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Switcher IC Eases Operation From High-Voltage EV Batteries

Power Integrations' InnoSwitch3-AQ is an AEC-Q100-qualified flyback switcher with integrated 750-V MOSFET and secondary-side sensing. The newly qualified device family targets automotive EV applications, such as traction inverter, on-board charger (OBC), energy management dc-dc bus converters (EMS) and battery management systems (BMSs). A key application for this switcher IC is the emergency power supply (EPS) in EVs, which is used to maintain 12-V power to gate drivers in the traction inverter.

The InnoSwitch3-AQ greatly simplifies the design of the EPS, which steps down the EV's 400-V or 800-V battery bus to 12 V, providing a backup to the 12-V battery bus. This is a safety critical function because loss of 12-V power to the gate drivers would leave the traction inverter's power switches in an undetermined state, which would in turn leave the traction motor in an uncertain state (see Fig 1).

This new device leverages the capabilities of Power Integrations' existing InnoSwitch offline switcher ICs, which provide very integrated design solutions for implementing flyback-based ac-dc power supplies for power levels up to 100 W. But while grid-based applications require existing Innoswitch ICs to operate over a voltage range of approximately 100-V to 400 V dc, the EV application demands that the new InnoSwitch3-AQ be able to operate from 30 V to 550 V dc, which represents the full range of fluctuation for a 400-V EV battery bus. (The 30-V minimum is worst case under cold cranking, the 550-V maximum would be a load dump condition.)

Integration of a 750-V MOSFET enables InnoSwitch3-AQ to meet the 550-V requirement. Another challenge of automotive applications is that they do not allow use of optocouplers because of aging. However, the InnoSwitch design inherently satisfies that requirement with its use of Power Integrations' FluxLink isolation technology, which is a form of magnetic coupling implemented within InnoSwitch packages for transmitting data from secondary to primary.

In the EPS application, designs based on InnoSwitch3-AQ are said to provide more compact and better performing alternatives to existing primary-side regulated (PSR) designs, which require more discrete components and tend to be more power limited. The InnoSwitch3-AQ, which employs secondary-side regulation, achieves a more integrated implementation by combining all of the power supply's control circuitry with an isolation barrier in package (Fig. 2).

Comments Power Integrations' product marketing manager, Edward Ong, "The InnoSwitch3-AQ represents the highest level of integration for a flyback controller, resulting in automotive power supplies with the lowest component count and smallest PCB area. The high efficiency of the device across a wide load range means that it easily meets the automotive industry's demanding thermal requirements." Ong adds, "FluxLink technology enables accurate performance and is highly reliable."

According to PI, their InnoSwitch-based solution for the EPS avoids compromises that are typically made when implementing this function with a standard PSR controller. "Basically, they [automotive companies] are not meeting their own specs," says Doug Bailey, VP of marketing at Power Integrations.

The InnoSwitch3-AQ uses Power Integrations' high-speed FluxLink coupling to achieve ±3% accuracy for combined line and load regulation while eliminating both dedicated isolated transformer sense-windings and optocouplers. FluxLink technology maintains output voltage regulation even under the transient stress test, which is particularly challenging for PSR-based implementations. The integrated 750-V MOSFET meets stringent automotive derating requirements, and an on-chip synchronous rectifier controller delivers above 90% efficiency at the nominal 400-Vdc input voltage (see Fig. 3).

It's worth noting that the fault condition which the EPS protects against—loss of the 12-V battery voltage—is considered to be a very rare event. So the high efficiency of the InnoSwitch3-AQ based EPS across the load range is needed more for thermal management than for power savings. From a power consumption point of view, the more important spec in this application is probably its power consumption when idling. In this regard, optimized InnoSwitch3-AQ designs achieve less than 10-mW no-load energy usage across the input voltage range.

Nevertheless, there are other applications for the InnoSwitch3-AQ that will benefit from its efficiency across the load range. These include the previously mentioned dc-dc converters, battery management systems, and on-board chargers as well as climate control power supplies.

The InnoSwitch3-AQ family ICs are packaged in a surface-mount InSOP-24D with 11-mm primary-to-secondary creepage, which exceeds the stringent requirements for high altitude (> 5000 m) isolation. The DER-840Q reference design incorporating the newly released IC demonstrates startup, shutdown and efficient operation from 30-Vdc to 550-Vdc input, as well as fast transient response and a variety of safety and protection features.

Devices are available now with prices starting at $2.75 each in 10,000-piece quantities. Technical support for the chipset is available from the Power Integrations website.

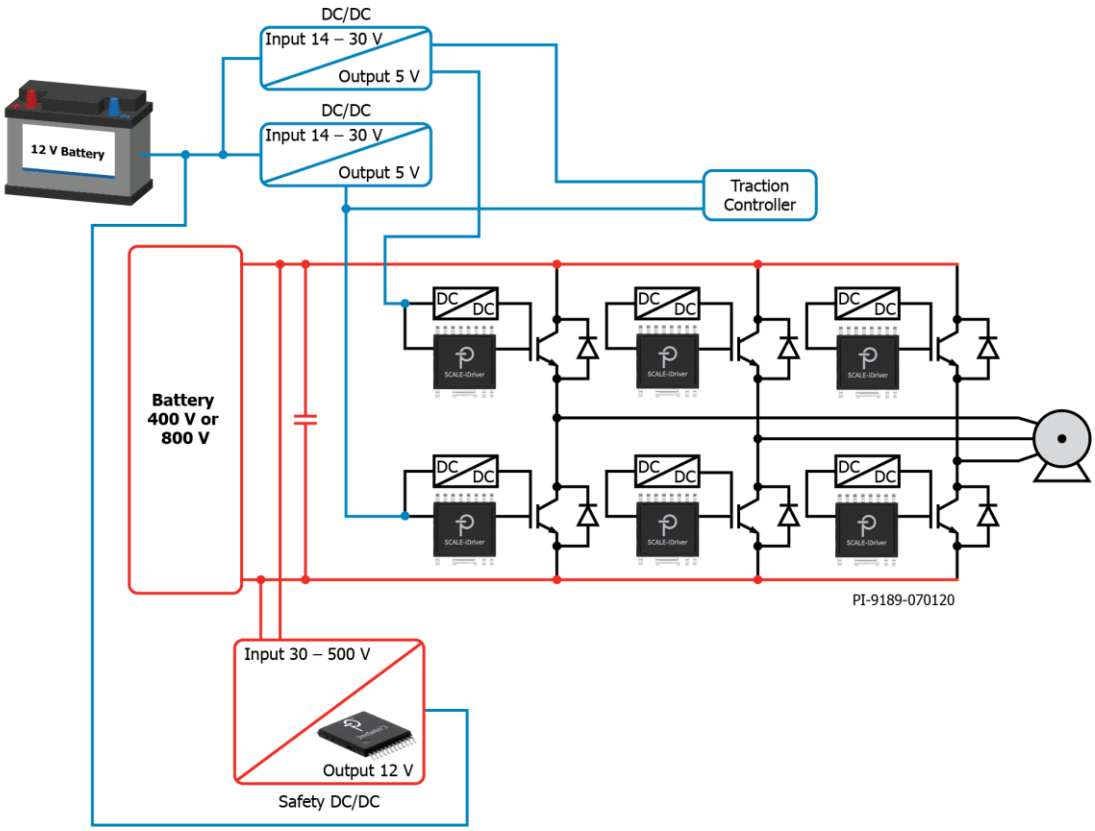

Fig. 1. The InnoSwitch3-AQ flyback switcher IC simplifies implementation of the emergency power supply (EPS) in EV applications. The EPS steps down the 400-V or 800-V battery bus to 12 V to power the gate drivers for the traction inverter in the event that the 12-V battery bus drops out. This is needed because a loss of 12-V power to the gate drivers, leaves the traction inverter's power switched in an undetermined state, which represents an unsafe driving condition for the vehicle.

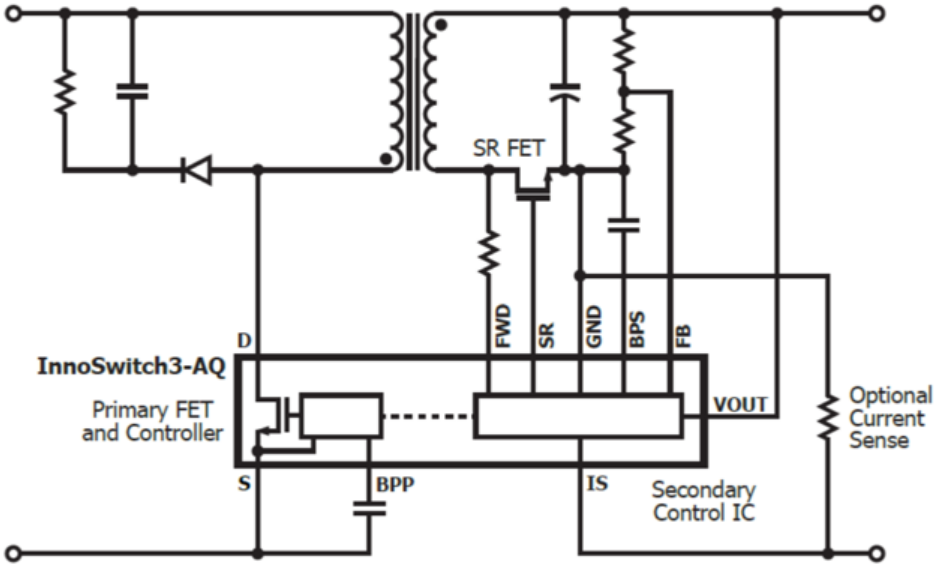

Fig. 2. As with other members of the InnoSwitch product line, InnoSwitch3-AQ combines a flyback controller and power switch with a secondary controller that implements synchronous rectification on the output and transmits output voltage (and optionally current) values across an internal isolation barrier (using PI's FluxLink technology). However, in the InnoSwitch3-AQ version for EV applications, the inclusion of a higher voltage MOSFET on the primary side, enables the power supply to operate from a wider voltage range of 30 to 550 V to accommodate operation from a 400-V EV battery bus. For applications with an 800-V battery, the addition of an external power MOSFET connected in cascode with the on-chip FET, extends Innoswitch's operating voltage range to 925 V.

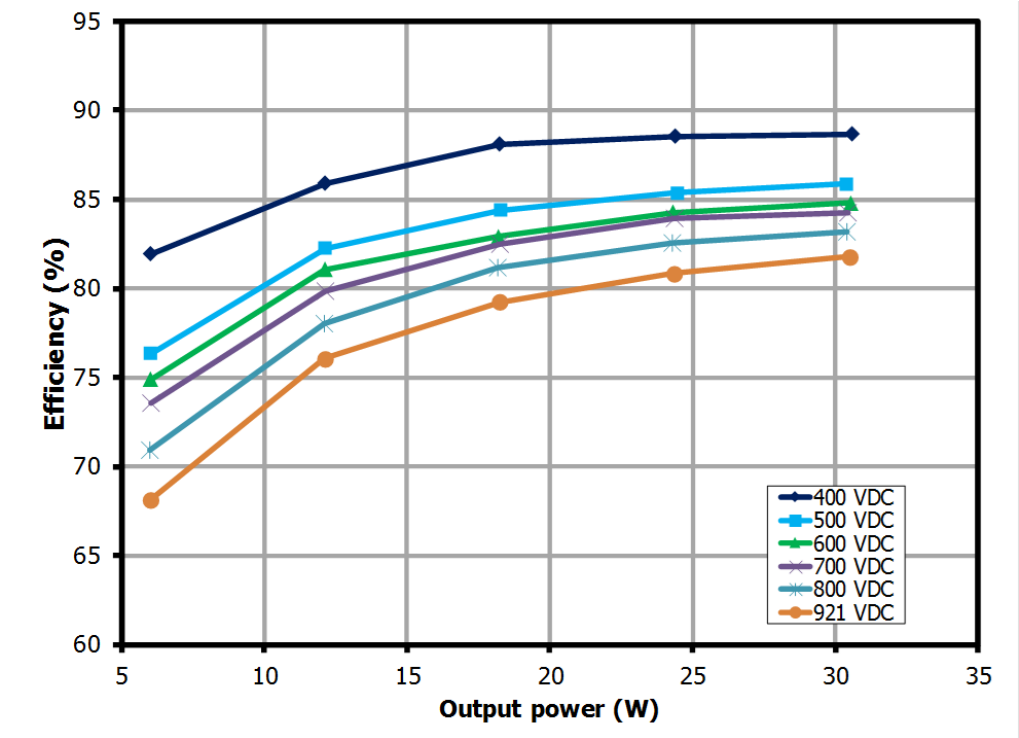

Fig. 3. InnoSwitch3-AQ operates efficiently from 30-V to 550-V dc input for EV applications with a 400-V battery. With the use of an external power MOSFET, this performance can be extended to 925 V for EVs with an 800-V battery.