DESIGN NOTES

Low Power, Fast Op Amps Have Low Distortion

Design Note 148

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Introduction

The LT®1351/LT1352/LT1353 family of low power operational amplifiers combines a slew rate of 200V/µs with a supply current of 250µA per amplifier. Both input and output stages have been optimized for linearity, achieving outstanding distortion performance with miserly quiescent current. The amplifier is available in single, dual and quad versions, in various packages, including the tiny MSOP package for the LT1351 single amplifier. A summary of key specifications is shown in Table 1.

Buffering Data Acquisition Systems

A low power data acquisition system using the LT1351 as a buffer is shown in Figure 1. The LTC®1274 is a 12-bit, 2mA, 100ksps, ±2.048V full-scale input ADC. Its input at Pin 1 can be modeled as a 200Ω switch connected to a 45pF sample cap. This light load presents no problem for the LT1351, which will pass full-scale,

Table 1. Key Performance Features of the LT1351/LT1352/LT1353

Power Supply Range	±2.5V to ±15V
Supply Current (per Amplifer)	250µA
Shutdown Current (LT1351)	10µA
Slew Rate (±15V Supplies) (±5V Supplies)	200V/µs 50V/µs
Gain Bandwidth	3MHz
C-Load™ Amplifiers Stable	All Capacitive Loads
Maximum Input Offset Voltage	600µV
Maximum Input Bias Current	50nA
Minimum DC Gain, R_L = 2k	30V/mV
Input Noise Voltage	14nV/√Hz
Packages: 8-Lead MSOP 8-Lead SO, PDIP 14-Lead SO	LT1351 LT1351, LT1352 LT1353

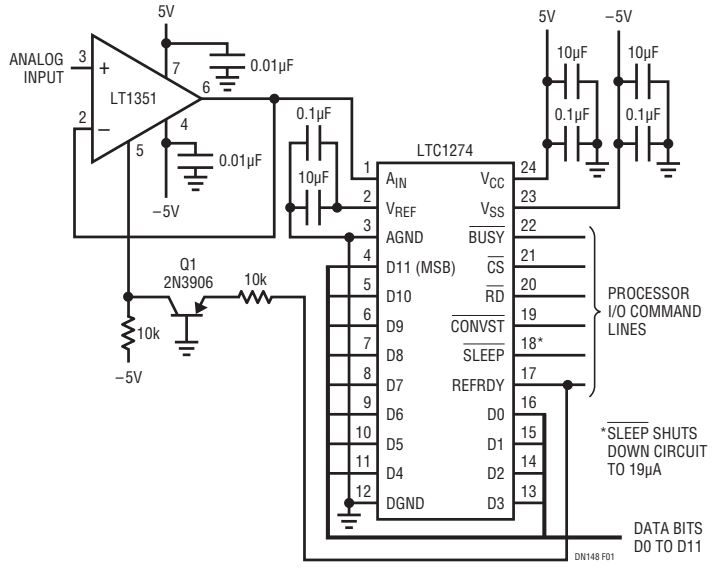

Figure 1. LT1351 as a Buffer for LTC1274 100ksps ADC

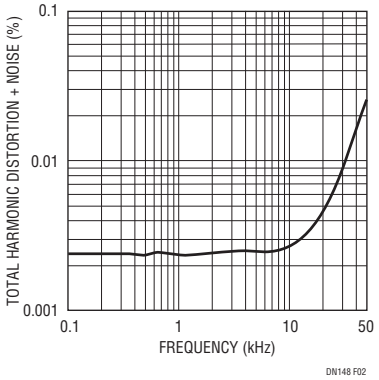

Figure 2. LT1351 A_V = 1, ±5V Supplies, V_{OUT} = $4V_{P-P}$, R_L = 10k

12-bit accurate signals up to 40kHz. Figure 2 shows the total harmonic distortion plus noise of the LT1351 configured as a unity-gain buffer driving $4V_{P-P}$ into 10kΩ on ±5V supplies. The buffer settles in under 1.5µs to less than 1mV for a 4V step, thus ensuring acquisition in 2µs. Additionally, the circuit exploits the shutdown feature of the LT1351 to reduce the total supply current to a mere 19µA when Pin 18 is pulled low. Pin 17 signals that the internal ADC voltage reference is valid. When it is high, the amplifier is ready for conversions. Transistor Q1 provides a level shift so that Pin 17 can control the Shutdown pin of the LT1351, which is turned off when its Pin 5 is pulled to V_{EE} (when Pin 17 is low) and is on when Pin 5 is 2V or more above V_{EE} (when Pin 17 is high).

Filters

For large signals, the slew rate of the LT1352 amplifier passes undistorted signals even with a stingy amount of supply current. The 20kHz, 4th order Butterworth filter shown in Figure 3 showcases this large-signal performance. The configuration is a standard textbook filter, but the large-signal distortion in Figure 4 shows that the $20V_{P-P}$ signals remain below 0.02% THD throughout the passband. This measurement is extraordinary, considering that the circuit draws a mere 500µA of quiescent current.

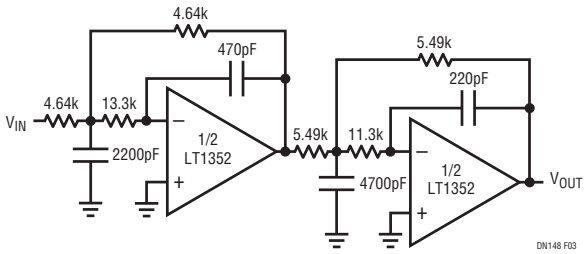

Figure 3. 20kHz, 4th Order Butterworth Filter

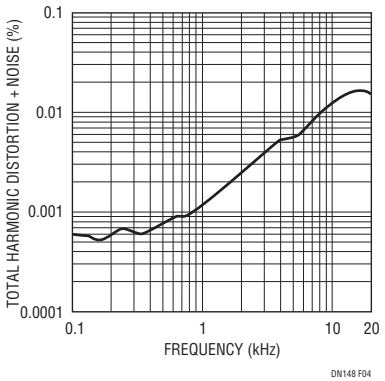

Figure 4. LT1352 20kHz, 4th Order Butterworth Filter ±15V Supplies, $20V_{P-P}$ Signals

A Two Op Amp Instrumentation Amplifer

The two op amp instrumentation amplifier shown in Figure 5 has a gain of 102 and a bandwidth of 30kHz. The circuit uses a combination of inversion and summation to cancel the common mode component at the two inputs. Differential gain can be analyzed by calculating the gain from each input with the other input grounded and adding the gains. Figure 6 is a plot of total harmonic distortion plus noise for various output levels. The noise of this configuration is a low $370µV_{RMS}$ at the output with an 80kHz measurement filter. At output levels below $2.5V_{P-P}$ ($884mV_{RMS}$), noise is the limiting factor in performance. This excellent blend of noise performance and bandwidth is unmatched at this power level.

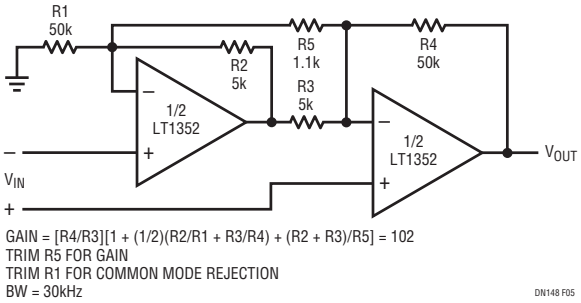

Figure 5. Instrumentation Amplifier

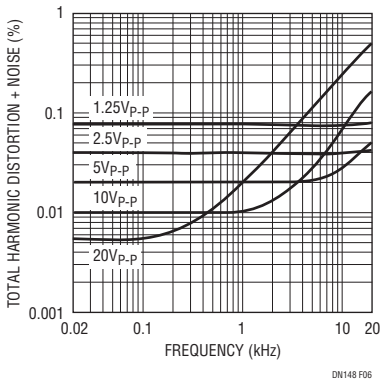

Figure 6. LT1352 2-Amplifier, A_V = 100 Instrumentation Amp, Varying Output Levels

Conclusion

In summary, the LT1351/LT1352/LT1353 family of amplifiers provides low power solutions for low distortion, low noise applications. Even though supply current is only 250µA per amplifier, large-signal performance is outstanding.

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