12A Monolithic Synchronous Buck Regulator Accepts Inputs up to 24V

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Introduction

The LTC3610 is a high power monolithic synchronous buck regulator capable of providing up to 12A from inputs as high as 24V in a complete solution that takes little space (Figure 1). It integrates the step-down controller and power MOSFETs into a single, compact 9mm × 9mm QFN package. Its high step-down ratio, wide input and output voltage range and high current capability present a single IC solution for many applications previously requiring separate FETs and controller ICs. Its very low profile (0.9mm max) allows mounting on the back of a circuit board, freeing up valuable front-side board space.

Flexible Control

High step-down ratios (Figure 2) are possible because of the LTC3610's constant on-time operation and valley current control architecture, which allow a minimum on-time of less than 100ns. Output voltages approaching V_{IN} are also possible (Figure 5). In either case, efficiency is very high—up to 97% (Figures 4 and 6). Synchronous operation affords high efficiency at low duty cycles, whereas a non-synchronous converter would conduct current through the forward drop of a Schottky diode most of the time. Transient response (Figure 3) is fast because the LTC3610 reacts *immediately* to a load increase. It does

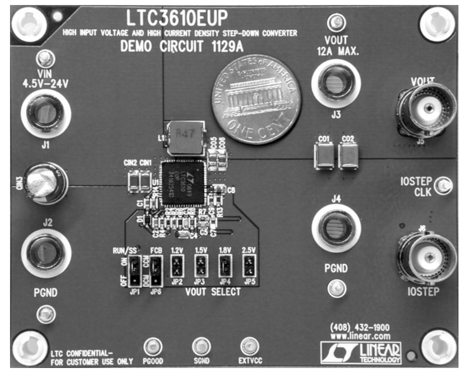

Figure 1. Who says a lot of space is needed for a complete high power density step-down regulator? The LTC3610 is capable of providing up to 12A from inputs as high as 28V. Its low 0.9mm profile allows it to be mounted on the back of the board too.

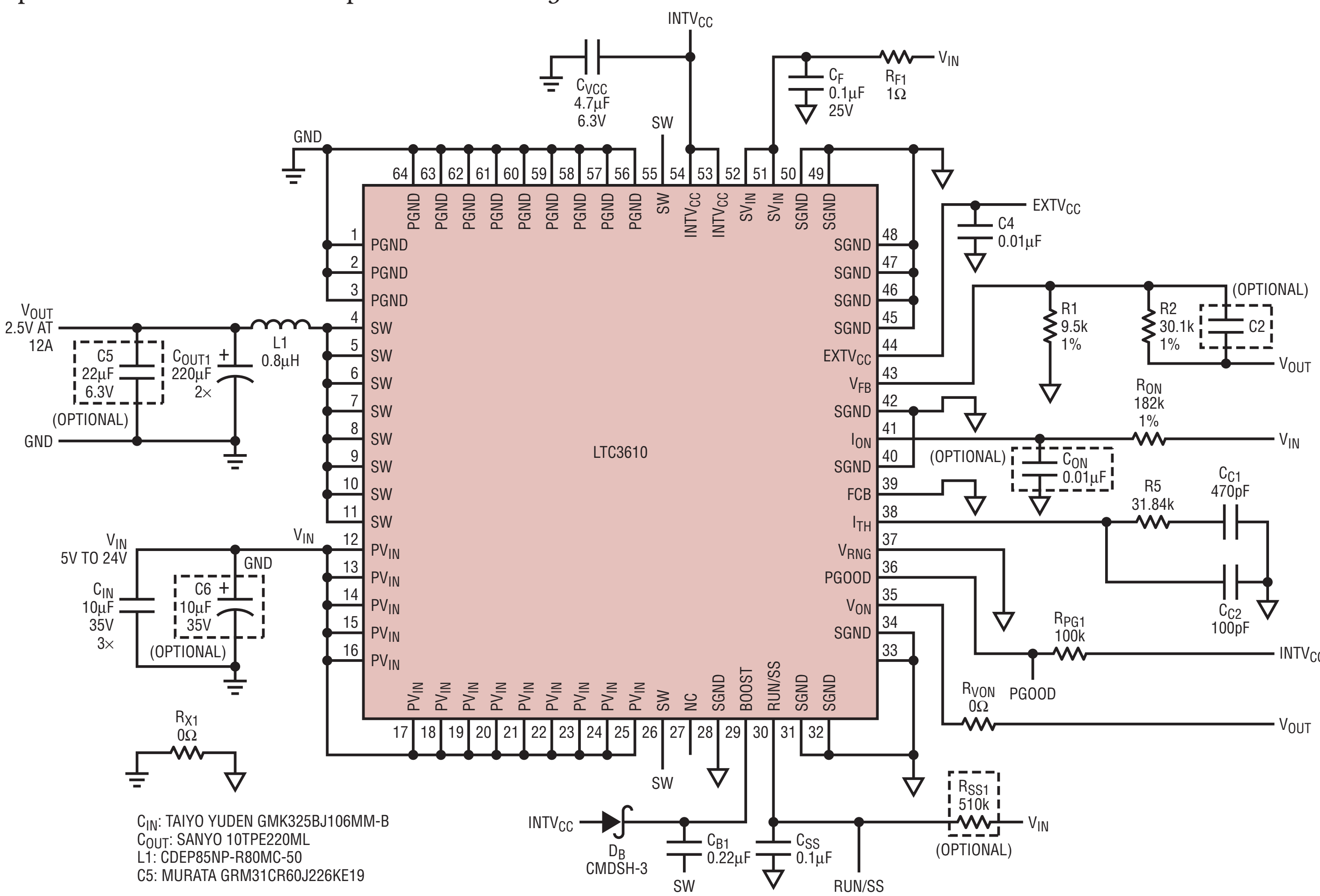

Figure 2. This converter runs at 550kHz and delivers 2.5V at 12A from an extremely wide 5V–24V input.

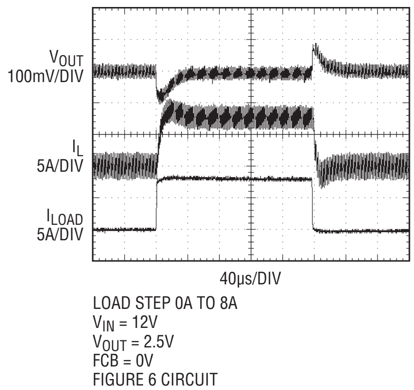

Figure 3. The LTC3610 responds quickly to an 8A transient (circuit of Figure 2).

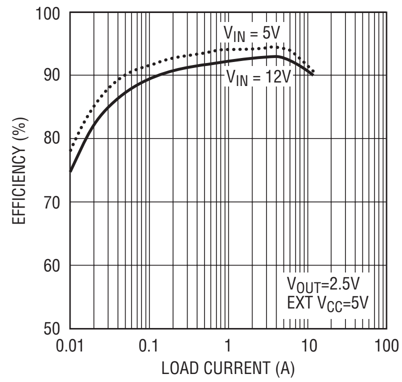

Figure 4. Efficiency vs load current for the circuit of Figure 2

not wait for the beginning of the next clock cycle to respond, so there is no clock latency.

The LTC3610 can be programmed for two kinds of light-load operation: forced continuous mode or discontinuous mode. Forced continuous operation offers the lowest possible noise and output ripple. The top MOSFET turns on for the programmed on-time and the bottom MOSFET turns on for the (remaining) off-time. Inductor current is allowed to reverse, even at no load.

In discontinuous mode, the top MOSFET turns on for a preset on-time. Then (after a brief non-overlap period) the bottom MOSFET turns on until the current comparator senses reverse inductor current. When the error amplifier senses a small decrease at the feedback node V_{FB}, its output (the I_{TH} pin) rises, initiating another cycle. As the load current rises, so does the average inductor current. Eventually, the interval between constant on-time pulses ends before the inductor current can reach zero, at which point the inductor continuously conducts current. This point is determined by duty cycle, inductance value, and the interval between constant on-time pulses. By using single on-time pulses of fixed width, this mode provides well-controlled output ripple at any supported load. This process also prevents reverse inductor current, which minimizes power loss at light loads.

The on-time is set by the current into the I_{ON} pin and the voltage at the V_{ON} pin according to a simple equation

$$T_{ON} = \frac{V_{VON}}{I_{ION} \bullet 10pF}$$

Tying a resistor R_{ON} from V_{IN} to the I_{ON} pin yields an on-time inversely proportional to V_{IN}.

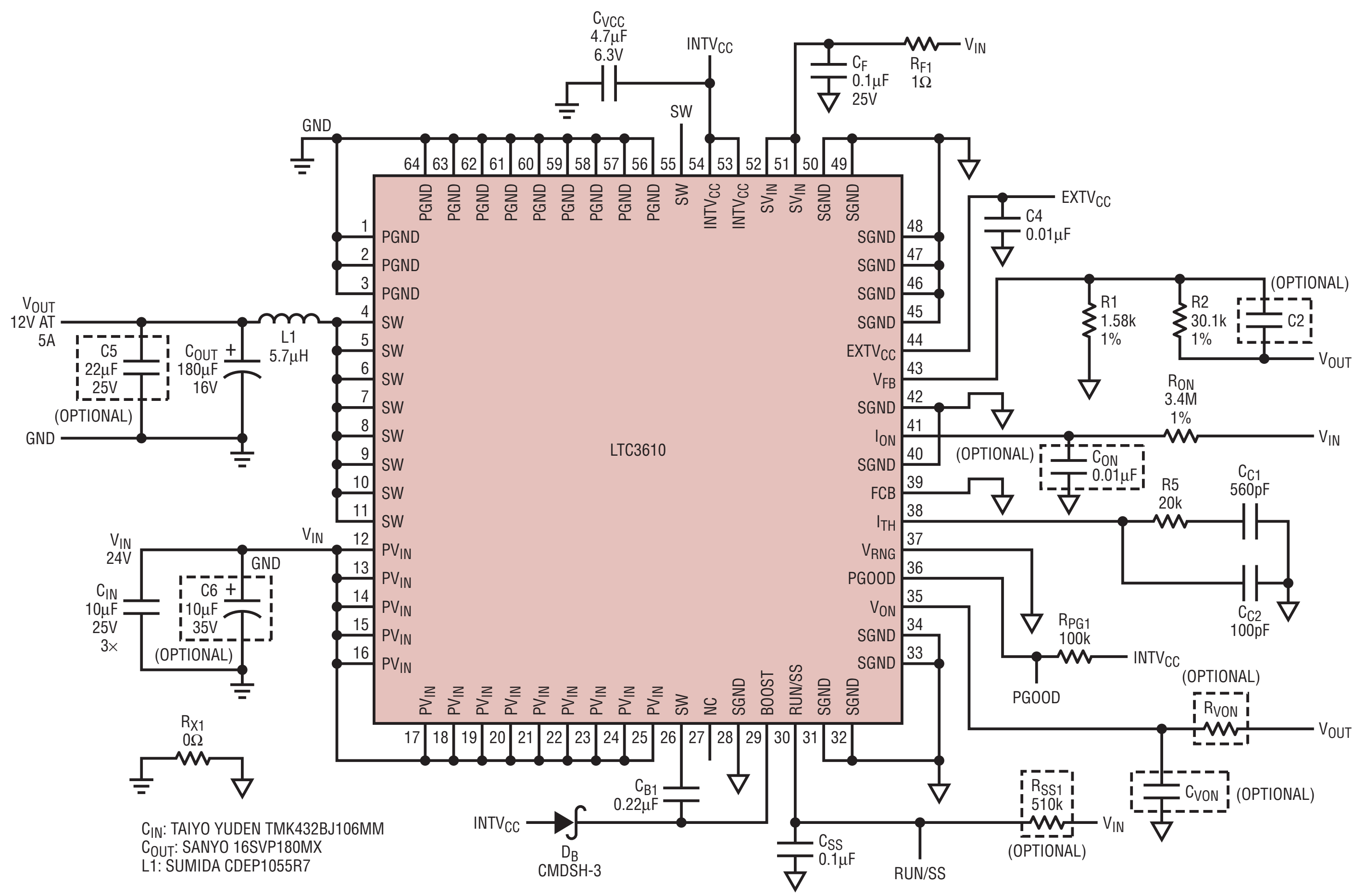

Figure 5. Although the LTC3610 is optimized for high step-down ratios, it can also regulate output voltages beyond the range of many DC/DC buck converters. For example, this schematic shows a 500kHz regulator delivering 12V at up to 5A, with high efficiency and low output ripple.

Adjustable current limit is also built-in. The inductor current of LTC3610 is determined by measuring the voltage across the sense resistance between the PGND and SW pins, where $R_{DS(ON)}$ of the bottom MOSFET is about 6.5mΩ. The current limit is set by applying a voltage to the V_{RNG} pin, which sets the relative maximum voltage across the sense resistance. An external resistive divider from the internal bias, INTVCC, can be used to set the voltage of the V_{RNG} pin between 0.5V and 1V resulting in a typical current limit of 16A to 19A. Tying V_{RNG} to SGND defaults the current limit to 19A.

The LTC3610 also has soft-start and latch off functions enabled by the Run/SS pin. Pulling the Run/SS below 0.8V puts the LTC3610 into a low quiescent current shut down state, whereas releasing the pin allows a 1.2µA current source to charge up the external soft-start capacitor. When the voltage on Run/SS reaches 1.5V, the LTC3610 begins operating with an initial clamp on I_{TH} of approximately 0.9V. This prevents current overshoot during start up. As the soft-start capacitor charges, the I_{TH} clamp increases, allowing normal operation at full load current. If the output voltage falls below 75% of the regulated voltage, then a short-circuit fault is assumed. At this point, a 1.8µA current discharges capacitor C_{SS}. If the fault condition persists until Run/SS drops to 3.5V, the controller's overcurrent latch off turns off the MOSFETS until Run/SS is grounded and released. If latch off is not desired, a pull-up current source at Run/SS defeats this feature.

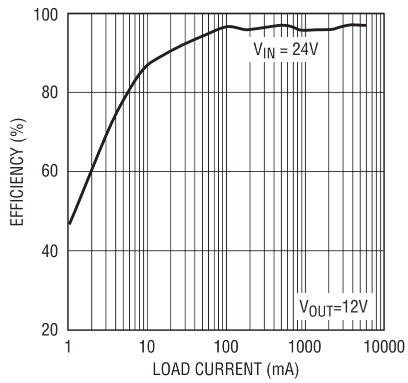

Figure 6. Efficiency vs load current for the circuit of Figure 4

Conclusion

Few synchronous monolithic DC/DC converters are versatile enough to use in low power portable devices such as notebook and palmtop computers, as well as high power industrial distributed power systems. The LTC3610's broad input and output ranges, efficiency greater than 90% and high current capability make it a superior alternative to many solutions requiring separate power switches.

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OUT voltage rises above the BAT voltage, the charge cycle restarts where it left off.

At any time, the user may monitor both instantaneous charge current and instantaneous USB current by observing the PROG pin and CLPROG pin voltages respectively.

Conclusion

The LTC4067 satisfies the needs of voltage sensitive battery operated devices, replacing as many as three separate devices. With accuracy better than ±0.4% on the battery float voltage, the LTC4067 is ideally suited for demanding high-precision applications. The LTC4067 offers both a power management strategy that complies with USB port specifications as well as providing an advanced battery charger. The LTC4067 also offers overvoltage protection up to 13V, to protect itself as well as system devices in the event that an incorrect wall adapter is attached.

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power, and small package makes the LTC2356-14 ideal for high speed, portable applications including data acquisition, communications, and medical instrumentation.

The LTC2356-14 achieves 72.3dB SINAD and –82dB SFDR with a 1.4MHz input frequency. While measuring ±1.25V bipolar inputs differentially, the LTC2356-14's 80dB common mode rejection ratio allows users to eliminate ground loops and common mode noise. When the ADC is not converting, power dissipation can be reduced to 4mW in nap mode, with the internal 2.5V reference remaining active, and 13µW with all analog circuitry powered down in sleep mode.

For applications requiring a unipolar measurement, the LTC2355-14 measures 0V to 2.5V input signals, but is otherwise identical to the LTC2356-14. For lower resolution applications, the LTC2356-12 and LTC2355-12 are pin- and software-compatible 12-bit versions of the LTC2356-14 and LTC2355-14.

The LTC2355-14/LTC2356-14/LTC2355-12/LTC2356-12 ADCs are pin- and software-compatible with the LTC1403 2.8Msps ADC family, allowing users to easily upgrade their design for a 25% faster sample rate. Table 2 details these fast single-channel unipolar and bipolar ADCs.

Summary

With PCB real estate getting tighter and designers always searching for lower power ICs, fast data acquisition can be a challenge. Linear Technology's families of simultaneous sampling ADCs and fast single-channel ADCs make it possible to optimize solution size, power and cost. The pin- and software-compatible families of 6-channel, 2-channel and single-channel ADCs offer flexibility to upgrade from 12-bit resolution to 14-bit resolution. Whatever your motor control, power monitoring, or data acquisition system requires, Linear Technology has a fast SAR ADC to do the job.