Produce Negative Voltages Using the Buck Controller

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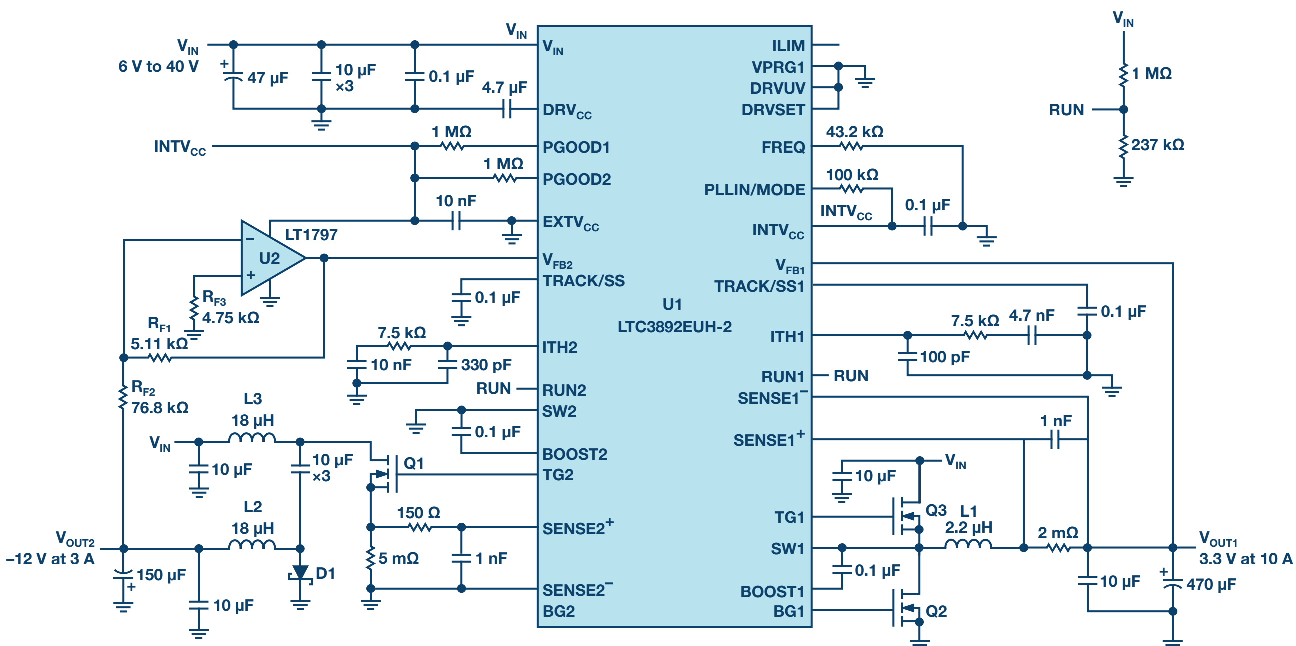
Introduction

Negative voltages are used to power an expanding number of LCD screens in automobile infotainment systems. Likewise, in industrial and railroad environments, negative rails satisfy the needs of instrumentation and monitoring applications. In all cases, the negative voltage rail must be produced from a positive source, but positive-to-negative ICs are not as readily available as buck controllers. Manufacturers are unlikely to have tested and qualified negative output converters, but probably already have a number of approved buck controllers, such as the LTC3892 dual output controller. To avoid the extra time and cost of testing a dedicated negative output converter, the LTC3892 dual output buck controller can be used to produce a negative output voltage with a Ćuk topology.

Dual Output Converter: –12 V at 3 A and 3.3 V at 10 A

The LTC3892 is a dual output controller, where one output can be used for a positive voltage and the other channel for a negative voltage, as shown in Figure 1. The input voltage range of this solution is 6 V to 40 V, with V_{OUT1} equal to 3.3 V at 10 A and V_{OUT2} equal to –12 V at 3 A. V_{OUT1} is configured as a straightforward buck converter topology with power train components Q2, Q3, L1, and the output filter capacitors. No voltage divider is required at the VFB pin (tied directly to the output) to set the output to 3.3 V, as the LTC3892-2 features fixed 3.3 V or 5 V outputs set by the grounding or by tying VPRG1 to $INTV_{CC}$, respectively.



D1: SBR8U60P5
Q1, Q2: BSC028N06LS3
Q3: BSC100N06LS3
L1: 74439369022 Wurth Elektroniks
L2, L3: PG0936.183NL Pulse
All 10 µF: 50 V, 12105C106KAT2A AVX

Figure 1. A solution for generating positive and negative voltages. V_{OUT1} is 3.3 V at 10 A and V_{OUT2} is –12 V at 3 A.

V_{OUT2} is a negative output voltage relative to GND. The op amp U2 (LT1797) is wired as a differential amplifier that is employed to sense the negative voltage and scale it to the 0.8 V reference of the LTC3892 error amplifier (EA). In this approach, both the EA of the LTC3892 and the op amp are referenced to system GND, which simplifies power supply control and functionality. The seed formulas for setting the negative output voltage are:

$$KR = \frac{0.8\ \text{V}}{|V_0|}$$

$$R_{F1} = 5.11\ \text{k}\Omega$$

$$R_{F2} = \frac{R_{F1}}{KR}$$

$$R_{F3} = \frac{R_{F1} \times R_{F2}}{R_{F1} + R_{F2}}$$

The V_{OUT2} employs a nonsynchronous Ćuk topology and includes power train components of Q1, D1, L2, and output filter capacitors. The Ćuk topology is widely covered in other technical literature, so it is not covered at length here. The stress on the power train components can be summed up by:

$$D = \frac{|V_0|}{|V_0| + V_{IN}}$$

$$V_C = \frac{V_{IN}}{1 - D}$$

$$V_{DS} = V_D = V_C$$

$$I_{L2} = \frac{I_0 \times V_0}{V_{IN}} + \Delta I_{L2}$$

$$I_{L3} = I_0 + \Delta I_{L3}$$

A DC2727A demonstration board was used to evaluate this solution, with the V_{OUT2} efficiency shown in Figure 2. This approach is also available in our LTspice® simulation model of the LTC3892-2.

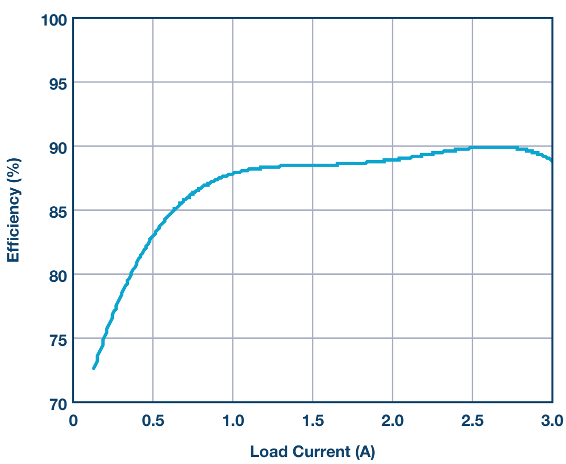


Figure 2. Efficiency for the negative output (V_{OUT2}) at 14 V input.

Conclusion

The LTC3892 is a versatile and flexible controller ostensibly designed for synchronous step-down conversion, but it can be used in a Ćuk topology to generate positive and negative voltages for automotive, industrial, and other applications.

About the Author

Victor Khasiev is a senior applications engineer at Analog Devices. Victor has extensive experience in power electronics both in ac-to-dc and dc-to-dc conversion. He holds two patents and wrote multiple articles. These article relate to use ADI semiconductors in automotive and industrial applications. They cover step-up, step-down, SEPIC, positive-to-negative, negative-to-negative, flyback, and forward converters, as well as bidirectional backup supplies. His patents are about efficient power factor correction solutions and advanced gate drivers. Victor enjoys supporting ADI customers: answering questions about ADI products, design and verification power supplies schematics, layout of the print circuit boards, troubleshooting, and participating in testing final systems. He can be reached at *victor.khasiev@analog.com*.

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