

## ADDITIONAL APPLICATIONS

### Inverting Regulator

An inverting buck–boost regulator using the LM2596–ADJ is shown in Figure 22. This circuit converts a positive input voltage to a negative output voltage with a common ground by bootstrapping the regulators ground to the negative output voltage. By grounding the feedback pin, the regulator senses the inverted output voltage and regulates it.

In this example the LM2596–12 is used to generate a –12 V output. The maximum input voltage in this case cannot exceed +28 V because the maximum voltage appearing across the regulator is the absolute sum of the input and output voltages and this must be limited to a maximum of 40 V.

This circuit configuration is able to deliver approximately 0.7 A to the output when the input voltage is 12 V or higher. At lighter loads the minimum input voltage required drops to approximately 4.7 V, because the buck–boost regulator topology can produce an output voltage that, in its absolute value, is either greater or less than the input voltage.

Since the switch currents in this buck–boost configuration are higher than in the standard buck converter topology, the available output current is lower.

This type of buck–boost inverting regulator can also require a larger amount of startup input current, even for light loads. This may overload an input power source with a current limit less than 5.0 A.

Such an amount of input startup current is needed for at least 2.0 ms or more. The actual time depends on the output voltage and size of the output capacitor.

Because of the relatively high startup currents required by this inverting regulator topology, the use of a delayed startup or an undervoltage lockout circuit is recommended.

Using a delayed startup arrangement, the input capacitor can charge up to a higher voltage before the switch–mode regulator begins to operate.

The high input current needed for startup is now partially supplied by the input capacitor  $C_{in}$ .

It has been already mentioned above, that in some situations, the delayed startup or the undervoltage lockout features could be very useful. A delayed startup circuit applied to a buck–boost converter is shown in Figure 27. Figure 29 in the “Undervoltage Lockout” section describes an undervoltage lockout feature for the same converter topology.

### Design Recommendations:

The inverting regulator operates in a different manner than the buck converter and so a different design procedure has to be used to select the inductor  $L1$  or the output capacitor  $C_{out}$ .

The output capacitor values must be larger than what is normally required for buck converter designs. Low input voltages or high output currents require a large value output capacitor (in the range of thousands of  $\mu\text{F}$ ).

The recommended range of inductor values for the inverting converter design is between 68  $\mu\text{H}$  and 220  $\mu\text{H}$ . To select an inductor with an appropriate current rating, the inductor peak current has to be calculated.

The following formula is used to obtain the peak inductor current:

$$I_{\text{peak}} \approx \frac{I_{\text{Load}} (V_{\text{in}} + |V_{\text{O}}|)}{V_{\text{in}}} + \frac{V_{\text{in}} \times t_{\text{on}}}{2L_1}$$

$$\text{where } t_{\text{on}} = \frac{|V_{\text{O}}|}{V_{\text{in}} + |V_{\text{O}}|} \times \frac{1.0}{f_{\text{osc}}}, \text{ and } f_{\text{osc}} = 52 \text{ kHz.}$$

Under normal continuous inductor current operating conditions, the worst case occurs when  $V_{\text{in}}$  is minimal.

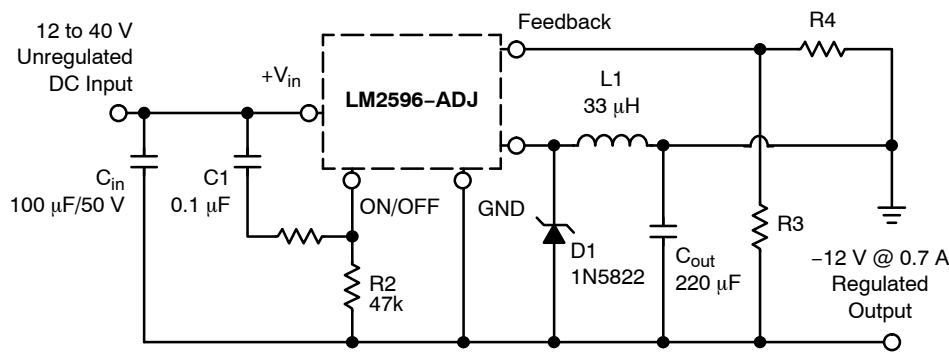


Figure 23. Inverting Buck–Boost Develops –12 V