



# 8-Bit, High-Speed, Multiplying D/A Converter (Universal Digital Logic Interface)

# DAC08

## FEATURES

**Fast Settling Output Current: 85 ns**

### Full-Scale Current Prematched to $\pm 1$ LSB

### Direct Interface to TTL, CMOS, ECL, HTL, PMOS

**Nonlinearity to 0.1% Maximum over**

### Temperature Range

### High Output Impedance and Compliance:

**-10 V to +18 V**

### Complementary Current Outputs

### Wide Range Multiplying Capability: 1 MHz Bandwidth

**Low FS Current Drift:  $\pm 10$  ppm/°C**

**Wide Power Supply Range:  $\pm 4.5$  V to  $\pm 18$  V**

**Low Power Consumption: 33 mW @  $\pm 5$  V**

### Low Cost

**Available in Die Form**

## GENERAL DESCRIPTION

The DAC08 series of 8-bit monolithic digital-to-analog converters provide very high-speed performance coupled with low cost and outstanding applications flexibility.

Advanced circuit design achieves 85 ns settling times with very low “glitch” energy and at low power consumption. Monotonic multiplying performance is attained over a wide 20-to-1 reference current range. Matching to within 1 LSB between reference and

full-scale currents eliminates the need for full-scale trimming in most applications. Direct interface to all popular logic families with full noise immunity is provided by the high swing, adjustable threshold logic input.

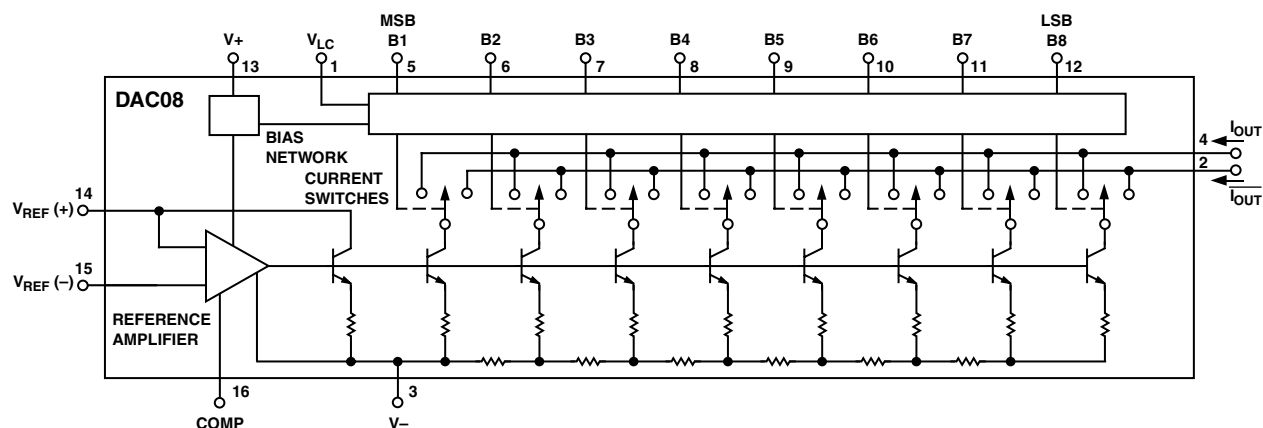
High voltage compliance complementary current outputs are provided, increasing versatility and enabling differential operation to effectively double the peak-to-peak output swing. In many applications, the outputs can be directly converted to voltage without the need for an external op amp.

All DAC08 series models guarantee full 8-bit monotonicity, and nonlinearities as tight as  $\pm 0.1\%$  over the entire operating temperature range are available. Device performance is essentially unchanged over the  $\pm 4.5\text{ V}$  to  $\pm 18\text{ V}$  power supply range, with 33 mW power consumption attainable at  $\pm 5\text{ V}$  supplies.

The compact size and low power consumption make the DAC08 attractive for portable and military/aerospace applications; devices processed to MIL-STD-883, Level B are available.

DAC08 applications include 8-bit, 1  $\mu$ s A/D converters, servo motor and pen drivers, waveform generators, audio encoders and attenuators, analog meter drivers, programmable power supplies, CRT display drivers, high-speed modems and other applications where low cost, high speed and complete input/output versatility are required.

### FUNCTIONAL BLOCK DIAGRAM



REV. B

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# DAC08—SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS

(@  $V_S = \pm 15\text{ V}$ ,  $I_{REF} = 2.0\text{ mA}$ ,  $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$  for DAC08/08A,  $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$  for DAC08E and DAC08H,  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  for DAC08C, unless otherwise noted. Output characteristics refer to both  $I_{OUT}$  and  $I_{OUT-}$ .)

| Parameter                      | Symbol                                             | Conditions                                                                                                                                                                           | DAC08A/H                                  |                                           |            | DAC08E                                    |                                           |                      | DAC08C                                    |                                           |            | Unit                                                             |
|--------------------------------|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------------------------------------------|------------|-------------------------------------------|-------------------------------------------|----------------------|-------------------------------------------|-------------------------------------------|------------|------------------------------------------------------------------|
|                                |                                                    |                                                                                                                                                                                      | Min                                       | Typ                                       | Max        | Min                                       | Typ                                       | Max                  | Min                                       | Typ                                       | Max        |                                                                  |
| Resolution                     |                                                    |                                                                                                                                                                                      | 8                                         |                                           |            | 8                                         |                                           |                      | 8                                         |                                           |            | Bits                                                             |
| Monotonicity                   |                                                    |                                                                                                                                                                                      | 8                                         |                                           |            | 8                                         |                                           |                      | 8                                         |                                           |            | Bits                                                             |
| Nonlinearity                   | NL                                                 |                                                                                                                                                                                      |                                           |                                           | $\pm 0.1$  |                                           |                                           | $\pm 0.19$           |                                           |                                           | $\pm 0.39$ | % FS                                                             |
| Settling Time                  | $t_S$                                              | To $\pm 1/2$ LSB,<br>All Bits Switched ON<br>or OFF, $T_A = 25^\circ\text{C}^1$                                                                                                      |                                           | 85                                        | 135        |                                           | 85                                        | 150                  |                                           | 85                                        | 150        | ns                                                               |
| Propagation Delay              |                                                    |                                                                                                                                                                                      |                                           |                                           |            |                                           |                                           |                      |                                           |                                           |            |                                                                  |
| Each Bit                       | $t_{PLH}$                                          | $T_A = 25^\circ\text{C}^1$                                                                                                                                                           |                                           | 35                                        | 60         |                                           | 35                                        | 60                   |                                           | 35                                        | 60         | ns                                                               |
| All Bits Switched              | $t_{PHL}$                                          |                                                                                                                                                                                      |                                           | 35                                        | 60         |                                           | 35                                        | 60                   |                                           | 35                                        | 60         | ns                                                               |
| Full-Scale Tempco <sup>1</sup> | $TCI_{FS}$                                         | DAC08E                                                                                                                                                                               |                                           | $\pm 10$                                  | $\pm 50$   |                                           | $\pm 10$                                  | $\pm 80$<br>$\pm 50$ |                                           | $\pm 10$                                  | $\pm 80$   | ppm/ $^\circ\text{C}$                                            |
| Output Voltage                 |                                                    |                                                                                                                                                                                      |                                           |                                           |            |                                           |                                           |                      |                                           |                                           |            |                                                                  |
| Compliance                     | $V_{OC}$                                           | Full-Scale Current<br>Change $< 1/2$ LSB,<br>$R_{OUT} > 20\text{ M}\Omega$ typ                                                                                                       | -10                                       |                                           | +18        | -10                                       |                                           | +18                  | -10                                       |                                           | +18        | V                                                                |
| Full Range Current             | $I_{FR4}$                                          | $V_{REF} = 10.000\text{ V}$<br>$R_{14}, R_{15} = 5.000\text{ k}\Omega$<br>$T_A = 25^\circ\text{C}$                                                                                   | 1.984                                     | 1.992                                     | 2.000      | 1.94                                      | 1.99                                      | 2.04                 | 1.94                                      | 1.99                                      | 2.04       | mA                                                               |
| Full Range Symmetry            | $I_{FRS}$                                          | $I_{FR4} - I_{FR2}$                                                                                                                                                                  |                                           | $\pm 0.5$                                 | $\pm 4$    |                                           | $\pm 1$                                   | $\pm 8$              |                                           | $\pm 2$                                   | $\pm 16$   | $\mu\text{A}$                                                    |
| Zero-Scale Current             | $I_{ZS}$                                           |                                                                                                                                                                                      |                                           | 0.1                                       | 1          |                                           | 0.2                                       | 2                    |                                           | 0.2                                       | 4          | $\mu\text{A}$                                                    |
| Output Current Range           | $I_{OR1}$<br>$I_{OR2}$                             | $R_{14}, R_{15} = 5.000\text{ k}\Omega$<br>$V_{REF} = +15.0\text{ V}$ ,<br>$V_- = -10\text{ V}$<br>$V_{REF} = +25.0\text{ V}$ ,<br>$V_- = -12\text{ V}$<br>$I_{REF} = 2\text{ mA}$   | 2.1                                       |                                           |            | 2.1                                       |                                           |                      | 2.1                                       |                                           |            | mA                                                               |
| Output Current Noise           |                                                    |                                                                                                                                                                                      |                                           | 25                                        |            |                                           | 25                                        |                      |                                           | 25                                        |            | nA                                                               |
| Logic Input Levels             |                                                    |                                                                                                                                                                                      |                                           |                                           |            |                                           |                                           |                      |                                           |                                           |            |                                                                  |
| Logic “0”                      | $V_{IL}$                                           | $V_{LC} = 0\text{ V}$                                                                                                                                                                |                                           |                                           | 0.8        |                                           |                                           | 0.8                  |                                           |                                           | 0.8        | V                                                                |
| Logic Input “1”                | $V_{IH}$                                           |                                                                                                                                                                                      | 2                                         |                                           |            | 2                                         |                                           |                      | 2                                         |                                           |            | V                                                                |
| Logic Input Current            |                                                    |                                                                                                                                                                                      |                                           |                                           |            |                                           |                                           |                      |                                           |                                           |            |                                                                  |
| Logic “0”                      | $I_{IL}$                                           | $V_{LC} = 0\text{ V}$<br>$V_{IN} = -10\text{ V}$ to $+0.8\text{ V}$                                                                                                                  |                                           | -2                                        | -10        |                                           | -2                                        | -10                  |                                           | -2                                        | -10        | $\mu\text{A}$                                                    |
| Logic Input “1”                | $I_{IH}$                                           | $V_{IN} = 2.0\text{ V}$ to $18\text{ V}$                                                                                                                                             |                                           | 0.002                                     | 10         |                                           | 0.002                                     | 10                   |                                           | 0.002                                     | 10         | $\mu\text{A}$                                                    |
| Logic Input Swing              | $V_{IS}$                                           | $V_- = -15\text{ V}$                                                                                                                                                                 | -10                                       |                                           | +18        | -10                                       |                                           | +18                  | -10                                       |                                           | +18        | V                                                                |
| Logic Threshold Range          | $V_{THR}$                                          | $V_S = \pm 15\text{ V}^1$                                                                                                                                                            | -10                                       |                                           | +13.5      | -10                                       |                                           | +13.5                | -10                                       |                                           | +13.5      | V                                                                |
| Reference Bias Current         | $I_{I5}$                                           |                                                                                                                                                                                      |                                           | -1                                        | -3         |                                           | -1                                        | -3                   |                                           | -1                                        | -3         | $\mu\text{A}$                                                    |
| Reference Input                | $dI/dt$                                            | $R_{EQ} = 200\text{ }\Omega$<br>$R_L = 100\text{ }\Omega$<br>$C_C = 0\text{ pF}$ See Fast Pulsed Ref. Info Following. <sup>1</sup>                                                   | 4                                         | 8                                         |            | 4                                         | 8                                         |                      | 4                                         | 8                                         |            | mA/ $\mu\text{s}$                                                |
| Slew Rate                      |                                                    |                                                                                                                                                                                      |                                           |                                           |            |                                           |                                           |                      |                                           |                                           |            |                                                                  |
| Power Supply Sensitivity       | $PSSI_{FS+}$<br>$PSSI_{FS-}$                       | $V_+ = 4.5\text{ V}$ to $18\text{ V}$<br>$V_- = -4.5\text{ V}$ to $-18\text{ V}$<br>$I_{REF} = 1.0\text{ mA}$                                                                        |                                           | $\pm 0.0003$                              | $\pm 0.01$ |                                           | $\pm 0.0003$                              | $\pm 0.01$           |                                           | $\pm 0.0003$                              | $\pm 0.01$ | % $\Delta I_O$ /% $\Delta V_+$<br>% $\Delta I_O$ /% $\Delta V_-$ |
| Power Supply Current           | $I_+$<br>$I_-$<br>$I_+$<br>$I_-$<br>$I_+$<br>$I_-$ | $V_S = \pm 15\text{ V}$ , $I_{REF} = 1.0\text{ mA}$<br>$V_S = +5\text{ V}$ , $-15\text{ V}$ ,<br>$I_{REF} = 2.0\text{ mA}$<br>$V_S = \pm 15\text{ V}$ ,<br>$I_{REF} = 2.0\text{ mA}$ | 2.3<br>-4.3<br>2.4<br>-6.4<br>2.5<br>-6.5 | 3.8<br>-5.8<br>3.8<br>-7.8<br>3.8<br>-7.8 |            | 2.3<br>-4.3<br>2.4<br>-6.4<br>2.5<br>-6.5 | 3.8<br>-5.8<br>3.8<br>-7.8<br>3.8<br>-7.8 |                      | 2.3<br>-4.3<br>2.4<br>-6.4<br>2.5<br>-6.5 | 3.8<br>-5.8<br>3.8<br>-7.8<br>3.8<br>-7.8 |            | mA<br>mA<br>mA<br>mA<br>mA<br>mA                                 |
| Power Dissipation              | $P_D$                                              | $\pm 5\text{ V}$ , $I_{REF} = 1.0\text{ mA}$<br>$+5\text{ V}$ , $-15\text{ V}$ ,<br>$I_{REF} = 2.0\text{ mA}$<br>$\pm 15\text{ V}$ , $I_{REF} = 2.0\text{ mA}$                       | 33<br>108<br>135                          | 48<br>136<br>174                          |            | 33<br>103<br>135                          | 48<br>136<br>174                          |                      | 33<br>108<br>135                          | 48<br>136<br>174                          |            | mW<br>mW<br>mW                                                   |

### NOTES

<sup>1</sup>Guaranteed by design.

Specifications subject to change without notice.

## TYPICAL ELECTRICAL CHARACTERISTICS

(@  $V_S = \pm 15\text{ V}$ , and  $I_{REF} = 2.0\text{ mA}$ , unless otherwise noted. Output characteristics apply to both  $I_{OUT}$  and  $I_{OUT-}$ .)

| Parameter                 | Symbol             | Conditions                                                                             | All Grades Typical | Unit                    |
|---------------------------|--------------------|----------------------------------------------------------------------------------------|--------------------|-------------------------|
| Reference Input Slew Rate | $dI/dt$            |                                                                                        | 8                  | $\text{mA}/\mu\text{s}$ |
| Propagation Delay         | $t_{PLH}, t_{PHL}$ | $T_A = 25^\circ\text{C}$ , Any Bit                                                     | 35                 | ns                      |
| Settling Time             | $t_s$              | $T_o \pm 1/2\text{ LSB}$ , All Bits<br>Switched ON or OFF,<br>$T_A = 25^\circ\text{C}$ | 85                 | ns                      |

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS<sup>1</sup>

## Operating Temperature

|                                                                  |                    |
|------------------------------------------------------------------|--------------------|
| DAC08AQ, Q                                                       | –55°C to +125°C    |
| DAC08HQ, EQ, CQ, HP, EP                                          | 0°C to +70°C       |
| DAC08CP, CS                                                      | –40°C to +85°C     |
| Junction Temperature ( $T_J$ )                                   | –65°C to +150°C    |
| Storage Temperature Q Package                                    | –65°C to +150°C    |
| Storage Temperature P Package                                    | –65°C to +125°C    |
| Lead Temperature (Soldering, 60 sec)                             | 300°C              |
| V+ Supply to V– Supply                                           | 36 V               |
| Logic Inputs                                                     | V– to V– plus 36 V |
| $V_{LC}$                                                         | V– to V+           |
| Analog Current Outputs (at $V_S = 15\text{ V}$ )                 | 4.25 mA            |
| Reference Input ( $V_{14}$ to $V_{15}$ )                         | V– to V+           |
| Reference Input Differential Voltage<br>( $V_{14}$ to $V_{15}$ ) | $\pm 18\text{ V}$  |
| Reference Input Current ( $I_{14}$ )                             | 5.0 mA             |

| Package Type            | $\theta_{JA}$ <sup>2</sup> | $\theta_{JC}$ | Unit |
|-------------------------|----------------------------|---------------|------|
| 16-Lead Cerdip (Q)      | 100                        | 16            | °C/W |
| 16-Lead Plastic DIP (P) | 82                         | 39            | °C/W |
| 20-Terminal LCC (RC)    | 76                         | 36            | °C/W |
| 16-Lead SO (S)          | 111                        | 35            | °C/W |

## NOTES

<sup>1</sup>Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.

<sup>2</sup> $\theta_{JA}$  is specified for worst-case mounting conditions, i.e.,  $\theta_{JA}$  is specified for device in socket for cerdip, Plastic DIP, and LCC packages;  $\theta_{JA}$  is specified for device soldered to printed circuit board for SO package.

ORDERING GUIDE<sup>1</sup>

| Model                      | NL           | Temperature Range | Package Description | Package Option      | # Parts Per Container |
|----------------------------|--------------|-------------------|---------------------|---------------------|-----------------------|
| DAC08AQ                    | $\pm 0.10\%$ | –55°C to +125°C   | Cerdip-16           | Q-16                | 25                    |
| DAC08AQ <sup>2</sup> /883C | $\pm 0.10\%$ | –55°C to +125°C   | Cerdip-16           | Q-16                | 25                    |
| DAC08HP                    | $\pm 0.10\%$ | 0°C to 70°C       | P-DIP-16            | N-16                | 25                    |
| DAC08HQ                    | $\pm 0.10\%$ | 0°C to 70°C       | Cerdip-16           | Q-16                | 25                    |
| DAC08Q                     | $\pm 0.19\%$ | –55°C to +125°C   | Cerdip-16           | Q-16                | 25                    |
| DAC08Q <sup>2</sup> /883C  | $\pm 0.19\%$ | –55°C to +125°C   | Cerdip-16           | Q-16                | 25                    |
| DAC08RC/883C               | $\pm 0.19\%$ | –55°C to +125°C   | LCC-20              | E-20                | 55                    |
| DAC08EP                    | $\pm 0.19\%$ | 0°C to 70°C       | P-DIP-16            | N-16                | 25                    |
| DAC08EQ                    | $\pm 0.19\%$ | 0°C to 70°C       | Cerdip-16           | Q-16                | 25                    |
| DAC08ES                    | $\pm 0.19\%$ | 0°C to 70°C       | SO-16               | R-16A (Narrow Body) | 47                    |
| DAC08ES-REEL               | $\pm 0.19\%$ | 0°C to 70°C       | SO-16               | R-16A (Narrow Body) | 2500                  |
| DAC08CP                    | $\pm 0.39\%$ | –40°C to +85°C    | P-DIP-16            | N-16                | 25                    |
| DAC08CQ                    | $\pm 0.39\%$ | 0°C to 70°C       | Cerdip-16           | Q-16                | 25                    |
| DAC08CS                    | $\pm 0.39\%$ | –40°C to +85°C    | SO-16               | R-16A (Narrow Body) | 47                    |
| DAC08CS-REEL               | $\pm 0.39\%$ | –40°C to +85°C    | SO-16               | R-16A (Narrow Body) | 2500                  |
| DAC08NBC                   | $\pm 0.10\%$ | 25°C              | DICE                |                     |                       |
| DAC08GBC                   | $\pm 0.19\%$ | 25°C              | DICE                |                     |                       |
| DAC08GRBC                  | $\pm 0.39\%$ | 25°C              | DICE                |                     |                       |

## NOTES

<sup>1</sup>Devices processed in total compliance to MIL-STD-883. Consult factory for 883 data sheet.

<sup>2</sup>For availability and burn-in information on SO and PLCC packages, contact your local sales office.

The DAC08 contains 84 transistors. Die size 63 mil x 87 mil = 5,481 square mils.

## CAUTION

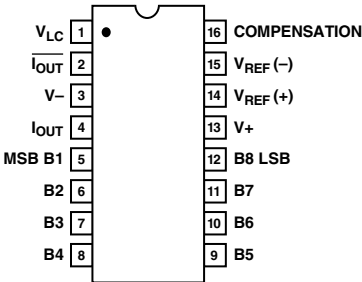
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the DAC08 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



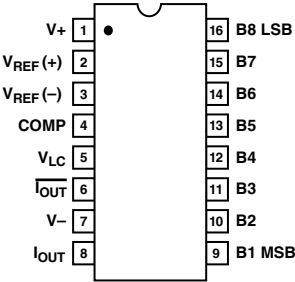
# DAC08

## PIN CONNECTIONS

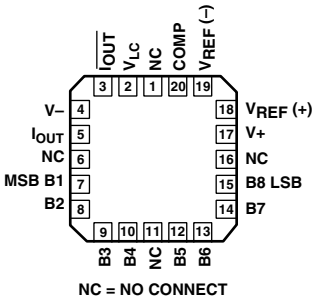
### 16-Lead Dual-In-Line Package (Q and P Suffix)



### 16-Lead SO (S Suffix)

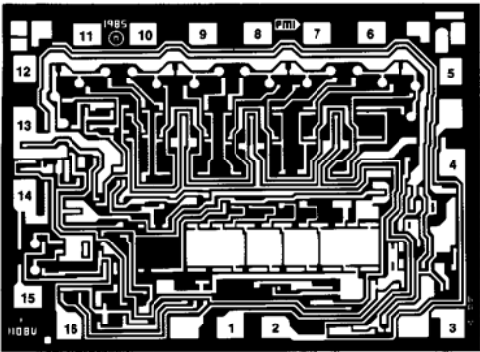


### DAC08RC/883 20-Lead LCC (RC Suffix)



## DICE CHARACTERISTICS

(125°C Tested Dice Available)



1. V<sub>LC</sub>
2. I<sub>OUT</sub>
3. V<sub>-</sub>
4. I<sub>OUT</sub>
5. BIT 1 (MSB)
6. BIT 2
7. BIT 3
8. BIT 4
9. BIT 5
10. BIT 6
11. BIT 7
12. BIT 8 (LSB)
13. V<sub>+</sub>
14. V<sub>REF</sub> (+)
15. V<sub>REF</sub> (-)
16. COMP

DIE SIZE 0.087 × 0.063 inch, 5,270 sq. mils  
(2.209 × 1.60 mm, 3.54 sq. mm)

# **WAFER TEST LIMITS** (@ $V_S = \pm 15\text{ V}$ , $I_{REF} = 2.0\text{ mA}$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted. Output characteristics apply to both $I_{OUT}$ and $I_{OUT-}$ .)

| Parameter                | Symbol                       | Conditions                                                                                                                                          | DAC08N<br>Limit | DAC08G<br>Limit | DAC08GR<br>Limit | Unit                        |
|--------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|------------------|-----------------------------|
| Resolution               |                              |                                                                                                                                                     | 8               | 8               | 8                | Bits min                    |
| Monotonicity             |                              |                                                                                                                                                     | 8               | 8               | 8                | Bits min                    |
| Nonlinearity             | NL                           |                                                                                                                                                     | $\pm 0.1$       | $\pm 0.19$      | $\pm 0.39$       | % FS max                    |
| Output Voltage           | $V_{OC}$                     | Full-Scale Current                                                                                                                                  | +18             | +18             | +18              | V max                       |
| Compliance               |                              | Change < 1/2 LSB                                                                                                                                    | -10             | -10             | -10              | V min                       |
| Full-Scale Current       | $I_{FS4}$ or $I_{FS2}$       | $V_{REF} = 10.000\text{ V}$<br>$R_{14}, R_{15} = 5.000\text{ k}\Omega$                                                                              | 2.04            | 2.04            | 2.04             | mA max                      |
| Full-Scale Symmetry      | $I_{FSS}$                    |                                                                                                                                                     | $\pm 8$         | $\pm 8$         | $\pm 16$         | $\mu\text{A}$ max           |
| Zero-Scale Current       | $I_{ZS}$                     |                                                                                                                                                     | 2               | 4               | 4                | $\mu\text{A}$ max           |
| Output Current Range     | $I_{FS1}$ or $I_{FS2}$       | $V_- = -10\text{ V}$ ,<br>$V_{REF} = +15\text{ V}$<br>$V_- = -12\text{ V}$ ,<br>$V_{REF} = +25\text{ V}$<br>$R_{14}, R_{15} = 5.000\text{ k}\Omega$ | 2.1             | 2.1             | 2.1              | mA min                      |
| Logic Input "0"          | $V_{IL}$                     |                                                                                                                                                     | 0.8             | 0.8             | 0.8              | V max                       |
| Logic Input "1"          | $V_{IH}$                     |                                                                                                                                                     | 2               | 2               | 2                | V min                       |
| Logic Input Current      |                              | $V_{LC} = 0\text{ V}$                                                                                                                               |                 |                 |                  |                             |
| Logic "0"                | $I_{IL}$                     | $V_{IN} = -10\text{ V}$ to $+0.8\text{ V}$                                                                                                          | $\pm 10$        | $\pm 10$        | $\pm 10$         | $\mu\text{A}$ max           |
| Logic "1"                | $I_{IH}$                     | $V_{IN} = +2.0\text{ V}$ to $+18\text{ V}$                                                                                                          | $\pm 10$        | $\pm 10$        | $\pm 10$         | $\mu\text{A}$ max           |
| Logic Input Swing        | $V_{IS}$                     | $V_- = -15\text{ V}$                                                                                                                                | +18<br>-10      | +18<br>-10      | +18<br>-10       | V max<br>V min              |
| Reference Bias Current   | $I_{15}$                     |                                                                                                                                                     | -3              | -3              | -3               | $\mu\text{A}$ max           |
| Power Supply Sensitivity | $PSSI_{FS+}$<br>$PSSI_{FS-}$ | $V_+ = +4.5\text{ V}$ to $+18\text{ V}$<br>$V_- = -4.5\text{ V}$ to $-18\text{ V}$<br>$I_{REF} = 1.0\text{ mA}$                                     | 0.01            | 0.01            | 0.01             | % FS/% V max                |
| Power Supply Current     | $I_+$                        | $V_S = \pm 15\text{ V}$<br>$I_{REF} \leq 2.0\text{ mA}$                                                                                             | 3.8<br>-7.8     | 3.8<br>-7.8     | 3.8<br>-7.8      | mA max<br>$\mu\text{A}$ max |
| Power Dissipation        | $P_D$                        | $V_S = \pm 15\text{ V}$<br>$I_{REF} \leq 2.0\text{ mA}$                                                                                             | 174             | 174             | 174              | mW max                      |

## NOTE

Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

# DAC08

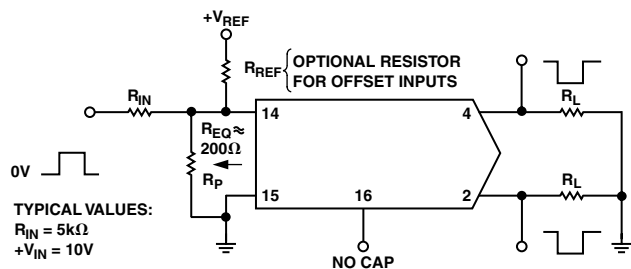


Figure 1. Pulsed Reference Operation

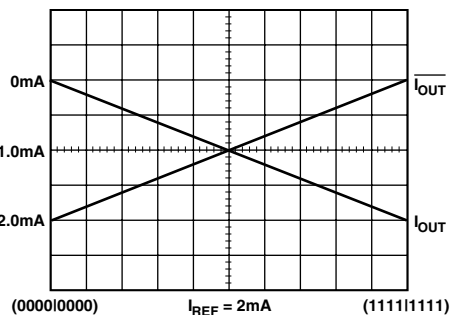


Figure 4. True and Complementary Output Operation

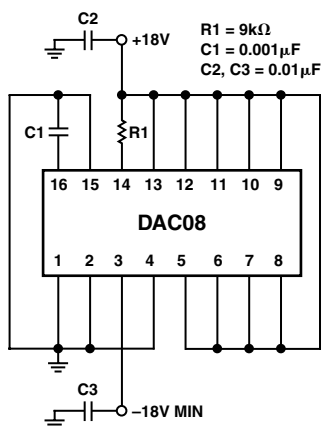


Figure 2. Burn-in Circuit

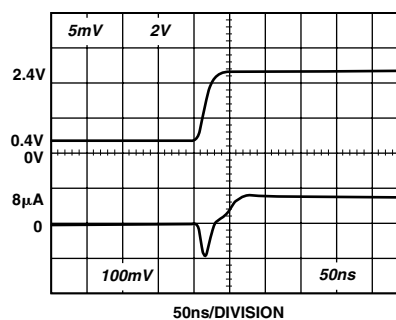


Figure 5. LSB Switching

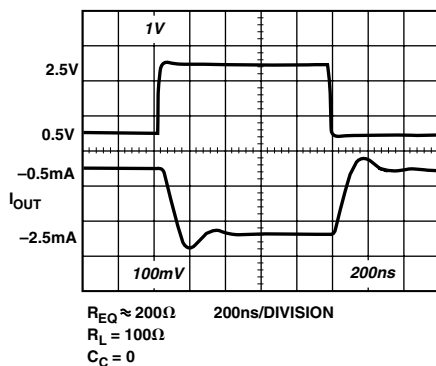


Figure 3. Fast Pulsed Reference Operation

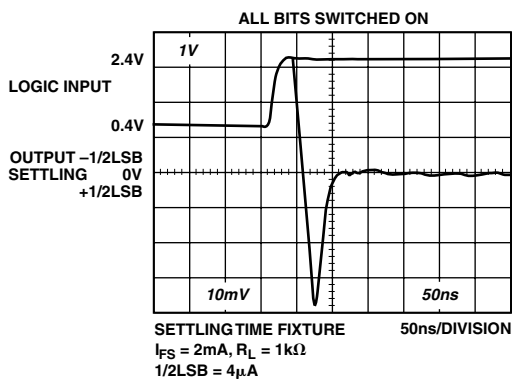
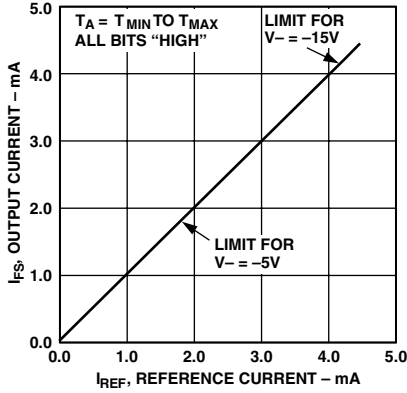
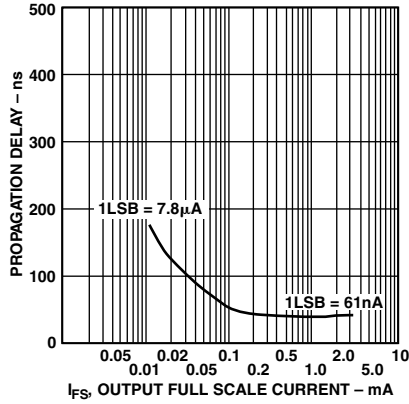


Figure 6. Full-Scale Settling Time

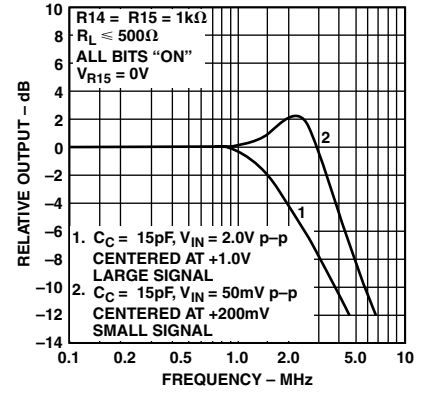
# Typical Performance Characteristics–DAC08



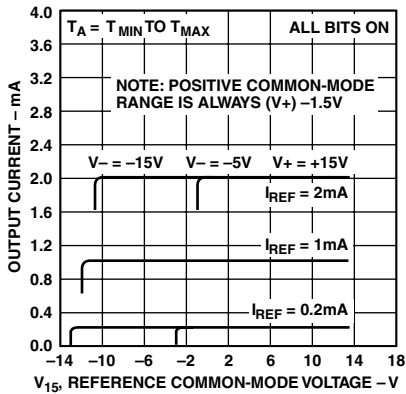
TPC 1. Full-Scale Current vs. Reference Current



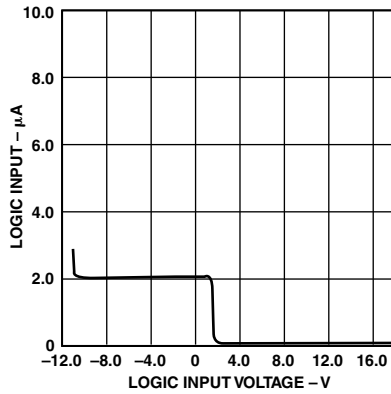
TPC 2. LSB Propagation Delay vs.  $I_{FS}$



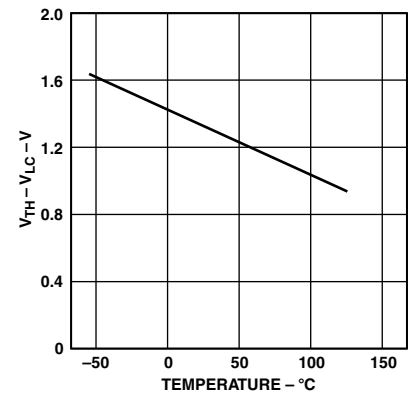
TPC 3. Reference Input Frequency Response



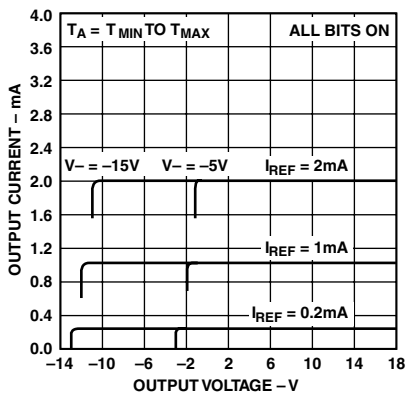
TPC 4. Reference Amp Common-Mode Range



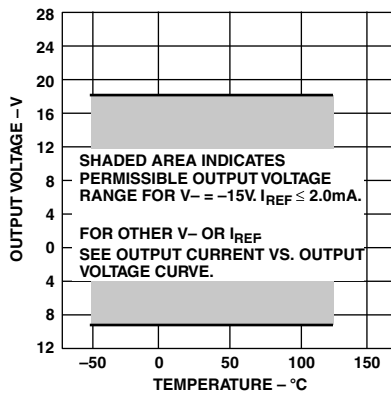
TPC 5. Logic Input Current vs. Input Voltage



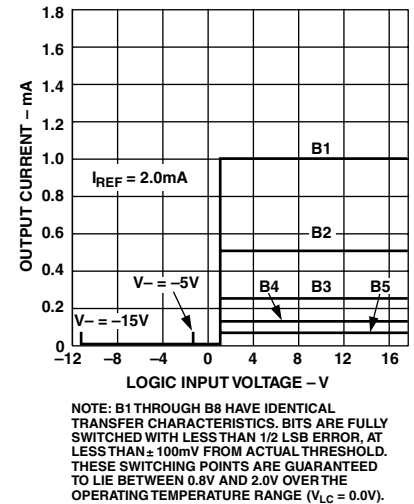
TPC 6.  $V_{TH} - V_{LC}$  vs. Temperature



TPC 7. Output Current vs. Output Voltage (Output Voltage Compliance)



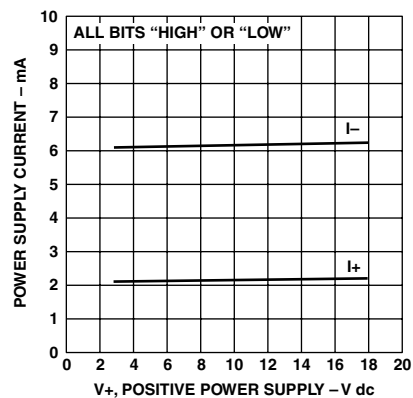
TPC 8. Output Voltage Compliance vs. Temperature



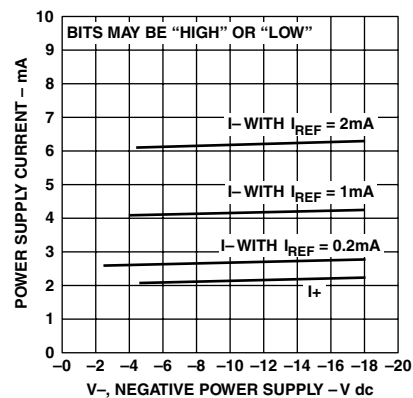
NOTE: B1 THROUGH B8 HAVE IDENTICAL TRANSFER CHARACTERISTICS. BITS ARE FULLY SWITCHED WITH LESS THAN 1/2 LSB ERROR, AT LESS THAN ±100mV FROM ACTUAL THRESHOLD. THESE SWITCHING POINTS ARE GUARANTEED TO LIE BETWEEN 0.8V AND 2.0V OVER THE OPERATING TEMPERATURE RANGE ( $V_{LC} = 0.0V$ ).

TPC 9. Bit Transfer Characteristics

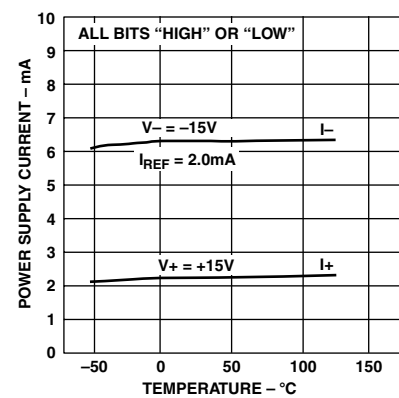
DAC08



TPC 10. Power Supply Current vs. V+



TPC 11. Power Supply Current vs. V-



TPC 12. Power Supply Current vs. Temperature

BASIC CONNECTIONS

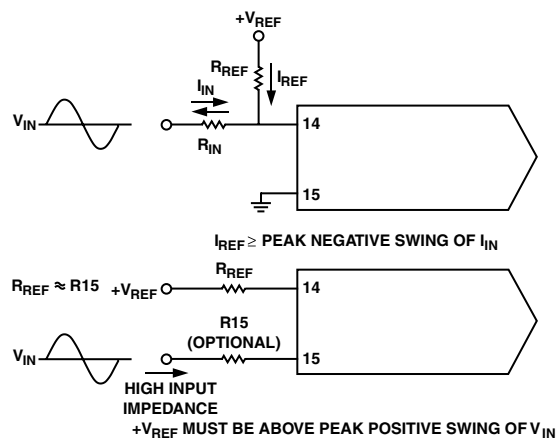


Figure 7. Accommodating Bipolar References

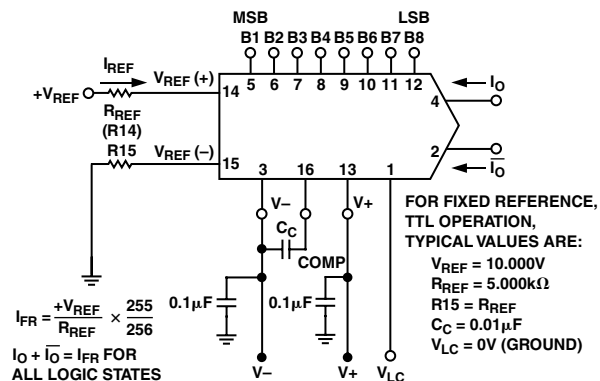


Figure 8. Basic Positive Reference Operation

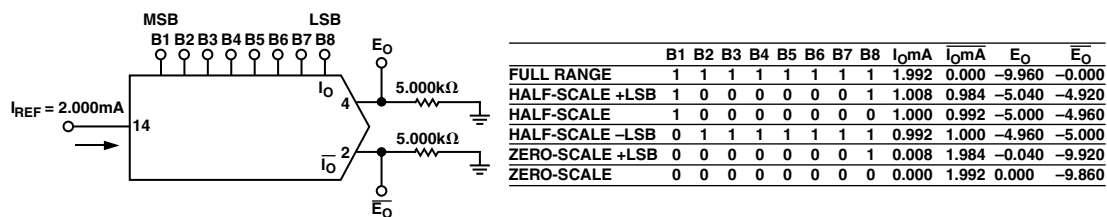


Figure 9. Basic Unipolar Negative Operation

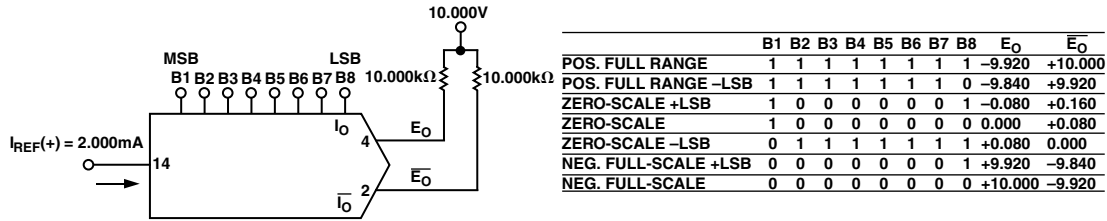


Figure 10. Basic Bipolar Output Operation

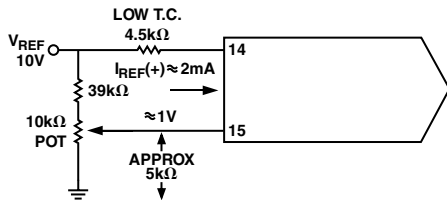


Figure 11. Recommended Full-Scale Adjustment Circuit

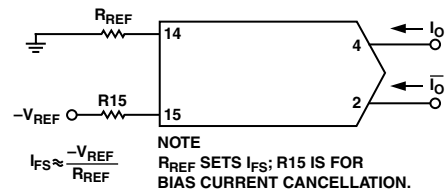


Figure 12. Basic Negative Reference Operation

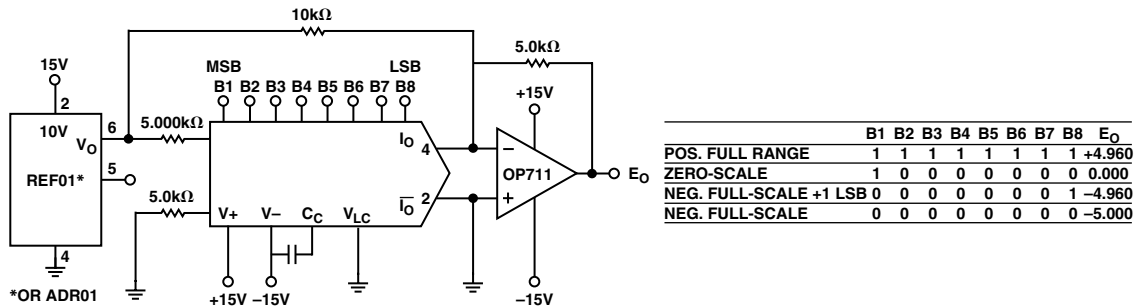


Figure 13. Offset Binary Operation

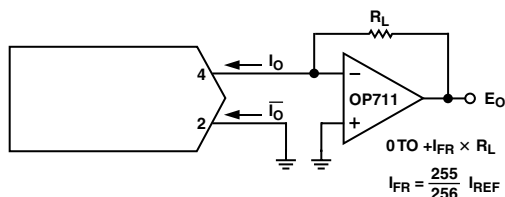


Figure 14. Positive Low Impedance Output Operation

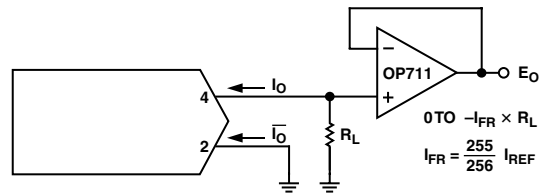


Figure 15. Negative Low Impedance Output Operation

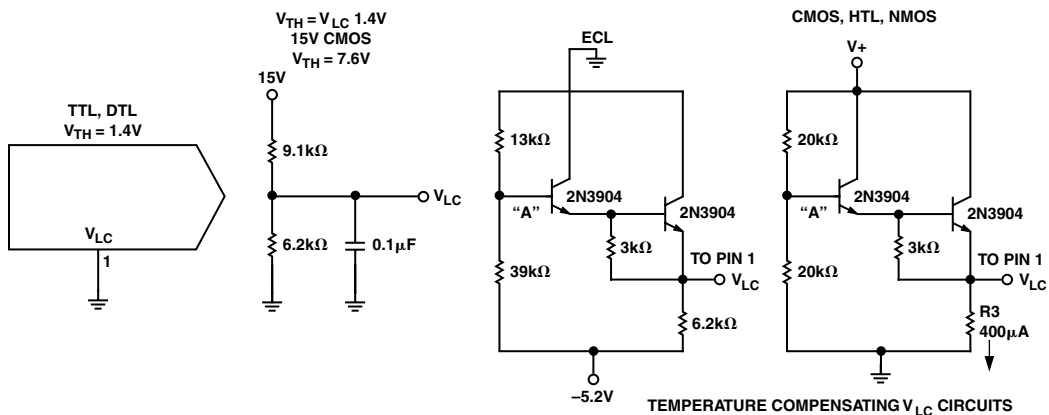


Figure 16. Interfacing with Various Logic Families

# DAC08

## APPLICATION INFORMATION REFERENCE AMPLIFIER SETUP

The DAC08 is a multiplying D/A converter in which the output current is the product of a digital number and the input reference current. The reference current may be fixed or may vary from nearly zero to 4.0 mA. The full-scale output current is a linear function of the reference current and is given by:

$$I_{FR} = \frac{255}{256} \times I_{REF}, \text{ where } I_{REF} = I_{14}$$

In positive reference applications, an external positive reference voltage forces current through R14 into the  $V_{REF(+)}$  terminal (Pin 14) of the reference amplifier. Alternatively, a negative reference may be applied to  $V_{REF(-)}$  at Pin 15; reference current flows from ground through R14 into  $V_{REF(+)}$  as in the positive reference case. This negative reference connection has the advantage of a very high impedance presented at Pin 15. The voltage at Pin 14 is equal to and tracks the voltage at Pin 15 due to the high gain of the internal reference amplifier. R15 (nominally equal to R14) is used to cancel bias current errors; R15 may be eliminated with only a minor increase in error.

Bipolar references may be accommodated by offsetting  $V_{REF}$  or Pin 15. The negative common-mode range of the reference amplifier is given by:  $V_{CM-} = V_-$  plus  $(I_{REF} \times 1 \text{ k}\Omega)$  plus 2.5 V. The positive common-mode range is  $V_+$  less 1.5 V.

When a dc reference is used, a reference bypass capacitor is recommended. A 5.0 V TTL logic supply is not recommended as a reference. If a regulated power supply is used as a reference, R14 should be split into two resistors with the junction bypassed to ground with a 0.1  $\mu\text{F}$  capacitor.

For most applications the tight relationship between  $I_{REF}$  and  $I_{FS}$  will eliminate the need for trimming  $I_{REF}$ . If required, full-scale trimming may be accomplished by adjusting the value of R14, or by using a potentiometer for R14. An improved method of full-scale trimming which eliminates potentiometer T.C. effects is shown in the recommended full-scale adjustment circuit.

Using lower values of reference current reduces negative power supply current and increases reference amplifier negative common-mode range. The recommended range for operation with a dc reference current is 0.2 mA to 4.0 mA.

## REFERENCE AMPLIFIER COMPENSATION FOR MULTIPLYING APPLICATIONS

AC reference applications will require the reference amplifier to be compensated using a capacitor from Pin 16 to  $V_-$ . The value of this capacitor depends on the impedance presented to Pin 14: for R14 values of 1.0, 2.5 and 5.0  $\text{k}\Omega$ , minimum values of  $C_C$  are 15, 37 and 75 pF. Larger values of R14 require proportionately increased values of  $C_C$  for proper phase margin, so the ratio of  $C_C$  (pF) to R14 ( $\text{k}\Omega$ ) = 15.

For fastest response to a pulse, low values of R14 enabling small  $C_C$  values should be used. If Pin 14 is driven by a high impedance such as a transistor current source, none of the above values will suffice and the amplifier must be heavily compensated which will decrease overall bandwidth and slew rate. For R14 = 1  $\text{k}\Omega$  and  $C_C$  = 15 pF, the reference amplifier slews at 4 mA/ $\mu\text{s}$  enabling a transition from  $I_{REF} = 0$  to  $I_{REF} = 2 \text{ mA}$  in 500 ns.

Operation with pulse inputs to the reference amplifier may be accommodated by an alternate compensation scheme. This

technique provides lowest full-scale transition times. An internal clamp allows quick recovery of the reference amplifier from a cutoff ( $I_{REF} = 0$ ) condition. Full-scale transition (0 mA to 2 mA) occurs in 120 ns when the equivalent impedance at Pin 14 is 200  $\Omega$  and  $C_C = 0$ . This yields a reference slew rate of 16 mA/ $\mu\text{s}$ , which is relatively independent of  $R_{IN}$  and  $V_{IN}$  values.

## LOGIC INPUTS

The DAC08 design incorporates a unique logic input circuit that enables direct interface to all popular logic families and provides maximum noise immunity. This feature is made possible by the large input swing capability, 2  $\mu\text{A}$  logic input current and completely adjustable logic threshold voltage. For  $V_- = -15 \text{ V}$ , the logic inputs may swing between  $-10 \text{ V}$  and  $+18 \text{ V}$ . This enables direct interface with 15 V CMOS logic, even when the DAC08 is powered from a 5 V supply. Minimum input logic swing and minimum logic threshold voltage are given by:  $V_-$  plus  $(I_{REF} \times 1 \text{ k}\Omega)$  plus 2.5 V. The logic threshold may be adjusted over a wide range by placing an appropriate voltage at the logic threshold control pin (Pin 1,  $V_{LC}$ ). The appropriate graph shows the relationship between  $V_{LC}$  and  $V_{TH}$  over the temperature range, with  $V_{TH}$  nominally 1.4 above  $V_{LC}$ . For TTL and DTL interface, simply ground pin 1. When interfacing ECL, an  $I_{REF} = 1 \text{ mA}$  is recommended. For interfacing other logic families, see preceding page. For general set-up of the logic control circuit, it should be noted that Pin 1 will source 100  $\mu\text{A}$  typical; external circuitry should be designed to accommodate this current.

Fastest settling times are obtained when Pin 1 sees a low impedance. If Pin 1 is connected to a 1  $\text{k}\Omega$  divider, for example, it should be bypassed to ground by a 0.01  $\mu\text{F}$  capacitor.

## ANALOG OUTPUT CURRENTS

Both true and complemented output sink currents are provided where  $I_O + \bar{I}_O = I_{FS}$ . Current appears at the "true" ( $I_O$ ) output when a "1" (logic high) is applied to each logic input. As the binary count increases, the sink current at pin 4 increases proportionally, in the fashion of a "positive logic" D/A converter. When a "0" is applied to any input bit, that current is turned off at Pin 4 and turned on at Pin 2. A decreasing logic count increases  $\bar{I}_O$  as in a negative or inverted logic D/A converter. Both outputs may be used simultaneously. If one of the outputs is not required, it must be connected to ground or to a point capable of sourcing  $I_{FS}$ ; do not leave an unused output pin open.

Both outputs have an extremely wide voltage compliance enabling fast direct current-to-voltage conversion through a resistor tied to ground or other voltage source. Positive compliance is 36 V above  $V_-$  and is independent of the positive supply. Negative compliance is given by  $V_-$  plus  $(I_{REF} \times 1 \text{ k}\Omega)$  plus 2.5 V.

The dual outputs enable double the usual peak-to-peak load swing when driving loads in quasi-differential fashion. This feature is especially useful in cable driving, CRT deflection and in other balanced applications such as driving center-tapped coils and transformers.

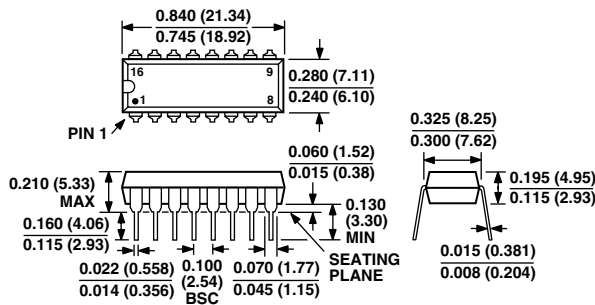
## POWER SUPPLIES

The DAC08 operates over a wide range of power supply voltages from a total supply of 9 V to 36 V. When operating at supplies of  $\pm 5 \text{ V}$  or less,  $I_{REF} \leq 1 \text{ mA}$  is recommended. Low reference current operation decreases power consumption and increases negative compliance, reference amplifier negative common-mode

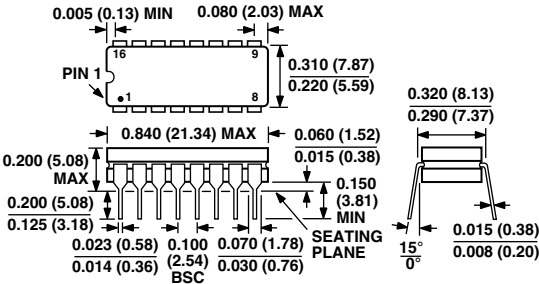


OUTLINE DIMENSIONS  
Dimensions shown in inches and (mm).

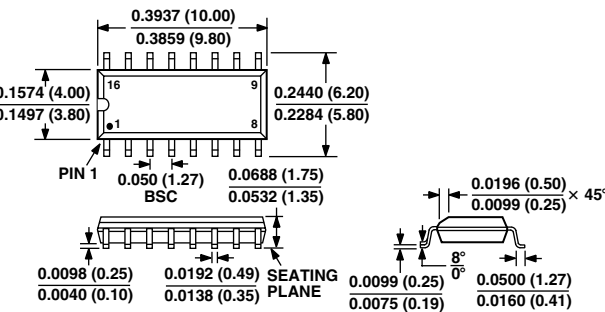
16-Lead Plastic DIP (N-16)



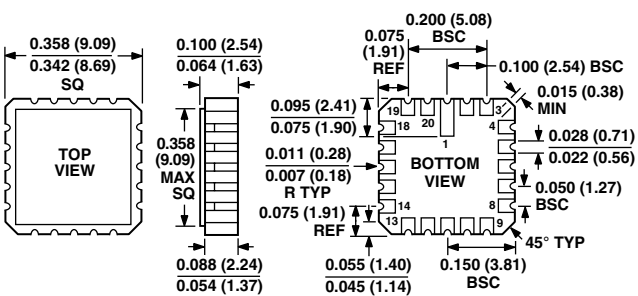
16-Lead Cerdip (Q-16)



16-Lead SO (R-16A)



20-Terminal Leadless Chip Carrier (E-20)



Revision History

| Location                                        | Page |
|-------------------------------------------------|------|
| Data Sheet changed from REV. A to REV. B.       |      |
| Edits to SPECIFICATIONS                         | 2    |
| Edits to ABSOLUTE MAXIMUM RATINGS               | 3    |
| Edits to ORDERING GUIDE                         | 3    |
| Edits to WAFER TEST LIMITS                      | 5    |
| Edit to Figure 13                               | 8    |
| Edits to Figures 14 and 15                      | 9    |
| Replacement of SO-16 with R-16A Package Outline | 12   |

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