Isolated Power Supplies Made Easy

John D. Morris

The LT3748 is a switching regulator controller specifically designed to simplify the design of isolated power supplies using a flyback topology. No third winding or opto-isolator is required as the LT3748 senses the isolated output voltage directly from the primary-side flyback waveform.

One challenge in designing a flyback converter is that information relating to the output voltage on the secondary side of the transformer must be fed back to the regulator on the primary side in order to maintain regulation. Historically, feedback across the isolation barrier is achieved using opto-isolators or extra transformer windings, though both methods present a number of design problems. Opto-isolator feedback circuits add components, increasing converter size and cost. They also draw power, degrading efficiency and complicating thermal design. Opto-isolators also make it difficult to accurately regulate the output due to their limited dynamic response, inherent nonlinearities, typical variation from unit-to-unit and variation with age. The usual alternative is to add an extra transformer winding, but this may introduce other problems, including bigger, more expensive magnetics or limited dynamic response.

By contrast, the LT3748 infers the isolated output voltage by examining the primary-side flyback pulse waveform. In this manner, neither an opto-isolator nor an extra transformer winding is required to maintain regulation, and the output voltage is easily programmed with two resistors.

The LT3748 features a boundary mode control method (also called critical conduction mode), where the part operates at the boundary between continuous conduction mode and discontinuous conduction mode, as illustrated in Figure 1. Due to the boundary control mode operation, the output voltage can be calculated from the transformer primary voltage when the secondary current is approximately zero. This method improves load regulation without external resistors and capacitors and results in typical line and load regulation of better than ±5% while allowing for a simple and compact solution, as shown by the 12V, 30W demo board in Figure 2.

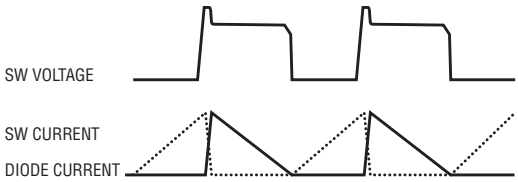


Figure 1. Idealized waveforms for an LT3748-based flyback converter operating in boundary mode

OUTPUT POWER

Because the MOSFET power switch is located outside the LT3748, the maximum output power is limited primarily by external components—not the LT3748. Output power limitations can be separated into three categories: voltage limitations, current limitations and thermal limitations. The voltage limitations in a flyback design are primarily the MOSFET switch maximum drain to source voltage and the output diode reverse-bias rating. The current limitation on output power delivery is generally constrained by transformer saturation current in higher power applications, although the MOSFET switch and output diode may need to be rated for the desired

Figure 2. A no-opto-coupler 30W design with an 18V-to-90V input range (actual size)

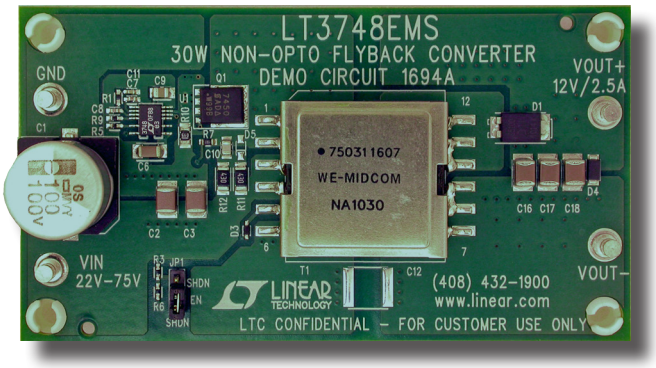
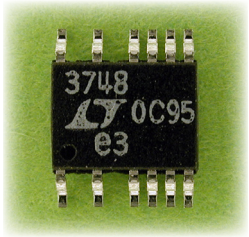


Figure 3. The LT3748 is available in an MSOP-16 package with four pins removed for high voltage operation.



The LT3748 infers the isolated output voltage by examining the primary-side flyback pulse waveform. In this manner, neither an opto-isolator nor an extra transformer winding is required to maintain regulation, and the output voltage is easily programmed with two resistors.

currents, as well. The thermal limitation in flyback applications for lower output voltages is dominated by losses in the output diode, with resistive and leakage losses in the transformer increasing in significance as the output voltage is increased.

OPTIMIZED FEATURES

The LT3748 is capable of driving the vast majority of appropriate MOSFETs at frequencies of up to several hundred kilohertz using its built-in gate driver capable of 1.9A average output current (both rising and falling) and its internal $INTV_{CC}$ low-dropout regulator. In addition, start-up is well controlled with programmable soft-start and undervoltage lockout. Although the LT3748 fits in a compact MSOP-16 package, four pins have been removed to provide sufficient spacing for high voltage operation, as shown in Figure 3.

OVERDRIVING $INTV_{CC}$ WITH A THIRD WINDING

The LT3748 provides excellent output voltage regulation without the need for an opto-coupler or third winding, but for some applications with high input voltages, an additional winding may improve overall system efficiency, particularly at lighter loads. The third winding should be designed to output a voltage above 7.2V but never exceeding 20V. In typical applications over 15W, overdriving the $INTV_{CC}$ pin may improve efficiency by several percent at maximum load and more than 10% at light loads. Figure 4 shows the efficiency of the circuit in Figure 5 with and without the third winding connected.

OVER-CURRENT PROTECTION

The LT3748 has an internal threshold to detect when current in the R_{SENSE} resistor exceeds the programmed range to protect external devices in case of a system fault. This can occur when an inductive output short-circuit causes the output voltage to dip below zero or when the transformer saturation current is exceeded. Regardless of the cause, when the voltage at the SENSE pin exceeds ~130mV—or 30% higher than the programmed maximum current limit in the R_{SENSE} resistor—the SS pin is reset, thus halting switching operation. Once the soft-start capacitor is recharged and the soft-start threshold is reached, switching resumes at the minimum current limit. In output short circuit cases where the reflected output voltage plus the forward diode drop is greater than zero, the LT3748 functions normally and no external components are stressed.

HIGH TEMPERATURE OPERATION

The LT3748 is available in E, I and H grades, and is designed for excellent performance across a wide temperature range. Other than the internal $INTV_{CC}$ regulator,

Figure 4. Efficiency of the LT3748 application in Figure 5 with and without a third winding

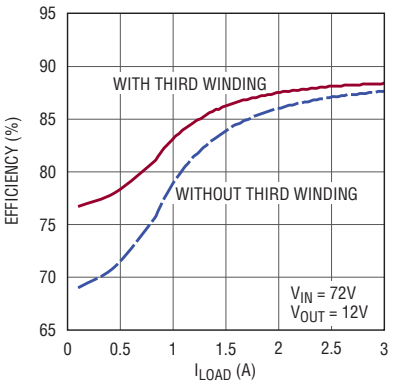
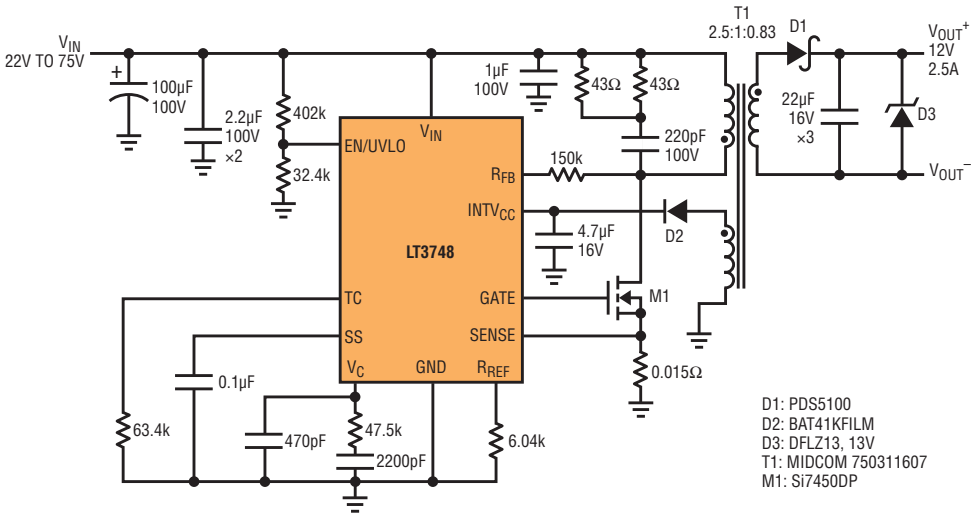


Figure 5. Schematic for the converter pictured in Figure 2. This converter takes an 18V-to-90V input and produces a 2.5A output at 12V.



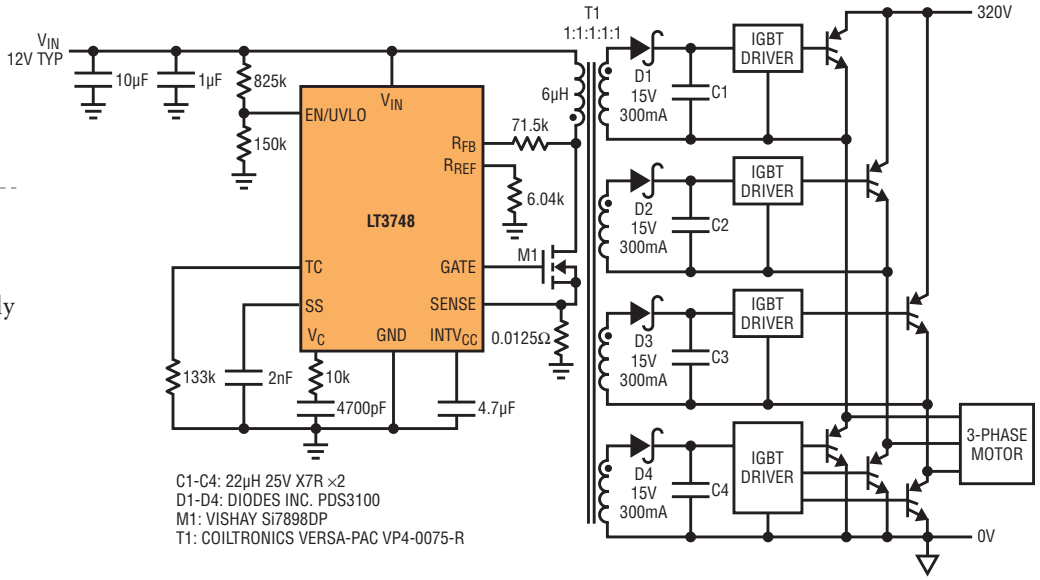


Figure 6. IGBT controller supply for hybrid and electric vehicle applications

the LT3748 dissipates very little power, even at high input voltages, so limitations to thermal performance are almost entirely in the external components, which can be correctly sized or cooled as needed.

12V, 3A OUTPUT FROM 18V–90V INPUT

Figure 5 shows an application that efficiently converts a wide input range to a 12V output. Because the LT3748 is capable of handling up to 100V at its input, no additional interface circuitry is required between the line voltage and the controller. A simple RC snubber is all that is required to protect the 200V Si7450 MOSFET from excessive voltage across the full line and load range. Although a third winding is normally connected to boost efficiency at lighter loads, all regulation is done on the primary winding—a transformer without a third winding would be nearly as efficient at lower input voltages and high output loads.

IGBT CONTROLLER SUPPLY FOR AUTOMOTIVE APPLICATIONS

The LT3748 can easily produce multiple isolated supplies to power IGBTs that drive synchronous motors from high battery voltages in electric or hybrid electric vehicles, as illustrated in Figure 6. A MOSFET with 150V maximum V_{DS} is selected so that any snubbing circuitry is optional and the hysteretic UVLO threshold is set to start switching when V_{IN} equals 10V while allowing V_{IN} to droop to 8V while switching.

HIGH OUTPUT VOLTAGE FOR REMOTE SENSORS

A flyback topology is often the only way to produce a high voltage isolated output for long cable runs or for powering interface equipment. Figure 7 shows a typical application for this style of application with complementary 300V outputs. For the low power levels in this application, an off-the-shelf EP13 transformer is more than sufficient and keeps the total solution size small.

CONCLUSION

The LT3748 simplifies the design of isolated flyback converters by using a primary-side sensing, boundary mode control scheme that precludes the need for an opto-coupler and its related circuitry. The LT3748 also features a wide input range, low internal power dissipation, a 1.9A gate driver and user-programmable protection features that further simplify design and add to its versatility. ■

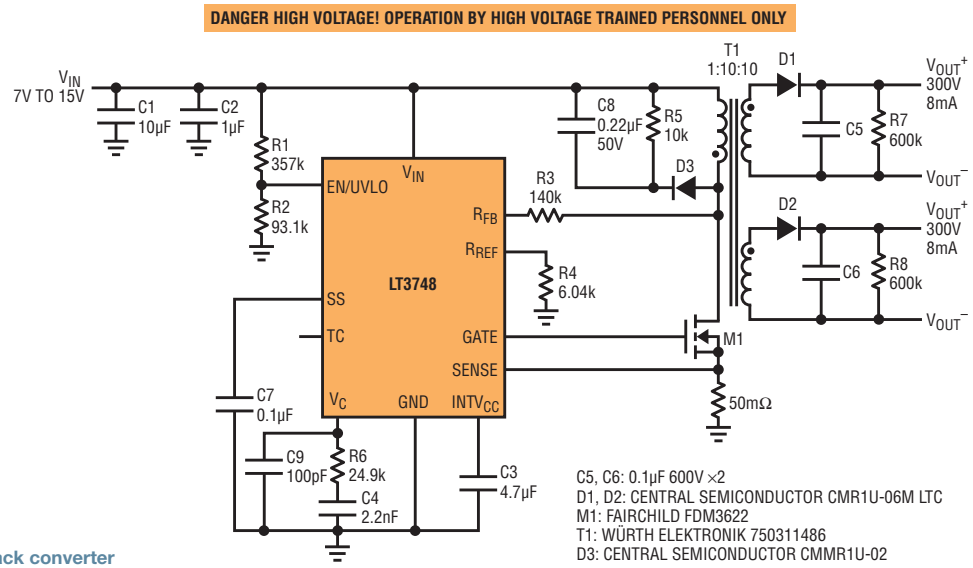


Figure 7. A ±300V isolated flyback converter