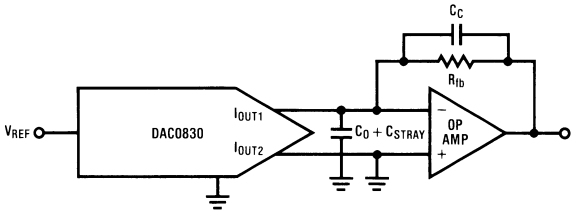
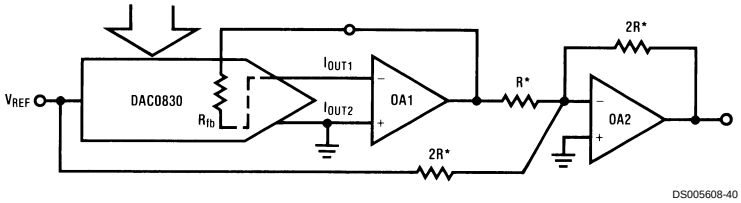
DAC0830 Series Application Hints (Continued)



OP Amp	C_C	t_s (O to Full Scale)
LF356	22 pF	4 µs
LF351	22 pF	5 µs
LF357*	10 pF	2 µs

***2.4 kΩ RESISTOR ADDED FROM−INPUT TO GROUND TO INSURE STABILITY**

FIGURE 8.



$$V_{OUT} = V_{REF} \frac{(\text{DIGITAL CODE} - 128)}{128}$$

$$1\ \text{LSB} = \frac{|V_{REF}|}{128}$$

Input Code								IDEAL V_{OUT}	
MSB							LSB	$+V_{REF}$	$-V_{REF}$
1	1	1	1	1	1	1	1	$V_{REF} - 1$ LSB	$-\lvert V_{REF}\rvert + 1$ LSB
1	1	0	0	0	0	0	0	$V_{REF}/2$	$-\lvert V_{REF}\rvert/2$
1	0	0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	1	-1 LSB	$+1$ LSB
0	0	1	1	1	1	1	1	$-\frac{\lvert V_{REF}\rvert}{2} - 1$ LSB	$\frac{\lvert V_{REF}\rvert}{2} + 1$ LSB
0	0	0	0	0	0	0	0	$-\lvert V_{REF}\rvert$	$+\lvert V_{REF}\rvert$

*THESE RESISTORS ARE AVAILABLE FROM BECKMAN INSTRUMENTS, INC. AS THEIR PART NO. 694-3-R10K-D

FIGURE 9.

2.6 Full-Scale Adjustment

In the case where the matching of R_{fb} to the R value of the R-2R ladder (typically ±0.2%) is insufficient for full-scale accuracy in a particular application, the V_{REF} voltage can be adjusted or an external resistor and potentiometer can be added as shown in *Figure 10* to provide a full-scale adjustment.

The temperature coefficients of the resistors used for this adjustment are of an important concern. To prevent degradation of the gain error temperature coefficient by the external resistors, their temperature coefficients ideally would have to match that of the internal DAC resistors, which is a highly impractical constraint. For the values shown in *Figure 10*, if the resistor and the potentiometer each had a temperature coefficient of ±100 ppm/°C maximum, the overall gain error temperature coefficent would be degraded a maximum of 0.0025%/°C for an adjustment pot setting of less than 3% of R_{fb}.

DAC0830 Series Application Hints

(Continued)

2.7 Using the DAC0830 in a Voltage Switching Configuration

The R-2R ladder can also be operated as a voltage switching network. In this mode the ladder is used in an inverted manner from the standard current switching configuration. The reference voltage is connected to one of the current output terminals (I_{OUT1} for true binary digital control, I_{OUT2} is for complementary binary) and the output voltage is taken from the normal V_{REF} pin. The converter output is now a voltage in the range from 0V to 255/256 V_{REF} as a function of the applied digital code as shown in *Figure 11*.

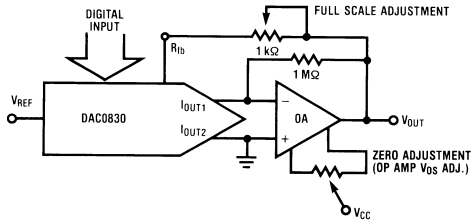


FIGURE 10. Adding Full-Scale Adjustment

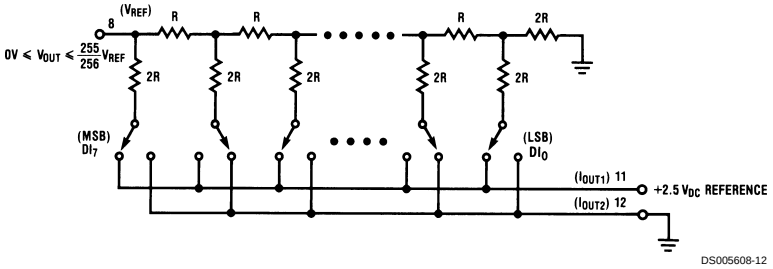
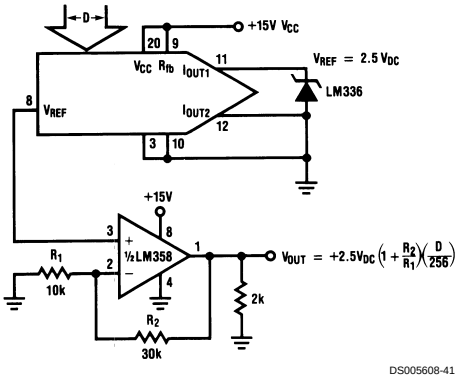


FIGURE 11. Voltage Mode Switching

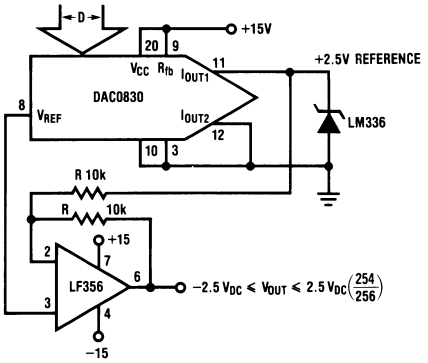
This configuration offers several useful application advantages. Since the output is a voltage, an external op amp is not necessarily required but the output impedance of the DAC is fairly high (equal to the specified reference input resistance of 10 kΩ to 20 kΩ) so an op amp may be used for buffering purposes. Some of the advantages of this mode are illustrated in *Figures 12, 13, 14, 15*.

There are two important things to keep in mind when using this DAC in the voltage switching mode. The applied reference voltage must be positive since there are internal parasitic diodes from ground to the I_{OUT1} and I_{OUT2} terminals which would turn on if the applied reference went negative. There is also a dependence of conversion linearity and gain error on the voltage difference between V_{CC} and the voltage applied to the normal current output terminals. This is a result of the voltage drive requirements of the ladder switches. To ensure that all 8 switches turn on sufficiently (so as not to add significant resistance to any leg of the ladder and thereby introduce additional linearity and gain errors) it is recommended that the applied reference voltage be kept less than $+5V_{DC}$ and V_{CC} be at least 9V more positive than V_{REF}. These restrictions ensure less than 0.1% linearity and gain error change. *Figures 16, 17, 18* characterize the effects of bringing V_{REF} and V_{CC} closer together as well as typical temperature performance of this voltage switching configuration.



- Voltage switching mode eliminates output signal inversion and therefore a need for a negative power supply.
- Zero code output voltage is limited by the low level output saturation voltage of the op amp. The 2 kΩ pull-down resistor helps to reduce this voltage.
- V_{OS} of the op amp has no effect on DAC linearity.

FIGURE 12. Single Supply DAC



- $V_{OUT} = 2.5V \left(\frac{D}{128} - 1\right)$
- Slewing and settling time for a full scale output change is $\approx 1.8\ \mu s$

FIGURE 13. Obtaining a Bipolar Output from a Fixed Reference with a Single Op Amp

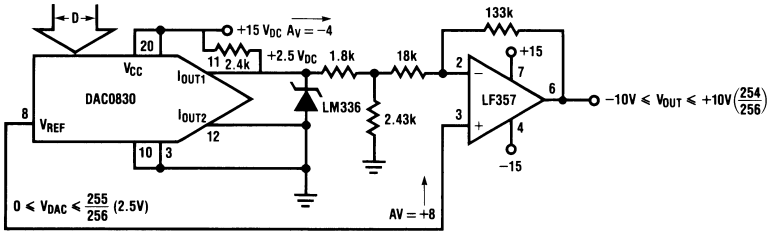
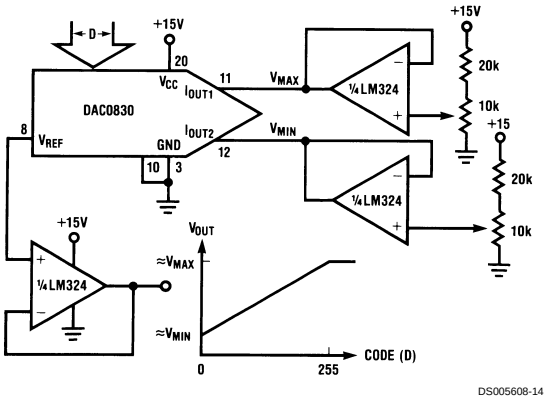


FIGURE 14. Bipolar Output with Increased Output Voltage Swing

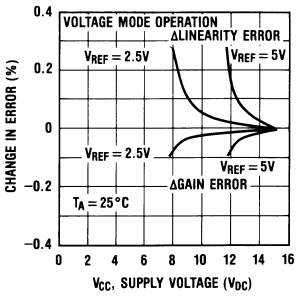
DAC0830 Series Application Hints (Continued)



- Only a single +15V supply required
- Non-interactive full-scale and zero code output adjustments
- V_{MAX} and V_{MIN} must be $\leq$ +5VDC and $\geq$ 0V.
- Incremental Output Step $= \frac{1}{256}(V_{MAX} - V_{MIN})$.
- $V_{OUT} = \frac{D}{256}(V_{MAX} - V_{MIN}) + \frac{255}{256}V_{MIN}$

FIGURE 15. Single Supply DAC with Level Shift and Span-Adjustable Output

Gain and Linearity Error Variation vs. Supply Voltage



Note: For these curves, V_{REF} is the voltage applied to pin 11 (I_{OUT1}) with pin 12 (I_{OUT2}) grounded.

FIGURE 16.

Gain and Linearity Error Variation vs. Reference Voltage

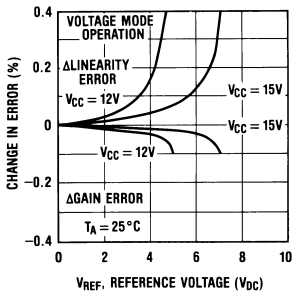


FIGURE 17.

DAC0830 Series Application Hints

(Continued)

Gain and Linearity Error Variation vs. Temperature

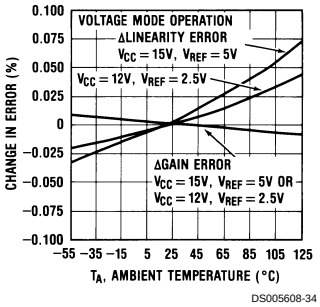


FIGURE 18.

2.8 Miscellaneous Application Hints

These converters are CMOS products and reasonable care should be exercised in handling them to prevent catastrophic failures due to static discharge.

Conversion accuracy is only as good as the applied reference voltage so providing a stable source over time and temperature changes is an important factor to consider.

A "good" ground is most desirable. A single point ground distribution technique for analog signals and supply returns keeps other devices in a system from affecting the output of the DACs.

During power-up supply voltage sequencing, the −15V (or −12V) supply of the op amp may appear first. This will cause the output of the op amp to bias near the negative supply potential. No harm is done to the DAC, however, as the on-chip 15 kΩ feedback resistor sufficiently limits the current flow from I_{OUT1} when this lead is internally clamped to one diode drop below ground.

Careful circuit construction with minimization of lead lengths around the analog circuitry, is a primary concern. Good high frequency supply decoupling will aid in preventing inadvertant noise from appearing on the analog output.

Overall noise reduction and reference stability is of particular concern when using the higher accuracy versions, the DAC0830 and DAC0831, or their advantages are wasted.

3.0 GENERAL APPLICATION IDEAS

The connections for the control pins of the digital input registers are purposely omitted. Any of the control formats discussed in Section 1 of the accompanying text will work with any of the circuits shown. The method used depends on the overall system provisions and requirements.

The digital input code is referred to as D and represents the decimal equivalent value of the 8-bit binary input, for example:

Binary Input								D
Pin 13						Pin 7		Decimal
MSB						LSB		Equivalent
1	1	1	1	1	1	1	1	255
1	0	0	0	0	0	0	0	128
0	0	0	1	0	0	0	0	16
0	0	0	0	0	0	1	0	2
0	0	0	0	0	0	0	0	0