

#### FEATURES

- MPS Pioneered Segmented DAC Approach
- Four 8-Bit DACs with Buffer Amplifiers
- Bipolar Amplifier Inputs for Low Noise and Drift
- Operates with Single or Dual Supplies
- $\mu$ P Compatible (95ns  $\overline{WR}$ )
- No External Adjustments Required
- Power-on-Reset Function
- Specified for 5 to 15 V Operation
- ESD Protection: 2000 Volts Minimum
- Latch-Up Proof
- Octal Available: MP7228

#### APPLICATIONS

- Function Generators
- Automatic Test Equipment
- Process Controls

#### BENEFITS

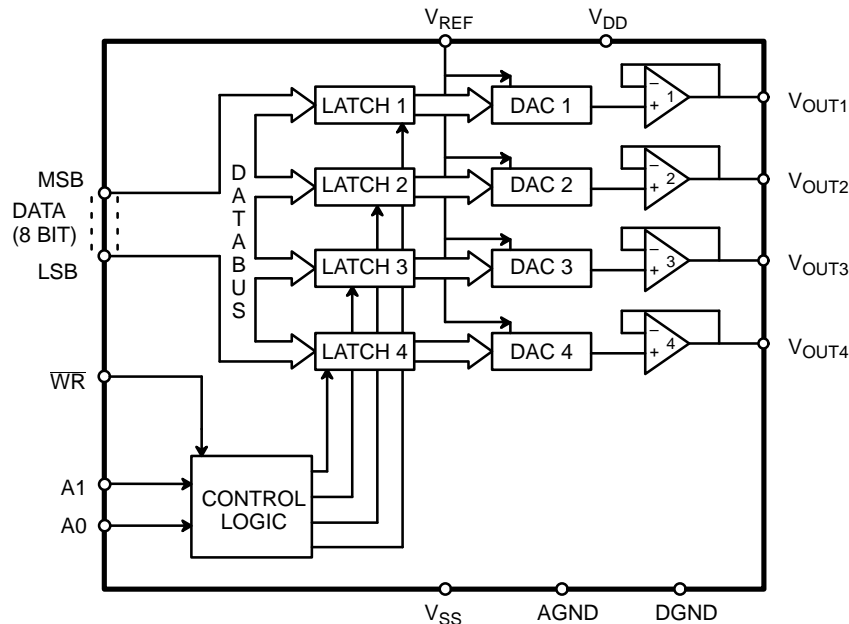
- Reduced Board Space; Lower System Cost
- Reduced System Errors due to Excellent DAC-to-DAC Matching and Tracking
- Easy to Design with Microprocessors
- Stable, High Reliability through Advanced Processing
- Lower 1/f Noise Increases Useful Dynamic Range

#### GENERAL DESCRIPTION

The MP7226 contains four 8-bit voltage-output Digital-to-Analog Converters, with BiCMOS output buffer amplifiers and interface logic on a monolithic chip. Separate on-chip latches are provided for each of the four D/A converters. The control logic is speed compatible with most 8-bit microprocessors. All digital inputs are TTL/CMOS(5V) compatible.

The MP7226 is manufactured using advanced thin film resistors on a double metal BiCMOS process. The MP7226 incorporates a unique bit decoding technique yielding lower glitch, higher speed and excellent accuracy over temperature and time. The MP7226 maintains 8-Bit accuracy over the full operating temperature range without laser trim or external adjustments.

#### SIMPLIFIED BLOCK DIAGRAM



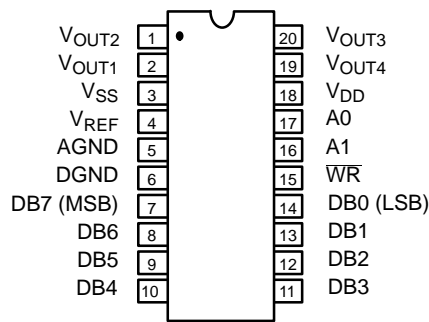
## ORDERING INFORMATION

| Package Type | Temperature Range | Part No.  | INL (LSB) | DNL (LSB) | Full Scale Error (LSB) |
|--------------|-------------------|-----------|-----------|-----------|------------------------|
| Plastic Dip  | -40 to +85°C      | MP7226KN  | 1         | ±1/2      | ±1                     |
| Plastic Dip  | -40 to +85°C      | MP7226LN* | 1/2       | ±1/2      | ±1/2                   |
| PLCC         | -40 to +85°C      | MP7226KP  | 1         | ±1/2      | ±1                     |
| PLCC         | -40 to +85°C      | MP7226LP* | 1/2       | ±1/2      | ±1/2                   |
| SOIC         | -40 to +85°C      | MP7226KS  | 1         | ±1/2      | ±1                     |
| SOIC         | -40 to +85°C      | MP7226LS* | 1/2       | ±1/2      | ±1/2                   |

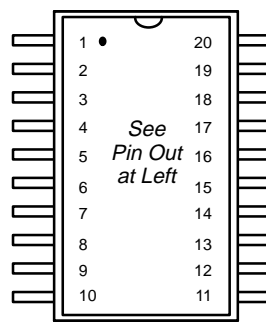
\*Contact factory for availability.

## PIN CONFIGURATIONS

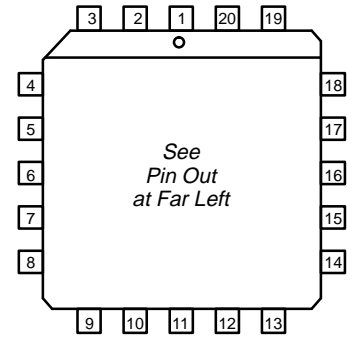
See Packaging Section for Package Dimensions



**20 Pin PDIP (0.300")**  
N20



**20 Pin SOIC (Jedec, 0.300")**  
S20



**20 Pin PLCC**  
P20

## PIN OUT DEFINITIONS

| PIN NO. | NAME              | DESCRIPTION                         |
|---------|-------------------|-------------------------------------|
| 1       | V <sub>OUT2</sub> | DAC 2 Voltage Output                |
| 2       | V <sub>OUT1</sub> | DAC 1 Voltage Output                |
| 3       | V <sub>SS</sub>   | Negative Power Supply (0 V to -5 V) |
| 4       | V <sub>REF</sub>  | Reference Input Voltage             |
| 5       | AGND              | Analog Ground                       |
| 6       | DGND              | Digital Ground                      |
| 7       | DB7               | Data Input Bit 7 (MSB)              |
| 8       | DB6               | Data Input Bit 6                    |
| 9       | DB5               | Data Input Bit 5                    |
| 10      | DB4               | Data Input Bit 4                    |

| PIN NO. | NAME              | DESCRIPTION                         |
|---------|-------------------|-------------------------------------|
| 11      | DB3               | Data Input Bit 3                    |
| 12      | DB2               | Data Input Bit 2                    |
| 13      | DB1               | Data Input Bit 1                    |
| 14      | DB0               | Data Input Bit 0 (LSB)              |
| 15      | $\overline{WR}$   | Write (Active Low)                  |
| 16      | A1                | DAC Address Bit 1                   |
| 17      | A0                | DAC Address Bit 0                   |
| 18      | V <sub>DD</sub>   | Positive Power Supply (+5 to +15 V) |
| 19      | V <sub>OUT4</sub> | DAC 4 Voltage Output                |
| 20      | V <sub>OUT3</sub> | DAC 3 Voltage Output                |

## ELECTRICAL CHARACTERISTICS

Single or Dual Supply Operation ( $V_{DD} = +10.8 \text{ V to } 16.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V or } -5 \text{ V} \pm 10\%$ ,  $AGND = 0 \text{ V}$ ,  $DGND = 0 \text{ V}$ ,  $V_{REF} = +2 \text{ V to } +10 \text{ V}$ ,  $R_L = 2 \text{ k}\Omega$ ,  $C_L = 100 \text{ pF}$  unless otherwise noted)

| Parameter                                  | Symbol    | 25°C |     |           | Tmin to Tmax |           | Units            | Test Conditions/Comments  |
|--|-----------|------|-----|-----------|--------------|-----------|------------------|---|
|  |           | Min  | Typ | Max       | Min          | Max       |                  |   |
| <b>STATIC PERFORMANCE</b>                  |           |      |     |           |              |           |                  |   |
| Resolution (All Grades)                    | N         | 8    |     |           | 8            |           | Bits             |   |
| Integral Non-Linearity (Relative Accuracy) | INL       |      |     |           |              |           | LSB              |   |
| K  |           |      |     | 1         |              | 1         |                  | End Point Linearity Spec  |
| L  |           |      |     | 1/2       |              | 1/2       |                  |   |
| Differential Non-Linearity                 | DNL       |      |     |           |              |           | LSB              | All grades monotonic over full temperature range.   |
| K  |           |      |     | $\pm 1/2$ |              | $\pm 3/4$ |                  |   |
| L  |           |      |     | $\pm 1/2$ |              | $\pm 3/4$ |                  |   |
| Total Unadjusted Error <sup>2</sup>        |           |      |     |           |              |           | LSB              | $V_{DD} = 15 \text{ V} \pm 10\%$ , $V_{REF} = +10 \text{ V}$  |
| K  |           |      |     | $\pm 2$   |              | $\pm 2$   |                  |   |
| L  |           |      |     | $\pm 1$   |              | $\pm 1$   |                  |   |
| Full Scale Error <sup>3</sup>              |           |      |     |           |              |           | LSB              | $V_{REF} = +10 \text{ V}$ typ. Tempco is 5 ppm/°C   |
| K  |           |      |     | $\pm 1$   |              | $\pm 1$   |                  |   |
| L  |           |      |     | $\pm 1/2$ |              | $\pm 1/2$ |                  |   |
| Zero Code Error                            |           |      |     |           |              |           | mV               | TA = 25°C typ. Tempco is 30 $\mu\text{V}/^\circ\text{C}$  |
| K  |           |      |     | $\pm 20$  |              | $\pm 30$  |                  |   |
| L  |           |      |     | $\pm 15$  |              | $\pm 20$  |                  |   |
| Output Load Resistance                     |           | 2    |     |           | 2            |           | k $\Omega$       | $V_{OUT} = +10 \text{ V}$   |
| <b>DYNAMIC PERFORMANCE<sup>4</sup></b>     |           |      |     |           |              |           |                  |   |
| Voltage Output Slew Rate                   |           | 2    | 4   |           | 2            | 5         | V/ $\mu\text{s}$ | $V_{REF} = +10 \text{ V}$ ; Settling Time to $\pm 1/2$ LSB<br>Code transition all 0s to all 1s<br>$V_{REF} = 0 \text{ V}$ , $\overline{WR} = V_{DD}$<br>Code transition all 0s to all 1s<br>$V_{REF} = +10 \text{ V}$ , $\overline{WR} = 0 \text{ V}$ |
| Voltage Output Settling Time               |           |      |     | 4         |              |           | $\mu\text{s}$    |   |
| Digital Feedthrough                        |           |      | 25  |           |              |           | nVs              |   |
| Digital Crosstalk <sup>5</sup>             |           |      | 25  |           |              |           | nVs              |   |
| <b>REFERENCE INPUT</b>                     |           |      |     |           |              |           |                  |   |
| Reference Input Range <sup>1</sup>         |           | 1    |     | 10        | 1            | 10        | V                | Limitation: $V_{REF} - V_{SS} < 11 \text{ V}$<br>Min $R_{IN}$ at Code 149 <sub>10</sub><br>Occurs when all DACs are loaded with all 1s<br>$V_{REF} = 10 \text{ kHz}$ , 5 V p-p sinewave   |
| Reference Input Resistance                 | $R_{IN}$  | 2    |     |           | 2            |           | k $\Omega$       |   |
| Reference Input Capacitance <sup>4</sup>   |           |      | 500 |           |              |           | pF               |   |
| AC Feedthrough                             |           |      | -70 |           |              |           | dB               |   |
| <b>DIGITAL INPUTS</b>                      |           |      |     |           |              |           |                  |   |
| Input High Voltage                         | $V_{INH}$ | 2.4  |     |           | 2.4          |           | V                | $V_{IN} = 0 \text{ V or } V_{DD}$<br><br>Binary   |
| Input Low Voltage                          | $V_{INL}$ |      |     | 0.8       |              | 0.8       | V                |   |
| Input Leakage Current                      | $I_{LKG}$ |      |     | $\pm 1$   |              | $\pm 1$   | $\mu\text{A}$    |   |
| Input Capacitance <sup>4</sup>             |           |      |     | 8         |              | 8         | pF               |   |
| Input Coding                               |           |      |     |           |              |           |                  |   |

## ELECTRICAL CHARACTERISTICS (CONT'D)

| Parameter  | Symbol          | 25°C |     |      | Tmin to Tmax |      | Units | Test Conditions/Comments   |
|--|-----------------|------|-----|------|--------------|------|-------|--|
|  |                 | Min  | Typ | Max  | Min          | Max  |       |  |
| <b>POWER SUPPLY</b>                                      |                 |      |     |      |              |      |       |  |
| V <sub>DD</sub> Range                                    |                 | 10.8 |     | 16.5 | 10.8         | 16.5 | V     | For specified performance<br>For specified performance<br>Outputs unloaded;<br>V <sub>IN</sub> =V <sub>INL</sub> or V <sub>INH</sub><br>Outputs unloaded;<br>V <sub>IN</sub> =V <sub>INL</sub> or V <sub>INH</sub> |
| V <sub>SS</sub> Range (Dual Supplies) <sup>8</sup>       |                 | 0    |     | -5.5 | 0            | -5.5 | V     |  |
| I <sub>DD</sub>  |                 |      |     | 12   |              | 14   | mA    |  |
| I <sub>SS</sub> (Dual Supplies)                          |                 |      |     | 10   |              | 12   |       |  |
| <b>SWITCHING CHARACTERISTICS<sup>4, 6, 7</sup></b>       |                 |      |     |      |              |      |       |  |
| Address to $\overline{WR}$ Setup Time, t <sub>1</sub>    | t <sub>AS</sub> | 0    |     |      | 0            |      | ns    |  |
| Address to $\overline{WR}$ Hold Time, t <sub>2</sub>     | t <sub>AH</sub> | 0    |     |      | 0            |      | ns    |  |
| Data Valid to $\overline{WR}$ Setup Time, t <sub>3</sub> | t <sub>DS</sub> | 70   |     |      | 95           |      | ns    |  |
| Data Valid to $\overline{WR}$ Hold Time, t <sub>4</sub>  | t <sub>DH</sub> | 10   |     |      | 10           |      |       |  |
| $\overline{WR}$ Pulse Width, t <sub>5</sub>              | t <sub>WR</sub> | 95   |     |      | 120          |      | ns    |  |

**NOTES:**

- 1 V<sub>OUT</sub> must be less than V<sub>DD</sub> by 3.5 V to ensure correct operation.
- 2 Total Unadjusted Error includes zero code error, relative accuracy and full-scale error.
- 3 Calculated after zero code error has been adjusted out.
- 4 Sample tested at 25°C to ensure compliance.
- 5 The glitch impulse transferred to the output of one converter (not adjusted) due to a change in the digital input code to another addressed converter.
- 6 All input rise and fall times are measured from 10% to 90% of +5 V, t<sub>R</sub> = t<sub>F</sub> = 5 ns.
- 7 Timing measurement reference level is (V<sub>INH</sub> + V<sub>INL</sub>)/2.

Specifications are subject to change without notice

## ELECTRICAL CHARACTERISTICS

Single & Dual  $\pm 5$  V Supply Operation ( $V_{DD} = +5$  V  $\pm 5\%$ ,  $V_{SS} = 0$  V to  $-5$  V  $\pm 10\%$ ,  $V_{REF} = +1.25$  V,  $AGND = 0$  V,  $DGND = 0$  V,  $R_L = 2$  k $\Omega$ ,  $C_L = 100$  pF unless otherwise noted)

| Parameter                                  | Symbol    | 25°C |         |          | Tmin to Tmax |         | Units      | Test Conditions/Comments  |
|--|-----------|------|---------|----------|--------------|---------|------------|---|
|  |           | Min  | Typ     | Max      | Min          | Max     |            |   |
| <b>STATIC PERFORMANCE</b>                  |           |      |         |          |              |         |            |   |
| Resolution (All Grades)                    | N         | 8    |         |          | 8            |         | Bits       |   |
| Integral Non-Linearity (Relative Accuracy) | INL       |      |         |          |              |         | LSB        |   |
| K  |           |      |         | 2        |              | 2       |            | End Point Linearity Spec  |
| L  |           |      |         | 1        |              | 1       |            |   |
| Differential Non-Linearity                 | DNL       |      |         |          |              |         | LSB        | All grades monotonic over full temperature range.   |
| K  |           |      |         | $\pm 1$  |              | $\pm 1$ |            |   |
| L  |           |      |         | $\pm 1$  |              | $\pm 1$ |            |   |
| Total Unadjusted Error <sup>2</sup>        |           |      |         | $\pm 4$  |              |         | LSB        | $V_{DD} = 5$ V $\pm 5\%$ , $V_{REF} = 1.25$ V   |
| Full Scale Error <sup>3</sup>              |           |      |         |          |              |         | LSB        | $V_{REF} = +1.25$ V   |
| K  |           |      |         | $\pm 4$  |              | $\pm 4$ |            |   |
| L  |           |      |         | $\pm 2$  |              | $\pm 2$ |            |   |
| Zero Code Error                            |           |      |         | $\pm 20$ |              |         | mV         |   |
| Output Load Resistance                     |           | 2    |         |          |              |         | k $\Omega$ | $V_{OUT} = +10$ V   |
| <b>DYNAMIC PERFORMANCE<sup>4</sup></b>     |           |      |         |          |              |         |            |   |
| Voltage Output Slew Rate                   |           | 2    | 4       |          |              |         | V/ $\mu$ s | $V_{REF} = +1.25$ V; Settling Time to $\pm 1/2$ LSB   |
| Voltage Output Settling Time               |           |      |         | 4        |              |         | $\mu$ s    |   |
| Digital Feedthrough                        |           |      | 25      |          |              |         | nVs        | Code transition all 0s to all 1s  |
| Digital Crosstalk <sup>5</sup>             |           |      | 25      |          |              |         | nVs        | $V_{REF} = 0$ V, $\overline{WR} = V_{DD}$<br>Code transition all 0s to all 1s<br>$V_{REF} = +1.25$ V, $\overline{WR} = 0$ V |
| <b>REFERENCE INPUT</b>                     |           |      |         |          |              |         |            |   |
| Reference Input Range                      |           | 1    |         | 1.6      | 1            | 1.6     | V          | $V_{OUT}$ must be $< V_{DD}$ by 3.2V  |
| Reference Input Resistance                 | $R_{IN}$  | 2    |         |          | 2            |         | k $\Omega$ |   |
| Reference Input Capacitance <sup>4</sup>   |           |      | 500     |          |              |         | pF         | Occurs when all DACs are loaded with all 1s   |
| AC Feedthrough                             |           |      | -70     |          |              |         | dB         | $V_{REF} = 10$ kHz, 1/2 V p-p sinewave  |
| <b>DIGITAL INPUTS</b>                      |           |      |         |          |              |         |            |   |
| Input High Voltage                         | $V_{INH}$ | 2.4  |         |          | 2.4          |         | V          | $V_{IN} = 0$ V or $V_{DD}$  |
| Input Low Voltage                          | $V_{INL}$ |      | 0.8     |          |              | 0.8     | V          |   |
| Input Leakage Current                      | $I_{LKG}$ |      | $\pm 1$ |          |              | $\pm 1$ | $\mu$ A    |   |
| Input Capacitance <sup>4</sup>             |           |      | 8       |          |              | 8       | pF         |   |
| Input Coding                               |           |      |         |          |              |         |            | Binary  |

## ELECTRICAL CHARACTERISTICS (CONT'D)

| Parameter  | Symbol          | 25°C |     |      | Tmin to Tmax |      | Units | Test Conditions/Comments  |
|--|-----------------|------|-----|------|--------------|------|-------|---|
|  |                 | Min  | Typ | Max  | Min          | Max  |       |   |
| <b>POWER SUPPLY</b>                                |                 |      |     |      |              |      |       |   |
| V <sub>DD</sub> Range                              |                 | 4.75 |     | 5.25 | 4.75         | 5.25 | V     | For specified performance<br>Outputs unloaded;<br>V <sub>IN</sub> =V <sub>INL</sub> or V <sub>INH</sub><br>Outputs unloaded;<br>V <sub>IN</sub> =V <sub>INL</sub> or V <sub>INH</sub> |
| I <sub>DD</sub>                                    |                 |      |     | 8    |              | 8    | mA    |   |
| I <sub>SS</sub> (Dual Supplies)                    |                 |      |     | 6    |              | 6    |       |   |
| <b>SWITCHING CHARACTERISTICS<sup>4, 6, 7</sup></b> |                 |      |     |      |              |      |       |   |
| Address to $\overline{WR}$ Setup Time, t1          | t <sub>AS</sub> | 0    |     |      | 0            |      | ns    |   |
| Address to $\overline{WR}$ Hold Time, t2           | t <sub>AH</sub> | 0    |     |      | 0            |      | ns    |   |
| Data Valid to $\overline{WR}$ Setup Time, t3       | t <sub>DS</sub> | 70   |     |      | 95           |      | ns    |   |
| Data Valid to $\overline{WR}$ Hold Time, t4        | t <sub>DH</sub> | 0    |     |      |              |      |       |   |
| WR Pulse Width, t5                                 | t <sub>WR</sub> | 95   |     |      | 120          |      | ns    |   |

### NOTES:

- V<sub>OUT</sub> must be less than V<sub>DD</sub> by 3.5 V to ensure correct operation.
- Total Unadjusted Error includes zero code error, relative accuracy and full-scale error.
- Calculated after zero code error has been adjusted out.
- Sample tested at 25°C to ensure compliance.
- The glitch impulse transferred to the output of one converter (not adjusted) due to a change in the digital input code to another addressed converter.
- All input rise and fall times are measured from 10% to 90% of +5 V, t<sub>R</sub> = t<sub>F</sub> = 5 ns.
- Timing measurement reference level is (V<sub>INH</sub> + V<sub>INL</sub>)/2.

Specifications are subject to change without notice

## ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub> = +25°C unless otherwise noted)<sup>1, 2</sup>

|                                   |                                |  |                 |
|-----------------------------------|--------------------------------|--|-----------------|
| V <sub>DD</sub> to AGND, DGND     | 0 to +17 V                     | Storage Temperature                      | -65°C to +150°C |
| Digital Input Voltage to DGND     | -0.5 to V <sub>DD</sub> +0.5 V | Lead Temperature (Soldering, 10 seconds) | +300°C          |
| V <sub>REF</sub> to AGND, DGND    | -0.5 to V <sub>DD</sub> +0.5 V | Package Power Dissipation Rating to 75°C |                 |
| V <sub>SS</sub> to AGND, DGND     | +0.5 to -7 V                   | PDIP, SOIC, PLCC                         | 900mW           |
| AGND to DGND                      | ±1 V                           | Derates above 75°C                       | 12mW/°C         |
| (Functionality Guaranteed ±0.5 V) |                                |  |                 |

### NOTES:

- Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation at or above this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.
- Any input pin which can see a value outside the absolute maximum ratings should be protected by Schottky diode clamps (HP5082-2835) from input pin to the supplies. All inputs have protection diodes which will protect the device from short transients outside the supplies of less than 100mA for less than 100µs.

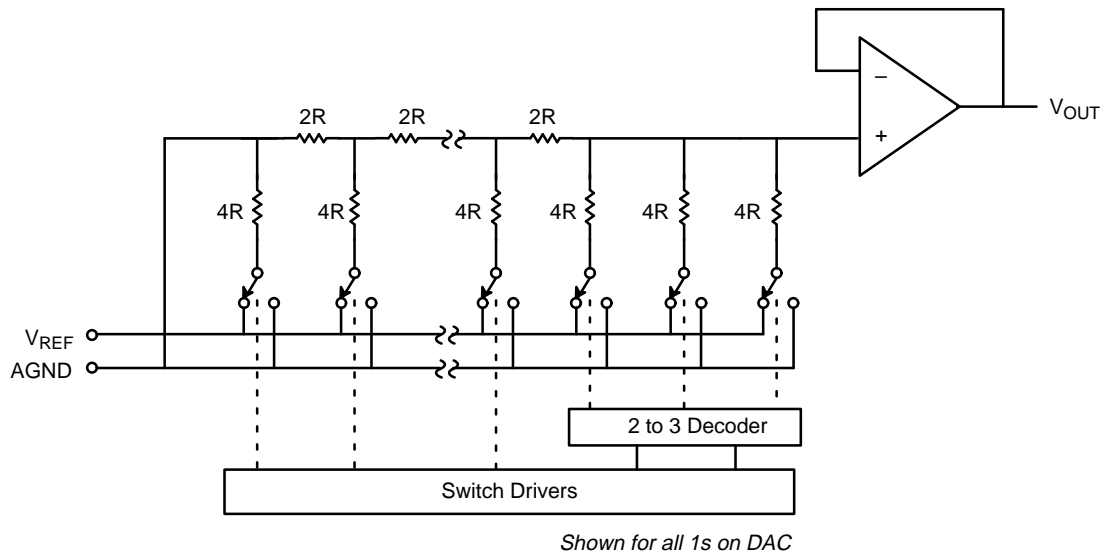
**D/A CONVERTER SECTION**

The MP7226 contains four matched, 8-bit, voltage-mode Digital-to-Analog Converters (DACs) which incorporate an MPS pioneered unique bit decoding technique. This decoding scheme reduces the maximum binary weight carried by any resistor switch, reducing the accuracy required of the switches and resistor network.

In the MP7226, the first three MSBs are decoded into three equal current sources, each contributing 25% of the full scale output current.

Decoding two bits to three, a 1% change in any one of the converter's three decoded current sources affects the output by no more than 0.25% of full scale, compared with 0.5% in a conventional R-2R type CMOS DAC.

The output voltages have the same polarity as the reference voltage, allowing single supply operation. The voltage reference range is from +2V to +10V. Each DAC uses a highly-stable, thin-film, ladder network and high-speed NMOS switches. *Figure 1.* shows a simplified circuit diagram for one channel.



**Figure 1. Simplified D/A Circuit Diagram**

**$V_{REF}$  Input**

The  $V_{REF}$  and  $AGND$  are common to all four DACs and set the full-scale output. The input impedance of the  $V_{REF}$  pin is the parallel combination of the four individual DAC reference impedances and is code dependent. This impedance varies from 2k $\Omega$  to 500k $\Omega$ . Therefore, it is very important that the external reference source output impedance is low enough so that its output voltage will not be affected by the varying digital code. Due to transient currents at the  $V_{REF}$  input during digital code changes, a 0.1 $\mu$ F or greater decoupling capacitor on that  $V_{REF}$  input is recommended. The input capacitance at the  $V_{REF}$  pin is also code dependent and typically varies from less than 120pF to 350pF.

Each  $V_{OUT}$  voltage can be represented by a digitally programmable voltage source using the following expression :

$$V_{OUT} = D_n \times V_{REF}/256$$

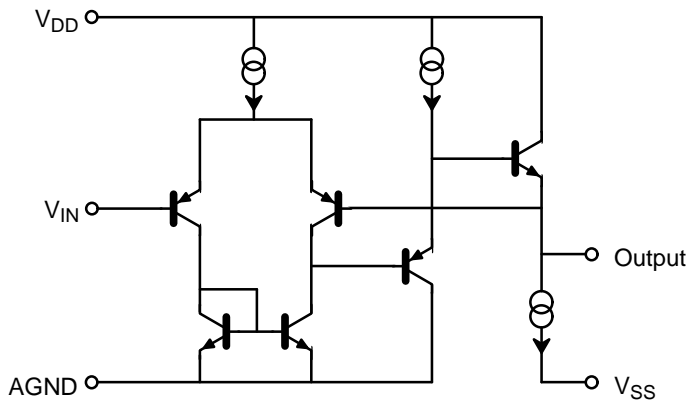
where  $D_n$  is the decimal equivalent to the digital input code and can vary from 0 to 255.

**Output Buffer Amp**

Each D/A converter output is buffered by a unity gain noninverting BiCMOS amplifier which has slew rate greater than 2 V/ $\mu$ s. The output buffer settles to  $\pm 1/2$  LSB in less than 4 $\mu$ s when driving a load of 2k $\Omega$  in parallel with 100pF with a full scale transition from 0V to +10V or from +10V to 0V. The buffers can drive 2k $\Omega$  and 500pF to 10V levels without oscillation.

A simplified circuit diagram of the output buffer is shown in *Figure 2.* The Input stage is provided by BiCMOS PNP transistors with resulting lower input offset voltage, offset voltage drift over time and noise when compared to MOS process. The amplifier output stage uses a substrate NPN bipolar device to provide a low output impedance, high-output current capability.

The MP7226 is specified for single or dual power supply operation, with only the buffer amplifier outputs using  $V_{SS}$  supply current. Operating the MP7226 from dual supplies will improve the negative going output settling time near ground. In dual supply voltage operation, the output amplifier can sink 500 $\mu$ A when  $V_{OUT} = 0$  V.



**Figure 2. Simplified Output Buffer Amplifiers**

The amplifiers outputs may be shorted to ground. However, the power dissipation of the package should not exceed the maximum limit.

### Digital Inputs

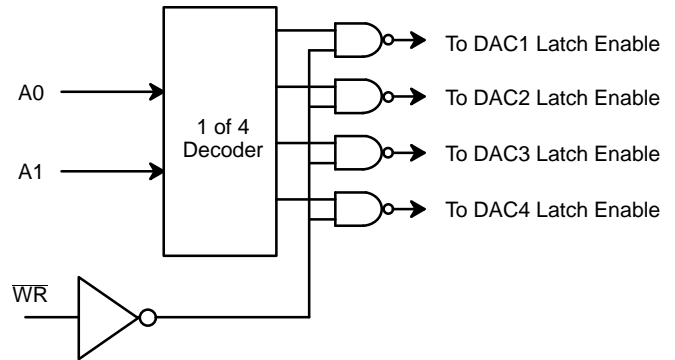
All of the digital inputs to this DAC maintain TTL level interface compatibility and can also be driven directly with 5V CMOS logic inputs. The digital inputs are ESD protected to a rating of 2000 volts.

### Digital Interface Logic

The MP7226 allows direct interface to most microprocessor buses without additional interface circuitry.

Figure 3. shows the input control logic circuit diagram and Table 1. shows the control logic truth table and operation for  $\overline{WR}$ , A1, A0. The address lines A0, and A1 determine which DAC will accept the input data. The  $\overline{WR}$  input determines whether the selected DAC is transparent (output follows the input), latched, or no operation. The  $\overline{WR}$  input will also inhibit power on reset of the DAC latches to 0, if its initial state = 0 after 5  $\mu$ s of power.

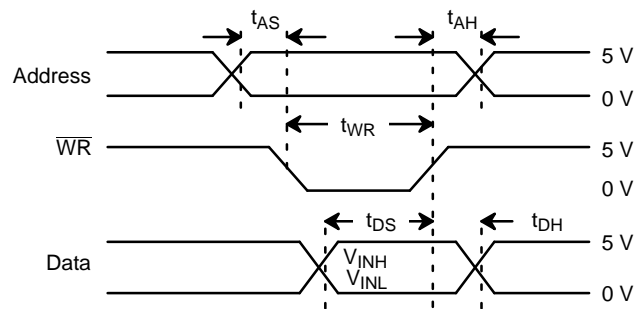
Figure 4. shows the write cycle timing diagram. When the  $\overline{WR}$  signal is low, the input latch of the selected DAC is transparent, and the DAC's output corresponds to the value present on the data bus. On some data buses, data is not always valid for the entire period that the  $\overline{WR}$  signal is low and can cause unwanted data at the output. Ensuring that the write pulse ( $\overline{WR}$ ) conforms to the data hold time, ( $t_4$ ) spec will prevent this problem.



**Figure 3. Input Control Logic**

| $\overline{WR}$ | A1 | A0 | Operation                            |
|-----------------|----|----|--------------------------------------|
| H               | X  | X  | No Operation;<br>Device Not Selected |
| L               | L  | L  | DAC 1 Transparent                    |
| $\uparrow$      | L  | L  | DAC 1 Latched                        |
| L               | L  | H  | DAC 2 Transparent                    |
| L               | H  | L  | DAC 3 Transparent                    |
| L               | H  | H  | DAC 4 Transparent                    |

**Table 1. Truth Table**



NOTE: When the  $\overline{WR}$  signal is low, the input latch of the selected DAC is transparent and any invalid data at this time will cause erroneous output.

**Figure 4. Write Cycle Timing Diagram**



## APPLICATIONS INFORMATION

### Power On Reset

At power up, all inputs are reset to 0 V if  $\overline{WR} = 1$ . For  $\overline{WR} = 0$ , the addressed DAC will receive input data.

### Power Supply

The MP7226 can operate with either a single or dual power supply. Improved zero-code settling error can be obtained by using dual power supplies. The dual power supply specifications are a positive supply ( $V_{DD}$ ) range of +10.5V to +16.5V, and a -5V supply ( $V_{SS}$ ). The single power supply specifications are a positive supply ( $V_{DD}$ ) range of +10.5V to +16.5V, or range of +4.75V to 5.5V. The specified reference voltage ( $V_{REF}$ ) range under these conditions is from +2V to  $V_{DD} - 4V$ . For those applications requiring +10V at the output ( $V_{REF} = +10V$ ),  $V_{DD}$  must be +14V minimum to meet data sheet limits. 8-bit performance is guaranteed for single supply operation ( $V_{SS} = 0V$ ); however, zero code output sink capability is improved with  $V_{SS} = -5V$ . For adequate DAC and Buffer operation,  $V_{REF}$  must always be below  $V_{DD}$  by at least 3.5V.

### Power Supply Decoupling

The Power Supplies used with the MP7226 should be well regulated and filtered. Local power supply decoupling consisting of a 10 $\mu$ F tantalum capacitor in parallel with a 0.01 $\mu$ F ceramic is recommended. The decoupling capacitors should be connected between the  $V_{DD}$  and AGND, and between  $V_{SS}$  and AGND if  $V_{SS} = -5V$ .

### Unipolar Output Operation

In this configuration, the reference voltage is the same polarity as the output voltage. Since the reference voltage must always be positive with respect to GND, the output can only be 0 or positive.

Table 2. shows the code relationship for the part in unipolar operation

| Digital Input   | Analog Output, $V_{OUT}$                                       |
|-----------------|--|
| 1 1 1 1 1 1 1 1 | $+ V_{REF} \left(\frac{255}{256}\right)$                       |
| 1 0 0 0 0 0 0 1 | $+ V_{REF} \left(\frac{129}{256}\right)$                       |
| 1 0 0 0 0 0 0 0 | $+ V_{REF} \left(\frac{128}{256}\right) = + \frac{V_{REF}}{2}$ |
| 0 1 1 1 1 1 1 1 | $+ V_{REF} \left(\frac{127}{256}\right)$                       |
| 0 0 0 0 0 0 0 1 | $+ V_{REF} \left(\frac{1}{256}\right)$                         |
| 0 0 0 0 0 0 0 0 | 0 V  |

Note :  $1 \text{ LSB} = (2^{-8}) (V_{REF}) = \frac{1}{256} (V_{REF})$

**Table 2. Unipolar Code Table**

| Digital Input   | Analog Output  |
|-----------------|--|
| 1 1 1 1 1 1 1 1 | $+ V_{REF} \left(\frac{127}{128}\right)$             |
| 1 0 0 0 0 0 0 1 | $+ V_{REF} \left(\frac{1}{128}\right)$               |
| 1 0 0 0 0 0 0 0 | 0 V  |
| 0 1 1 1 1 1 1 1 | $- V_{REF} \left(\frac{1}{128}\right)$               |
| 0 0 0 0 0 0 0 1 | $- V_{REF} \left(\frac{127}{128}\right)$             |
| 0 0 0 0 0 0 0 0 | $- V_{REF} \left(\frac{128}{128}\right) = - V_{REF}$ |

**Table 3. Bipolar Code Table**

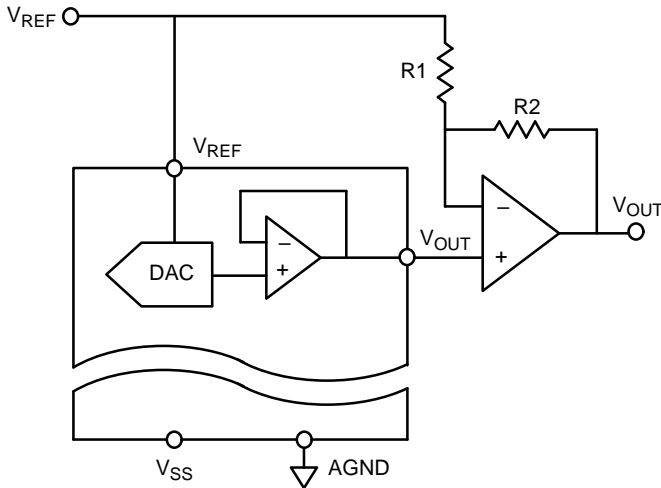
## Bipolar Binary Operation

The Bipolar Mode configuration for each DAC requires one external op-amp and two resistors per channel.

Figure 5. shows a typical Bipolar Operation circuit using the MP7226. Table 3. shows the code relationship for the circuit of Figure 5. assuming  $R1 = R2$ .

## AC Reference Signal

An AC signal can be applied to the reference of the MP7226 for multiplying capability within the upper (+10V) and lower (+2V) limits of the reference voltage input, with either single or dual supplies. This signal must be level shifted or AC coupled with proper bias level before being applied to the reference input. Figure 6. shows techniques for applying an AC signal to the MP7226. Since all four DACs share a common reference, they will all share this AC modulated reference. Input frequencies up to 50kHz will typically be distorted less than 0.1%.



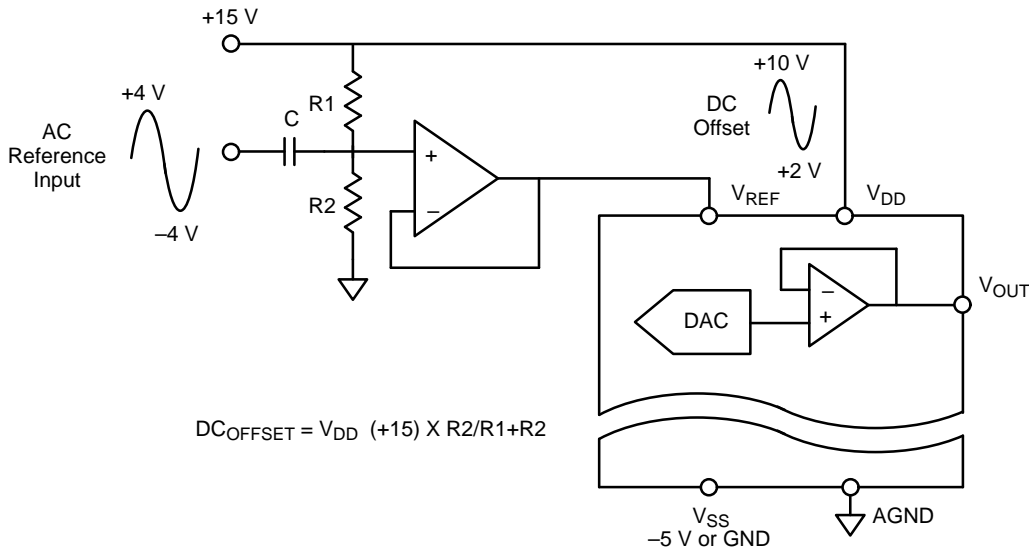
$$V_{OUT} = D_n \times V_{REF} \times (1 + R2/R1) - V_{REF} \times R2/R1$$

if  $R1 = R2$

$$V_{OUT} = V_{REF} \times (2D_n - 1)$$

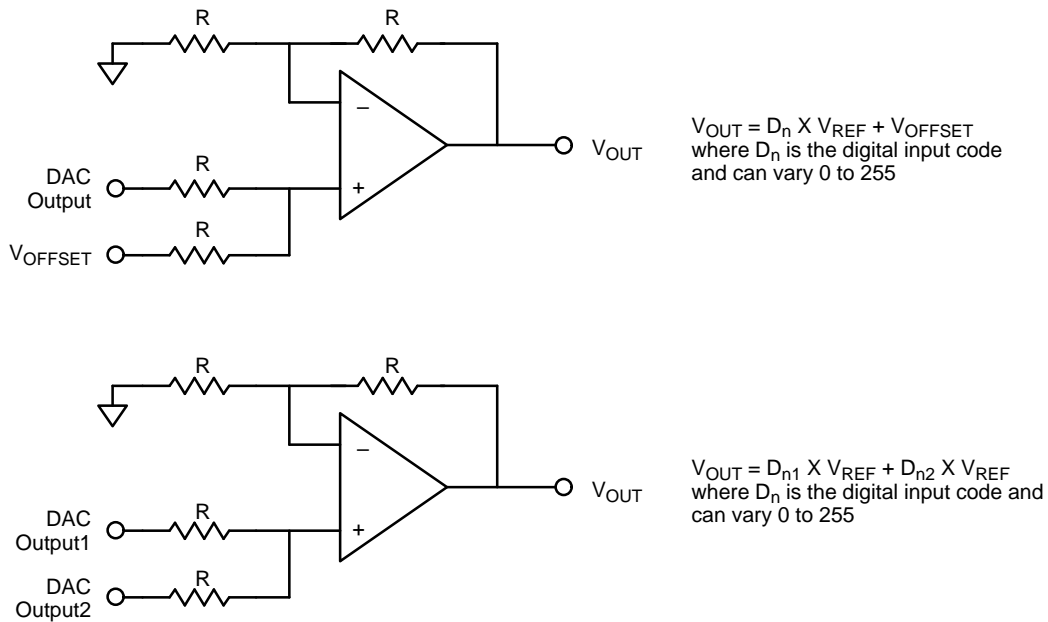
Where  $D_n$  is the digital input code and can vary from 0 to 255

**Figure 5. Bipolar Output Circuit**

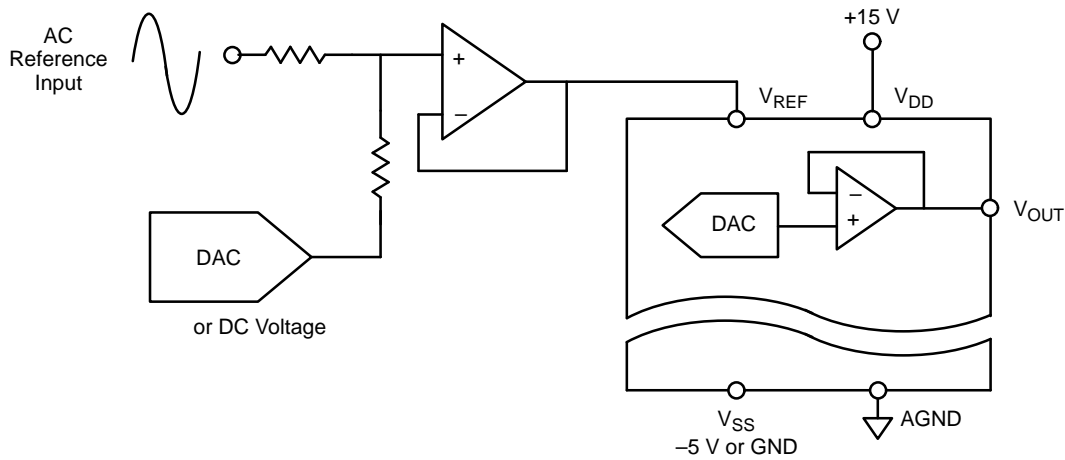


$$DC_{OFFSET} = V_{DD} (+15) \times R2/R1 + R2$$

**Figure 6. AC Reference Input Signal Circuit (AC Couple)**



**Figure 7. Digitally Programmable Offset Adjustment Circuits**



**Figure 8. Digitally Programmable AC Reference Input Signal Circuit (DC Couple)**

**Offsetting DAC Outputs**

Figure 7. shows examples of offset circuits.

**DAC offset effects**

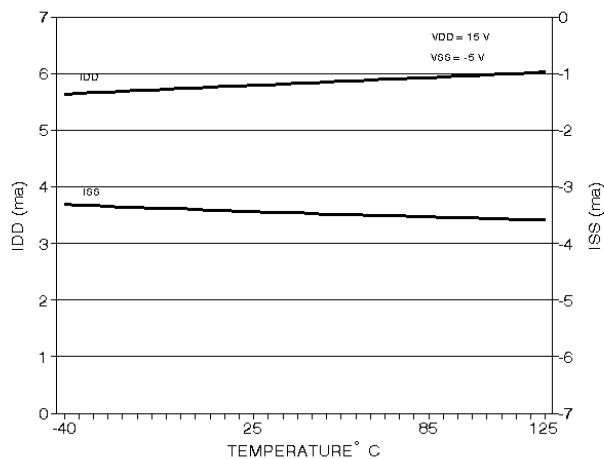
When using the device in single supply applications, and minimum reference voltage, there is a possibility that the DAC output will not change when the code is incremented from 0. Once the DAC has reached the offset voltage of the output

buffer, the DAC output will begin to increment in a normal operation.

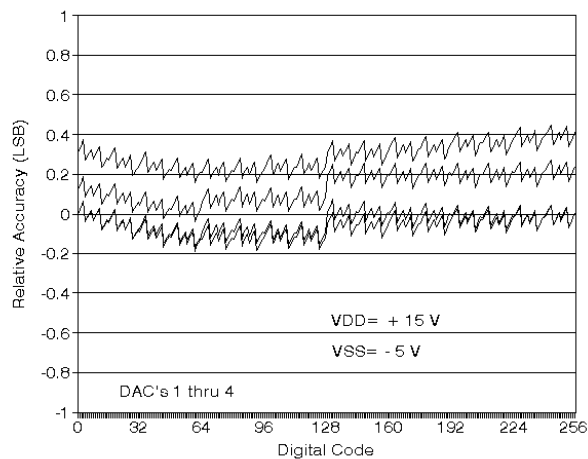
**5V Operation**

The MP7226 can be operated with a single power supply ( $V_{DD} = +5V$ ) or dual power supplies ( $V_{DD} = +5V$  and  $V_{SS} = -5V$ ). The reference voltage range is reduced along with Some performance parameter degradation. However the DNL of each DAC remains at  $\pm 1$  LSB guaranteeing monotonicity.

## PERFORMANCE CHARACTERISTICS

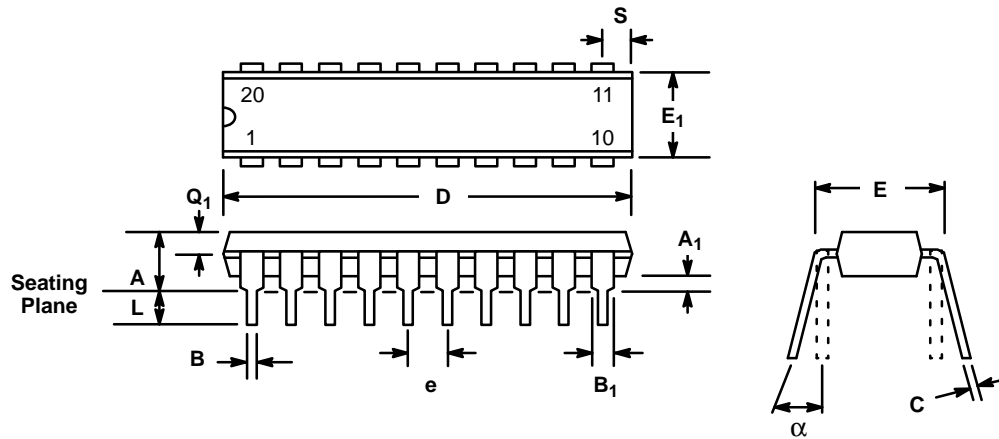


**Graph 1. Power Supply Current vs. Temperature**



**Graph 2. Relative Accuracy vs. Digital Code**

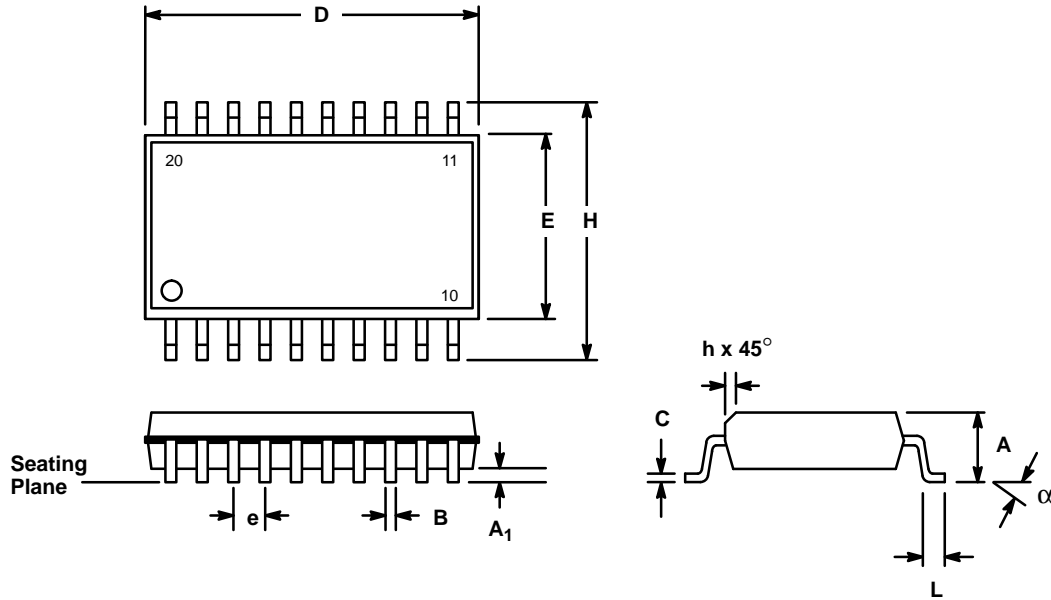
**20 LEAD PLASTIC DUAL-IN-LINE  
(300 MIL PDIP)  
N20**



| SYMBOL             | INCHES    |       | MILLIMETERS |       |
|--------------------|-----------|-------|-------------|-------|
|                    | MIN       | MAX   | MIN         | MAX   |
| A                  | —         | 0.200 | —           | 5.08  |
| A <sub>1</sub>     | 0.015     | —     | 0.38        | —     |
| B                  | 0.014     | 0.023 | 0.356       | 0.584 |
| B <sub>1</sub> (1) | 0.038     | 0.065 | 0.965       | 1.65  |
| C                  | 0.008     | 0.015 | 0.203       | 0.381 |
| D                  | 0.945     | 1.060 | 24.0        | 26.92 |
| E                  | 0.295     | 0.325 | 7.49        | 8.26  |
| E <sub>1</sub>     | 0.220     | 0.310 | 5.59        | 7.87  |
| e                  | 0.100 BSC |       | 2.54 BSC    |       |
| L                  | 0.115     | 0.150 | 2.92        | 3.81  |
| α                  | 0°        | 15°   | 0°          | 15°   |
| Q <sub>1</sub>     | 0.055     | 0.070 | 1.40        | 1.78  |
| S                  | 0.040     | 0.080 | 1.02        | 2.03  |

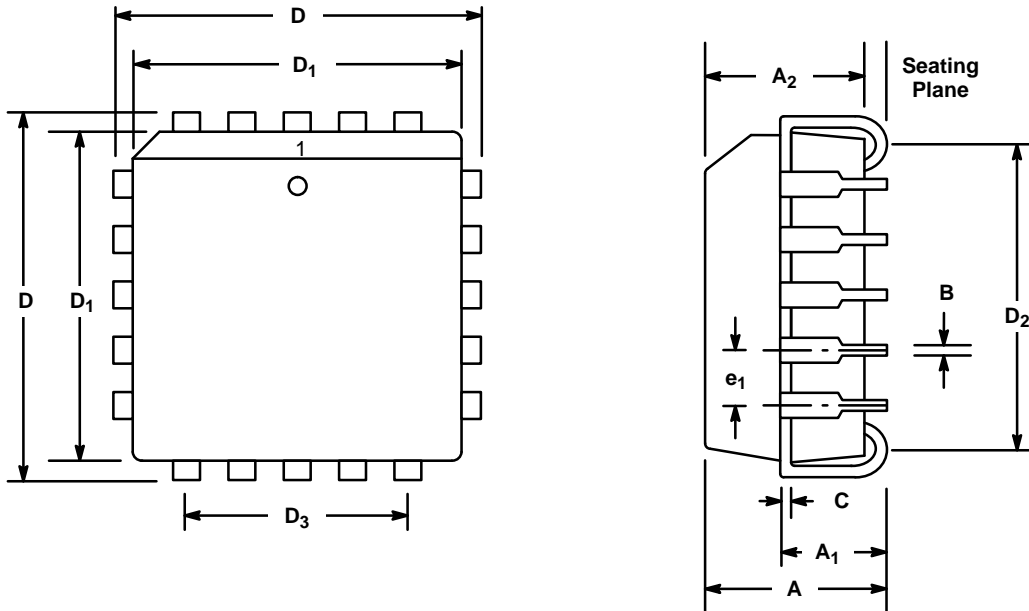
Note: (1) The minimum limit for dimensions B<sub>1</sub> may be 0.023" (0.58 mm) for all four corner leads only.

## 20 LEAD SMALL OUTLINE (300 MIL JEDEC SOIC) S20



| SYMBOL         | INCHES    |        | MILLIMETERS |       |
|----------------|-----------|--------|-------------|-------|
|                | MIN       | MAX    | MIN         | MAX   |
| A              | 0.097     | 0.104  | 2.464       | 2.642 |
| A <sub>1</sub> | 0.0050    | 0.0115 | 0.127       | 0.292 |
| B              | 0.014     | 0.019  | 0.356       | 0.483 |
| C              | 0.0091    | 0.0125 | 0.231       | 0.318 |
| D              | 0.500     | 0.510  | 12.70       | 12.95 |
| E              | 0.292     | 0.299  | 7.42        | 7.59  |
| e              | 0.050 BSC |        | 1.27 BSC    |       |
| H              | 0.400     | 0.410  | 10.16       | 10.41 |
| h              | 0.010     | 0.016  | 0.254       | 0.406 |
| L              | 0.016     | 0.035  | 0.406       | 0.889 |
| α              | 0°        | 8°     | 0°          | 8°    |

**20 LEAD PLASTIC LEADED CHIP CARRIER  
(PLCC)  
P20**



| SYMBOL             | INCHES    |       | MILLIMETERS |       |
|--------------------|-----------|-------|-------------|-------|
|                    | MIN       | MAX   | MIN         | MAX   |
| A                  | 0.165     | 0.180 | 4.19        | 4.57  |
| A <sub>1</sub>     | 0.100     | 0.110 | 2.54        | 2.79  |
| A <sub>2</sub>     | 0.148     | 0.156 | 3.76        | 3.96  |
| B                  | 0.013     | 0.021 | 0.330       | 0.533 |
| C                  | 0.008     | 0.012 | 0.203       | 0.305 |
| D                  | 0.385     | 0.395 | 9.78        | 10.03 |
| D <sub>1</sub> (1) | 0.350     | 0.354 | 8.89        | 8.99  |
| D <sub>2</sub>     | 0.290     | 0.330 | 7.37        | 8.38  |
| D <sub>3</sub>     | 0.200 Ref |       | 5.08 Ref.   |       |
| e <sub>1</sub>     | 0.050 BSC |       | 1.27 BSC    |       |

Note: (1) Dimension D<sub>1</sub> does not include mold protrusion.  
Allowed mold protrusion is 0.254 mm/0.010 in.

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