

Multiple Power Sources No Problem for 1A, Low Noise Buck-Boost Converter with 1.8V–5.5V Input Voltage Range

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Users expect their portable devices to operate from a range of power sources including USB, wall adapters and various types of batteries — alkaline, lithium-ion and LiFePO₄. The LTC[®]3536 monolithic synchronous buck-boost converter easily accommodates a variety of power sources by efficiently operating in both buck and boost modes from an input voltage range of 1.8V to 5.5V. No complicated topology is required to accommodate power source inputs above, below or equal to the output.

The LTC3536 utilizes a proprietary switching algorithm that provides seamless transitions between buck and boost modes while simultaneously optimizing efficiency and minimizing noise over all operating conditions. This advanced control algorithm uses only a single inductor, which greatly simplifies the power supply design and minimizes the total PCB footprint. As a result, the LTC3536 easily fits lithium-ion/polymer, 2-3 cell alkaline/NiMH and lithium phosphate battery applications, which often require a supply voltage that is somewhere in the middle of the battery voltage range. In such cases, the high efficiency and extended input operating range of the LTC3536 offer greatly improved battery run time and design versatility.

DESIGN VERSATILITY

At 3.3V output, a load current of up to 1A can be supported over the entire lithium-ion input voltage range; 300mA of load current is supported when the input is 1.8V. The 1% accurate output voltage is programmable from 1.8V to 5.5V via an external resistor divider.

The switching frequency of the LTC3536 is user programmable from 300kHz to 2MHz via a single external resistor, allowing the converter to be optimized to meet the space and efficiency requirements of each

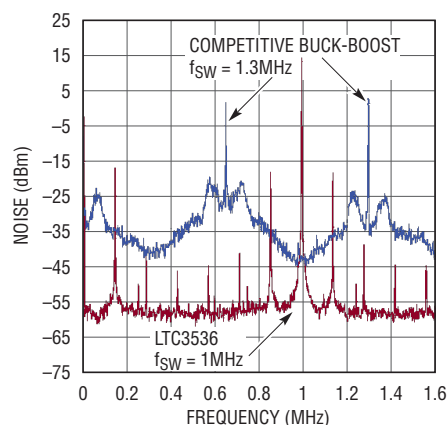


Figure 1. Worst-case spectral comparison of the LTC3536 and typical competitor's part. Note the much lower noise floor exhibited by the LTC3536 and its lower integrated subharmonic noise.

particular application. The default frequency is set to 1.2MHz by tying the RT pin to V_{IN}. The switching frequency can also be synchronized to an external clock applied to the MODE/SYNC pin. In case of synchronization, the free running frequency of the oscillator can be programmed slower or faster than the external clock frequency.

External resistors and capacitors provide compensation of the feedback loop, enabling the frequency response to be adjusted to suit a wide array of external components. This flexibility allows for rapid output voltage

transient response regardless of inductor value and output capacitor size.

Depending on the application requirements, a designer can prioritize light load efficiency or minimize supply noise by choosing from two operating modes: Burst Mode[®] operation and PWM operation, which can be enabled via a dedicated pin.

Burst Mode operation is an efficient solution for low current conditions. It reduces the amount of switching to the minimum level required to support the load, thereby minimizing the power supply switching losses. Sometimes noise suppression is of higher importance and PWM operation, though not as efficient as Burst Mode operation at light loads, maintains a steady frequency, making it easier to reduce noise and RF interference. The output current capability in Burst Mode operation is lower than in PWM mode. Therefore, higher load current applications require that the MODE/SYNC pin be driven externally to enter PWM mode operation.

The LTC3536 includes robust V_{OUT} short circuit protection. If V_{OUT} is shorted to ground, the inductor current decays very slowly during a single switching cycle. During a short-circuit condition, the LTC3536 reduces its peak current limit

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to a safe level and forces the device to enter PWM mode, guaranteeing a smooth recovery when the output short is released.

NOISE PERFORMANCE

Many applications are sensitive to noise generated by switching converters. The LTC3536 uses a low noise switching architecture to reduce unwanted subharmonic frequencies. Subharmonic noise or jitter is difficult to filter and can interfere with other sensitive circuitry, and is most prominent when V_{IN} and V_{OUT} are approximately equal. Some buck-boost converters operating in this region produce pulse-width and frequency jitter. The LTC3536 employs Linear Technology's latest generation buck-boost PWM modulation circuitry, which dramatically minimizes jitter, satisfying the demanding requirements of noise-sensitive RF applications.

Figure 1 shows worst-case spectral comparisons of the LTC3536 (switching frequency 1MHz) and a competitive buck-boost converter (switching frequency 1.3MHz) that does not feature the low noise architecture of the LTC3536.

The worst-case condition is achieved by placing a fixed 1A load on the output and slowly increasing or decreasing the input voltage until the highest harmonic content in the converter spectrum was observed.

The LTC3536 exhibits the expected single large magnitude tone at its switching frequency of 1MHz, but note that the total integrated noise is very low when compared to the competition.

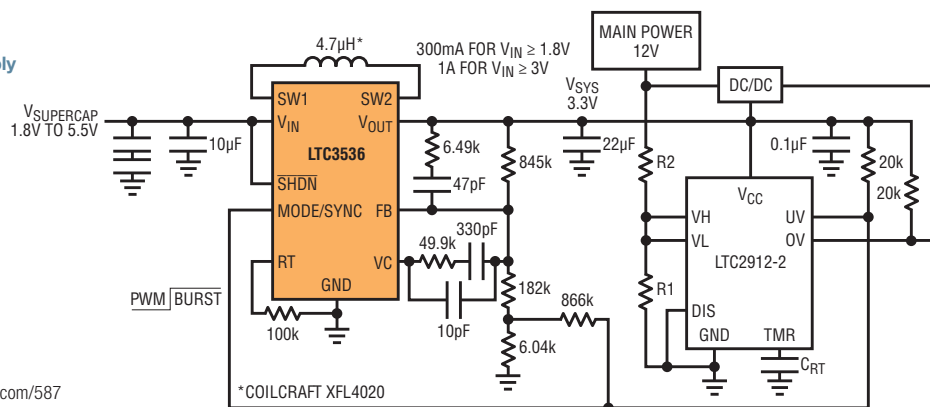
Remember, this test is specifically designed to produce absolute worst-case subharmonic peaks for the LTC3536—if the input voltage is slightly higher or lower, the magnitudes of the subharmonics are much smaller. In contrast, in the competing buck-boost, there is less reduction in subharmonic content over a much wider input voltage range. Also, it exhibits a much higher noise floor than the LTC3536, indicative of significant pulse-width jitter and potential noise interference issues.

SUPERCAPACITOR BACKUP POWER

The LTC3536 includes a soft-start circuit to minimize the inrush current transient during power-up. If at start-up the output voltage is already pre-charged, the internal soft-start is skipped and the LTC3536 immediately enters the mode of operation that has been set on the MODE pin. If the MODE pin is tied high and Burst Mode operation is selected, the output voltage is regulated smoothly to the target voltage value without discharging the output.

This feature makes the LTC3536 ideal for supercapacitor-powered backup power supply systems, as shown in Figure 2. In this application, two series of supercapacitors are charged to 5V during normal operation to provide the needed backup energy in case the primary power fails. As long as the primary power is present, the LTC3536 remains in Burst Mode operation with very low quiescent current, minimizing drain on the backup storage capacitor. The MODE pin is used to change from Burst Mode to PWM mode operation when primary power is interrupted.

Figure 2. Supercapacitor-based backup power supply



The LTC3536 maintains an accurate output voltage with input voltages above or below the output. Its programmable switching frequency and internal low $R_{DS(ON)}$ power switches, in combination with low noise architecture, enable the LTC3536 to offer high performance, compact and highly efficient solutions.

Figure 3. Solar panel application

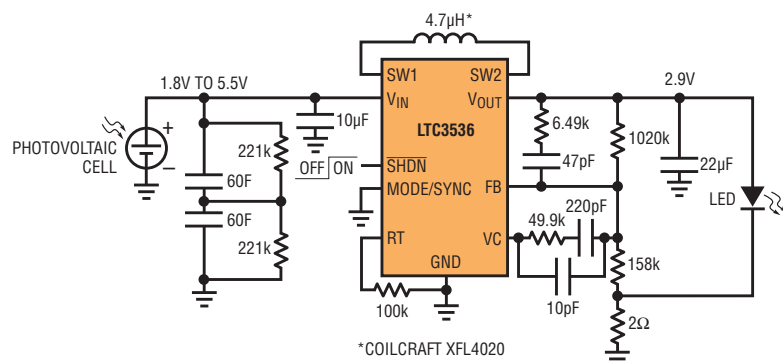
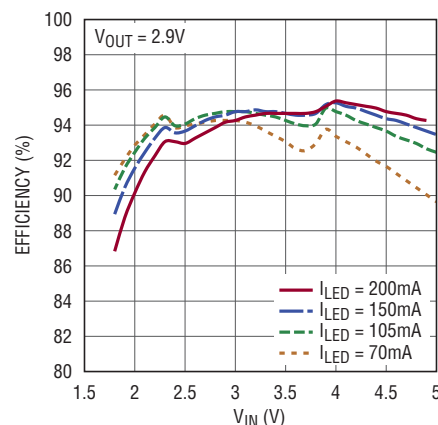


Figure 4. Efficiency of the solar panel application in Figure 3



LTC3536 in backup mode can provide a regulated 3.3V at a constant 1A load for input voltages higher than 3V, and it can operate down to V_{IN} at 1.8V at a constant 300mA, while maintaining V_{OUT} at 3.3V. By covering the voltage range of the supercapacitor, the supply maximizes operating time, allowing systems enough time to recover or perform housekeeping tasks before shutting down.

SOLAR-POWERED LED DRIVER

The power generated by a solar cell varies significantly with lighting conditions. So a rechargeable storage device, such as a supercapacitor, is required to provide continuous power when the solar cell is insufficiently illuminated. Although it has much less charge storage capacity compared to a battery, a supercapacitor requires significantly less maintenance,

is easy to charge and its cycle lifetime is orders of magnitude longer than a battery.

The storage device can be combined with the LTC3536 buck-boost DC/DC converter, which is designed to simplify the task of harvesting and managing energy from low input voltage such as photovoltaic cells. LTC3536 can work down to input voltages as low as 1.8V, and provides very high efficiency over a wide range of input voltages above or below the output voltage.

Figure 3 shows an application for an LED driver supplied with a solar cell for an emergency LED torch. When the torch is off, the LTC3536 is in shutdown. The quiescent current of less than 1μA minimizes supercapacitor drain when the ambient light is no longer available.

When the LED torch is switched on, the LTC3536 is turned on via the \overline{SHDN} pin to supply 105mA constant load current to the LED. Figure 4 shows the high efficiency of this supply, enabling a slow discharge of the two series 60F capacitors down to 1.8V. The LTC3536 regulates the output and the LED current, guaranteeing light for 14 minutes if the supercap is charged up to 5V. It is possible to extend this time by increasing the supercap value or using a battery with an adequate charge control.

CONCLUSION

The LTC3536 maintains an accurate output voltage with input voltages above or below the output. Its programmable switching frequency and internal low $R_{DS(ON)}$ power switches, in combination with low noise architecture, enable the LTC3536 to offer high performance, compact and highly efficient solutions. ■