XEMICS

AN8000.08
Application note

Guidelines on how to build a barometer around the XE88LC05 and a piezoresistive pressure sensor

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Introduction

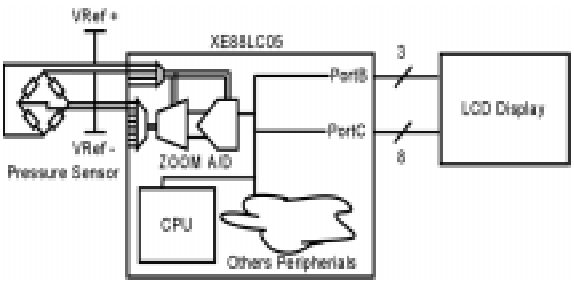
The aim of this application note is to describe a barometer built around a XE88LC05 microcontroller. To implement this application, the following elements are needed:.

- Pro-Start (Programmer and Starter-Kit for the XE8000 series)
- CoolRIDE (Software development environment for XE8000 series, included in the Pro-Start)
- XE88LC05M (MTP version of the XE88LC05, included in the Pro-Start)
- Pressure sensor (AM 5801 AV Intersema)
- LCD display (2 lines X 16 rows)

Application bloc diagram

This bloc diagram represents the connection between the XE88LC05, the LCD display and pressure sensor.

Figure 1



Microcontroller interface

To build this barometer, you must interface the XE88LC05 with the pressure sensor and the LCD display.

Pressure sensor overview

The pressure sensor is based on micro-machined silicon with piezoresistive elements. The device produces differential output voltages proportional to the applied pressure.

Most piezoresistive pressure sensors intended for OEM users are compatible for this application.

Since the system is fully programmable, any other sensor can replace the model taken here.

The table below presents the main parameters need to set the interface.

Values have been taken from the Intersema sensor.

Table 1

Parameter	Units	Typical	Min	Max
Pressure Range	m Bar kPa	- -	0 0	100 100
Supply current	Is	10.00	0	20
Supply Voltage	V	1.5	0	3-0
Full-scale output at 10V bias	mV	50.0	49.5	50.05
Sensitivity at 10V bias	mV	0.5	-	-
Output impedence	kΩ	2.5	2	3.8

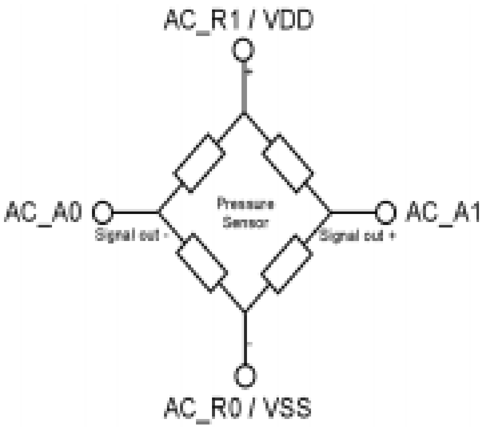
The utilised sensor is compensated and calibrated in temperature. Some sensors are smaller, yet neither of these are compensated nor calibrated. Software within the XE88LC05 can be used to correct the sensor's linearity.

Pressure is applied to the top of the die and a single pressure port is provided. The optimum pressure media is non-conductive and optimally clean dry air.

For a barometer application, the output of the sensor must have a linear response over the expected pressure range of 850-1050 mBar (85-105 kPa). The sensor is designed to measure pressure with respect to a sealed vacuum in the sensor cavity.

The model used has a constant voltage compensated resistor network. The advantage here is that the device does not need to interface with a variable gain instrumentation amplifier

Figure 2. The Piezorative Pressure Sensor Interface



The following below presents the necessary guidelines to interface the sensor with the XE8000 product.

Any differential resistive sensor is well suited to XE88LC05 given that no external specific additional device is required thanks to the integrated programmable gain and offset signal-conditioning circuitry. Gain and offset compensation is executed within the XE88LC05 by programming the parameters of the analog chain.

In most common systems, the output of the sensor must be converted to a ground referenced analog voltage. With the XE88LC05, the signal is treated fully differentially on the analog input chain.

In order to minimize variations that could affect the accuracy of the output signal, the reference voltage of the A/D converter and the amplifiers is ratio-metric to the power supply. The voltage of the demo board operated at 2.4V provides the sensor supply voltage.

The sensor's output is ratio-metric to the supply voltage. With a sensitivity of 0.05mV/mBar (0.5 mV/kPa) at 10 V, it will result in 0.012 mV/mBar at 2.4V.

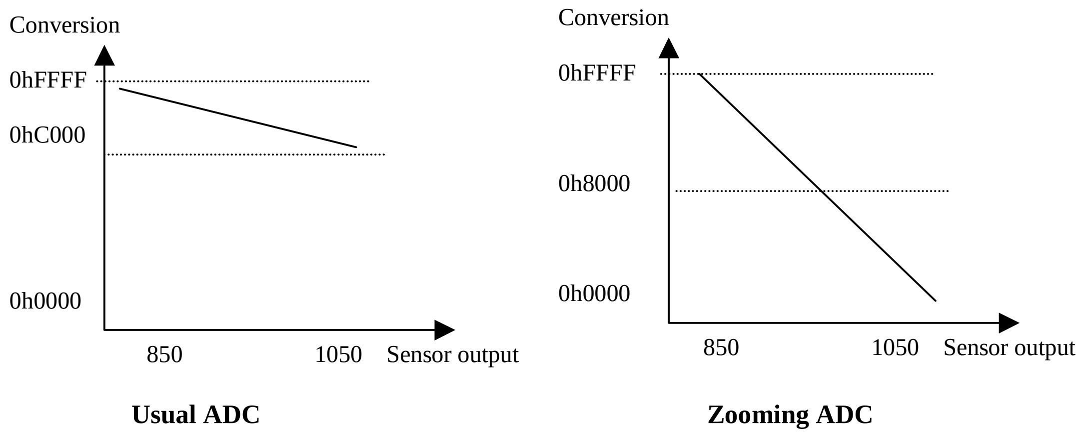
In addition, the sensor is driven by a constant voltage supply that is usually easier to generate than constant current sources

Zooming ADC

In general, concepts using the maximum resolution of the A/D have the power supply as full-scale. It is advisable for a barometer to have a pressure range of 850-1050 mBar.

This is the useful range that is converted to the maximum resolution of the ADC using the zoom included in the acquisition chain.

Figure 3. ADC Conversion

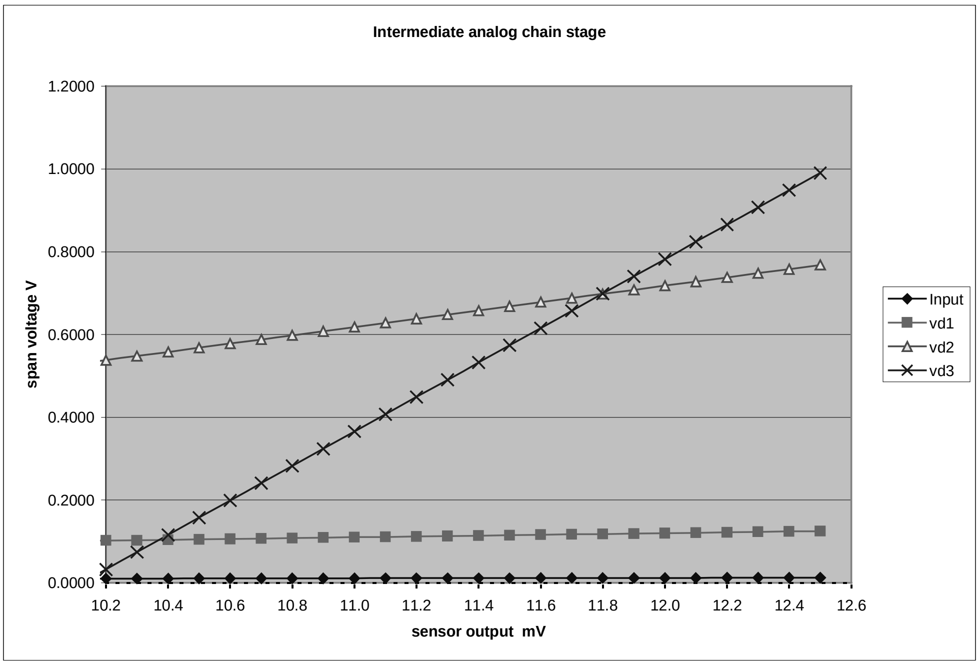


The gain made in the amplification stage of the zooming ADC increases the signal so that the value of the LSB of the ADC referring to the input of the circuit is smaller. This enables it to detect a very small signal variation. The XE88LC05 pre-amplifier maximum gain (-1000) is such that the ADC can measure the input signal down to the noise of the pre-amplifier.

In order to adapt the sensor output as well as possible to the span of the A/D, the output signal of the sensor is amplified and offset at the different stages of the zoom.

The diagram below shows the signal at the input of the XE88LC05, and at the output of the 1st, 2nd and 3rd amplifier.

Figure 4. Intermediate Analog Chain Stage



The signal is amplified to have a span voltage of 1.0 V at the input of the A/D converter, whereas the sensor signal is within 10 to 12.5 mV.

The tables below show the calculated parameters that represent the response above.

Values are in decimals.

Parameter	Value
Vref	2.41
Gain 1	10
Offset2	1
Gain2	10
Offset3	11
Gain3	50

Table 2

Pressure mBar	Vin V	Vd1 V	Vd2 V	Vd3 V	ADC code
1050	0.0126	0.126	0.778	1.032	28065
1000	0.0120	0.120	0.718	0.782	21269
950	0.0114	0.114	0.658	0.532	14474
900	0.0108	0.108	0.598	0.282	7678
850	0.0102	0.102	0.538	0.032	883

Table 3

The values of the registers give the correct range of the span voltage. To convert the ADC code to an exact pressure value, the RISC core capabilities provide the developer with optimal flexibility

The formula below gives the equation to compute the correct value of the pressure:

$$Pout = \frac{P_{high} - P_{low}}{code_{high} - code_{low}}.ADC\_code + code_{null} = \frac{1050-850}{28065-883}.ADC\_code + 844$$

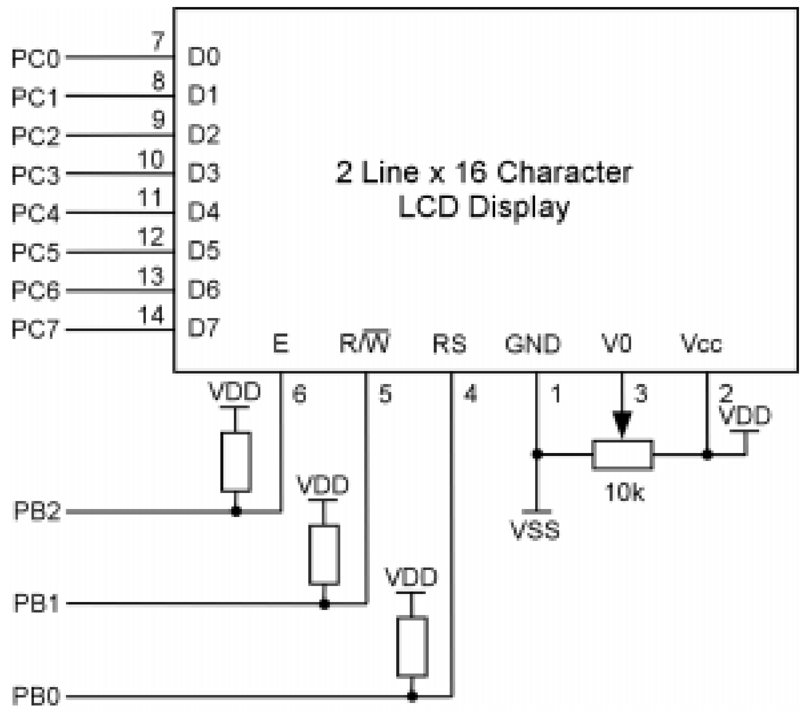
$Code_{null}$ is the equivalent pressure value corresponding to a null ADC code

LCD display interface

The LCD display module uses a standard protocol. We have a choice between a 4 lines serial protocol and 8 lines parallel protocol. For this application we chose the 8 lines parallel protocol.

To interface the LCD display we used the two parallel ports of XE88LC05. In this case, we used the PortC to transfer the 8 bits of data , and the PortB to transfer the 3 bits of control.

Figure 5. Connections between LCD Display and the XE88LC05 Pro-Start



Application program

Flow chart

The following flow chart describes all program implementation.

Main Routine

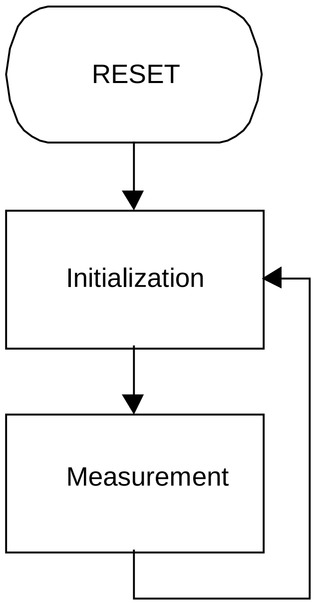


Figure 6

Initialization routine

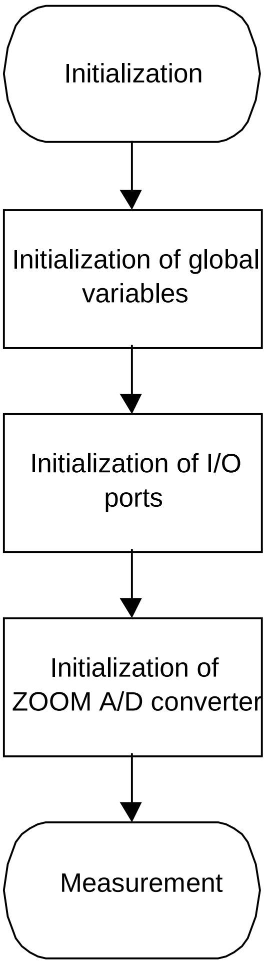
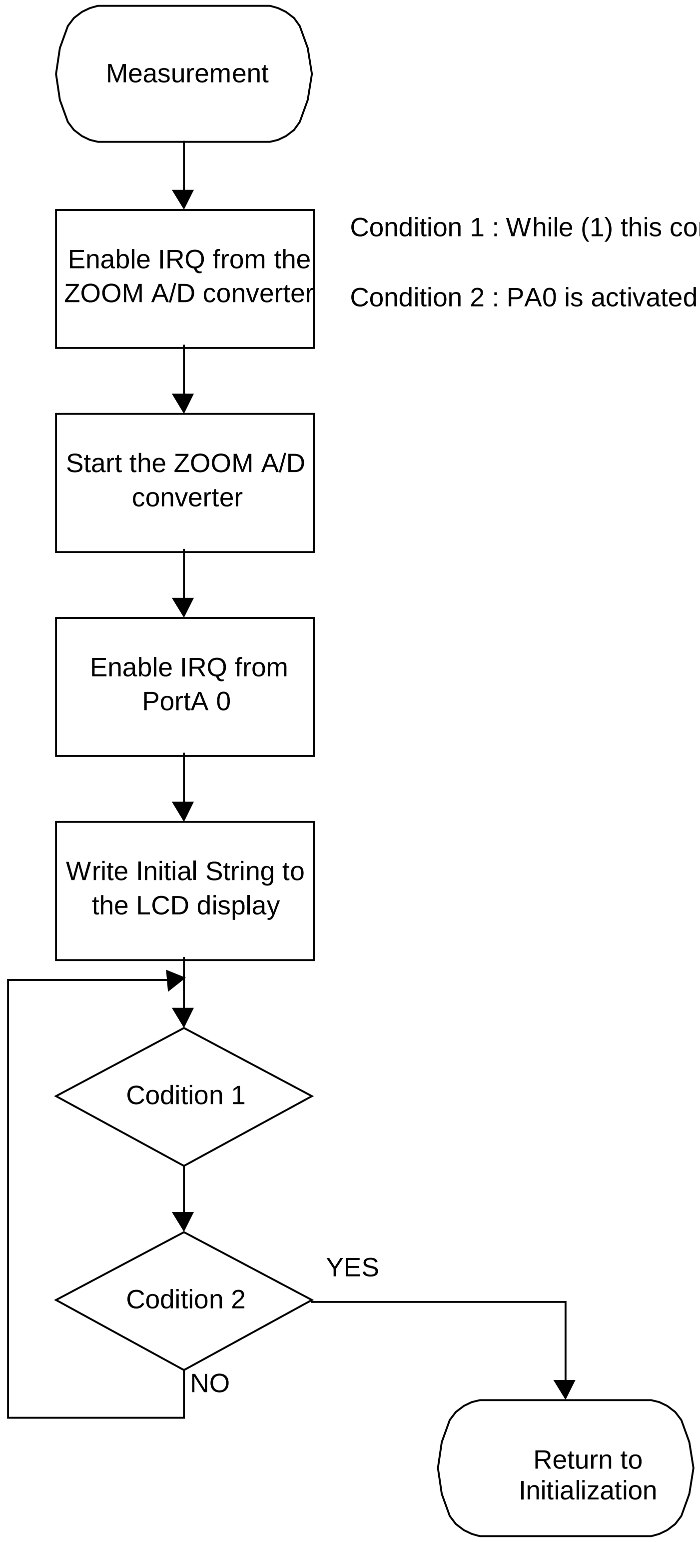


Figure 7

Measurement routine



Condition 1 : While (1) this condition is always true

Condition 2 : PA0 is activated

Figure 8

Zoom ADC Irq handler routine

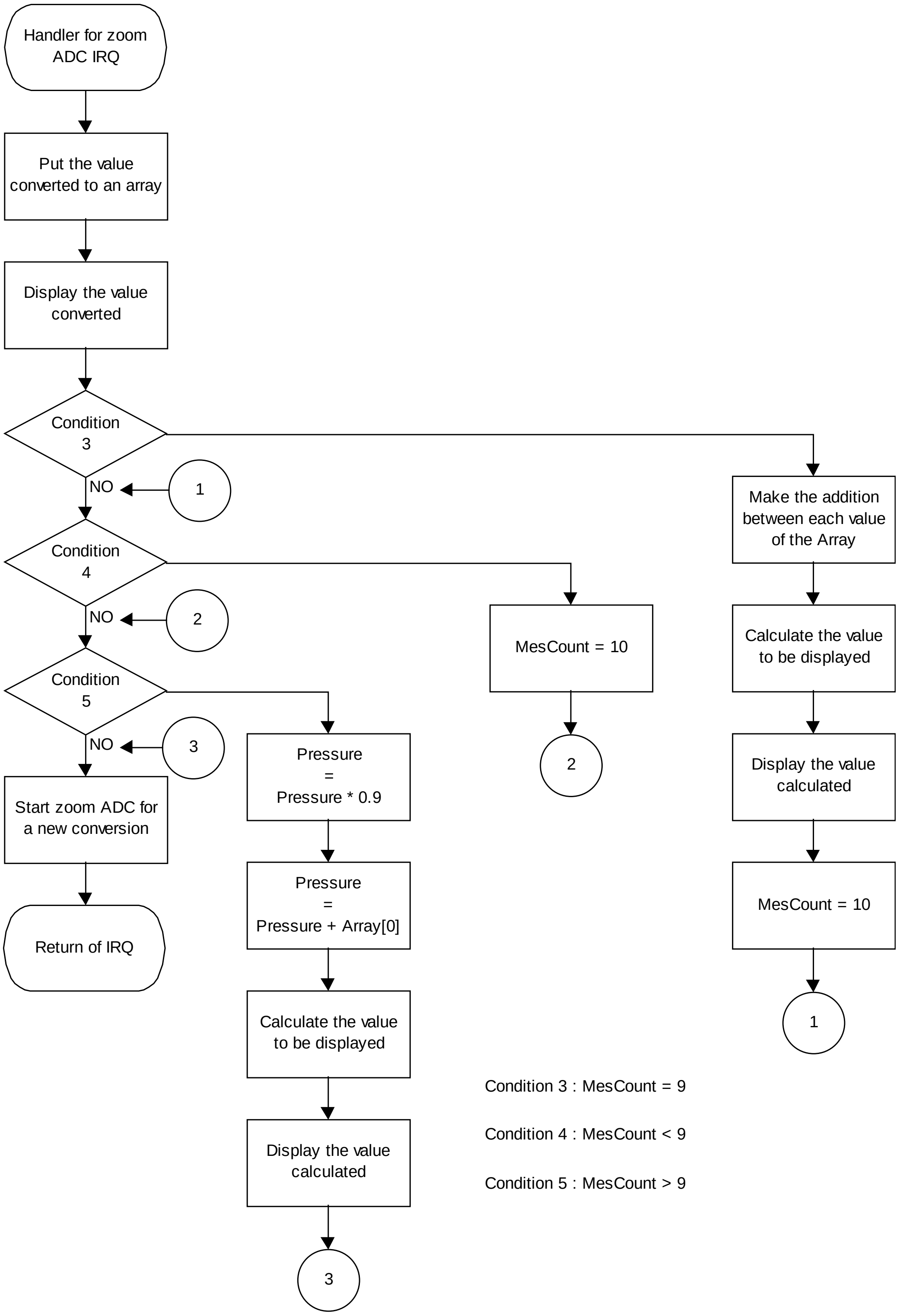


Figure 9

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