



# MP7680

## 5 V CMOS 12-Bit Quad Double-Buffered Multiplying Digital-to-Analog Converter

June 2000-2

### FEATURES

- Exar Pioneered Segmented DAC Approach
- Four Double-Buffered 12-bit DACs on a Single Chip
- Independent Reference Inputs
- Lowest Gain Error in a Multiple DAC Chip
- Guaranteed Monotonic
- TTL/5 V CMOS Compatible Inputs
- Industry Standard Digital Interface
- Four Quadrant Multiplication
- Latch-Up Free

### BENEFITS

- Reduced Board Space; Lower System Cost.
- Independent Control of DACs
- Excellent DAC-to-DAC Matching and Tracking

### APPLICATIONS

- Function Generators
- Automatic Test Equipment
- Precision Process Controls
- Recording Studio Control Boards

### GENERAL DESCRIPTIONS

The MP7680 integrates four 12-bit four-quadrant-multiplying DACs with independent reference inputs and excellent matching characteristics. The MP7680 grades offer 1/2, 1 and 2 LSB of relative accuracy. The superior offers a low 2 LSB of gain error.

Each DAC has double-buffering (an 8 and 4-bit latch and a 12-bit latch) between the data bus (DB11 - DB0) and the DAC. The internal 4-bit mux allows the use of 8 or 16-bit buses. The flexible latch control logic allows to update one or more DACs simultaneously.

### ORDERING INFORMATION

Package Type	Temperature Range	Part No.	INL (LSB)	DNL (LSB)	Gain Error (LSB)
Plastic Dip	-40 to +85 C	MP7680JN	$\pm 2$	$\pm 4$	$\pm 16$
Plastic Dip	-40 to +85 C	MP7680KN	$\pm 1$	$\pm 2$	$\pm 16$
PQFP	-40 to +85 C	MP7680JE	$\pm 2$	$\pm 4$	$\pm 16$
PQFP	-40 to +85 C	MP7680KE	$\pm 1$	$\pm 2$	$\pm 16$

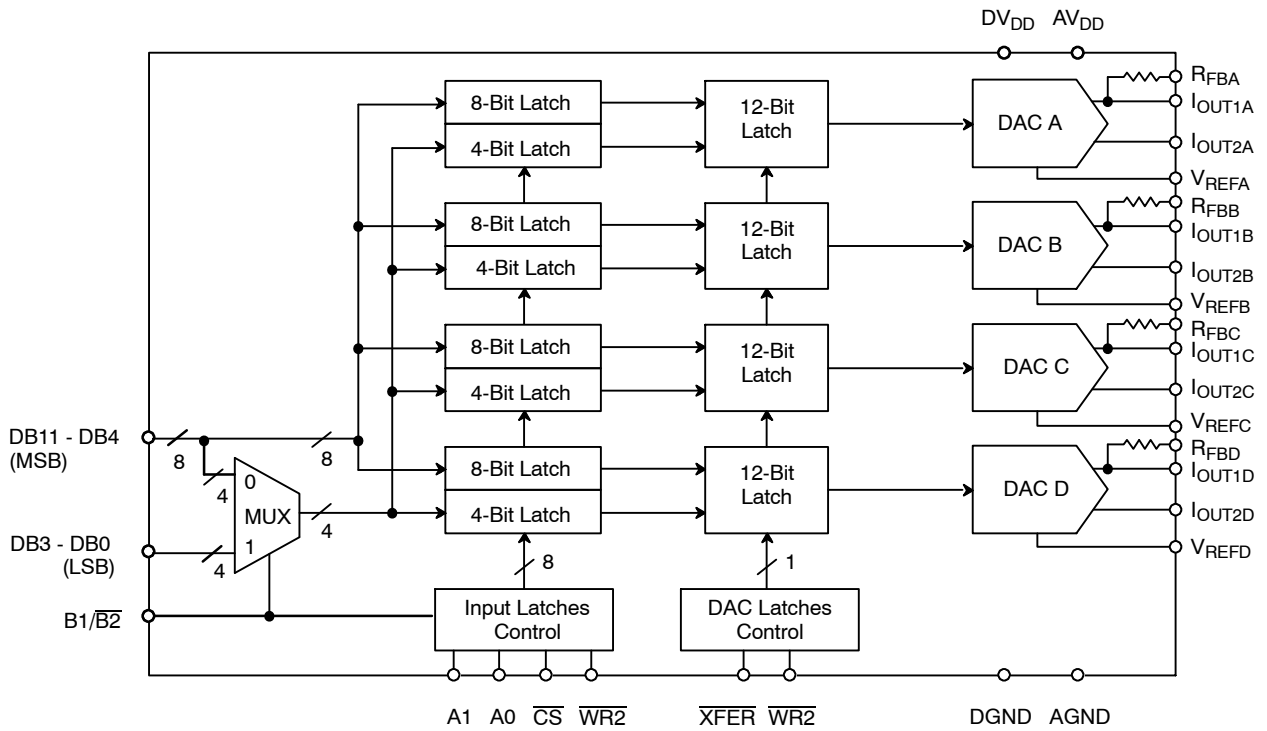
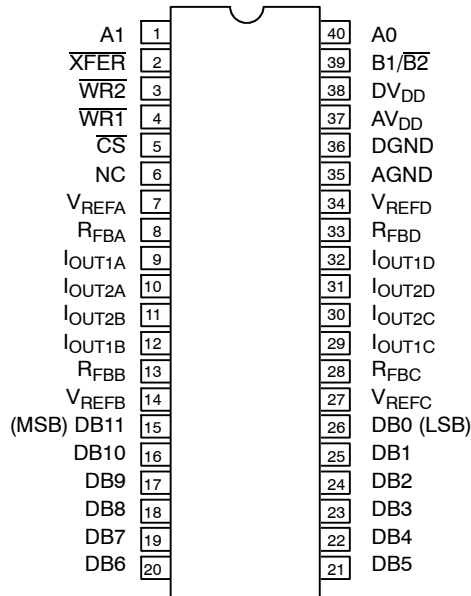
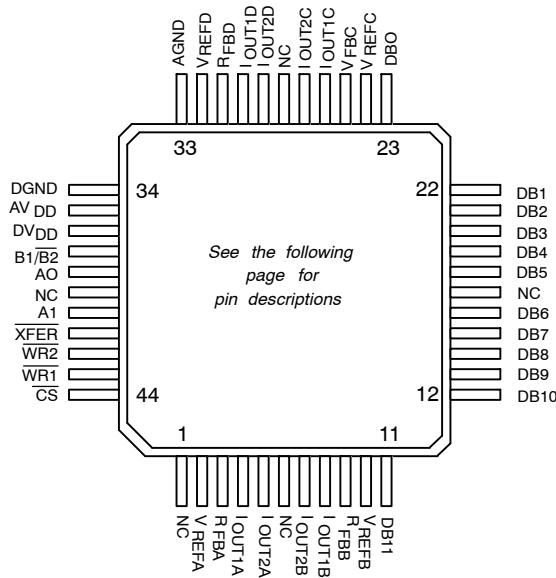


Figure 1. Simplified Block Diagram

**PIN CONFIGURATIONS**



**40 Pin PDIP , (0.600 )**



**44 Pin PQFP**

## PIN DESCRIPTION

40 Pin PDIP , CDIP

PIN NO.	NAME	DESCRIPTION
1	A1	DAC Address Bit 1
2	$\overline{XFER}$	Transfer: Updates all DAC s
3	$\overline{WR2}$	Write 2: Gates the $\overline{XFER}$ Function
4	$\overline{WR1}$	Write 1: Gates the DAC Selection
5	$\overline{CS}$	Chip Select
6	NC	No Connection
7	V <sub>REFA</sub>	Reference Input for DAC A
8	R <sub>FBA</sub>	Feedback Resistor for DAC A
9	I <sub>OUT1A</sub>	Current Output A
10	I <sub>OUT2A</sub>	Complement of Output A
11	I <sub>OUT2B</sub>	Complement of Output B
12	I <sub>OUT1B</sub>	Current Output B
13	R <sub>FBB</sub>	Feedback Resistor for DAC B
14	V <sub>REFB</sub>	Reference Input for DAC B
15 - 26	DB11 to DB0	Input Data Bits 11 (MSB) to 0 (LSB)
27	V <sub>REFC</sub>	Reference input for DAC C
28	R <sub>FBC</sub>	Feedback Resistor for DAC C
29	I <sub>OUT1C</sub>	Current Output C
30	I <sub>OUT2C</sub>	Complement of Output C
31	I <sub>OUT2D</sub>	Complement of Output D
32	I <sub>OUT1D</sub>	Current Output D
33	R <sub>FBD</sub>	Feedback Resistor for DAC D
34	V <sub>REFD</sub>	Reference input for DAC D
35	AGND	Analog Ground
36	DGND	Digital Ground
37	AV <sub>DD</sub>	Analog Power Supply
38	DV <sub>DD</sub>	Digital Power Supply
39	B1/ $\overline{B2}$	Select Input Format (8/4 or 12 bits in)
40	A0	DAC Address Bit 0

44 Pin PQFP

PIN NO.	NAME	DESCRIPTION
1	NC	No Connection
2	V <sub>REFA</sub>	Reference Input for DAC A
3	R <sub>FBA</sub>	Feedback Resistor for DAC A
4	I <sub>OUT1A</sub>	Current Output A
5	I <sub>OUT2A</sub>	Complement of Output A
6	NC	No Connection
7	I <sub>OUT2B</sub>	Complement of Output B
8	I <sub>OUT1B</sub>	Current Output B
9	R <sub>FBB</sub>	Feedback Resistor for DAC B
10	V <sub>REFB</sub>	Reference Input for DAC B
11-16	DB11 to DB6	Input Data Bits 11 (MSB) to 6
17	NC	No Connection
18-23	DB5-DB0	Input Data Bits 5 to 0 (LSB)
24	V <sub>REFC</sub>	Reference input for DAC C
25	R <sub>FBC</sub>	Feedback Resistor for DAC C
26	I <sub>OUT1C</sub>	Current Output C
27	I <sub>OUT2C</sub>	Complement of Output C
28	NC	No Connection
29	I <sub>OUT2D</sub>	Complement of Output D
30	I <sub>OUT1D</sub>	Current Output D
31	R <sub>FBD</sub>	Feedback Resistor for DAC D
32	V <sub>REFD</sub>	Reference input for DAC D
33	AGND	Analog Ground
34	DGND	Digital Ground
35	AV <sub>DD</sub>	Analog Power Supply
36	DV <sub>DD</sub>	Digital Power Supply
37	B1/ $\overline{B2}$	Select Input Format (8/4 or 12 bits in)
38	A0	DAC Address Bit 0
39	NC	No Connection
40	A1	DAC Address Bit 1
41	$\overline{XFER}$	Transfer: Updates all DAC s
42	$\overline{WR2}$	Write 2: Gates the $\overline{XFER}$ Function
43	$\overline{WR1}$	Write 1: Gates the DAC Selection
44	$\overline{CS}$	Chip Select

**ELECTRICAL CHARACTERISTICS**
 $(V_{DD} = +5\text{ V}, V_{REF} = +10\text{ V}, I_{OUT1} = I_{OUT2} = DGND = AGND = 0\text{ V}$  Unless Otherwise Noted)

Parameter	Symbol	25 °C			Tmin to Tmax		Units	Test Conditions/Comments
		Min	Typ	Max	Min	Max		
<b>STATIC PERFORMANCE</b> <sup>1</sup>								
Resolution (All Grades)	N	12			12		Bits	Best Fit Straight Line Spec. (Max INL - Min INL) / 2
Integral Non-Linearity (Relative Accuracy)	INL						LSB	
K				±1			±1	
J				±2			±2	
Differential Non-Linearity	DNL						LSB	
K				±1			±2.0	
J				±4			±4.0	
Gain Error	GE						LSB	
K				±16			±16	
J				±16			±16	
Gain Temperature Coefficient <sup>2</sup>	TC <sub>GE</sub>						±2 ppm/°C	Gain/ Temperature
Power Supply Rejection Ratio	PSRR			±50			±70 ppm/%	Gain/ V <sub>DD</sub> V <sub>DD</sub> = ±5%
Output Leakage Current	I <sub>OUT</sub>			±50			±200 nA	I <sub>OUT1</sub> V <sub>IN</sub> = 0 V I <sub>OUT2</sub> V <sub>IN</sub> = V <sub>DD</sub>
<b>DYNAMIC PERFORMANCE</b> <sup>2</sup>								
Current Settling Time	t <sub>S</sub>		1.0				s	R <sub>L</sub> =100 Ω, C <sub>EXT</sub> =13pF Full scale change to 1/2 LSB
<b>REFERENCE INPUT</b>								
Input Resistance	R <sub>IN</sub>	3	5	7	3	7	k	
Voltage Input Range <sup>2</sup>	V <sub>IN</sub>		±10	±25			V	
<b>DIGIT AL INPUTS</b>								
Input High Voltage	V <sub>IH</sub>	2.4			2.4		V	V <sub>IN</sub> = 0 V and V <sub>DD</sub>
Input Low Voltage	V <sub>IL</sub>			0.8		0.8	V	
Input Current	I <sub>LKG</sub>			±1		±4	A	
Input Capacitance <sup>2</sup>								
Data	C <sub>IN</sub>		7.0				pF	
Control	C <sub>IN</sub>		7.0				pF	
<b>ANALOG OUTPUTS</b> <sup>2</sup>								
Output Capacitance								
	C <sub>OUT1</sub>		100				pF	DAC all 1 s
	C <sub>OUT1</sub>		50				pF	DAC all 0 s
	C <sub>OUT2</sub>		50				pF	DAC all 1 s
	C <sub>OUT2</sub>		100				pF	DAC all 0 s

## ELECTRICAL CHARACTERISTICS (CONT D)

Parameter	Symbol	25 C			Tmin to Tmax		Units	Test Conditions/Comments
		Min	Typ	Max	Min	Max		
<b>POWER SUPPLY<sup>4</sup></b>								
Functional Voltage Range	$V_{DD}$	4.5		5.5	4.5	5.5	V	Digital inputs = $V_{IL}$ or $V_{IH}$ Digital inputs = 0 or 5 V
Supply Current	$I_{DD}$			2		2	mA	
				1		1	mA	
<b>TIMING CHARACTERISTICS<sup>2, 3</sup></b>								
Write Pulse Width	$t_{WR}$	75			85		ns	
Chip Select Set-Up Time	$t_{CS}$	100			120		ns	
Address Set-Up Time	$t_{AS}$	100			120		ns	
Chip Select and Address Hold Time	$t_H$	0			0		ns	
Latch Select Set-Up Time	$t_{BS}$	120			150		ns	
Latch Select Hold Time	$t_{BH}$	10			15		ns	
Data Valid Set-Up Time	$t_{DS}$	100			120		ns	
Data Valid Hold Time	$t_{DH}$	0			0		ns	
Transfer Pulse Width	$t_{XFER}$	65			75		ns	
Write Cycle (per DAC)	$t_{WC}$	175			200		ns	

**Notes:**

- <sup>1</sup> Full Scale Range (FSR) is 10V for unipolar mode.
- <sup>2</sup> Guaranteed but not production tested.
- <sup>3</sup> See timing diagram (Figure 2).
- <sup>4</sup>  $DV_{DD}$  and  $AV_{DD}$  are connected through the silicon substrate. Connect together at the package. DC voltage differences will cause undesirable internal currents.

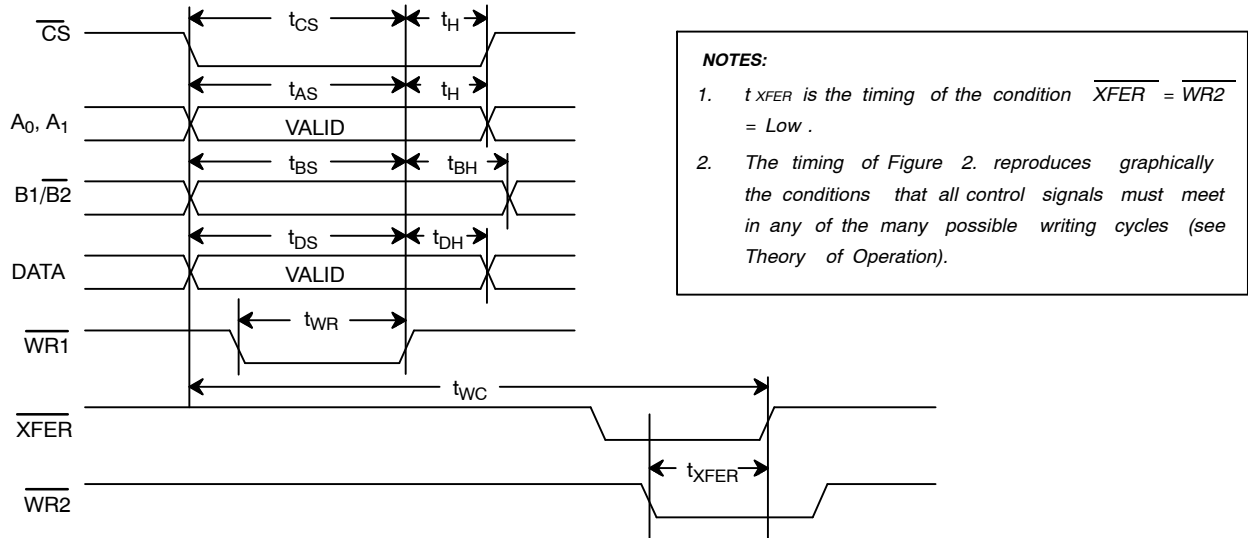
Specifications are subject to change without notice

**ABSOLUTE MAXIMUM RATINGS (TA = +25 C unless otherwise noted)<sup>1, 2</sup>**

$V_{DD}$ to AGND	-0.5 to +7 V	Any $V_{RFB}$ to AGND	$\pm 25$ V
$V_{DD}$ to DGND	-0.5 to +7 V	Storage Temperature	-65 C to +150 C
Digital Input Voltage to DGND	GND -0.5 to $V_{DD}$ +0.5 V	Lead Temperature (Soldering, 10 seconds)	+300 C
Any $I_{OUT1}$ , $I_{OUT2}$ to AGND	GND -0.5 to $V_{DD}$ +0.5 V	Package Power Dissipation Rating to 75 C	
Any $V_{REF}$ to AGND	$\pm 25$ V	CDIP, PDIP, PQFP	800mW
AGND to DGND	$\pm 1$ V	Derates above 75 C	11mW/ C
(Functionality Guaranteed $\pm 0.5$ V)			

**Notes:**

- <sup>1</sup> 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.
- <sup>2</sup> 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 100 s.



**Figure 2. Write Cycle Timing (Each DAC)**

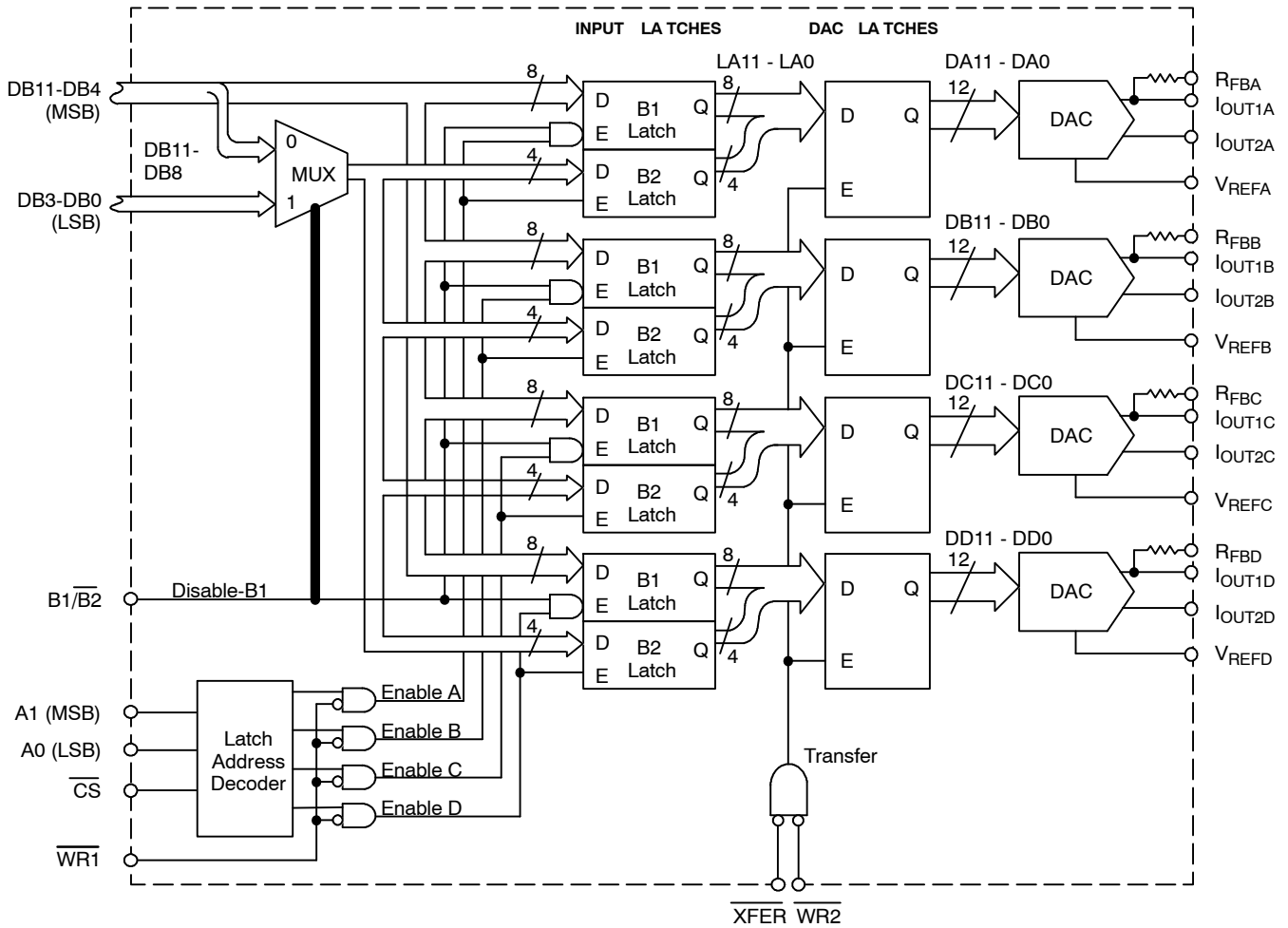


Figure 3. Latches Control Logic

THEORY OF OPERATION

Digital Interface

Figure 3. shows the internal control logic. The logic that controls the writing of the input latches and the one that controls the DAC latches are completely separated. It is easy to understand how the MP7680/80A works by understanding each basic operation.

Writing to Input Latches

By keeping  $B1/\overline{B2}$  = high, a 12-bit bus has direct access to the 12 bits of the input latches. The condition  $\overline{CS} = \overline{WR1} = 0$  loads the values contained in the data bus DB11-DB0 into the input latch addresses by  $A_1$ ,  $A_0$  (Figure 4., Table 1.).



A <sub>1</sub>	A <sub>0</sub>	SELECTED DAC
0	0	A
0	1	B
1	0	C
1	1	D

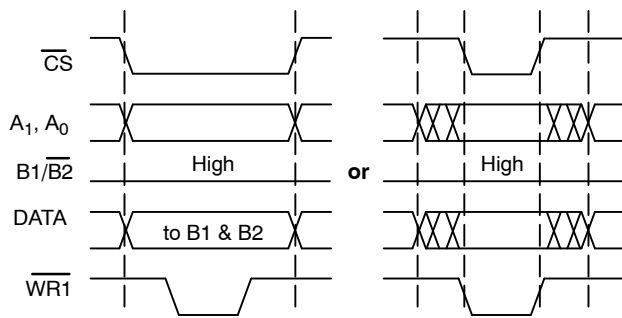
**Table 1. DAC Selection**

An 8-bit bus must use two cycles. The second cycle is like the first one with the difference that B1/ $\overline{B2}$  = low

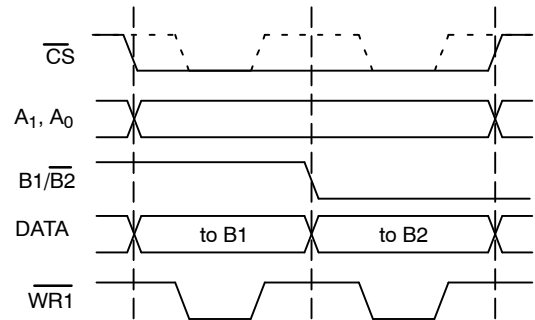
(Figure 5.) During the second cycle the condition B1/ $\overline{B2}$  = low muxes DB11-DB8 to the B2 latches (Figure 3.).

Two important notes:

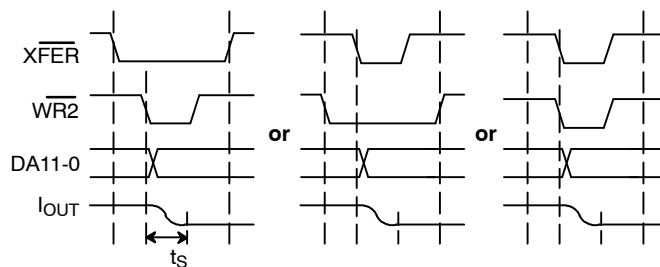
- 1) Timing diagrams show the inputs  $\overline{CS}$ , A<sub>1</sub>, A<sub>0</sub>, DB11-DB0 to be stable during the entire writing cycle. In reality all the above signals can change (Figure 4.) as long as they meet the timing conditions specified in the Electrical Characteristic Table.
- 2) Only 16-bit bus cycles are shown in the next few examples of interface timing. It is possible to generate an 8-bit interface timing by replacing a single 12-bit write cycle (Figure 4.) with a double 8-bit write cycles (Figure 5.) 8-bit applications should ground inputs DB3-DB0.



**Figure 4. 12 Bit Write Cycle**



**Figure 5. 8-Bit Double Write Cycle**



**Figure 6. Transfer Cycles from Input Latches to DAC Latches**

## Transferring Data to the DAC Latches

Once one or all of the input latches have been loaded, the condition  $\overline{XFER} = \overline{WR2} = \text{low}$  transfers the content of ALL the input latches in the DAC latches. The output of the DAC latches (DA11-DA0) changes and the DAC current ( $I_{OUT}$ ) will reach a new stable value within the settling time  $t_S$  (Figure 6.).

Examples of DACs updating sequences:

- 1) Simultaneous updates of any number of DACs. The system uses from one (two) to four (eight) cycles to write from a 12 (8) bit bus into B1/B2 latches. One

transfer cycle updates the output of all DACs (Figure 7.)

- 2) Individual DAC update. The condition  $\overline{WR2} = \overline{XFER} = \text{low}$  makes the DAC latches transparent. A writing to the B1/B2 latches updates the DAC outputs (Figure 8.).
- 3) Automatic transfer to DAC latches. An 8-bit bus can update any DAC with two cycles by connecting  $\overline{WR1} = \overline{WR2}$  and  $B1/\overline{B2} = \overline{XFER}$ . This is the correct individual DAC update for 8-bit busses (Figure 9.).
- 4) Transfer by a second device. A processor may load the input latches while the final  $\overline{XFER}$  pulse is left to another device.

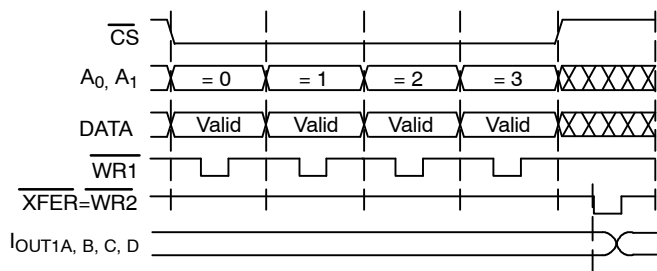


Figure 7. Simultaneous Updates of DACs

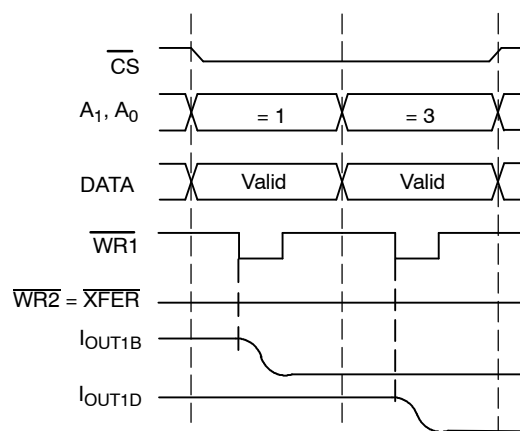


Figure 8. Individual DAC Update

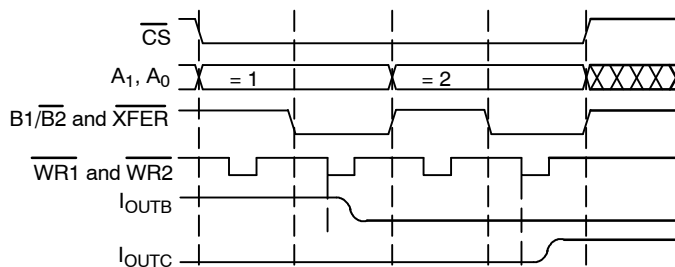


Figure 9. Automatic Transfer to DAC Latches

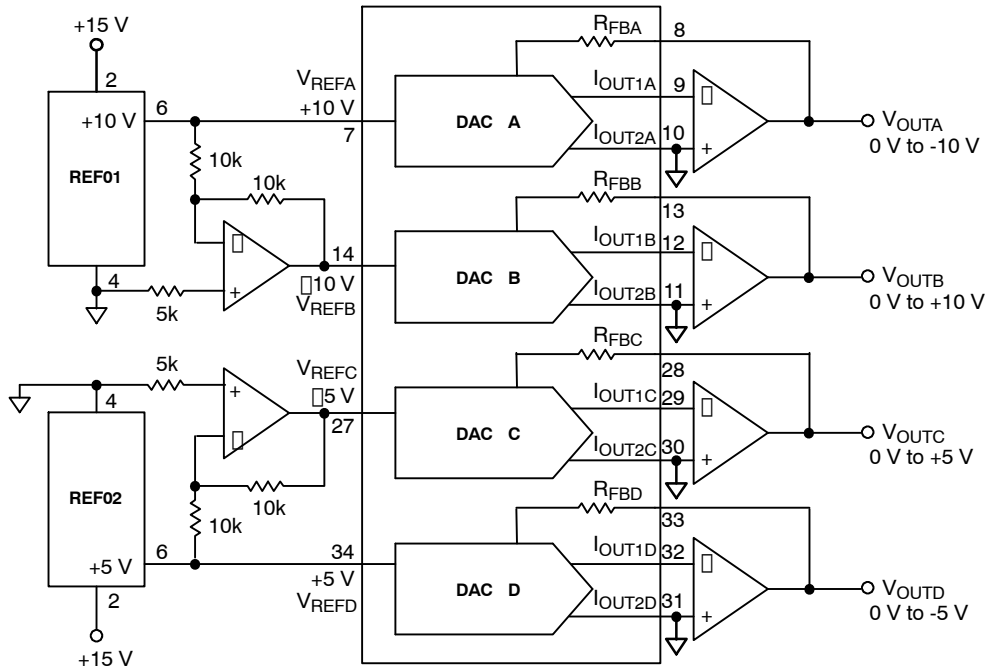


Figure 10. Digitally Programmable Quad Voltage Output  $\pm 10$  V,  $\pm 5$  V

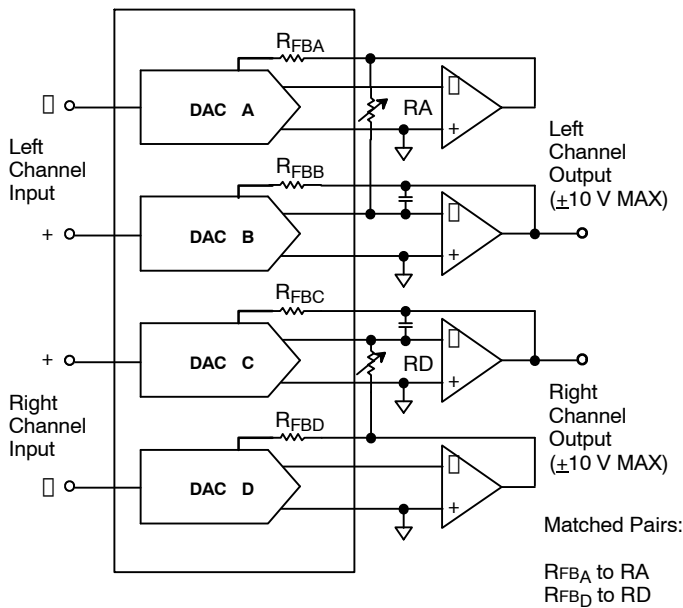


Figure 11. Clickless Audio Attenuator/Amplifier

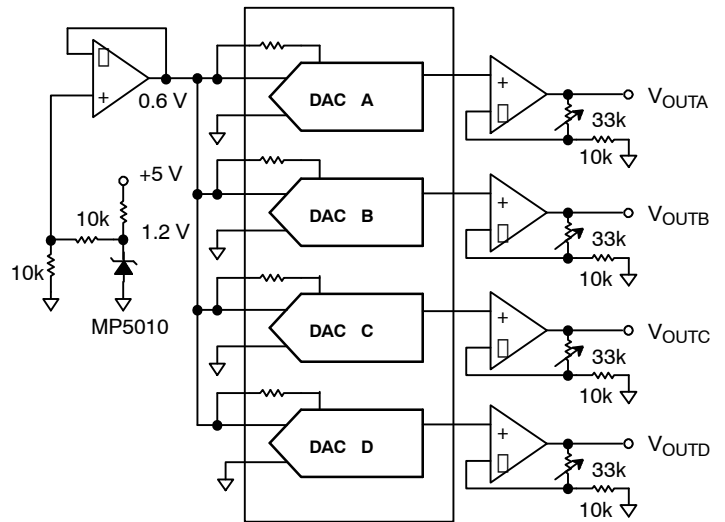


Figure 12. Quad DAC for Single +5 V Supply

# Notes