Designing-Out High-Power Automotive Relays

The Last Frontier for Advanced Vehicle Electrification

The electromechanical relay – at one time the power switch of choice for all automotive electrical systems – is progressively being replaced throughout the vehicle by lighter, smaller, more reliable and longer lasting semiconductor switches. Advanced fabrication processes such as BCDMOS, allowing power and logic circuitry to coexist on the same chip, enable manufacturers to deliver controllers comprising one or more MOSFET switches with an integrated driver as a single chip. These have already proved successful in a variety of low-power applications.

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With increasing electrification of major vehicle functions such as electric power steering (EPS), integrated starter/alternator (ISA) and other high-power loads both in internal combustion engine and hybrid-electric vehicles, demand is growing for efficient and durable semiconductor power switches for loads above 10A. The electromagnetic relay retains some advantages when used with higher loads, due to its inherently low resistance when turned on. This helps avoid unwanted conduction losses that otherwise would waste energy and cause internal heating which compromises reliability.

In order to replace electromechanical relays in high-current applications, a combination of discrete low on-resistance MOSFETs and separate driver IC can provide a better, lower-power solution a fully integrated controller.

Relay Replacement for High-Current loads

Ideally, a MOSFET with on-resistance ($R_{DS(ON)}$) of only a few milliohms, at logic-level gate drive, is required. An even lower overall resistance can be achieved by connecting two MOSFETs in parallel using a control IC capable of driving a pair of MOSFET gates. The AUIRLS3034 and AUIRLS3034-7P are 40V MOSFETs are designed for high efficiency when controlling heavy loads. They are packaged as D2Pak or 7-pin D2Pak-7P surface-mount power devices. The D2Pak-7P package enables lower $R_{DS(ON)}$ by providing five pins for connection to the source, complementing the large exposed tab for connecting the drain. A single pin is provided for the gate connection. The standard D2Pak has one pin for connection to the source. Both devices use IR’s latest trench HEXFET® semiconductor technology. The package-limited maximum drain current is 195A for D2Pak or 240A for the AUIRLS3034-7P in D2Pak-7P.

Effective use of either of these devices for relay replacement, or in battery switch applications, is dependent on a suitable controller/drive providing the necessary protection and diagnostic capabilities. The AUIR3200S automotive-qualified MOSFET driver IC can drive two power MOSFETs such as the AUIRLS3034-7P, thereby enabling a protected high-side switch to achieve $R_{DS(ON)}$ as low as 0.75mΩ.

Figure 1 shows the schematic of a high-side switch configured with a single MOSFET. Most of the circuitry needed for protection and diagnostics is integrated in the controller, which reduces external components to a small number of bias resistors, a gate-drive resistor, two capacitors, and a PTC (Positive Temperature Coefficient) temperature sensor, as shown.

Building a Protected High-Side Switch

Figure 2 shows the major functional blocks of the control IC, highlighting the current-source reference used for short-circuit protection.

Shortcut Protection

Short-circuit protection is one of the most important functions in a protected high-side switch or battery switch. Usually this kind of
Over-Temperature Protection
In a typical application using a protected switch, over-temperature protection is also required. The AUIR3200S simplifies over-temperature protection by providing a dedicated pin as shown in figure 1 for connecting an external PTC sensor. The PTC sensor displays rapidly increasing resistance within a few degrees of its nominal temperature, allowing fast and accurate temperature protection.

Diagnostic Reporting
In a protected switch application, the host system must be informed whether the load condition is normal, short circuit, or over-temperature. The AUIR3200S provides a diagnostic indication by shorting the input pin to ground during a fault condition. This allows the system to detect abnormal load conditions by monitoring the input pin voltage. The fault condition is latched until the AUIR3200S is deactivated allowing the device to enter sleep mode.

Repetitive Short-Circuit Ruggedness
A high-side protected switch comprising the AUIR3200S controller and AUJRL3034S MOSFET has been tested under short-circuit conditions according to AEC Q100-12, which requires the MOSFET case temperature to be fixed at 125°C by adjusting the activation frequency. The switch was able to sustain 10 million cycles without failure.

Conclusion
Electrification of automotive systems such as power steering can be enhanced by replacing bulky and less reliable electromechanical relays with alternative semiconductors switches. Low RDS(ON) MOSFETs can be used to overcome the last remaining barrier to relay replacement by significantly reducing power dissipation when the switch is turned on.

To use such devices successfully, designers need an automotive-qualified driver that integrates the necessary protection features and diagnostic capability. The AUIR3200S is a highly integrated driver capable of controlling two MOSFETs such as the AUJRL30304-7P connected in parallel, to create a protected high-side switch of extremely low resistance enabling efficient and reliable control of high-power loads.