Micropower LDO Has the Lowest Noise and Quiescent Current in SOT-23

by Todd Owen

Introduction

A cell phone rings, a pager beeps. Wireless communications devices are everywhere. These RF circuits have a myriad of power supply requirements. Most important in many applications is low noise operation, to prevent unwanted sidebands on RF amplifiers. Second is low power operation, which translates directly to extended operating time in battery-powered devices. In addition, portability requires small size, which makes small packages for regulators and stability with small surface mount ceramic capacitors a plus. Another factor that can weigh in is low voltage operation, both for the input and output. Satisfying all of these needs at once can be a difficult challenge.

New LDO

Makes a Quiet Entrance

Figure 1 shows a typical application for the LT1761, a new micropower low dropout regulator in a 5-lead SOT-23 package with the lowest noise available from any LDO regulator. Designed into the regulator are many other features that make it useful in a variety of applications. It is stable with a wide range of output capacitors. Small ceramic capacitors can be used without the necessary addition of series resistance as is common with other regulators. The output capacitor can be as low as 1μF, with an ESR in the range from milliohms up to 3 ohms. For low noise operation, the addition of a small bypass capacitor from the output to the BYPASS pin can reduce output voltage noise to 20μV_RMS over the 10Hz to 100kHz frequency range. However, when using a noise bypass capacitor, it is recommended that a minimum output capacitor of 3.3μF be used.

Table 1. Evaluation of available SOT-23 low noise, low dropout regulators

<table>
<thead>
<tr>
<th>Part</th>
<th>Quiescent Operating Current</th>
<th>Output Voltage Noise (Specified with Bypass Cap)</th>
<th>Output Voltage Noise (Measured with Bypass Cap)</th>
<th>Output Voltage Noise (Measured, No Bypass Cap)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitor 1 (5V Output)</td>
<td>80μA</td>
<td>260nV/√Hz&lt;sup&gt;1&lt;/sup&gt;</td>
<td>100μV_RMS</td>
<td>245μV_RMS</td>
</tr>
<tr>
<td>Competitor 2 (5V Output)</td>
<td>95μA</td>
<td>30μV_RMS</td>
<td>55μV_RMS</td>
<td>340μV_RMS</td>
</tr>
<tr>
<td>Competitor 3 (3.3V Output)</td>
<td>85μA</td>
<td>30μV_RMS</td>
<td>30μV_RMS</td>
<td>265μV_RMS</td>
</tr>
<tr>
<td>Linear Technology LT1761</td>
<td>20μA</td>
<td>20μV_RMS (1.22V)</td>
<td>15μV_RMS (1.22V)</td>
<td>56μV_RMS (1.22V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20μV_RMS (3.3V)</td>
<td>16μV_RMS (3.3V)</td>
<td>110μV_RMS (3.3V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20μV_RMS (5V)</td>
<td>18μV_RMS (5V)</td>
<td>135μV_RMS (5V)</td>
</tr>
</tbody>
</table>

1. The data sheet specification is 260nV/√Hz, with no spot frequency given.
2. Measurement on the bench is over the 10Hz–100kHz frequency range, where 30μV_RMS is specified in the data sheet over the 300Hz–50kHz frequency range.

Figure 1. New low noise, low dropout, micropower regulator
tive supply, the output can be pulled below ground by several volts and the device will still start and operate. These features are in addition to standard protection features for linear regulators, such as current limiting and thermal limiting.

The LT1761 regulators are available in several fixed voltage options as well as two different adjustable versions. Fixed voltage options include 2.5V, 3V, 3.3V and 5V. The adjustable versions of the LT1761 are available with a reference voltage of 1.22V and a minimum input operating voltage of 2V. The adjustable LT1761 has to sacrifice one of the function pins to bring out the adjust pin. For the LT1761-SD, the SHUTDOWN pin remains while the BYPASS pin has been removed. This allows the regulator to be
operated normally, with the exception that noise reduction cannot be achieved. For the LT1761-BYP, the BYPASS pin has been brought out to allow for low noise operation with the addition of a small capacitor. The shutdown pin is internally tied to the input to ensure that the regulator will operate normally with the minimum operating voltage.

How Does It Measure Up?
There are a number of low noise, low dropout regulators in SOT-23 packages on the market. The LT1761 gives many performance advantages over the competition. Comparisons based on data sheet specifications can be difficult and confusing, since many manufacturers specify different measurement methods and frequency ranges. Table 1 summarizes the distinctions between the parts to help designers make a quick comparison.

These parts were compared on the bench side by side. This A/B comparison eliminates any variations in test equipment or measurement methods. All measurements were taken with a 50mA load, 10µF output capacitor and the manufacturer’s maximum recommended noise capacitor (0.01µF). Noise was measured using a noise amplifier with a gain of 60dB (the amplifier adds 0.5µVRMS of noise into the measurement, providing accuracy within 0.5% for a 20µVRMS noise signal). The noise was amplified to eliminate any noise added by the instrumentation used for measurements.

Noise measurements given as RMS values over a frequency bandwidth may often not provide enough information to decide on a regulator for your design. Figures 2 through 7 show peak-to-peak noise for the regulators showcased in the article. Again, the devices were tested with identical 10µF output capacitors, the manufacturer’s recommended maximum 0.01µF bypass capacitor and identical 50mA loads. The difference in performance is readily apparent.

Finally, Figures 8 and 9 show noise spectral density over the 10Hz to 100kHz range for the parts. These curves show the dramatic difference that the LT1761’s unique architecture makes in reducing output voltage noise. Noise over the entire frequency range is reduced, providing an exceptionally quiet output. By any of these measurement methods, the LT1761 offers the lowest noise available.

Other Performance Advantages
The unique internal architecture of the LT1761 provides other performance advantages. For transient performance, Figure 10 shows two photos of a 10mA to 100mA transient load step on the 5V output of the LT1761. This test was done with 6V on the input and 10µF capacitors on both input and output. The only difference in test conditions between the two is the addition of a 0.01µF bypass capacitor to lower the output voltage noise. The difference in circuit response is readily apparent. The LT1761 also allows for direct connection of the output to the adjust pin, which provides a minimum 1.22V regulated output. Competing devices are either unavailable in adjustable versions or require some minimum

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DESIGN FEATURES

Figure 3. LT1684 typical application

This circuit has the output current limit set at ±200mA, more than enough to ring ten phones. For current limits less than 200mA, two current limit resistors can be added in the Lim+ and Lim– leads, allowing the current limit to be set anywhere from 20mA to 200mA.

If additional output current is required, the LT1684 can be paired up with the LT1166 automatic bias control to provide any amount of current that is required.

Conclusion

By enabling direct software control of frequency, amplitude and cadence, the LT1684 allows a single design to be used in phone systems globally.

Figure 4. Ring signal from Figure 3’s circuit