LINEAR TECHNOLOGY

DESIGN NOTES

Negative Buck Converter with Short-Circuit Protection and Shutdown

Design Note 1022

Victor Khasiev

Introduction

Negative buck converters are increasingly used to "step down" (by absolute value) negative voltages. The main reason behind the increasing demand is the standardization of switching transformers, which are typically produced with one or two secondary windings. For example, if a system employs a transformer with two secondary windings to produce ±12V, and the design also requires –3.3V, engineers tend to lean toward solutions, such as a negative buck, that don't require changing the main transformer.

Circuit Description and Performance

Figure 1 shows a negative buck converter that generates –3.3V at 3A from a –12V rail. The power train includes inductor L1, diode D1 and MOSFET Q1. The LTC3805-5 controller IC includes a complete set of essential functions including short-circuit protection (the current level can be precisely set), converter enable/disable, and programmable switching frequency. An internal shunt regulator allows biasing the IC directly from the input rail. Despite the simplicity of the topology, which makes it an attractive choice for many designers, there are two important design considerations in a negative buck converter: sensing the output voltage and remote shutdown. The controller is referenced to the negative voltage, yet the output voltage and ON/OFF signal are referenced to the system ground (see Figure 1).

To close the regulation loop, a current mirror based on transistor Q3 is used. Resistor RPRG programs the current flowing into resistor RFB, which sets the output voltage. In this example, when the output voltage is equal to –3.3V, the 3.31k RPRG resistor sets the current into resistor RFB at 1mA. This current creates a 0.8V drop across resistor RFB, which is equal to the reference voltage of the internal error amplifier.

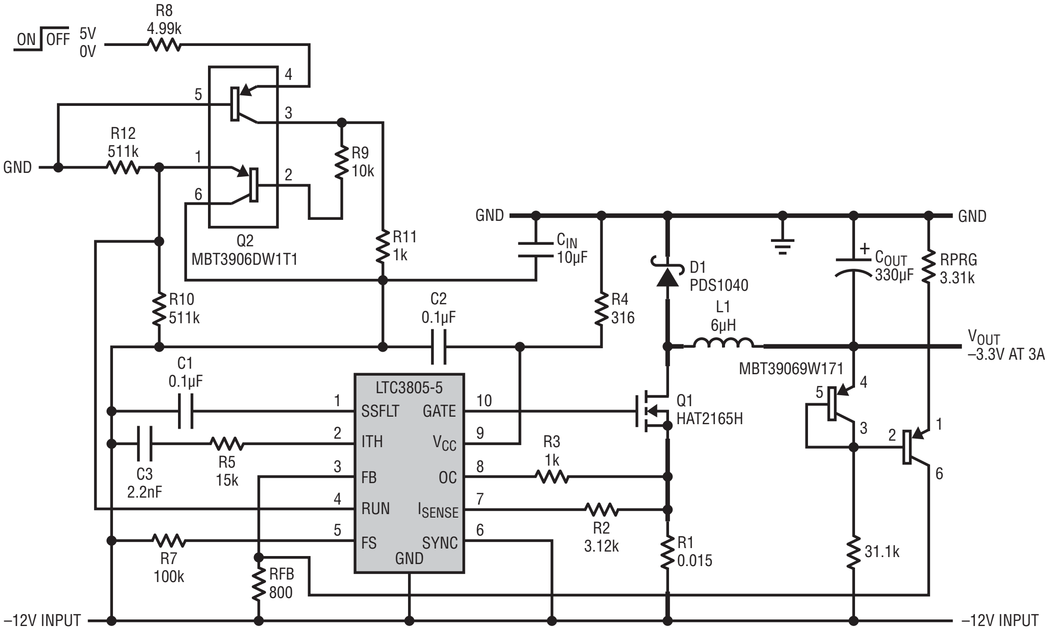

Figure 1. A Negative Buck Converter Based on the LTC3805 Produces –3.3V at 3A from a –10V to –14V Input

---

The optional shut-down circuit is based on transistor Q2. If 5V is applied to resistor R8, the LTC3805-5 shuts down. Both circuits are referenced to the system ground. The voltage stress on the power train components, transfer function and other parameters are similar to the well-known buck converter.

The efficiency is about 90%, as shown Figure 2. The load characteristic is shown in Figure 3. At loads exceeding 4.5A, the output voltage begins to drop and at 5.0A the converter enters into a short-circuit protection state. In this state, the input current does not exceed 20mA. The output voltage recovers after the short circuit is removed. Line and load regulation are better than ±1% over a wide –40°C to 70°C temperature range. Waveforms of the start-up and transient response for the circuit in Figure 1 are shown in Figures 4 and 5, respectively.

Conclusion

Negative buck converters are a popular way to produce additional negative rails from a standard –12V rail. The solution shown here produces –3.3V at 3A from a –12V rail with a design that features high efficiency, overcurrent protection, fast transient response and a smooth start-up.

References

Erickson, Robert, W, *Fundamentals of Power Electronics*, 2nd edition, ISBN 0-7923-7270-0

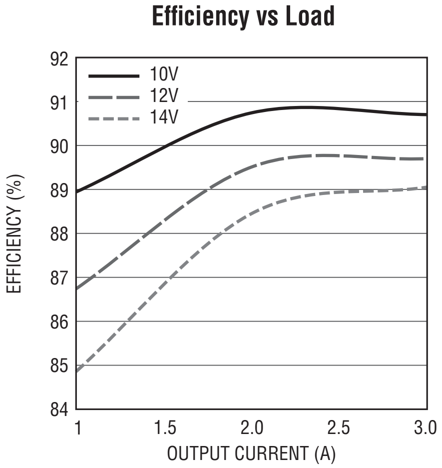

Figure 2. Efficiency vs Input Voltage and Output Current

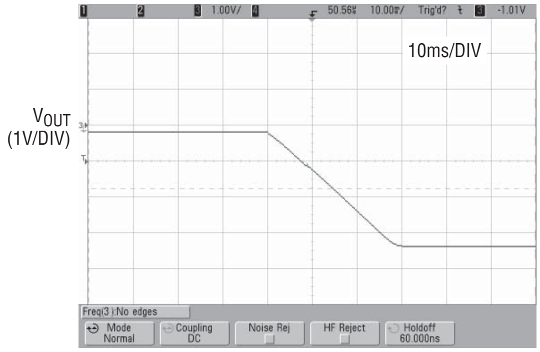

Figure 4. Start-Up into Full Load

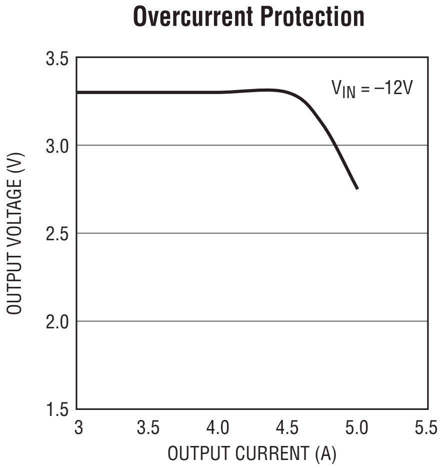

Figure 3. Output Voltage vs Output Current, with a –12V Input Voltage

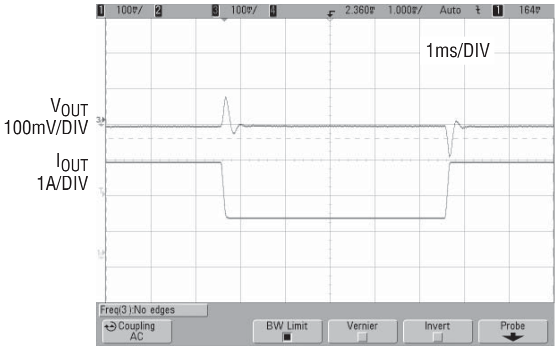

Figure 5. Transient Response for a Load Current Step from 1A to 2.5A

Data Sheet Download

www.linear.com

For applications help,
call (408) 432-1900, Ext. 2134

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 ● FAX: (408) 434-0507 ● www.linear.com

dn1022 LT 0911 • PRINTED IN THE USA