Efficiency Revolution in Auxiliary and Standby Power Supplies

The new InnoSwitch TM-EP family of ICs simplify the development and manufacturing of low-voltage, high-current power supplies, particularly those in compact enclosures or with high efficiency requirements. Its architecture is revolutionary in that the devices incorporate both primary and secondary controllers, with sense elements and a safety-rated feedback mechanism into a single IC. It combines a high-voltage power MOSFET along with both primary-side and secondary-side controllers in one device. A novel inductive coupling feedback scheme using the package leadframe and bond wires o provide accurate direct sensing of the output voltage and output current on the secondary to communicate information to the primary IC.

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Usually, different methods for solving similar problems arise because a designer is trying to optimize one particular characteristic – size, efficiency, cost etc. However, an optimized performance in one aspect of a specification often leads to a compromise somewhere else. This is especially true in power supply design. When we look at the available switching power topologies there are many types that have evolved to suit specific requirements Nonetheless, true break-through developments occur from time-to-time when designers develop a new idea that radically changes the traditional balance of engineering trade-offs.

This is perhaps why the word 'revolutionary' has been used to describe a new series of switcher ICs launched last year. The new devices combine primary and secondary switcher circuitry, reducing component count and eliminating optocouplers. In addition to benefits over traditional opto-based topologies, the new ICs outperform primary-side controllers in efficiency at full-load and standby power and in transient load response. The first devices – named InnoSwitch-CH™ - targeted smart mobile devices; now the company has introduced InnoSwitch-EP™ ICs (Figure 1) designed to bring the same benefits to higher power applications.

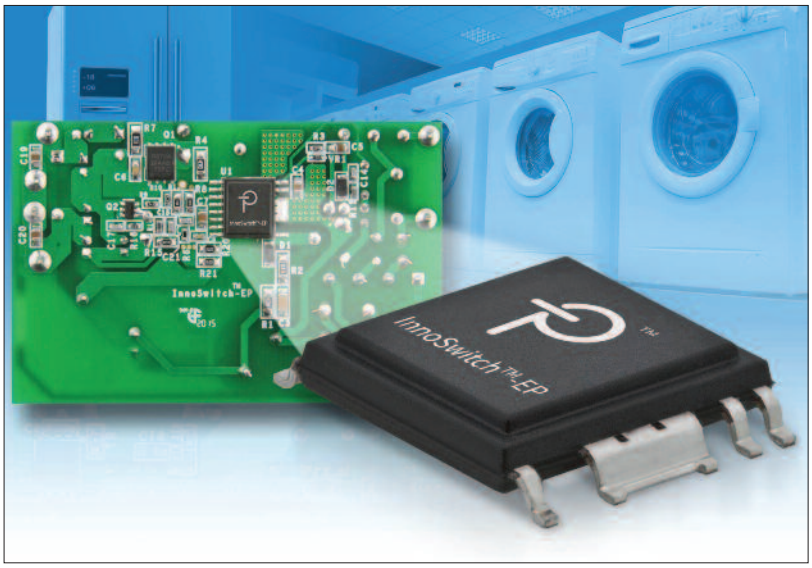


Figure 1: **InnoSwitch-EP™ CV/CC flyback switching ICs**

New power IC topology

These new CV/CC flyback switching ICs feature an integrated 725 V MOSFET, synchronous rectification and precise secondary-side feedback sensing controller. InnoSwitch parts employ a proprietary high speed magneto-inductive communication – termed FluxLink™ – incorporated in the device package which creates a magnetic coupling between the primary and secondary side. No integrated magnetic core is required and the bill-of-materials for the manufacture of the IC package remains the same. FluxLink technology provides very accurate control of the switching function, enabling synchronous rectification techniques to be employed, delivering high efficiency without complex control circuitry (Figure 2).

Replacing the traditional Schottky diode with a MOSFET is the basis of synchronous rectification. MOSFETs have a very low on-resistance ($R_{DS(ON)}$), so the voltage drop across the transistor is much lower than for diodes, resulting in a significant increase in efficiency. However, moving to synchronous rectification is not straightforward. Control circuitry is required to correctly phase the drive for the transistor on the primary side with that of the transistor on the secondary side. This control circuit must ensure that current only flows through one of the transistors at any given time.

To prevent overlap in the switching of the primary (flyback) and synchronous rectification MOSFETs which would result in highly destructive cross conduction, controllers typically introduce a delay between the turn off of one transistor and the turn on of the other. This 'dead-time' must be sufficient to account for the variable propagation delays associated with

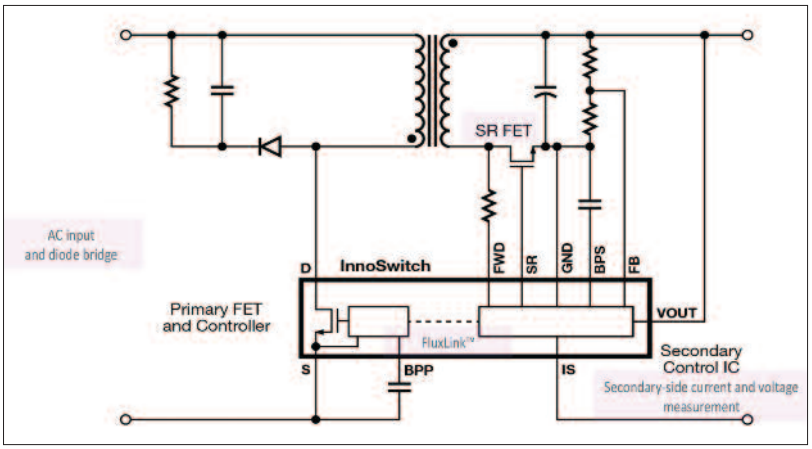


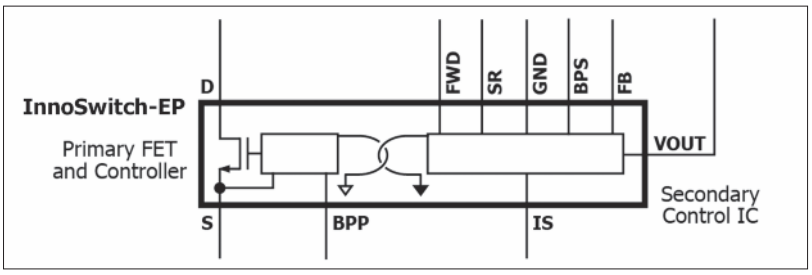
Figure 2: High-speed magneto-inductive communication FluxLink

the circuitry necessary to drive transistors on opposite sides of an isolation barrier. Integration of key switching elements (controller, MOSFETs and drivers) reduces this uncertainty and allows the dead-time to be reduced with a corresponding increase in efficiency.

MOSFETS contain an integral body diode and in the synchronous rectification MOSFET will conduct during the dead-time. The body diode has a slow turn-off characteristic and significant forward voltage-drop leading to a 1 to 2 % drop in efficiency. A Schottky diode placed in parallel with the body diode of the synchronous rectification MOSFET prevents the body diode from conducting and reduces the loss in efficiency.

So although synchronous rectification has advantages, it can be difficult to implement because the timing of the MOSFET's switching is challenging. The ideal approach is to control the primary-side switch from the secondary-side of the power supply. This avoids the need to predict of the state of either MOSFET allowing greatly reduced dead-time whilst ensuring that the two MOSFETs are never simultaneously in the on-state.

However, until recently, synchronous rectification required a complex and expensive circuit often involving multiple pulse transformers, limiting the utility of synchronous rectification in compact and/or high-reliability applications. FluxLink technology (Figure 3) within InnoSwitch ICs eliminates the need for this extra circuitry. Accurate feedback is provided and precise control made possible, so that circuits are neither too conservative - which would adversely affect efficiency - nor too aggressive which would risk the damaging effects of shoot-through. InnoSwitch ICs sit across the isolation barrier utilizing what would otherwise be dead-space on the PCB.

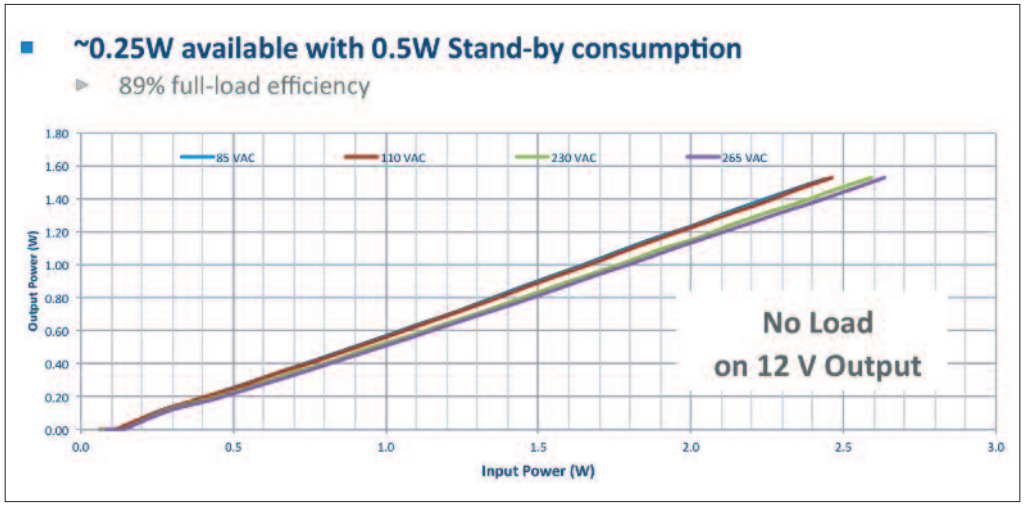


ABOVE Figure 3: FluxLink technology provides accurate feedback enabling precise control

Typical applications

The first application for InnoSwitch ICs was increasingly power-hungry smart mobile devices, but auxiliary and standby power in appliances, HVAC, consumer electronics, computing, telecom and data communication applications would also gain substantial benefits from increased efficiency across the load range. InnoSwitch-EP ICs are an answer to engineers looking to address increasingly demanding Total Energy Consumption (TEC) regulations from bodies such as ENERGY STAR® and ErP with an easy-to-implement solution that improves power supply efficiency from standby to full load. For example, InnoSwitch-EP ICs enable a 20 W power supply to achieve 90 % efficiency in a multi-output design, while reducing no load consumption to less than 30 mW. Voltage regulation across line is highly accurate at +/-5 % with tightly controlled over-current protection also provided (Figure 4).

As well as efficiency, InnoSwitch-EP CV/CC flyback switching ICs also deliver excellent multi-output cross-regulation without requiring linear regulators, and provide full line protection and instantaneous transient response. With appliances becoming increasingly sophisticated and correspondingly high cost items, reliability is crucial, especially for brands that promise long life and uninterrupted service by offering lifetime guarantees. Multi-output regulation is also an important consideration for appliance designers who deal with multiple functions that need power – clocks, motors, displays, microprocessors etc. Some functions require very tight voltage tolerances and to meet this engineers have previously used



RIGHT Figure 4: High efficiency at light loads

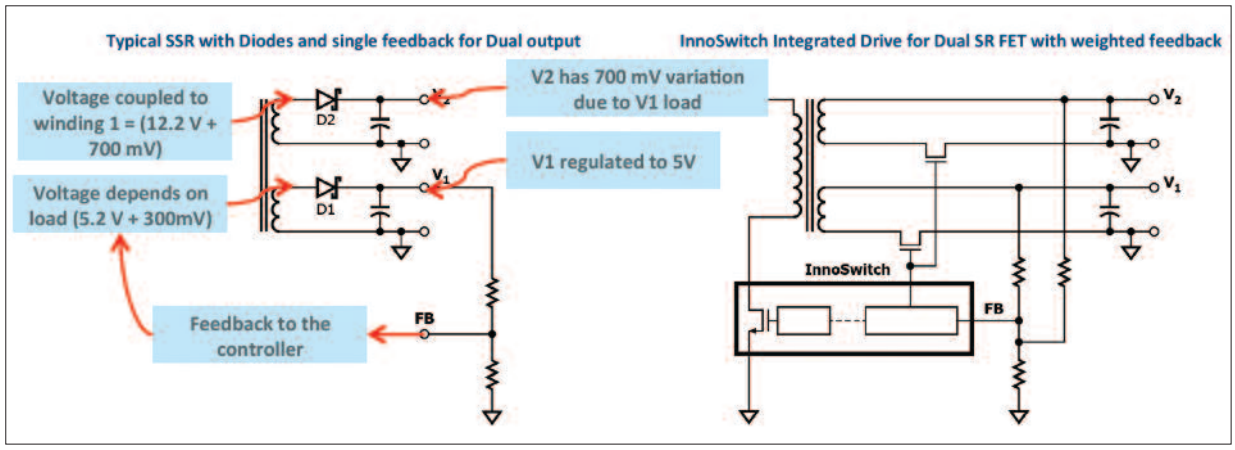


Figure 5: InnoSwitch-EP uses a synchronous rectification MOSFET which is relatively insensitive to changes in load current, reducing cross regulation effects on the other outputs

complex multi-stage architectures.

Figure 5 compares a design using a Schottky diode rectifier with an InnoSwitch-based circuit using synchronous rectification. In the circuit on the left, a Schottky diode is used for output rectification. The forward voltage drop of a Schottky diode is current sensitive (and can be modeled as a diode plus a series resistor) causing forward voltage drop to increase with rising load current. Primary side regulation cannot control multiple outputs, so the other outputs increase when the controller acts to regulate the primary output to compensate for this increase in voltage drop.

The circuit shown in the right had side of the diagram – based on InnoSwitch-EP - uses a synchronous rectification MOSFET which is relatively insensitive to changes in load current. This reduces cross regulation effects on the other outputs.

InnoSwitch-EP ICs feature advanced protection and safety features including: primary sensed output OVP; secondary sensed output overshoot clamping; secondary sensed output over-current protection down to zero output voltage; hysteretic thermal shutdown; and an input voltage monitor with accurate brown-in/brown-out plus line over-voltage protection.

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InnoSwitch-EP switcher ICs can safely be connected across the isolation barrier. All parts undergo HIPOT compliance test during production equivalent to 6 kV DC/1-sec and have reinforced insulation with an isolation voltage of greater than 3500 V AC. They are UL1577 and TUV (EN60950) safety approved and EN61000-4-8 (100 A/m) and EN61000-4-9 (1000 A/m) compliant.

A reference design (RDR 469) is freely downloadable at: https://ac-dc.power.com/design-support/reference-designs/design-examples/rdr-469-dual-output-20-w-embedded-power/ (Figure 6). It describes a dual output 20 W embedded power supply based on the InnoSwitch-EP INN2605K which has universal 85 – 264 V AC input and 12 V, 1.5 A and 5 V, 0.5 A outputs. A reference design kit is also available for purchase.

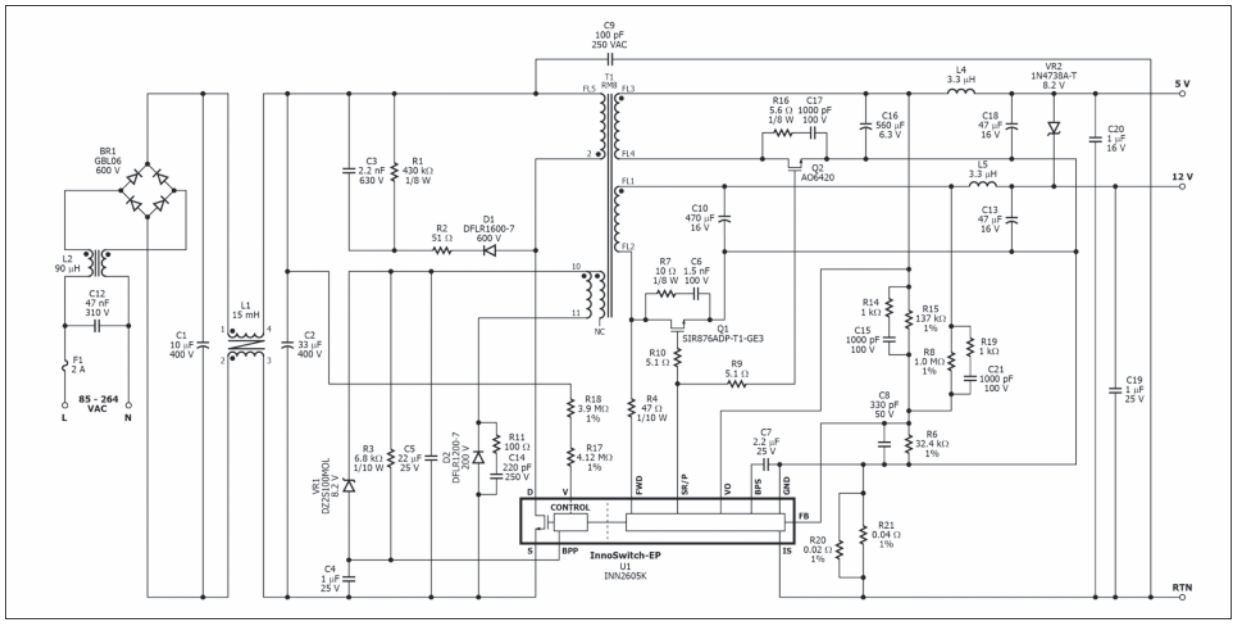

Figure 6: A dual output 20 W embedded power supply based on the InnoSwitch-EP INN2605K