Inverting DC/DC Controller Converts a Positive Input to a Negative Output with a Single Inductor

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There are a number of ways to produce a negative voltage from a positive voltage source, including using a transformer or two inductors and/or multiple switches, but none are as easy as using the LTC3863, which is elegant in its simplicity, has superior efficiency at light loads and reduces parts count when compared to these solutions.

ADVANCED CONTROLLER CAPABILITIES

The LTC3863 can produce a –0.4V to –150V negative output voltage from a positive input range of 3.5V to 60V. It uses a single-inductor topology with one active P-channel MOSFET switch and one diode. The high level of integration yields a simple, low parts count solution.

The LTC3863 offers excellent light load efficiency, drawing only 70µA quiescent current in user programmable Burst Mode® operation. Its peak current mode, constant frequency PWM architecture provides positive control of inductor current, easy loop compensation and top-notch loop dynamics. The switching frequency can be programmed from 50kHz to 850kHz with an external resistor and can be synchronized to an external clock from 75kHz to 750kHz. The LTC3863 offers programmable soft-start or output tracking. Safety features include overvoltage, overcurrent, and short-circuit protection including frequency foldback.

–12V, 1A CONVERTER OPERATES FROM 4.5V–16V SOURCE

The circuit shown in Figure 1 produces a –12V, 1A output from a 4.5V–16V input. Operation is similar to a flyback converter, storing energy in the inductor when the switch is on and releasing it through the diode to the output when the switch is off, except that with the LTC3863, no transformer is required. To prevent excessive current that can result from minimum on-time when the output is short-circuited, the controller folds back the switching frequency when the output is below half of nominal.

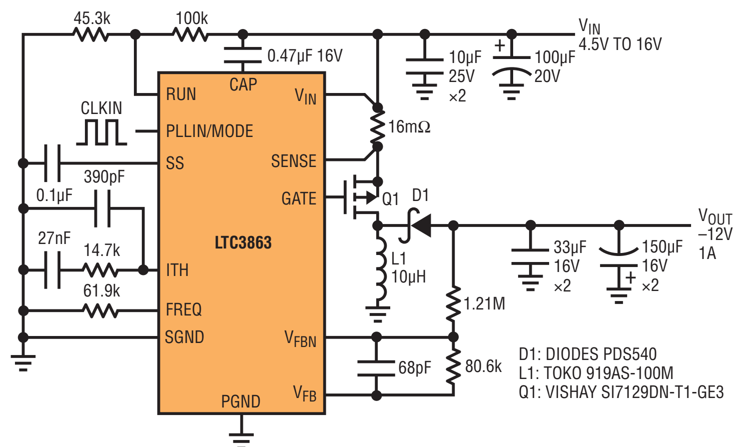


Figure 1. Inverting converter produces –12V at 1A from a 4.5V–16V source

Figure 2. Switch node voltage, inductor current and ripple waveforms at 5V input and –12V output at 1A

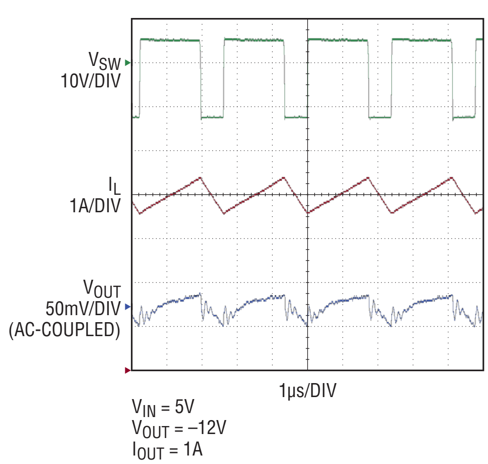
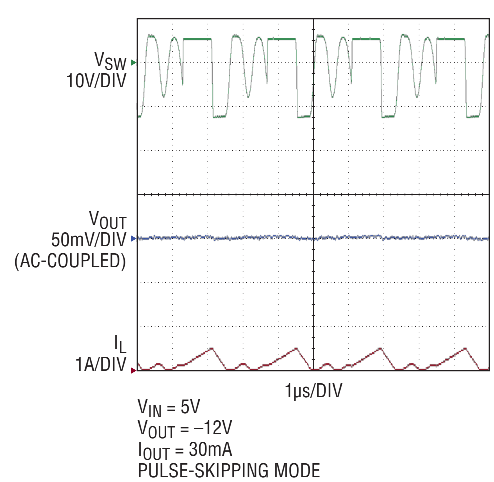


Figure 3. Switch node voltage, inductor current and ripple waveforms at 5V input and –12V output at 30mA in pulse-skipping mode



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The LTC3863 can be programmed to enter either high efficiency Burst Mode operation or pulse-skipping mode at light loads. In Burst Mode operation, the controller directs fewer, higher current pulses and then enters a low current quiescent state for a period of time depending on load. In pulse-skipping mode, the LTC3863 skips pulses at light loads. In this mode, the modulation comparator may remain tripped for several cycles and force the external MOSFET to remain off, thereby skipping pulses. This mode offers the benefits of smaller output ripple, lower audible noise, and reduced RF interference, at the expense of lower efficiency when compared to Burst Mode operation. This circuit fits in about 0.5in² (3.2cm²) with components on both sides of the board.

Figure 2 shows switch node voltage, inductor current, and ripple waveforms at 5V input and –12V output at 1A. The inductor is charged (current rises) when the PMOSFET is on, and discharges through the diode to the output when the PMOS turns off. Figure 3 shows the same waveforms at 30mA out in pulse-skipping mode. Notice how the switch node rings out around 0V when the inductor current reaches zero. The effective period stops when the current reaches zero. Figure 4 shows the same load condition with Burst Mode operation enabled. Power dissipation drops by 36% at this operating point, and efficiency increases from 72% to 80%. Figure 5 shows waveforms with the output shorted. The switching frequency is reduced to about 80kHz in this condition to prevent excessive current that could otherwise result.

HIGH EFFICIENCY

Figure 6 shows efficiency curves for both pulse-skipping and Burst Mode operation. Exceptional efficiency of 89.3% is achieved at 1A load and 12V input. Notice how Burst Mode operation dramatically improves efficiency at loads less than 0.1A. Pulse-skipping efficiency at light loads is still much higher than that obtained from synchronous operation.

CONCLUSION

The LTC3863 simplifies the design of converters producing a negative output from a positive source. It is elegant in its simplicity, high in efficiency, and requires only a small number of inexpensive external components to form a complete converter. ■

Figure 4. Switch node voltage, inductor current and ripple waveforms at 5V input and –12V output at 30mA in Burst Mode operation

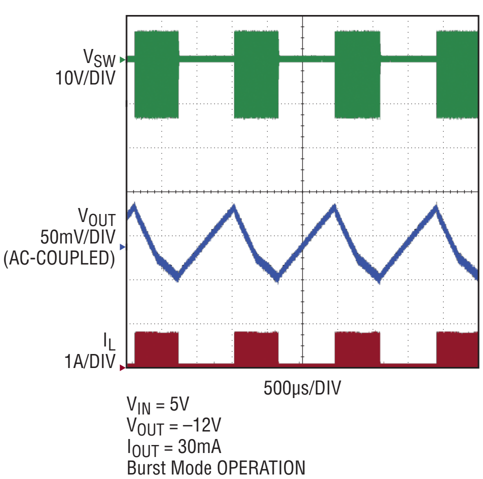

Figure 5. Switch node voltage, inductor current and ripple waveforms at 5V input with the output shorted

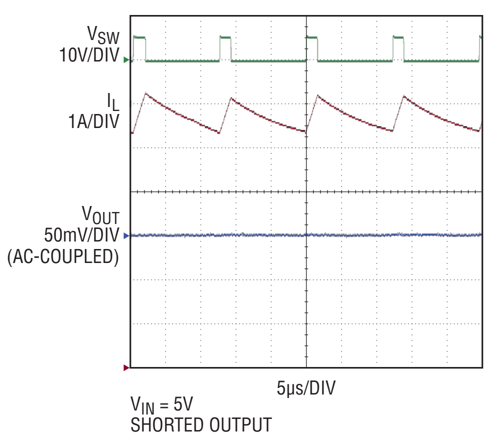

Figure 6. Efficiency in normal and Burst Mode operation