Coreless Transformers Isolate SiC Gate Drivers For EV & Industrial Applications

Along with requirements for higher voltage operation and greater efficiency, the latest EV and industrial power system trends push for greater integration and safety of power system devices. A key element in enabling these features are isolated gate drivers. Of the few methods of isolating a gate driver, the latest innovations of coreless transformer technology are paving the way for compact and efficient gate drivers for high voltage systems.

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Conventional isolated gate driver technology, including discrete transformer, opto isolated, and capacitive methods, though viable in some applications, present challenges for the latest EV and industrial power systems. For instance, discrete transformers are low cost, but only allow for one-way communication from the microcontroller to the power device, and don't allow for communication of information back to the microcontroller such as temperature and overcurrent/short circuit. In the case of opto-isolators, this method suffers from LED output drop from higher temperature operation and aging, which requires higher current input over time and temperature to compensate for the LED output degradation. Lastly, capacitive gate drivers require a sine wave signal input to turn the output on, which may cause electromagnetic interference with wireless communications, such as WiFi.

Coreless Transformers Transform SiC Gate Drivers

Coreless transformer gate drivers, on the other hand, don't pose any of the challenges of other isolated gate driver technologies, and with innovative design, can provide several system enhancing features. Though there are a variety of coreless transformer implementations, ROHM's coreless transformer technology is built using three internal slabs with a low voltage section that provides a silicon interface with a DSP or microcontroller and a high voltage section that drivers the IGBT or MOSFET. The copper coils of ROHM's coreless transformers are separated by a slab of silicon dioxide, which is a very robust dielectric with a very high melting temperature and with similar properties to quartz. The low voltage section operates with 3.3 V to 5 V signals, compatible with a wide range of either 3.3 V or 5V microcontrollers or DSPs.

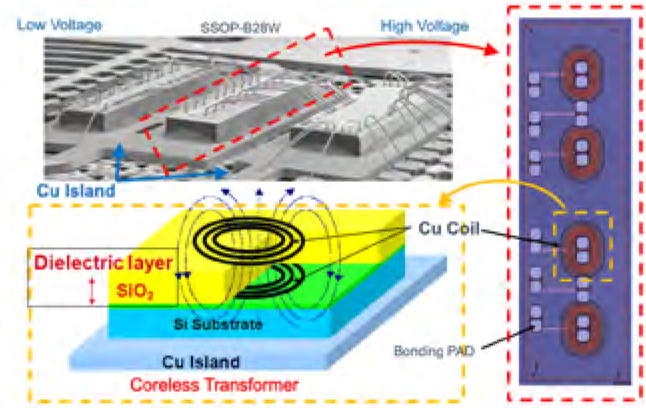
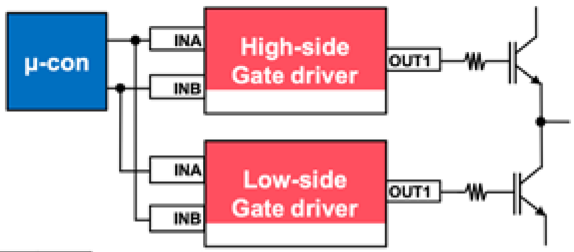


Figure 1: Coreless transformer gate drivers provide system-enhancing features

Unlike opto-isolator gate drivers, coreless transformer gate drivers exhibit a relatively flat turn on and turn off times over temperature. Opto-isolator gate drivers tend, on the other hand, to change behavior substantially with temperature variations with a much longer difference between turn on and turn off times, which equates to reduced efficiency due to larger dead times.



INA	INB	OUT1
L	H	L
L	L	L
H	L	H
H	H	L

Only one configuration of the two output INA and INB on the 4 possible gives output HIGH, this excludes the cross conduction when are connected like in the picture.

Figure 2: Exclusive OR configuration

Key Coreless Transformer Gate Driver Features

HS LS Cross Conduction Prevention With XOR Function

Cross wiring the XOR inputs of a half-bridge gate driver prevents both the low-side and high-side from turning on simultaneously, which is a key advantage of coreless transformer gate drivers over opto-isolator based drivers as this isn't viable with opto-isolators. Without this feature it is possible to enter a destructive mode where both the high-side and low-side are on simultaneously, which may even lead to a small explosion in addition to device failure.

Desaturation Detection Prevents Excessive Power Damage

A nominally operating power device will have roughly a 3 V difference between the source and the drain. However, during a major malfunction in the load, such as a shorted motor or power supply, the current passing through the device may reach 10 to 20 times that of the nominal operating current range. The result of this excessive current is greater than a 3 V difference between the source and drain, which results in large amounts of dissipation across the power device and puts the device at risk for overtemperature.

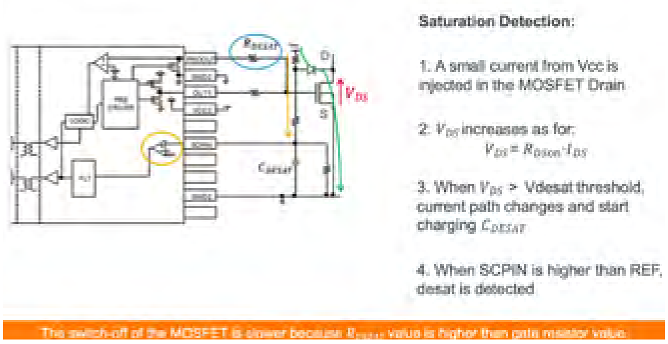


Figure 3: Desaturation circuitry

A method of addressing this is the use of desaturation detection and soft switch-off. Desaturation detection monitors the voltage across the device, and in the case of overvoltage, softly switches the device off preventing damage from excessive power.

Temperature Monitoring Flexibility With PWM Temperature Signal

Typical power device temperature monitoring uses a negative temperature coefficient thermistor where the resistance changes as a function of the device temperature. These thermistors are driven using a secondary side feed with a constant current through the thermistor, and the voltage across the device provides a voltage as a function of the thermistors temperature coefficient.

In the case of catastrophic device failure, it is not unknown for the failure to create a conductive plasma that could lead to an overvoltage of the thermistor. Power device bond wires or the DC bus traces may even separate from their pads and make contact with a thermistor traces or the thermistor itself leading to overvoltage events. The result of a thermistor overvoltage event could be failure of the device, which makes mitigation challenging without the necessary temperature information from the thermistor.

ROHM's solution to this with the coreless transformer technology is to use pulse-width modulated (PWM) signals to carry the temperature signal, where the signal is modulated based on the temperature profile. This allows for isolation from the primary side, and enables continuous monitoring of the baseplate temperature with less risk from catastrophic failures.

Integrated Miller Clamp Mitigates Transients

For typical half-bridge power devices, a very sudden dv/dt of 10s of nanoseconds from 0 to 800 V is experienced when the low-side device is shut off and the high-side device is engaged with the drain voltage of the low-side spiking toward the power rail. This is problematic as the intrinsic gate to drain capacitance of the low-side device may become charged and develop a voltage bump that exceeds 2 V to 2.5 V, which approaches the turn-on voltage for the lower device. This situation could lead to shoot through issues where both low-side and high-side of the half-bridge power device is on simultaneously.

Using a positive and negative voltage is a method of preventing this occurrence, as is the use of a Miller clamp. As there are additional costs and design complexities associated with use of a negative supply, the preferred method for many applications where it is viable is the use of a Miller clamp.

A Miller clamp is a transistor designed to provide a low resistance path from the gate of the mosfet source which clamps transient voltages, preventing too high a voltage being developed form the gate to the drain of the low-side device. In some power devices a Miller clamp is built in, or there is a port open in the gate driver to introduce a Miller clamp. ROHM's coreless transformer gate drivers include an integrated, active Miller clamping function with a gate control pin for the active miller clamp along with a power supply pin for the driving MOSFET for the Miller clamping function.

Conclusion

ROHM's latest Coreless Transformer Gate Drivers bring many features and performance advantages to the latest EV and Industrial power system applications. Along with extremely high isolation voltages, ROHM's gate drivers, such as the BM6112FV-C, also include many value added features that reduce a driver BOM and ensure the safety, efficiency, and monitoring of critical power circuit parameters.

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