



# PM-7528

## DUAL 8-BIT BUFFERED MULTIPLYING CMOS D/A CONVERTER

Precision Monolithics Inc.

### FEATURES

- On-Chip Latches For Both DACs
- +5V To +15V Single Supply Operation
- DACs Matched To 1%
- Four-Quadrant Multiplication
- TTL/CMOS Compatible
- 8-Bit Endpoint Linearity ( $\pm 1/2$  LSB)
- Full Temperature Operation
- Low Power Consumption
- Microprocessor Compatible
- Improved ESD Resistance
- Automatically Insertable Cerdip and Plastic Packages
- Available in Surface Mount SO, PLCC and LCC Packages

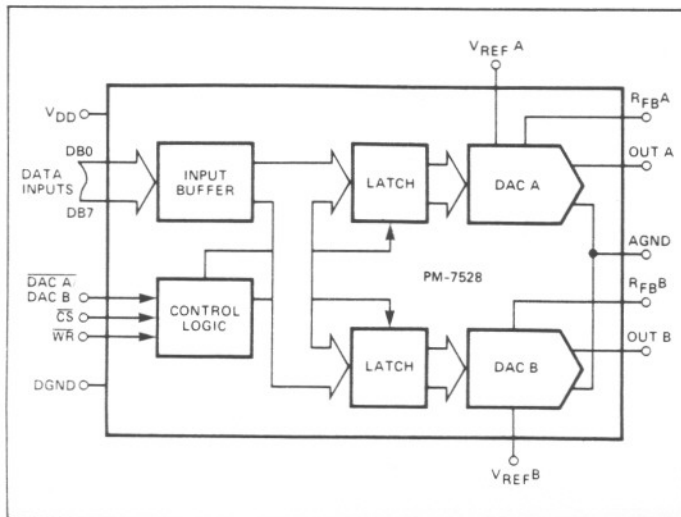
### APPLICATIONS

- Digital Gain/Attenuation Control
- Digital Control Of Filter Parameters
- Digitally-Controlled Audio Circuits
- X-Y Graphics
- Digital/Synchro Conversion
- Robotics
- Ideal For Battery-Operated Equipment

### CROSS REFERENCE

| PMI       | ADI      | TEMPERATURE RANGE |
|-----------|----------|-------------------|
| PM7528AR  | AD7528UD | MILITARY          |
| PM7528BR  | AD7528TD |                   |
| PM7528BR  | AD7528SD |                   |
| PM7528ER  | AD7528CQ | INDUSTRIAL        |
| PM7528FR  | AD7528BQ |                   |
| PM7528FR  | AD7528AQ |                   |
| PM7528GP  | AD7528LN | COMMERCIAL        |
| PM7528HP  | AD7528KN |                   |
| PM7528HP  | AD7528JN |                   |
| PM7528HPC | AD7528KP |                   |
| PM7528HPC | AD7528JP |                   |

### FUNCTIONAL DIAGRAM



### ORDERING INFORMATION†

| PACKAGE: 20-PIN   |             |                                       |                                       |                                     |
|-------------------|-------------|---------------------------------------|---------------------------------------|-------------------------------------|
| RELATIVE ACCURACY | GAIN ERROR  | MILITARY* TEMPERATURE -55°C TO +125°C | INDUSTRIAL TEMPERATURE -25°C TO +85°C | COMMERCIAL TEMPERATURE 0°C TO +70°C |
| $\pm 1/2$ LSB     | $\pm 1$ LSB | PM7528AR                              | PM7528ER                              | PM7528GP                            |
| $\pm 1/2$ LSB     | $\pm 1$ LSB | PM7528ARC/883                         | —                                     | —                                   |
| $\pm 1/2$ LSB     | $\pm 2$ LSB | PM7528BR                              | PM7528FR                              | PM7528HP                            |
| $\pm 1/2$ LSB     | $\pm 2$ LSB | PM7528BRC/883                         | —                                     | PM7528HPC††                         |
| $\pm 1/2$ LSB     | $\pm 2$ LSB | —                                     | —                                     | PM7528HS††                          |

\* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

† Burn-in is available on commercial and industrial temperature range parts in cerdip, plastic dip, and TO-can packages. For ordering information, see 1988 Data Book, Section 2.

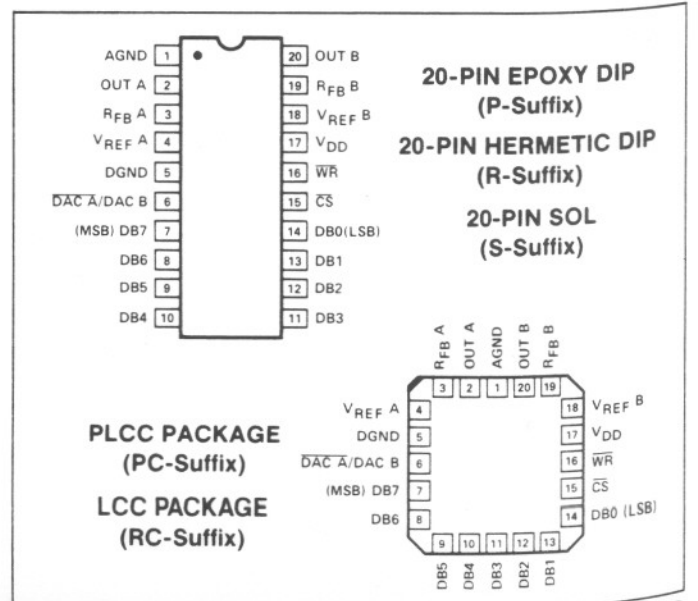
†† For availability and burn-in information on SO and PLCC packages, contact your local sales office.

### GENERAL DESCRIPTION

The PM-7528 contains two 8-bit multiplying digital-to-analog converters. Excellent DAC-to-DAC matching and tracking results from monolithic construction. The PM-7528 consists of two thin-film R-2R resistor-ladder networks, tracking span resistors, two data latches, one input buffer, and control logic. Operation from a 5 to 15 volt single power supply dissipates only 20mW of power in a space saving 20-pin 0.3" wide DIP. The PM-7528 features circuitry designed to protect against damage from electrostatic discharges.

Digital input data is directed into one of the DAC data latches determined by the DAC selection control line DAC A/DAC B. The 8-bit wide input data path provides TTL/CMOS compatibility. The data load cycle is similar to the write cycle of a random access memory. The PM-7528 is bus compatible with most 8-bit microprocessors, including the 6800, 8080, 8085, and Z80.

### PIN CONNECTIONS





**ABSOLUTE MAXIMUM RATINGS**

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

|  |   |
|--|---|
| $V_{DD}$ to AGND                                       | 0V, +17V                                    |
| $V_{DD}$ to DGND                                       | 0V, +17V                                    |
| AGND to DGND   | 0V, $V_{DD}$                                |
| Digital Input Voltage to DGND                          | -0.3V, +15V                                 |
| $V_{PIN 2}$ , $V_{PIN 20}$ to AGND                     | -0.3V, +15V                                 |
| $V_{REF A}$ , $V_{REF B}$ to AGND                      | $\pm 25\text{V}$                            |
| $V_{RFB A}$ , $V_{RFB B}$ to AGND                      | $\pm 25\text{V}$                            |
| Power Dissipation (Any Package) to $+75^\circ\text{C}$ | 450mW                                       |
| Derate Above $+75^\circ\text{C}$ by                    | 6mW/ $^\circ\text{C}$                       |
| <b>Operating Temperature Range</b>                     |   |
| AR, ARC, BR, BRC Versions                              | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ |
| ER, FR Versions  | $-25^\circ\text{C}$ to $+85^\circ\text{C}$  |
| GP, HP, HPC, HS Versions                               | $0^\circ\text{C}$ to $+70^\circ\text{C}$    |

|                                      |   |
|--------------------------------------|---|
| Dice Junction Temperature            | $+150^\circ\text{C}$                        |
| Storage Temperature                  | $-65^\circ\text{C}$ to $+150^\circ\text{C}$ |
| Lead Temperature (Soldering, 60 sec) | $+300^\circ\text{C}$                        |

**CAUTION:**

- Do not apply voltages higher than  $V_{DD}$  or less than GND potential on any terminal except  $V_{REF}$ .
- The digital control inputs are zener-protected; however, permanent damage may occur on unprotected units from high-energy electrostatic fields. Keep units in conductive foam at all times until ready to use.
- Do not insert this device into powered sockets; remove power before insertion or removal.
- Use proper anti-static handling procedures.
- Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

**ELECTRICAL CHARACTERISTICS** at  $V_{DD} = +5\text{V}$  or  $+15\text{V}$ ,  $V_{REF A} = V_{REF B} = +10\text{V}$ ,  $\text{OUT A} = \text{OUT B} = 0\text{V}$ ;  $T_A = -55^\circ\text{C}$  to  $+125^\circ\text{C}$  apply for PM-7528AR/ARC/BR/BRC;  $T_A = -25^\circ\text{C}$  to  $+85^\circ\text{C}$  apply for PM-7528ER/FR;  $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$  apply for PM-7528GP/HP/HPC/HS, unless otherwise noted.

| PARAMETER  | SYMBOL                | CONDITIONS                      | PM-7528     |     |             | UNITS               |         |
|--|-----------------------|---------------------------------|-------------|-----|-------------|---------------------|---------|
|  |                       |                                 | MIN         | TYP | MAX         |                     |         |
| <b>STATIC ACCURACY</b><br>(Note 1)   |                       |                                 |             |     |             |                     |         |
| Resolution   | N                     |                                 | 8           | —   | —           | Bits                |         |
| Relative Accuracy<br>(Note 2)  | NL                    |                                 | —           | —   | $\pm 1/2$   | LSB                 |         |
| Differential Nonlinearity<br>(Note 3)  | DNL                   |                                 | —           | —   | $\pm 1$     | LSB                 |         |
| Full Scale Gain Error<br>(Note 4)  | $G_{FSE}$             | $T_A = +25^\circ\text{C}$       |             |     | $\pm 1$     | LSB                 |         |
|  |                       |                                 | PM7528A/E/G | —   | —           |                     | $\pm 2$ |
|  |                       | $V_{DD} = +5\text{V}$           | PM7528A/E/G | —   | —           |                     | $\pm 3$ |
|  |                       | $T_A = \text{Full Temp. Range}$ | PM7528B/F/H | —   | —           |                     | $\pm 4$ |
|  |                       | $V_{DD} = +15\text{V}$          | PM7528A/E/G | —   | —           | $\pm 1$             |         |
|  |                       | $T_A = \text{Full Temp. Range}$ | PM7528B/F/H | —   | —           | $\pm 3$             |         |
| Gain Temperature<br>Coefficient<br>( $\Delta\text{Gain}/\Delta\text{Temperature}$ )<br>(Notes 4, 10) | $TCG_{FS}$            | $V_{DD} = +5\text{V}$           | —           | —   | $\pm 0.007$ | $\%/^\circ\text{C}$ |         |
|  |                       | $V_{DD} = +15\text{V}$          | —           | —   | $+0.0035$   |                     |         |
| Output Leakage Current<br>Out A (Pin 2)/Out B (Pin 20)<br>(Note 5)                                   | $I_{LKG}$             | $T_A = +25^\circ\text{C}$       | —           | 5   | $\pm 50$    | nA                  |         |
|  |                       | $V_{DD} = +5\text{V}$           | —           | —   | $\pm 400$   |                     |         |
|  |                       | $T_A = \text{Full Temp. Range}$ | —           | —   | $+200$      |                     |         |
|  |                       | $V_{DD} = +15\text{V}$          | —           | —   | $+200$      |                     |         |
| Input Resistance<br>( $V_{REF A}$ , $V_{REF B}$ )<br>(Note 6)  | $R_{REF}$             |                                 | 8           | —   | 15          | k $\Omega$          |         |
| $V_{REF A}/V_{REF B}$<br>(Input Resistance Match)  | $\Delta V_{REF A, B}$ |                                 | —           | 0.1 | $\pm 1$     | %                   |         |



**ELECTRICAL CHARACTERISTICS** at  $V_{DD} = +5V$  or  $+15V$ ,  $V_{REF A} = V_{REF B} = +10V$ ,  $OUT A = OUT B = 0V$ ;  $T_A = -55^\circ C$  to  $+125^\circ C$  apply for PM-7528AR/ARC/BR/BRC;  $T_A = -25^\circ C$  to  $+85^\circ C$  apply for PM-7528ER/FR;  $T_A = 0^\circ C$  to  $+70^\circ C$  apply for PM-7528GP/HP/HPC/HS, unless otherwise noted. (Continued)

| PARAMETER   | SYMBOL    | CONDITIONS   | PM-7528     |           |                     | UNITS   |
|---|-----------|--|-------------|-----------|---------------------|---------|
|   |           |  | MIN         | TYP       | MAX                 |         |
| <b>DIGITAL INPUTS</b><br>(Note 9)                                     |           |  |             |           |                     |         |
| Digital Input High<br>(Note 8)  | $V_{INH}$ | $V_{DD} = +5V$<br>$V_{DD} = +15V$                      | 2.4<br>13.5 | —<br>—    | —<br>—              | V       |
| Digital Input Low<br>(Note 8)   | $V_{INL}$ | $V_{DD} = +5V$<br>$V_{DD} = +15V$                      | —<br>—      | —<br>—    | 0.8<br>1.5          | V       |
| Input Current<br>(Note 7)   | $I_{IN}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | —<br>—      | .001<br>— | $\pm 1$<br>$\pm 10$ | $\mu A$ |
| Input Capacitance<br>(Note 10)  | $C_{IN}$  | DB0-DB7<br>WR, CS, DAC A/DAC B                         | —<br>—      | —<br>—    | 10<br>15            | pF      |
| <b>SWITCHING CHARACTERISTICS</b> at $V_{DD} = +5V$<br>(Notes 10, 11)  |           |  |             |           |                     |         |
| Chip Select to<br>Write Set-Up Time                                   | $t_{CS}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 200<br>230  | —<br>—    | —<br>—              | ns      |
| Chip Select to<br>Write Hold Time                                     | $t_{CH}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 20<br>30    | —<br>—    | —<br>—              | ns      |
| DAC Select to<br>Write Set-Up Time                                    | $t_{AS}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 200<br>230  | —<br>—    | —<br>—              | ns      |
| DAC Select to<br>Write Hold Time                                      | $t_{AH}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 20<br>30    | —<br>—    | —<br>—              | ns      |
| Data Valid to<br>Write Set-Up Time                                    | $t_{DS}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 110<br>130  | —<br>—    | —<br>—              | ns      |
| Data Valid to<br>Write Hold Time                                      | $t_{DH}$  |  | 0           | —         | —                   | ns      |
| Write Pulse Width   | $t_{WR}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 180<br>200  | —<br>—    | —<br>—              | ns      |
| <b>SWITCHING CHARACTERISTICS</b> at $V_{DD} = +15V$<br>(Notes 10, 11) |           |  |             |           |                     |         |
| Chip Select to<br>Write Set-Up Time                                   | $t_{CS}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 60<br>80    | —<br>—    | —<br>—              | ns      |
| Chip Select to<br>Write Hold Time                                     | $t_{CH}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 10<br>15    | —<br>—    | —<br>—              | ns      |
| DAC Select to<br>Write Set-Up Time                                    | $t_{AS}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 60<br>80    | —<br>—    | —<br>—              | ns      |
| DAC Select to<br>Write Hold Time                                      | $t_{AH}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 10<br>15    | —<br>—    | —<br>—              | ns      |
| Data Valid to<br>Write Set-Up Time                                    | $t_{DS}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 50<br>70    | —<br>—    | —<br>—              | ns      |
| Data Valid to<br>Write Hold Time                                      | $t_{DH}$  |  | 10          | —         | —                   | ns      |
| Write Pulse Width   | $t_{WR}$  | $T_A = +25^\circ C$<br>$T_A = \text{Full Temp. Range}$ | 60<br>80    | —<br>—    | —<br>—              | ns      |



**ELECTRICAL CHARACTERISTICS** at  $V_{DD} = +5V$  or  $+15V$ ,  $V_{REF A} = V_{REF B} = +10V$ ,  $OUT A = OUT B = 0V$ ;  $T_A = -55^\circ C$  to  $+125^\circ C$  apply for PM-7528AR/ARC/BR/BRC;  $T_A = -25^\circ C$  to  $+85^\circ C$  apply for PM-7528ER/FR;  $T_A = 0^\circ C$  to  $+70^\circ C$  apply for PM-7528GP/HP/HPC/HS, unless otherwise noted. (Continued)

| PARAMETER   | SYMBOL      | CONDITIONS                                | PM-7528 |     |      | UNITS   |
|---|-------------|---|---------|-----|------|---------|
|   |             |   | MIN     | TYP | MAX  |         |
| <b>POWER SUPPLY</b><br>(Note 12)  |             |   |         |     |      |         |
| Supply Current<br>(Note 21)   | $I_{DD}$    | All Digital Inputs $V_{INL}$ or $V_{INH}$ | —       | —   | 1    | mA      |
|   |             | All Digital Inputs $0V$ or $V_{DD}$       | —       | —   | 100  | $\mu A$ |
| <b>AC PERFORMANCE CHARACTERISTICS</b><br>(Note 13)                          |             |   |         |     |      |         |
| DC Supply Rejection Ratio<br>( $\Delta Gain / \Delta V_{DD}$ )<br>(Note 14) | PSRR        | $V_{DD} = +5V$                            | —       | —   | 0.02 | %/%     |
|   |             | $T_A = +25^\circ C$                       | —       | —   | 0.04 |         |
|   |             | $T_A = \text{Full Temp. Range}$           | —       | —   | 0.01 |         |
|   |             | $V_{DD} = +15V$                           | —       | —   | 0.02 |         |
| Propagation Delay<br>(Notes 15, 16, 17)                                     | $t_{PD}$    | $V_{DD} = +5V$                            | —       | —   | 220  | ns      |
|   |             | $T_A = +25^\circ C$                       | —       | —   | 270  |         |
|   |             | $T_A = \text{Full Temp. Range}$           | —       | —   | 80   |         |
|   |             | $V_{DD} = +15V$                           | —       | —   | 100  |         |
| Current Settling Time<br>(Notes 16, 17, 22)                                 | $t_s$       | $V_{DD} = +5V$                            | —       | —   | 350  | ns      |
|   |             | $T_A = +25^\circ C$                       | —       | —   | 400  |         |
|   |             | $T_A = \text{Full Temp. Range}$           | —       | —   | 180  |         |
|   |             | $V_{DD} = +15V$                           | —       | —   | 200  |         |
| Digital Charge Injection<br>(Note 18)                                       | Q           | $T_A = +25^\circ C$                       | —       | 160 | —    | nVs     |
|   |             | $V_{DD} = +5V$                            | —       | 440 | —    |         |
|   |             | $V_{DD} = +15V$                           | —       | —   | —    |         |
| Output Capacitance  | $C_{OUT A}$ | DAC Latches Loaded                        | —       | —   | 50   | pF      |
|   | $C_{OUT B}$ | with 00000000                             | —       | —   | 50   |         |
|   | $C_{OUT A}$ | DAC Latches Loaded                        | —       | —   | 120  |         |
|   | $C_{OUT B}$ | with 11111111                             | —       | —   | 120  |         |
| AC Feedthrough<br>(Note 19)   | $FT_A$      | $V_{REF A}$ to $OUT A$ ;                  | —       | —   | -70  | dB      |
|   |             | $T_A = +25^\circ C$                       | —       | —   | -65  |         |
|   | $FT_B$      | $V_{REF B}$ to $OUT B$ ;                  | —       | —   | -70  |         |
|   |             | $T_A = +25^\circ C$                       | —       | —   | -65  |         |
|   |             | $T_A = \text{Full Temp. Range}$           | —       | —   | —    |         |



PM-7528 DUAL 8-BIT BUFFERED MULTIPLYING CMOS D/A CONVERTER

**ELECTRICAL CHARACTERISTICS** at  $V_{DD} = +5V$  or  $+15V$ ,  $V_{REF A} = V_{REF B} = +10V$ ,  $OUT A = OUT B = 0V$ ;  $T_A = -55^\circ C$  to  $+125^\circ C$  apply for PM-7528AR/ARC/BR/BRC;  $T_A = -25^\circ C$  to  $+85^\circ C$  apply for PM-7528ER/FR;  $T_A = 0^\circ C$  to  $+70^\circ C$  apply for PM-7528GP/HP/HPC/HS, unless otherwise noted. (Continued)

| PARAMETER                              | SYMBOL     | CONDITIONS   | PM-7528 |          |     | UNITS |
|--|------------|--|---------|----------|-----|-------|
|  |            |  | MIN     | TYP      | MAX |       |
| <b>AC PERFORMANCE CHARACTERISTICS</b>  |            |  |         |          |     |       |
| (Note 13)                              |            |  |         |          |     |       |
| Channel-to-Channel Isolation (Note 20) | $CCI_{BA}$ | $V_{REF A}$ to OUT B;<br>$V_{REF A} = 20V_{p-p}$ Sinewave<br>@ $f = 100kHz$<br>$V_{REF B} = 0V$ .<br>$T_A = +25^\circ C$ | —       | -77      | —   | dB    |
|  | $CCI_{AB}$ | $V_{REF B}$ to OUT A;<br>$V_{REF B} = 20V_{p-p}$ Sinewave<br>@ $f = 100kHz$<br>$V_{REF A} = 0V$ .<br>$T_A = +25^\circ C$ | —       | -77      | —   | dB    |
| Digital Crosstalk                      | Q          | For Code Transition From 00000000 to 11111111.<br>$T_A = +25^\circ C$<br>$V_{DD} = +5V$<br>$V_{DD} = +15V$               | —       | 30<br>60 | —   | nVs   |
| Harmonic Distortion                    | THD        | $V_{IN} = 6V_{rms}$ @ $f = 1kHz$ .<br>$T_A = +25^\circ C$  | —       | -85      | —   | dB    |

**NOTES:**

- Specifications apply to both DAC A and DAC B.
- This is an endpoint linearity specification.
- All grades guaranteed to be monotonic over the full operating temperature range.
- Measured using internal  $R_{FB A}$  and  $R_{FB B}$ . Both DAC latches loaded with 11111111. Gain error is adjustable using circuits of Figures 5 and 6.
- DAC loaded with 00000000.
- Input resistance  $TC = +50ppm/^\circ C$ ; typical input resistance = 11k $\Omega$ .
- $V_{IN} = 0V$  or  $V_{DD}$ .
- For all data bits DB0-DB7,  $\overline{WR}$ ,  $\overline{CS}$ ,  $\overline{DAC A}/DAC B$ .
- Logic inputs are MOS gates. Typical input current ( $+25^\circ C$ ) is less than 1nA.
- Guaranteed and not tested.
- See timing diagram.
- See Figure 3.
- These characteristics are for design guidance only and are not subject to test.
- $\Delta V_{DD} = \pm 5\%$ .
- From digital input to 90% of final analog-output current.
- $V_{REF A} = V_{REF B} = +10V$ ;  $OUT A$ ,  $OUT B$  load = 100 $\Omega$ ,  $C_{EXT} = 13pF$ .
- $\overline{WR}$ ,  $\overline{CS} = 0V$ ,  $DB0-DB7 = 0V$  to  $V_{DD}$  or  $V_{DD}$  to  $0V$ .
- For code transition 00000000 to 11111111.
- $V_{REF A}$ ,  $V_{REF B} = 20V_{p-p}$  Sinewave @  $f = 100kHz$ .
- Both DAC latches loaded with 11111111.
- $I_{DD} = 500\mu A$  at  $T_A =$  Full Temp. Range.
- Extrapolated:  $t_s$  (1/2 LSB) =  $t_p D + 6.2\tau$ , where  $\tau$  = the measured first time constant of the final RC decay.