

# DESIGN NOTES

## Tiny Versatile Buck Regulators Operate from 3.6V to 36V Input

Design Note 367

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### Introduction

Linear Technology offers two new buck regulators that operate from a wide input voltage range (3.6V to 36V) and take so little space that they easily solve many difficult power supply problems. The LT<sup>®</sup>1936 and LT1933 are perfect for applications with disparate power inputs or wide range input power supplies such as automotive batteries, 24V industrial supplies, 5V logic supplies and various wall adapters. Both parts are monolithic current mode PWM regulators which provide excellent line and load regulation and dynamic response. They operate at a 500kHz switching frequency, enabling the use of small, low cost inductors and ceramic capacitors, resulting in low, predictable output ripple.

### Small Size and Versatility

The LT1936 regulator includes a 1.9A power switch in a tiny, thermally enhanced 8-lead MSOP. The LT1933 regulator includes an internal 0.75A power switch in a tiny 6-lead ThinSOT<sup>™</sup> package, which occupies less than 0.15in<sup>2</sup> board space. The LT1936 offers the option of external compensation for design flexibility or internal compensation for compact solution size. Both parts offer soft-start via the SHDN pin, thus reducing maximum inrush currents during start-up. Both parts also have a very low, 2 $\mu$ A shutdown current which significantly extends battery life in applications that spend long periods of time in sleep or shutdown mode. During

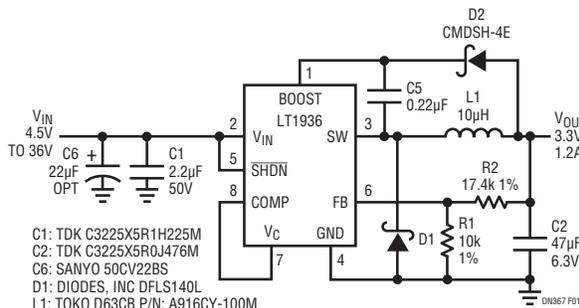
short circuit, both parts offer frequency foldback, where the switching frequency decreases by about a factor of ten. The lower frequency allows the inductor current to safely discharge, thereby preventing current runaway.

### LT1936 Produces 3.3V at 1.2A from 4.5V to 36V

Figure 1 shows a typical application for the LT1936. This circuit generates 3.3V at 1.2A from an input of 4.5V to 36V. With the same input voltage range, the LT1933 circuit can supply 500mA. The typical output voltage ripple of the Figure 1 circuit is less than 16mV while efficiency is as high as 89%. Excellent transient response is possible with either external compensation or the internal compensation; this circuit uses internal compensation to minimize component count. A high ESR electrolytic capacitor, C6 in Figure 1, is recommended to damp overshoot voltage in applications where the circuit is plugged into a live input source through long leads. For more information, refer to the LT1933 or LT1936 data sheet.

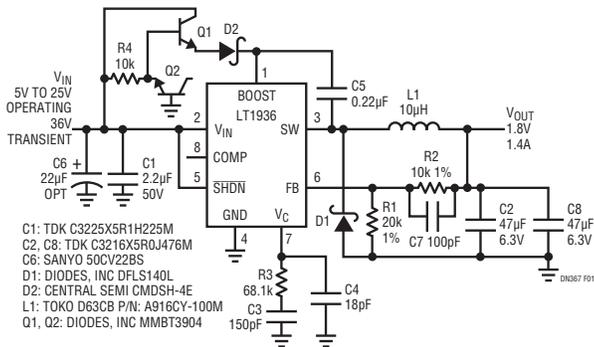
### Producing a Lower Output Voltage from the LT1936

In order to fully saturate the internal NPN power transistor of the LT1936, the BOOST pin voltage must be at least 2.3V above the SW pin voltage. A charge pump comprising D2 and C5 creates this headroom in Figure 1. Nevertheless, when the output voltage is less than 2.5V, different approaches are needed. Figure 2 shows one example. It allows  $V_{IN}$  to go up to 36V and generates 1.4A at 1.8V. In this circuit, Q2 serves as an inexpensive Zener. The emitter-base breakdown voltage of Q2 gives a stable 6V reference. The charging current for the BOOST capacitor, C5, passes through the follower, Q1. R4, Q1 and Q2 limit the BOOST pin voltage below its maximum rating of 43V. If the maximum  $V_{IN}$  in an application is less than 20V, simply tie  $V_{IN}$  to D2 to allow a lower minimum input voltage.



**Figure 1. Typical Application of LT1936 Accepts 4.5V to 36V and Produces 3.3V/1.2A**

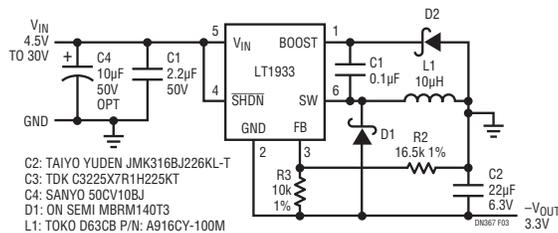
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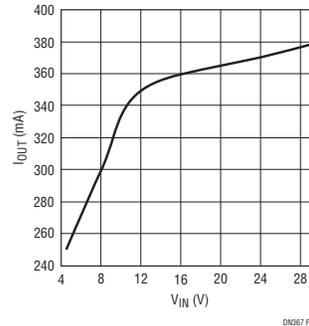
**Figure 2. This Circuit Generates Lower Output Voltage While Allowing Maximum Input Up to 36V**

### Negative Output from a Buck Regulator

The circuit shown in Figure 3 can generate a negative voltage of  $-3.3V$  from a buck regulator such as the LT1933. This circuit effectively sets the ground reference of the LT1933 to  $-3.3V$ . The average inductor current of this circuit is the summation of the input and output current. The available output current is a function of the input voltage as shown in Figure 4.



**Figure 3. This Circuit Produces  $-3.3V$  from 4.5V to 30V**



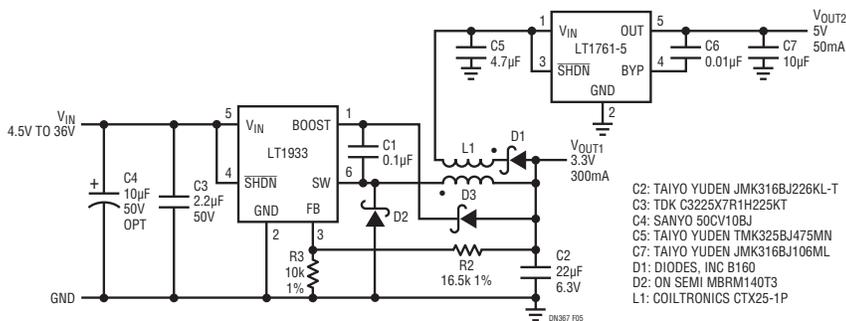
**Figure 4. Maximum Output Current of the Circuit in Figure 3 as a Function of the Input Voltage**

### Tiny Circuit Generates 3.3V and 5V from a Minimum 4.5V Supply

The circuit in Figure 5 is capable of generating two output voltages from a minimum 4.5V supply. One output is 3.3V at 300mA, the other 5V at 50mA. The circuit is especially useful in automotive cold crank conditions when the battery voltage drops below 5V but both the 3.3V and 5V outputs need to be alive. If more current is needed, the circuit can also be implemented using the LT1936. Even though the input of the LT1761-5 is unregulated, the 5V output is regulated by the LT1761-5 LDO. To maintain regulation, the 3.3V output current should be always well above the 5V output current, especially when  $V_{IN}$  is low.

### Conclusion

The LT1933 and LT1936 step-down switching regulators accept a wide variety of input sources as well as offer compact, efficient and versatile solutions to many otherwise hard-to-solve problems.



**Figure 5. From a Minimum 4.5V, This Circuit Produces Two Outputs at 3.3V/300mA and 5V/50mA**

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