Circuits from the Lab™ tested circuit designs address common design challenges and are engineered for quick and easy system integration. For more information and/or support, visit www.analog.com/CN0180.

Devices Connected/Referenced	
AD8475	Fully Differential Funnel Amplifier and ADC Driver
AD7982	Fully Differential, 18-Bit, 1 MSPS SAR ADC
ADR435	Ultralow Noise XFET® Voltage Reference with Current Sink and Source Capability

Precision, Low Power, Single-Supply, Fully Integrated Differential ADC Driver for Industrial-Level Signals

EVALUATION AND DESIGN SUPPORT

Circuit Evaluation Boards
  AD8475 Evaluation Board (EVAL-AD8475Z)
  AD7982 Evaluation Board (EVAL-AD7982CBZ)
  Converter Evaluation and Development Board
    (EVAL-CED1Z)
Design and Integration Files
  Schematics, Layout Files, Bill of Materials

CIRCUIT FUNCTION AND BENEFITS

Standard single-ended industrial signal levels of ±5 V, ±10 V, and 0 V to +10 V are not directly compatible with the differential input ranges of modern high performance 16-bit or 18-bit single-supply SAR ADCs. A suitable interface drive circuit is required to attenuate, level shift, and convert the industrial signal into a differential one with the correct amplitude and common-mode voltage that match the input requirements of the ADC.
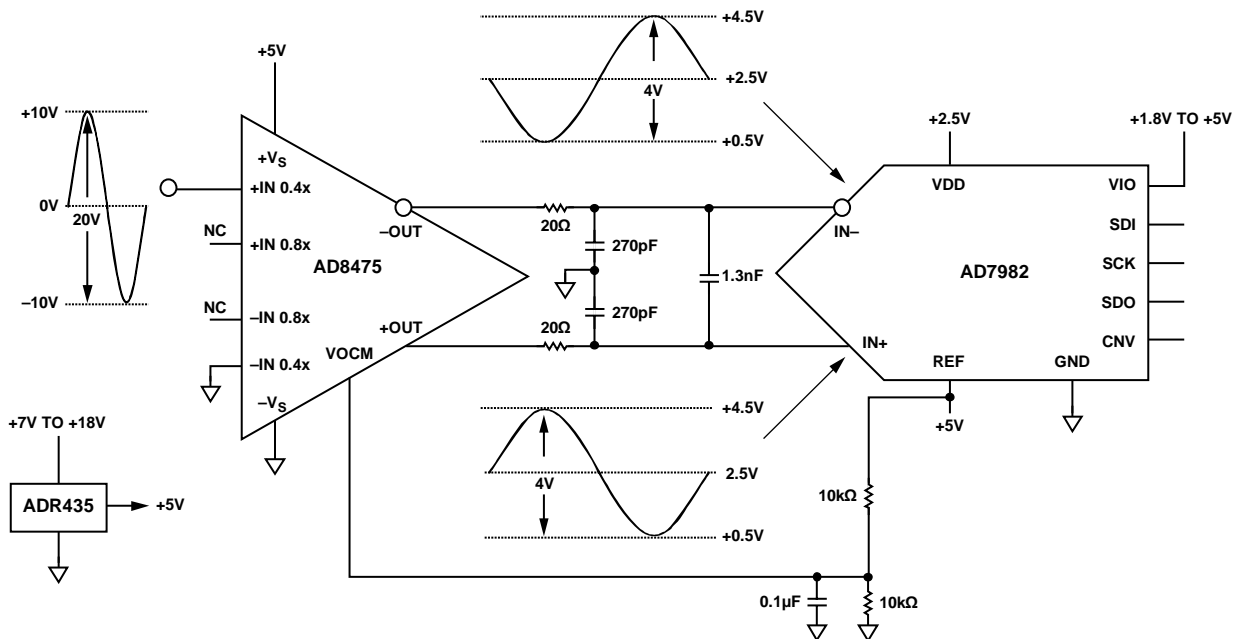

Figure 1. Single-Ended-to-Differential ADC Driver (Simplified Schematic: All Connections and Decoupling Not Shown)

Rev. A

Whereas suitable interface circuits can be designed using resistor networks and dual op amps, errors in the ratio matching of the resistors, and between the amplifiers, produce errors at the final output. Achieving the required output phase matching and settling time can be a challenge, especially at low power levels.

The circuit shown in Figure 1 uses the AD8475 differential funnel amplifier to perform attenuation, level shifting, and conversion to differential without the need for any external components. The ac and dc performances are compatible with those of the 18-bit, 1 MSPS AD7982 PulSAR® ADC and other 16- and 18-bit members of the family, which have sampling rates up to 4 MSPS.

The AD8475 is a fully differential attenuating amplifier with integrated precision thin film gain setting resistors. It provides precision attenuation (by 0.4× or 0.8×), common-mode level shifting, and single-ended-to-differential conversion along with input overvoltage protection. Power dissipation on a single 5 V supply is only 15 mW. The 18-bit, 1 MSPS AD7982 consumes only 7 mW, which is 30× lower than competitive ADCs. The total power dissipated by the combination is only 22 mW.

CIRCUIT DESCRIPTION

The AD8475 attenuating amplifier and AD7982 18-bit differential ADC can be used in a high precision analog front-end system to process large voltages using a single 5 V supply.

The AD8475 is connected to attenuate the input signal by a factor of 0.4×, accomplished through integrated precision trimmed resistors. On a single 5 V supply, it can accept voltages as large as 25 V p-p. The differential rail-to-rail outputs require only 50 mV of headroom at low frequencies. The AD8475 can be driven by a true differential input, or it can be driven by a single-ended input and provide the single-ended-to-differential conversion as shown in Figure 1.

An RC network between the AD8475 and ADC provides a single-pole filter that reduces undesirable aliasing effects and high frequency noise. The common-mode bandwidth of the filter is 29.5 MHz (20 Ω, 270 pF), and the differential bandwidth is 3.1 MHz (40 Ω, 1.3 nF).

The AD7982 is an 18-bit successive approximation (SAR) ADC that operates from a single power supply, VDD. The I/O interface voltage, VIO, can range between 1.8 V and 5 V, depending on the interface logic supply. The AD7892 has true differential inputs that accept voltages of up to $\pm V_{REF}$. The ADR435 is a 5 V, low noise (8 µV p-p, 0.1 Hz to 10 Hz), high accuracy (±2 mV for B grade) voltage reference that provides the REF voltage for the AD7982, as well as the supply voltage for the AD8475 differential driver.

A divider composed of two 10 kΩ resistors connected to the ADR435 output is used to set the 2.5 V common-mode voltage (VOCM) of the AD8475 outputs. This maximizes the dynamic range of the ADC by positioning the input differential signals around the optimum common-mode input voltage.

A 20 V p-p single-ended input signal produces a signal on each differential output that swings between +0.5 V and +4.5 V, 180° out of phase.

A 20 kHz, 20 V p-p input signal to the AD8475 results in a final SNR of 96.3 dBFS and THD of −112.3 dBFS, both referenced to the AD7982's full-scale range as shown in the FFT plot in Figure 2.

The signal levels shown in the summary data below the FFT are measured at the input to the AD7982. Full-scale range at this point is 10 V p-p differential. This is 25 V p-p reflected to the input of the AD8475. The input test signal is 20 V p-p, which results in a signal that is 2 dB below the full-scale input of the ADC.
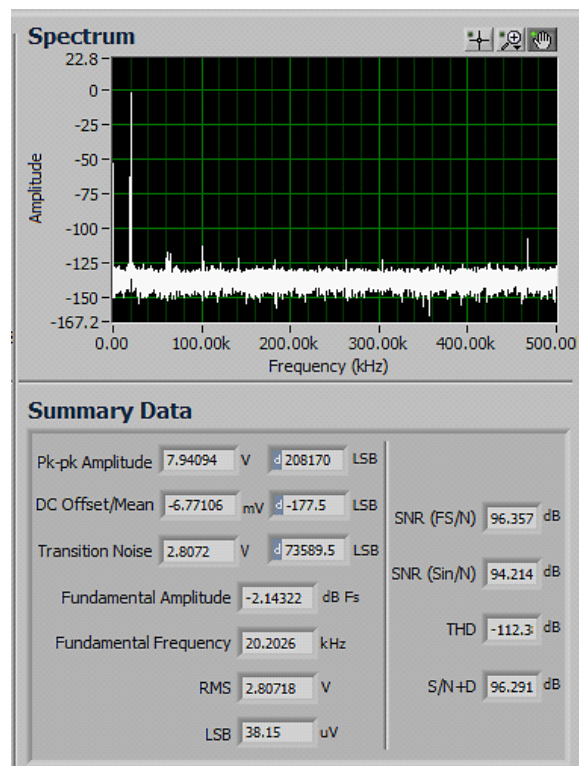

Figure 2. FFT Plot for 20 kHz Signal, 2 dB Below Full-Scale, with Sampling Frequency of 1 MSPS

Note that under these conditions, the outputs of the AD8475 each swing within 500 mV of the supply rails and still yield excellent distortion performance because of the rail-to-rail output structure.

A complete design support documentation package for this circuit note can be found at http://www.analog.com/CN0180-DesignSupport.

COMMON VARIATIONS

The circuit is proven to work with good stability and accuracy with component values shown. Other Analog Devices, Inc., analog-to-digital converters can be used in place of the AD7982 to achieve the maximum desired performance. The AD8475 is capable of driving up to 18-bit, 4 MSPS ADCs with minimal degradation in performance. Faster sampling 18-bit ADCs include the AD7984 (1.33 MSPS) and AD7986 (2 MSPS). Differential 16-bit ADCs include the AD7688 (500 kSPS) and the AD7693 (500 kSPS).

The AD8475 can also be used directly to drive single-ended or pseudodifferential input ADCs. The AD8475's rail-to-rail outputs can be driven to within 0.5 V of each rail without significant ac performance degradation.

The AD8475 can also provide a differential attenuation of 0.8× by driving the IN 0.8× inputs. The supply voltage is flexible and can range between a single 3 V to 10 V supply. Dual supply operation is also possible up to ±5 V.

CIRCUIT EVALUATION AND TEST

This circuit is tested using the AD8475 evaluation board (EVAL-AD8475Z) connected to the Analog Devices PulSAR evaluation board and software. The EVAL-AD8475Z is a customer evaluation board intended to ease standalone testing of AD8475 performance and functionality. The board also enables quick testing with any of the Analog Devices SAR converters—it provides output connectors that mate directly with the analog input connectors (SMB) of the PulSAR evaluation board (EVAL-AD7982CBZ). The ADC converter evaluation and development board (EVAL-CED1Z) connects the setup to a PC through a USB, as shown in Figure 3.

PC EQUIPPED WITH:
• WINDOWS XP OR WINDOWS 2000
• 1 USB 2.0 SLOT

CONVERTER EVALUATION AND DEVELOPMENT BOARD (EVAL-CED1Z)
• NOT REQUIRED FOR STANDALONE EVALUATION
• COMMON TO MANY ANALOG DEVICES ADCs
• SOLD SEPARATELY FROM THE EVALUATION BOARD
• INCLUDES DC POWER SUPPLY
• INCLUDES USB CABLE

ANALOG INPUT CONNECTORS (SMB)

USB 2.0 CABLE (INCLUDED)

PulSAR EVALUATION BOARD (EVAL-AD76xx-CBZ)

UNIVERSAL WORLD COMPATIBLE DC POWER SUPPLY (INCLUDED);
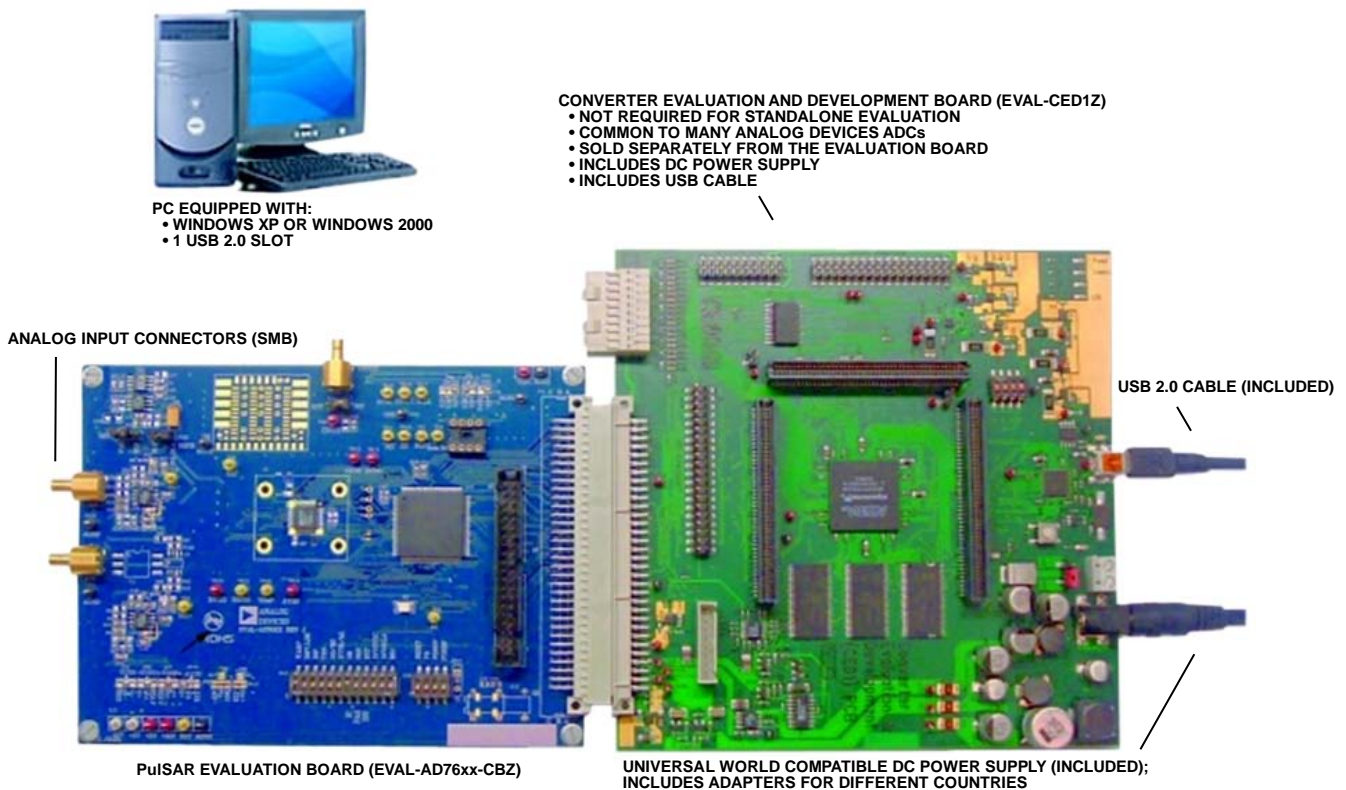INCLUDES ADAPTERS FOR DIFFERENT COUNTRIES

Figure 3. SAR ADC Converter Evaluation Platform (Note That the AD8475 Differential Amplifier Evaluation Board Connects to the SMB Analog Input Connectors of the PulSAR ADC Evaluation Board)

Equipment Needed

In addition to the three evaluation boards, a +5 V power supply is required for the AD8475 evaluation board. Alternately, the ADR435 5 V REF output of the AD7982 board can be connected to the AD8475 power supply input that configures the system as shown in Figure 1. An ac wallwart supplies a +12 V dc output for the CED1Z evaluation board. Appropriate voltages are supplied to the AD7982 evaluation board from the CED1Z board.

A suitable signal source such as an Audio Precision® AP2700 is also required.

A PC with Windows® 2000 or Windows XP equipped with a USB 2.0 port is needed to run the PulSAR evaluation software.

Getting Started

Connect the AD7982 evaluation board to the CED1Z board. Connect the AD8475 evaluation board to the AD7982 board using the SMB connectors on each board.

Install the software as described at http://www.analog.com/en/analog-to-digital-converters/ad-converters/ad7982/products/evaluation-boardstools/CU_PulsarADC_evaluation_tools/resources/fca.html#EVAL-CED1Z.

Setup and Test

An Audio Precision AP2700 source was used to provide the input signal to the AD8475. The PulSAR evaluation software, which is LabVIEW® based, can be used to control the Audio Precision input signals and also to monitor the ADC inputs and output.

LEARN MORE

CN0180 Design Support Package: http://www.analog.com/CN0180-DesignSupport.

ADI DiffAmpCalcuator™ Design Tool.

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Kester, Walt. 2004. *Analog-Digital Conversion*. Analog Devices. ISBN 0916550273. Chapter 9. Also available as *The Data Conversion Handbook*. Elsevier/Newnes. 2005. ISBN 0750678410, Chapter 9.

Kester, Walt. 2006. *High Speed System Applications*. Analog Devices. Chapter 2, "Optimizing Data Converter Interfaces."

MT-031 Tutorial, *Grounding Data Converters and Solving the Mystery of "AGND" and "DGND,"* Analog Devices.

MT-035 Tutorial, *Op Amp Inputs, Outputs, Single-Supply, and Rail-to-Rail Issues,* Analog Devices.

MT-074 Tutorial, *Differential Drivers for Precision ADCs,* Analog Devices.

MT-075 Tutorial, *Differential Drivers for High Speed ADCs Overview*, Analog Devices.

MT-076 Tutorial, *Differential Driver Analysis*, Analog Devices.

MT-101 Tutorial, *Decoupling Techniques*, Analog Devices.

Data Sheets and Evaluation Boards

Converter Evaluation and Development (CED) Board (EVAL-CED1Z)

PulSAR ADC Evaluation Platform

AD7982 Data Sheet

AD7982 Evaluation Board (EVAL-AD76XXCBZ)

AD8475 Data Sheet

AD8475 Evaluation Board (EVAL-AD8475Z).

ADR435 Data Sheet

REVISION HISTORY

5/11—Rev. 0 to Rev. A

10/10—Rev. 0: Initial Version

ANALOG DEVICES

www.analog.com