

IGBTs Challenge MOSFETs

In Switching Power Supplies

by Kevin Covi, Senior Technical Staff Member, IBM Corporation

IBM's Mainframe Power System

Figure 1 shows the power system architecture of the latest IBM mainframe computers (this system was described in the *July 2000 issue of SPM*). The phase-shifted bus converter is a full-bridge topology, and this is the main isolating element in the power system. It operates from a regulated input voltage, and provides 350 VDC at the output for distribution around the mainframe computer. This high level voltage allows for efficient power distribution with small gauge wires.

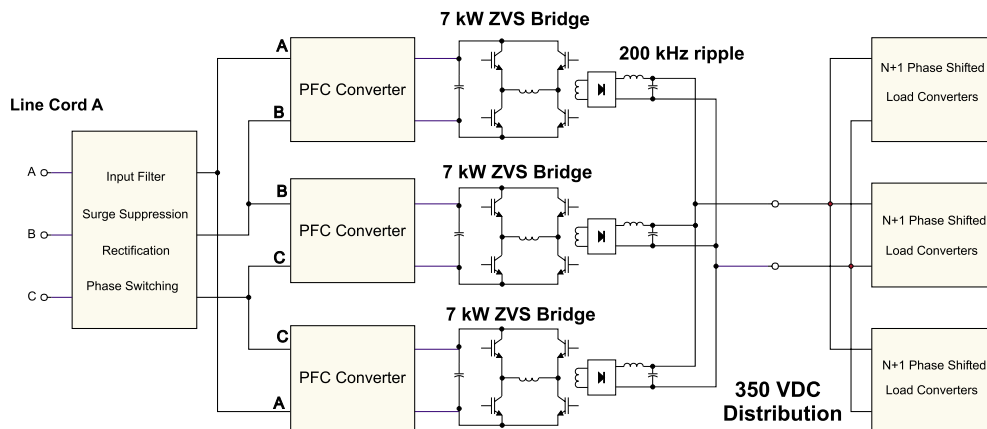


Fig 1: Zero-voltage-switched full bridge power stage in IBM power system

The specifications of the full-bridge power stage are as follows:

- 300 - 405 VDC input (allows for line holdup and battery operation),
- 350 VDC, 20 A output, and
- Bridge switching frequency of 100 kHz (200 kHz output ripple)

Until recently, this converter has relied on MOSFETs for efficiency and reliable operation. We needed Size 8 MOSFETs to provide the 7 kW output.

IGBT Benefits

Recently, we worked closely with semiconductor manufacturers to test IGBTs in this application. IGBTs are minority carrier devices that allow for lower conduction loss for the same die area. Past generations of IGBTs have been too slow for application at this switching frequency but devices released in the last year have improved dramatically.

The anticipated benefits of the new generation IGBTs were:

- Reduced die size,
- Reduced cost,
- Low capacitive switching losses,
- 600 V rating allows 67% derating (vs. only 500 V and 80% derating for FETs),
- Reduced gate drive power, and
- Anti-parallel FRED in co-pack

Although the converter used is a zero-voltage-switching (ZVS) bridge, the low capacitance of the smaller device is very important. At light load, the ZVS converter no longer has enough inductive energy to fully charge and discharge the device capacitance, and hard switching is inevitable. This must not result in excessive dissipation, or excessive noise which may cause failure.

Other light-load circuit events drive the need for a very fast anti-parallel diode, and this has always been a source of problems when using FETs in the ZVS bridge. Unlike hard-switched converters where full load presents the most problems, light load on these ZVS converters has required a lot of engineering time to solve reliability concerns. The internal diodes of FETs are slow, and if they are faced with high dv/dt after conducting, failure can result. IGBTs do not have an inherent internal diode, and do not suffer from this failure mechanism.

Test Results

Figure 2 shows the test results comparing the full-bridge converter with MOSFETs and IGBTs. Two different die sizes were used for the IGBTs— size 5 and size 6.

From 25% load to 100% load (20A), the MOSFETs still have the better efficiency. But the margin is very small— just 0.2% versus the size 6 IGBT at full load,

and 0.45% versus the size 5 IGBT. At light loads, the IGBTs are better. In fact, the size 5 die has the lowest loss at minimum load due to its reduced output capacitance.

The results have surpassed our initial expectations. A year ago, we would not have expected that a size 5 die could be used reliably in this circuit. Many of the component vendors that come to visit us still find this hard to believe.

Preliminary testing has confirmed our belief that high-speed IGBTs really can replace MOSFETs at these power levels. Field testing is now under way, and we fully expect that these parts will improve our converter reliability while at the same time, significantly reducing our component costs.

Kevin Covi is a Senior Technical Staff Member with IBM in Poughkeepsie, New York. He joined IBM in 1978 after receiving a B.S. degree in electrical engineering from Princeton University, and he received his M.S. degree in electrical engineering from Syracuse University in 1988. Since 1984 he has focused primarily on high-current and high-power switching regulators and holds eight patents in this area. His recent work includes the development of a three-phase 20kW off-line rectifier with power-factor correction and a universal input voltage range for use in IBM's high-end servers.

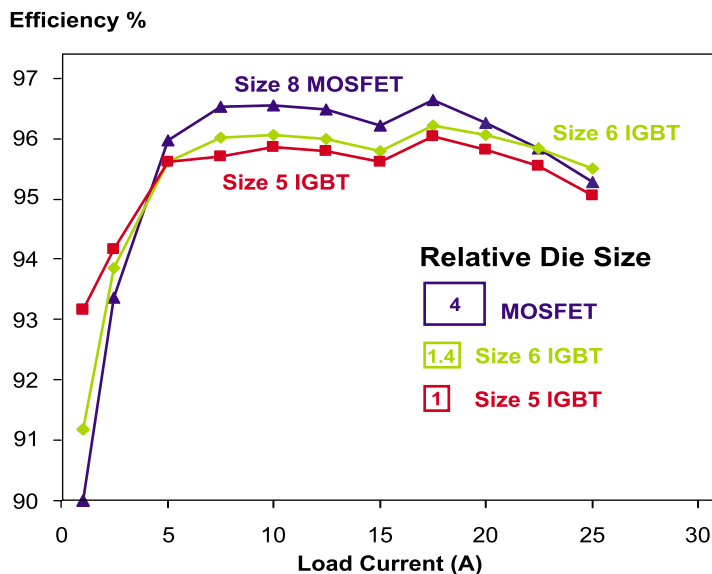
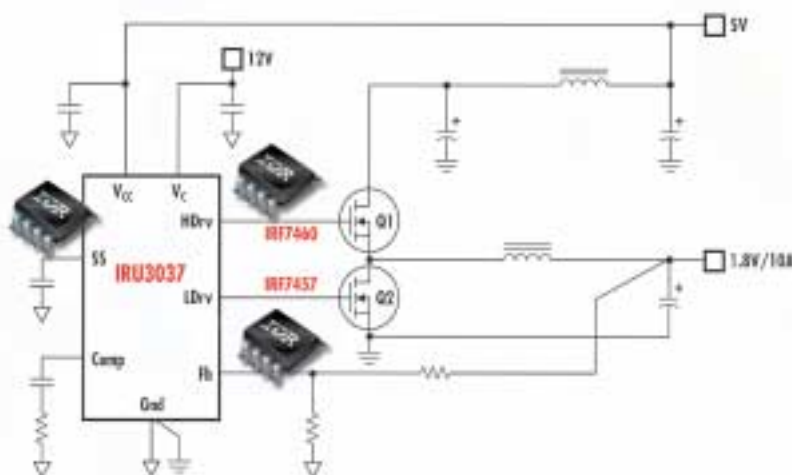


Fig. 2: Power Stage Efficiency Measurements with IGBT and FETs

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Selector Table Makes MOSFET Selection as Easy as 1, 2, 3:

1. Select input/output voltage
2. Select output current
3. Determine the optimum FETs for your application.

		5V INPUT VOLTAGE			
		Output Voltage			
Output Current		3.3V	2.5V	1.8V	1.25V
4A	Four Single MOSFETs	IR7111	IR7111	IR7111R1	IR7111R1
8A	Two Single MOSFETs High Side Low Side	IR7147	IR7148	IR7147	IR7148
10A	Two Single MOSFETs High Side Low Side	IR7147	IR7147	IR7148	IR7148



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