



# CMOS Dual 8-Bit Buffered Multiplying DACs

## General Description

The MX7528/MX7628 contains two 8-bit multiplying digital-to-analog converters (DACs). Separate on-chip latches hold the input data for each DAC to allow easy interface to microprocessors. The data load operation is similar to a static RAM write cycle. Data is loaded using only CS, WR, and DAC Select (DAC A/DAC B) inputs.

Each DAC has a separate reference input and internal feedback resistor which allow fully independent operation while maintaining excellent DAC-to-DAC matching.

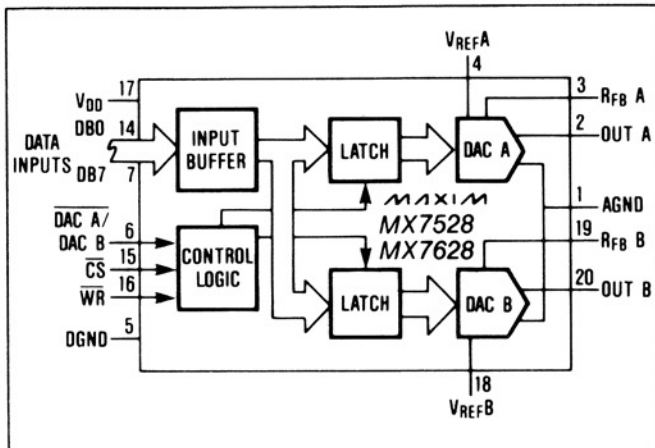
The MX7528 operates from a single +5V to +15V power supply whereas the MX7628 operates from +12V to +15V. The MX7528 has TTL compatible inputs at +5V supply only and the MX7628 has TTL compatible inputs from +12V to +15V supplies.

The MX7528/MX7628 is supplied in 20-lead narrow DIP and Small Outline Packages.

## Applications

- Programmable Attenuators
- Digitally Controlled Filters
- X-Y Graphics
- Motion Control Systems
- Digital-to-Synchro Conversion
- Disk Drives

## Functional Diagram



## Features

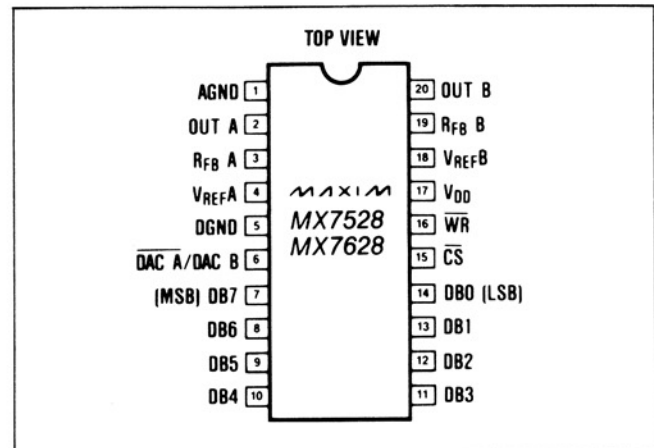
- ◆ Data Latches For Both DACs
- ◆ MX7528—+5V to +15V Single Supply Operation
- ◆ MX7628—+12V to +15V Single Supply Operation With TTL/CMOS Compatible Inputs
- ◆  $\pm 1/2$  LSB Linearity
- ◆ Microprocessor Compatible
- ◆ Four-Quadrant Multiplication
- ◆ DACs Matched to 1%

## Ordering Information

| PART       | TEMP. RANGE    | PACKAGE*    | ERROR         |
|------------|----------------|-------------|---------------|
| MX7528JN   | 0°C to +70°C   | Plastic DIP | $\pm 1$ LSB   |
| MX7528KN   | 0°C to +70°C   | Plastic DIP | $\pm 1/2$ LSB |
| MX7528LN   | 0°C to +70°C   | Plastic DIP | $\pm 1/2$ LSB |
| MX7528JCWP | 0°C to +70°C   | Wide SO     | $\pm 1$ LSB   |
| MX7528KCWP | 0°C to +70°C   | Wide SO     | $\pm 1/2$ LSB |
| MX7528LCWP | 0°C to +70°C   | Wide SO     | $\pm 1/2$ LSB |
| MX7528J/D  | 0°C to +70°C   | Dice        | $\pm 1$ LSB   |
| MX7528AQ   | -25°C to +85°C | CERDIP**    | $\pm 1$ LSB   |
| MX7528BQ   | -25°C to +85°C | CERDIP**    | $\pm 1/2$ LSB |
| MX7528CQ   | -25°C to +85°C | CERDIP**    | $\pm 1/2$ LSB |

\* All devices — 20 lead packages  
 \*\* Maxim reserves the right to ship Ceramic packages in lieu of CERDIP packages  
 Ordering Information continued on last page.

## Pin Configuration



MX7528/MX7628



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## ABSOLUTE MAXIMUM RATINGS—MX7528, MX7628

|  |                        |
|--|------------------------|
| V <sub>DD</sub> to AGND.....                         | 0V, +17V               |
| V <sub>DD</sub> to DGND.....                         | 0V, +17V               |
| AGND to DGND.....                                    | V <sub>DD</sub>        |
| DGND to AGND.....                                    | V <sub>DD</sub>        |
| Digital Input Voltage to DGND.....                   | -0.3V, V <sub>DD</sub> |
| Pin 2, Pin 20 to AGND.....                           | -0.3V, V <sub>DD</sub> |
| V <sub>REFA</sub> , V <sub>REFB</sub> , to AGND..... | ±25V                   |
| V <sub>RFBA</sub> , V <sub>RFBB</sub> , to AGND..... | ±25V                   |

|  |                 |
|--|-----------------|
| Operating Temperature Ranges:                              |                 |
| MX7528JN, KN, LN, JCWP,<br>KCWP, LCWP; MX7628KN, KCWP..... | 0°C to +70°C    |
| MX7528AQ, BQ, CQ; MX7628BQ.....                            | -25°C to +85°C  |
| MX7528KE, LE.....  | -40°C to +85°C  |
| MX7528SD, SQ, TD, TQ,<br>UD, UQ; MX7628TQ.....             | -55°C to +125°C |
| Storage Temperature Range.....                             | -65°C to +160°C |
| Power Dissipation (any Package) to +75°C.....              | 450mW           |
| Derate Above +75°C by.....                                 | 6mW/°C          |
| Lead Temperature (soldering, 10sec).....                   | +300°C          |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS—MX7528, +5V Operation

(V<sub>DD</sub> = +5V; V<sub>REF</sub> = +10V; V<sub>OUTA</sub> = V<sub>OUTB</sub> = 0V; T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub> unless otherwise noted)

| PARAMETER   | SYMBOL | CONDITIONS   | MIN | TYP            | MAX                | UNITS  |
|---|--------|--|-----|----------------|--------------------|--------|
| <b>DC ACCURACY (Note 1)</b>                                     |        |  |     |                |                    |        |
| Resolution  |        |  | 8   |                |                    | Bits   |
| Relative Accuracy   | INL    | J,A,S<br>K,B,T<br>L,C,U  |     |                | ±1<br>±1/2<br>±1/2 | LSB    |
| Differential Non-Linearity                                      | DNL    | All Grades Guaranteed<br>Monotonic Over Temp.  |     |                | ±1                 | LSB    |
| Gain Error (Note 2)   |        | J,A,S<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>  |     |                | ±4<br>±6           | LSB    |
|   |        | K,B,T<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>  |     |                | ±2<br>±4           |        |
|   |        | L,C,U<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>  |     |                | ±1<br>±3           |        |
| Gain Temp. Coefficient<br>(Note 2, 3)                           |        |  |     | ±2             | ±70                | ppm/°C |
| Supply Rejection (Note 4)                                       | PSR    | ΔV <sub>DD</sub> = ±5%<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>   |     | 0.001<br>0.001 | 0.02<br>0.04       | %FSR/% |
| Output Leakage Current<br>(OUTA)                                |        | DAC A is 00000000<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>  |     |                | ±50<br>±400        | nA     |
| Output Leakage Current<br>(OUTB)                                |        | DAC B is 00000000<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>  |     |                | ±50<br>±400        | nA     |
| <b>REFERENCE INPUT</b>  |        |  |     |                |                    |        |
| R <sub>IN</sub> (V <sub>REFA</sub> , V <sub>REFB</sub> )        |        |  | 8   | 10             | 15                 | kΩ     |
| V <sub>REFA</sub> , V <sub>REFB</sub> Input<br>Resistance Match |        |  |     |                | ±1                 | %      |
| <b>DYNAMIC PERFORMANCE (Note 4)</b>                             |        |  |     |                |                    |        |
| Output Current Settling-Time<br>to 1/2 LSB                      |        | DB0-DB7 = 0V to V <sub>DD</sub> to 0V<br>WR = CS = 0V<br>OUTA = OUTB<br>Load = 100Ω,<br>C <sub>EXT</sub> = 13pF;<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |     |                | 350<br>400         | ns     |

# CMOS Dual 8-Bit Buffered Multiplying DACs

## ELECTRICAL CHARACTERISTICS—MX7528, +5V Operation (Continued)

( $V_{DD} = +5V$ ,  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER  | SYMBOL     | CONDITIONS  | MIN        | TYP | MAX                 | UNITS    |
|--|------------|---|------------|-----|---------------------|----------|
| <b>DYNAMIC PERFORMANCE (Note 4) (Continued)</b>                              |            |   |            |     |                     |          |
| Propagation Delay (from digital input to 90% of final analog output current) |            | DB0-DB7 = 0V to $V_{DD}$ to 0V<br>WR = CS = 0V<br>OUTA = OUTB<br>Load = 100Ω,<br>$C_{EXT} = 13pF$ ;<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ |            |     | 220<br>270          | ns       |
| Digital to Analog Glitch Impulse   |            | For code transition 00000000 to 11111111  |            | 60  |                     | nV-sec   |
| AC Feedthrough ( $V_{REFA}$ to OUTA)   |            | $V_{REFA} = \pm 10V$<br>100kHz Sinewave<br>$V_{REFB} = 0V$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |            |     | -70<br>-65          | dB       |
| AC Feedthrough ( $V_{REFB}$ to OUTB)   |            | $V_{REFB} = \pm 10V$<br>100kHz Sinewave<br>$V_{REFA} = 0V$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |            |     | -70<br>-65          | dB       |
| Channel to Channel Isolation ( $V_{REFA}$ to OUTB)                           |            | $V_{REFA} = \pm 10V$ 100kHz Sinewave<br>$V_{REFB} = 0V$ , both DACs loaded with 11111111  |            | -90 |                     | dB       |
| Channel to Channel Isolation ( $V_{REFB}$ to OUTA)                           |            | $V_{REFB} = \pm 10V$ 100kHz Sinewave<br>$V_{REFA} = 0V$ , both DACs loaded with 11111111  |            | -90 |                     | dB       |
| Digital Crosstalk  |            | Measured with code transition 0 to FS   |            | 30  |                     | nV-sec   |
| Harmonic Distortion  | THD        | $V_{IN} = 6V$ rms @ 1kHz  |            | -85 |                     | dB       |
| <b>ANALOG OUTPUTS (Note 4)</b>   |            |   |            |     |                     |          |
| OUTA Capacitance   | $C_{OUTA}$ | DAC latches loaded with 00000000<br>DAC latches loaded with 11111111  |            |     | 50<br>120           | pF<br>pF |
| OUTB Capacitance   | $C_{OUTB}$ | DAC latches loaded with 00000000<br>DAC latches loaded with 11111111  |            |     | 50<br>120           | pF<br>pF |
| <b>DIGITAL INPUTS</b>  |            |   |            |     |                     |          |
| Input High Voltage   | $V_{IH}$   |   | 2.4        |     |                     | V        |
| Input Low Voltage  | $V_{IL}$   |   |            | 0.8 |                     | V        |
| Input Current  | $I_{IN}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |            |     | $\pm 1$<br>$\pm 10$ | $\mu A$  |
| Input Capacitance (Note 4)   | $C_{IN}$   | DB0-DB7<br>WR, CS, DAC A/DAC B  |            |     | 10<br>15            | pF       |
| <b>POWER REQUIREMENTS</b>  |            |   |            |     |                     |          |
| Supply Current   | $I_{DD}$   | Digital inputs $V_{IL}$ or $V_{IH}$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   |            |     | 1<br>1              | mA       |
|  |            | Digital inputs 0V or $V_{DD}$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   |            |     | 100<br>500          | $\mu A$  |
| <b>SWITCHING CHARACTERISTICS (Note 4) (See Timing Diagram)</b>               |            |   |            |     |                     |          |
| Chip Select to Write Setup Time  | $t_{CS}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  | 200<br>230 |     |                     | ns       |
| Chip Select to Write Hold Time   | $t_{CH}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  | 20<br>30   |     |                     | ns       |

**Note 1:** Specifications apply to both DACs in MX7528.

**Note 2:** Gain error is measured using internal feedback resistor. Full Scale Range (FSR) =  $V_{REF}$ .

**Note 3:** Guaranteed, but not tested.

**Note 4:** These characteristics are for design guidance only and are not subject to test.

MX7528/MX7628

# CMOS Dual 8-Bit Buffered Multiplying DACs

## ELECTRICAL CHARACTERISTICS—MX7528, +5V Operation (Continued)

( $V_{DD} = +5V$ ,  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER  | SYMBOL   | CONDITIONS   | MIN | TYP | MAX | UNITS |
|--|----------|--|-----|-----|-----|-------|
| <b>SWITCHING CHARACTERISTICS</b> (Note 4) (See Timing Diagram) (Continued) |          |  |     |     |     |       |
| DAC Select to Write Setup Time   | $t_{AS}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 200 |     | 230 | ns    |
| DAC Select to Write Hold Time  | $t_{AH}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 20  |     | 30  | ns    |
| Write Pulse Width  | $t_{WR}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 180 |     | 200 | ns    |
| Data Setup Time  | $t_{DS}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 110 |     | 130 | ns    |
| Data Hold Time   | $t_{DH}$ |  | 0   |     |     | ns    |

## ELECTRICAL CHARACTERISTICS—MX7528, +15V Operation

( $V_{DD} = +15V$ ;  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER                                      | SYMBOL | CONDITIONS   | MIN | TYP            | MAX                               | UNITS           |
|--|--------|--|-----|----------------|-----------------------------------|-----------------|
| <b>DC ACCURACY</b> (Note 1)                    |        |  |     |                |                                   |                 |
| Resolution                                     |        |  | 8   |                |                                   | Bits            |
| Relative Accuracy                              | INL    | J,A,S<br>K,B,T<br>L,C,U  |     |                | $\pm 1$<br>$\pm 1/2$<br>$\pm 1/2$ | LSB             |
| Differential Non-Linearity                     | DNL    | Guaranteed Monotonic Over Temp.  |     |                | $\pm 1$                           | LSB             |
| Gain Error (Note 2)                            |        | J,A,S<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     |                | $\pm 4$<br>$\pm 5$                | LSB             |
|  |        | K,B,T<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     |                | $\pm 2$<br>$\pm 3$                |                 |
|  |        | L,C,U<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     |                | $\pm 1$<br>$\pm 1$                |                 |
| Gain Temp. Coefficient (Note 2, 3)             |        |  |     | $\pm 2$        | $\pm 35$                          | ppm/ $^\circ C$ |
| Supply Rejection (Note 4)                      | PSR    | $\Delta V_{DD} = \pm 5\%$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     | 0.001<br>0.001 | 0.01<br>0.02                      | %FSR/%          |
| Output Leakage Current (OUTA)                  |        | DAC A is 00000000<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     |                | $\pm 50$<br>$\pm 200$             | nA              |
| Output Leakage Current (OUTB)                  |        | DAC B is 00000000<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     |                | $\pm 50$<br>$\pm 200$             | nA              |
| <b>REFERENCE INPUT</b>                         |        |  |     |                |                                   |                 |
| $R_{IN}$ ( $V_{REFA}$ , $V_{REFB}$ )           |        |  | 8   | 10             | 15                                | k $\Omega$      |
| $V_{REFA}$ , $V_{REFB}$ Input Resistance Match |        |  |     |                | $\pm 1$                           | %               |
| <b>DYNAMIC PERFORMANCE</b> (Note 4)            |        |  |     |                |                                   |                 |
| Output Current Settling-Time to 1/2 LSB        |        | DB0-DB7 = 0V to $V_{DD}$ to 0V<br>WR = CS = 0V<br>OUTA = OUTB<br>Load = 100 $\Omega$ ,<br>$C_{EXT} = 13pF$ ;<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ |     |                | 180<br>200                        | ns              |

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MX7528/MX7628

## ELECTRICAL CHARACTERISTICS—MX7528, +15V Operation (Continued)

( $V_{DD} = +15V$ ,  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER  | SYMBOL     | CONDITIONS   | MIN      | TYP | MAX                 | UNITS    |
|--|------------|--|----------|-----|---------------------|----------|
| <b>DYNAMIC PERFORMANCE</b> (Note 4) (Continued)                              |            |  |          |     |                     |          |
| Propagation Delay (from digital input to 90% of final analog output current) |            | DB0-DB7 = 0V to $V_{DD}$ to 0V<br>WR = CS = 0V<br>OUTA = OUTB<br>Load = 100 $\Omega$ ,<br>$C_{EXT} = 13pF$ ;<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ |          |     | 80<br>100           | ns       |
| Digital to Analog Glitch Impulse   |            | For code transition 00000000 to 11111111   |          | 125 |                     | nV-sec   |
| AC Feedthrough ( $V_{REFA}$ to OUTA)   |            | $V_{REFA} = \pm 10V$<br>100kHz Sinewave<br>$V_{REFB} = 0V$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   |          |     | -70<br>-65          | dB       |
| AC Feedthrough ( $V_{REFB}$ to OUTB)   |            | $V_{REFB} = \pm 10V$<br>100kHz Sinewave<br>$V_{REFA} = 0V$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   |          |     | -70<br>-65          | dB       |
| Channel to Channel Isolation ( $V_{REFA}$ to OUTB)                           |            | $V_{REFA} = \pm 10V$ 100kHz Sinewave<br>$V_{REFB} = 0V$ , both DACs loaded with 11111111   |          | -90 |                     | dB       |
| Channel to Channel Isolation ( $V_{REFB}$ to OUTA)                           |            | $V_{REFB} = \pm 10V$ 100kHz Sinewave<br>$V_{REFA} = 0V$ , both DACs loaded with 11111111   |          | -90 |                     | dB       |
| Digital Crosstalk  |            | Measured with code transition 0 to FS  |          | 60  |                     | nV-sec   |
| Harmonic Distortion  | THD        | $V_{IN} = 6V$ rms @ 1kHz   |          | -85 |                     | dB       |
| <b>ANALOG OUTPUTS</b> (Note 4)   |            |  |          |     |                     |          |
| OUTA Capacitance   | $C_{OUTA}$ | DAC latches loaded with 00000000<br>DAC latches loaded with 11111111   |          |     | 50<br>120           | pF<br>pF |
| OUTB Capacitance   | $C_{OUTB}$ | DAC latches loaded with 00000000<br>DAC latches loaded with 11111111   |          |     | 50<br>120           | pF<br>pF |
| <b>DIGITAL INPUTS</b>  |            |  |          |     |                     |          |
| Input High Voltage   | $V_{IH}$   |  | 13.5     |     |                     | V        |
| Input Low Voltage  | $V_{IL}$   |  |          | 1.5 |                     | V        |
| Input Current  | $I_{IN}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   |          |     | $\pm 1$<br>$\pm 10$ | $\mu A$  |
| Input Capacitance (Note 4)   | $C_{IN}$   | DB0-DB7<br>WR, CS, DAC A/DAC B   |          |     | 10<br>15            | pF       |
| <b>POWER REQUIREMENTS</b>  |            |  |          |     |                     |          |
| Supply Current   | $I_{DD}$   | Digital inputs $V_{IL}$ or $V_{IH}$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |          |     | 1<br>1              | mA       |
|  |            | Digital inputs 0V or $V_{DD}$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |          |     | 100<br>500          | $\mu A$  |
| <b>SWITCHING CHARACTERISTICS</b> (Note 4) (See Timing Diagram)               |            |  |          |     |                     |          |
| Chip Select to Write Setup Time  | $t_{CS}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   | 60<br>80 |     |                     | ns       |
| Chip Select to Write Hold Time   | $t_{CH}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   | 10<br>15 |     |                     | ns       |

**Note 1:** Specifications apply to both DACs in MX7528.

**Note 2:** Gain error is measured using internal feedback resistor. Full Scale Range (FSR) =  $V_{REF}$ .

**Note 3:** Guaranteed, but not tested.

**Note 4:** These characteristics are for design guidance only and are not subject to test.

# CMOS Dual 8-Bit Buffered Multiplying DACs

## ELECTRICAL CHARACTERISTICS—MX7528, +15V Operation (Continued)

( $V_{DD} = +15V$ ,  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER  | SYMBOL   | CONDITIONS   | MIN      | TYP | MAX | UNITS |
|--|----------|--|----------|-----|-----|-------|
| <b>SWITCHING CHARACTERISTICS</b> (Note 4) (See Timing Diagram) (Continued) |          |  |          |     |     |       |
| DAC Select to Write Setup Time   | $t_{AS}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 60<br>80 |     |     | ns    |
| DAC Select to Write Hold Time  | $t_{AH}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 10<br>15 |     |     | ns    |
| Write Pulse Width  | $t_{WR}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 60<br>80 |     |     | ns    |
| Data Setup Time  | $t_{DS}$ | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | 30<br>40 |     |     | ns    |
| Data Hold Time   | $t_{DH}$ |  | 0        |     |     | ns    |

## ELECTRICAL CHARACTERISTICS—MX7628, +12V to +15V Operation

( $V_{DD} = +10.8V$  to  $+15.75V$ ;  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER                                      | SYMBOL | CONDITIONS  | MIN | TYP            | MAX                   | UNITS           |
|--|--------|---|-----|----------------|-----------------------|-----------------|
| <b>DC ACCURACY</b> (Note 1)                    |        |   |     |                |                       |                 |
| Resolution                                     |        |   | 8   |                |                       | Bits            |
| Relative Accuracy                              | INL    |   |     |                | $\pm 1/2$             | LSB             |
| Differential Non-Linearity                     | DNL    | Guaranteed Monotonic Over Temp.   |     |                | $\pm 1$               | LSB             |
| Gain Error (Note 2)                            |        | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$  |     |                | $\pm 2$<br>$\pm 3$    | LSB             |
| Gain Temp. Coefficient (Note 2, 3)             |        |   |     | $\pm 2$        | $\pm 35$              | ppm/ $^\circ C$ |
| Supply Rejection (Note 4)                      | PSR    | $\Delta V_{DD} = \pm 5\%$   |     | 0.001<br>0.001 | 0.01<br>0.02          | %FSR/%          |
| Output Leakage Current (OUTA)                  |        | DAC A is 00000000   |     |                | $\pm 50$<br>$\pm 200$ | nA              |
| Output Leakage Current (OUTB)                  |        | DAC B is 00000000   |     |                | $\pm 50$<br>$\pm 200$ | nA              |
| <b>REFERENCE INPUT</b>                         |        |   |     |                |                       |                 |
| $R_{IN}$ ( $V_{REFA}$ , $V_{REFB}$ )           |        |   | 8   | 10             | 15                    | k $\Omega$      |
| $V_{REFA}$ , $V_{REFB}$ Input Resistance Match |        |   |     |                | $\pm 1$               | %               |
| <b>DYNAMIC PERFORMANCE</b> (Note 4)            |        |   |     |                |                       |                 |
| Output Current Settling-Time to 1/2 LSB        |        | DB0-DB7 = 0V to +5V to 0V<br>WR = CS = 0V<br>OUTA = OUTB<br>Load = 100 $\Omega$ ,<br>$C_{EXT} = 13pF$ ; |     |                | 350<br>400            | ns              |
| Digital to Analog Glitch Impulse               |        | For code transition 00000000 to 11111111  |     | 125            |                       | nV-sec          |
| AC Feedthrough ( $V_{REFA}$ to OUTA)           |        | $V_{REFA} = \pm 10V$<br>100kHz Sinewave<br>$V_{REFB} = 0V$  |     |                | -70<br>-65            | dB              |

**Note 1:** Specifications apply to both DACs in MX7628.

**Note 2:** Gain error is measured using internal feedback resistor. Full Scale Range (FSR) =  $V_{REF}$ .

**Note 3:** Guaranteed, but not tested.

**Note 4:** These characteristics are for design guidance only and are not subject to test.

# CMOS Dual 8-Bit Buffered Multiplying DACs

## ELECTRICAL CHARACTERISTICS—MX7628, +12V to +15V Operation (Continued)

( $V_{DD} = +10.8V$  to  $+15.75V$ ,  $V_{REF} = +10V$ ;  $V_{OUTA} = V_{OUTB} = 0V$ ;  $T_A = T_{MIN}$  to  $T_{MAX}$  unless otherwise noted)

| PARAMETER  | SYMBOL     | CONDITIONS   | MIN  | TYP                 | MAX           | UNITS    |
|--|------------|--|--|---------------------|---------------|----------|
| <b>DYNAMIC PERFORMANCE</b> (Note 4) (Continued)                |            |  |  |                     |               |          |
| AC Feedthrough ( $V_{REFB}$ to $OUTB$ )                        |            | $V_{REFB} = \pm 10V$<br>100kHz Sinewave<br>$V_{REFA} = 0V$<br>$T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$ |  |                     | -70<br>-65    | dB       |
| Channel to Channel Isolation ( $V_{REFA}$ to $OUTB$ )          |            | $V_{REFA} = \pm 10V$ 100kHz Sinewave<br>$V_{REFB} = 0V$ , both DACs loaded with 11111111                         |  | -90                 |               | dB       |
| Channel to Channel Isolation ( $V_{REFB}$ to $OUTA$ )          |            | $V_{REFB} = \pm 10V$ 100kHz Sinewave<br>$V_{REFA} = 0V$ , both DACs loaded with 11111111                         |  | -90                 |               | dB       |
| Digital Crosstalk  |            | Measured with code transition 0 to FS  |  | 60                  |               | nV-sec   |
| Harmonic Distortion  | THD        | $V_{IN} = 6V$ rms @ 1kHz   |  | -85                 |               | dB       |
| <b>ANALOG OUTPUTS</b> (Note 4)                                 |            |  |  |                     |               |          |
| OUTA Capacitance   | $C_{OUTA}$ | DAC latches loaded with 00000000<br>DAC latches loaded with 11111111   |  |                     | 25<br>60      | pF<br>pF |
| OUTB Capacitance   | $C_{OUTB}$ | DAC latches loaded with 00000000<br>DAC latches loaded with 11111111   |  |                     | 25<br>60      | pF<br>pF |
| <b>DIGITAL INPUTS</b>  |            |  |  |                     |               |          |
| Input High Voltage   | $V_{IH}$   |  | 2.4  |                     |               | V        |
| Input Low Voltage  | $V_{IL}$   |  |  | 0.8                 |               | V        |
| Input Current  | $I_{IN}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$   |  | $\pm 1$<br>$\pm 10$ |               | $\mu A$  |
| Input Capacitance (Note 4)                                     | $C_{IN}$   | DB0-DB7<br>WR, CS, DAC A/DAC B   |  |                     | 10<br>15      | pF       |
| <b>POWER REQUIREMENTS</b>                                      |            |  |  |                     |               |          |
| Supply Current   | $I_{DD}$   | Digital inputs<br>$V_{IL}$ or $V_{IH}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$<br>$T_A = T_{MIN}$ to $T_{MAX}$ | K<br>B<br>T         | 2<br>2<br>2.5 | mA       |
|  |            | Digital inputs<br>0V or $V_{DD}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$                                 |                     | 100<br>500    | $\mu A$  |
| <b>SWITCHING CHARACTERISTICS</b> (Note 4) (See Timing Diagram) |            |  |  |                     |               |          |
| Chip Select to Write Setup Time                                | $t_{CS}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$<br>$T_A = T_{MIN}$ to $T_{MAX}$                               | K,B<br>T   | 160<br>160<br>210   |               | ns       |
| Chip Select to Write Hold Time                                 | $t_{CH}$   |  |  | 10                  |               | ns       |
| DAC Select to Write Setup Time                                 | $t_{AS}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$<br>$T_A = T_{MIN}$ to $T_{MAX}$                               | K,B<br>T   | 160<br>160<br>210   |               | ns       |
| DAC Select to Write Hold Time                                  | $t_{AH}$   |  |  | 10                  |               | ns       |
| Write Pulse Width  | $t_{WR}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$<br>$T_A = T_{MIN}$ to $T_{MAX}$                               | K,B<br>T   | 150<br>170<br>210   |               | ns       |
| Data Setup Time  | $t_{DS}$   | $T_A = 25^\circ C$<br>$T_A = T_{MIN}$ to $T_{MAX}$<br>$T_A = T_{MIN}$ to $T_{MAX}$                               | K,B<br>T   | 160<br>160<br>210   |               | ns       |
| Data Hold Time   | $t_{DH}$   |  |  | 10                  |               | ns       |

MX7528/MX7628

# CMOS Dual 8-Bit Buffered Multiplying DACs

## Interface Logic Information

### DAC Selection

Both DAC latches share a common 8-Bit input port. The control input DAC A/DAC B selects which DAC will accept data from the input port.

### Mode Selection

The inputs  $\overline{CS}$  and  $\overline{WR}$  control the operating mode of the selected DAC. See Mode Selection Table.

### Mode Selection Table

| DAC A/DAC B | $\overline{CS}$ | $\overline{WR}$ | DAC A | DAC B |
|-------------|-----------------|-----------------|-------|-------|
| L           | L               | L               | WRITE | HOLD  |
| H           | L               | L               | HOLD  | WRITE |
| X           | H               | X               | HOLD  | HOLD  |
| X           | X               | H               | HOLD  | HOLD  |

L = Low state, H = High state, X = Don't care

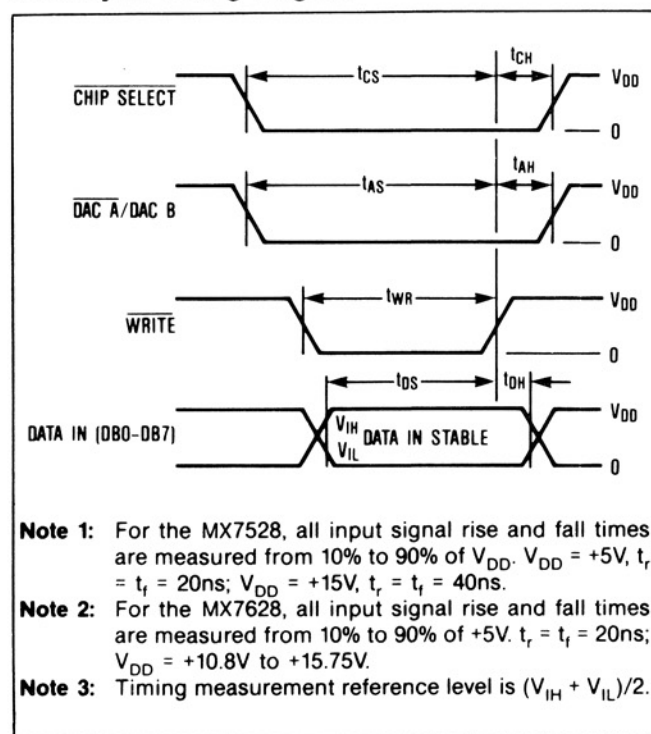
### Write Mode

When  $\overline{CS}$  and  $\overline{WR}$  are both low, the selected DAC is in the write mode. The input latches of the selected DAC are transparent and its analog output responds to the data on the data bit lines DB0-DB7.

### Hold Mode

The selected DAC latch retains the data that was present on DB0-DB7 just prior to  $\overline{CS}$  or  $\overline{WR}$  assuming a high state. Both analog outputs remain at the values corresponding to the data in their respective latches.

### Write Cycle Timing Diagram



## Detailed Description

The MX7528/MX7628 contains two identical 8-Bit multiplying digital-to-analog converters (DAC). Each DAC circuit consists of a thin-film R-2R resistor array with CMOS current steering switches. Figure 1 shows a simplified schematic of the DAC. The inverted R-2R ladder divides the voltage or current reference in a binary manner among the eight steering switches. The magnitude of the current appearing at the OUT terminal depends on the number of switches selected, and therefore the output is an analog representation of the digital input. The DAC OUT and analog ground terminals must be maintained at the same potential for proper operation.

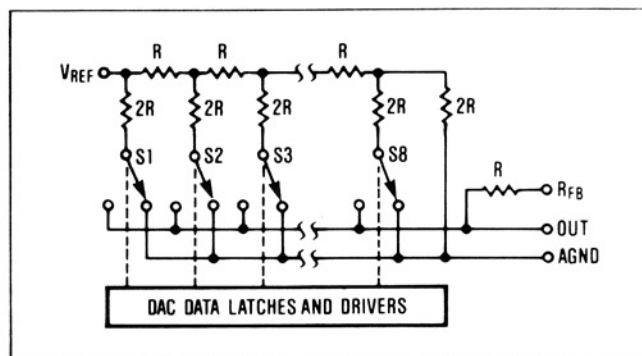


Figure 1. Simplified DAC Schematic

## Equivalent-Circuit Analysis

The DAC equivalent-circuit, typical of both DACs, is shown in figure 2. Each DAC shares the analog ground pin 1. When all the digital inputs are high, 255/256 of the reference current flows to OUT A. A small junction leakage current ( $I_{LEAKAGE}$ ), which doubles every  $10^\circ C$ , also flows to the output. The R-2R ladder termination resistor generates a constant 1/256 current which represents 1 LSB of the reference current,  $I_{REF}$ .  $C_{OUT}$  is the parallel combination of the capacitance associated with the individual NMOS current steering switches. The value of output capacitance is input code dependent and lies in the range 20pF to 30pF. The equivalent output resistance,  $R_O$ , also varies with input code in the range  $0.8R$  to  $3R$ , where  $R$  is the nominal ladder resistance.

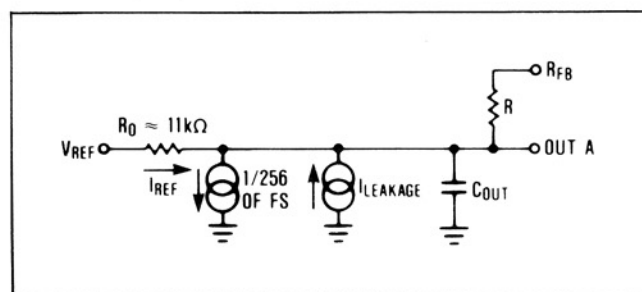


Figure 2. DAC Equivalent Circuit. All Digital Inputs High

# CMOS Dual 8-Bit Buffered Multiplying DACs

## Circuit Information—Digital Section

The MX7528's digital inputs are TTL compatible when operated with a  $V_{DD}$  of +5V ( $V_{IH} = 2.4V$ ,  $V_{IL} = 0.8V$ ). Internal level shifters convert from TTL to CMOS logic levels. When  $V_{IN}$  is in the region of 1.0 to 3.5 volts, the input buffers operate in their linear region and the quiescent current increases as indicated by the graph in figure 3. Therefore to minimize supply current it is recommended that the digital inputs be as close to the supply rails as possible ( $V_{DD}$  and DGND).

The MX7528 may be operated with any supply voltage in the range  $5V < V_{DD} < 15V$ . With  $V_{DD} = +15V$ , the input logic levels are CMOS compatible only, i.e. 1.5V and 13.5V.

The MX7628's digital inputs are TTL and CMOS compatible with any supply voltage in the range of +12V to +15V.

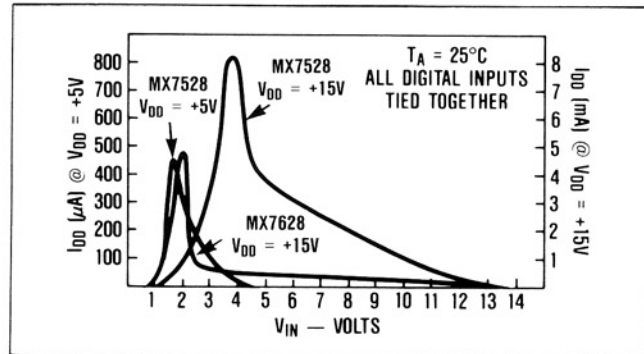


Figure 3. Typical Plots of Supply Current,  $I_{DD}$  vs. Logic Input Voltage  $V_{IN}$ , for  $V_{DD} = +5V$  and +15V

MX7528/MX7628

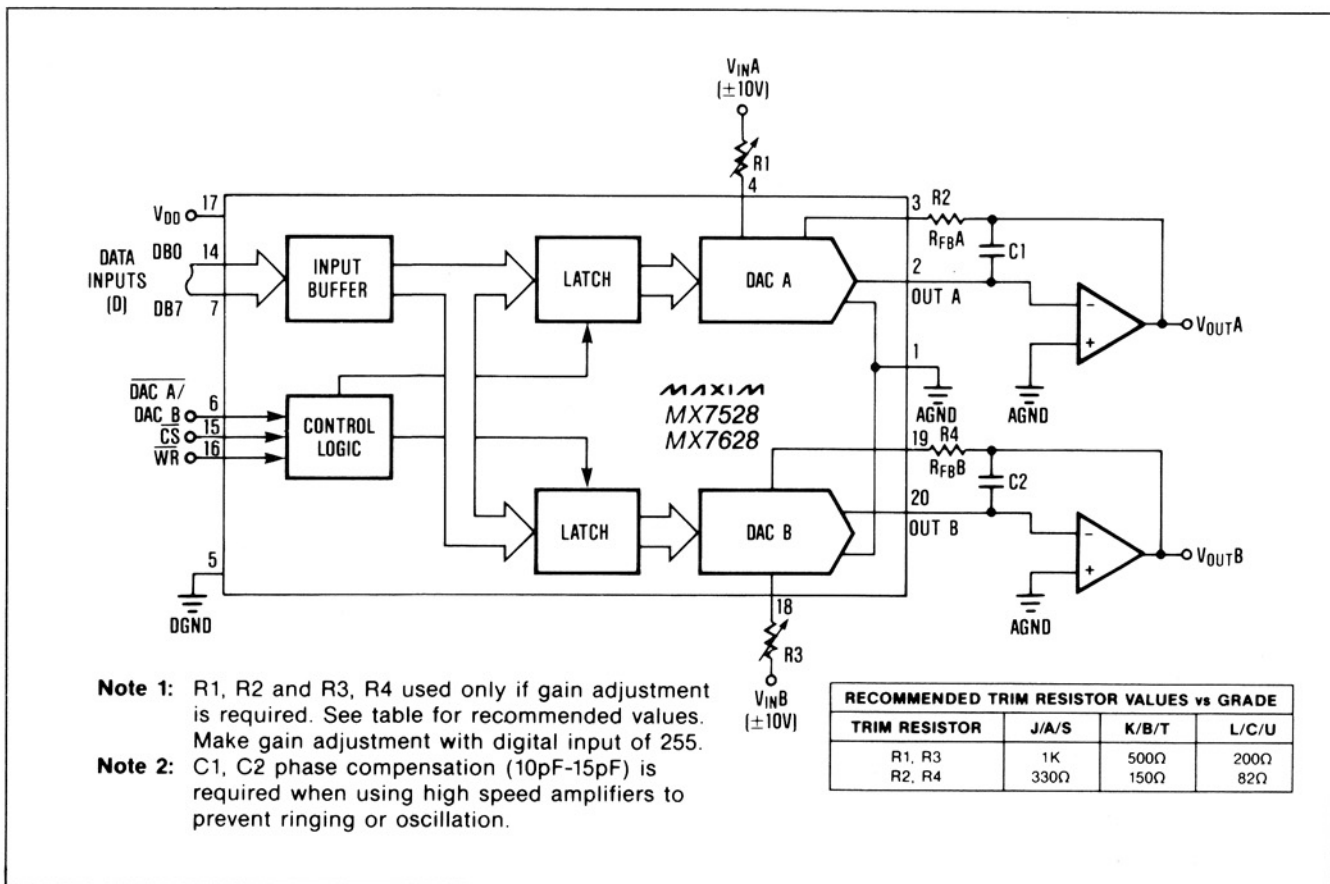


Figure 4. Dual DAC Unipolar Binary Operation (2 Quadrant Multiplication)

# CMOS Dual 8-Bit Buffered Multiplying DACs

## Applications Information

To ensure system performance consistent with the MX7528/MX7628 specifications, careful attention must be given to the following points:

1. General Ground Management:

AC or transient voltages between the MX7528/MX7628 AGND and DGND can cause noise injection into the analog output. Therefore, whenever possible, the analog and digital ground pins should be tied together at the MX7528/MX7628.

2. Output Amplifier Offset:

CMOS DACs exhibit a code-dependent output resistance which in turn causes a code-dependent amplifier noise gain. The result is a code-dependent differential nonlinearity term at the amplifier output which depends on the amplifier's offset voltage,  $V_{OS}$ . The offset dependent nonlinearity term adds to the R/2R differential nonlinearity. To maintain monotonic operation, it is recommended that amplifier offset voltage should be no more than 1/10 LSB over the operating temperature range.

3. High Frequency Considerations:

The combination of DAC output capacitance and the amplifier's feedback resistance adds a pole to the open-loop response which can cause ringing or oscillation in severe cases. Stability can be restored by adding a phase compensation capacitor in parallel with the feedback resistor.

4. Dynamic Performance:

The dynamic performance of the two DACs in the MX7528/MX7628 depends on the gain and phase

characteristics of the output amplifiers, together with the stray capacitance contributed by the PC layout, and the power supply decoupling components. A  $0.1\mu\text{F}$  decoupling capacitor is recommended between  $V_{DD}$  and DGND.

5. Circuit Layout Suggestions:

Analog and digital ground traces should be routed between the package pins to reduce coupling between the digital inputs and the analog output. Analog ground traces should also be placed between pins 17-18, 18-19, 3-4, and 4-5 to minimize reference feedthrough to the output in multiplying applications.

## Single Supply Operation

The MX7528/MX7628 R-2R ladder termination resistors are internally connected to AGND. This arrangement is particularly convenient for single supply operation because AGND may be biased at any voltage between  $V_{DD}$  and DGND. Figure 5 shows a circuit which provides dual +5V to +8V analog outputs by biasing AGND 5V above DGND. The two DAC reference inputs are tied together and a reference input voltage is obtained without a buffer amplifier by making use of the stable matched impedances of the DAC A and DAC B reference inputs. Current flows through the two DAC A and DAC B reference inputs. Current flows through the two DAC R-2R ladders into R1, and R1 is adjusted until  $V_{REFA}$  and  $V_{REFB}$  inputs are at +2V. DAC codes from 00000000 to 11111111 adjust the analog output voltages from +5V to +8V in 11.7mV steps.

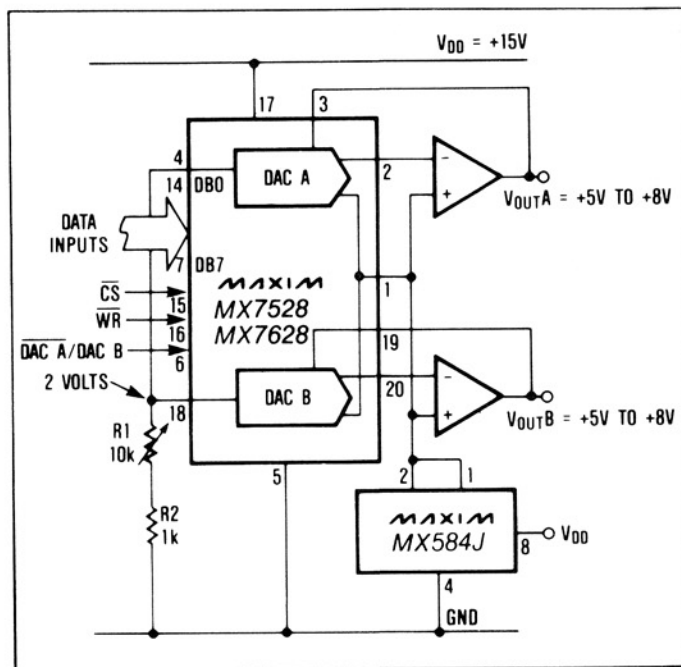


Figure 5. MX7528/MX7628 Single Supply Operation

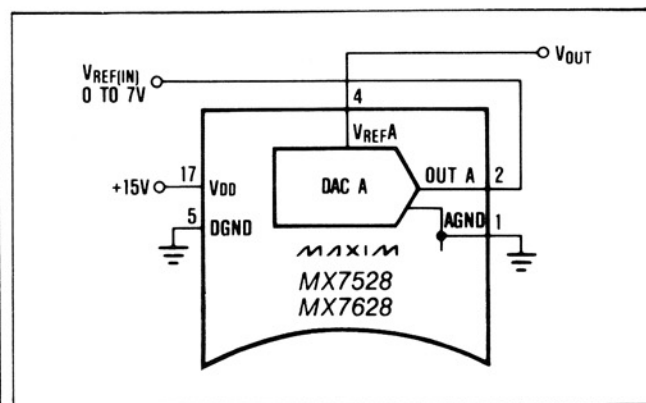


Figure 6. MX7528/MX7628 in Single Supply, Voltage Switching Mode

Figure 6 shows one DAC of the MX7528/MX7628 connected in the voltage switching mode which uses a positive reference voltage. This configuration is useful in that  $V_{OUT}$  is the same polarity as  $V_{IN}$  allowing single supply operation. However, to maintain linearity,  $V_{IN}$  must be limited to approximately +7V ( $V_{DD} = +15V$ ), and the output must be buffered or loaded with a high impedance. In the voltage switching mode, the output resistance is independent of the digital input code and is typically  $10k\Omega$ .

# CMOS Dual 8-Bit Buffered Multiplying DACs

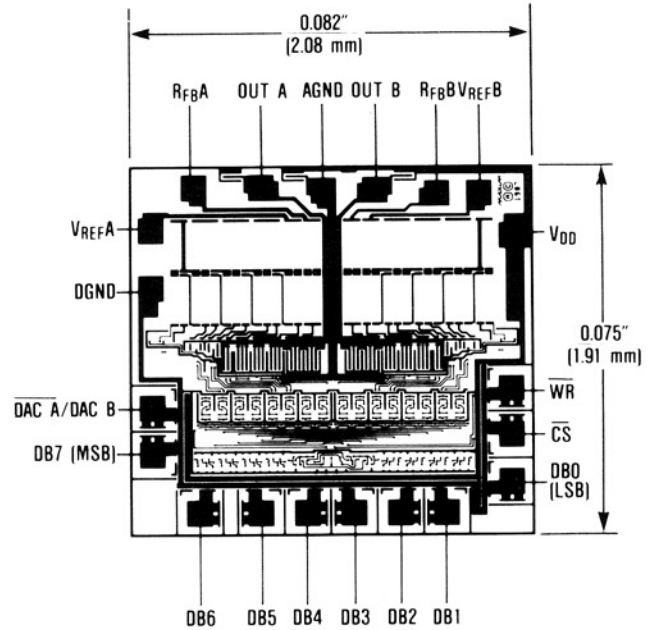
## Ordering Information (continued)

## Chip Topography

| PART       | TEMP. RANGE     | PACKAGE*    | ERROR    |
|------------|-----------------|-------------|----------|
| MX7528KEPP | -40°C to +85°C  | Plastic DIP | ±1/2 LSB |
| MX7528LEPP | -40°C to +85°C  | Plastic DIP | ±1/2 LSB |
| MX7528KEWP | -40°C to +85°C  | Wide SO     | ±1/2 LSB |
| MX7528LEWP | -40°C to +85°C  | Wide SO     | ±1/2 LSB |
| MX7528SD   | -55°C to +125°C | Ceramic     | ±1 LSB   |
| MX7528TD   | -55°C to +125°C | Ceramic     | ±1/2 LSB |
| MX7528UD   | -55°C to +125°C | Ceramic     | ±1/2 LSB |
| MX7528SQ   | -55°C to +125°C | CERDIP**    | ±1 LSB   |
| MX7528TQ   | -55°C to +125°C | CERDIP**    | ±1/2 LSB |
| MX7528UQ   | -55°C to +125°C | CERDIP**    | ±1/2 LSB |
| MX7628KN   | 0°C to +70°C    | Plastic DIP | ±1/2 LSB |
| MX7628KCWP | 0°C to +70°C    | Wide SO     | ±1/2 LSB |
| MX7628KC/D | 0°C to +70°C    | Dice        | ±1/2 LSB |
| MX7628BQ   | -25°C to +85°C  | CERDIP      | ±1/2 LSB |
| MX7628TQ   | -55°C to +125°C | CERDIP      | ±1/2 LSB |

\* All devices – 20 lead packages

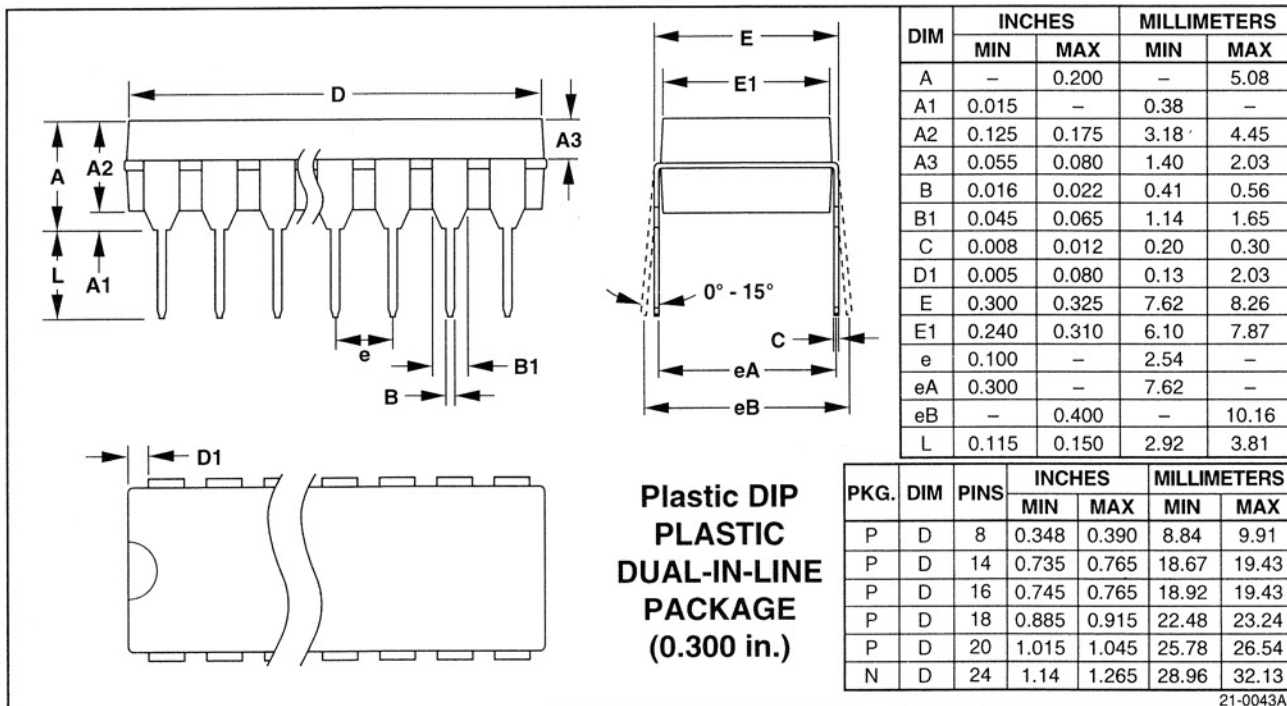
\*\* Maxim reserves the right to ship Ceramic packages in lieu of CERDIP packages



MX7528/MX7628

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



**Plastic DIP  
PLASTIC  
DUAL-IN-LINE  
PACKAGE  
(0.300 in.)**

# CMOS Dual 8-Bit Buffered Multiplying DACs

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

**Wide SO  
SMALL-OUTLINE  
PACKAGE  
(0.300 in.)**

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.093  | 0.104 | 2.35        | 2.65  |
| A1  | 0.004  | 0.012 | 0.10        | 0.30  |
| B   | 0.014  | 0.019 | 0.35        | 0.49  |
| C   | 0.009  | 0.013 | 0.23        | 0.32  |
| E   | 0.291  | 0.299 | 7.40        | 7.60  |
| e   | 0.050  |       | 1.27        |       |
| H   | 0.394  | 0.419 | 10.00       | 10.65 |
| L   | 0.016  | 0.050 | 0.40        | 1.27  |

| DIM | PINS | INCHES |       | MILLIMETERS |       |
|-----|------|--------|-------|-------------|-------|
|     |      | MIN    | MAX   | MIN         | MAX   |
| D   | 16   | 0.398  | 0.413 | 10.10       | 10.50 |
| D   | 18   | 0.447  | 0.463 | 11.35       | 11.75 |
| D   | 20   | 0.496  | 0.512 | 12.60       | 13.00 |
| D   | 24   | 0.598  | 0.614 | 15.20       | 15.60 |
| D   | 28   | 0.697  | 0.713 | 17.70       | 18.10 |

21-0042A

**CERDIP  
CERAMIC DUAL-IN-LINE  
PACKAGE  
(0.300 in.)**

| DIM | INCHES |       | MILLIMETERS |      |
|-----|--------|-------|-------------|------|
|     | MIN    | MAX   | MIN         | MAX  |
| A   | –      | 0.200 | –           | 5.08 |
| B   | 0.014  | 0.023 | 0.36        | 0.58 |
| B1  | 0.038  | 0.065 | 0.97        | 1.65 |
| C   | 0.008  | 0.015 | 0.20        | 0.38 |
| E   | 0.220  | 0.310 | 5.59        | 7.87 |
| E1  | 0.290  | 0.320 | 7.37        | 8.13 |
| e   | 0.100  |       | 2.54        |      |
| L   | 0.125  | 0.200 | 3.18        | 5.08 |
| L1  | 0.150  | –     | 3.81        | –    |
| Q   | 0.015  | 0.070 | 0.38        | 1.78 |
| S   | –      | 0.098 | –           | 2.49 |
| S1  | 0.005  | –     | 0.13        | –    |

| DIM | PINS | INCHES |       | MILLIMETERS |       |
|-----|------|--------|-------|-------------|-------|
|     |      | MIN    | MAX   | MIN         | MAX   |
| D   | 8    | –      | 0.405 | –           | 10.29 |
| D   | 14   | –      | 0.785 | –           | 19.94 |
| D   | 16   | –      | 0.840 | –           | 21.34 |
| D   | 18   | –      | 0.960 | –           | 24.38 |
| D   | 20   | –      | 1.060 | –           | 26.92 |
| D   | 24   | –      | 1.280 | –           | 32.51 |

21-0045A

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