Product Overview

Choosing an Amplifier for Wide Bandwidth, High-Impedance, Data Acquisition Analog Front Ends

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High-Speed Amplifiers

The input amplifier that starts the signal chain of a wide-bandwidth data acquisition system needs to have high speed and high input impedance, but there are also many other specifications such as precision, output swing, and power consumption that play an important role in choosing the best amplifier. To meet the demands of a wide-range of applications, Texas Instruments offers several amplifiers, each with different tradeoffs, to meet the demands of wide-bandwidth, high-impedance systems.

This article focuses on three specific devices that cover a range of speed, complexity, voltage-swing, and power consumption: the BUF802, OPA817, and OPA859 high-speed amplifiers. Each of these devices provides their own unique set of benefits and tradeoffs when implementing a high-impedance front end.

Highest Bandwidth: BUF802

When an application demands the highest bandwidth for a high impedance front end, an open loop buffer is often the best solution. One example, TI's BUF802, is a JFET input buffer with 3.1 GHz of large signal bandwidth and 7,000 V/µs slew rate. The device provides a 50-GΩ input impedance along with a low flat-band noise of 2.3 nV/$\sqrt{Hz}$ and linearity performance of –55 dBc (HD2), –59 dBc (HD3) at 1 GHz and 1 V_{PP}. These performance specifications allow the BUF802 to provide the highest possible bandwidth while maintaining high impedance and good linearity performance for applications demanding the best performance.

The drawback of using an open loop buffer such as the BUF802 is that this device has poor DC accuracy. To provide good DC performance, the BUF802 must be used in a composite loop circuit that relies on a precision amplifier to control the low frequency signal inputs. Figure 1 shows an example of the BUF802 in a composite circuit configuration.

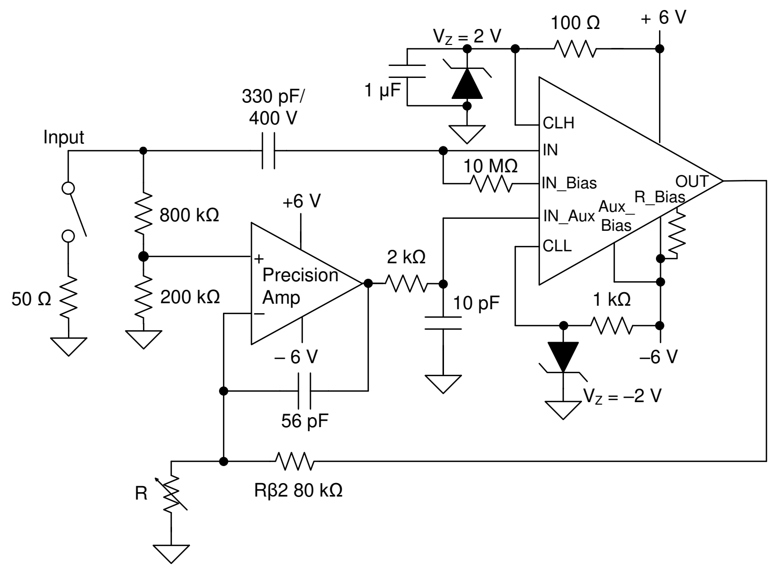

Figure 1. Example BUF802 Composite Loop Configuration

In the composite loop circuit, a secondary precision op amp such as the OPA140 or OPA828 controls DC and low frequency, while the open loop buffer continues to control high frequency. A uniform gain across the transition frequency region is allowed by the auxiliary input of the BUF802 and the feedback capacitor setting of the precision amplifier. The circuit combines the precision of an op-amp with the high bandwidth of an open-loop buffer, but this method does increase component count, layout area, and design complexity.

Most Flexibility: OPA817

For applications that demand a lot of flexibility, a unity gain buffer such as the BUF802 does not always suffice. When looking for wide input range, configurable gain, and precision all in one package, it is best to use a high-speed op amp such as the OPA817. Texas Instrument's OPA817 op amp has a JFET input for high-input impedance, 800-MHz bandwidth, 50-µV_{OS} precision, and 1-µV/°C drift that is best-in-class when compare to many industry leading op amps. In a unity gain configuration, OPA817 has a 245-MHz, 2-V_{PP} bandwidth and a 970-V/µs slew rate. While not as high speed as the BUF802, the OPA817 can be configured for gains > 1 V/V with a single 3-mm × 3-mm package op amp for a smaller design size. This is also a simplified circuit compared to the BUF802 circuitry, which requires a two-part composite loop with frequency response matching. Additionally, for gains > 7 V/V and transimpedance applications, TI offers the OPA818, which is the decompensated version with a higher 2.7 GHz of gain-bandwidth product and lower noise of 2.2 nV/ √Hz.

Figure 2 shows the OPA817 example circuit for a 200-MHz digitizer front end. In this example, the 60 GΩ of the OPA817 makes it easy to configure the front end with a simple switch to choose between 50-Ω or 1-MΩ inputs.

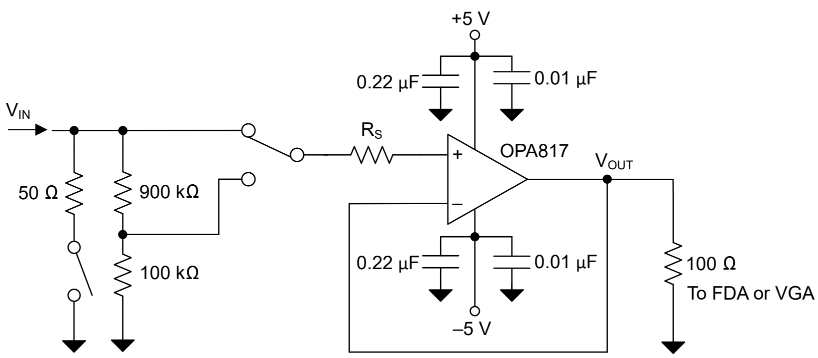

Figure 2. OPA817 Example Digitizer Front End Design

One additional benefit of the low-input bias current of 2 pA of the OPA817, is that an input slew limiting resistor (R_S) can be added to the circuit to limit overshoot without any penalties to other performance specifications. In conjunction with the input capacitance of the amplifier, R_S can be tuned to limit the input signals maximum slew rate to reduce any overshoot from the output of the amplifier depending on the applications needs.

Small Size and Low Voltage: OPA859

Not all high-speed, high-impedance applications have the power supply voltages and power available to drive parts like the OPA817 or BUF802. In these cases, a device like TI's OPA859 is an excellent candidate to implement a simple high-speed front end with supply voltages as low as 3.3 V.

The OPA859 is a 3.3-V to 5-V supply amplifier with 900-MHz, gain-bandwidth product, 3.3 nV/√Hz noise, and high impedance MOSFET inputs. The device is available in a small 2-mm × 2-mm package to save on space and reduce packaging parasitics. Although the OPA859 is a smaller size, the device still provides strong output drive with a unity gain large signal bandwidth of 200 MHz with a 2 V_{PP} output and a slew rate of 1,150 V/µs. Additionally, the OPA859 also has a decompensated counterpart, the OPA858, which increases the gain bandwidth to 5.5 GHz and reduces the noise to 2.5 nV/√Hz.

Summary

This article presented three different options from Texas Instruments for high-speed, high-impedance front ends that are flexible depending on the applications requirements. Table 1 shows a comparison of many of the specifications highlighted between the three devices.

Table 1. BUF802, OPA817, OPA859 Summary Comparison

Parameter	BUF802	OPA817	OPA859
VS Max (V)	13	12.6	5.25
VS Min (V)	9	6	3.3
Gain Bandwidth Product	3.1 GHz	400 MHz	900 MHz
Slew Rate (V/µs)	7000	1000	1150
Noise (nV/√Hz)	2.3	4.5	3.3
Maximum Drift (µV/℃)	±1330(1)	±3.5	N/A
Fixed Gain	Yes (1 V/V)	No	No
Package Size	3 × 3 mm^2 (1)	3 × 3 mm^2	2 × 2 mm^2
Input Impedance (Ω)	50 G	60 G	1 G

(1) BUF802 package size and drift represent values for the standalone device not in a composite configuration.

Overall, these three devices are a great starting point when choosing a part for a high-speed, high-impedance front end, but Texas Instruments has many other devices that can fit even better for specific applications needs. To view all of TI's amplifier products, see *Amplifiers*.