Converting a Single-Ended Signal with the AD7982 Differential PulSAR ADC

CIRCUIT FUNCTION AND BENEFITS
There are many applications that require a single-ended analog signal, either bipolar or unipolar, to be converted by a high resolution, differential input analog-to-digital converter (ADC). This dc-coupled circuit converts a single-ended input signal to a differential signal suitable for driving the AD7982, an 18-bit, 1 MSPS member of the PulSAR® family of ADCs.

This circuit uses the ADA4941-1 single-ended to differential driver and the ADR435 ultralow noise 5.0 V voltage reference. The circuit can accept many types of single-ended input signals, including bipolar or unipolar, ranging from high voltage to low voltage. Direct coupling is maintained throughout. If board space is at a premium, all the integrated circuits (ICs) shown in Figure 1 come in small packages; either a 3 mm × 3 mm lead-frame chip scale package (LFCSP) or a 3 mm × 5 mm micro small outline package (MSOP).

Figure 1. Single-Ended to Differential DC-Coupled Driver Circuit (Simplified Schematic)
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REVISION HISTORY

Document Title Changed from CN0032 to AN-1494......Universal
Changes to Figure 1 .......................................................................... 1
Changes to Circuit Description Section and Table 1 ............... 3
Changes to Common Variations Section ................................. 4

7/2009—Rev. 0 to Rev. A
Updated Format ............................................................................... Universal

7/2009—Revision 0: Initial Version
**CIRCUIT DESCRIPTION**

The differential input voltage range of the **AD7982** is set by the voltage on the **REF** pin. For \( V_{\text{REF}} = 5 \text{ V} \), the differential input voltage range is \( \pm V_{\text{REF}} = \pm 5 \text{ V} \). The voltage gain (or attenuation) from the single-ended source, \( V_{\text{IN}} \), to the **OUT+** pin of the **ADA4941-1** is set by the ratio of **R2** to **R1**. The ratio of Resistor **R2** to Resistor **R1** is equal to the ratio of **V_{\text{REF}}** to the peak-to-peak input voltage at **V_{\text{IN}}**. For a peak-to-peak, single-ended input voltage of 10 V and \( V_{\text{REF}} = 5 \text{ V} \), the ratio of Resistor **R2** to Resistor **R1** is 0.5. The signal at the **OUT+** pin is inverted (gain = -1) by the upper half of the **ADA4941-1**, which supplies the opposite phase output signal at the **OUT−** pin. The absolute value of Resistor **R1** determines the input impedance of the circuit. Feedback capacitor \( C_F \) is chosen based on the desired signal bandwidth, which is approximately \( 1/(2\pi R_2 C_F) \). The 20 \( \Omega \) resistors and the 2.7 nF capacitors act as a 3 MHz, single-pole, low-pass noise filter.

Resistors **R3** and **R4** set the common-mode voltage on the **IN−** input of the **AD7982**. The value of this common-mode voltage is \( V_{\text{OFFSET2}} = V_{\text{REF}} \times (1 + R_2/R_1) \), where \( V_{\text{OFFSET2}} = V_{\text{REF}} \times (R_3/(R_3 + R_4)) \). Resistors **R5** and **R6** set the common-mode voltage on the **IN+** input of the **ADC**. This voltage is equal to \( V_{\text{OFFSET1}} = V_{\text{REF}} \times (R_5 + R_6) \). The common-mode voltage of the **ADC**, which is equal to \( V_{\text{OFFSET1}} \), should be close to \( V_{\text{REF}}/2 \). This implies that \( R_5 = R_6 \). Table 1 shows some possible standard 1% values for the resistors for popular input voltage ranges.

The **ADA4941-1** operates on supply voltages of 7 V and −2 V. Because each output must swing from 0 V to 5 V, the positive supply voltage must be a few hundred millivolts greater than 5 V and the negative supply must be a few hundred millivolts more negative than 0 V. For this circuit, supply voltages of 7 V and −2 V are chosen. The 7 V supply also provides sufficient headroom to power the **ADR435**. Other voltages are possible, provided the absolute maximum total supply voltage on the **ADA4941-1** does not exceed 12 V and the headroom requirement of the **ADR435** is observed.

The **AD7982** requires a 2.5 V supply for \( V_{\text{IO}} \) as well as a \( V_{\text{IO}} \) supply (not shown in Figure 1), which can range between 1.8 V and 5 V, depending upon the input/output logic interface levels. This circuit is not sensitive to power supply sequencing. The **AD7982** inputs can withstand up to ±130 mA maximum during momentary overvoltage conditions.

The **AD7982** serial peripheral interface (SPI)-compatible serial interface (not shown in Figure 1) has the ability to daisy-chain several ADCs on a single 3-wire bus and provides an optional busy indicator using the **SDI** input pin. It is compatible with 1.8 V, 2.5 V, 3 V, and 5 V logic, using the separate \( V_{\text{IO}} \) supply. For full details on the SPI interface, digital modes, and logic power options, see the **AD7982** data sheet.

Excellent layout, grounding, and decoupling techniques must be utilized to achieve the desired performance from the circuits discussed in this note. As a minimum, use a 4-layer printed circuit board (PCB) with one ground plane layer, one power plane layer, and two signal layers.

All IC power pins must be decoupled to the ground plane with low inductance, multilayer ceramic capacitors (MLCC) of 0.01 \( \mu \text{F} \) to 0.1 \( \mu \text{F} \) (this is not shown in Figure 1 for simplicity). Follow the recommendations on the individual data sheets for the ICs referenced in the References section.

Consult the **EVAL-FDA-1** and **EVAL-AD7982** evaluation board user guides for the recommended layout and critical component placement of each product.

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**Table 1. Circuit Values and Voltages for Popular Input Voltage Ranges**

<table>
<thead>
<tr>
<th><strong>VIN (V)</strong></th>
<th><strong>V_{OFFSET1} (V)</strong></th>
<th><strong>V_{OFFSET2} (V)</strong></th>
<th><strong>OUT+ (V)</strong></th>
<th><strong>OUT− (V)</strong></th>
<th><strong>R1 (kΩ)</strong></th>
<th><strong>R2 (kΩ)</strong></th>
<th><strong>R4 (kΩ)</strong></th>
<th><strong>R3, R5, R6 (kΩ)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>+20, −20</td>
<td>2.5</td>
<td>2.203</td>
<td>−0.01, +4.96</td>
<td>5.0, 0.04</td>
<td>8.06</td>
<td>1.00</td>
<td>12.70</td>
<td>10.00</td>
</tr>
<tr>
<td>+10, −10</td>
<td>2.5</td>
<td>2.000</td>
<td>0.01, 4.99</td>
<td>4.99, 0.01</td>
<td>4.02</td>
<td>1.00</td>
<td>15.00</td>
<td>10.00</td>
</tr>
<tr>
<td>+5, −5</td>
<td>2.5</td>
<td>1.667</td>
<td>0.00, 5.00</td>
<td>5.00, 0.00</td>
<td>2.00</td>
<td>1.00</td>
<td>20.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>
COMMON VARIATIONS
For different reference voltages, the ADR430, ADR431, ADR433, ADR434, and ADR435 family of references has a wide range of values that can interface with the ADC.

REFERENCES


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


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


Voltage Reference Wizard Design Tool.