Primary-side Power Switch and Control Function Integration Benefits

The consolidation of a high-voltage MOSFET switch with its lower power PWM control circuitry provides some unexpected benefits for design engineers.

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The never-ending pressure to produce higher quality, lower cost and increasingly robust power supplies within ever-decreasing time frames, puts the designer in constant need of better methods for meeting such high expectations. Without question, the one factor that has been most responsible for the majority of improvements in power supply performance, efficiency, affordability, reliability, sophistication and design cycle time reduction has been the advances made in circuit integration.

A Brief History of Power IC Evolution

The consolidation of primary-side, pulse width modulation (PWM) control circuitry into a single IC was the first shot fired in the power-conversion component-integration revolution. This was followed by secondary-side ASICs, which put most of the output housekeeping functions into a single package. Since then, more sophisticated integration has taken place, reducing the size, parts count and cost, while increasing the reliability, performance and robustness of the solutions which utilize them. But, the integration of a high-voltage MOSFET switch, with its lower power PWM control circuitry, was not feasible until quite recently. Since then, some surprising benefits have resulted from that consolidation, besides the obvious reductions in component count.

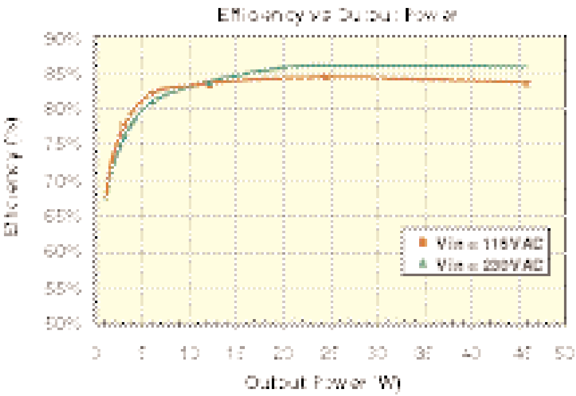

Figure 1. TOPSwitch-GX Efficiency vs. Load

The General Benefits of Integration

The benefits afforded by a lowered discrete parts count inherent with integration are worth a brief mention. Fewer parts usually result in a lower Bill of Materials (BOM) cost, higher reliability, fewer components to stock, fewer production halts due to component shortages, and fewer failures due to component misplacement, which results in less rework and/or scrap to be dealt with. In the spirit of 'doing it right the first time', using highly integrated components to create quality products that are easy to manufacture can give a company a better shot at maintaining profitable operations and a healthy bottom line. Additionally, a Design Engineering group can only improve its reputation with Manufacturing by introducing designs that are easy and profitable to produce. But integration can provide more benefits than mere parts count reduction.

The Benefits of Integrated Protection Functions

Integration allows increased functionality to be added while keeping external component count low. Besides the PWM controller, numerous detection and protection functions can be integrated with the MOSFET, which usually results in improved performance of those functions.

MOSFET Vulnerabilities and Required Protection

As an ElectroStatic Discharge (ESD) sensitive component, MOSFETs need to be protected from ESD damage before assembly. The MOSFET's gate is its ESD Achilles' heel. Therefore, having it internally connected to the low impedance gate drive circuit almost eliminates ESD damage to the gate, as a potential cause of latent switch failure. During operation, a MOSFET must also be protected from over-voltage, over-temperature and excessive currents, especially under abnormal conditions. To adequately protect the MOSFET in a discrete power supply can require under-voltage (UV) and over-voltage (OV) detection and lockout, soft start, thermal shutdown (with auto-recovery), peak and overload current limiting and duty cycle reduction with increasing input voltage. Implementing these protection functions discretely can easily require from 10 to 20 or more additional components, and substantially increase the cost of the supply.

Benefit: Integrated Over-Voltage Protection

The TOPSwitch–GX, from Power Integrations (PI), has all of those protection functions built-in. But what benefit, besides fewer external parts, could an integrated line UV/OV protection circuit provide? How about better protection than an MOV or a transorb? An external resistor connected from the rectified line to a sense pin on the IC sets the UV and OV thresholds and activates the function. When an OV condition is detected, the IC halts normal operation until the rectified line voltage drops below its built-in OV deactivation limit. This effectively allows the –GX to withstand line surges and swells, of up to 495V ACRMS (the 700V DC rating of its internal MOSFET), without requiring an MOV or transorb for protection. Since aluminum electrolytic capacitors survive transient OVs fairly well, a supply designed around this device will be incredibly robust without MOVs or transorbs. Countries with poor power quality can have relatively long duration (>100 msec) line voltage swells, so this OV shutdown function is far more valuable than a discrete MOSFET's millijoule avalanche rating, or even an MOV's transient power dissipation rating, both of which are inadequate to survive such conditions.

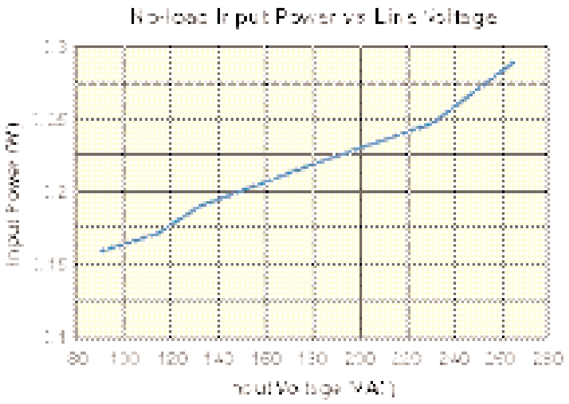

Figure 2. TOPSwitch-GX No-Load Consumption vs. Input Voltage

Benefit: Better Light-Load Efficiency and Lower No-Load Consumption

Another advantage of having virtually all functions integrated onto the same chip, is the ease with which Multi-Modal Operation (MMO) can be realized, as line and load conditions change. To meet emerging worldwide standards for energy efficiency and no-load energy consumption, at light loads the –GX linearly reduces its switching frequency, after the PWM has restricted the switching duty cycle to its minimum of 10 percent.

This reduction in switching frequency can enable a power supply, that is properly designed around the scalable –GX family, to maintain high operating efficiency at light loads (see Figure 1), while reducing its no-load power consumption (see Figure 2) to levels below those specified in all existing global energy-efficiency standards.

Benefit: Tighter Tolerances

Integration can also produce tighter overall solution tolerances. With the minimal die temperature gradient that monolithic circuitry typically exhibits, and by deriving all critical internal voltages and currents from a trimmed, temperature-compensated band-gap reference,

the critical parameters of the TOPSwitch-GX stay within tight tolerances, even over its wide operating junction-temperature range of -40° C to +150° C. Using a thoroughly documented, simple methodology, the circuit designer can quickly and easily generate high CPK designs that can be mass-produced in high-volume, without going through tedious tolerance verification calculations.

Benefit: Fewer Hardware Development Cycles

Lastly, the reduction in hardware development iterations that typically results from using integrated functions that are already tested and known to be 'good,' can make the goal of meeting demandingly short design cycles actually attainable.

Conclusion

Using highly integrated power conversion ICs can help today's designers reduce the cost, complexity, standby power consumption and development time of their designs, without sacrificing reliability or robustness.

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