

## USING THE ADS7800 12 BIT ADC WITH UNIPOLAR INPUT SIGNALS

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The ADS7800 12 bit Sampling analog-to-digital-converter is designed to operate with bipolar inputs of  $\pm 5V$  or  $\pm 10V$ . With the addition of an external amplifier, the ADS7800 can be used for 10V or 20V unipolar inputs. Four unipolar input options are shown in this Bulletin.

### ADS7800 UNIPOLAR VOLTAGE INPUT RANGES

INPUT	SEE FIGURE
0 to +10V	2
0 to -10V	3
0 to +20V	4
0 to -20V	5

To understand how the circuits work, consider the ADS7800 input voltage divider network shown in Figure 1. Since the input resistor divider network drives a high impedance at  $V_o$ , the transfer function is:

$$V_o = \frac{R_3 (R_2 V_1 + R_1 V_2)}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

since  $R_2 = R_3$  and  $R_1 = 2 R_2$ ,

$$V_o = \frac{V_1 + 2 V_2}{5}$$

Where:

$V_1$  = voltage at pin 1 (V)

$V_2$  = voltage at pin 2 (V)

$V_o$  = voltage into ADC cell (V)

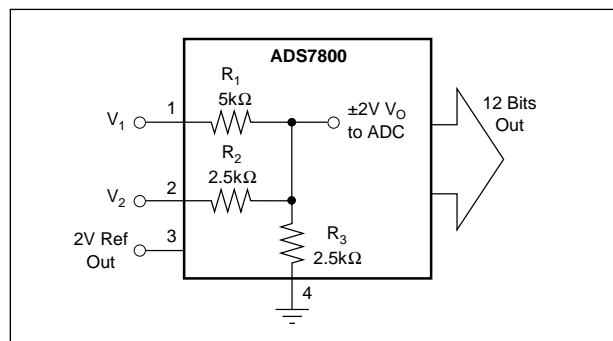


FIGURE 1. ADS7800 Input-Voltage Scaling Resistor Network.

The internal ADC gives a zero to full-scale digital output with  $\pm 2V$  at  $V_o$  (the internal ADC node voltage shown in Figure 1). When used in the standard bipolar voltage input mode, with  $V_2 = 0$  (i.e.  $V_2$  connected to analog ground),  $\pm 10V$  input at pin 1 of the ADS7800 produces  $\pm 2V$  output at  $V_o$ . Similarly,  $\pm 5V$  input at pin 2 produces  $\pm 2V V_o$  with  $V_1$

grounded. There are four unipolar input range connections to the ADS7800 that will produce  $\pm 2V V_o$  when  $V_1$  or  $V_2$  is connected to an appropriate offsetting voltage instead of ground. A summary of the four cases is shown in Table I.

INPUT RANGE	$V_1$	$V_2$	$V_o$
$\pm 5V$	0 (Ground)	INPUT	$\pm 2V$
$\pm 10V$	INPUT	0 (Ground)	$\pm 2V$
0 to +10V	-10.000V	INPUT	$\pm 2V$
0 to -10V	+10.000V	INPUT	$\pm 2V$
0 to +20V	INPUT	-5.000V	$\pm 2V$
0 to -20V	INPUT	+5.000V	$\pm 2V$

TABLE I. ADS7800 Input Ranges (see Figure 1).

The +2.0V reference output from the ADS7800 can be amplified to provide the  $\pm 5V$  or  $\pm 10V$  offsetting voltage needed. The circuits in Figures 2 to 5 show how to connect inverting or noninverting amplifiers for the various input ranges.

Adjustment of the offsetting voltage is required because the absolute accuracy of the 2.0V ADS7800 reference output may vary by a few percent. Adjust the 1k $\Omega$  pot for an accurate offsetting voltage (e.g.  $V_2 = 5.000V$  or  $V_1 = 10.000V$ ). Even though the reference output of the ADS7800 does not have absolute accuracy, the gain of the ADC is scaled to its value. Scaling the internal reference to generate the offsetting voltage preserves gain accuracy with temperature and supply variation so long as the  $R_4/R_5$  resistor ratio tracks with temperature and a low drift op amp, such as the OPA177, is used.

If desired, the ADC zero (negative full-scale) can be adjusted by fine trimming the offsetting voltage with the 1k $\Omega$  pot. To adjust the ADC zero, apply a 1/2 LSB voltage to the input of the ADC and adjust the gain adjust pot so the LSB output, pin 17, toggles between 1 and 0.

The 1/2 LSB zero-adjust voltage can be derived from a resistor divider connected to a voltage source (See Application Bulletin AB-003, 004, and 005 for  $\pm 10V$  references). Remember to consider the input impedance of the ADC when using a resistor divider. In the 10V range, the input impedance is  $2.5k\Omega + (2.5k\Omega \parallel 5k\Omega) = 4.17k\Omega$ , in the 20V range the input impedance is  $5k\Omega + (2.5k\Omega \parallel 2.5k\Omega) = 6.25k\Omega$ . Recommended values for a zero-adjust divider are:

INPUT RANGE (V)	1/2 LSB (V)	$V_{REF}$ (V)	$R_{D1}$ (k $\Omega$ )	$R_{D2}$ ( $\Omega$ )
0 to +10	0.012	+10.00	8.25	10.0
0 to -10	-0.012	-10.00	8.25	10.0
0 to +20	0.024	+10.00	4.12	10.0
0 to -20	-0.024	-10.00	4.12	10.0

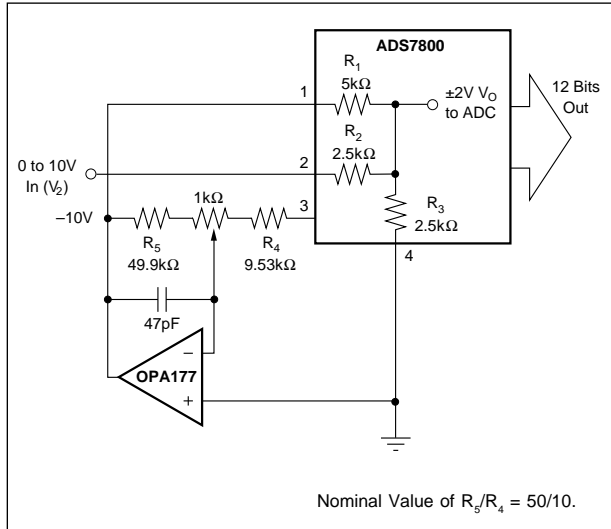


FIGURE 2. 12-Bit ADC with 0 to 10V Unipolar Input Range Using the ADC7800.

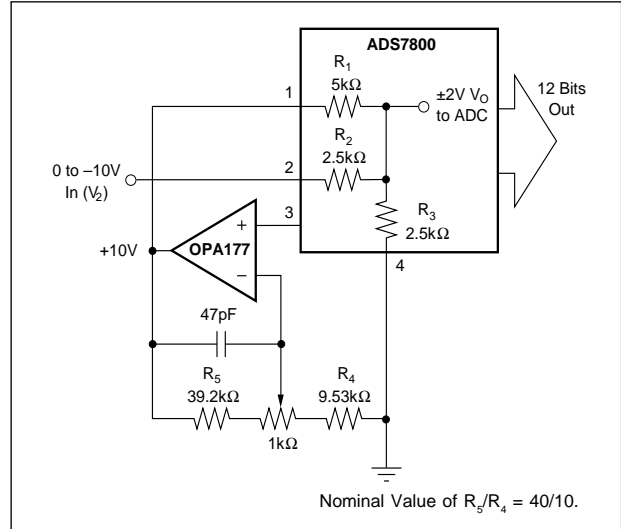


FIGURE 3. 12-Bit ADC with 0 to -10V Unipolar Input Range Using the ADC7800.

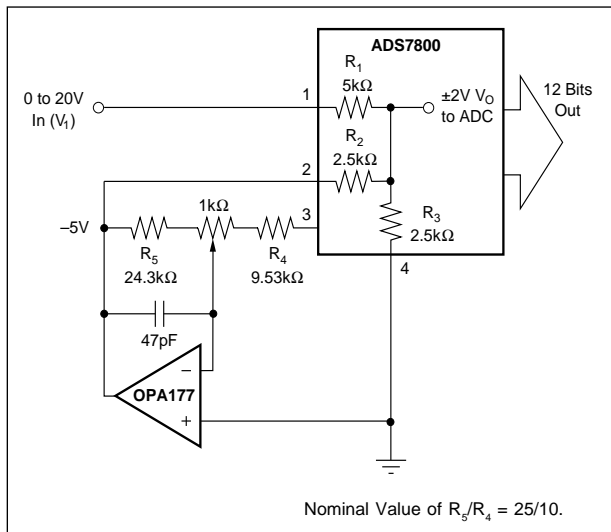


FIGURE 4. 12-Bit ADC with 0 to 20V Unipolar Input Range Using the ADC7800.

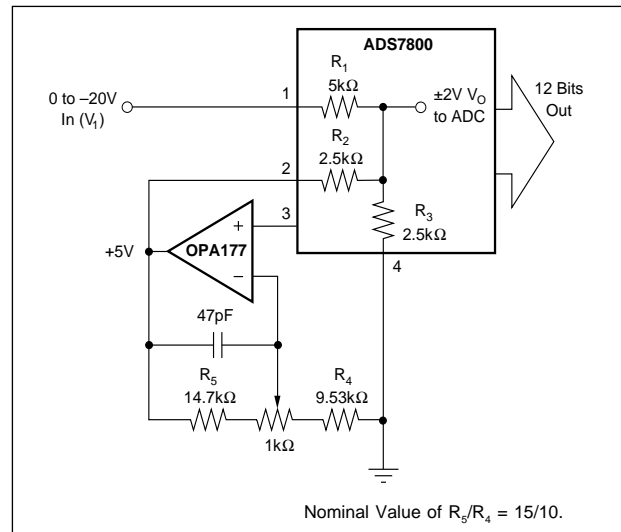


FIGURE 5. 12-Bit ADC with 0 to -20V Unipolar Input Range Using the ADC7800.

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