LINEAR TECHNOLOGY

DESIGN NOTES

Dual 25µV Micropower Op Amp Fits in 3mm × 3mm Package

Design Note 331

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Introduction

Conventional monolithic micropower op amps with a wide supply voltage range require a large die area and therefore, a large package and footprint. The unconventional LT®6011 dual op amp fits 25µV input precision micropower operation and wide 2.7V to 36V supply range in a tiny new package—its 3mm × 3mm DFN package is so small it doesn't even have leads. The LT6011 also provides rail-to-rail output swing and utilizes superbeta input transistors to achieve picoampere input currents.

Hall Sensor Amplifier

Figure 1 shows the LT6011 applied as a low power Hall sensor amplifier. The magnetic sensitivity of a Hall sensor is proportional to the DC excitation voltage applied across it. With a 1V bias voltage, the sensitivity of this Hall sensor is specified as 4mV/mTesla of magnetic field. At that level of DC bias, however, the 400Ω bridge consumes 2.5mA. Reducing the excitation voltage would reduce the power consumption, but it would also reduce the sensitivity. This is where the beauty of precision micropower amplification becomes especially apparent.

The LT1790-1.25 micropower reference provides a stable 1.25V reference voltage. The 7.87k:100k resistive ladder attenuates this to about 90mV across the 7.87k and the LT1782 acts as a buffer. When this 90mV is applied as excitation across the Hall bridge, the current is only 230µA. This is less than 1/10 of the original value. (Just imagine if all your batteries could last 10 times longer than they do.) But as mentioned earlier, the sensitivity is now likewise reduced by the same factor, down to 0.4mV/mT.

The way back to high sensitivity is to take gain with a precision micropower amplifier. The LT6011 is therefore configured as an instrumentation amplifier in a gain of 101. Such high gains are permissible and advantageous using an LT6011 because of its exceptional input precision and low drift. The output sensitivity of the circuit is raised to a whopping 40mV/mT, while consuming a total supply current of only 600µA. To have achieved this sensitivity by increasing the bridge excitation would have required a prohibitive 25mA from the supply! (As an interesting note, here in Milpitas, California, the Earth's 50µT field is about 60° from horizontal and causes a 2mV shift in the circuit's output.)

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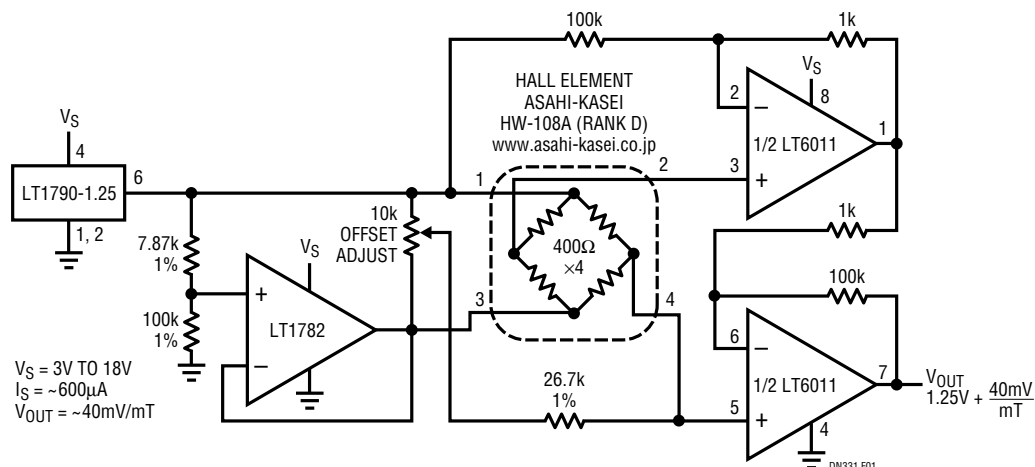

Figure 1. Hall Sensor Amplifier Optimizes Sensitivity vs Supply Current

DAC Amplifier

Figure 2 shows the LT6011 applied as both a reference amplifier and I-to-V converter with the LTC1592 16-bit DAC. Whereas faster amplifiers such as the LT1881 and LT1469 are also suitable for use with this DAC, the LT6011 is desirable when power consumption is more important than speed. The total supply current of this application varies from 1.6mA to 4mA, depending on code, and is almost entirely dominated by the DAC resistors and the reference.

The DAC itself is powered only from a single 5V supply. Op amp B of the LT6011 inverts the 5V reference using the DAC's internal precision resistors R1 and R2, thus providing the DAC with a negative reference allowing bipolar output polarities. Op amp A provides the I-to-V conversion and buffers the final output voltage. The precision required of the I-to-V converter function is critical because the DAC output resistor network is obviously very code dependent, so the noise gain which the op amp sees is also code dependent. An imprecise op amp in this function would have its input errors amplified somewhat chaotically versus code.

The speed of the circuit is shown in Figure 3. Settling is achieved within 250µs. Because the outputs of the LT6011 swing to within 40mV of either supply rail, the supply voltages to the amplifier need to be only barely wider than the desired ±10V output.

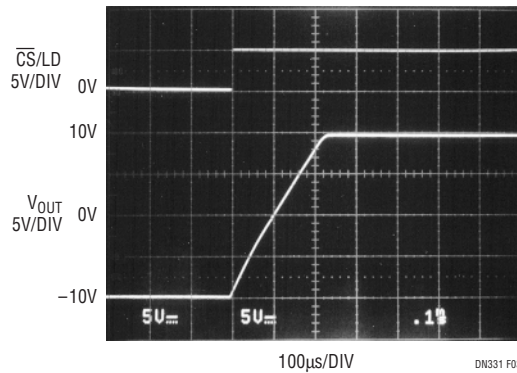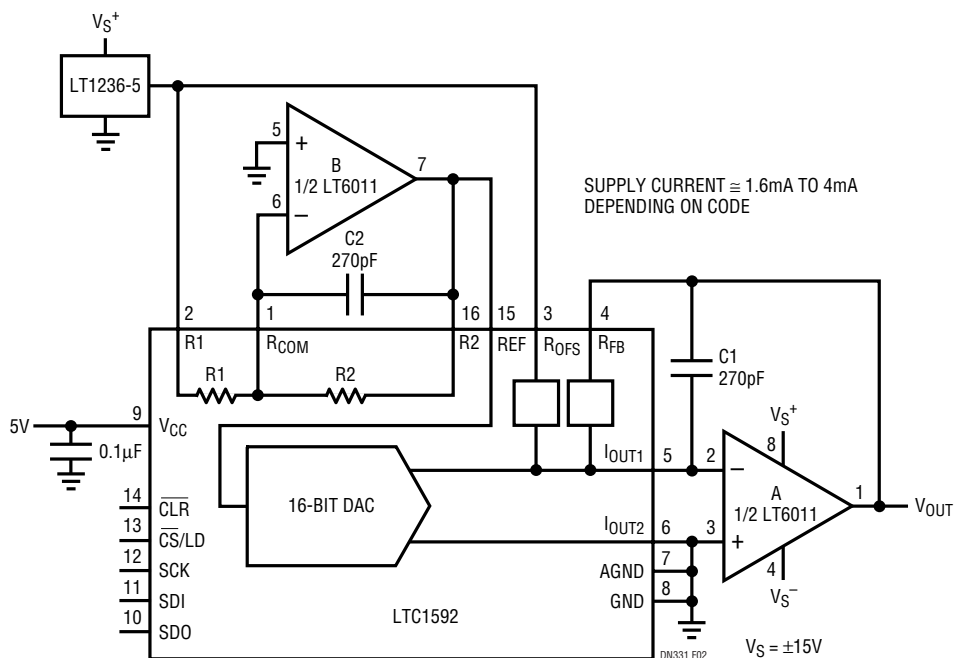Figure 3. 20V Output Step Time Domain Response

Figure 2. DAC Reference Inverter and I-to-V Converter