ANALOG DEVICES

AN-0986
APPLICATION NOTE

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Adjusting the Output Range and Span of the AD5362

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INTRODUCTION

This application note describes how the features of the AD5362 can be used to set up different output ranges on the DAC channels. While this application note uses the AD5362 as an example, the methods are also valid for the AD5360, the AD5361, and the AD5363. The relevant data sheet should be used in conjunction with this application note. Being able to set up different output ranges on different channels can be advantageous in PLC and analog I/O applications because it allows the user to use the full 16-bit digital code range (0 to 65,535) regardless of the output range of the DAC.

USING THE REFERENCE TO SELECT AN OUTPUT SPAN

In its default operating condition, the AD5362 produces a bipolar output span that is four times the reference value. For example, a 5 V reference gives a span of ±10 V, and a 3 V reference gives a span of ±6 V. The AD5362 has two independent reference input pins, VREF0 and VREF1. VREF0 is the reference source for DAC 0 to DAC 3, and VREF1 is the reference source for DAC 4 to DAC 7. Figure 1 shows how the separate reference values can be used to implement different DAC output ranges.

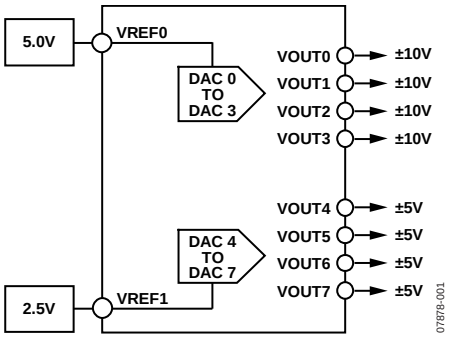

Figure 1. Using Separate References

CHANGING THE OUTPUT RANGE

By default, the DAC outputs swing positive and negative around 0 V. The center point of the span can be altered to give output ranges that do not necessarily center at 0 V. This is achieved by programming the offset DAC registers. There are two offset DAC registers in the AD5362. OFS0 controls the offset of DAC 0 to DAC 3 and OFS1 controls the offset of DAC 4 to DAC 7. The offset DACs in the AD5362 are 14-bit DACs and have a span of four times the reference value. In theory, this allows the user to move the output span up or down by up to 10 V. However, the outputs can only be adjusted within the limits of the supplies and headroom requirements. For example, using a 2.5 V reference, the nominal ±5 V output can be offset to produce either a −10 V to 0 V or 0 V to +10 V output. However, with a 5 V reference, producing a nominal ±10 V output, the offset DAC registers cannot be used to generate a 0 V to +20 V output because this violates the power supply and headroom limitations.

The output voltage of any DAC channel is governed by the following formula:

$$V_{OUT} = 4 \times V_{REF} \times \frac{DAC\_CODE - (4 \times OFFSET\_CODE)}{2^{16}} + V_{SIGGND}$$

where:

DAC_CODE is the data written to the X1A or X1B register of a DAC. It should be within the range of 0 to 65,535.

OFFSET_CODE is the value loaded to the relevant offset DAC register. It should be in the range of 0 to 16,383. Note that the *OFFSET_CODE* is multiplied by 4 in the equation because the offset DAC has 14 bits of resolution and the AD5362 DACs have 16 bits of resolution.

V_{REF} is the reference voltage and is in the range of 2.0 V to 5.0 V.

V_{SIGGND} is the voltage on the relevant SIGGND pin. This is normally 0 V.

The default value of the offset DAC register is 8192. This gives a voltage output that is bipolar and centered around 0 V. It can be seen from the preceding equation that values above 8192 move the center of the span below 0 V and values below 8192 move the center of the span above 0 V. Figure 2 shows how the offset DACs can be used to set up different ranges on different DACs.

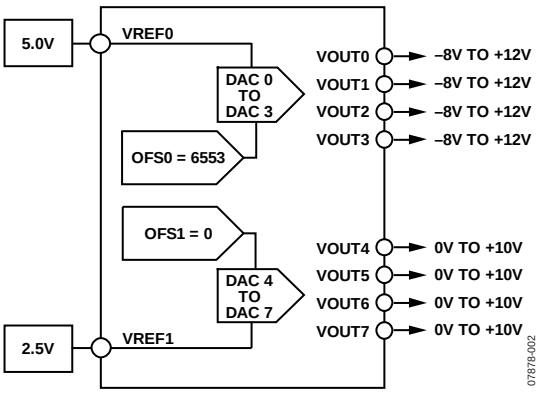

Figure 2. Generating Different Output Ranges

USING THE M AND C REGISTERS

Each DAC channel in the AD5362 has a dedicated gain (M) and offset (C) adjustment register. These registers work on the principle that, because the transfer function of the AD5362 is a straight line, it can be represented by the equation

$$y = mx + c \quad (1)$$

where:
y is the output.
x in the input.
m is the slope of the transfer function.
c is the offset.

Figure 3 shows how the registers are configured.

The default value for the M register is 65,535, which corresponds to a gain of 1. The default value of the C register is 32,768, corresponding to an offset of 0 V. All the M and C registers are 16 bits in resolution, meaning that each LSB is

$$1\ \text{LSB} = \frac{\left(4 \times V_{REF}\right)}{65{,}536} \quad (2)$$

Example 1

The AD5362 is required to produce a ±8 V output. A 4.096V reference is available.

Solution

The 4.096 V reference produces, by default, a ±8.192 V output (assuming there are no offset or gain errors). The zero code voltage, −8.192 V, can be converted to −8 V by adding 0.192 V of positive offset. This is achieved by programming the C register. With a 4.096 V reference, the output span is 16.384 V, which gives 1 LSB = 250 µV.

Moving the zero code from −8.192 V to +8 V therefore requires

$$\frac{0.192}{0.00025} = 768\ \text{LSBs}$$

to be added to the default value of the C register.

In theory, the full-scale voltage should now be 0.192 V higher. In reality, however, the positive full-scale voltage does not move. This is because the output is at a maximum when

$mx + 768 \geq 65{,}535$ (that is, when $x > 64{,}767$)

To alter the span from 16.384 V to 16 V requires that the gain register (that is, the slope of the transfer function) be reduced by

$$65{,}535 \times \left(\frac{16}{16.384}\right) = 63{,}999$$

The M register is programmed with 63,999.

The output now gives voltages between ±8 V for DAC codes between 0 and 65,535.

Example 2

The AD5362 is required to output −4 V to +12 V. A 4.096 V reference is available.

Solution

The output span for this example, 16 V, is the same as for Example 1. In this case, the offset DAC register can be used to move the span to the required range. The transfer function needs to be moved up by 4 V to obtain the desired span.

Because the offset DAC register is a 14-bit register, the LSB size is

$$\frac{16}{16{,}384} = 976.56\ \mu\text{V}$$

The default value for the offset DAC register is 8192.

To add 4 V to the transfer function requires programming the offset DAC register with

$$8192 - \left(\frac{4}{976.56\ \mu\text{V}}\right) = 4096$$

The output now gives voltages between −4 V and +12 V for DAC codes between 0 and 65,535.

ADDITIONAL INFORMATION

Note that the preceding examples assume that there are no gain or offset errors associated with the AD5362. The AD5362 is factory calibrated to produce the most accurate results when the default value of the offset DAC register is used. Altering the offset DAC register from its default value may add additional offset error to the DAC outputs. The offset can be compensated for by changing the offset DAC register until the correct output range is achieved.

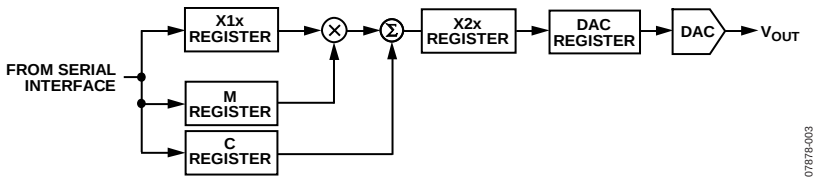

Figure 3. AD5362 Register Configuration

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