Multi-die ICs Optimize Power Control for Automotive

By David Morrison, Editor, *Power Electronics Technology*

In many automotive subsystems, there are opportunities to integrate power control and power switch functions. However, the high power levels involved often don't lend themselves to development of monolithic solutions where control circuitry and power discretes are built on the same die. Recognizing this situation, semiconductor developers are crafting multi-die designs that provide a high degree of functional integration without the performance and cost penalties inflicted by monolithic approaches.

Although in the past multi-die devices were routinely referred to as multi-chip modules (MCMs), vendors today shy away from that description. In part, this may be because advanced surface-mount IC packaging makes the new multi-die components almost indistinguishable from monolithic ICs and less like MCMs of the past.

One vendor taking the multi-die approach is Fairchild Semiconductor, which introduced its Smart Power Switch technology at the recent Convergence conference in Detroit.

Fairchild's use of the expression "smart power" to describe a multi-chip component is a departure from the precedent set by other companies who use "smart power" to mean the monolithic integration of power discretes and control circuitry. However, Fairchild points out that its smart power technology is being used to achieve integration at power levels beyond the capabilities of existing monolithic devices.

The company is using the new technology to develop custom power components that provide many benefits over existing monolithic devices. These include an enhanced system interface, increased device and system protection, improved control for power and current sensing, and reduced system power dissipation.

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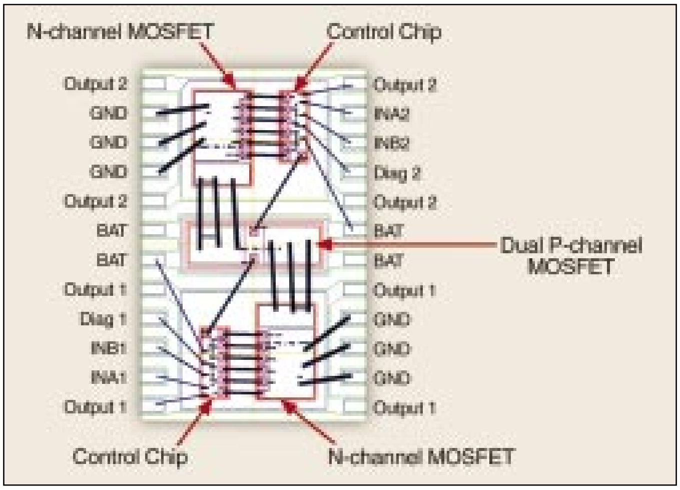

Fig. 1. *Fairchild Semiconductor's dual-integrated solenoid driver integrates multiple power MOSFETs and control ICs in a 12-mm × 8-mm power QFN package.*

The multi-die approach enables use of the latest generation of power discrete technology, as well as IC technology optimized for control and driver functions. In addition, designers have the luxury of selecting die designed for a maximum junction temperature of 175°C. The Smart Power Switch technology also affords designers a choice of packaging options, including PQFNs, DPAKs, D2PAKs and TO-220s. In devices such as the PQFN, mounting pads are easily configurable.

MOSFET on-resistance provides one measure of the higher performance available with the multi-die approach. For example, the specific on-resistance of a leading-edge 30-V power trench process is approximately 30% lower than a leading-edge 30-V smart power IC process. Moreover, adding the multilayer interconnect resistance to the monolithic MOS device can raise the drivers' specific on-resistance to more than three times that of the discrete device. In addition to offering greater power handling capabilities, the multi-die method offers a high degree of isolation between power and control silicon.

Target applications for the smart power switch technology include resistive load controls, interior heating and cooling fans, and solenoid and ignition coil plus smart switch on plug designs. One of the first applications for

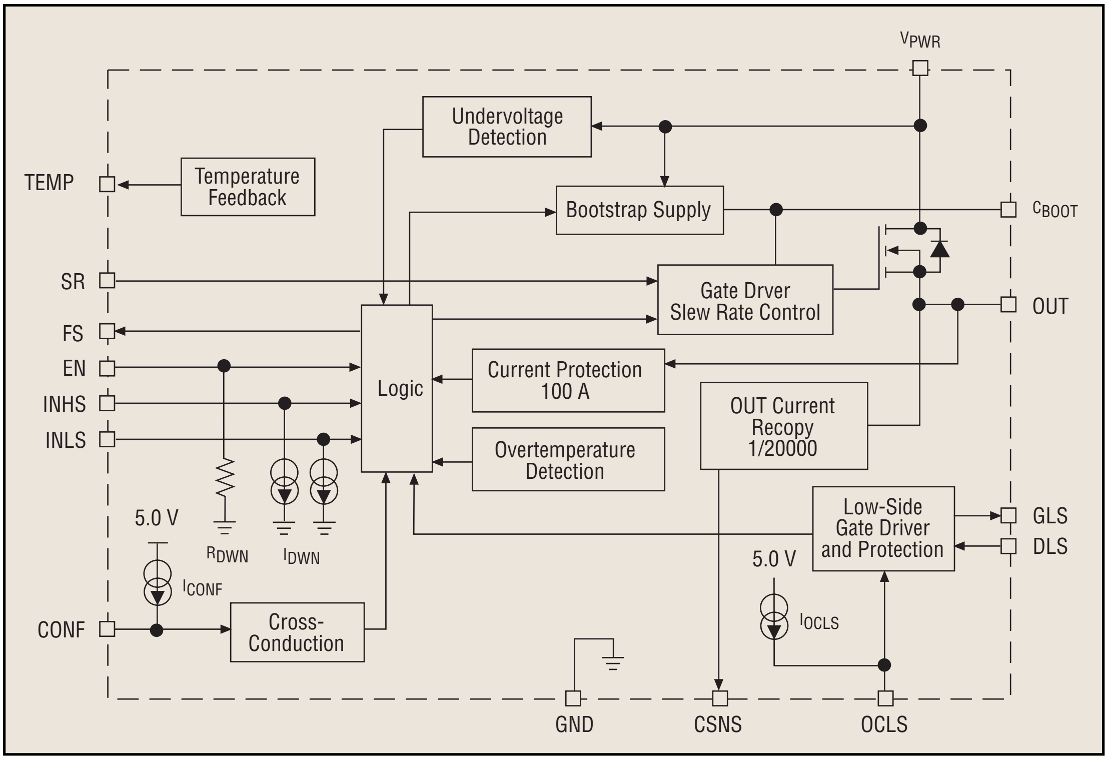

Fig. 2. *Freescale Semiconductor's MC33981 self-protected, high-side switch combines two die—one containing high-speed logic and analog circuitry and another implementing a high-current output stage—in a 12-mm × 12-mm PQFN.*

the Smart Power Switch technology is a dual-integrated solenoid driver (FDMS2380). Within a 12-mm × 8-mm power QFN package, this device combines two PowerTrench N-channel MOSFETs with integrated recirculating diode for low-side operation, a PowerTrench dual P-channel MOSFET for high-side operation, and two dielectrically isolated control ICs (Fig. 1). The N-channel MOSFETs feature just 40-mΩ of on-resistance. All of the die in the FDMS2380 are rated for a junction temperature of 175°C.

In terms of performance, the device offers different recirculation and flyback clamp levels plus protection against undervoltage, overvoltage, overcurrent and overtemperature. Other features include open-load detection, soft-short detection and clamp feedback. The solenoid driver uses a combination of gold and aluminum bond wires, and solder and epoxy die attach. For heatsinking, the PQFN package includes three die attach pads. According to the vendor, this package is capable of dissipating 2 W to 3 W. More information on this packaging technology is available at www.fairchildsemi.com/smartpowerswitch.

Another vendor, Freescale Semiconductor, also is exploiting the advantages of a mult-chip design to provide functional integration in automotive subsystems. The company's MC33981 eXtreme Switch is a self-protected, 4-mΩ high-side MOSFET switch. The device combines two die—one using a SMARTMOS process to implement high-speed logic and precision analog circuitry and another using HDTMOS for the high-current output stage. The combination of these two technologies enables built-in protection, logic-level control and various configuration features in a 12-mm × 12-mm PQFN package (Fig. 2). This allows features such as low-side synchronous gate drive, analog temperature feedback and remote diagnostics like output current monitoring and fault reporting. Other features include low standby current (10 mA max) and slew rate control via an external capacitor. The switch is protected against numerous faults, including overcurrent, overtemperature, undervoltage and reverse-battery conditions.

The MC33981 follows in the footsteps of the company's MC33982, a device that replaces high current relays and fuses in smart junction boxes, lighting and static load control applications. The new IC replaces electromechanical relays and discrete devices that control pulse width controlled dynamic loads such as dc motors used in fans and fuel pumps.

When digitally controlled by a microcontroller, the MC33981 can drive a dc motor at PWM frequencies up to 60 kHz. Using PWM for motor speed control can eliminate the need for the power resistors, relays and heatsinks, drastically reducing the size and weight of the power module, while increasing system reliability. In addition, fast PWM allows for variable speed and torque control, enabling system designers to maximize motor performance and efficiency. Furthermore, the device features slew rate control that helps minimize power dissipation while meeting strict EMC (electromagnetic compatibility) requirements.

For more information on this device, see www.freescale.com/analog. **PETech**

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