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Design Tip

Using WARP Speed™ IGBTs In Place Of Power MOSFETs at Over 100kHz Converter Applications

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Introduction:

International Rectifier's latest development in IGBT technology has offered the power converter industry with optimized power switches - the WARP Speed™ IGBTs. They have switching characteristics that are very close to those of power MOSFETs, without sacrificing the inherently superior conduction characteristics of IGBTs. Thus, in higher-power power supply type applications where power MOSFETs can become prohibitively expensive, the IGBT offers a more cost-effective solution.

Due to the higher usable current density of IGBTs, it can usually handle two to three times more current than a typical MOSFET it replaces. This means that a single IGBT device can replace multiple MOSFETs in parallel operation or any of the super-large single power MOSFETs that are available today. IGBTs have already been replacing MOSFETs and Bipolars at up to 75Khz for several years. Now, with the advent of higher-frequency WARP Speed IGBTs, which improves their Eoff (turn-off switching loss) by more than 50%, the same can apply at frequencies up to 150 kHz.

How to replace MOSFETs with IGBTs

To replace a power MOSFET with an IGBT is easy. The IGBT has the same pinouts, it blocks the same voltage, all you need to do is to factor in a few design criteria indicated below in order to take full advantage of this device.

The Gate Drive Requirement

The gate drive for MOSFETs and IGBTs are essentially the same. In fact, due to a smaller input capacitance the IGBT is, if anything, a little simpler.

As with any technology replacement there are invariably some differences, for instance the gate voltage (Vge) for an IGBT is recommended to be 12V (preferably 15V) for the device to turn on fully, while a FET has a 10V recommendation. This is probably the single most important detail to watch out for when replacing a FET, if the device is not fully turned on then the Vce(on) will be greater losses and potentially device failure.

You will also find, in the case of existing designs, the change in gate capacitance (lower for the IGBT) may require a change of gate resistor to re-tune the gate circuit. Adjusting the value of the IGBT gate resistor will normally have minimal effect on the switching-loss behavior and is of secondary importance.

EMI Consideration

The slope of the current waveform characteristics during device turn-off is important when considering EMI. Compared with a typical 600V power MOSFET, the WARP Speed IGBT turn-off waveform has made 25% improvement in di/dt which gives the device a slower slope during turn-off (see Figure 1 for details). If anything, this will probably lower the EMI noise level significantly.

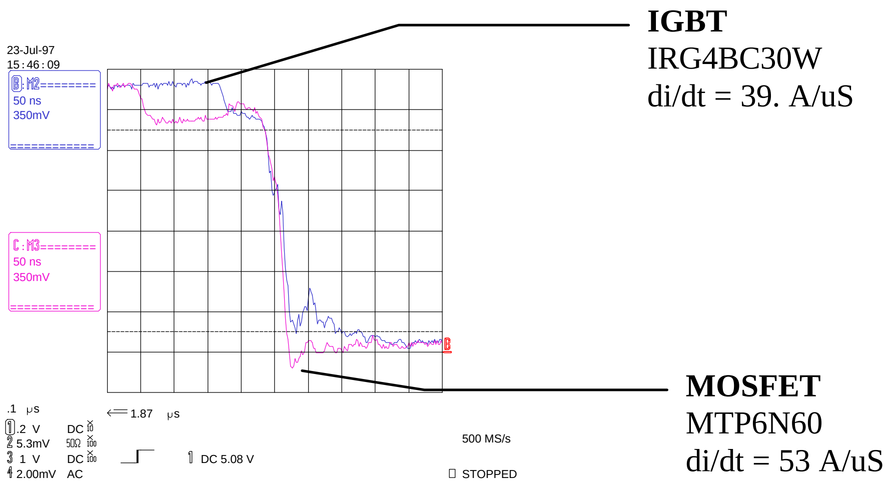

Figure 1. Current Turn-off di/dt Comparison - IGBT vs. MOSFET

Higher Junction Temperature

One should notice that the IGBT will often a slightly higher junction temperature than the equivalent Power MOSFET. As the Vce(on) and switching losses don't change significantly when you add more silicon area, one should select the minimum IGBT device rating to fulfill the application requirement.

Some well known methods of calculating the junction temperature for both MOSFET and IGBT are listed below :

<u>**MOSFET**</u>	<u>**IGBT**</u>
Conduction Loss :	
$Pcond = I^2_{D(rms)} * Rds(on)_{Hot} * D$	$Pcond = Vce(on) * Ic * D$
(where D - Duty cycle)	
Switching Loss :	
$Psw = Id * Vds * t_{SW} * f_{SW}$	$Psw = Ets_{(Hot)} * f_{SW}$

(where f_{SW} - switching frequency $Ets_{(Hot)}$ - total switching losses (in data sheet)
t_{SW} - total switching time (on + off, in data sheet))

Total Loss Pd :	
$Pd = Pcond + Psw$	$Pd = Pcond + Psw$
$Tj = Pd * Rth\text{-}jc + Tc$	$Tj = Pd * Rth\text{-}jc + Tc$

(where Tc - Case temperature   Tj - Junction Temperature
Rth-jc Thermal Resistance Junction to Case (in data book))

Packaging Design

The package style and pinouts of IGBTs and MOSFETs are similar, all the basic primary functions are the same, no fundamental mechanical or layout changes are required.

PCB Layout

All the same criteria that are useful in MOSFET layout apply to the IGBT layout, good design rules such as very low inductance tracks to the device, control and power tracks separate and not running parallel etc.

Conclusion

The WARP Speed IGBT can be used to generate same amount of output power as a much larger Power MOSFET does in a hard-switching applications. In resonant converter applications, the difference is even greater. The component cost saving and board space saving as a result of this can be considerable.