ANALOG DEVICES

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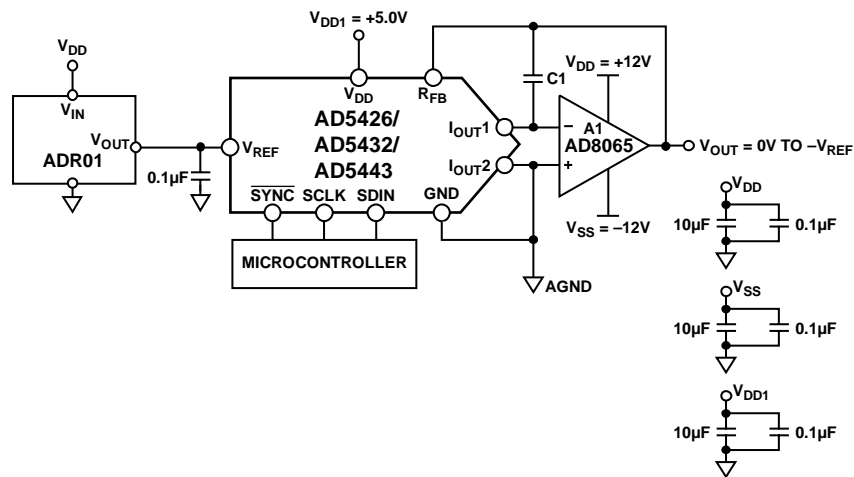
Unipolar, Precision, DC Digital-to-Analog Conversion Using the AD5426/AD5432/AD5443 8-Bit to 12-Bit DACs

CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 is a high performance, unipolar, precision, dc digital-to-analog conversion configuration that employs the AD5426/AD5432/AD5443 family of precision multiplying digital-to-analog converters (DACs), the AD8065 low noise operational amplifier (op amp), and the ADR01 precision reference. The op amp dictates the overall circuit performance in terms of precision or speed; therefore, the AD8065 high precision, low noise op amp is well matched for performance driven applications. This circuit also uses the ADR01, which is a high accuracy, high stability, 10 V precision voltage reference. Because voltage reference temperature coefficient and long-term drift are primary considerations for applications requiring high precision conversion, this device is an ideal candidate.

NOTES
1. C1 PHASE COMPENSATION (1pF TO 5pF) MAY BE REQUIRED IF A1 IS A HIGH SPEED AMPLIFIER.

Figure 1. Unipolar Output Precision DC Configuration (Simplified Schematic)

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REVISION HISTORY

11/2017—Rev. A to Rev. B
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Changes to Circuit Description Section 3

7/2009—Rev. 0 to Rev. A
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CIRCUIT DESCRIPTION

This circuit utilizes the AD5426/AD5432/AD5443 complementary metal-oxide semiconductor (CMOS), current output DACs that provide 8-bit, 10-bit, and 12-bit operation, respectively. Because the AD5426/AD5432/AD5443 is a current output DAC, an op amp is required for current to voltage (I to V) conversion at the output of the DAC. The bias current and offset voltage of the op amp are both important selection criteria for precision current output DACs; therefore, this circuit uses the AD8065 op amp, which has ultralow offset voltage (0.4 mV typical) and bias current (2 pA typical). The AD8065 and the AD5426/AD5432/AD5443 can be configured to provide a two-quadrant multiplying operation or a unipolar output voltage swing, as shown in Figure 1.

When an output amplifier is connected in unipolar mode, the output voltage (V_{OUT}) is calculated with the following equation:

$$V_{OUT} = -V_{REF} \times (D/2^N)$$

where:
V_{REF} is the input reference voltage.
D is the digital word loaded to the DAC: D = 0 to 255 (8-bit AD5426); D = 0 to 1023 (10-bit AD5432); and D = 0 to 4095 (12-bit AD5443).
N is the number of bits.

The input offset voltage of an op amp is multiplied by the variable noise gain (due to the code-dependent output resistance of the DAC) of the circuit. A change in this noise gain between two adjacent digital codes produces a step change in the output voltage due to the input offset voltage of the amplifier. This output voltage change is superimposed on the desired change in output between the two codes and gives rise to a differential linearity error that, if large enough, can cause the DAC to be nonmonotonic. In general, the input offset voltage should be a fraction of an LSB to ensure monotonic behavior when stepping through codes. For

the 12-bit AD5443, the LSB size is 10 V/2^{12} = 2.44 mV, whereas the input offset voltage of the AD8065 is only 0.4 mV.

COMMON VARIATIONS

The OP1177 is another excellent op amp candidate for the I to V conversion circuit. It also provides a low input offset voltage (15 μV typical) and ultralow input bias current (0.5 nA typical).

The 10.0 V ADR01 reference can be replaced by either the ADR02 or ADR03, which are low noise references available from the same reference family as the ADR01 and provide 5.0 V and 2.5 V, respectively. The ADR445 and ADR441 ultralow noise references are suitable substitutes that also provide 5.0 V and 2.5 V, respectively. Note that the size of the reference input voltage is restricted by the rail-to-rail voltage of the operational amplifier selected.

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