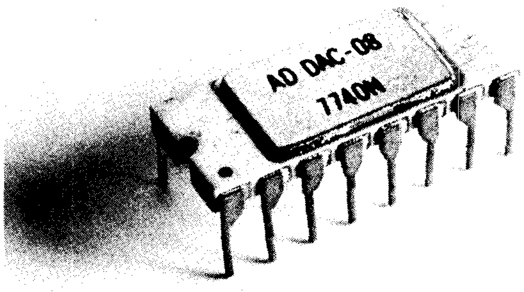
# 8-Bit Monolithic High Speed Multiplying D/A Converter

## AD DAC-08

ANALOG DEVICES

**PRELIMINARY TECHNICAL DATA**

**FEATURES**
- **Exact Replacement for Industry Standard DAC-08**
- **Fast (85ns typical) Settling Time**
- **Linearity Error ±1/4LSB (±0.1%) Guaranteed Over Full Temperature Range**
- **Wide Output Voltage Compliance: -10V to +18V**
- **Single Chip Monolithic Construction**
- **16-Pin Ceramic DIP Packaging**
- **Low Cost**
- **MIL-STD-883 Processing Available**




**PRODUCT DESCRIPTION**

The AD DAC-08 is a low-cost, 8-bit monolithic multiplying digital-to-analog converter featuring typical settling times of 85ns. The chip contains 8 matched bipolar current steering switches, a precision resistor network, and high-speed control amplifier, thus integrating all important circuit functions on a single chip.

The AD DAC-08 provides matching of full-scale output current to within 1LSB of the reference current. Analog Devices' precision linear processing makes this matching possible without the use of laser trimming. Diffused resistors are used rather than thin-film resistors in an effort to provide specified performance at low cost.

The AD DAC-08 is recommended for use in applications requiring 8-bit accuracy and fast settling times coupled with ease of use. The AD DAC-08 also provides an alternate source for designs already using the standard DAC-08.

The AD DAC-08 is available in 5 performance grades: the AD DAC-08A and AD DAC-08 are rated for the full -55°C to +125°C military temperature range; and the AD DAC-08H, E, and C grades are specified for the 0 to +70°C commercial temperature range. All models are guaranteed monotonic over their full temperature range, and all are packaged in a hermetically-sealed 16-pin ceramic dual-in-line package.

**PRODUCT HIGHLIGHTS**

1. The AD DAC-08 is a true second-source equivalent to the industry standard DAC-08.
2. The versatile current-in, current-out design, choice of fixed or variable reference, and CMOS or TTL compatible inputs offer the user greater flexibility in applying the device.
3. The fast settling time allows the AD DAC-08 to be used in applications such as CRT displays, waveform generators, and high-speed analog-to-digital converters.
4. The high impedance current output can drive a resistor directly, or be used with an external op amp to produce a low impedance output voltage.
5. The AD DAC-08 is available in chip form for use in hybrid microcircuits. Consult Analog Devices' chip catalog for available grades and application details.
6. The AD DAC-08 and AD DAC-08A are available fully screened to MIL-STD-883, Method 5004 Class B. A full list of tests is available upon request.

# SPECIFICATIONS

**The AD DAC-08 and AD DAC-08A specifications apply for $V_S = \pm15V$, $I_{REF} = 2.0mA$, $T_A = -55°C$ to $+125°C$ unless otherwise noted.**

| MODEL CHARACTERISTIC | SYMBOL | CONDITIONS | AD DAC-08 MIN | AD DAC-08 TYP | AD DAC-08 MAX | AD DAC-08A MIN | AD DAC-08A TYP | AD DAC-08A MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| RESOLUTION | | | | | 8 | | | 8 | Bits |
| MONOTONICITY | | $T_A = -55°C$ to $+125°C$ | | GUARANTEED | | | GUARANTEED | | |
| NONLINEARITY | | $T_A = -55°C$ to $+125°C$ | | | ±0.19 | | | ±0.1 | % FS |
| SETTLING TIME | $t_s$ | Full Scale Step to ±1/2LSB | | 85 | 135 | | 85 | 135 | ns |
| PROPAGATION DELAY | $t_{PLH}, t_{PHL}$ | All Bits Switched | | 35 | 60 | | 35 | 60 | ns |
| FULL SCALE TEMPCO | $TC\ I_{FS}$ | | | ±10 | ±50 | | ±10 | ±50 | ppm/°C |
| OUTPUT VOLTAGE COMPLIANCE | $V_{OC}$ | $\Delta I_{FS} < 1/2LSB$; $R_{OUT} > 20M\Omega$ typ | -10 | | -18 | -10 | | +18 | V dc |
| FULL SCALE CURRENT | $I_{FS4}$ | $V_{REF} = 10.000V$; $R_{14}, R_{15} = 5.000k\Omega$; $T_A = 25°C$ | 1.94 | 1.99 | 2.04 | 1.984 | 1.992 | 2.000 | mA |
| FULL SCALE SYMMETRY | $I_{FSS}$ | $(I_{FS4} - I_{FS2})$ | | ±1.0 | ±8.0 | | ±0.5 | ±4.0 | μA |
| ZERO SCALE CURRENT | $I_{ZS}$ | | | 0.2 | 2.0 | | 0.1 | 1.0 | μA |
| OUTPUT CURRENT RANGE | $I_{FSR}$ | $V- = -5.0V$ | 0 | 2.0 | 2.1 | 0 | 2.0 | 2.1 | mA |
| | | $V- = -7.0$ to $-18V$ | 0 | 2.0 | 4.2 | 0 | 2.0 | 4.2 | mA |
| LOGIC INPUT LEVELS | | | | | | | | | |
| Logic "0" | $V_{IL}$ | $V_{LC} = 0V$ | | | 0.8 | | | 0.8 | V |
| Logic "1" | $V_{IH}$ | $V_{LC} = 0V$ | 2.0 | | | 2.0 | | | V |
| LOGIC INPUT CURRENTS | | $V_{LC} = 0V$ | | | | | | | |
| Logic "0" | $I_{IL}$ | $-10V < V_{IN} < +0.8V$ | | -2.0 | -10 | | -2.0 | -10 | μA |
| Logic "1" | $I_{IH}$ | $2.0V < V_{IN} < 18V$ | | 0.002 | 10 | | 0.002 | 10 | μA |
| LOGIC INPUT SWING | $V_{IS}$ | $V- = -15V$ | -10 | | +18 | -10 | | +18 | V |
| LOGIC THRESHOLD RANGE | $V_{THR}$ | $V_S = \pm15V$ | -10 | | +13.5 | -10 | | +13.5 | V |
| REFERENCE BIAS CURRENT | $I_{REF}$ | | +0.1 | -1.0 | -3.0 | +0.1 | -1.0 | -3.0 | μA |
| REFERENCE INPUT SLEW RATE | dI/dt | | 4.0 | 8.0 | | 4.0 | 8.0 | | mA/μs |
| POWER SUPPLY SENSITIVITY | $PSSI_{FS+}$ | $V+ = 4.5V$ to $18V$ | | +0.0003 | ±0.01 | | ±0.0003 | ±0.01 | %/% |
| | $PSSI_{FS-}$ | $V- = 4.5V$ to $-18V$; $I_{REF} = 1.0mA$ | | ±0.002 | ±0.01 | | ±0.002 | ±0.01 | %/% |
| POWER SUPPLY CURRENT | | | | | | | | | |
| From $+V_S$ | I+ | | 0.4 | 2.3 | 3.8 | 0.4 | 2.3 | 3.8 | mA |
| From $-V_S$ | I- | | -0.8 | -6.4 | -7.8 | -0.8 | -6.4 | -7.8 | mA |
| POWER DISSIPATION | $P_D$ | ±5V, $I_{REF} = 1.0mA$ | | 33 | 48 | | 33 | 48 | mW |
| | | +5V, -15V, $I_{REF} = 2.0mA$ | | 108 | 136 | | 108 | 136 | mW |
| | | ±15V, $I_{REF} = 2.0mA$ | | 135 | 174 | | 135 | 174 | mW |

## ABSOLUTE MAXIMUM RATINGS

Operating Temperature
- AD DAC-08, DAC-08A . . . . . . . . . . . . . -55°C to +125°C
- AD DAC-08E, C, H . . . . . . . . . . . . . . . . . . . 0 to +70°C

Storage Temperature . . . . . . . . . . . . . . . . -65°C to +150°C
- Power Dissipation . . . . . . . . . . . . . . . . . . . . . . 500mW
- Above 100°C Derate by . . . . . . . . . . . . . . . 10mW/°C

Lead Soldering Temperature . . . . . . . . . . . . . 300°C (60sec)
$-V_S$ Supply to $+V_S$ Supply . . . . . . . . . . . . . . . . . . . . 36V
Logic Inputs. . . . . . . . . . . . . . . . . . . . $-V_S$ to $(-V_S + 36V)$
- $V_{LC}$ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $-V_S$ to $+V_S$

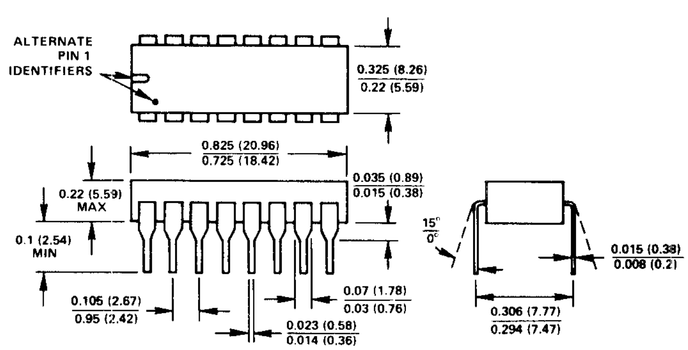
Reference Inputs $(V_{14}, V_{15})$. . . . . . . . . . . . . . $-V_S$ to $+V_S$
Reference Input Differential
- Voltage ($V_{14}$ to $V_{15}$). . . . . . . . . . . . . . . . . . . . . ±18V

Reference Input Current $(I_{14})$ . . . . . . . . . . . . . . . . . 5.0mA

## OUTLINE DIMENSIONS

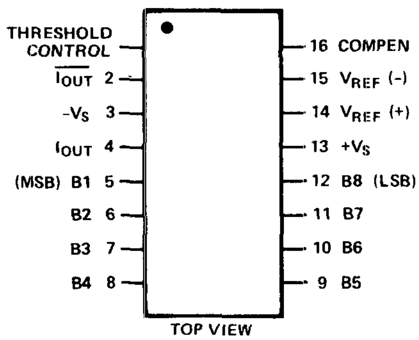
Dimensions shown in inches and (mm).

### 16-PIN DUAL-IN-LINE

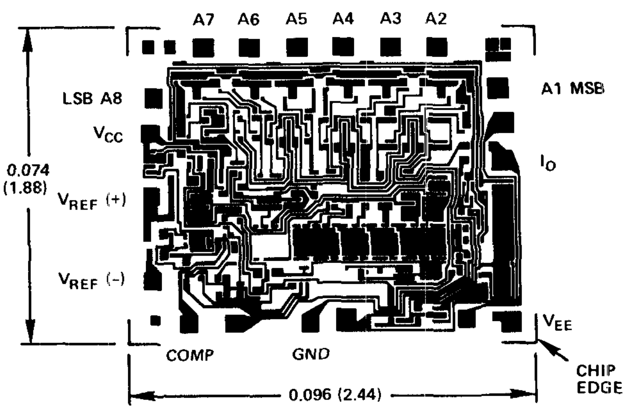


# SPECIFICATIONS The AD DAC-08C, E, and H specifications apply for $V_S = \pm 15V$, $I_{REF} = 2.0mA$, $T_A = 0$ to $+70°C$ unless otherwise noted.

| MODEL CHARACTERISTIC | SYMBOL | CONDITIONS | AD DAC-08C MIN | AD DAC-08C TYP | AD DAC-08C MAX | AD DAC-08E MIN | AD DAC-08E TYP | AD DAC-08E MAX | AD DAC-08H MIN | AD DAC-08H TYP | AD DAC-08H MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RESOLUTION | | | | | 8 | | | 8 | | | 8 | Bits |
| MONOTONICITY | | $T_A = 0$ to $+70°C$ | | GUARANTEED | | | GUARANTEED | | | GUARANTEED | | |
| NONLINEARITY | | $T_A = 0$ to $+70°C$ | | | ±0.39 | | | ±0.19 | | | ±0.1 | % FS |
| SETTLING TIME | $t_s$ | Full Scale Step to ±1/2LSB | | 85 | 150 | | 85 | 150 | | 85 | 135 | ns |
| PROPAGATION DELAY | $t_{PLH}$, $t_{PHL}$ | All Bits Switched | | 35 | 60 | | 35 | 60 | | 35 | 60 | ns |
| FULL SCALE TEMPCO | TC $I_{FS}$ | | | ±10 | ±80 | | ±10 | ±50 | | ±10 | ±50 | ppm/°C |
| OUTPUT VOLTAGE COMPLIANCE | $V_{OC}$ | $\Delta I_{FS} < 1/2LSB$; $R_{OUT} > 20M\Omega$ | -10 | | +18 | -10 | | +18 | -10 | | +18 | V dc |
| FULL SCALE CURRENT | $I_{FS4}$ | $V_{REF} = 10.000V$; $R_{14}$, $R_{15}$ = 5.000kΩ; $T_A = 25°C$ | 1.94 | 1.99 | 2.04 | 1.94 | 1.99 | 2.04 | 1.984 | 1.992 | 2.000 | mA |
| FULL SCALE SYMMETRY | $I_{FSS}$ | $(I_{FS4} - I_{FS2})$ | | ±2.0 | ±16 | | ±1.0 | ±8.0 | | ±0.5 | ±4.0 | μA |
| ZERO SCALE CURRENT | $I_{ZS}$ | | | 0.2 | 4.0 | | 0.2 | 2.0 | | 0.1 | 1.0 | μA |
| OUTPUT CURRENT RANGE | $I_{FSR}$ | $V- = -5.0V$ | 0 | 2.0 | 2.1 | 0 | 2.0 | 2.1 | 0 | 2.0 | 2.1 | mA |
| | | $V- = -7.0$ to $-18V$ | 0 | 2.0 | 4.2 | 0 | 2.0 | 4.2 | 0 | 2.0 | 4.2 | mA |
| LOGIC INPUT LEVELS | | | | | | | | | | | | |
| Logic "0" | $V_{IL}$ | $V_{LC} = 0V$ | | | 0.8 | | | 0.8 | | | 0.8 | V |
| Logic "1" | $V_{IH}$ | $V_{LC} = 0V$ | 2.0 | | | 2.0 | | | 2.0 | | | V |
| LOGIC INPUT CURRENTS | | $V_{LC} = 0V$ | | | | | | | | | | |
| Logic "0" | $I_{IL}$ | $-10V < V_{IN} < +0.8V$ | | -2.0 | -10 | | -2.0 | -10 | | -2.0 | -10 | μA |
| Logic "1" | $I_{IH}$ | $2.0V < V_{IN} < 18V$ | | 0.002 | 10 | | 0.002 | 10 | | 0.002 | 10 | μA |
| LOGIC INPUT SWING | $V_{IS}$ | $V- = -15V$ | -10 | | +18 | -10 | | +18 | -10 | | +18 | V |
| LOGIC THRESHOLD RANGE | $V_{IHL}$ | $V_S = \pm 15V$ | -10 | | +13.5 | -10 | | +13.5 | -10 | | +13.5 | V |
| REFERENCE BIAS CURRENT | $I_{REF}$ | | +0.1 | -1.0 | -3.0 | +0.1 | -1.0 | -3.0 | +0.1 | -1.0 | -3.0 | μA |
| REFERENCE INPUT SLEW RATE | dI/dt | | 4.0 | 8.0 | | 4.0 | 8.0 | | 4.0 | 8.0 | | mA/μs |
| POWER SUPPLY SENSITIVITY | $PSSI_{FS+}$ | $V+ = 4.5V$ to $18V$ | | +0.0003 | ±0.01 | | ±0.0003 | ±0.01 | | ±0.0003 | ±0.01 | %/% |
| | $PSSI_{FS-}$ | $V- = -4.5V$ to $-18V$; $I_{REF} = 1.0mA$ | | ±0.002 | ±0.01 | | ±0.002 | ±0.01 | | ±0.002 | ±0.01 | %/% |
| POWER SUPPLY CURRENT | I+ | From $+V_S$ | 0.4 | 2.3 | 3.8 | 0.4 | 2.3 | 3.8 | 0.4 | 2.3 | 3.8 | mA |
| | I- | From $-V_S$ | -0.8 | -6.4 | -7.8 | -0.8 | -6.4 | -7.8 | -0.8 | -6.4 | -7.8 | mA |
| POWER DISSIPATION | $P_D$ | ±5V, $I_{REF} = 1.0mA$ | | 33 | 48 | | 33 | 48 | | 33 | 48 | mW |
| | | +5V, -15V, $I_{REF} = 2.0mA$ | | 108 | 136 | | 108 | 136 | | 108 | 136 | mW |
| | | ±15V, $I_{REF} = 2.0mA$ | | 135 | 174 | | 135 | 174 | | 135 | 174 | mW |




*Pin Connections*




THE AD DAC-08 IS ALSO AVAILABLE IN CHIP FORM. CONSULT ANALOG DEVICES' CHIP CATALOG FOR SPECIFICATIONS AND APPLICATIONS INFORMATION.

*Chip Dimensions and Pad Layout. Dimensions shown in inches and (mm).*

## APPLYING THE AD DAC-08

### Reference Connections

Figure 1 shows the block diagram of the AD DAC-08 circuit. A reference current (equal to the desired full-scale output current) is applied to pin 14. The reference amplifier adjusts the base voltage of the NPN current source transistors. The collector currents are binarily weighted, and their sum is equal to 255/256 times the reference current. The binary weighting is accomplished by the diffused resistor R-2R ladder network. The individual collector currents are steered into either the $I_{OUT}$ or $\overline{I_{OUT}}$ lines by the current switches. These switches are driven by level shifters which can accept TTL or CMOS logic levels directly. The $I_{OUT}$ and $\overline{I_{OUT}}$ lines can drive an op amp summing junction or can drive resistive loads directly due to the wide range of output compliance voltage.

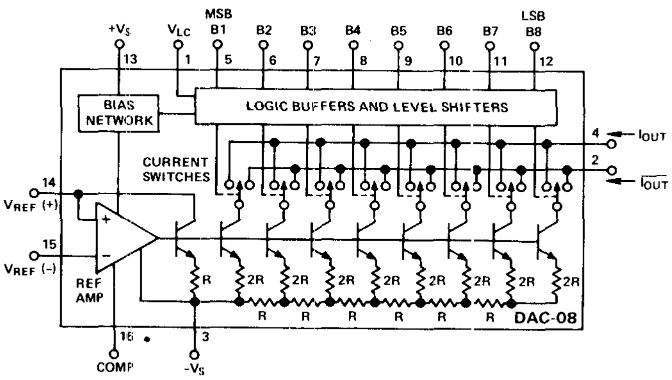



*Figure 1. AD DAC-08 Block Diagram*

Figure 2 illustrates the connections for positive and negative references. When a positive reference is used (Figure 2a), resistor R14 (equal to $V_{REF}$ divided by the desired $I_{FS}$) establishes the reference current into pin 14. Reference amplifier bias current errors are minimized by connecting R15 (equal to R14) from pin 15 to ground. Adjustment of the output scale can be done by trimming R14, although in most applications the tight initial matching between reference current and output current will be adequate.

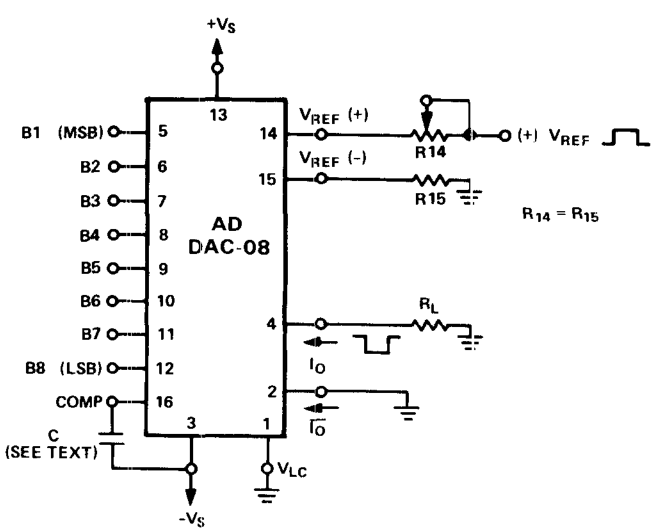



*Figure 2a. Connections for Use with Positive Reference*

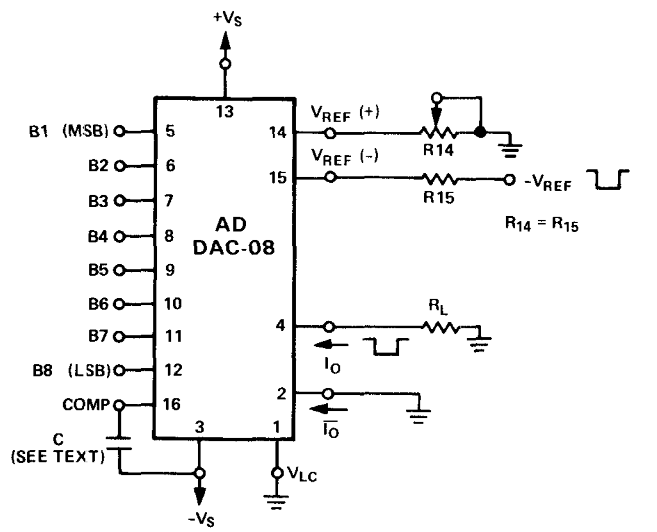



*Figure 2b. Connections for Use with Negative Reference*

Figure 2b shows the connections for a negative reference. Note that the reference current flows from ground into pin 14 through R14, which should be a low TC resistor as in the positive reference configuration. Resistor R15 serves the purpose of bias current cancellation only and need not be a precision resistor. Note that the input impedance for a negative reference is very high, while a positive reference sees an impedance equal to R14.

When a dc reference is used, a reference bypass capacitor is recommended. The reference should be a low-drift, well-regulated and filtered type, such as the AD581 10V reference IC. Other values of reference voltage may be used, provided that R14 is chosen for a reference current between 0.2mA and 4.0mA.

The reference amplifier requires an external compensation capacitor from pin 16 to $-V_S$. When a fixed dc reference is used, a 0.01μF capacitor is recommended.

## MULTIPLYING MODE PERFORMANCE

The AD DAC-08 can be used to perform two-quadrant digital-analog multiplication by applying an ac reference signal. When an ac reference is used, pin 15 must be offset to insure that pin 14 is always at a higher potential than pin 15.

The reference amplifier must be properly compensated in ac applications to insure stability. The value of the capacitor from pin 16 to $-V_S$ depends on the value of R14. Minimum values of compensation capacitor for R14 values of 1, 2 and 5kΩ are 15, 37 and 75pF respectively.

## LOGIC INPUT CIRCUIT

The AD DAC-08 digital inputs will accommodate all popular logic families. The switching threshold is adjustable by applying a voltage to the logic threshold control pin (pin 1). The threshold is nominally 1.4 volts above $V_{LC}$ at room temperature. For TTL/DTL interface, pin 1 is simply grounded. The logic inputs will tolerate wide voltage swings; for example, for $-V_S = -15V$, the inputs may swing between -10V and +18V.