

Two Monolithic DC/DC Converters Take 3.6V–15V Inputs Down to 0.6V at High Frequency, Shrinking Battery-Powered Applications in Everything from Handhelds to Automobiles

Mylien Tran and Theo Phillips

When a relatively high voltage rail (12V) must be stepped down to a relatively low level (3.3V, 1.8V), the traditional go-to converter is a DC/DC switching controller that drives external MOSFETs. In many applications, replacing the typical controller-MOSFET-diode combo with a monolithic regulator would save space, design time and cost. The problem is that 12V rails are too high for many monolithic buck converters, which usually cannot be used with inputs above 6V. Additionally, switching losses typically prevent practical operation above ~1MHz, precluding the use of the smallest possible inductors, and in the end, negating some size advantages of a monolithic regulator.

The LTC3601 and LTC3604 are high performance monolithic synchronous step-down regulators capable of supplying up to 1.5A and 2.5A, respectively. They operate from a wide input voltage range of 3.6V to 15V—a range encompassing battery chemistries found in handheld devices, PCs, and automobiles. Their unique constant frequency/controlled on time architecture has a minimum on-time of 20ns, ideal for high step-down ratio applications that demand high switching frequencies and fast transient response while maintaining high efficiency.

DEFAULT CONFIGURATION WITH MINIMAL COMPONENTS

To reduce external component count, cost, and design time, switching frequency and loop compensation may be set with simple pin configurations. Figure 1 shows a typical application. To enable 2MHz operation, the oscillator frequency program pin (RT) is tied to the internal 3.3V regulator output pin (INTVCC). Default compensation is applied when the compensation pin (ITH) is tied to INTVCC, producing a clean load transient response (Figure 2).

Operating frequency is programmable from 800kHz to 4MHz with an external resistor from RT to ground. For switching-noise-sensitive applications, the LTC3601 and LTC3604 can be externally synchronized over the same frequency range regardless of the state of RT. No external PLL components are required for syncing.

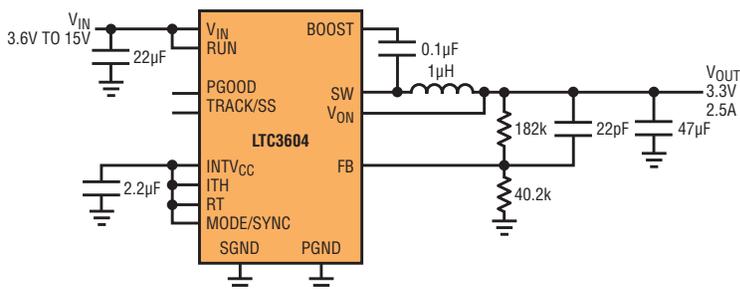
Some applications call for shifting the switching frequency during operation, usually to avoid interference with adjacent radio receivers. Figure 3 shows that the deviation in output voltage is minimal even when the sync frequency introduced at MODE/SYNC is changing rapidly.

Both ICs feature optional Burst Mode® operation for superior efficiency at low load currents (Figure 4), or alternatively,

forced continuous mode, which gives up light load efficiency for minimal output ripple and constant frequency operation. Even so, Burst Mode operation ripple is typically only 20mV.

The built-in internal 400µs soft-start timer prevents current surges at V_{IN} during start-up. Longer soft-start times can be implemented by ramping the TRACK pin or connecting a capacitor from TRACK pin to ground ($t_{SS} = 430,000 \times C_{TRACK/SS}$). An open drain PGOOD pin monitors the output and pulls low if the output voltage is $\pm 8\%$ from the regulation point. The additional V_{IN} overvoltage and short-circuit protection make for an all-around robust IC.

Figure 1. A wide input range to 3.3V, 2.5A application



The LTC3601 and LTC3604 employ a unique constant frequency/controlled on time architecture with a minimum on-time of 20ns—ideal for high step-down ratio applications that demand high switching frequencies and fast transient response.

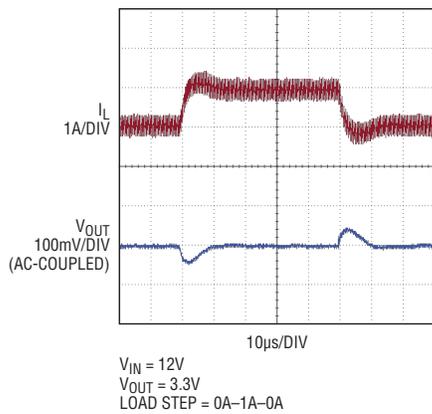


Figure 2. Fast transient response of the circuit in Figure 1

HIGH FREQUENCY, LOW DUTY CYCLE, NO PROBLEM

Many microprocessors require low voltage 1.x volt rails, but they also reside in applications that demand high switching frequencies to keep passive components small and avoid RF interference with critical frequency bands. The problem is that achieving the magic combination of high a step-down ratio and high switching frequency can be elusive, because it requires such a short minimum on-time. Figure 5 shows the schematic for the LTC3604 in a 4 MHz, 12V–1.8V application. The 38ns

Figure 5. The LTC3604 can operate at high frequency (4 MHz) and low duty cycle, allowing high step-down ratios from a compact footprint

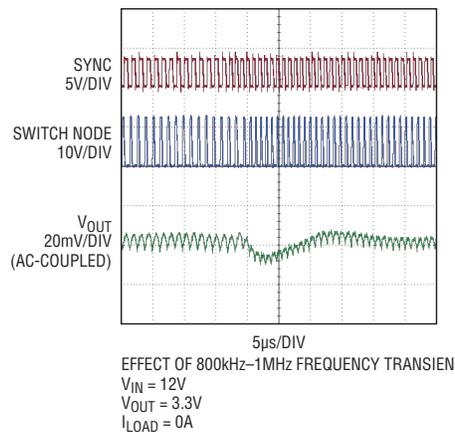
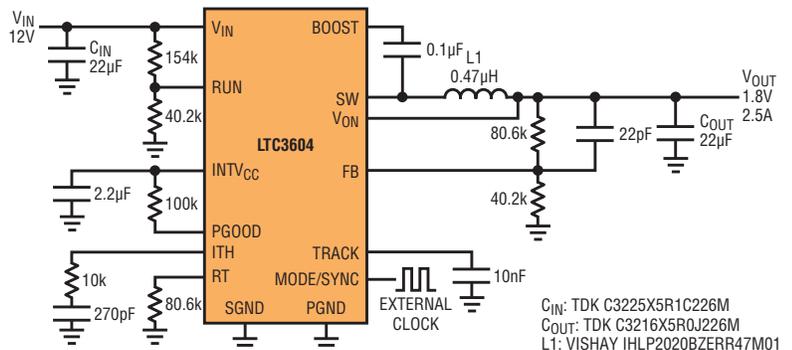


Figure 3. The synchronized switching frequency can be shifted on the fly, with little change in V_{OUT} .

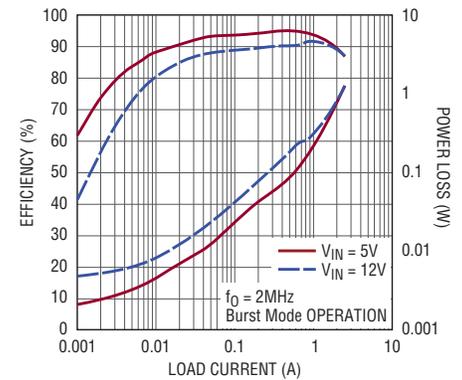


Figure 4. Burst Mode operation yields high efficiency at light loads, and low $R_{DS(ON)}$ switches maintain high efficiency at maximum load.

on-time required for this application is well above the LTC3604's 20ns minimum.

The design in Figure 5 takes advantage of a number of the LTC3604's features. Normally the minimum input voltage is 3.6V, but here the undervoltage lock-out is raised to 6V by adding a resistive divider from V_{IN} to RUN. Soft-start time is increased to 4.3ms by adding 10nF capacitance from TRACK to ground. The switching frequency is synchronized to 4MHz from an external source. If that source should fail, the internal

oscillator (also set at 4MHz) will take over. Finally, loop compensation is external.

CONCLUSION

The LTC3601 and LTC3604 are part of a new generation of monolithic DC/DC converters capable of handling relatively high input voltages and lower duty cycles. Their compact size, high performance, and minimal components design make them ideal for compact applications. Both ICs are offered in compact, thermally enhanced 3mm × 3mm QFN and MSOP packages. ■