

# DESIGN NOTES

## Single Resistor Sets Positive or Negative Output for DC/DC Converter – Design Note 435

Jesus Rosales

### Introduction

Many electronic subsystems, such as VFD (vacuum fluorescent display), TFT-LCD, GPS or DSL applications, require more than just a simple step-down or step-up DC/DC converter. They may require inverting, noninverting converters or both. Designers usually resort to different regulator ICs to control various polarity outputs, thus increasing the inventory list. The LT<sup>®</sup>3580 solves this problem by controlling either positive or negative outputs using the same feedback configuration. It contains an integrated 2A, 42V switch and packs many popular features such as soft-start, adjustable frequency, synchronization and a wide input range into a small footprint. The LT3580 comes in an 8-pin 3mm × 3mm DFN or MSOP packages and can be used in multiple configurations such as boost, SEPIC, flyback and Cuk topologies.

### Sensing Output Voltage Has Never Been Easier

The LT3580 has a novel FB pin architecture that simplifies the design of inverting and noninverting topologies. Namely, there are two internal error amplifiers; one senses positive outputs and the other negative. Additionally, the LT3580 has integrated the ground side feedback resistor to minimize component count. To illustrate the benefits, notice how the schematics in Figures 1, 3 and 5 need only one feedback resistor.

A single sense resistor simply connects to the FB pin on one side and to the output on the other regardless of the output polarity, eliminating the confusion associated with positive or negative output sensing and simplifying the board layout. A user decides the output polarity he needs, the topology he wants to use and the LT3580 does the rest.

### Adjustable/Synchronizable Switching Frequency

It is often necessary to operate a converter at a particular frequency, especially if the converter is used in an RF communications product that is sensitive to spectral noise in certain frequency bands. Also, if the area available for a converter is limited, operating at higher frequencies allows

the use of tiny component sizes, reducing the real estate required and the output ripple. If power loss is a concern, switching at a lower frequency reduces switching losses, improving efficiency. The switching frequency can be set from 200kHz to 2.5MHz via a single resistor from the RT pin to ground. The device can also be synchronized to an external clock via the SYNC pin.

### Soft-Start and Undervoltage Lockout

To alleviate high inrush current levels during start-up, the LT3580 includes a soft-start feature which controls the ramp rate of the switch current by the use of a capacitor from SS to ground.

The  $\overline{\text{SHDN}}$  pin in the LT3580 serves two purposes. Tying it high or low turns the converter on or off. In situations where the input supply is current limited, has a high source impedance or ramps up/down slowly, the  $\overline{\text{SHDN}}$  pin can be configured to provide undervoltage lockout through a simple resistor divider from  $V_{\text{IN}}$  to ground.

### Boost Converters

A boost converter, shown in Figure 1, produces a positive output voltage always higher than its input. Figure 2 shows the efficiency graph for the boost converter in Figure 1 at a 4.2V input.

LT, LTC and LTM are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

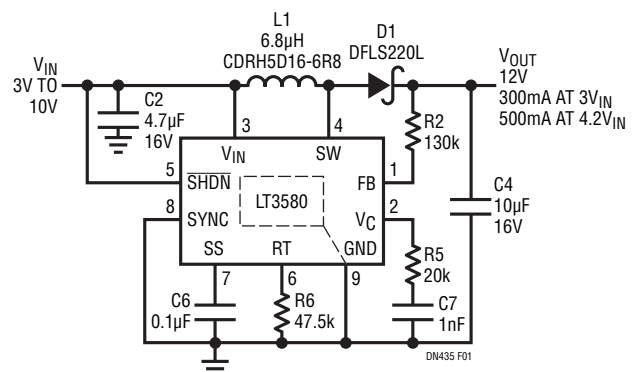


Figure 1. 3V-10V to 12V, 300mA Boost Converter

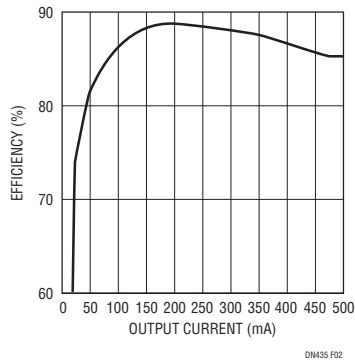


Figure 2. Efficiency for the Figure 1 Converter at  $4.2V_{IN}$

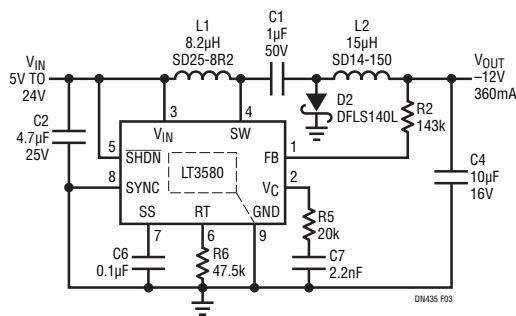


Figure 3. 5V-24V to  $-12V$ , 350mA Cuk Converter

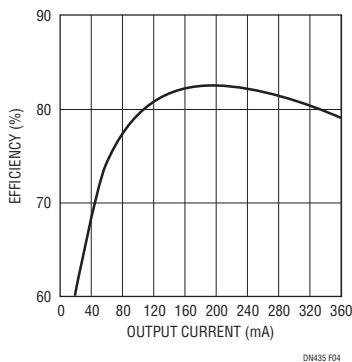


Figure 4. Efficiency for the Figure 3 Converter at  $5V_{IN}$

### Cuk Converter

Figure 3 shows a schematic for a Cuk converter, which produces a negative output with no DC path to the source. The output can be either higher or lower in amplitude than the input. The Cuk converter has output short-circuit protection, which is made more robust by the frequency foldback feature in the LT3580. Figure 4 shows the efficiency graph for the Cuk converter in Figure 3 at a 5V input.

[Data Sheet Download](#)

[www.linear.com](http://www.linear.com)

### SEPIC Converters

Figure 5 shows a SEPIC converter. A SEPIC converter is similar to the Cuk in that it can step up or step down the input; it offers output disconnect and short-circuit protection but produces a positive output. Figure 6 shows the switch waveform of the SEPIC converter during an output short-circuit event. Notice how the switching frequency folds back to one-fourth of the regular frequency as soon as the output voltage is shorted to ground. This feature enhances short-circuit performance for both Cuk and SEPIC converters.

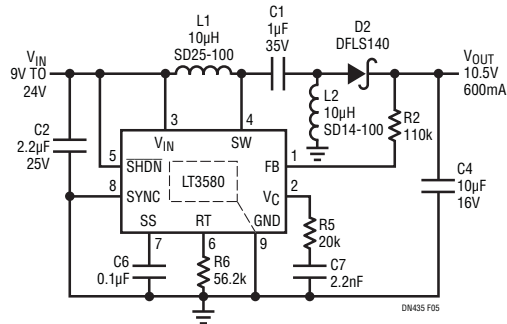


Figure 5. 9V-24V to 10.5V, 600mA SEPIC Converter

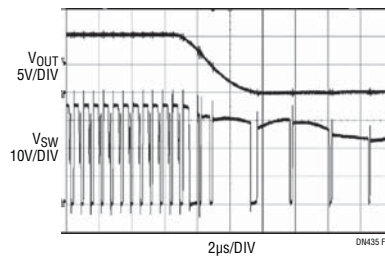


Figure 6. Short-Circuit Event for the Figure 5 Converter at  $24V_{IN}$

### Conclusion

The LT3580 features a unique feedback architecture that allows it to be configured as an inverting or noninverting converter. Now, the same device can be used to produce regulated voltages of either polarity, allowing for a reduction in inventory count. Its many additional features such as soft-start, adjustable switching frequency, shutdown, synchronizing capability, configurable undervoltage lockout, frequency foldback, external compensation and wide input range simplify the design of inverting and noninverting converters.

For applications help,  
call (408) 432-1900, Ext. 3231