

## 1.5A Rail-to-Rail Output Synchronous Step-Down Regulator Adjusts with a Single Resistor

Design Note DN506

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### Introduction

A new regulator architecture the LTC3600 (first introduced with the LT3080 linear regulator) has wider output range and better regulation than traditional regulators. Using a precision 50 $\mu$ A current source and a voltage follower, the output is adjustable from “0V” to close to  $V_{IN}$ . Normally, the lowest output voltage is limited to the reference voltage. However, this new regulator has a constant loop gain independent of the output voltage giving excellent regulation at any output and allowing multiple regulators to be paralleled for higher output currents.

### Operation

The LTC3600 is a current mode monolithic step-down buck regulator with excellent line and load transient responses. The 200kHz to 4MHz operating frequency can be set by a resistor or synchronized to an external clock. The LTC3600 internally generates an accurate 50 $\mu$ A current source, allowing the use of a single external

resistor to program the reference voltage from 0V to 0.5V below  $V_{IN}$ . As shown in Figure 1, the output feeds directly back to the error amplifier with unity gain. The output equals the reference voltage at the  $I_{SET}$  pin. A capacitor can be paralleled with  $R_{SET}$  for soft start or to improve noise while an external voltage applied to the  $I_{SET}$  pin is tracked by the output.

Internal loop compensation stabilizes the output voltage in most applications, though the design can be customized with external RC components. The device also features a power good output, adjustable soft-start or voltage tracking and selectable continuous/discontinuous mode operation. These features, combined with less than 1 $\mu$ A supply current in shutdown,  $V_{IN}$  overvoltage protection and output overcurrent protection, make this regulator suitable for a wide range of power applications.

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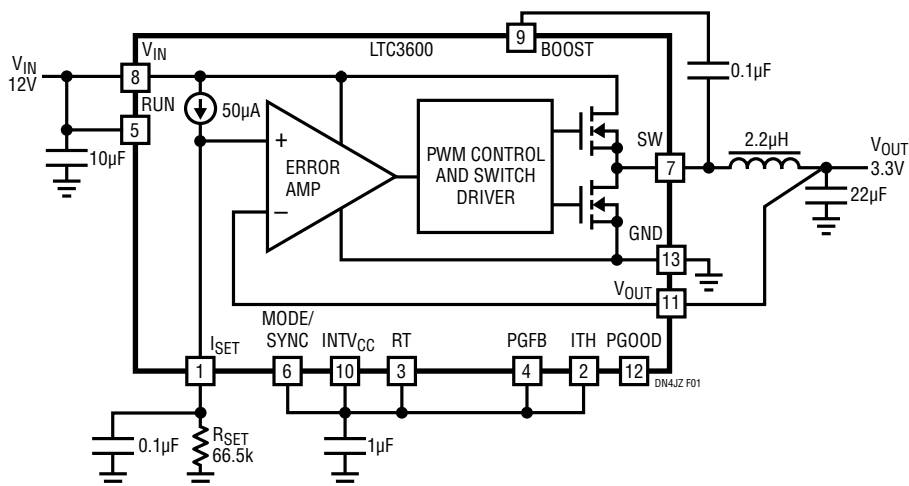
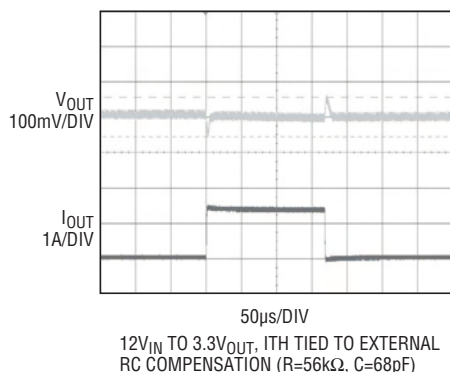
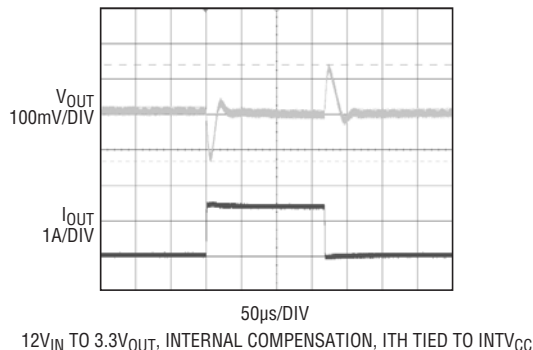


Figure 1. High Efficiency, 12V to 3.3V 1MHz Step-Down Regulator with Programmable Reference

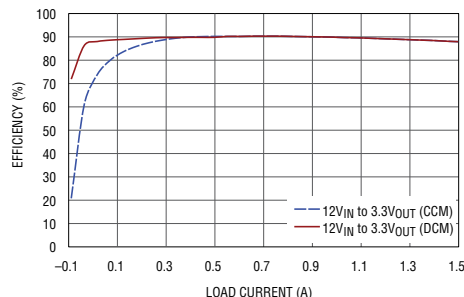
## Applications

Figure 1 shows the complete LTC3600 schematic in a typical application that generates a 3.3V output voltage from 12V input. Figure 2 shows the load step transient



**Figure 2. 0A to 1.5A Load Step Response of the Figure 1 Schematic**

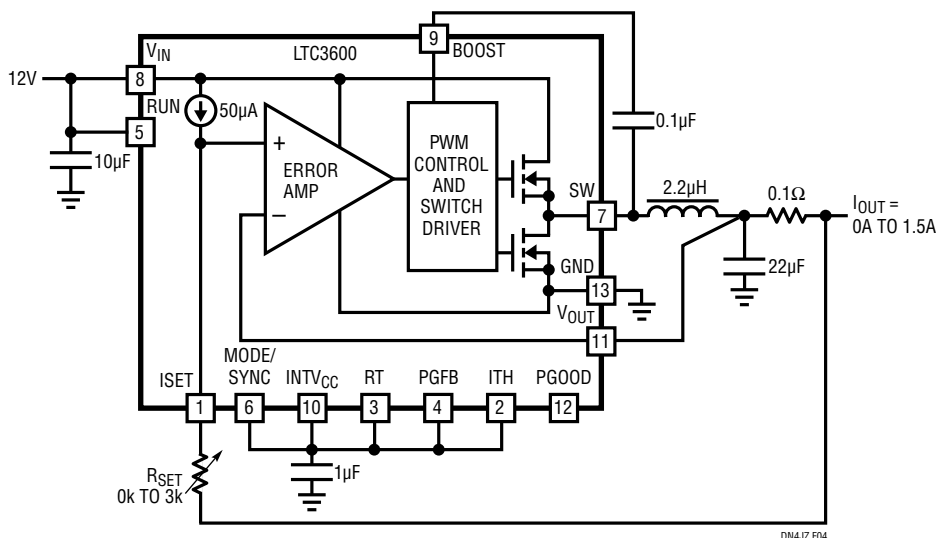
response using internal compensation and with external compensation. Figure 3 shows the efficiency in CCM and DCM modes. Furthermore, the LTC3600 can be easily configured to be a current source, as shown in Figure 4. By changing the  $R_{SET}$  resistance from  $0\Omega$  to  $3k\Omega$ , the output current can be programmed from 0A to 1.5A.



**Figure 3. Efficiency of 12V Input to 3.3V Output Regulator in CCM and DCM Mode**

## Conclusion

The LTC3600 uses an accurate internal current source to generate a programmable reference, expanding the range of output voltages. This unique feature gives the LTC3600 great flexibility, making it possible to dynamically change the output voltage, generate current sources, and parallel regulators for applications that would be difficult to implement using a standard DC/DC regulator configuration.



**Figure 4. The LTC3600 as a Programmable 0A to 1.5A Current Source**

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