µModule Regulator Fits a (Nearly) Complete Buck-Boost Solution in 15mm × 15mm × 2.8mm for 4.5V–36V V_{IN} to 0.8V–34V V_{OUT}

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Introduction

Linear Technology offers a number of high efficiency synchronous 4-switch buck-boost DC/DC converter solutions for applications where V_{OUT} falls within the range of V_{IN}. The LTM4605, LTM4607 and LTM4609 µModule regulators are nearly self-contained buck-boost solutions that share pin-compatible 15mm × 15mm × 2.8mm packages. The package includes the controller, four power FETs and a number of other discrete components. Only an external inductor, a sensing resistor, a voltage setting resistor and a few input and output capacitors are needed to complete a high efficiency buck-boost converter.

Table 1 shows the input voltage, output voltage and current specifications of these three buck-boost µModule regulators. The LTM4609 is the latest addition to this family. It satisfies the needs of high output voltage applications with an output range of 0.8V–34V.

High Performance with Minimum Component Count

As with all Linear Technology µModule regulators, the LTM4609 requires only a few external components to complete a wide input range buck-boost converter. Figure 1 shows a 10V to 36V input, 30V output design. The output current capability is 3A at 10V V_{IN}, and 8A with 36V input.

Figure 2 shows the efficiency of this converter, up to 98% in buck mode and 95% in boost mode. The low profile LGA package features low thermal resistance from junction to pin, thus maintaining an acceptable junction temperature even at high output power. The LTM4609's high

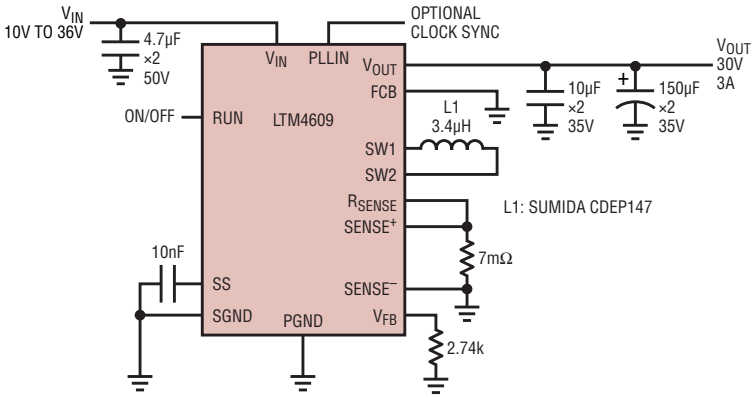


Figure 1. Just a few components form a complete 10V to 36V input, 30V/3A output converter using the LTM4609.

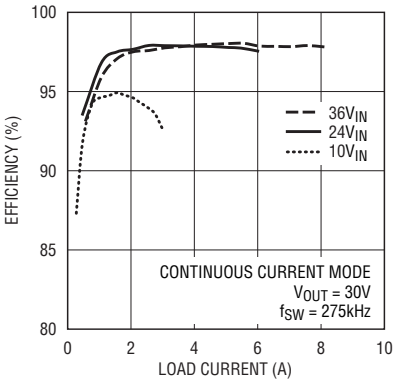
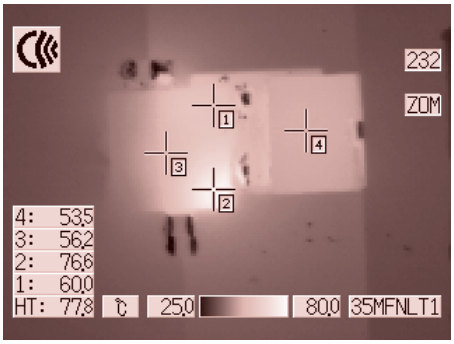
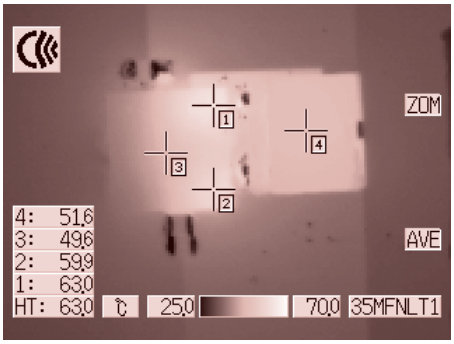


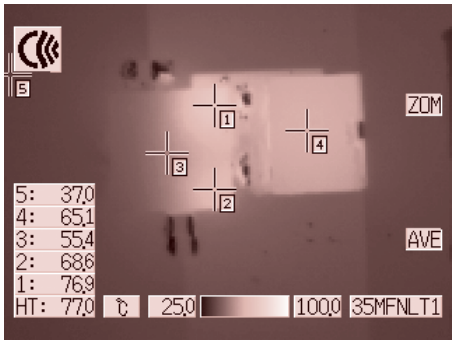
Figure 2. Efficiency of the 30V buck-boost converter



V_{IN} = 36V, V_{OUT} = 30V, I_{OUT} = 8A



V_{IN} = 24V, V_{OUT} = 30V, I_{OUT} = 6A



V_{IN} = 12V, V_{OUT} = 30V, I_{OUT} = 3A

Figure 3. Thermal-graph taken with the LTM4609 running at different input voltages. The LTM4609 is on the left, the inductor (Sumida CDEP147) is on the right. No heat sink or forced air flow. Ambient temperature = 25°C.

efficiency combined with its excellent thermal management capability enables it to deliver up to 240W output power without a heat sink or forced airflow. Figure 3 shows the thermal-graphs taken with three different input voltages and loads at 25°C ambient temperature. With 240W output and 36V input, the maximum temperature rise of the LTM4609 is only 52.8°C.

Input Ripple Reduction

One way to improve efficiency in a switching DC/DC converter is to minimize the turn-on and turn-off times of the MOSFET—shorter transitions correspond to lower switch losses. However, fast transitions also lead to high frequency switching noise, which can pollute the input power source. For the applications where the input voltage ripple must be limited, a simple LC π filter can be inserted at the input side to attenuate the high frequency input voltage noise. Figure 4 shows the LTM4609 with an input π filter. The filter includes two 10µF low ESR ceramic capacitors and two very small magnetic beads. For lower output power applications, only one magnetic bead is necessary.

Figure 5 shows the input ripple reduction with the π filter. Figure 5a shows the input ripple with 100µF aluminum electrolytic plus 2 × 4.7µF ceramic input capacitors. Figure 5b shows the input ripple with the filter shown in Figure 4. Both waveforms are measured across the 100µF aluminum capacitor. A 67% reduction in input ripple is obtained with the input π filter, which requires only two small additional magnetic beads.

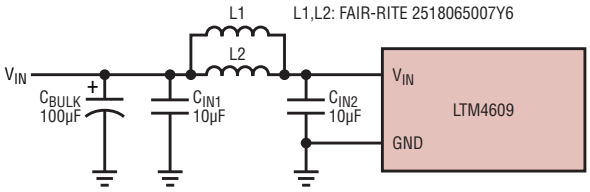
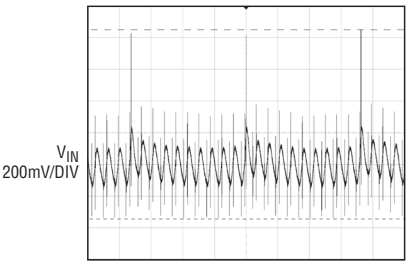
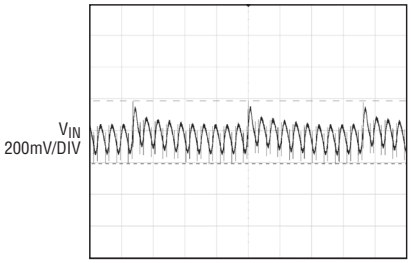


Figure 4. The LTM4609 µModule regulator with an input π filter.



5a. Input voltage waveform without the input π filter shown in Figure 4



5b. Input voltage waveform with input π filter as shown in Figure 4

Figure 5. The input π filter shown in Figure 4 effectively reduces the input voltage spike caused by switching action of the MOSFETs.

Table 1. Specification comparison of the LTM4605, LTM4607 and LTM4609

	LTM4605	LTM4607	LTM4609
V_{IN}	4.5V ~ 20V	4.5V ~ 36V	4.5V ~ 36V
V_{OUT}	0.8V ~ 16V	0.8V ~ 24V	0.8V ~ 34V
I_{OUT}	5A (12A in buck mode)	5A (10A in buck mode)	4A (10A in buck mode)
Package	15mm × 15mm × 2.8mm LGA		

Conclusion

Buck-boost µModule regulators are easy-to-use, high performance solutions for applications where a regulated output voltage sits within the range of the input voltage. The 15mm × 15mm × 2.8mm LTM4609 widens the input/output voltage range of the pin compatible LTM4605 and LTM4607. The advanced package technology, as well as the high efficiency design of the LTM4609, allows it to deliver up to 240W of output power without heat sinks or forced airflow. For applications that require low input voltage ripple, a simple π filter can be added by inserting one or two small magnetic beads to significantly reduce the high frequency input noise.

LT3755/56, continued from page 32

PWM on- and off-times are 1µs as with the other circuits. Figure 7 shows the waveforms during a short circuit fault on the output. The input current remains in control as the switch current ramps up to the set limit of 10A, then skips the next few cycles while the current sensed by the LED resistor ramps down to 1.5A. This faulted mode of circuit operation can continue indefinitely without damage to the components.

Conclusion

The LT3755 and LT3756 offer unparalleled performance for an LED controller generating PWM pulse widths as narrow as 1µs, which enables 50:1 PWM dimming at frequencies above the audible range. Other features include open LED protection, an open LED status indicator, and programmability of the LED current via an analog input.