

Features and Applications of the FMMT618 and 619

High Current SOT23 replaces SOT89, SOT223 and D-PAK

David Bradbury

Switch 6A loads using a SOT23 transistor?

Zetex has developed this new range to meet ever increasing demands for higher performance in smaller packages.

At first sight the performance of the FMMT618 and FMMT619 transistors may appear unbelievable for SOT23 packaged devices, however the following note describes how this has been achieved. The note also discusses a number of applications where they are ideally suited, which until now were often forced to utilise the larger SOT89 or SOT223 packaged devices. Figure 1 provides a graphic example of this performance.

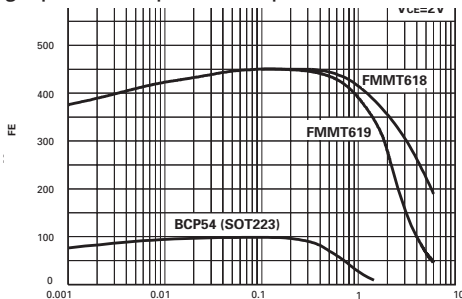


Figure 1 Collector Current (A)
Comparison of h_{FE} profiles.

Main Product Features

- * V_{CE0} up to 50V
- * I_{CM} up to 6A
- * $I_{C\text{ CONT}}$ up to 2.5A
- * P_{tot} of 625mW
- * High h_{FE} - e.g 300 min @ 200mA
- * Very low $V_{CE(sat)}$ - 200mV max @ 2.5A

Comparison with SOT89 and SOT223 Parts

Table 1 gives a quick comparison of the performance of the Zetex FMMT618 & FMMT619 with two industry standard SOT89 and SOT223 parts.

Package	ZETEX product		Industry Standard	
	FMMT618 SOT23	FMMT619 SOT23	BCX54 SOT89	BCP54 SOT223
BV_{CE0}	20V	50V	45V	45V
I_C	2.5A	2A	1A	1A
$I_{C(max)}$	6A	6A	1.5A	1.5A
$h_{FE(min)}$ @ I_C	200 2A	200 1A	25 0.5A	25 0.5A
$V_{CE(sat)}$ max @ I_C	50mV 1A	200mV 1A	500mV 0.5A	500mV 0.5A
P_{tot} (mW)	625	625	1000	1500

Table 1
Parametric Comparison.

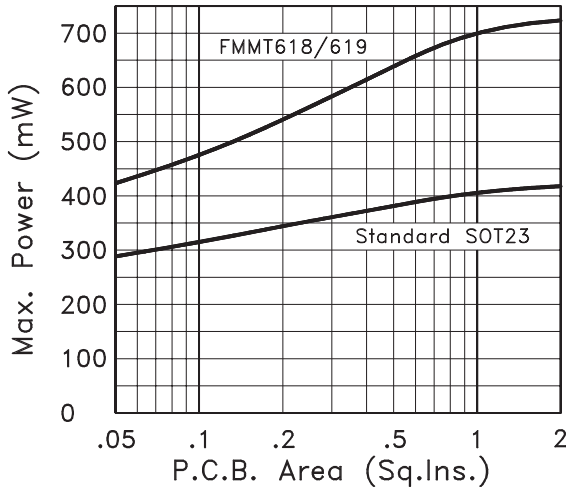


Figure 2
Practical P_D vs PCB area (FR4).

No other manufacturer in the world offers similar performance parts to the FMMT618 and FMMT619 in SOT23. Even in the larger SOT89 and SOT223 packages, few devices are available that can match the current handling and low saturation voltage of the new Zetex range. This level of performance has been achieved by a unique combination of package and chip development.

The Zetex SOT23 Package

The FMMT618 SOT23 series is capable of dissipating 625mW measured on the industry standard 15 x 15mm ceramic substrate.

Most other manufacturers offer power ratings of half this level. The key factor in obtaining such a high power rating is minimising the thermal resistance between the back of the chip and the solder points.

For a standard SOT23 package, this thermal resistance is of the order of 280°C/W. Using a custom designed lead frame and multi-metal plating system Zetex have been able to reduce this to only 100°C/W. On an infinite heatsink (say if the test substrate is clamped to a fan cooled heatsink) the package could actually dissipate 1.25W safely but such facilities are rarely available.

The graph shown in Figure 2 provides a more practical demonstration, and shows the power rating of the device against PCB area. The Zetex SOT23 package requires far less PCB area than standard SOT23 for a given power dissipation. The practical advantages of this are increased packing densities and/or reduced chip temperatures, thus giving cost and reliability improvements.

Zetex Matrix Chip Technology

The saturation voltage of the FMMT618 is typically only 130mV at 2.5A and h_{FE} remains useful up to its peak current limit of 6A.

Two major feature enhancements have contributed to the very impressive performance of the FMMT618 and FMMT619 transistors.

Firstly a custom designed SOT23 frame has allowed an extremely large chip to be encapsulated ie. 34 x 36 thou. Secondly and more importantly, the Zetex pioneered 'Matrix' chip design has been used.

In a matrix transistor it is possible to utilise virtually all the die as active area yet minimise the distributed base resistance, ensuring all the area works effectively.

The low saturation voltage obtained is both useful to the circuit designer in maximising circuit efficiency and power

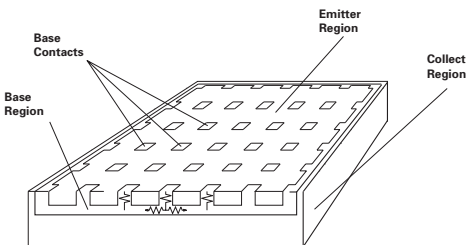


Figure 3
The Matrix Geometry

Distributed base resistance is minimised using a large matrix of base contact holes. By keeping the size of these holes small, little emitter area is lost and so active chip area is maximised.

applied to the load, whilst also extending current ratings. For most SOT23 packaged bipolar devices, the maximum current capability is defined by power rating and saturation voltage. By optimising both of these characteristics Zetex has produced a range of devices that outperforms many SOT89 and SOT223 parts.

Replacing these larger package types with the low saturation voltage FMMT618 and FMMT619 transistors will reduce power dissipation, improve circuit efficiency and reliability, while saving on PCB area and component costs.

FMMT618 Applications

Designed with heavy duty battery powered applications in mind, the 20V FMMT618 handles 2.5A continuously, giving a typical saturation voltage of only 130mV at this current. With a minimum h_{FE} at 2A of 200 and at 6A of 100, this transistor is an ideal driver of heavy loads such as motors, lamps, IR LEDs etc. It is also very useful in saturation voltage critical applications such as supply switching and low voltage DC-DC converters.

In Figure 4 an FMMT618 is being used to drive two ZME50 infra-red LEDs in a domestic remote control link. When a key is pressed on the 8 x 4 keypad, the MV500 control IC generates a sequence of pulses which includes synchronisation and key identity data. These 16ms wide pulses are amplified by the FMMT618 and transmitted by the ZME50 diodes. To maximise range, each photodiode must be pulsed at 1-2A so the combined load current for the FMMT618 is 2-4A.

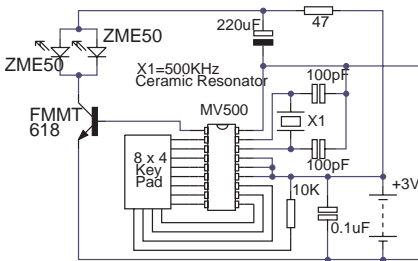


Figure 4
IR Remote Control Transmitter.

Since the remote control unit must be kept small, its power source is just two 1.5V cells giving a 3V nominal supply. To achieve the required LED current, all of this supply must be applied across them so low saturation voltage is essential. Replacing TO126 packaged devices commonly used for this application the FM618 provides lower saturation voltages, lower component costs and reduced size. It also allows more of the PCB to be automatically assembled - reducing assembly costs too.

Figure 5 shows the output stage of an LED based 'Moving Messages' display. These systems use thousands of LEDs so it would be impractical to have individual drivers for each LED. To avoid this, the LEDs are wired in the form of a matrix which ideally reduces the number of drivers required to the square root of the number of LEDs. The penalty for this saving is that the drivers must pass much higher currents. The circuit shown is just a segment of a 32 x 32 matrix display. Each is given an average current of 15mA by pulsing it at 0.5A with a duty cycle of 3.125%. The column

drivers must be capable of supplying 0.5A but as they are driven from low power logic shift registers they must have high gain. The FM618 transistors work well as column drivers, needing only 5mA of base drive to ensure a saturation voltage below 50mV.

For pagers and other 5V circuits that for size reasons must be powered from a 1.5V cell, the FM618 can be used as part of an efficient up-converter. The standard boost converter shown in Figure 6 exploits the fast switching and low saturation voltage of the SOT23 transistor to give up to 300mA at efficiencies over 70%.

Real applications are likely to require lower current but significant board area and efficiency gains are to be made by replacing SOT89 and SOT223 transistors in this application.

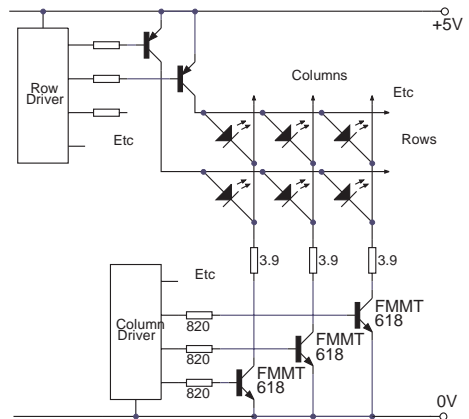


Figure 5
Lamp Matrix.

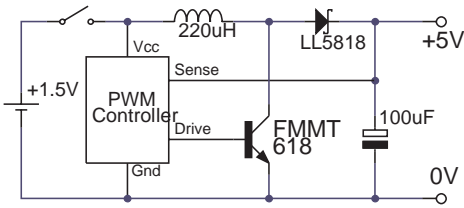


Figure 6
Step-Up converter.

FMMT619 Applications

Intended for higher voltage applications, the 50V FMMT619 still handles a creditable 2A continuous and 6A peak. Giving a typical saturation voltage of just 125mV at 1A for just 10mA of base drive, this transistor can be used to replace inefficient Darlington's in stepper motor drivers and print head drivers. Also, hybrid DC-DC switching converters where small size and low losses are important can significantly gain by the use of FMMT619 transistors.

Figure 7 shows all that is necessary to use the FMMT619 in a printer's stepper motor driver. Running from a switched 24V-12V

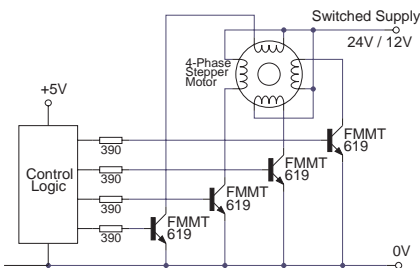


Figure 7
Stepper Motor Driver.

supply, the 4-phase motor takes a peak current of around 0.8A. With just 10mA base drive from a CMOS logic buffer the FMMT619 gives a saturation voltage of only 100mV.

The resulting power loss in the device is so low that the four drivers required can be packed into a PCB area limited by component size rather than power dissipation. Stepping motors can force reverse collector currents through their drivers but the high reverse beta of the FMMT619 allows this to occur safely, without risk to the transistor or it's driver.

Hybrid DC-DC converter manufacturers are continually working to provide ever higher output power from decreasing package sizes. The push-pull converter shown in Figure 8 is typical of unregulated versions of this type of product and one that can significantly benefit from the use of FMMT619 transistors.

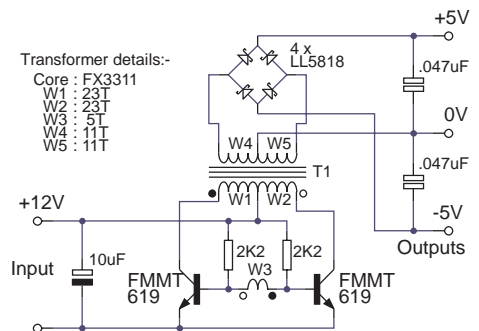


Figure 8
Typical hybrid DC-DC converter.

Taking 12V in and producing $\pm 5V$ isolated supplies, this self oscillating converter runs at a switching frequency of around 40kHz. The transformer is wound on a small toroidal core and the complete circuit built on a small PCB or ceramic substrate that can be encapsulated in a DIL style package. Conceivably by employing FMMT619 switching transistors this circuit could give a power throughput of over 10W but output rectifier losses and the low power dissipation capability of the small substrates used means a more conservative throughput must be specified. By providing lower saturation voltages and lower thermal resistance the FMMT619 transistors give this standard circuit improved output, load regulation and power.

Higher power converters no longer need use SOT89 or SOT223 types as the ZETEX SOT23 devices offer better performance at lower cost.

One final application area to benefit from the very low saturation voltage of the FMMT619 is pin drivers for EPROM and FPLA programmers. These drivers are complex, since to provide the necessary versatility such programmers must be capable of switching logic signals, supplies and programming pulses to 24-28-40 pin sockets. Despite a small supply current requirement, low saturation voltage is vital. Figure 9 shows the typical saturation voltage of an FMMT619 against collector current demonstrating how the transistor can be used as a supply switch, introducing only 10-20mV of offset.

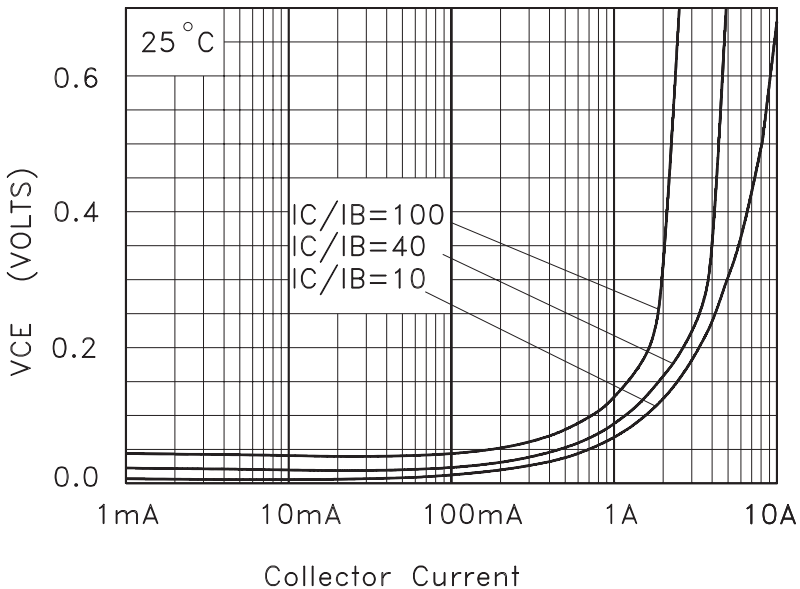


Figure 9
FMMT619 $V_{CE(sat)}$ vs I_C .