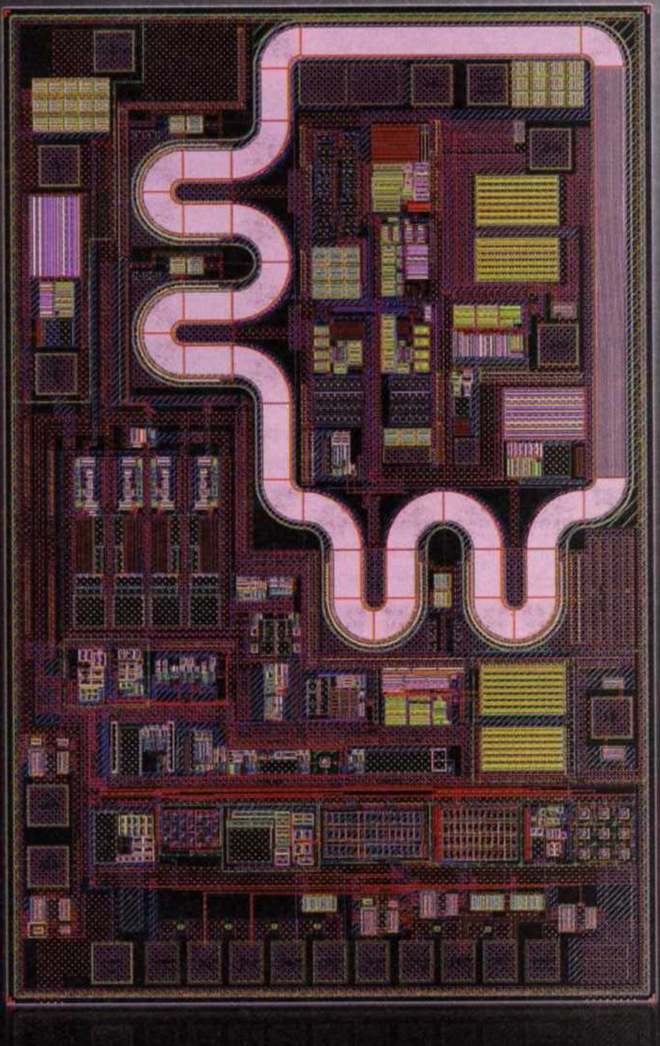
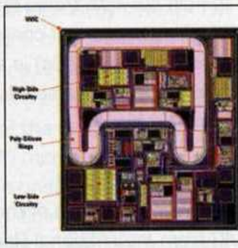
POWER SUPPLEMENT

april 2011

HVICs





COVER STORY

HVIC Technology

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IR'S HVICS LEAD THE WAY TOWARDS ENERGY EFFICIENCY

With the tremendous global initiative towards increased energy efficiency, off-line power converters have drawn a significant amount of attention resulting in more stringent requirements to reduce power losses.

This places more and more emphasis on the control circuits used to drive the various types of power converters available in the marketplace today. Fulfilling these requirements across all line and load conditions while reducing cost and size continues to present difficult challenges to circuit designers as they wrestle with design trade-offs.

To help alleviate these challenges, one particular category of control ICs known as high-voltage ICs (HVICs) is stepping up to deliver cost-effective solutions with increased performance.

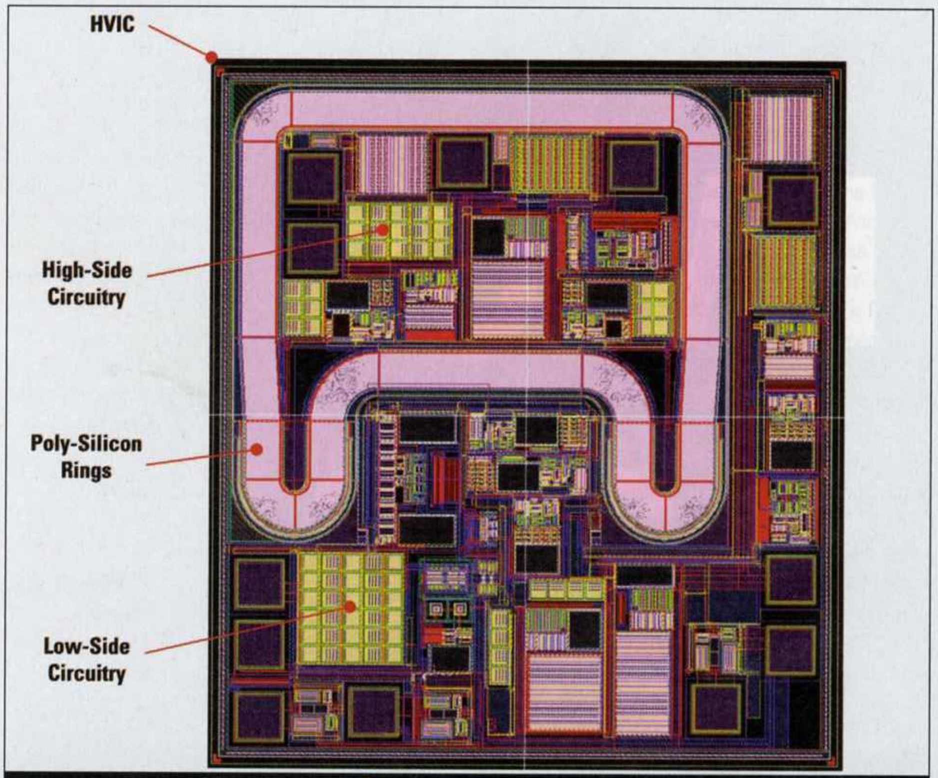

Figure 1: HVIC technology

HVIC Technology

With the introduction of the first monolithic HVIC from International Rectifier in 1984, the IC designers at that time probably could not have imagined the impact of such a technology in the world of power electronics today. The ability to place high-voltage circuitry on the same silicon that can 'float' up to 600 V away from the rest of the low-voltage circuitry offers a seemingly endless amount of design flexibility for controlling many different types of off-line converter topologies. This technology includes a high-voltage 'well' (as shown in figure 1) formed by polysilicon rings.

As the voltage potential inside the well increases away from the lower voltage potential outside the well, the voltage differential gets distributed uniformly across the polysilicon rings without breaking down. The high-side circuitry is placed conveniently inside the well so that it can perform circuit functions that are referenced to higher voltage potentials than the ground-referenced low-side circuitry. This is particularly useful for controlling high-side power MOSFETs or IGBTs that exist in many popular off-line circuit topologies such as buck, synchronous boost, half-bridge, full-bridge and 3-phase.

The low-side circuitry can then be placed on the same silicon to control other low-side power circuits. This potentially allows for a single HVIC to control a multi-stage converter, where previous solutions would have required multiple ICs, higher component count and higher costs.

Off-line converter topologies

Off-line converters are traditionally associated with AC/DC power supplies. However, off-line converters encompass any type of power supply that is connected to the AC line. These can include AC/DC (power supplies, LED) and AC/AC (electronic ballasts, audio, motor drive) converters. These different types of converters hold their own unique set of load, line and circuit requirements and therefore generally

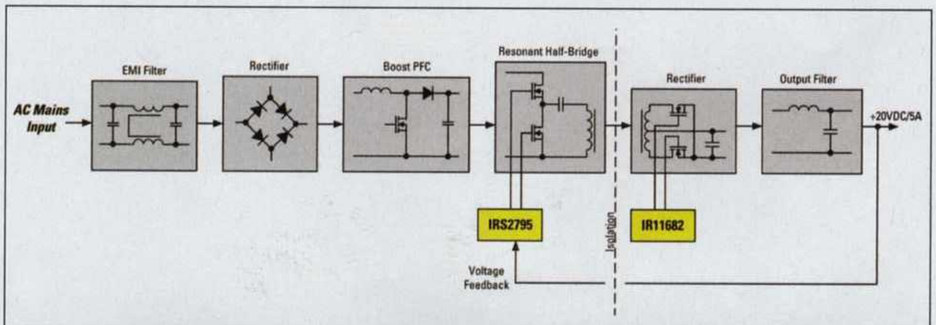

Figure 2: AC/DC laptop power supply block diagram

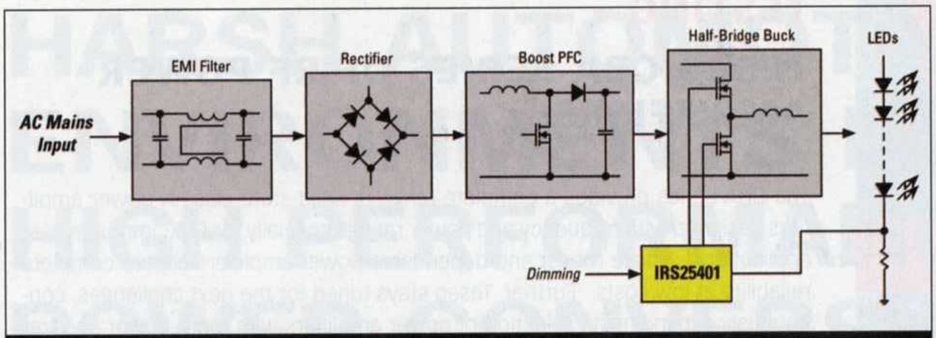

Figure 3: LED power supply block diagram

require a dedicated, or application-specific, solution for each.

A typical AC/DC power supply for laptop adapters includes an EMI filter to block high-frequency switching noise, rectification, power factor correction (PFC) to make the input current 'resistive' to the AC line voltage, a resonant-mode DC/AC step-down stage, AC/DC synchronous rectification, and output filtering (as seen in figure 2). This approach requires multiple ICs for controlling all of the stages. Where HVIC technology finds its home in this mixture of topologies is in the control of the half-bridge power MOSFETs using the IRS2795 and of the synchronous rectifier using the IR11682. The gate of the upper half-bridge switch (MHS) needs to be turned on and off while 'floating' 400 V away from the low-side circuitry. The half-bridge MOSFETs are then turned on and off synchronously by the IRS2795 at a given frequency and duty cycle, as determined by the feedback loop, to keep the DC output voltage regulated to a constant level. A synchronous rectifier is typically used on the secondary side to improve efficiency. The IR11682 is used here to measure the drain voltages of the synchronous rectifier MOSFETs for detecting the zero-crossing of the secondary current during the on-state of each switch. The high-voltage ability of the IR11682 is used to block the higher drain voltages present during the off-state. An AC/DC converter that utilises this topology together with synchronous rectification can achieve efficiencies as high as 90% at full load conditions. Additional functions are integrated into the half-bridge controller such as high-voltage start-up and burst mode to reduce standby losses during open or light load conditions.

An LED power supply also requires AC/DC conversion, except that the output is a constant DC current instead of a constant DC voltage. A typical non-isolated LED power supply includes an EMI filter, rectification, PFC, and a synchronous buck stage for generating the final LED current (as seen in figure 3). HVIC technology is applied here to control the half-bridge power MOSFETs. Also integrated on the same silicon is the complete low-side control loop to keep the LED current regulated to a constant level. The LED string current is sensed with a resistor and then fed back to the IRS25401 for monitoring. The IRS25401 switches the half-bridge synchronously to keep the current regulated within a precise window, and the half-bridge can be operated at higher switching frequencies to reduce the size of the external buck inductor.

An additional enable input is also provided for PWM dimming purposes. Integrating the high and low-side drivers, oscillator and logic in a single HVIC allows for reliable switching over temperature, circuit tolerances, or under harsh external noise conditions. This type of circuit topology can reach efficiencies of around 90% depending on the input voltage and number of LEDs. The low-side half-bridge MOSFET can be replaced with a diode to save cost, but efficiency will then decrease.

An electronic ballast for fluorescent lighting is a good example of an AC/AC converter and includes an EMI filter, rectification, PFC, and a resonant mode DC/AC stage for the lamp (see figure 4).

Efficiency of this topology typically exceeds 92%. HVIC technology is applied here with the IRS2168D to control the entire ballast by integrating the half-bridge resonant control together with the PFC control. The 'floating' high-voltage circuitry is used to control the upper half-bridge power MOSFET, while the low-voltage circuitry is used to control the lower half-bridge power MOSFET, the PFC power MOSFET, and all necessary PFC and ballast control and protection functions. Two independent oscillators and control circuits are included for performing the PFC control and the resonant lamp control which greatly simplifies the design, saves board space and lowers costs. Dimming control can also be included for additional energy savings. By combining all control blocks into a single HVIC, additional circuit benefits can be gained as well. Since the PFC block now knows the state of the lamp, the PFC circuit can be dynamically modified to best supply power to the lamp under different operating conditions. During dimming, for example, the PFC loop compensation can be modified depending on the dimming level of the lamp for improved stability. A single HVIC can now take the performance of the design beyond multi-chip solutions while at the same time reducing costs.

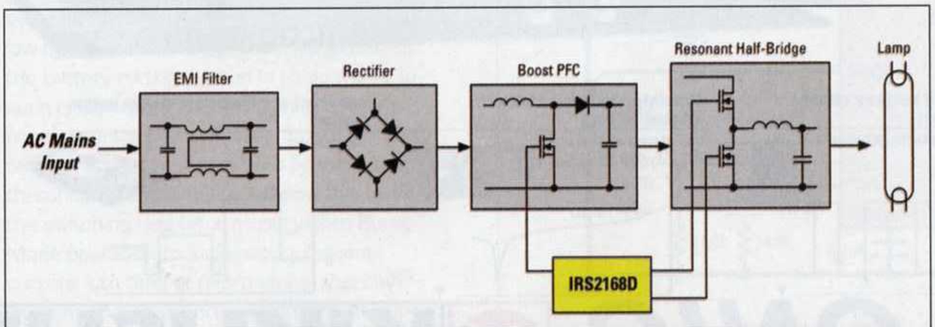

Figure 4: Electronic ballast block diagram

Conclusion

Each of these topologies is known to have high efficiencies for their respective application. By utilising HVIC technology to integrate all of the high and low-side control and driver functions, these solutions can be realised at a lower size and cost while increasing reliability and manufacturability. This will then result in increased global adoption of energy efficient power converters. The integration possibilities for each of these high-voltage topologies are endless, including ultimately integrating the power switches themselves. However, each case needs to be analysed carefully for best internal/external partitioning while paying attention to flexibility, risk, design time and cost. Full integration may be attractive to the IC designer, but is not always lower cost or the most flexible solution for the power supply designer.

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