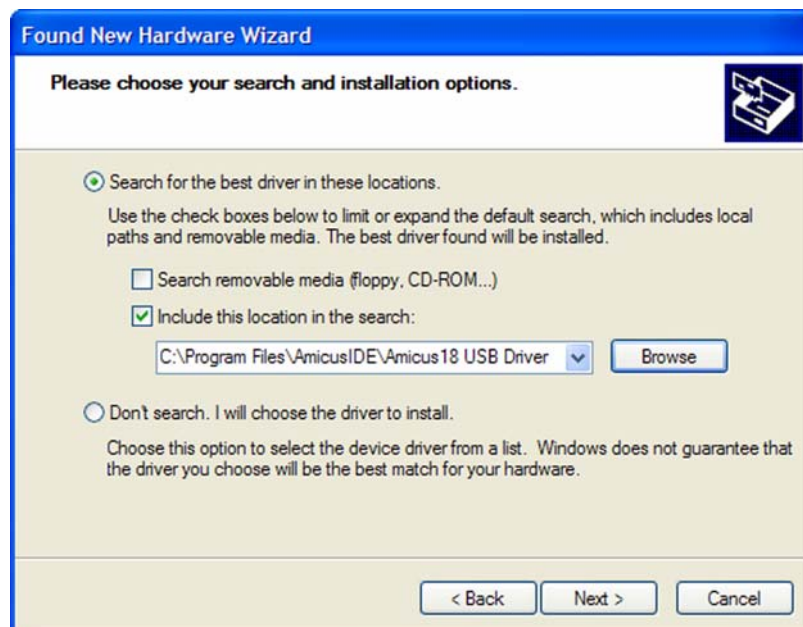
The USB drivers are now installed and will not require re-doing, unless the Amicus board is in-serted into a different USB port on the computer, in which case, choose the "**Install the soft-ware automatically**" option on the initial driver install window.

Built in Amicus18 Peripheral Macros

The Proton compiler has several built-in macros for configuring the most popular peripheral modules contained with the Amicus18's microcontroller, these are the ADC (Analogue to Digital Converter), Timers, and SPI (Serial Peripheral Interface).

ADC macros Introduction

The ADC (Analogue to Digital Converter) peripheral on the Amicus18 is supported with the following macros. The macros are a mixture of compiler types and preprocessor types, and can be found in "Includes\Sources\Amicus18_ADC.inc"

A/D Converter Macros
- BusyADC   Is A/D Converter currently performing a Conversion?
- CloseADC   Disable the A/D Converter.
- ConvertADC   Start an A/D Conversion.
- OpenADC   Configure the A/D Converter.
- ReadADC   Read the results of an A/D Conversion.
- SetChanADC   Select A/D channel to be used.
- SelChanConvADC Select A/D channel to be used and start an A/D Conversion.

BusyADC
Syntax
Variable = **BusyADC**()

Include file
Amicus18_ADC.inc

Overview
This macro indicates if the A/D peripheral is in the process of converting a value.

Return Value
- 1 if the A/D peripheral is performing a conversion.
- 0 if the A/D peripheral isn't performing a conversion.

CloseADC
Syntax
CloseADC()

Include file
Amicus18_ADC.inc

Overview
This macro disables the A/D converter and A/D interrupt mechanism.

ConvertADC
Syntax
ConvertADC()

Include file
Amicus18_ADC.inc

Overview
This macro starts an A/D conversion. The **BusyADC**() macro or A/D interrupt may be used to detect completion of the conversion. The result is held in registers ADRESL and ADRESH.

OpenADC
Syntax
OpenADC(pConfig, pConfig2, pPortConfig)

Include file
Amicus18_ADC.inc

Overview
This macro resets the A/D-related registers to the POR state and then Configures the clock, result format, voltage reference, port and channel.

Parameters
- **pConfig** A bitmask that is created by performing a bitwise AND operation ('&') with a value from each of the categories listed below. These values are defined in the file Amicus18_ADC.inc.

A/D clock source:

ADC_FOSC_2	Fosc / 2
ADC_FOSC_4	Fosc / 4
ADC_FOSC_8	Fosc / 8
ADC_FOSC_16	Fosc / 16
ADC_FOSC_32	Fosc / 32
ADC_FOSC_64	Fosc / 64
ADC_FOSC_RC	Internal RC Oscillator

A/D result justification:

ADC_RIGHT_JUST	Result in Least Significant bits (Used for 10-bit ADC result)
ADC_LEFT_JUST	Result in Most Significant bits (Used for 8-bit ADC result)

A/D acquisition time select:

ADC_0_TAD	0 Tad
ADC_2_TAD	2 Tad
ADC_4_TAD	4 Tad
ADC_6_TAD	6 Tad
ADC_8_TAD	8 Tad
ADC_12_TAD	12 Tad
ADC_16_TAD	16 Tad
ADC_20_TAD	20 Tad

- **pConfig2** A bitmask that is created by performing a bitwise AND operation ('&'), as shown in the example at the end of this document, with a value from each of the categories listed below. These values are defined in the file Amicus18_ADC.inc.

Channel:

ADC_CH0	Channel 0
ADC_CH1	Channel 1
ADC_CH2	Channel 2
ADC_CH3	Channel 3
ADC_CH4	Channel 4
ADC_CH5	Channel 5
ADC_CH6	Channel 6
ADC_CH7	Channel 7
ADC_CH8	Channel 8
ADC_CH9	Channel 9
ADC_CH10	Channel 10
ADC_CH11	Channel 11
ADC_CH12	Channel 12

A/D Vref+ and Vref- Configuration:

ADC_REF_VDD_VREFMINUS	VREF+ = VDD & VREF- = Ext.
ADC_REF_VREFPLUS_VREFMINUS	VREF+ = Ext. & VREF- = Ext.
ADC_REF_VREFPLUS_VSS	VREF+ = Ext. & VREF- = VSS
ADC_REF_VDD_VSS	VREF+ = VDD & VREF- = VSS

🔵 *pPortConfig* The *pPortConfig* can have 8192 different combinations, defined below:

ADC_0ANA	All digital
ADC_1ANA	analogue: AN0
ADC_2ANA	analogue: AN0-AN1
ADC_3ANA	analogue: AN0-AN2
ADC_4ANA	analogue: AN0-AN3
ADC_5ANA	analogue: AN0-AN4
ADC_6ANA	analogue: AN0-AN5
ADC_7ANA	analogue: AN0-AN6
ADC_8ANA	analogue: AN0-AN7
ADC_9ANA	analogue: AN0-AN8
ADC_10ANA	analogue: AN0-AN9
ADC_11ANA	analogue: AN0-AN10
ADC_12ANA	analogue: AN0-AN11

Example

```
'
' Open the ADC:
'            Fosc/32
'            Right justified for 10-bit operation
'            Tad value of 2
'            Vref+ at Vcc : Vref- at Gnd
'            Make AN0 an analogue input
OpenADC(ADC_FOSC_32 & ADC_RIGHT_JUST & ADC_2_TAD, ADC_REF_VDD_VSS, ADC_1ANA)
```

ReadADC
Syntax
Variable = **ReadADC**(pChannel)

Include file
Amicus18_ADC.inc

Overview
This macro returns the Word (10 bit) result of the A/D conversion. Based on the configuration of the A/D converter (e.g., using the **OpenADC**() macro).

Operator
pChannel is an *optional* ADC channel to take the reading from. This *must* be one of the values used for the **SetChanADC** macro.

Example

```
Dim wResult as Word

wResult = ReadADC(ADC_CH0)
```

SetChanADC
Syntax
SetChanADC(pChannel)

Include file
Amicus18_ADC.inc

Overview
Selects the pin that will be used as input to the A/D Converter.

Operator
pChannel One of the following values (defined in Amicus18_ADC.inc):

ADC_CH0	Channel 0
ADC_CH1	Channel 1
ADC_CH2	Channel 2
ADC_CH3	Channel 3
ADC_CH4	Channel 4
ADC_CH5	Channel 5
ADC_CH6	Channel 6
ADC_CH7	Channel 7
ADC_CH8	Channel 8
ADC_CH9	Channel 9
ADC_CH10	Channel 10
ADC_CH11	Channel 11
ADC_CH12	Channel 12
ADC_CH13	Channel 13
ADC_CH14	Channel 14
ADC_CH15	Channel 15
ADC_CH_CTMU	Channel 13
ADC_CH_VDDCORE	Channel 14
ADC_CH_VBG	Channel 15

SelChanConvADC
Syntax
SelChanConvADC(pChannel)

Include file
Amicus18_ADC.inc

Overview
Selects the pin that will be used as input to the A/D converter. And starts an A/D conversion.
The **BusyADC**() macro or A/D interrupt may be used to detect completion of the conversion.

Operator
pChannel One of the values used for the SetChanADC macro.

Example
```
SelChanConvADC(ADC_CH0)
```

ADC_IntEnable()   Enables the ADC interrupt i.e. sets PEIE and ADIE bits.
ADC_IntDisable()   Disables the ADC interrupt i.e. clears ADIE bit.

Example use of the A/D Converter Macros:

```
  Include "Amicus18.inc"      ' Configure the compiler to use the Amicus18 board
  Include "Amicus18_ADC.inc"  ' Load the Amicus18 ADC macros into the program

  Dim ADC_Result as Word
'
' Open the ADC:
'               Fosc / 32
'               Right justified for 10-bit operation
'               Tad value of 2
'               Vref+ at Vcc : Vref- at Gnd
'               Make AN0 an analogue input
'
  OpenADC(ADC_FOSC_32 & ADC_RIGHT_JUST & ADC_2_TAD, ADC_REF_VDD_VSS, ADC_1ANA)
  DelayUs 2                     ' Delay for 2 microSeconds
  ADC_Result = ReadADC(ADC_CH0) ' Read result of AN0
  CloseADC()                    ' Disable A/D converter
```

Timer macros Introduction

The timer peripherals are supported with the following macros. The macros are a mixture of compiler types and preprocessor types, and can be found in:
"Includes\Sources\Amicus18_Timers.inc"

- CloseTimerx   Disable timer x.
- OpenTimerx   Configure and enable timer x.
- ReadTimerx   Read the value of timer x.
- WriteTimerx   Write a value into timer x.
- SetTmrCCPSrc Configure the timer as a clock source to CCP module.

CloseTimer0
Syntax
CloseTimer0()

Include file
Amicus18_Timers.inc

Overview
This macro disables timer0 and it's interrupt.

CloseTimer1
Syntax
CloseTimer1()

Include file
Amicus18_Timers.inc

Overview
This macro disables timer1 and it's interrupt.

CloseTimer2
Syntax
CloseTimer2()

Include file
Amicus18_Timers.inc

Overview
This macro disables timer2 and it's interrupt.

CloseTimer3
Syntax
CloseTimer3()

Include file
Amicus18_Timers.inc

Overview
This macro disables timer3 and it's interrupt.

OpenTimer0
Syntax
OpenTimer0(pConfig)

Include file
Amicus18_Timers.inc

Overview
This macro configures timer0 according to the options specified and then enables it.

Operator
pConfig A bitmask that is created by performing either a bitwise AND operation ('&'), which is user configurable, with a value from each of the categories listed below. These values are defined in the file Amicus18_Timers.inc.

Enable Timer0 Interrupt:
    TIMER_INT_ON   Interrupt enabled
    TIMER_INT_OFF   Interrupt disabled

Timer Width:
    T0_8BIT   8-bit mode
    T0_16BIT   16-bit mode

Clock Source:
    T0_SOURCE_EXT External clock source (I/O pin)
    T0_SOURCE_INT Internal clock source (Tosc)

External Clock Trigger (for T0_SOURCE_EXT):
    T0_EDGE_FALL   External clock on falling edge
    T0_EDGE_RISE   External clock on rising edge

Prescale Value:
    T0_PS_1_1   1:1 prescale
    T0_PS_1_2   1:2 prescale
    T0_PS_1_4   1:4 prescale
    T0_PS_1_8   1:8 prescale
    T0_PS_1_16   1:16 prescale
    T0_PS_1_32   1:32 prescale
    T0_PS_1_64   1:64 prescale
    T0_PS_1_128   1:128 prescale
    T0_PS_1_256   1:256 prescale

Example
```
OpenTimer0(TIMER_INT_OFF & T0_8BIT & T0_SOURCE_INT & T0_PS_1_32)
```

OpenTimer1
Syntax
OpenTimer1(pConfig)

Include file
Amicus18_Timers.inc

Overview
This macro configures timer1 according to the options specified and then enables it.

Operator
pConfig A bitmask that is created by performing either a bitwise AND operation ('&'), which is user configurable, with a value from each of the categories listed below. These values are defined in the file Amicus18_Timers.inc.

Enable Timer1 Interrupt:

TIMER_INT_ON	Interrupt enabled
TIMER_INT_OFF	Interrupt disabled

Timer Width:

T1_8BIT_RW	8-bit mode
T1_16BIT_RW	16-bit mode

Clock Source:

T1_SOURCE_EXT	External clock source (I/O pin)
T1_SOURCE_INT	Internal clock source (Tosc)

Prescaler:

T1_PS_1_1	1:1 prescale
T1_PS_1_2	1:2 prescale
T1_PS_1_4	1:4 prescale
T1_PS_1_8	1:8 prescale

Oscillator Use:

T1_OSC1EN_ON	Enable Timer1 oscillator
T1_OSC1EN_OFF	Disable Timer1 oscillator

Synchronise Clock Input:

T1_SYNC_EXT_ON	Sync external clock input
T1_SYNC_EXT_OFF	Don't sync external clock input

Example
```
OpenTimer1(TIMER_INT_ON & T1_8BIT_RW & T1_SOURCE_EXT & T1_PS_1_1)
```

OpenTimer2
Syntax
OpenTimer2(pConfig)

Include file
Amicus18_Timers.inc

Overview
This macro configures timer2 according to the options specified and then enables it.

Operator
pConfig A bitmask that is created by performing either a bitwise AND operation ('&'), which is user configurable, with a value from each of the categories listed below. These values are defined in the file Amicus18_Timers.inc.

Enable Timer2 Interrupt:

TIMER_INT_ON	Interrupt enabled
TIMER_INT_OFF	Interrupt disabled

Prescale Value:

T2_PS_1_1	1:1 prescale
T2_PS_1_4	1:4 prescale
T2_PS_1_16	1:16 prescale

Postscale Value:

T2_POST_1_1	1:1 postscale
T2_POST_1_2	1:2 postscale
T2_POST_1_3	1:3 postscale
T2_POST_1_4	1:4 postscale
T2_POST_1_5	1:5 postscale
T2_POST_1_6	1:6 postscale
T2_POST_1_7	1:7 postscale
T2_POST_1_8	1:8 postscale
T2_POST_1_9	1:9 postscale
T2_POST_1_10	1:10 postscale
T2_POST_1_11	1:11 postscale
T2_POST_1_12	1:12 postscale
T2_POST_1_13	1:13 postscale
T2_POST_1_14	1:14 postscale
T2_POST_1_15	1:15 postscale
T2_POST_1_16	1:16 postscale

Example
```
OpenTimer2(TIMER_INT_OFF & T2_PS_1_1 & T2_POST_1_8)
```

OpenTimer3
Syntax
OpenTimer3(pConfig)

Include file
Amicus18_Timers.inc

Overview
This macro configures timer3 according to the options specified and then enables it.

Operator
pConfig A bitmask that is created by performing either a bitwise AND operation ('&'), which is user configurable, with a value from each of the categories listed below. These values are defined in the file Amicus18_Timers.inc.

Enable Timer3 Interrupt:

TIMER_INT_ON	Interrupt enabled
TIMER_INT_OFF	Interrupt disabled

Timer Width:

T3_8BIT_RW	8-bit mode
T3_16BIT_RW	16-bit mode

Clock Source:

T3_SOURCE_EXT	External clock source (I/O pin)
T3_SOURCE_INT	Internal clock source (Tosc)

Prescale Value:

T3_PS_1_1	1:1 prescale
T3_PS_1_2	1:2 prescale
T3_PS_1_4	1:4 prescale
T3_PS_1_8	1:8 prescale

Synchronise Clock Input:

T3_SYNC_EXT_ON	Sync external clock input
T3_SYNC_EXT_OFF	Don't sync external clock input

Example
```
OpenTimer3(T3_8BIT_RW & T3_SOURCE_EXT & T3_PS_1_1 & T3_SYNC_EXT_OFF)
```

ReadTimer0
Syntax
Variable = **ReadTimer0**()

Include file
Amicus18_Timers.inc

Overview
This macro reads the value of the Timer0 register pair.
Timer0: TMR0L,TMR0H

ReadTimer1
Syntax
Variable = **ReadTimer1**()

Include file
Amicus18_Timers.inc

Overview
This macro reads the value of the Timer1 register pair.
Timer1: TMR1L,TMR1H

ReadTimer2
Syntax
Variable = **ReadTimer2**()

Include file
Amicus18_Timers.inc

Overview
This macro reads the value of the Timer2 register.
Timer2: TMR2

ReadTimer3
Syntax
Variable = **ReadTimer3**()

Include file
Amicus18_Timers.inc

Overview
This macro reads the value of the Timer3 register pair.
Timer3: TMR3L,TMR3H

WriteTimer0
Syntax
WriteTimer0(pTimer)

Include file
Amicus18_Timers.inc

Overview
This macro writes a value to the timer0 register pair:
Timer0: TMR0L,TMR0H

Operator
pTimer The value that will be loaded into timer0.

Example
```
WriteTimer0(12340)
```

WriteTimer1
Syntax
WriteTimer1(pTimer)

Include file
Amicus18_Timers.inc

Overview
This macro writes a value to the timer1 register pair:
Timer1: TMR1L,TMR1H

Operator
pTimer The value that will be loaded into timer1.

Example
```
WriteTimer1(12340)
```

WriteTimer2
Syntax
WriteTimer2(pTimer)

Include file
Amicus18_Timers.inc

Overview
This macro writes a value to the timer1 register:
Timer2: TMR2

Operator
pTimer The value that will be loaded into timer2.

Example
```
WriteTimer2(100)
```

WriteTimer3
Syntax
WriteTimer3(pTimer)

Include file
Amicus18_Timers.inc

Overview
This macro writes a value to the timer1 register pair:
Timer3: TMR3L,TMR3H

Operator
pTimer The value that will be loaded into timer3.

Example
```
WriteTimer3(10000)
```

SetTmrCCPSrc
Syntax
SetTmrCCPSrc(pConfig)

Include file
Amicus18_Timers.inc

Overview
This macro configures a timer as a clock source for the CCP module.

Operator
pConfig A constant value from the list below. The values are defined in the file TimerDefs.inc.

T3_SOURCE_CCP	Timer3 source for both CCP's
T1_CCP1_T3_CCP2	Timer1 source for CCP1 and Timer3 source for CCP2
T1_SOURCE_CCP	Timer1 source for both CCP's

Example
```
SetTmrCCPSrc(T34_SOURCE_CCP12)
```

T3_OSC1EN_ON

Syntax
T3_OSC1EN_ON()

Include file
Amicus18_Timers.inc

Overview
This Macro enables the oscillator associated with Timer1 as source of external clock input for Timer3.

T3_OSC1EN_OFF

Syntax
T3_OSC1EN_OFF()

Include file
Amicus18_Timers.inc

Overview
This Macro disables the oscillator associated with Timer1 and selects the signal on pin T13CKI as the source of the external clock input for Timer3.

Example Use of the Timer0 Macro:

```
Include "Amicus18.inc"        ' Configure the compiler to use the Amicus18 board
Include "Amicus18_Timers.Inc" ' Load the Amicus18 Timer Macros into the program

Dim MyResult As Word

' Configure Timer0
OpenTimer0(TIMER_INT_OFF & T0_SOURCE_INT & T0_PS_1_32 & T0_16BIT)

HRSOutLn "Press a Key"
Do
  While Inkey = 16 : Wend        ' Wait for a Keypress on the keypad
  MyResult = ReadTimer0()        ' Read Timer0
  WriteTimer0(0)                 ' Reset Timer0
  HRSOutLn "Timer0 Value = ", Dec MyResult ' Display the value of Timer0
  While InKey <> 16 : Wend       ' Wait for the key to released
  DelayMS 50
Loop
CloseTimer0()                    ' Close Timer0
```

SPI macros Introduction

The following macros are provided for the SPI™ peripheral:

- CloseSPI   Disable the SSP module used for SPI™ communications.
- DataReadySPI   Determine if a new value is available from the SPI buffer.
- OpenSPI   Initialise the SSP module used for SPI communications.
- ReadSPI   Read a byte from the SPI bus.
- WriteSPI   Write a byte to the SPI bus.

CloseSPI

Syntax
CloseSPI()

Include file
Amicus18_SPI.inc

Overview
This Macro disables the SSP module. Pin I/O returns under the control of the appropriate TRIS and LAT registers.

DataReadySPI

Syntax
Variable = **DataReadySPI**()

Include file
Amicus18_SPI.inc

Overview
This Macro determines if there is a byte to be read from the SSPBUF register.

Return Values
0 if there is no data in the SSPBUF register
1 if there is data in the SSPBUF register

Example
```
While DataReadySPI() = 0 : Wend
```

OpenSPI
Syntax
OpenSPI(pSyncMode, pBusMode, pSmpPhase)

Include file
Amicus18_SPI.inc

Overview
This Macro sets up the SSP module for use with a SPIx bus device.

Parameters
pSyncMode One of the following values, defined in Amicsu18_SPI.inc:

SPI_FOSC_4	SPI Master mode, clock = Fosc / 4, resulting in a 1MHz interface.
SPI_FOSC_16	SPI Master mode, clock = Fosc / 16, resulting in a 4MHz interface.
SPI_FOSC_64	SPI Master mode, clock = Fosc / 64, resulting in a 16MHz interface.
SPI_FOSC_TMR2	SPI Master mode, clock = TMR2 output / 2
SLV_SSON	SPI Slave mode, /SS pin control enabled
SLV_SSOFF	SPI Slave mode, /SS pin control disabled

pBusMode One of the following values, defined in SPIdefs.inc:

MODE_00	Setting for SPI bus Mode 0,0
MODE_01	Setting for SPI bus Mode 0,1
MODE_10	Setting for SPI bus Mode 1,0
MODE_11	Setting for SPI bus Mode 1,1

pSmpPhase One of the following values, defined in SPIdefs.inc:

SMPEND	Input data sample at end of data out
SMPMID	Input data sample at middle of data out

Example
```
OpenSPI(SPI_FOSC_16, MODE_00, SMPEND)
```

ReadSPI
Syntax
Variable = **ReadSPI**()

Include file
Amicus18_SPI.inc

Overview
This macro initiates a SPI bus cycle for the acquisition of a byte of data.

WriteSPI
Syntax
WriteSPI(pDataOut)

Include file
Amicus18_SPI.inc

Overview
This Macro writes a single data byte out.

Operator
pDataOut Value to be written to the SPI bus.

Example of SPI macros
```
Include "Amicus18.inc"        ' Configure the compiler to use the Amicus18 board
Include "Amicus18_SPI.inc"    ' Load the Amicus18 SPI macros into the program

Dim bTemp as Byte

OpenSPI(SPI_FOSC_16, MODE_01, SMPMID)
WriteSPI($55)
bTemp = ReadSPI()
DataReadySPI()
CloseSPI()
```

Hardware PWM macro Introduction
The PWM peripheral is supported with the following macros:

- CloseAnalog1   Disable the CCP1 peripheral
- CloseAnalog2   Disable the CCP2 peripheral
- OpenAnalog1   Enable and configure the CCP1 peripheral
- OpenAnalog2   Enable and configure the CCP2 peripheral
- WriteAnalog1   Output an 8-bit or 10-bit Pulse Width Modulated waveform from CCP1
- WriteAnalog2   Output an 8-bit or 10-bit Pulse Width Modulated waveform from CCP2

CloseAnalog1
Syntax
CloseAnalog1()

Include file
Amicus18_hpwm8.inc for 8-bit PWM
or
Amicus18_hpwm10.inc for 10-bit PWM

Overview
Disable the CCP1 peripheral and set its appropriate pin as an input.

CloseAnalog2
Syntax
CloseAnalog2()

Include file
Amicus18_hpwm8.inc for 8-bit PWM
or
Amicus18_hpwm10.inc for 10-bit PWM

Overview
Disable the CCP2 peripheral and set its appropriate pin as an input.

OpenAnalog1
Syntax
OpenAnalog1()

Include file
Amicus18_hpwm8.inc for 8-bit PWM
or
Amicus18_hpwm10.inc for 10-bit PWM

Overview
Enable and configure the CCP1 peripheral and set its appropriate pin as an output.

OpenAnalog2
Syntax
OpenAnalog2()

Include file
Amicus18_hpwm8.inc for 8-bit PWM
or
Amicus18_hpwm10.inc for 10-bit PWM

Overview
Enable and configure the CCP2 peripheral and set its appropriate pin as an output.

WriteAnalog1
Syntax
WriteAnalog1(pValue)

Include file
Amicus18_hpwm8.inc for 8-bit PWM
or
Amicus18_hpwm10.inc for 10-bit PWM

Note. The CCP1 peripheral will be operating at the highest frequency possible for 8-bit (0 to 255) or 10-bit (0 to 1023). With the default 64MHz oscillator this will be 62.5KHz for 10-bit and 250KHz for 8-bit.

Only one of the above include files may be used within a program an any one time.

Overview
Output an 8-bit or 10-bit PWM waveform from the CCP1 peripheral's pin (RC2).

Operator
pValue a constant, variable, or expression that will alter the duty cycle of the PWM Waveform.

Example

```
' An LED attached to RC2 will increase illumination, then dim, repeatedly
' The voltage produced by the PWM signal is displayed on the serial terminal
'
Include "Amicus18.inc"          ' Configure the compiler to use the Amicus18 board
Include "Amicus18_Hpwm10.inc"   ' Load the Amicus18 10-bit PWM macros into program
Declare Float_Display_Type = fast  ' Faster, more accurate float display
Dim fVolts As Float             ' Holds the Voltage calculation
Dim wTemp As Word               ' Holds the duty cycle value for the PWM
'
' Quantasise the Voltage. i.e. Volts per-bit, based upon 3.3 Volts at 10-bits
'
Symbol Quanta = 3.3 / 1024
OpenAnalog1()                   ' Enable and configure the CCP1 peripheral
Do                              ' Create an infinite loop
  '
  ' Increase LED illumation
  ' Cycle the full range of 10-bits. i.e. 0 to 1023
  For wTemp = 0 To 1023
    WriteAnalog1(wTemp)         ' PWM on CCP1 (Bit-2 of PORTC)
    fVolts = wTemp * Quanta     ' Calculate the Voltage
    HRSOutLn Dec wTemp, " = ", Dec fVolts, " Volts" ' Display Voltage
  Next
  '
  ' Decrease LED illumination
  ' Cycle the full range of 10-bits (reversed). i.e. 1023 to 0
  For wTemp = 1023 To 0 Step -1
    WriteAnalog1 (wTemp)        ' PWM on CCP1 (Bit-2 of PORTC)
    fVolts = wTemp * Quanta     ' Calculate the Voltage
    HRSOutLn Dec wTemp, " = ", Dec fVolts, " Volts" ' Display Voltage
  Next
Loop                            ' Do it forever
```

A suitable layout for the above program built on the Companion Shield using a solderless breadboard is shown below:
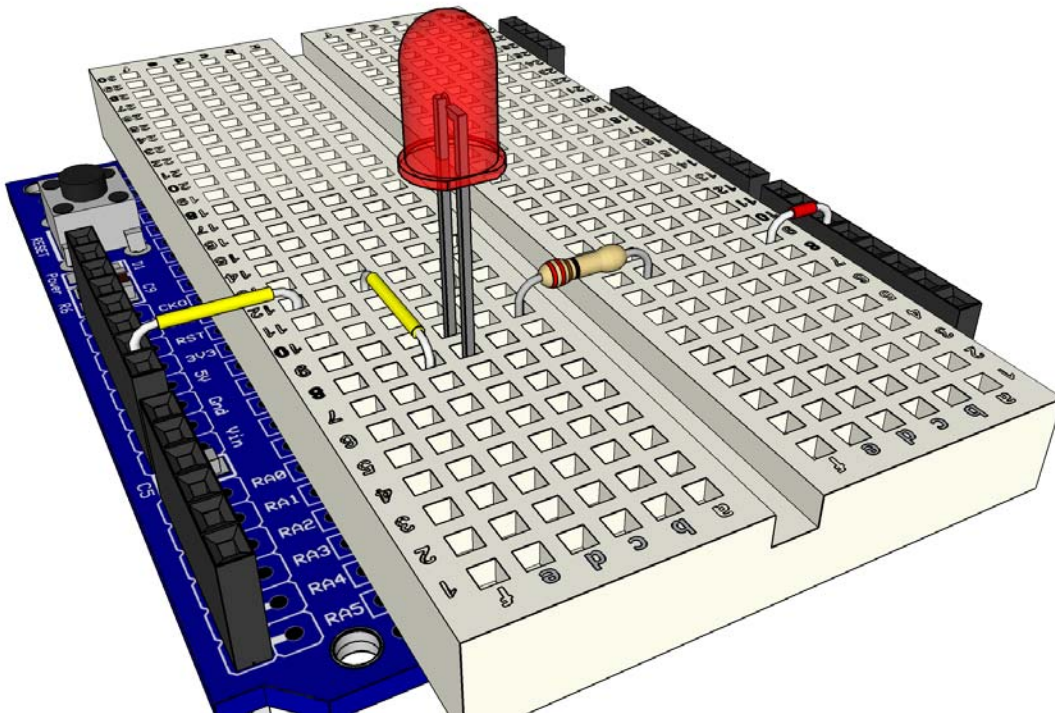
WriteAnalog2

Syntax
WriteAnalog2(pValue)

Include file
Amicus18_hpwm8.inc for 8-bit PWM
or
Amicus18_hpwm10.inc for 10-bit PWM

Note. The CCPx peripherals will be operating at the highest frequency possible for 8-bit (0 to 255) or 10-bit (0 to 1023). With the default 64MHz oscillator this will be 62.5KHz for 10-bit and 250KHz for 8-bit.

Only one of the above include files may be used within a program an any one time.

Overview
Output an 8-bit or 10-bit PWM waveform from the CCP2 peripheral's pin (RC1).

Operator
pValue a constant, variable, or expression that will alter the duty cycle of the PWM Waveform.

Example
```
' An LED attached to RC1 will increase illumination, then dim, repeatedly
' The voltage produced by the PWM signal is displayed on the serial terminal
'
Include "Amicus18.inc"         ' Configure the compiler to use the Amicus18 board
Include "Amicus18_Hpwm10.inc"  ' Load the Amicus18 8-bit PWM macros into program
Declare Float_Display_Type = fast   ' Faster, more accurate float display

Dim fVolts As Float                 ' Holds the Voltage calculation
Dim wTemp As Word                   ' Holds the duty cycle value for the PWM
'
' Quantasise the Voltage. i.e. Volts per-bit, based upon 3.3 Volts at 10-bits
'
Symbol Quanta = 3.3 / 1023
OpenAnalog2()                       ' Enable and configure the CCP2 peripheral
Do                                  ' Create an infinite loop
  '
  ' Increase LED illumation
  ' Cycle the full range of 10-bits. i.e. 0 to 1023
  For wTemp = 0 To 1023
    WriteAnalog2(wTemp)            ' PWM on CCP2 (Pin-1 of PORTC)
    fVolts = wTemp * Quanta        ' Calculate the Voltage
    HRSOutLn Dec wTemp, " = ", Dec fVolts, " Volts" ' Display Voltage
  Next
  '
  ' Decrease LED illumination
  ' Cycle the full range of 10-bits (reversed). i.e. 1023 to 0
  For wTemp = 1023 To 0 Step -1
    WriteAnalog2 (wTemp)          ' PWM on CCP2 (Pin-1 of PORTC)
    fVolts = wTemp * Quanta        ' Calculate the Voltage
    HRSOutLn Dec wTemp, " = ", Dec fVolts, " Volts" ' Display Voltage
  Next
Loop                                ' Do it forever
```

A suitable layout for the previous program built on the Companion Shield using a solderless breadboard is shown below:
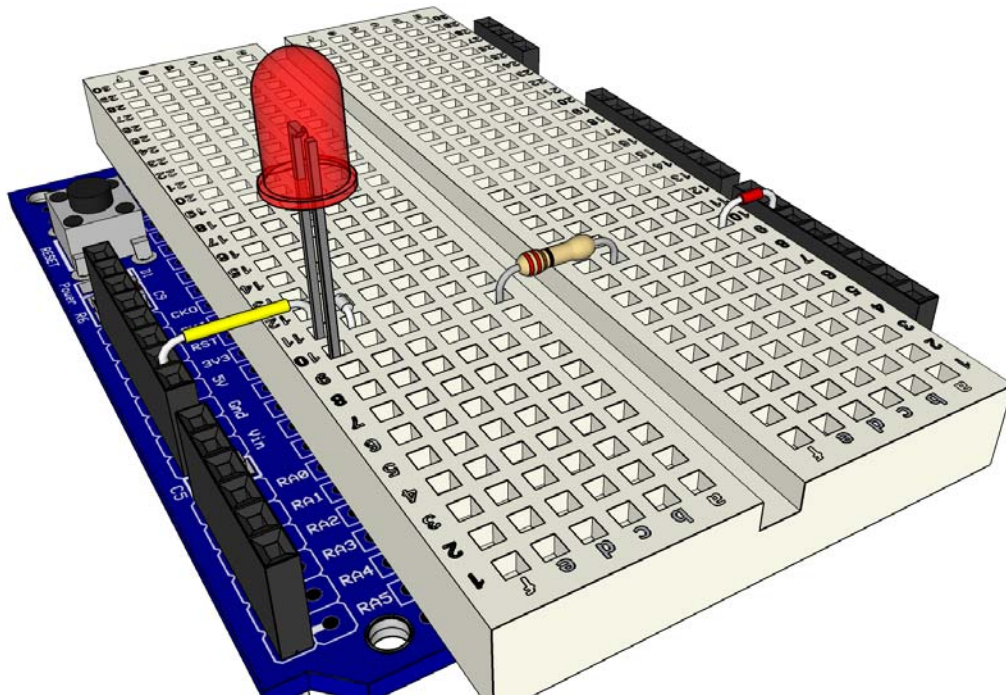
Using the Proton Compiler with MPLAB IDE™

The compiler can be used within the MPLAB™ IDE environment and allows single stepping of the code on a high-level basis. i.e. BASIC lines of code, or the use of the ICD2, PICkit 2, PICkit3, or a device Programmer.

We'll walk through the method of operation step by step.

First, download a copy of the latest MPLAB™ IDE because this method will only work on versions 8.0 onwards. The release at the time of writing is 8.60, and it is recommend to use this version. MPLAB™ can be downloaded from *www.microchip.com*

Locate the files *tlchill.ini* and *proton.mtc* within the compiler's folder (default location *C:\Program Files\ProtonIDE\PDS*) and copy them into MPLAB's folder "Core\MTC Suites", overwriting any previous files. MPLAB™ will default to location *C:\Program Files\Microchip\MPLAB IDE*, therefore, the legacy folder should be located at:

C:\Program Files\Microchip\MPLAB IDE\Core\MTC Suites.

Once these files have been copied, locate and run the file Mplab_Proton.reg, which can also be found within the compiler's folder. This will add entries into the registry that will register the Proton Compiler as a toolsuite within MPLAB™. If using a 64-bit OS, run the file Mplab_Proton_64.reg instead.

Open MPLAB™, then click on the *Project Wizard* menu option.
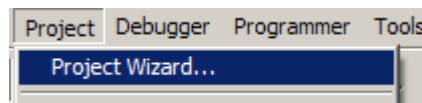
This will open the intro window as shown below.
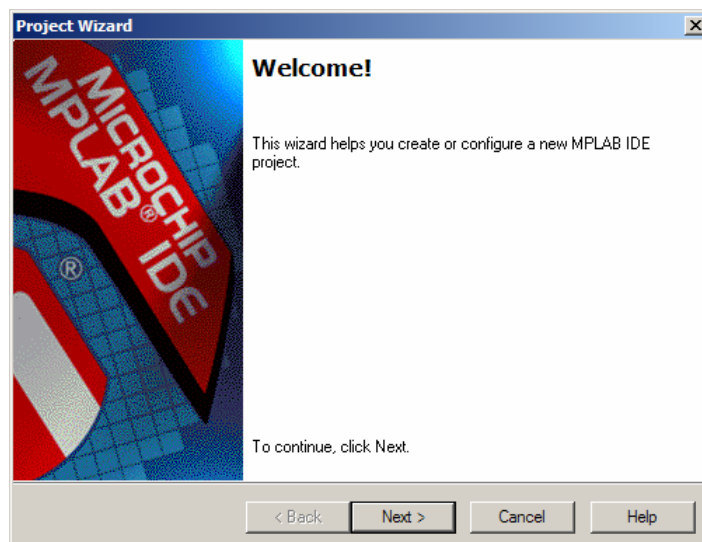
For this demonstration program, the microcontroller of choice is the 16F628A, so in the step 1 window, choose the 16F628A device.
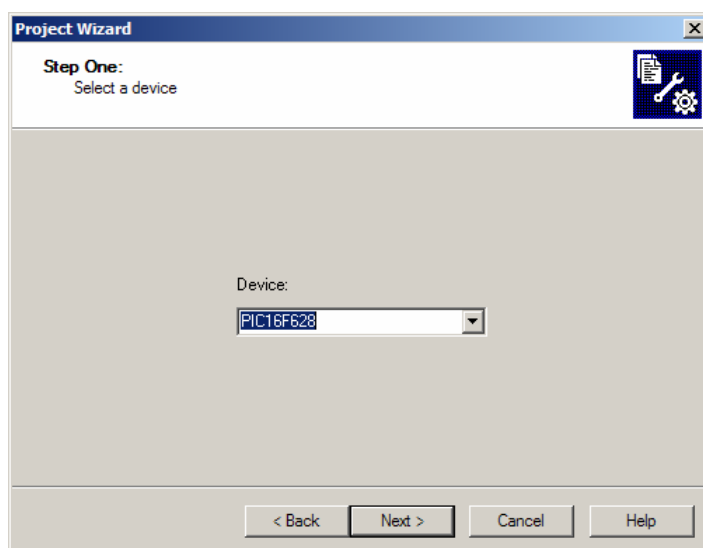
By default the device chosen in this window will be the device that the compiler uses, regardless of a **Device** directive within the BASIC listing. The **Device** directive will be ignored (see end of document to disable this).

Click *Next*, then choose the Proton Compiler toolsuite, and *browse* to where the Proton compiler's executable is stored.

The default location for this is *C:\Program Files\ProtonIDE\PDS*.

Browse to the file named **PrPlus.exe** and enter this in the Location window. It should be within the compiler's folder.
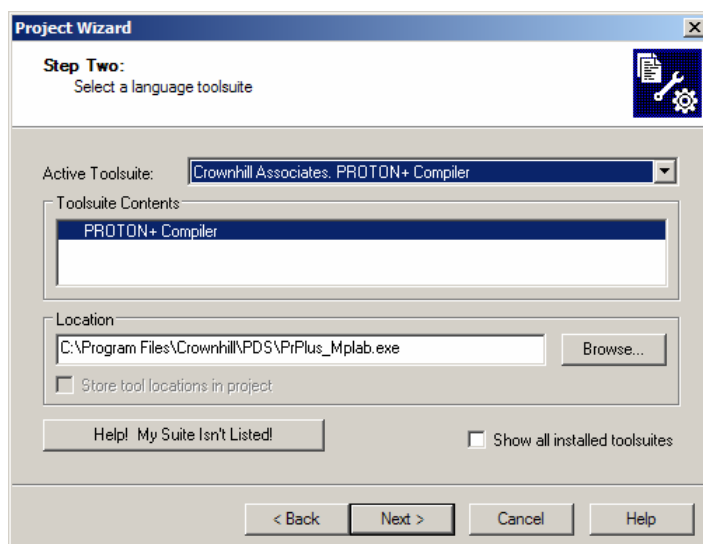
After clicking *Next*, a project name and location needs to be chosen in the step 3 window. The name given to the demonstration project is MPLAB_Test, and it's located, in this case, in the compiler's source code folder. But it can be placed virtually anywhere on the hard drive as long as it is not nested too deeply.
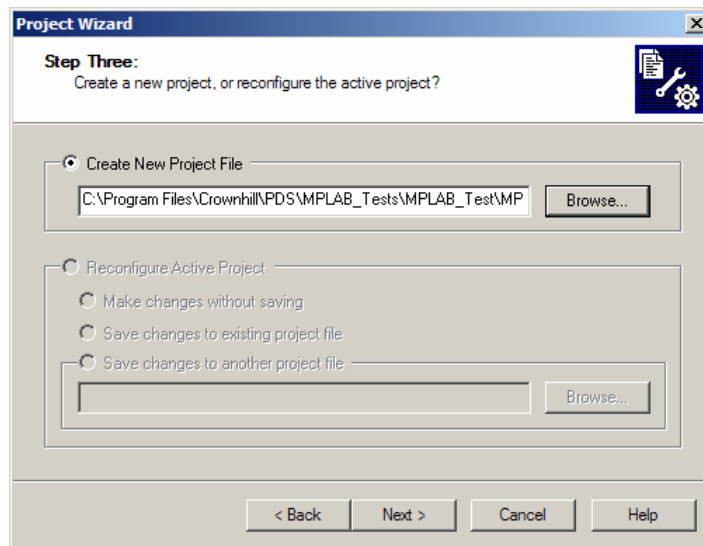
Now we need to add the BASIC file to the project. The BASIC file for the demonstration is named MP_Test.bas.
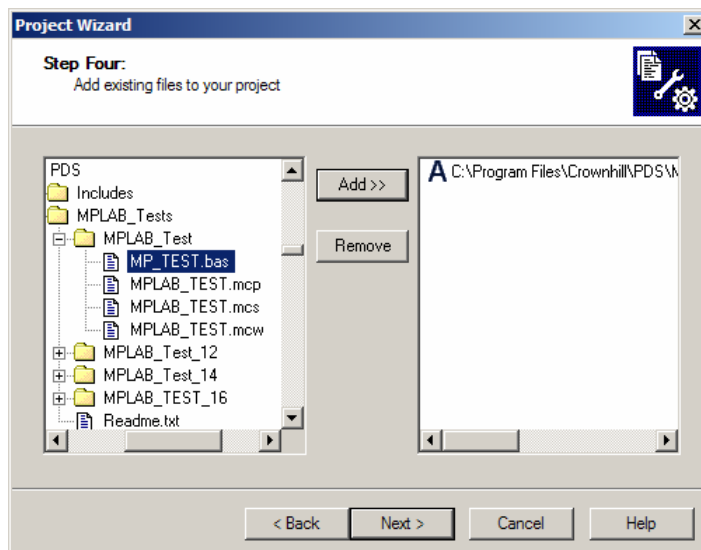
Clicking *Next* a few times after step 4 will create the project. But no BASIC filename has been loaded into the IDE, so right click on *Source File* option located in the *MPLAB_Test.mcw* window, and choose the appropriate BASIC file.
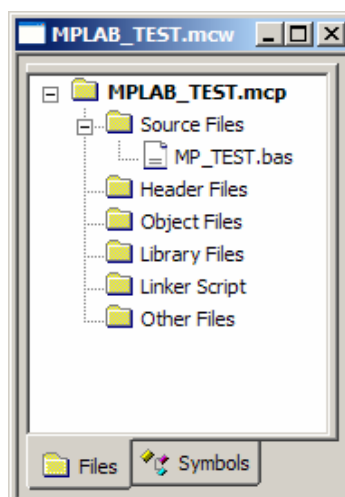
Double click on the *MP_Test.bas* text in the MPLAB_Text.mcw window, and the BASIC file will be opened ready to compile. Choose *Project* then *Build* or (*Ctrl F10*) to compile the program.
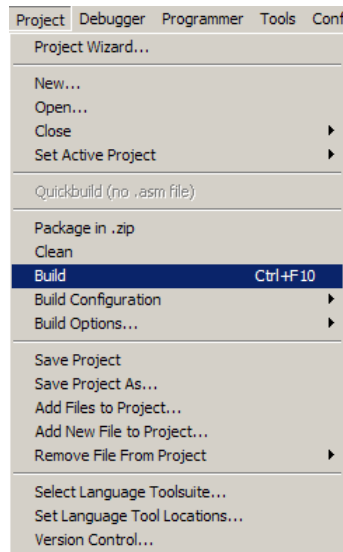
For this demonstration the Logic Analyser will be used. Choose *View->Simulator Logic Analyser* from the menu bar.
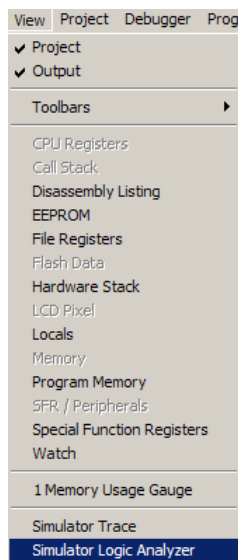
The logic analyser window will then appear.
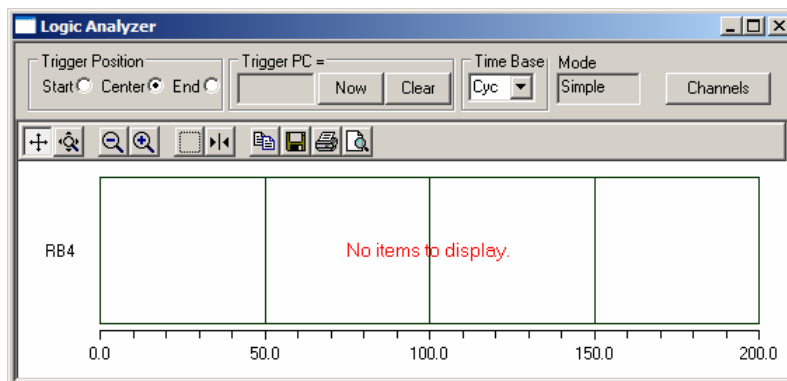
Click on the Channels button and choose the Port and Pin used in the BASIC program. i.e. PORTB.4.
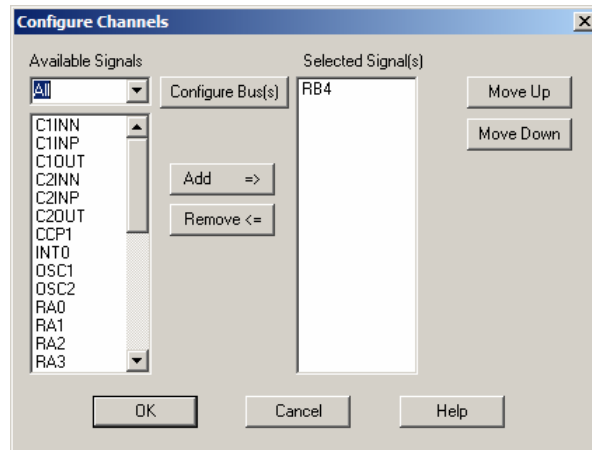
Run the simulator using the animate icon.

And the logic analyser will show the condition of PORTB.4.
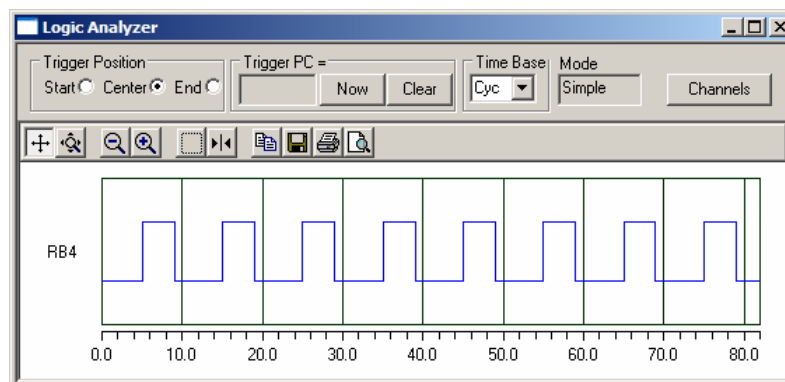
Disabling the Automatic Device Selection.
By default, MPLAB™ forces the compiler to ignore any **Device** directives within the BASIC pro-
gram in favour of whatever device is chosen in the *Configure->Select Device* Options menu.
This can be disabled by right clicking on the filename within the *MCW* window and choosing
Build Options.
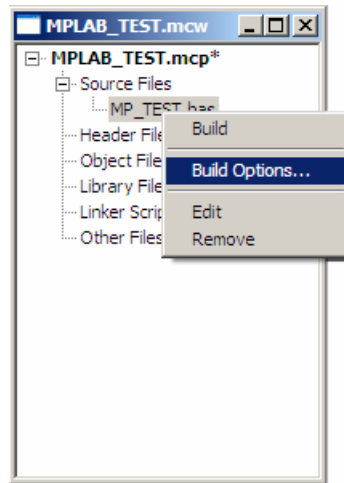
You will be presented with a configuration window containing a single switch.
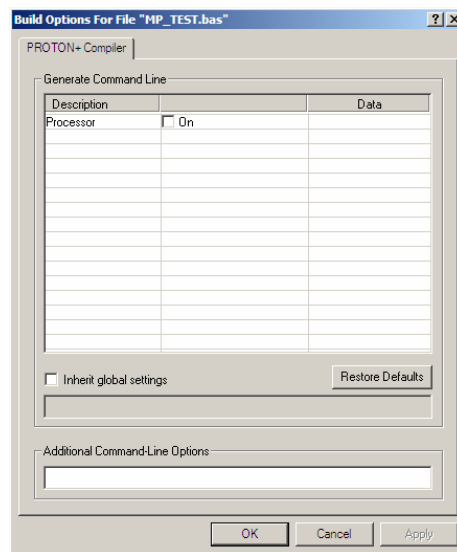
Untick the *On* switch and click *Apply*.

The microcontroller that the compiler recognises is now issued by the **Device** directive within
the BASIC program, therefore ensure that MPLAB™ is configured for the correct device for any
simulations of programming.

An Easier Method

There is another way to simulate within MPLAB™ without going through the tedious process of creating a project.

When the directive `Declare Create_Coff = On` is placed within the BASIC program, a cof file (common Object File) is produced during compilation. A cof file has all the information required for simulation, and is as close as it gets to a standard format.
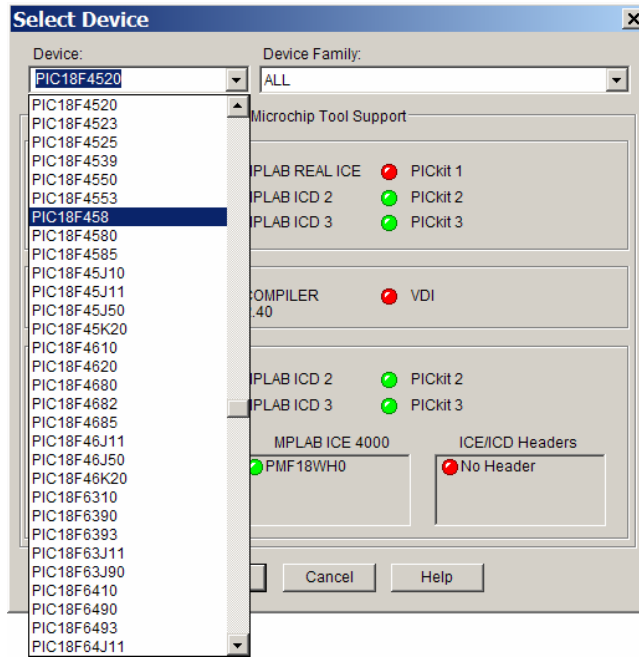
Open MPLAB™, and close any open projects, this is an important procedure. You should now be presented with an empty workspace. Choose the debugger of choice from the *debugger* toolbar menu.
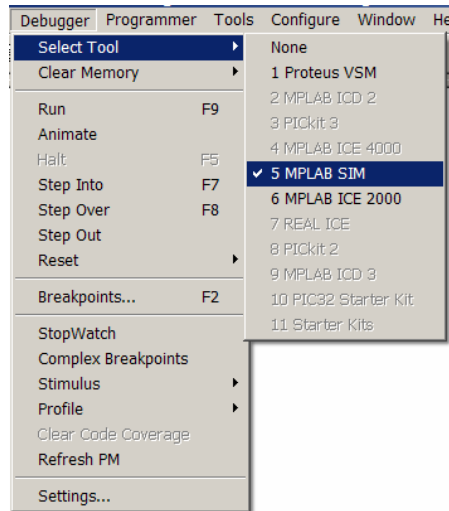
Then choose the appropriate device that the BASIC program is compiled for, by clicking on the *configure->select device* toolbar menu.
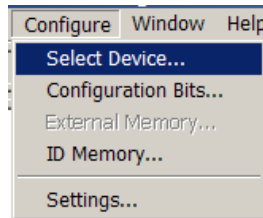
You can now choose the device from a list.

Open the folder where the BASIC file was situated, and drag the file with the extension '.cof' on to the the MPLAB™ workspace. It will be automatically opened to show the BASIC file.

The program can now be simulated, either by animation or single stepping. However, there are still 2 steps to carry out that will improve the simulation. Click on the *debugger* toolbar menu, and choose the bottom option. i.e. *settings*.

When the window shows, click the *Animation/Realtime Updates* tab.
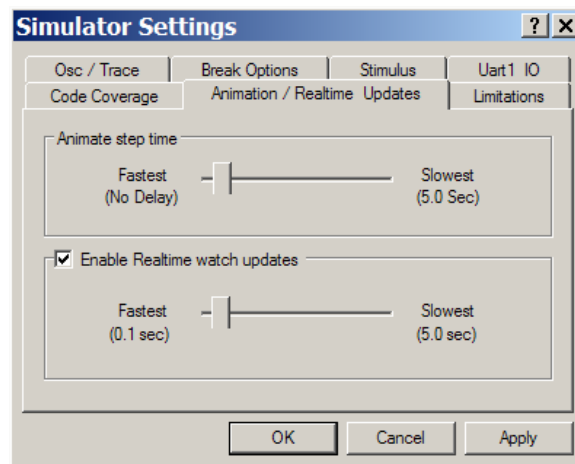
Tick *Enable Realtime watch updates*, and move the step time closer to the fastest side. i.e. far left.

Now click on the *Osc/Trace* tab, and choose the oscillator frequency used in the BASIC program.
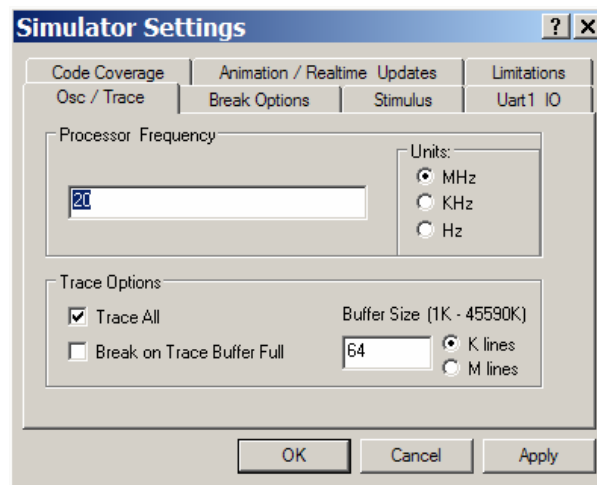
Click *Apply* for the settings to take effect, then *OK*.

You can now open watch windows, dissasemby listings etc, and watch the variables update as the simulation is in progress.

Protected Compiler Words

Below is a list of protected words that the compiler or assembler uses internally. Be sure not to use any of these words as variable or label names, otherwise errors will be produced.

(A)
Abs, Access_Upper_64K, Acos, Actual_Banks, ADC_Resolution, Adcin, Addlw, Addwf, Addwfc, Adin, Adin_Delay, Adin_Res, Adin_Stime, Adin_Tad, All_Digital, Andlw, Asin, Asm, Atan, Auto_Context_Save, Available_RAM

(B)
Bank0_End, Bank0_Start, Bank10_End, Bank10_Start, Bank11_End, Bank11_Start, Bank12_End, Bank12_Start, Bank13_End, Bank13_Start, Bank14_End, Bank14_Start, Bank15_End, Bank15_Start, Bank1_End, Bank1_Start, Bank2_End, Bank2_Start, Bank3_End, Bank3_Start, Bank4_End, Bank4_Start, Bank5_End, Bank5_Start, Bank6_End, Bank6_Start, Bank7_End, Bank7_Start, Bank8_End, Bank8_Start, Bank9_End, Bank9_Start, Bank_Select_Switch, BankiSel, BankSel, Bc, Bcf, Bin, Bin1, Bin10, Bin11, Bin12, Bin13, Bin14, Bin15, Bin16, Bin17, Bin18, Bin19, Bin2, Bin20, Bin21, Bin22, Bin23, Bin24, Bin25, Bin26, Bin27, Bin28, Bin29, Bin3, Bin30, Bin31, Bin32, Bin4, Bin5, Bin6, Bin7, Bin8, Bin9, Bit, Bn, Bnc, Bnn, Bnov, Bnz, Bootloader, Bov, Box, Bra, Branch, Branchl, Break, Brestart, Bsf, Bstart, Bstop, Btfsc, Btfss, Btg, Bus_DelayMs, Bus_SCL, BusAck, Busin, Busout, Button, Button_Delay, Byte, Byte_Math, BZ, Bit_Bit, Bit_Byte, Bit_Dword, Bit_Float, Bit_Word, Bit_Wreg, Byte_Bit, Byte_Byte, Byte_Dword, Byte_Float, Byte_Word, Byte_Wreg, Brw

(C)
Call, Case, Cblock, CCP1_Pin, CCP2_Pin, CCP3_Pin, CCP4_Pin, CCP5_Pin, Cdata, Cerase, CF_ADPort, CF_ADPort_Mask, CF_CD1Pin, CF_CE1Pin, CF_DTPort, CF_Init, CF_OEPin, CF_RDYPin, CF_Read, CF_Read_Write_Inline, CF_RSTPin, CF_Sector, CF_WEPin, CF_Write, Chr$, Circle, Clear, ClearBit, ClearPin, Clrf, Clrw, Cls, Code, Comf, Config, Constant, Context, Continue, Core, Cos, Count, Counter, Cpfseq, Cpfsgt, Cpfslt, Cread, Cread8, Cread16, Cread32, Cursor, Cwrite, Callw, cPtr8, cPtr16, cPtr32

(D)
Da, Data, Daw, Db, Dc, Dcd, Dcfsnz, De, Dead_Code_Remove, Dword_Bit, Dword_Byte, Dword_Dword, Dword_Float, Dword_Word, Dword_Wreg,
Debug_Req, Debugin, Dec, Dec, Dec1, Dec1, Dec10, Dec2, Dec2, Dec3, Dec3, Dec4, Dec4, Dec5, Dec5, Dec6, Dec6, Dec7, Dec7, Dec8, Dec8, Dec9, Decf, Decfsz, Declare, Dectrment, Define, Delayms, Delayus, DelayCs, Device, Dig, Dim, Disable, Div32, Djc, Djnc, Djnz, Djz, Dt, DTMfout, Dw, Dword, Do

(E)
Edata, Eeprom_Size, Else, ElseIf, Enable, End, EndAsm, EndIf, EndM, EndSelect, equ, Eread, Error, ErrorLevel, Ewrite, ExitM, Exp, Expand

(F)
Fill, Fix16_8Add, Fix16_8Div, Fix16_8Greater, Fix16_8GreaterEqual, Fix16_8Less, Fix16_8LessEqual, Fix16_8Mul, Fix16_8Sub, Fix16_8ToFloat, Fix16_8ToInt, Fix8_8Add, Fix8_8Div, Fix8_8Greater Fix8_8GreaterEqual, Fix8_8Less, Fix8_8LessEqual, Fix8_8Mul, Fix8_8Sub, Fix8_8ToFloat, Fix8_8ToInt, Flash_Capable, Float, Float_Display_Type, Float_Rounding, FloatToFix16_8, FloatToFix8_8, Font_Addr, For, Freqout, Float_Bit, Float_Byte, Float_Dword, Float_Float, Float_Word, Float_Wreg

(G)
Get#Proton#Version, GetBit, GLCD_CS_Invert, GLCD_Fast_Strobe, GLCD_Read_Delay, GLCD_Strobe_Delay, Gosub, Goto, GetPin

(H)
HbRestart, HbStart, HbStop, Hbus_Bitrate, HbusAck, Hbusin, Hbusout, Hex, Hex1, Hex2, Hex3, Hex4, Hex4, Hex5, Hex6, Hex7, Hex8, High, High_Int_Sub_End, High_Int_Sub_Start, HighLow_Tris_Reverse, Hpwm, Hrsin, Hrsin2, Hrsin3, Hrsin4, Hrsout, Hrsout2, Hrsout3, Hrsout4, HrsoutLn, Hrsout2Ln, Hrsout3Ln, Hrsout4Ln
Hserial4_Baud, Hserial4_Clear, Hserial4_Parity, Hserial4_RCSTA, Hserial4_SPBRG, Hserial4_TXSTA, Hserial3_Baud, Hserial3_Clear, Hserial3_Parity, Hserial3_RCSTA, Hserial3_SPBRG, Hserial3_TXSTA, Hserial2_Baud, Hserial2_Clear, Hserial2_Parity, Hserial2_RCSTA, Hserial2_SPBRG, Hserial2_TXSTA, Hserial_Baud, Hserial_Clear, Hserial_Parity, Hserial_RCSTA, Hserial_SPBRG, Hserial_TXSTA, Hserin, Hserin2, Hserin3, Hserin4, Hserout, Hserout2, Hserout3, Hserout4, HseroutLn, Hserout2Ln, Hserout3Ln, Hserout4Ln, Hserial1_ChangeBaud, Hserial2_ChangeBaud, Hserial3_ChangeBaud, Hserial4_ChangeBaud

(I)
I2C_Bus_SCL, I2C_Slow_Bus, I2Cin, I2Cout, I2CWrite, I2CRead, ICD_Req, Icos, Idata, If, Ijc, Ijnc, Ijnz, Ijz, Inc, Incf, Incfsz, Include, Increment, Infsnz, Inkey, Input, Int_Sub_End, Int_Sub_Start, Internal_Bus, Internal_Font, IntToFix16_8, IntToFix8_8, Iorlw, Iorwf, IrIn, IrIn_Pin, Isin, ISqr

(K)
Keyboard_CLK_Pin, Keyboard_DTA_Pin, Keyboard_IN, Keypad_Port

(L)
Label_Word, Label_Bank_Resets, LCD_CDPin, LCD_CEPin, LCD_CommandUS, LCD_CS1Pin, LCD_CS2Pin, LCD_DataUs, LCD_DTPin, LCD_DTPort, LCD_ENPin, LCD_Font_HEIGHT, LCD_Font_Width, LCD_Graphic_Pages, LCD_Interface, LCD_Lines, LCD_RAM_Size, LCD_RDPin, LCD_RSPin, LCD_RSTPin, LCD_RWPin, LCD_Text_Home_Address, LCD_Text_Pages, LCD_Type, LCD_WRPin, LCD_X_Res, LCD_Y_Res, LCDread, LCDwrite, Ldata, Left$, Len, Let, Lfsr, Lslf, Lsrf, Library_Core, Line, LineTo, LoadBit, Local, Log, Log10, LookDown, LookDownL, LookUp, LookUpL, Low, Low_Int_Sub_End, Low_Int_Sub_Start, Lread, Lread16, Lread32, Lread8, Lread64, Loop

(M)
Macro_Params, Max, Mid$, Min, Mouse_CLK_Pin, Mouse_Data_Pin, Mouse_In, Movf, Movff, Movlw, Movwf, Mssp_Type, Mullw, Mulwf, Movwi, Moviw

(N)
Ncd, Negf, Next, Nop, Num_Bit, Num_Byte, Num_Dword, Num_Float, Num_FSR, Num_FSR0, Num_FSR2, Num_Word, Num_Wreg

(O)
On_Hard_Interrupt, On_Hardware_Interrupt, On_Interrupt, On_Low_Interrupt, On_Soft_Interrupt, On_Software_Interrupt, Onboard_Adc, Onboard_Uart, Onboard_Usb, Optimise_Bit_Test, Optimiser_Level, Oread, Org, Output, Owin, Owout, Owrite

(P)
Page, PageSel, Pause, PauseUS, Peek, PIC_Pages, Pixel, PLL_Req, Plot, Poke, Pop, Portb_Pullups, Pot, Pow, Print, Prm_1, Prm_10, Prm_11, Prm_12, Prm_13, Prm_14, Prm_15, Prm_2, Prm_3, Prm_4, Prm_5, Prm_6, Prm_7, Prm_8, Prm_9, Prm_Count, Proton_Start_Address, PulsIn, PulseIn, Pulsin_Maximum, PulseOut, Push, Pwm, Ptr8, Ptr16, Ptr32, Pin_A0, Pin_A1, Pin_A2, Pin_A3, Pin_A4, Pin_A5, Pin_A6, Pin_A7, Pin_B0, Pin_B1, Pin_B2, Pin_B3, Pin_B4, Pin_B5, Pin_B6, Pin_B7, Pin_C0, Pin_C1, Pin_C2, Pin_C3, Pin_C4, Pin_C5, Pin_C6, Pin_C7, Pin_D0, Pin_D1, Pin_D2, Pin_D3, Pin_D4, Pin_D5, Pin_D6, Pin_D7,

Pin_E0, Pin_E1, Pin_E2, Pin_E3, Pin_E4, Pin_E5, Pin_E6, Pin_E7, Pin_F0, Pin_F1, Pin_F2, Pin_F3, Pin_F4, Pin_F5, Pin_F6, Pin_F7, Pin_G0, Pin_G1, Pin_G2, Pin_G3, Pin_G4, Pin_G5, Pin_G6, Pin_G7, Pin_H0, Pin_H1, Pin_H2, Pin_H3, Pin_H4, Pin_H5, Pin_H6, Pin_H7, Pin_J0, Pin_J1, Pin_J2, Pin_J3, Pin_J4, Pin_J5, Pin_J6, Pin_J7, Pin_K0, Pin_K1, Pin_K2, Pin_K3, Pin_K4, Pin_K5, Pin_K6, Pin_K7, Pin_L0, Pin_L1, Pin_L2, Pin_L3, Pin_L4, Pin_L5, Pin_L6, Pin_L7

(R)

RAM_Bank, RAM_Banks, Random, RC5in, RC5in_Extended, RC5in_Pin, RCall, RCin, RcTime, Read, Rem, Remarks, Reminders, Rep, Repeat, Res, Reserve_RAM, Reset_Bank, Restore, Resume, Retfie, Retlw, Return, Return_Type, Return_Var, Rev, Right$, Rlcf, Rlf, Rlncf, Rol, Ror, Rrcf, Rrf, Rrncf, Rsin, Rsin_Mode, Rsin_Pin, Rsin_Timeout, Rsout, RsoutLn, Rsout_Baud, Rsout_Mode, Rsout_Pace, Rsout_Pin, Return_Bit, Return_Byte, Return_Dword, Return_Float, Return_Word, Return_Wreg

(S)

SBreak, SCL_Pin, SDA_Pin, Seed, Select, Serial_Baud, Serial_Data, Serial_Parity, Serin, Serout, Servo, Set, Set_Bank, Set_Defaults, Set_OSCCAL, SetBit, SetPin, Setf, Shift_DelayUs, ShiftIn, Shin, Shout, Show_Expression_Parts, Show_System_Variables, Signed_Dword_Terms, Sin, Single_Page_Model, SizeOf, Sleep, Slow_Bus, Small_Micro_Model, Snooze, SonyIn, SonyIn_Pin, Sound, Sound2, Sqr, Stack_Size, Stamp _Cos, Stamp_Sin, Stamp _Sqr, Step, Stop, Str, Str$, Str$, StrCmp, String, Strn, Subfwb, Sublw, Subwf, Subwfb, Swap, Swapf, Symbol, Sbyte, Sword, SDword

(T)

Tan, Tblrd, Tblwt, TCase, Then, to, Toggle, ToLower, Toshiba_Command, Toshiba_UDG, ToUpper, Tstfsz

(U)

Udata, UnPlot, Unsigned_Dwords, Until, Upper, USB_At_TOM, USB_Class_File, USB_Count_Errors, USB_Descriptor, USB_Self_Power_Pin, USB_Sense_Pin, USB_Show_Enum, USB_Type, USBin, USBin_Auto_Poll, USBin_Buffer_Length, USBin_Buffer_Start, USbinit, USBout, USBout_Auto_Poll, USBout_ Buffer _Length, USBout _Buffer_Start, USBpoll, USBService

(V)

Val, Var, Variable, VarPtr

(W)

Wait, Warnings, WatchDog, Wend, While, Word, Write, Word_Bit, Word_Byte, Word_Dword, Word_Float, Word_Word, Word_Wreg, Wreg_Bit, Wreg_Byte, Wreg_Dword, Wreg_Float, Wreg_Word

(X)

Xin, Xorlw, Xorwf, Xout, Xtal

_adc, _adcres, _code, _core, _defined, _device, _eeprom, _flash, _mssp, _ports, _ram, _uart _usb, _xtal