Technical Article

Go Differential to Differentiate Your Precision Design

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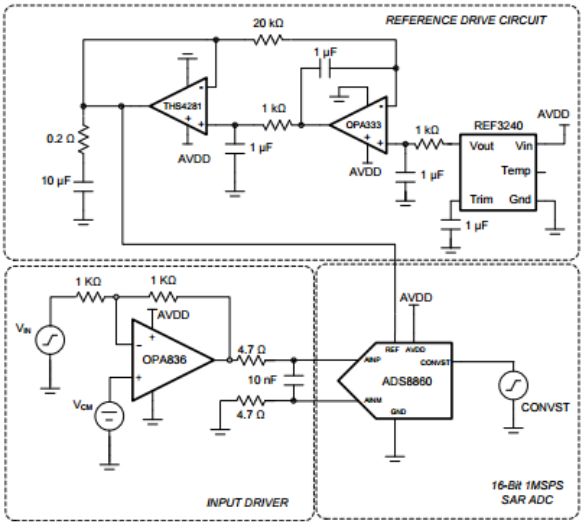
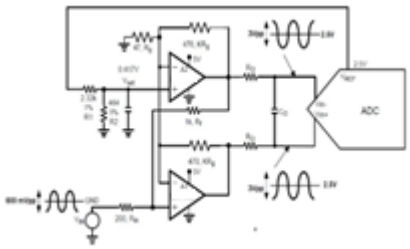
While more of the industry's newest high-resolution, precision analog-to-digital converters (ADCs) implement differential inputs to maximize performance, many designers still choose to use single-ended amplifiers because that's what they're comfortable with. But low-power fully differential amplifiers (FDAs) offer many system advantages without sacrificing precision. In this post, I will use the new THS4551 low noise, precision, 150MHz FDA as an example of how to realize many of the benefits of fully differential amplifiers.

FDAs enable simple single-ended to differential signal conversion with direct current (DC) coupling. In Figure 1, you can see three different examples of driving a single-ended signal into the differential input of an ADC. However, the FDA offers lower power, lower noise and an improved dynamic range.

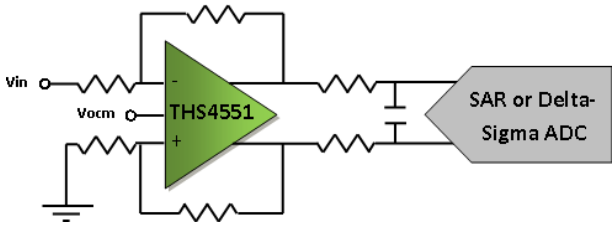
Figure 1. Pseudo Differential Input (a); Dual Operational Amplifier (Op Amp) Method (b); and Fully Differential Amplifier Method (c)



(a)



(b)



(c)

The FDA architecture can help significantly lower total harmonic distortion (THD) by reducing HD2. Implementing the FDA method shown in Figure 1c, you can achieve an improvement of >4dB in THD. This >4dB improvement can result in an overall system performance improvement, or give you the flexibility to use a lower-power/lower-bandwidth amplifier to meet the same THD.

A single FDA (Figure 1c) will have 1/√2 lower noise for the same power than a pair of single-ended op amps (Figure 1b). For example, an op amp with an input-voltage noise of 3nV√Hz will have a total input-voltage noise of 3*√2 nV/√Hz in the dual op amp circuit shown in Figure 1b.

The FDA can operate from a single supply voltage and still accept bipolar input signals. Figure 2 shows the THS4551 accepting a 20Vpp input (0V common mode) and outputting 8Vpp with a 2.5V common mode. This capability allows you to reduce system complexity by eliminating the negative power supply and any unnecessary signal-attenuation stages.

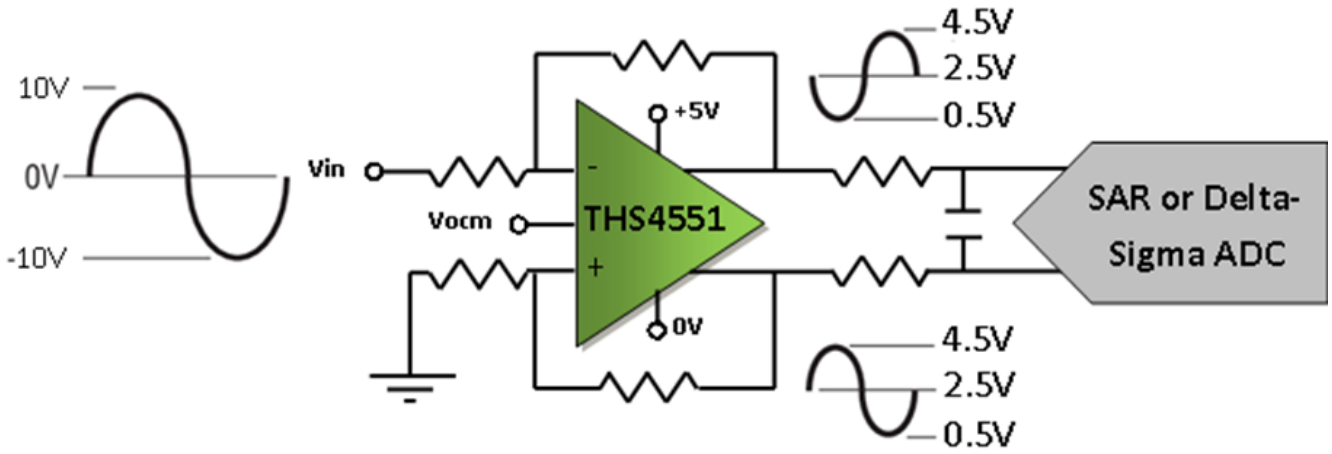
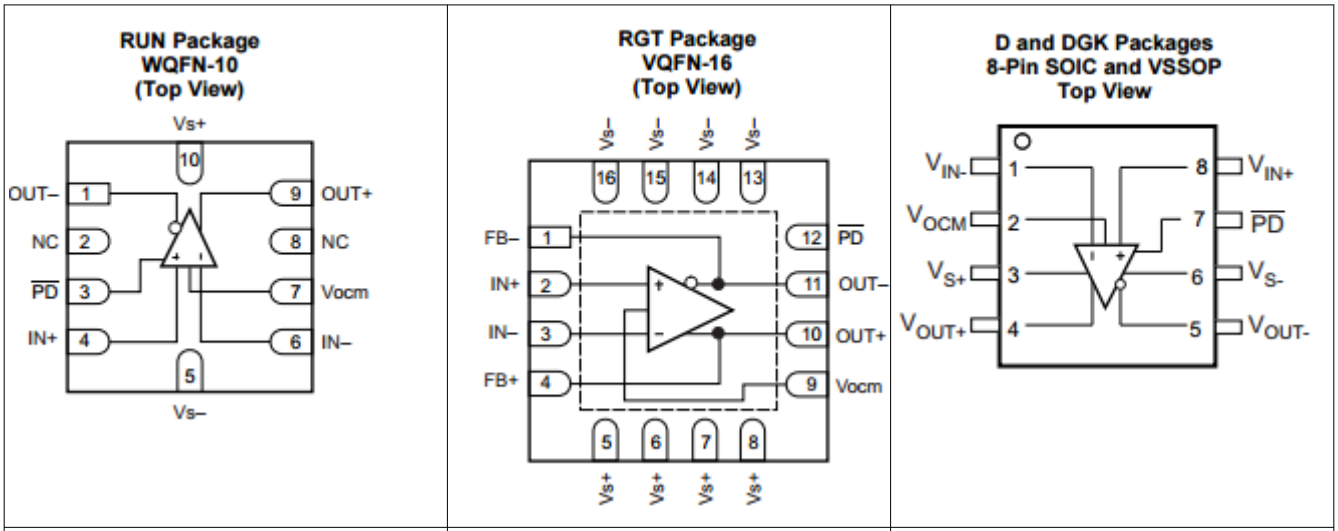


Figure 2. FDA Attenuation Example

FDAs include a common-mode output loop to perfectly match the expected ADC input common mode. The Vocm pin sets the output common mode of the amplifier. You can leave this pin floating if your desired common mode is at the midpoint of the supplies.

As shown in Figure 3, TI FDAs are offered in a number of small packages including 2mm-by-2mm QFN, making them suitable for use in even the most space-constrained application.

Figure 3. 2mm-by-2mm 10-Pin QFN (a); 3mm-by-3mm 16-Pin QFN (b); 5mm-by-3mm 8-Pin VSSOP (c)



(a) (b) (c)

TI's new THS4551 is one of the highest-precision FDAs in the industry, with ±0.175mV input offset and <2V/C offset drift. This enables the improved system performance and minimizes the need for costly and time-consuming system calibrations.

The evaluation module (EVM) for TI's new ADS127L01 24-bit 512Ksps delta-sigma ADC offers an example of the power of FDAs. The EVM for the ADC implements an ADC driver using the THS4551 configured as a multifeedback (MFB) filter. As Figure 4 shows, the ADC-plus-driver pair achieves a signal-to-noise ratio (SNR) of 110.6dB and a THD of 119.1dB with a 1kHz input signal. As shown in the ADS127L01 data sheet (and the goal of all ADC driver implementations), the performance of the THS4551 does not have any impact on the performance of the data converter. This level of performance was achieved while adding less than 7mW of system power, making the THS4551 an essential part of designs that require the lowest power while also delivering the best harmonic distortion and precision.

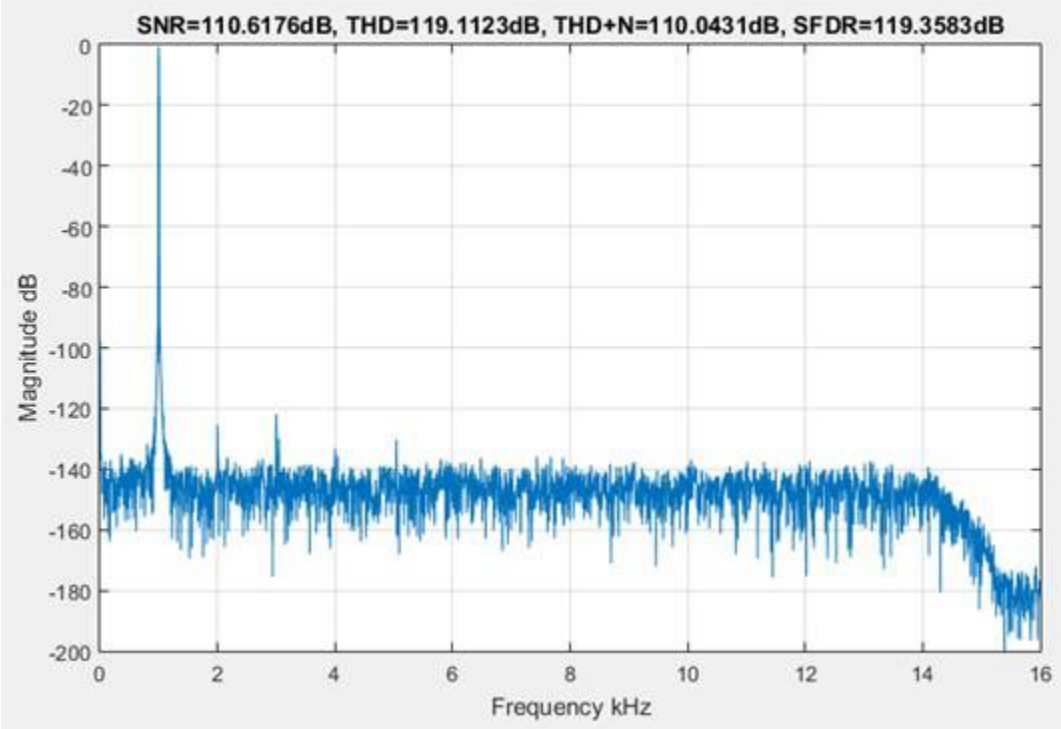


Figure 4. ADS127L01 with THS4551 Spectrum

If your ADC has a differential input, a precision FDA, such as the THS4551 could be a good choice to simplify your system design and enable low noise, low power, and low harmonic distortion. What is your experience designing with FDAs? Login and leave a comment below about your experience.

Additional Resources

- Try an FDA in a system design using one of our TI Designs reference designs, including:
  - Data Acquisition Optimized for Lowest Distortion, Lowest Noise, 18 bit, 1Msps Reference Design (TIPD115).
  - Ultrasonic Water Flow Measurement Reference Design (TIDM-ULTRASONIC-WATER-FLOW-MEASUREMENT).
  - High Performance Single Ended to Differential Active Interface for High Speed ADC Developed by Dallas Logic Corp. (TIDA-00294).
- Read more blogs on differentiated amplifiers.
- Read application notes on FDAs:
  - Using single-supply fully diff. amps with neg. input voltages to drive ADCs
  - Using fully differential op amps as attenuators
  - Analysis of fully differential amplifiers
- Learn about TI's entire portfolio of amplifier ICs and find technical resources.

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