

DESIGN NOTES

A New, High Efficiency Monolithic Buck Converter

Design Note 105

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The LTC[®]1265 is a 14-pin SOIC step-down converter capable of operating at frequencies up to 700kHz. High frequency operation permits the use of small inductors for size sensitive applications. The LTC1265 has an internal 0.3Ω (at a supply voltage of 10V) P-channel power MOSFET switch, which is capable of supplying up to 1.2A of output current. With no load, the converter requires only 160μA of quiescent current; this decreases to a mere 5μA in shutdown conditions. In dropout mode, the internal P-channel power MOSFET switch is turned on continuously (at DC), thereby maximizing battery life. The part is protected from output shorts by its built-in current limiting. In addition to the features already mentioned, the LTC1265 incorporates a low-battery detector.

The LTC1265 is a current mode DC/DC converter with Burst Mode[®] operation. The current mode architecture gives the LTC1265 excellent load and line regulation. Burst Mode operation results in high efficiency with both high and low load currents. The LTC1265 comes in three versions: LTC1265-5 (5V output), LTC1265-3.3 (3.3V output) and LTC1265 (adjustable). All versions operate down to an input voltage of 3.5V and up to an absolute maximum of 13V.

Efficiency

Figure 1 shows a typical LTC1265-5 application circuit. The efficiency curves for two different input voltages are shown in Figure 2. Note that the efficiency for a 6V input exceeds 90% over a load range from less than 10mA to 850mA. This makes the LTC1265 attractive for all battery-operated products and efficiency sensitive applications.

High Frequency Operation

Although the LTC1265 is capable of operation at frequencies up to 700kHz, the highest efficiency is achieved at an operating frequency of about 200kHz. As the frequency increases, losses due to the gate charge of the P-channel power MOSFET increase. In space sensitive applications, high frequency operation allows the use of smaller components at the cost of four to five efficiency points.

Constant Off-Time Architecture

The LTC1265 uses a constant off-time, current mode architecture. This results in a power supply that has very high efficiency over a wide load current range, fast

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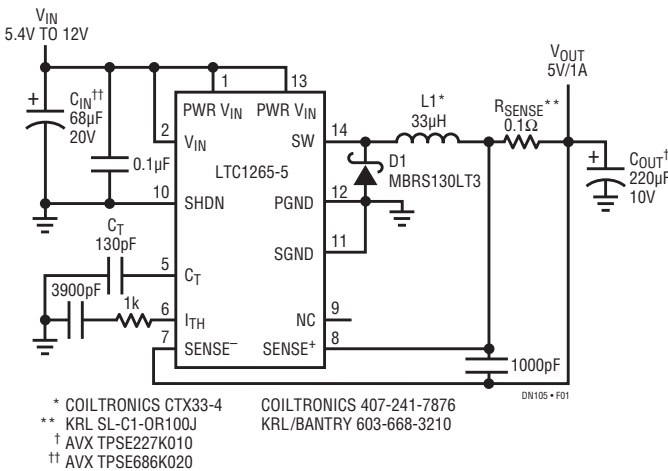


Figure 1. High Efficiency 5V/1A Step-Down Converter

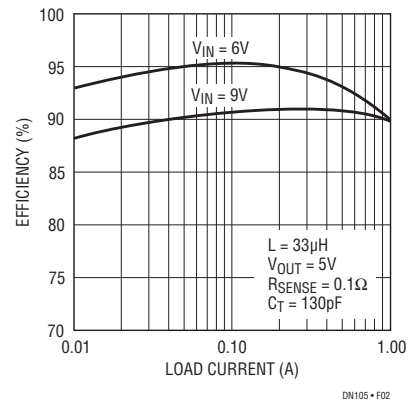


Figure 2. Efficiency vs Load Current

transient response and very low dropout characteristics. The off-time is set by an external timing capacitor C_T and is constant whenever the output is in regulation. When the output is not in regulation, the off-time is inversely proportional to the output voltage. By using a constant off-time scheme, the inductor's ripple current is predictable and well controlled under all operating conditions, making the selection of the inductor much easier. The inductor's peak-to-peak ripple current is inversely proportional to the inductance in continuous mode. If a lower ripple current is desired, a larger inductor can be used for a given value of timing capacitor.

100% Duty Cycle in Dropout Mode

When the input voltage decreases, the switching frequency decreases. With the off-time constant, the on-time is increased to maintain the same peak-to-peak ripple current in the inductor. When the input-to-output voltage differential drops below 2.0V, the off-time is reduced. This prevents the operating frequency from dropping below 20kHz as the regulator approaches the dropout region. As the input voltage drops further, the P-channel switch is turned on for 100% of the cycle. The dropout voltage is governed by the switch resistance, load current and current sense resistor.

Good Start-Up and Transient Behavior

The LTC1265 exhibits excellent start-up behavior when it is initially powered on or recovering from a short circuit. This is achieved by making the off-time inversely

proportional to the output voltage while the output is still in the process of reaching its regulated value. When the output is shorted to ground, the off-time is extended long enough to prevent inductor current runaway. When the short is removed, the output capacitor begins to charge and the off-time gradually decreases.

In addition, the LTC1265 has excellent load transient response. When the load current drops suddenly, the feedback loop responds quickly by turning off the internal P-channel switch. Sudden increases in output current will be met initially by the output capacitor, causing the output voltage to drop slightly. Tight control of the inductor's current, as mentioned above, means that output voltage overshoot and undershoot are virtually eliminated.

2.5mm Typical Height 5V-to-3.3V Regulator

Figure 3 shows the schematic for a very thin 5V-to-3.3V converter. For the LTC1265 to be able to source 500mA output current and yet meet the height requirement, a small value inductor must be used. The circuit operates at a high frequency (typically 500kHz), increasing the gate charge losses.

Conclusion

The LTC1265, with its low dropout and high efficiency, is ideal for battery-operated products and efficiency sensitive applications. In addition, its ability to operate at high frequencies allows the use of small inductors for size sensitive applications.

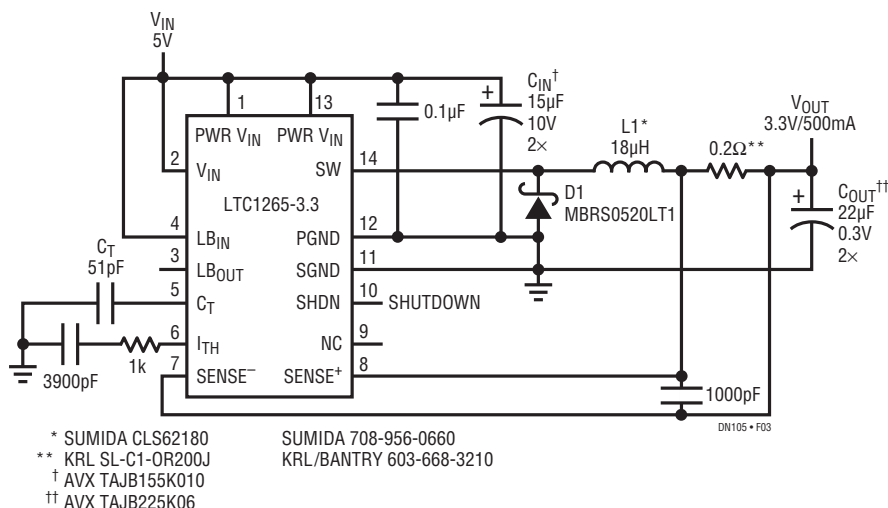


Figure 3. 2.5mm High 5V-to-3.3V Converter (500mA Output Current)

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