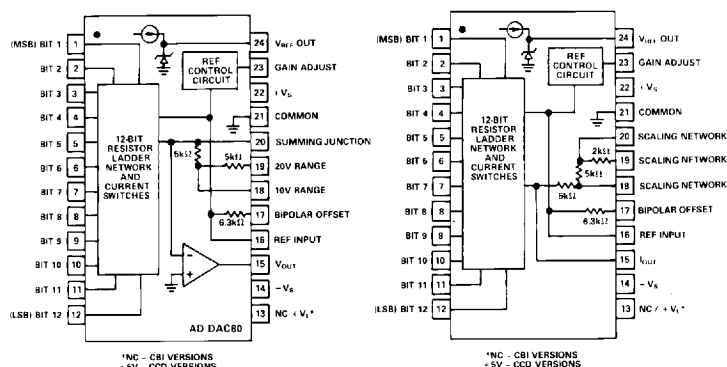




## FEATURES

## FUNCTIONAL BLOCK DIAGRAMS



Analog Devices has developed a number of technologies to support products within the data acquisition market. In serving the market new products are implemented with the technology best suited to the application. The DAC80 series of products was first implemented in hybrid form and now it is available in a single monolithic chip. We will provide both the hybrid and monolithic versions of the family so that in existing designs changes to documentation or product qualification will not have to be done. Specifications and ordering information for both versions are delineated in this data sheet.

**One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.**  
**Tel: 617/329-4700 Fax: 617/326-8703 Twx: 710/394-6577**  
**Telex: 924491 Cable: ANALOG NORWOODMASS**

# AD DAC80/AD DAC85/AD DAC87—SPECIFICATIONS ( $T_A = +25^\circ\text{C}$ , rated power supplies unless otherwise noted.)

| Model                                                                               | AD DAC80     |                                   |             | AD DAC85     |                                   |             | AD DAC87     |                                   |             | Units                        |
|-------------------------------------------------------------------------------------|--------------|-----------------------------------|-------------|--------------|-----------------------------------|-------------|--------------|-----------------------------------|-------------|------------------------------|
|                                                                                     | Min          | Typ                               | Max         | Min          | Typ                               | Max         | Min          | Typ                               | Max         |                              |
| TECHNOLOGY                                                                          | Monolithic   |                                   |             | Monolithic   |                                   |             | Monolithic   |                                   |             |                              |
| DIGITAL INPUT                                                                       |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Binary—CBI                                                                          |              |                                   | 12          |              |                                   | 12          |              |                                   | 12          | Bits                         |
| BCD—CCD                                                                             |              |                                   |             |              |                                   |             |              |                                   |             | Digits                       |
| Logic Levels (TTL Compatible)                                                       |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| $V_{IH}$ (Logic "1")                                                                | +2.0         |                                   | +5.5        | +2.0         |                                   | +5.5        | +2.0         |                                   | +5.5        | V                            |
| $V_{IL}$ (Logic "0")                                                                | 0            |                                   | +0.8        | 0            |                                   | +0.8        | 0            |                                   | +0.8        | V                            |
| $I_{IH}$ ( $V_{IH} = 5.5\text{V}$ )                                                 |              |                                   | 250         |              |                                   | 250         |              |                                   | 250         | $\mu\text{A}$                |
| $I_{IL}$ ( $V_{IL} = 0.8\text{V}$ )                                                 |              |                                   | 100         |              |                                   | 100         |              |                                   | 100         | $\mu\text{A}$                |
| TRANSFER CHARACTERISTICS                                                            |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| ACCURACY                                                                            |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Linearity Error @ $+25^\circ\text{C}$                                               |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| CBI                                                                                 |              |                                   | $\pm 1/2$   |              |                                   | $\pm 1/2$   |              |                                   | $\pm 1/2$   | LSB <sup>1</sup>             |
| CCD                                                                                 |              |                                   |             |              |                                   |             |              |                                   |             | LSB                          |
| $T_A$ @ $T_{min}$ to $T_{max}$                                                      | $\pm 1/4$    |                                   | $\pm 1/2$   | $\pm 1/4$    |                                   | $\pm 1/2$   | $\pm 1/2$    |                                   | $\pm 3/4$   | LSB                          |
| Differential Linearity Error @ $+25^\circ\text{C}$                                  |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| CBI                                                                                 |              |                                   | $\pm 3/4$   |              |                                   | $\pm 3/4$   |              |                                   | $\pm 3/4$   | LSB                          |
| CCD                                                                                 |              |                                   |             |              |                                   |             |              |                                   |             | LSB                          |
| $T_A$ @ $T_{min}$ to $T_{max}$                                                      |              |                                   | $\pm 3/4$   |              |                                   | $\pm 1$     |              |                                   | $\pm 1$     | LSB                          |
| Gain Error <sup>2</sup>                                                             | $\pm 0.1$    |                                   | $\pm 0.3$   | $\pm 0.1$    |                                   | $\pm 0.2$   | $\pm 0.1$    |                                   | $\pm 0.2$   | %FSR <sup>3</sup>            |
| Offset Error <sup>2</sup>                                                           | $\pm 0.05$   |                                   | $\pm 0.15$  | $\pm 0.05$   |                                   | $\pm 0.1$   | $\pm 0.05$   |                                   | $\pm 0.1$   | %FSR <sup>3</sup>            |
| Temperature Range for Guaranteed Monotonicity                                       | 0            |                                   | +70         | -25          |                                   | +85         | -55          |                                   | +125        | $^\circ\text{C}$             |
| DRIFT ( $T_{min}$ to $T_{max}$ )                                                    |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Total Bipolar Drift, max (includes gain, offset, and linearity drifts)              |              |                                   | $\pm 20$    |              |                                   | $\pm 20$    |              |                                   | $\pm 30$    | ppm of FSR/ $^\circ\text{C}$ |
| Total Error ( $T_{min}$ to $T_{max}$ ) <sup>4</sup>                                 |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Unipolar                                                                            | $\pm 0.08$   |                                   | $\pm 0.15$  | $\pm 0.12$   |                                   | $\pm 0.2$   | $\pm 0.18$   |                                   | $\pm 0.3$   | % of FSR                     |
| Bipolar                                                                             | $\pm 0.06$   |                                   | $\pm 0.10$  | $\pm 0.08$   |                                   | $\pm 0.12$  | $\pm 0.14$   |                                   | $\pm 0.24$  | % of FSR                     |
| Gain                                                                                |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Including Internal Reference                                                        | $\pm 15$     |                                   | $\pm 30$    |              |                                   | $\pm 20$    |              |                                   | $\pm 20$    | ppm of FSR/ $^\circ\text{C}$ |
| Excluding Internal Reference                                                        | $\pm 4$      |                                   | $\pm 7$     |              |                                   | $\pm 10$    |              |                                   | $\pm 10$    | ppm of FSR/ $^\circ\text{C}$ |
| Unipolar Offset                                                                     | $\pm 1$      |                                   | $\pm 3$     |              |                                   | $\pm 3$     |              |                                   | $\pm 3$     | ppm of FSR/ $^\circ\text{C}$ |
| Bipolar Offset                                                                      | $\pm 5$      |                                   | $\pm 10$    |              |                                   | $\pm 10$    |              |                                   | $\pm 10$    | ppm of FSR/ $^\circ\text{C}$ |
| CONVERSION SPEED                                                                    |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Voltage Model ( $V$ ) <sup>5</sup>                                                  |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Settling Time to $\pm 0.01\%$ of FSR for FSR change ( $2k\Omega/500\text{pF}$ load) |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| with $10k\Omega$ Feedback                                                           | 3            |                                   | 4           | 3            |                                   | 4           | 3            |                                   | 4           | $\mu\text{s}$                |
| with $5k\Omega$ Feedback                                                            | 2            |                                   | 3           | 2            |                                   | 3           | 2            |                                   | 3           | $\mu\text{s}$                |
| For LSB Change                                                                      | 1            |                                   |             | 1            |                                   |             | 1            |                                   |             | $\mu\text{s}$                |
| Slew Rate                                                                           | 10           |                                   |             | 10           |                                   |             | 10           |                                   |             | V/ $\mu\text{s}$             |
| ANALOG OUTPUT                                                                       |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Voltage Models                                                                      |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Ranges—CBI                                                                          |              | $\pm 2.5, \pm 5, \pm 10, +5, +10$ |             |              | $\pm 2.5, \pm 5, \pm 10, +5, +10$ |             |              | $\pm 2.5, \pm 5, \pm 10, +5, +10$ |             | V                            |
| —CCD                                                                                |              |                                   |             |              |                                   |             |              |                                   |             | V                            |
| Output Current                                                                      | $\pm 5$      |                                   |             | $\pm 5$      |                                   |             | $\pm 5$      |                                   |             | mA                           |
| Output Impedance (dc)                                                               | 0.05         |                                   |             | 0.05         |                                   |             | 0.05         |                                   |             | $\Omega$                     |
| Short Circuit Current                                                               |              |                                   | 40          |              |                                   | 40          |              |                                   | 40          | mA                           |
| Internal Reference Voltage ( $V_R$ )                                                | +6.23        | +6.3                              | +6.37       | +6.23        | +6.3                              | +6.37       | +6.23        | +6.3                              | +6.37       | V                            |
| Output Impedance                                                                    |              | 1.5                               |             |              | 1.5                               |             |              | 1.5                               |             | $\Omega$                     |
| Max External Current <sup>6</sup>                                                   |              |                                   | +2.5        |              |                                   | +2.5        |              |                                   | +2.5        | mA                           |
| Tempco of Drift                                                                     | $\pm 10$     |                                   | $\pm 20$    | $\pm 10$     |                                   | $\pm 20$    | $\pm 10$     |                                   | $\pm 10$    | ppm of $V_R/^\circ\text{C}$  |
| POWER SUPPLY SENSITIVITY                                                            |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| $\pm 15\text{V} \pm 10\%$ , 5V supply when applicable                               |              |                                   | $\pm 0.002$ |              |                                   | $\pm 0.002$ |              |                                   | $\pm 0.002$ | % of FSR/% $V_S$             |
| $\pm 12\text{V} \pm 5\%$                                                            |              |                                   | $\pm 0.002$ |              |                                   | $\pm 0.002$ |              |                                   | $\pm 0.002$ | % of FSR/% $V_S$             |
| POWER SUPPLY REQUIREMENTS                                                           |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Rated Voltages                                                                      |              | $\pm 15$                          |             |              | $\pm 15$                          |             |              | $\pm 15$                          |             | V                            |
| Range                                                                               |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Analog Supplies                                                                     | $\pm 11.4^7$ |                                   | $\pm 16.5$  | $\pm 11.4^7$ |                                   | $\pm 16.5$  | $\pm 11.4^7$ |                                   | $\pm 16.5$  | V                            |
| Logic Supplies                                                                      |              |                                   |             |              |                                   |             |              |                                   | V           |                              |
| Supply Drain                                                                        |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| +12, +15V                                                                           | 5            |                                   | 10          | 5            |                                   | 10          | 5            |                                   | 10          | mA                           |
| -12, -15V                                                                           | 14           |                                   | 20          | 14           |                                   | 20          | 14           |                                   | 20          | mA                           |
| TEMPERATURE RANGE                                                                   |              |                                   |             |              |                                   |             |              |                                   |             |                              |
| Specification                                                                       | 0            |                                   | +70         | -25          |                                   | +85         | -55          |                                   | +125        | $^\circ\text{C}$             |
| Operating                                                                           | -25          |                                   | +85         | -55          |                                   | +125        | -55          |                                   | +125        | $^\circ\text{C}$             |
| Storage                                                                             | -25          |                                   | +125        | -65          |                                   | +150        | -65          |                                   | +150        | $^\circ\text{C}$             |

## NOTES

<sup>1</sup>Least Significant Bit.

<sup>2</sup>Adjustable to zero with external trim potentiometer.

<sup>3</sup>FSR means "Full Scale Range" and is 20V for the  $\pm 10\text{V}$  range and 10V for the  $\pm 5\text{V}$  Range.

<sup>4</sup>Gain and offset errors adjusted to zero at  $+25^\circ\text{C}$ .

<sup>5</sup> $C_F = 0$ , see Figure 1a.

<sup>6</sup>Maximum with no degradation of specification, must be a constant load.

<sup>7</sup>A minimum of  $\pm 12.3\text{V}$  is required for a  $\pm 10\text{V}$  full scale output and

$\pm 11.4\text{V}$  is required for all other voltage ranges.

Specifications subject to change without notice.

Specifications shown in boldface are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels. All min and max specifications are guaranteed, although only those shown in boldface are tested on all production units.

# AD DAC80/AD DAC85/AD DAC87

| Model                                                                             | AD DAC80 |                        |       | AD DAC85C              |                      |       | AD DAC85               |                      |       | Units                     |
|-----------------------------------------------------------------------------------|----------|------------------------|-------|------------------------|----------------------|-------|------------------------|----------------------|-------|---------------------------|
|                                                                                   | Min      | Typ                    | Max   | Min                    | Typ                  | Max   | Min                    | Typ                  | Max   |                           |
| TECHNOLOGY                                                                        | Hybrid   |                        |       | Hybrid                 |                      |       | Hybrid                 |                      |       |                           |
| DIGITAL INPUT                                                                     |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Binary - CBI                                                                      |          |                        | 12    |                        |                      | 12    |                        |                      | 12    | Bits                      |
| BCD - CCD                                                                         |          |                        | 3     |                        |                      | 3     |                        |                      | 3     | Digits                    |
| Logic Levels (TTL Compatible)                                                     |          |                        |       |                        |                      |       |                        |                      |       |                           |
| V <sub>IH</sub> (Logic "1")                                                       | +2.0     |                        | +5.5  | +2.0                   |                      | +5.5  | +2.0                   |                      | +5.5  | V                         |
| V <sub>IL</sub> (Logic "0")                                                       | 0        |                        | +0.8  | 0                      |                      | +0.8  | 0                      |                      | +0.8  | V                         |
| I <sub>IH</sub> (V <sub>IH</sub> = 5.5V)                                          |          | +250                   |       |                        | +250                 |       |                        | +250                 |       | μA                        |
| I <sub>IL</sub> (V <sub>IL</sub> = 0.8V)                                          |          | -100                   |       |                        | -100                 |       |                        | -100                 |       | μA                        |
| TRANSFER CHARACTERISTICS                                                          |          |                        |       |                        |                      |       |                        |                      |       |                           |
| ACCURACY                                                                          |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Linearity Error @ +25°C                                                           |          |                        |       |                        |                      |       |                        |                      |       |                           |
| CBI                                                                               |          | ±1/4                   | ±1/2  |                        |                      | ±1/2  |                        |                      | ±1/2  | LSB <sup>1</sup>          |
| CCD                                                                               |          | ±1/8                   | ±1/4  |                        |                      | ±1/4  |                        |                      | ±1/4  | LSB                       |
| T <sub>A</sub> @ T <sub>min</sub> to T <sub>max</sub>                             |          | ±1/4                   | ±1/2  | ±1/4                   |                      | ±1/2  | ±1/2                   |                      | ±1/2  | LSB                       |
| Differential Linearity Error @ +25°C                                              |          |                        |       |                        |                      |       |                        |                      |       |                           |
| CBI                                                                               |          | ±1/2                   | ±3/4  | ±1/2                   |                      | ±1/2  | ±1/2                   |                      | ±1/2  | LSB                       |
| CCD                                                                               |          | ±1/4                   | ±1/2  | ±1/2                   |                      | ±1/2  | ±1/2                   |                      | ±1/2  | LSB                       |
| T <sub>A</sub> @ T <sub>min</sub> to T <sub>max</sub>                             |          |                        | ±1    |                        |                      | ±1    |                        |                      | ±1    | LSB                       |
| Gain Error <sup>2</sup>                                                           |          | ±0.1                   | ±0.3  | ±0.1                   |                      | ±0.3  | ±0.1                   |                      | ±0.3  | %FSR <sup>3</sup>         |
| Offset Error <sup>2</sup>                                                         |          | ±0.05                  | ±0.15 | ±0.05                  |                      | ±0.15 | ±0.05                  |                      | ±0.15 | %FSR <sup>3</sup>         |
| Temperature Range for Guaranteed Monotonicity                                     | 0        |                        | +70   | 0                      |                      | +70   | -25                    |                      | +85   | °C                        |
| DRIFT (T <sub>min</sub> to T <sub>max</sub> )                                     |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Total Bipolar Drift, max (includes gain, offset, and linearity drifts)            |          |                        | ±20   |                        |                      | ±20   |                        |                      | ±20   | ppm of FSR/°C             |
| Total Error (T <sub>min</sub> to T <sub>max</sub> ) <sup>4</sup>                  |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Unipolar                                                                          |          | ±0.08                  | ±0.15 |                        |                      | ±0.15 |                        |                      | ±0.15 | % of FSR                  |
| Bipolar                                                                           |          | ±0.06                  | ±0.10 |                        |                      | ±0.10 |                        |                      | ±0.10 | % of FSR                  |
| Gain                                                                              |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Including Internal Reference                                                      |          | ±15                    | ±30   |                        |                      | ±30   |                        |                      | ±30   | ppm of FSR/°C             |
| Excluding Internal Reference                                                      |          | ±5                     | ±7    |                        |                      | ±10   |                        |                      | ±10   | ppm of FSR/°C             |
| Unipolar Offset                                                                   |          | ±1                     | ±3    | ±1                     |                      | ±3    | ±1                     |                      | ±3    | ppm of FSR/°C             |
| Bipolar Offset                                                                    |          | ±5                     | ±10   |                        |                      | ±10   |                        |                      | ±10   | ppm of FSR/°C             |
| CONVERSION SPEED                                                                  |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Voltage Model (V) <sup>5</sup>                                                    |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Settling Time to ±0.01% of FSR for FSR change (2kΩ/500pF load) with 10kΩ Feedback |          | 5                      |       | 5                      |                      |       | 5                      |                      |       | μs                        |
| with 5kΩ Feedback                                                                 |          | 3                      |       | 3                      |                      |       | 3                      |                      |       | μs                        |
| For LSB Change                                                                    |          | 1.5                    |       | 1.5                    |                      |       | 1.5                    |                      |       | μs                        |
| Slew Rate                                                                         | 10       | 15                     |       | 20                     |                      |       | 20                     |                      |       | V/μs                      |
| Current Model (I)                                                                 |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Settling Time to ±0.01% of FSR for FSR Change 10 to 100Ω Load for 1kΩ Load        |          | 300                    |       | 300                    |                      |       | 300                    |                      |       | ns                        |
|                                                                                   |          | 1                      |       | 1                      |                      |       | 1                      |                      |       | μs                        |
| ANALOG OUTPUT                                                                     |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Voltage Models                                                                    |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Ranges - CBI                                                                      |          | ±2.5, ±5, ±10, +5, +10 |       | ±2.5, ±5, ±10, +5, +10 |                      |       | ±2.5, ±5, ±10, +5, +10 |                      |       | V                         |
| - CCD                                                                             |          | ±10                    |       | ±10                    |                      |       | ±10                    |                      |       | V                         |
| Output Current                                                                    | ±5       | 0.05                   |       | ±5                     | 0.05                 |       | ±5                     | 0.05                 |       | mA                        |
| Output Impedance (dc)                                                             |          | Indefinite to Common   |       |                        | Indefinite to Common |       |                        | Indefinite to Common |       | Ω                         |
| Short Circuit Duration                                                            |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Current Models                                                                    |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Ranges - Unipolar                                                                 |          | -2.0                   |       | -2.0                   |                      |       | -2.0                   |                      |       | mA                        |
| - Bipolar                                                                         |          | ±1.0                   |       | ±1.0                   |                      |       | ±1.0                   |                      |       | mA                        |
| Output Impedance - Bipolar                                                        |          | 3.2                    |       | 3.2                    |                      |       | 3.2                    |                      |       | kΩ                        |
| - Unipolar                                                                        |          | 6.6                    |       | 6.6                    |                      |       | 6.6                    |                      |       | kΩ                        |
| Compliance                                                                        |          | -1.5, +10              |       | -2.5, +10              |                      |       | -2.5, +10              |                      |       | V                         |
| Internal Reference Voltage (V <sub>R</sub> )                                      | +6.17    | +6.3                   | +6.43 | +6.17                  | +6.3                 | +6.43 | +6.17                  | +6.3                 | +6.43 | V                         |
| Output Impedance                                                                  |          | 1.5                    |       | 1.5                    |                      |       | 1.5                    |                      |       | Ω                         |
| Max External Current <sup>6</sup>                                                 |          |                        | +2.5  |                        | +2.5                 |       |                        | +2.5                 |       | mA                        |
| Tempco of Drift                                                                   |          | ±10                    | ±20   | ±10                    | ±20                  |       | ±10                    | ±20                  |       | ppm of V <sub>R</sub> /°C |
| POWER SUPPLY SENSITIVITY                                                          |          |                        |       |                        |                      |       |                        |                      |       |                           |
| ±15V ±10%, 5V supply when applicable                                              |          | ±0.002                 |       | ±0.002                 |                      |       | ±0.002                 |                      |       | % of FSR/%V <sub>S</sub>  |
| POWER SUPPLY REQUIREMENTS                                                         |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Rated Voltages                                                                    |          | ±15, 5                 |       | ±15, 5                 |                      |       | ±15, 5                 |                      |       | V                         |
| Range                                                                             |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Analog Supplies                                                                   | ±14      |                        | ±16   | ±14.5                  |                      | ±15.5 | ±14.5                  |                      | ±15.5 | V                         |
| Logic Supplies                                                                    | +4.5     |                        | +16   | +4.5                   |                      | +15.5 | +4.5                   |                      | +15.5 | V                         |
| Supply Drain <sup>7</sup>                                                         |          |                        |       |                        |                      |       |                        |                      |       |                           |
| +15V                                                                              | 10       | 20                     |       | 15                     | 20                   |       | 15                     | 20                   |       | mA                        |
| -15V                                                                              | 20       | 35                     |       | 25                     | 30                   |       | 25                     | 30                   |       | mA                        |
| +5V <sup>8</sup>                                                                  | 8        | 20                     |       | 15                     | 20                   |       | 15                     | 20                   |       | mA                        |
| TEMPERATURE RANGE                                                                 |          |                        |       |                        |                      |       |                        |                      |       |                           |
| Specification                                                                     | 0        |                        | +70   | 0                      |                      | +70   | -25                    |                      | +85   | °C                        |
| Operating                                                                         | -25      |                        | +85   | -25                    |                      | +85   | -55                    |                      | +125  | °C                        |
| Storage                                                                           | -55      |                        | +130  | -65                    |                      | +150  | -65                    |                      | +150  | °C                        |

## NOTES

<sup>1</sup>Least Significant Bit.

<sup>2</sup>Adjustable to zero with external trim potentiometer.

<sup>3</sup>FSR means "Full Scale Range" and is 20V for the ±10V range and 10V for the ±5V range.

<sup>4</sup>Gain and offset errors adjusted to zero at +25°C.

<sup>5</sup>C<sub>P</sub> = 0, see Figure 1a.

<sup>6</sup>Maximum with no degradation of specification, must be a constant load.

<sup>7</sup>Including 5mA load.

<sup>8</sup>+5V supply required only for CCD versions.

Specifications subject to change without notice.

# AD DAC80/AD DAC85/AD DAC87 — SPECIFICATIONS ( $T_A = +25^\circ\text{C}$ , rated power supplies unless otherwise noted.)

| Model                                                                                                                       | AD DAC85LD |                                   |            | AD DAC85MIL |                                   |            | AD DAC87   |                                   |             | Units                        |
|-----------------------------------------------------------------------------------------------------------------------------|------------|-----------------------------------|------------|-------------|-----------------------------------|------------|------------|-----------------------------------|-------------|------------------------------|
|                                                                                                                             | Min        | Typ                               | Max        | Min         | Typ                               | Max        | Min        | Typ                               | Max         |                              |
| TECHNOLOGY                                                                                                                  | Hybrid     |                                   |            | Hybrid      |                                   |            | Hybrid     |                                   |             |                              |
| DIGITAL INPUT                                                                                                               |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Binary — CBI                                                                                                                |            |                                   | 12         |             |                                   | 12         |            |                                   | 12          | Bits                         |
| BCD — CCD                                                                                                                   |            |                                   |            |             |                                   |            |            |                                   |             | Digits                       |
| Logic Levels (TTL Compatible)                                                                                               |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| $V_{IH}$ (Logic "1")                                                                                                        | +2.0       |                                   | +5.5       | +2.0        |                                   | +5.5       | +2.0       |                                   | +5.5        | V                            |
| $V_{IL}$ (Logic "0")                                                                                                        | 0          |                                   | +0.8       | 0           |                                   | +0.8       | 0          |                                   | +0.8        | V                            |
| $I_{IH}$ ( $V_{IH} = 5.5\text{V}$ )                                                                                         |            | +250                              |            |             | +250                              |            |            | +250                              |             | $\mu\text{A}$                |
| $I_{IL}$ ( $V_{IL} = 0.8\text{V}$ )                                                                                         |            | -100                              |            |             | -100                              |            |            | -100                              |             | $\mu\text{A}$                |
| TRANSFER CHARACTERISTICS                                                                                                    |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| ACCURACY                                                                                                                    |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Linearity Error ( $@ +25^\circ\text{C}$ )                                                                                   |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| CBI                                                                                                                         |            |                                   | $\pm 1/2$  |             |                                   | $\pm 1/2$  |            |                                   | $\pm 1/4$   | LSB <sup>1</sup>             |
| CCD                                                                                                                         |            |                                   |            |             |                                   |            |            |                                   | $\pm 1/2$   | LSB                          |
| $T_A$ ( $@ T_{min}$ to $T_{max}$ )                                                                                          |            |                                   | $\pm 1/2$  |             |                                   | $\pm 3/4$  |            |                                   | $\pm 3/4$   | LSB                          |
| Differential Linearity Error ( $@ +25^\circ\text{C}$ )                                                                      |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| CBI                                                                                                                         |            | $\pm 1/2$                         |            |             | $\pm 1/2$                         |            |            | $\pm 1/2$                         |             | LSB                          |
| CCD                                                                                                                         |            |                                   |            |             |                                   |            |            |                                   |             | LSB                          |
| $T_A$ ( $@ T_{min}$ to $T_{max}$ )                                                                                          |            |                                   | $\pm 1$    |             |                                   | $\pm 1$    |            |                                   | $\pm 1$     | LSB                          |
| Gain Error <sup>2</sup>                                                                                                     |            | $\pm 0.1$                         |            |             | $\pm 0.1$                         |            |            | $\pm 0.1$                         |             | %FSR <sup>3</sup>            |
| Offset Error <sup>2</sup>                                                                                                   |            | $\pm 0.05$                        |            |             | $\pm 0.05$                        |            |            | $\pm 0.05$                        |             | %FSR <sup>3</sup>            |
| Temperature Range for Guaranteed Monotonicity                                                                               | -25        |                                   | +85        | -55         |                                   | +125       | -55        |                                   | +125        | $^\circ\text{C}$             |
| DRIFT ( $T_{min}$ to $T_{max}$ )                                                                                            |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Total Bipolar Drift, max (includes gain, offset, and linearity drifts)                                                      |            |                                   |            |             |                                   |            |            | $\pm 15$                          | $\pm 30$    | ppm of FSR/ $^\circ\text{C}$ |
| Total Error ( $T_{min}$ to $T_{max}$ ) <sup>4</sup>                                                                         |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Unipolar                                                                                                                    |            |                                   |            |             |                                   |            |            | $\pm 0.13$                        | $\pm 0.30$  | % of FSR                     |
| Bipolar                                                                                                                     |            |                                   |            |             |                                   |            |            | $\pm 0.12$                        | $\pm 0.24$  | % of FSR                     |
| Gain                                                                                                                        |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Including Internal Reference                                                                                                |            |                                   | $\pm 10$   |             |                                   | $\pm 20$   |            | $\pm 10$                          | $\pm 25$    | ppm of FSR/ $^\circ\text{C}$ |
| Excluding Internal Reference                                                                                                |            |                                   |            |             |                                   |            |            | $\pm 5$                           | $\pm 10$    | ppm of FSR/ $^\circ\text{C}$ |
| Unipolar Offset                                                                                                             |            | $\pm 1$                           |            |             | $\pm 2$                           |            |            | $\pm 1$                           | $\pm 3$     | ppm of FSR/ $^\circ\text{C}$ |
| Bipolar Offset                                                                                                              |            |                                   | $\pm 5$    |             |                                   | $\pm 10$   |            | $\pm 5$                           | $\pm 10$    | ppm of FSR/ $^\circ\text{C}$ |
| CONVERSION SPEED                                                                                                            |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Voltage Model ( $V$ ) <sup>5</sup>                                                                                          |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Settling Time to $\pm 0.01\%$ of FSR for FSR change ( $2\text{k}\Omega/500\text{pF}$ load) with $10\text{k}\Omega$ Feedback |            | 5                                 |            |             | 5                                 |            |            | 5                                 |             | $\mu\text{s}$                |
| with $5\text{k}\Omega$ Feedback                                                                                             |            | 3                                 |            |             | 3                                 |            |            | 3                                 |             | $\mu\text{s}$                |
| For LSB Change                                                                                                              |            | 1.5                               |            |             | 1.5                               |            |            | 1.5                               |             | $\mu\text{s}$                |
| Slew Rate                                                                                                                   |            | 20                                |            |             | 20                                |            |            | 20                                |             | $\text{V}/\mu\text{s}$       |
| Current Model ( $I$ )                                                                                                       |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Settling Time to $\pm 0.01\%$ of FSR for FSR Change 10 to $100\Omega$ Load                                                  |            | 300                               |            |             | 300                               |            |            | 300                               |             | ns                           |
| for $1\text{k}\Omega$ Load                                                                                                  |            | 1                                 |            |             | 1                                 |            |            | 1                                 |             | $\mu\text{s}$                |
| ANALOG OUTPUT                                                                                                               |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Voltage Models                                                                                                              |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Ranges — CBI                                                                                                                |            | $\pm 2.5, \pm 5, \pm 10, +5, +10$ |            |             | $\pm 2.5, \pm 5, \pm 10, +5, +10$ |            |            | $\pm 2.5, \pm 5, \pm 10, +5, +10$ |             | V                            |
| — CCD                                                                                                                       |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Output Current                                                                                                              | $\pm 5$    |                                   |            | $\pm 5$     |                                   |            | $\pm 5$    |                                   |             | V                            |
| Output Impedance (dc)                                                                                                       |            | 0.05                              |            |             | 0.05                              |            |            | 0.05                              |             | mA                           |
| Short Circuit Duration                                                                                                      |            | Indefinite to Common              |            |             | Indefinite to Common              |            |            | Indefinite to Common              |             | $\Omega$                     |
| Current Models                                                                                                              |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Ranges — Unipolar                                                                                                           |            | -2.0                              |            |             | -2.0                              |            |            | -2.0                              |             | mA                           |
| — Bipolar                                                                                                                   |            | $\pm 1.0$                         |            |             | $\pm 1.0$                         |            |            | $\pm 1.0$                         |             | mA                           |
| Output Impedance — Bipolar                                                                                                  |            | 3.2                               |            |             | 3.2                               |            | 2.5        | 3.2                               | 4.1         | $\text{k}\Omega$             |
| — Unipolar                                                                                                                  |            | 6.6                               |            |             | 6.6                               |            | 5.0        | 6.6                               | 8.2         | $\text{k}\Omega$             |
| Compliance                                                                                                                  |            | -2.5, +10                         |            |             | -2.5, +10                         |            |            | -1.5, +10                         |             | V                            |
| Internal Reference Voltage ( $V_R$ )                                                                                        | +6.17      | +6.3                              | +6.43      | +6.17       | +6.3                              | +6.43      | +6.17      | +6.3                              | +6.43       | V                            |
| Output Impedance                                                                                                            |            | 1.5                               |            |             | 1.5                               |            |            | 1.5                               |             | $\Omega$                     |
| Max External Current <sup>6</sup>                                                                                           |            |                                   | +2.5       |             |                                   | +2.5       |            |                                   | +2.5        | mA                           |
| Tempco of Drift                                                                                                             |            | $\pm 10$                          | 20         |             | 10                                | 20         |            | $\pm 5$                           | 10          | ppm of $V_R/^\circ\text{C}$  |
| POWER SUPPLY SENSITIVITY                                                                                                    |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| $\pm 15\text{V} \pm 10\%$ , 5V supply when applicable                                                                       |            | $\pm 0.002$                       |            |             | $\pm 0.002$                       |            |            | $\pm 0.002$                       | $\pm 0.003$ | % of FSR/ $\%V_S$            |
| POWER SUPPLY REQUIREMENTS                                                                                                   |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Rated Voltages                                                                                                              |            | $\pm 15, 5$                       |            |             | $\pm 15, 5$                       |            |            | $\pm 15, 5$                       |             | V                            |
| Range                                                                                                                       |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Analog Supplies                                                                                                             | $\pm 14.5$ |                                   | $\pm 15.5$ | $\pm 14.5$  |                                   | $\pm 15.5$ | $\pm 13.5$ |                                   | $\pm 16.5$  | V                            |
| Logic Supplies                                                                                                              | +4.5       |                                   | +15.5      | +4.5        |                                   | +15.5      | +4.5       |                                   | +16.5       | V                            |
| Supply Drain <sup>7</sup>                                                                                                   |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| +15V                                                                                                                        | 15         | 20                                |            | 15          | 20                                |            | 10         | 20                                |             | mA                           |
| -15V                                                                                                                        | 25         | 30                                |            | 25          | 30                                |            | 20         | 35                                |             | mA                           |
| +5V <sup>8</sup>                                                                                                            | 15         | 20                                |            | 15          | 20                                |            | 10         | 20                                |             | mA                           |
| TEMPERATURE RANGE                                                                                                           |            |                                   |            |             |                                   |            |            |                                   |             |                              |
| Specification                                                                                                               | -25        |                                   | +85        | -55         |                                   | +125       | -55        |                                   | +125        | $^\circ\text{C}$             |
| Operating                                                                                                                   | -55        |                                   | +125       | -55         |                                   | +125       | -55        |                                   | +125        | $^\circ\text{C}$             |
| Storage                                                                                                                     | -55        |                                   | +125       | -55         |                                   | +120       | -65        |                                   | +150        | $^\circ\text{C}$             |

## NOTES

<sup>1</sup>Least Significant Bit.

<sup>2</sup>Adjustable to zero with external trim potentiometer.

<sup>3</sup>FSR means "Full Scale Range" and is 20V for the  $\pm 10\text{V}$  range and 10V for the  $\pm 5\text{V}$  range.

<sup>4</sup>Gain and offset errors adjusted to zero at  $+25^\circ\text{C}$ .

<sup>5</sup> $C_P = 0$ , see Figure 1a.

<sup>6</sup>Maximum with no degradation of specification, must be a constant load.

<sup>7</sup>Including 3mA load.

<sup>8</sup>+5V supply required only for CCD versions.

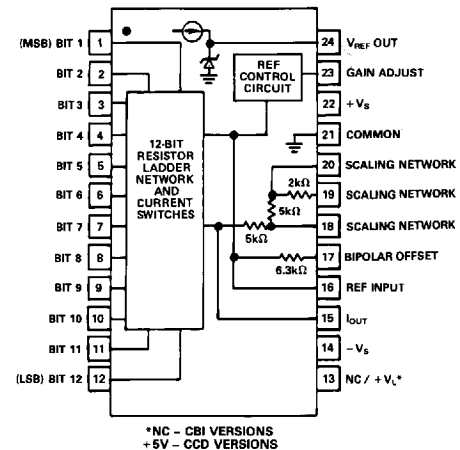
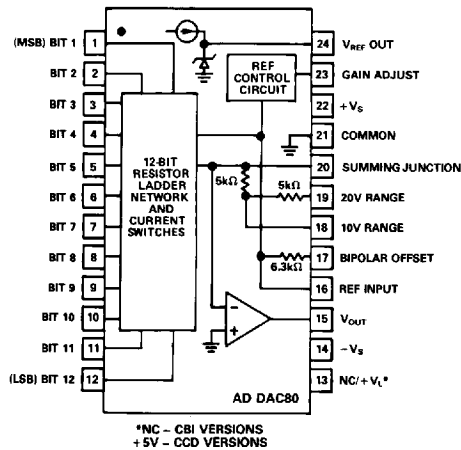
Specifications subject to change without notice.

# AD DAC80/AD DAC85/AD DAC87

## ABSOLUTE MAXIMUM RATINGS

+V<sub>S</sub> to Power Ground . . . . . 0V to +18V  
 -V<sub>S</sub> to Power Ground . . . . . 0V to -18V  
 Digital Inputs (Pins 1 to 12) to Power Ground . . . -1.0V to +7V

Ref In to Reference Ground . . . . . ±12V  
 Bipolar Offset to Reference Ground . . . . . ±12V  
 10V Span R to Reference Ground . . . . . ±12V  
 20V Span R to Reference Ground . . . . . ±24V  
 Ref Out . . . . . Indefinite short to power ground or +V<sub>S</sub>



Voltage Model Functional Diagram and Pin Configuration

Current Model Functional Diagram and Pin Configuration

## ORDERING GUIDE

| Model             | Input Code           | Output Mode | Technology | Temperature Range | Linearity Error | Package Option* |
|-------------------|----------------------|-------------|------------|-------------------|-----------------|-----------------|
| AD DAC80N-CBI-V   | Binary               | Voltage     | Monolithic | 0 to +70°C        | ± 1/2LSB        | N-24            |
| AD DAC80D-CBI-V   | Binary               | Voltage     | Monolithic | 0 to +70°C        | ± 1/2LSB        | D-24            |
| AD DAC85D-CBI-V   | Binary               | Voltage     | Monolithic | -25°C to +85°C    | ± 1/2LSB        | D-24            |
| AD DAC87D-CBI-V   | Binary               | Voltage     | Monolithic | -55°C to +125°C   | ± 1/2LSB        | D-24            |
| AD DAC80-CBI-V    | Binary               | Voltage     | Hybrid     | 0 to +70°C        | ± 1/2LSB        | DH-24A          |
| AD DAC80-CBI-I    | Binary               | Current     | Hybrid     | 0 to +70°C        | ± 1/2LSB        | DH-24A          |
| AD DAC80-CCD-V    | Binary Coded Decimal | Voltage     | Hybrid     | 0 to +70°C        | ± 1/4LSB        | DH-24A          |
| AD DAC80-CCD-I    | Binary Coded Decimal | Current     | Hybrid     | 0 to +70°C        | ± 1/4LSB        | DH-24A          |
| AD DAC80Z-CBI-V** | Binary               | Voltage     | Hybrid     | 0 to +70°C        | ± 1/2LSB        | DH-24A          |
| AD DAC80Z-CBI-I** | Binary               | Current     | Hybrid     | 0 to +70°C        | ± 1/2LSB        | DH-24A          |
| AD DAC80Z-CCD-V** | Binary Coded Decimal | Voltage     | Hybrid     | 0 to +70°C        | ± 1/4LSB        | DH-24A          |
| AD DAC80Z-CCD-I** | Binary Coded Decimal | Current     | Hybrid     | 0 to +70°C        | ± 1/4LSB        | DH-24A          |
| AD DAC85C-CBI-V   | Binary               | Voltage     | Hybrid     | 0 to +70°C        | ± 1/2LSB        | DH-24A          |
| AD DAC85C-CBI-I   | Binary               | Current     | Hybrid     | 0 to +70°C        | ± 1/2LSB        | DH-24A          |
| AD DAC85-CBI-V    | Binary               | Voltage     | Hybrid     | -25°C to +85°C    | ± 1/2LSB        | DH-24A          |
| AD DAC85-CBI-I    | Binary               | Current     | Hybrid     | -25°C to +85°C    | ± 1/2LSB        | DH-24A          |
| AD DAC85LD-CBI-V  | Binary               | Voltage     | Hybrid     | -25°C to +85°C    | ± 1/2LSB        | DH-24A          |
| AD DAC85LD-CBI-I  | Binary               | Current     | Hybrid     | -25°C to +85°C    | ± 1/2LSB        | DH-24A          |
| AD DAC85MIL-CBI-V | Binary               | Voltage     | Hybrid     | -55°C to +125°C   | ± 1/2LSB        | DH-24A          |
| AD DAC85MIL-CBI-I | Binary               | Current     | Hybrid     | -55°C to +125°C   | ± 1/2LSB        | DH-24A          |
| AD DAC85C-CCD-V   | Binary Coded Decimal | Voltage     | Hybrid     | 0 to +70°C        | ± 1/4LSB        | DH-24A          |
| AD DAC85C-CCD-I   | Binary Coded Decimal | Current     | Hybrid     | 0 to +70°C        | ± 1/4LSB        | DH-24A          |
| AD DAC85-CCD-V    | Binary Coded Decimal | Voltage     | Hybrid     | -25°C to +85°C    | ± 1/4LSB        | DH-24A          |
| AD DAC85-CCD-I    | Binary Coded Decimal | Current     | Hybrid     | -25°C to +85°C    | ± 1/4LSB        | DH-24A          |
| AD DAC87-CBI-V    | Binary               | Voltage     | Hybrid     | -55°C to +125°C   | ± 1/2LSB        | DH-24A          |
| AD DAC87-CBI-I    | Binary               | Current     | Hybrid     | -55°C to +125°C   | ± 1/2LSB        | DH-24A          |

\*For outline information see Package Information section.

\*\*Z-Suffix devices guarantee performance of 0 to +5V and ±5V spans with minimum supply voltages of ±11.4V.

# AD DAC80/AD DAC85/AD DAC87

## DIGITAL INPUT CODES

The AD DAC80 Series accepts complementary digital input code in binary (CBI) format. The CBI model may be connected by the user for anyone of three complementary codes: CSB, COB or CTC.

Table 1. Digital Input Codes

| Digital Input       |     | Analog Output              |                          |                          |
|---------------------|-----|----------------------------|--------------------------|--------------------------|
| MSB                 | LSB | CSB Compl. Straight Binary | COB Compl. Offset Binary | CTC* Compl. Two's Compl. |
| 0 0 0 0 0 0 0 0 0 0 |     | + Full Scale               | + Full Scale             | - 1LSB                   |
| 0 1 1 1 1 1 1 1 1 1 |     | + 1/2 Full Scale           | Zero                     | - Full Scale             |
| 1 0 0 0 0 0 0 0 0 0 |     | Mid-Scale                  | - 1LSB                   | + Full Scale             |
| 1 1 1 1 1 1 1 1 1 1 |     | Zero                       | - Full Scale             | Zero                     |

\*Invert the MSB of the COB code with an external inverter to obtain CTC code.

## ACCURACY

Accuracy error of a D/A converter is the difference between the analog output that is expected when a given digital code is applied and the output that is actually measured with that code applied to the converter. Accuracy error can be caused by gain error, zero error, linearity error, or any combination of the three. Of these three specifications, the linearity error specification is the most important since it cannot be corrected. Linearity error is specified over its entire temperature range. This means that the analog output will not vary by more than its maximum specification, from an ideal straight line drawn between the end points (inputs all "1"s and all "0"s) over the specified temperature range.

Differential linearity error of a D/A converter is the deviation from an ideal 1LSB voltage change from one adjacent output state to the next. A differential linearity error specification of  $\pm 1/2$ LSB means that the output voltage step sizes can range from 1/2LSB to 1 1/2LSB when the input changes from one adjacent input state to the next.

## DRIFT

**Gain Drift** is a measure of the change in the full scale range output over temperature expressed in parts per million of full scale range per °C (ppm of FSR/°C). Gain drift is established by: 1) testing the end point differences for each AD DAC80 model at the lowest operating temperature, +25°C and the highest operating temperature; 2) calculating the gain error with respect to the +25°C value and; 3) dividing by the temperature change.

**Offset Drift** is a measure of the actual change in output with all "1"s on the input over the specified temperature range. The maximum change in offset is referenced to the offset at +25°C and is divided by the temperature range. This drift is expressed in parts per million of full scale range per °C (ppm of FSR/°C).

## SETTLING TIME

Settling time for each model is the total time (including slew time) required for the output to settle within an error band around its final value after a change in input.

**Voltage Output Models.** Three settling times are specified to  $\pm 0.01\%$  of full scale range (FSR); two for maximum full scale range changes of 20V, 10V and one for a 1LSB change. The

1LSB change is measured at the major carry (0 1 1 1 . . . 1 1 to 1 0 0 0 . . . 0 0), the point at which the worst case settling time occurs. The settling time characteristic depends on the compensation capacitor selected, the optimum value is 25pF as shown in Figure 1a.

**Current Output Models.** Two settling times are specified to  $\pm 0.01\%$  of FSR. Each is given for current models connected with two different resistive loads: 10 to 100 ohms and 1000 to 1875 ohms. Internal resistors are provided for connecting nominal load resistances of approximately 1000 to 1800 ohms for output voltage ranges of  $\pm 1$ V and 0 to -2V.

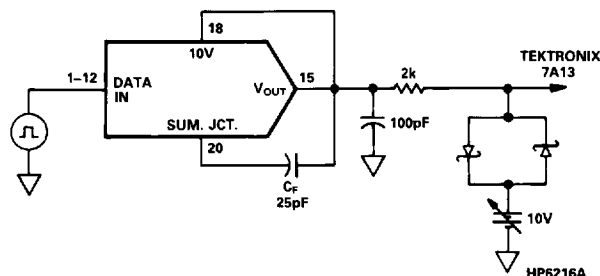


Figure 1a. Voltage Model Settling Time Circuit

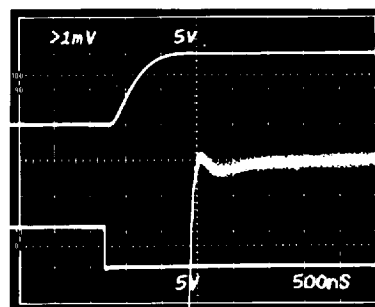


Figure 1b. Voltage Model Settling Time  $C_f = 25$ pF

## POWER SUPPLY SENSITIVITY

Power supply sensitivity is a measure of the effect of a power supply change on the D/A converter output. It is defined as a per cent of FSR per per cent of change in either the positive or negative supplies about the nominal power supply voltages.

## REFERENCE SUPPLY

All models are supplied with an internal 6.3 volt reference voltage supply. This voltage (pin 24) is accurate to  $\pm 1\%$  and must be connected to the Reference Input (pin 16) for specified operation. This reference may also be used externally with external current drain limited to 2.5mA. An external buffer amplifier is recommended if this reference is to be used to drive other system components. Otherwise, variations in the load driven by the reference will result in gain variations. All gain adjustments should be made under constant load conditions.

# Performance Over Temperature – AD DAC80/AD DAC85/AD DAC87

## ANALYZING DEVICE ACCURACY OVER THE TEMPERATURE RANGE

For the purposes of temperature drift analysis, the major device components are shown in Figure 2. The reference element and buffer amplifier drifts are combined to give the total reference temperature coefficient. The input reference current to the DAC,  $I_{REF}$ , is developed from the internal reference and will show the same drift rate as the reference voltage. The DAC output current,  $I_{DAC}$ , which is a function of the digital input codes, is designed to track  $I_{REF}$ ; if there is a slight mismatch in these currents over temperature, it will contribute to the gain T.C. The bipolar offset resistor,  $R_{BP}$ , and gain setting resistor,  $R_{GAIN}$ , also have temperature coefficients which contribute to system drift errors. The input offset voltage drift of the output amplifier, OA, also contributes a small error.

There are three types of drift errors over temperature: offset, gain, and linearity. Offset drift causes a vertical translation of the entire transfer curve; gain drift is a change in the slope of the curve; and linearity drift represents a change in the shape of the curve. The combination of these three drifts results in the complete specification for total error over temperature.

Total error is defined as the deviation from a true straight line transfer characteristic from exactly zero at a digital input which calls for zero output to a point which is defined as full scale. A specification for total error over temperature assumes that both the zero and full scale points have been trimmed for zero error at  $+25^{\circ}\text{C}$ . Total error is normally expressed a percentage of the full scale range. In the bipolar situation, this means the total range from  $-V_{FS}$  to  $+V_{FS}$ .

Several new design concepts not previously used in DAC80-type devices contribute to a reduction in all the error factors over temperature. The incorporation of low temperature coefficient silicon-chromium thin-film resistors deposited on a single chip, a patented, fully differential, emitter weighted, precision current steering cell structure, and a T.C. trimmed buried zener diode reference element results in superior wide temperature range performance. The gain setting resistors and bipolar offset resistor are also fabricated on the chip with the same SiCr material as the ladder network, resulting in low gain and offset drift.

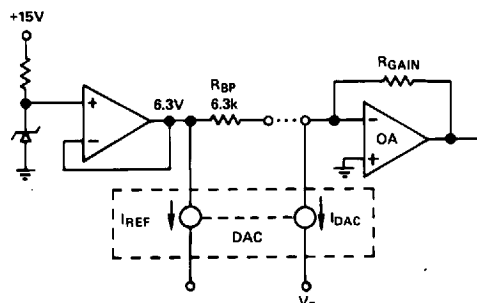


Figure 2. Bipolar Configuration

## MONOTONICITY AND LINEARITY

The initial linearity error of  $\pm 1/2\text{LSB}$  max and the differential linearity error of  $\pm 3/4\text{LSB}$  max guarantee monotonic performance over the specified range. It can, therefore, be assumed that linearity errors are insignificant in computation of total temperature errors.

## UNIPOLAR ERRORS

Temperature error analysis in the unipolar mode is straightforward: there is an offset drift and a gain drift. The offset drift (which comes from leakage currents and drift in the output amplifier (OA)) causes a linear shift in the transfer curve as shown in Figure 3. The gain drift causes a change in the slope of the curve and results from reference drift, DAC drift, and drift in  $R_{GAIN}$  relative to the DAC resistors.

## BIPOLAR RANGE ERRORS

The analysis is slightly more complex in the bipolar mode. In this mode  $R_{BP}$  is connected to the summing node of the output amplifier (see Figure 2) to generate a current which, exactly balances the current of the MSB so that the output voltage is zero with only the MSB on.

Note that if the DAC and application resistors track perfectly, the bipolar offset drift will be zero even if the reference drifts. A change in the reference voltage, which causes a shift in the bipolar offset, will also cause an equivalent change in  $I_{REF}$  and thus  $I_{DAC}$ , so that  $I_{DAC}$  will always be exactly balanced by  $I_{BP}$  with the MSB turned on. This effect is shown in Figure 3. The net effect of the reference drift then is simply to cause a rotation in the transfer around bipolar zero. However, consideration of second order effects (which are often overlooked) reveals the errors in the bipolar mode. The unipolar offset drifts discussed before will have the same effect on the bipolar offset. A mismatch of  $R_{BP}$  to the DAC resistors is usually the largest component of bipolar drift, but in the AD DAC80 this error is held to  $10\text{ppm}/^{\circ}\text{C}$  max. Gain drift in the DAC also contributes to bipolar offset drift, as well as full scale drift, but again is held to  $10\text{ppm}/^{\circ}\text{C}$  max.

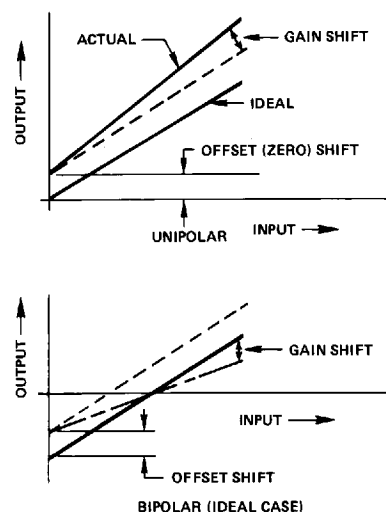


Figure 3. Unipolar and Bipolar Drifts

# AD DAC80/AD DAC85/AD DAC87

## Using the AD DAC80 Series

### POWER SUPPLY CONNECTIONS

For optimum performance power supply decoupling capacitors should be added as shown in the connection diagrams. These capacitors (1 $\mu$ F electrolytic recommended) should be located close to the AD DAC80. Electrolytic capacitors, if used, should be paralleled with 0.01 $\mu$ F ceramic capacitors for optimum high frequency performance.

### EXTERNAL OFFSET AND GAIN ADJUSTMENT

Offset and gain may be trimmed by installing external OFFSET and GAIN potentiometers. These potentiometers should be connected as shown in the block diagrams and adjusted as described below. TCR of the potentiometers should be 100ppm/ $^{\circ}$ C or less. The 3.9M $\Omega$  and 10M $\Omega$  resistors (20% carbon or better) should be located close to the AD DAC80 to prevent noise pickup. If it

is not convenient to use these high-value resistors, a functionally equivalent "T" network, as shown in Figure 6 may be substituted in each case. The gain adjust (pin 23) is a high impedance point and a 0.01 $\mu$ F ceramic capacitor should be connected from this pin to common to prevent noise pickup.

**Offset Adjustment.** For unipolar (CSB) configurations, apply the digital input code that should produce zero potential output and adjust the OFFSET potentiometer for zero output. For bipolar (COB, CTC) configurations, apply the digital input code that should produce the maximum negative output voltage. Example: If the FULL SCALE RANGE is connected for 20 volts, the maximum negative output voltage is -10V. See Table II for corresponding codes.

**Gain Adjustment.** For either unipolar or bipolar configurations, apply the digital input that should give the maximum positive voltage output. Adjust the GAIN potentiometer for this positive full scale voltage. See Table II for positive full scale voltages.

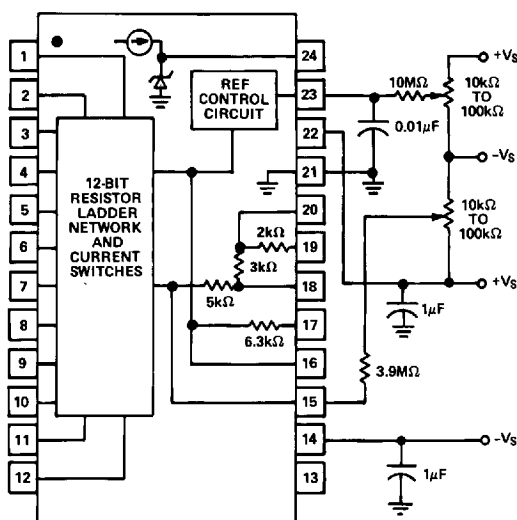


Figure 4. External Adjustment and Voltage Supply Connection Diagram, Current Model

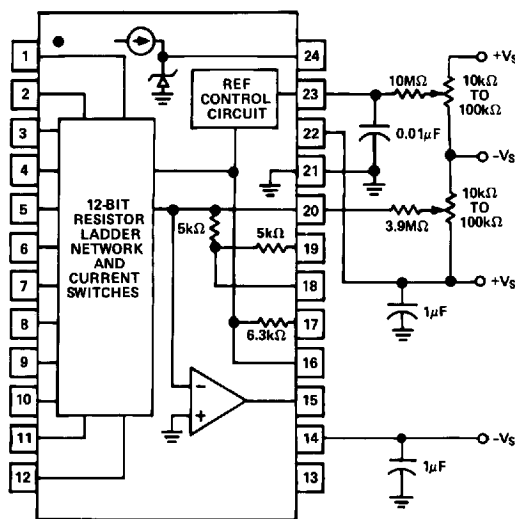


Figure 5. External Adjustment and Voltage Supply Connection Diagram, Voltage Model

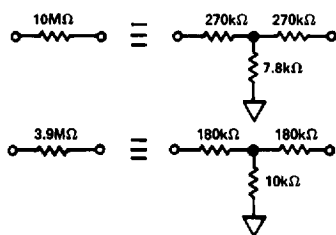


Figure 6. Equivalent Resistances

Table II. Digital Input/Analog Output

| Digital Input           |     | Analog Output |           |               |               |
|-------------------------|-----|---------------|-----------|---------------|---------------|
| 12 Bit Resolution       |     | Voltage*      |           | Current       |               |
| MSB                     | LSB | 0 to +10V     | $\pm 10V$ | 0 to -2mA     | $\pm 1mA$     |
| 0 0 0 0 0 0 0 0 0 0 0 0 |     | +9.9976V      | +9.9951V  | -1.9995mA     | -0.9995mA     |
| 0 1 1 1 1 1 1 1 1 1 1 1 |     | +5.0000V      | 0.0000V   | -1.0000mA     | 0.0000mA      |
| 1 0 0 0 0 0 0 0 0 0 0 0 |     | +4.9976V      | 4.88mV    | -0.9995mA     | +0.0005mA     |
| 1 1 1 1 1 1 1 1 1 1 1 1 |     | 0.0000V       | -10.0000V | 0.0000mA      | -1.00mA       |
| 1LSB                    |     | 2.44mV        | -0.0049V  | 0.488 $\mu$ A | 0.488 $\mu$ A |

\*To obtain values for other binary ranges 0 to +5V range: divide 0 to +10 values by 2;  
 $\pm 5V$  range: divide  $\pm 10V$  range values by 2;  $\pm 2.5V$  range: divide  $\pm 10V$  range values by 4.



# Applying the AD DAC80/AD DAC85/AD DAC87

## VOLTAGE OUTPUT MODELS

Internal scaling resistors provided in the AD DAC80 may be connected to produce bipolar output voltage ranges of  $\pm 10$ ,  $\pm 5$  or  $\pm 2.5$ V or unipolar output voltage ranges of 0 to +5 or 0 to +10V (see Figure 7).

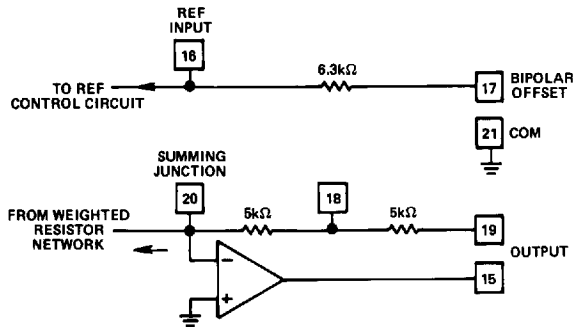


Figure 7. Output Amplifier Voltage Range Scaling Circuit

Gain and offset drift are minimized in the AD DAC80 because of the thermal tracking of the scaling resistors with other device components. Connections for various output voltage ranges are shown in Table III. Settling time is specified for a full scale range change: 4 microseconds for a 10kΩ feedback resistor; 3 microseconds for a 5kΩ feedback resistor when using the compensation capacitor shown in Figure 1.

The equivalent resistive scaling network and output circuit of the current model are shown in Figures 8 and 9. External  $R_{LS}$  resistors are required to produce exactly 0 to -2V or  $\pm 1$ V output. TCR of these resistors should be  $\pm 100$ ppm/°C or less to maintain the AD DAC80 output specifications. If exact output ranges are not required, the external resistors are not needed.

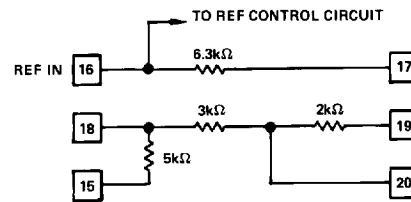


Figure 8. Internal Scaling Resistors

Internal resistors are provided to scale an external op amp or to configure a resistive load to offer two output voltage ranges of  $\pm 1$ V or 0 to -2V. These resistors ( $R_{LI}$ : TCR = 20ppm/°C) are an integral part of the AD DAC80 and maintain gain and bipolar offset drift specifications. If the internal resistors are not used, external  $R_L$  (or  $R_F$ ) resistors should have a TCR of  $\pm 25$ ppm/°C or less to minimize drift. This will typically add  $\pm 50$ ppm/°C + the TCR of  $R_L$  (or  $R_F$ ) to the total drift.

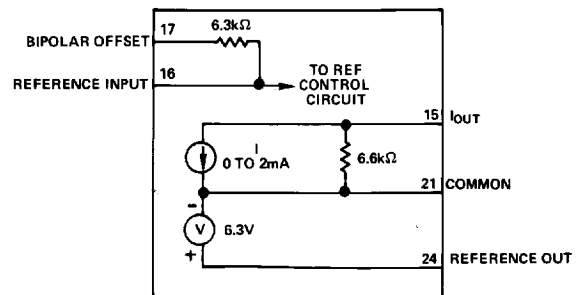


Figure 9. AD DAC80 Current Model Equivalent Output Circuit

Table III. Output Voltage Range Connections-Voltage Model AD DAC80

| Output Range | Digital Input Codes | Connect Pin 15 to | Connect Pin 17 to | Connect Pin 19 to | Connect Pin 16 to |
|--------------|---------------------|-------------------|-------------------|-------------------|-------------------|
| $\pm 10$ V   | COB or CTC          | 19                | 20                | 15                | 24                |
| $\pm 5$ V    | COB or CTC          | 18                | 20                | N.C.              | 24                |
| $\pm 2.5$ V  | COB or CTC          | 18                | 20                | 20                | 24                |
| 0 to +10V    | CSB                 | 18                | 21                | N.C.              | 24                |
| 0 to +5V     | CSB                 | 18                | 21                | 20                | 24                |
| 0 to +10V    | CCD                 | 19                | N.C.              | 15                | 24                |

Table IV. Current Model/Resistive Load Connections

| Digital Input Codes | Output Range   | Internal Resistance $R_{LI}$ | 1% Metal Film External Resistance $R_{LS}$ | $R_{LI}$ Connections |                   |                   | Reference         | Bipolar Offset    |                           |
|---------------------|----------------|------------------------------|--------------------------------------------|----------------------|-------------------|-------------------|-------------------|-------------------|---------------------------|
|                     |                |                              |                                            | Connect Pin 15 to    | Connect Pin 18 to | Connect Pin 20 to | Connect Pin 16 to | Connect Pin 17 to | $R_{LS}$                  |
| CSB                 | 0 to -2V       | 0.968kΩ                      | 210Ω                                       | 20                   | 19 & $R_{LS}$     | 15                | 24                | Com (21)          | Between Pin 18 & Com (21) |
| COB or CTC          | $\pm 1$ V      | 1.2kΩ                        | 249Ω                                       | 18                   | 19                | $R_{LS}$          | 24                | 15                | Between Pin 20 & Com (21) |
| CCD                 | 0 to $\pm 2$ V | 3kΩ                          | N/A                                        | N.C.                 | 21                | N.C.              | 24                | N.C.              | N/A                       |

# AD DAC80/AD DAC85/AD DAC87

## DRIVING A RESISTIVE LOAD UNIPOLAR

A load resistance,  $R_L = R_{LI} + R_{LS}$ , connected as shown in Figure 10 will generate a voltage range,  $V_{OUT}$ , determined by:

$$V_{OUT} = -2\text{mA} \left( \frac{6.6\text{k} \times R_L}{6.6\text{k} + R_L} \right)$$

Where  $R_L \text{ max} = 1.54\text{k}\Omega$

and  $V_{OUT} \text{ max} = -2.5\text{V}$

To achieve specified drift, connect the internal scaling resistor ( $R_{LI}$ ) as shown in Table IV to an external metal film trim resistor ( $R_{LS}$ ) to provide full scale output voltage range of 0 to  $-2\text{V}$ . With  $R_{LS} = 0$ ,  $V_{OUT} = -1.69\text{V}$ .

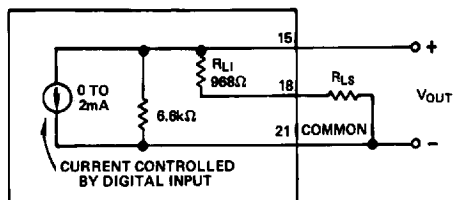


Figure 10. Equivalent Circuit AD DAC80-CBI-I Connected for Unipolar Voltage Output with Resistive Load

## DRIVING A RESISTOR LOAD BIPOLAR

The equivalent output circuit for a bipolar output voltage range is shown in Figure 11,  $R_L = R_{LI} + R_{LS}$ .  $V_{OUT}$  is determined by:

$$V_{OUT} = \pm 1\text{mA} \left( \frac{R_L \times 3.22\text{k}}{R_L + 3.22\text{k}} \right)$$

Where  $R_L \text{ max} = 11.18\text{k}\Omega$

and  $V_{OUT} \text{ max} = \pm 2.5\text{V}$

To achieve specified drift, connect the internal scaling resistors ( $R_{LI}$ ) as shown in Table IV for the COB or CTC codes and add an external metal film resistor ( $R_{LS}$ ) in series to obtain a full scale output range of  $\pm 1\text{V}$ . In this configuration, with  $R_{LS}$  equal to zero, the full scale range will be  $\pm 0.874\text{V}$ .

## DRIVING AN EXTERNAL OP AMP

The current model AD DAC80 will drive the summing junction of an op amp used as a current to voltage converter to produce an output voltage. As seen in Figure 12,

$$V_{OUT} = I_{OUT} \times R_F$$

where  $I_{OUT}$  is the AD DAC80 output current and  $R_F$  is the feedback resistor. Using the internal feedback resistors of the current model AD DAC80 provides output voltage ranges the

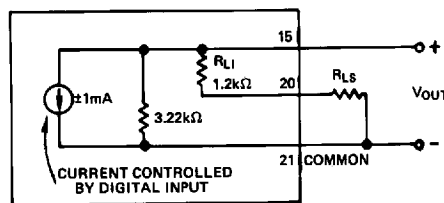


Figure 11. AD DAC80-CBI-I Connected for Bipolar Output Voltage with Resistive Load

same as the voltage model AD DAC80. To obtain the desired output voltage range when connecting an external op amp, refer to Table V and Figure 12.

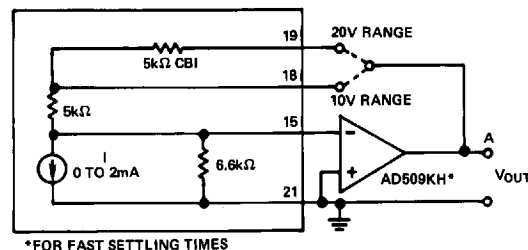


Figure 12. External Op Amp—Using Internal Feedback Resistors

## OUTPUT LARGER THAN 20V RANGE

For output voltage ranges larger than  $\pm 10$  volts, a high voltage op amp may be employed with an external feedback resistor. Use  $I_{OUT}$  values of  $\pm 1\text{mA}$  for bipolar voltage ranges and  $-2\text{mA}$  for unipolar voltage ranges (see Figure 13). Use protection diodes when a high voltage op amp is used.

The feedback resistor,  $R_F$ , should have a temperature coefficient as low as possible. Using an external feedback resistor, overall drift of the circuit increases due to the lack of temperature tracking between  $R_F$  and the internal scaling resistor network. This will typically add  $50\text{ppm}/^\circ\text{C} + R_F \text{ drift}$  to total drift.

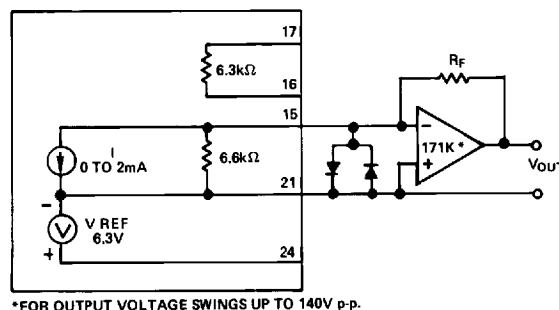


Figure 13. External Op Amp—Using External Feedback Resistors

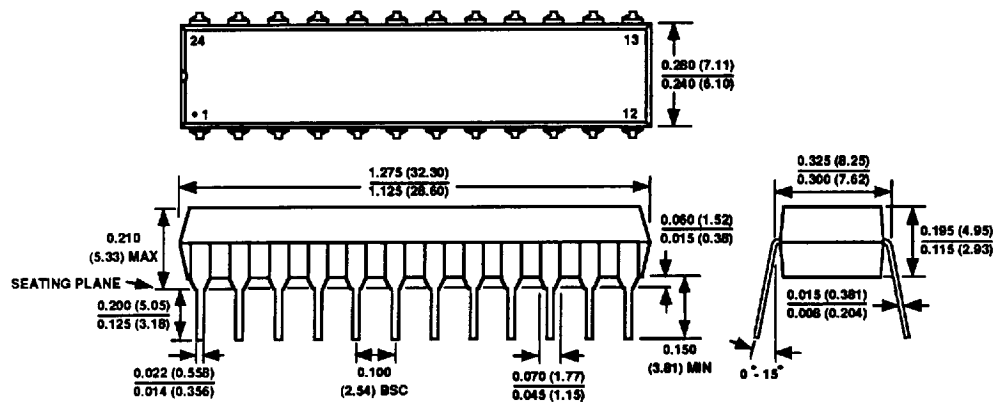
Table V. External Op Amp Voltage Mode Connections

| Output Range       | Digital Input Codes | Connect A to | Connect Pin 17 to | Connect Pin 19 to | Connect Pin 16 to |
|--------------------|---------------------|--------------|-------------------|-------------------|-------------------|
| $\pm 10\text{V}$   | COB or CTC          | 19           | 15                | A                 | 24                |
| $\pm 5\text{V}$    | COB or CTC          | 18           | 15                | N.C.              | 24                |
| $\pm 2.5\text{V}$  | COB or CTC          | 18           | 15                | 15                | 24                |
| 0 to $+10\text{V}$ | CSB                 | 18           | 21                | N.C.              | 24                |
| 0 to $+5\text{V}$  | CSB                 | 18           | 21                | 15                | 24                |

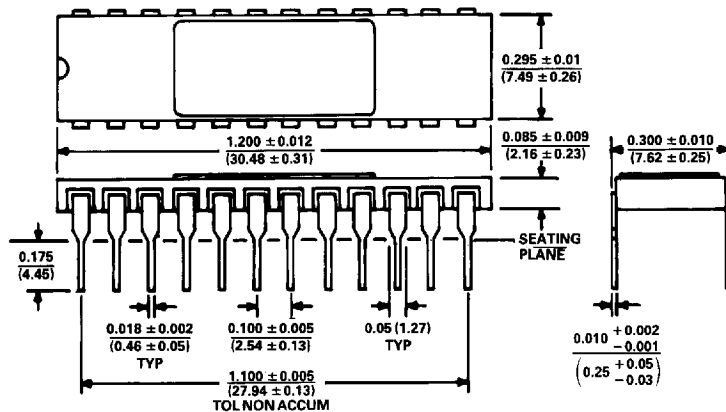
## OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

### 24-Pin Plastic DIP (N-24)



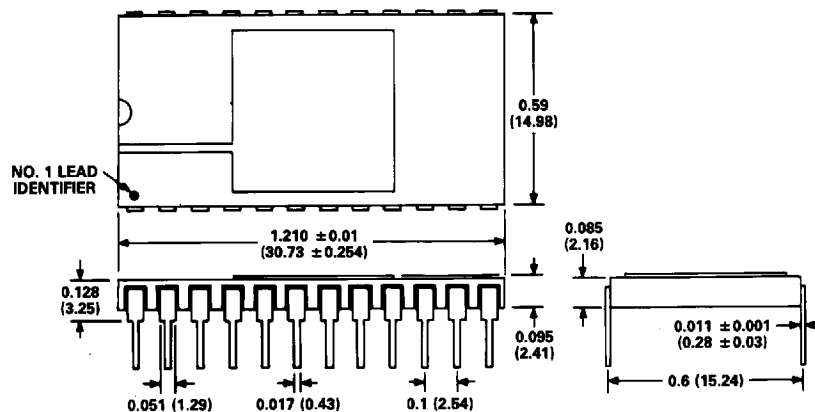
### 24-Pin Ceramic DIP (D-24)



#### NOTES

1. LEAD NO. 1 IDENTIFIED BY DOT OR NOTCH.
2. CERAMIC DIP LEADS WILL BE EITHER GOLD OR TIN PLATED IN ACCORDANCE WITH MIL-M-385 TO REQUIREMENTS.
3. METAL LID IS CONNECTED TO DGND.

### 24-Pin Ceramic DIP (DH-24A)





## Данный компонент на территории Российской Федерации

**Вы можете приобрести в компании MosChip.**

Для оперативного оформления запроса Вам необходимо перейти по данной ссылке:

<http://moschip.ru/get-element>

Вы можете разместить у нас заказ для любого Вашего проекта, будь то серийное производство или разработка единичного прибора.

В нашем ассортименте представлены ведущие мировые производители активных и пассивных электронных компонентов.

Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

Skype отдела продаж:

moschip.ru

moschip.ru\_4

moschip.ru\_6

moschip.ru\_9