Application Report
SNVA698–September 2013

Reducing Output Ripple and Noise using the LMZ34002

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ABSTRACT

Analog circuits that need a negative output voltage, such as high-speed data converters, power amplifiers, and sensors are sensitive to noise. This application report examines different techniques to minimize the output ripple and noise with the LMZ34002 negative output voltage power module. Other modules in the LMZ3 family can also implement these noise-reducing techniques, such as adding additional output capacitance, a pi-filter, or a low noise low drop-out regulator.

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1 Introduction

Many industrial applications require both positive and negative voltages to power their analog circuitry. Many of these analog circuits such as data converters, audio amplifiers, sensors, and RF applications require low noise and ripple. The LMZ34002 is a negative output voltage power module which can provide the negative output voltage for these circuits. Although the LMZ34002 produces very little ripple over many operating conditions, some applications require better ripple performance than the LMZ34002 provides. For those applications, additional filtering can reduce the noise and ripple to acceptable levels.

2 LMZ34002 with Standard Filtering

Standard applications not requiring extremely low noise and ripple may be able to get by with the minimum required ceramic output capacitance. Figure 1 shows the LMZ34002 with only 2 × 47-µF ceramic capacitors to filter the output. Figure 2 shows the output voltage ripple waveform of the LMZ34002 operating from 24-V input, –12-V output at 1 A with only 2 × 47-µF, X5R, ceramic output capacitors. The output ripple is approximately 21 mV under these operating conditions.

The output filtering for this minimum solution size only requires two ceramic capacitors, each in a 1206 package. These two capacitors take up 10.3 mm^2 of board space.

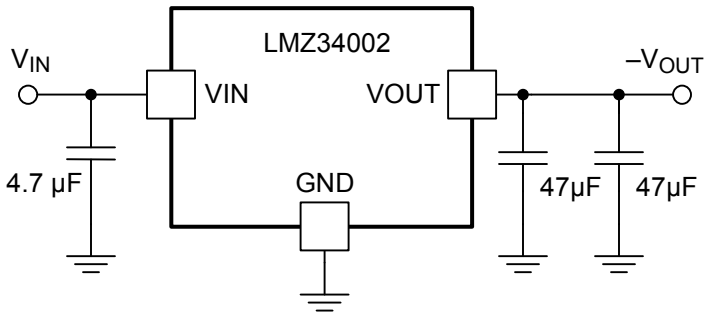

Figure 1. Diagram of the LMZ34002 with Standard Filtering

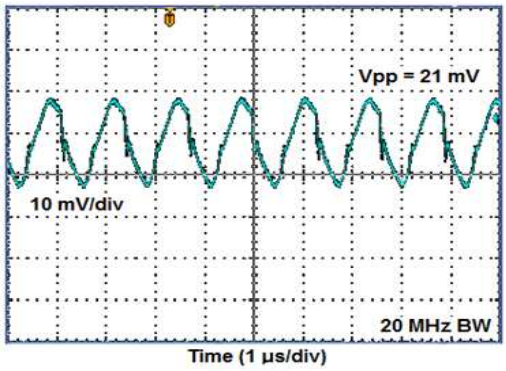

Figure 2. Output Ripple Waveform with Standard Filtering

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3 LMZ34002 with Additional Ceramic Output Capacitance

Applications that require slightly lower noise and ripple than what is achieved with the minimum required output capacitance benefit by adding additional ceramic output capacitance. Figure 3 shows the LMZ34002 with 2 times the minimum-required ceramic output capacitance. The output ripple waveform for this circuit is shown in Figure 4. By doubling the amount of ceramic output capacitors, the output ripple voltage was reduced to approximately 12 mV.

By adding the extra output capacitors, the output filter solution size is increased. These four 1206 package capacitors take up 20.6 mm2 of board space.

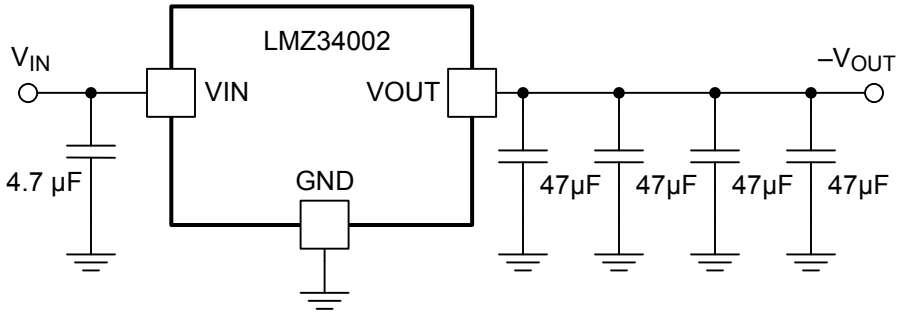

Figure 3. Diagram of the LMZ34002 with Additional Ceramic Capacitance

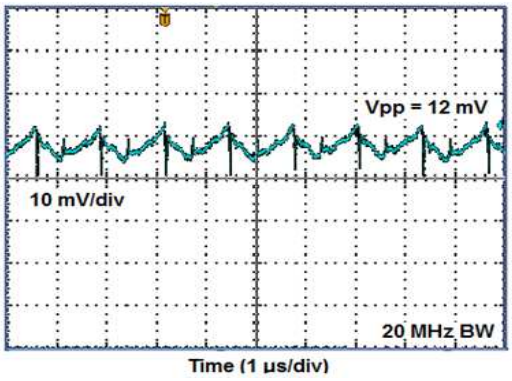

Figure 4. Output Ripple Waveform with Additional Ceramic Capacitance

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4 LMZ34002 Filtering for Noise Sensitive Applications

This section discusses filtering options for noise-sensitive applications.

4.1 PI Filter

Applications requiring extremely low noise and ripple (less than 5 mV) can add additional filtering along with ceramic output capacitance. In these applications a pi-filter can be added to the output. Figure 5 shows the LMZ34002 with 2 × 47-µF, X5R, ceramic output capacitors along with a pi-filter. The additional pi-filter is made up of a surface-mount ferrite bead and a 22-µF, X5R, 1206 package ceramic capacitor. The ferrite bead is 73-type material rated for up to 5 A (Fair-Rite part number 2773021447). This output filter is able to reduce the output ripple waveform to approximately 3 mV peak-to-peak, as shown in Figure 6.

Figure 7 shows the attenuation of the pi filter over frequency. The pi filter is most effective over the switching frequency range of the LMZ34002.

The output filter size, including the two minimum required output capacitors, the SMD ferrite bead, and the 22-µF, X5R, ceramic capacitor, takes up 44.7 mm^2 of board space.

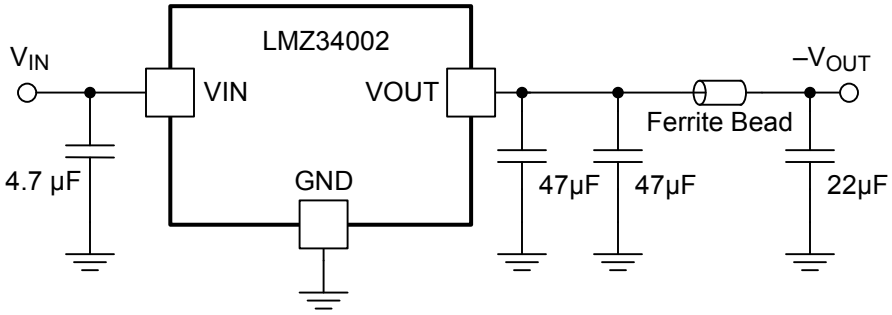

Figure 5. PI-Filter Added to the LMZ34002

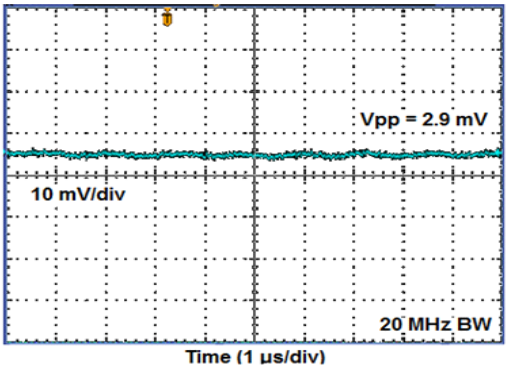

Figure 6. Output Ripple Waveform with PI-Filter

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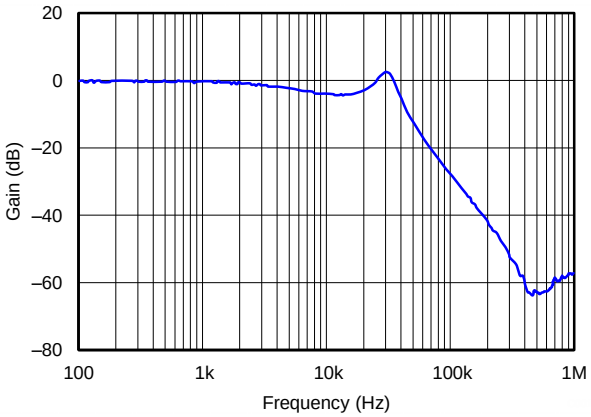

Figure 7. PI-Filter Attenuation Versus Frequency

4.2 Linear Regulator

Another option for achieving extremely low noise and ripple is adding an ultra-low-noise LDO to the output as shown in Figure 8. The output voltage of the LMZ34002 must be adjusted up to allow for the voltage drop-out of the LDO. The LDO used in this application is the TPS7A3301. The TPS7A3301 is a negative-input-voltage, negative-output-voltage LDO capable of handling up to 1 A of current. Figure 9 shows the low noise measured on the output. The amount of output ripple measured was approximately 3 mV.

Figure 10 shows the PSRR of the TPS7A3301 over frequency for different output currents. Other graphs are found in the TPS7A3301 datasheet (SBVS169). This output filter solution size which includes the required output capacitors along with the LDO and its required components is 46.8 mm^2.

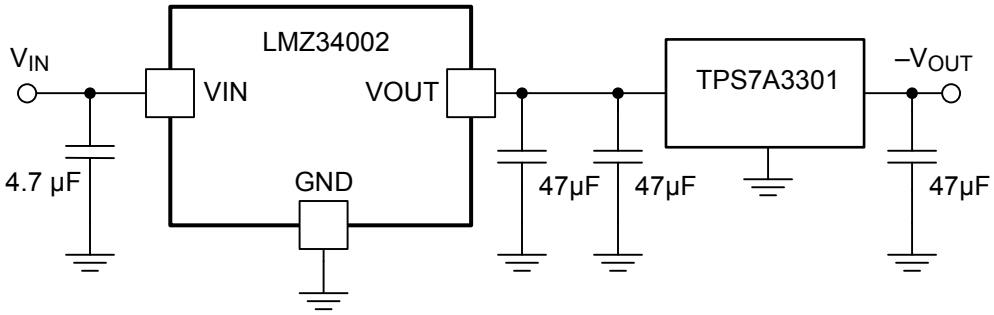

Figure 8. Diagram of the LMZ34002 with Ultra-Low Noise LDO

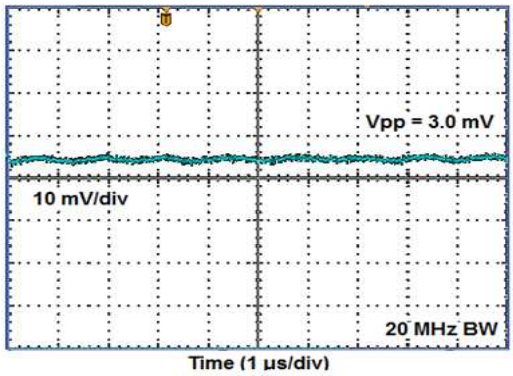

Figure 9. Low-Noise on LMZ34002 Output

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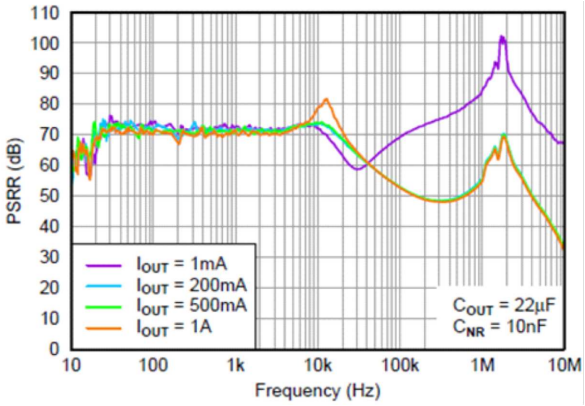

Figure 10. Power-Supply Rejections Ratio Versus I_{OUT}

5 Summary

In summary, the amount of output filtering required depends on the application. For many standard applications the minimum required output capacitance suffices. However, for low-noise applications additional output filtering may be required. In these cases adding extra capacitance, a pi-filter, or a linear regulator reduces the output ripple and noise to acceptable levels. Table 1 summarizes the four output filter solutions discussed above. Included in the table are the resulting output ripple voltage and the board size required for the filter components.

Table 1. Output Filter Solutions

Output Filter	Vpp (TYP)	Board Side
2 × 47-µF ceramic capacitors	21 mV	10.3 mm^2
4 × 47-µF ceramic capacitors	12 mV	20.6 mm^2
2 × 47-µF ceramic caps + pi filter	2.9 mV	44.7 mm^2
2 × 47-µF ceramic caps + LDO	3.0 mV	46.8 mm^2

Each solution is fairly simple and takes up very little board space. Each application's noise requirement determines how much, if any, additional filtering is required.

The LMZ34002, combined with the appropriate output filter, is the perfect device for providing a negative output voltage for low-noise applications.

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