



# MP7611

Octal 14-Bit DAC Array™  
D/A Converter with Output Amplifier  
and Parallel Data/Address  $\mu$ P Control Logic

June 1998-3

## FEATURES

- Eight Independent Channel 14-Bit DACs with Output Amplifiers
- Low Power 320 mW (typ.)
- Parallel Digital Data and Address Port
- Double Buffered Data Interface
- Readback of DAC Latches
- Zero Volt Output Preset (Data = 10 .. 00)
- 14-Bit Resolution, 12-Bit Accuracy
- Extremely Well Matched DACs
- Extremely Low Analog Ground Current (<60 $\mu$ A/Channel)
- $\pm 10$  V Output Swing with  $\pm 11.4$  V Supplies

- Rugged Construction – Latch-Up Free
- Serial Version: MP7610

## APPLICATIONS

- Data Acquisition Systems
- ATE
- Process Control
- Self-Diagnostic Systems
- Logic Analyzers
- Digital Storage Scopes
- PC Based Controller/DAS

## GENERAL DESCRIPTION

The MP7611 provides eight independent 14-bit resolution Digital-to-Analog Converters with voltage output amplifiers and a parallel digital address and data port.

Built using an advanced linear BiCMOS, these devices offer rugged solutions that are latch-up free, and take advantage of EXAR's patented thin-film resistor process which exhibits excellent long term stability and reliability.

A standard  $\mu$ -processor and TTL/CMOS compatible

14-bit input data port loads the data into the pre-selected DACs.

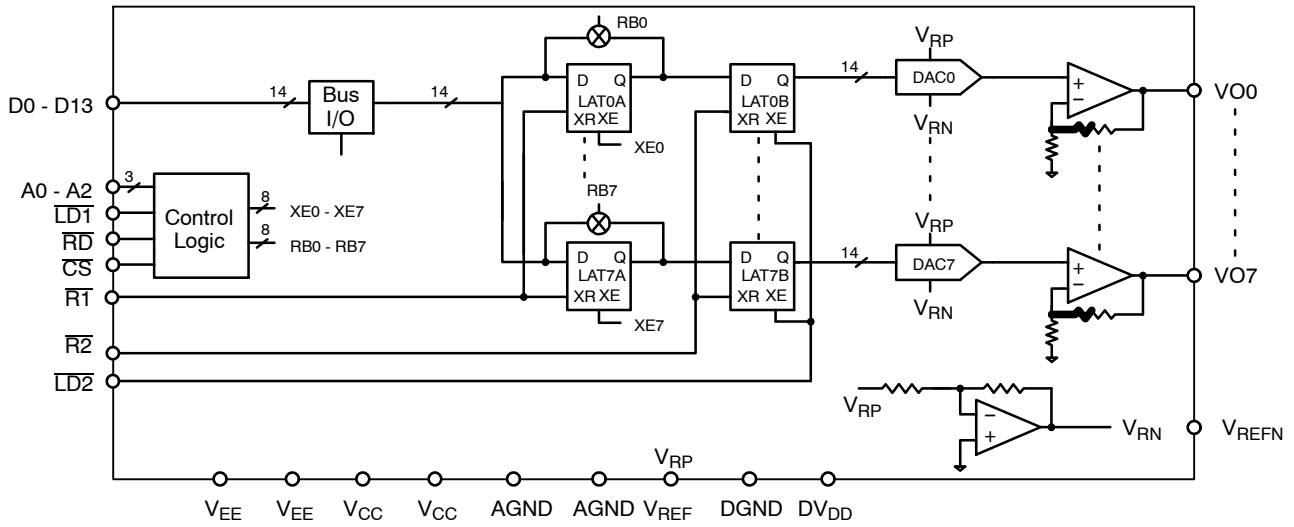
This device can easily be interfaced to a data bus, and digital readback of each channel is available.

Typical DAC matching for C grade versions is 1.5 LSB across all codes. The output amplifier is capable of sinking and sourcing 5mA, and the output voltage settles to 12-bits in less than 30 $\mu$ s (typ.).

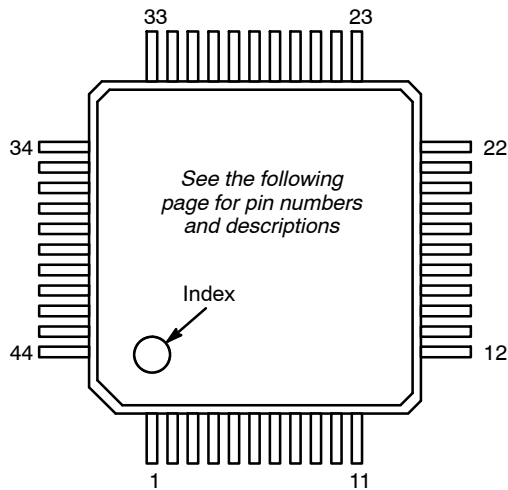
## ORDERING INFORMATION

Package Type	Temperature Range	Part No.	Res. (Bits)	INL (LSB)	DNL (LSB)	FSE (LSB)
PQFP	0 to +70°C	MP7611CE	14	$\pm 2$	$\pm 2$	$\pm 16$
PQFP	-40 to +85°C	MP7611BE	14	$\pm 4$	$\pm 3$	$\pm 24$
PQFP	-40 to +85°C	MP7611AE	14	$\pm 8$	$\pm 4$	$\pm 32$
PLCC	0 to +70°C	MP7611CP	14	$\pm 2$	$\pm 2$	$\pm 16$
PLCC	-40 to +85°C	MP7611BP	14	$\pm 4$	$\pm 3$	$\pm 24$
PLCC	-40 to +85°C	MP7611AP	14	$\pm 8$	$\pm 4$	$\pm 32$

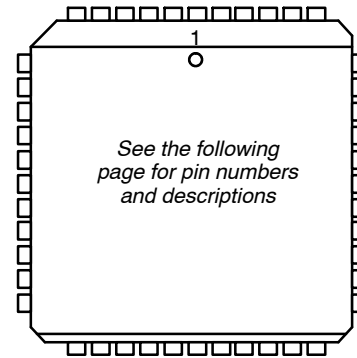
## SIMPLIFIED BLOCK DIAGRAM



## PIN CONFIGURATIONS



44-Pin PQFP (14 mm x 14 mm)



44-Pin PLCC

## PIN OUT DEFINITIONS

PLCC PIN NO.	PQFP PIN NO.	NAME	DESCRIPTION
29	1	N/C	No Connection
30	2	VO3	DAC 3 Output
31	3	VEE	Analog Negative Power Supply (-12 V)
32	4	VCC	Analog Positive Power Supply (+12 V)
33	5	N/C	No Connection or DV <sub>DD</sub>
34	6	VREF	Analog Voltage Reference Input (+5 V)
35	7	VREFN	Analog Negative Voltage Reference Output (-2.5 V)
36	8	VCC	Analog Positive Power Supply (+12 V)
37	9	VEE	Analog Negative Power Supply (-12 V)
38	10	VO4	DAC 4 Output
39	11	N/C	No Connection
40	12	VO5	DAC 5 Output
41	13	VO6	DAC 6 Output
42	14	VO7	DAC 7 Output
43	15	AGND	Analog Ground (0 V)
44	16	$\overline{CS}$	Chip Select Enable
1	17	$\overline{RD}$	Read Back Enable
2	18	$\overline{R2}$	Second-Latch-Bank Reset Enable
3	19	$\overline{R1}$	First-Latch-Bank Reset Enable
4	20	$\overline{LD2}$	Second-Latch-Bank Load Enable
5	21	$\overline{LD1}$	First-Latch-Bank Load Enable
6	22	A2	Digital Address Bit 2
7	23	A1	Digital Address Bit 1
8	24	A0	Digital Address Bit 0
9	25	DB0	Digital Input Data Bit 0
10	26	DB1	Digital Input Data Bit 1
11	27	DB2	Digital Input Data Bit 2
12	28	DB3	Digital Input Data Bit 3
13	29	DB4	Digital Input Data Bit 4
14	30	DB5	Digital Input Data Bit 5
15	31	DB6	Digital Input Data Bit 6
16	32	DB7	Digital Input Data Bit 7
17	33	DB8	Digital Input Data Bit 8
18	34	DB9	Digital Input Data Bit 9
19	35	DB10	Digital Input Data Bit 10
20	36	DB11	Digital Input Data Bit 11
21	37	DB12	Digital Input Data Bit 12
22	38	DB13	Digital Input Data Bit 13 (MSB)
23	39	DV <sub>DD</sub>	Digital Positive Power Supply (+5 V)
24	40	DGND	Digital Ground (0 V)
25	41	AGND	Analog Ground (0 V)
26	42	VO0	DAC 0 Output
27	43	VO1	DAC 1 Output
28	44	VO2	DAC 2 Output

## ELECTRICAL CHARACTERISTICS

$V_{CC} = +12\text{ V}$ ,  $V_{EE} = -12\text{ V}$ ,  $V_{REF} = 5\text{ V}$ ,  $DV_{DD} = 5.0\text{ V}$ ,  $T = 25^\circ\text{C}$ , Output Load =  $5\text{ k}\Omega$  (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	14					Bits	
Integral Non-Linearity (Relative Accuracy)	INL						LSB	End Point Linearity Spec
A				±8			±8	
B				±4			±4	
C				±2			±2.5	
Differential Non-Linearity	DNL						LSB	
A				±4			±4	
B				±3			±3	
C				±2			±2.5	
Positive Full Scale Error	+FSE						LSB	
A			24	±32			±32	
B			16	±24			±24	
C			12	±16			±16	
Positive Full Scale Error Temperature Coefficient	$\Delta+FSE/\Delta T$		4				ppm/°C	0°C to 85°C
Negative Full Scale Error	-FSE						LSB	
A			24	±32			±32	
B			16	±24			±24	
C			12	±16			±16	
Negative Full Scale Error Temperature Coefficient	$\Delta-FSE/\Delta T$		4				ppm/°C	0°C to 85°C
Bipolar Zero Offset	ZOFS						LSB	
A				±16			±16	
B				±12			±12	
C				±12			±12	
Bipolar Zero Offset Temperature Coefficient	$\Delta ZOFS/\Delta T$		2				ppm/°C	0°C to 85°C
INL Matching	$\Delta INL$						LSB	
A				±8			±8	
B				±6			±6	
C				±6			±6	
All Channels Maximum Error with DAC 0 adjusted to minimum error	ME						LSB	
A				±16			±16	
B				±8			±8	
C				±6			±6	
Bipolar Zero Matching	$\Delta ZOFS$						LSB	
A				±16			±16	
B				±12			±12	
C				±12			±12	
Full Scale Error Matching	$\Delta FSE$						LSB	
A				±16			±16	
B				±12			±12	
C				±12			±12	

## ELECTRICAL CHARACTERISTICS (CONT D)

Parameter	Symbol	25°C			Tmin to Tmax		Units	Test Conditions/Comments
		Min	Typ	Max	Min	Max		
<b>DYNAMIC PERFORMANCE</b>								
Voltage Settling from $\overline{LD}$ to VDAC Out <sup>1</sup>	$t_{sd}$		30	50		50	$\mu s$	ZS to FS (20 V Step) 5k, 50pF load
Channel-to-Channel Crosstalk <sup>6</sup>	CT		0.04				LSB	DC
Digital Feedthrough <sup>1, 6</sup>	Q		-70				dB	CLK and Data to $V_{OUTi}$
Power Supply Rejection Ratio	PSRR		5				ppm/%	$\Delta V_{EE}$ & $\Delta V_{CC} = \pm 5\%$ , ppm of FS
<b>REFERENCE INPUTS</b>								
Impedance of $V_{REF}$	REF	350	700	1.05k	350	1.05k	$\Omega$	See Application Hints for driving the reference input
$V_{REF}$ Voltage <sup>1, 2</sup>	$V_{REF}$	3.5		6			V	
<b>DIGITAL INPUTS<sup>3</sup></b>								
Logic High	$V_{IH}$	2.4					V	
Logic Low	$V_{IL}$			0.8			V	
Input Current	$I_L$			$\pm 10$			$\mu A$	
Input Capacitance <sup>1</sup>	$C_L$			8			pF	
<b>ANALOG OUTPUTS</b>								
Output Swing		$-V_{EE} + 1.4$	$V_{CC} - 1.4$				V	
Output Drive Current		-5		5			mA	
$V_{REFN}$ Output Drive Current		-10		+10			$\mu A$	For test purposes only
Output Impedance	$R_O$		1				$\Omega$	
Output Short Circuit Current	$I_{SC}$		25				mA	+FS to AGND
			30				mA	+FS to $V_{EE}$
			40				mA	-FS to AGND
			55				mA	-FS to $V_{CC}$
<b>DIGITAL OUTPUTS</b>								
Output High Voltage	$V_{OH}$		4.5				V	
Output Low Voltage	$V_{OL}$		0.5				V	
<b>POWER SUPPLIES</b>								
$V_{CC}$ Voltage <sup>5</sup>	$V_{CC}$	$V_{REF} + 1.5$	12	12.75	$V_{REF} + 1.5$	12.75	V	
$V_{EE}$ Voltage <sup>5</sup>	$V_{EE}$	-12.75	-12	-5	-12.75	-5	V	
DV <sub>DD</sub> Voltage	DV <sub>DD</sub>	4.5	5	5.5	4.5	5.5	V	
Positive Supply Current	$I_{CC}$		8	10		10	mA	Bipolar zero
Negative Supply Current	$I_{EE}$		15	20		20	mA	Bipolar zero
Digital Supply Current	$I_{DD}$			2		2	mA	Bipolar zero
Power Dissipation	PD <sub>ISS</sub>		320	420		450	mW	Bipolar zero
<b>ANALOG GROUND CURRENT</b>								
Per Channel <sup>1</sup>	$I_{AGND}$		$\pm 60$				$\mu A$	See Application Notes
<b>DIGITAL TIMING SPECIFICATIONS<sup>1,4</sup></b>								
Data Setup Time	$t_{DS}$		20				ns	$V_{IL} = 0 V, V_{IH} = 5 V, C_L = 20 pF$
Data Hold Time	$t_{DH}$		20				ns	
Address Set-up Time	$t_{AS}$		100				ns	
Address Hold Time	$t_{AH}$		0				ns	
Chip Select to $\overline{LD1}$ Set-up Time	$t_{CS1}$		6				ns	
Chip Select to $\overline{LD1}$ Hold Time	$t_{CH1}$		0				ns	
$\overline{LD1}$ Pulse Width	$t_{LD1W}$		50				ns	
$\overline{LD1}$ Negative Edge to $\overline{LD2}$ Positive Edge	$t_{LD1LD2}$		60				ns	
$\overline{LD2}$ Pulse Width	$t_{LD2W}$		60				ns	
Chip Select to $\overline{RD}$ Set-Up Time	$t_{CS2}$		6				ns	
Chip Select to $\overline{RD}$ Hold Time	$t_{CH2}$		0				ns	

## ELECTRICAL CHARACTERISTICS (CONT D)

Parameter	Symbol	25°C			Tmin to Tmax		Units	Test Conditions/Comments
		Min	Typ	Max	Min	Max		
<b>DIGITAL TIMING SPECIFICATIONS<sup>1, 4</sup> (CONT D)</b>								
$\overline{RD}$ Pulse Width	$t_{RD}$	600					ns	
High Z to Data Valid for Readback	$t_{DA}$	600					ns	
Data Valid for Readback to High Z	$t_{DR}$	200					ns	
$\overline{RT}$ Pulse Width	$t_{R1W}$	100					ns	
$\overline{RZ}$ Pulse Width	$t_{R2W}$	100					ns	

### NOTES:

- Guaranteed; not tested.
- Specified values guarantee functionality.
- Digital inputs should not go below digital GND or exceed  $DV_{DD}$  supply voltage.
- See Figures 1, 2 and 3. All digital input signals are specified with  $t_R = t_F = 10$  ns 10% to 90% and timed from a 50% voltage level.
- For power supply values  $< \pm 2 \cdot V_{REF}$ , the output swing is limited as specified in Analog Outputs.
- Digital feedthrough and channel-to-channel crosstalk are heavily dependent on the board layout and environment.

**Specifications are subject to change without notice**

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

$V_{CC}$ to AGND	+16.5 V	$DV_{DD}$	+5 V
$V_{EE}$ to AGND	-16.5 V	DGND	-5 V
$DV_{DD}$ to DGND	+6.5 V	Operating Temperature Range	
$V_{REF}$ to DGND	+7.0 V	Extended Industrial	-40°C to +85°C
Analog Outputs & Inputs		Military	-55°C to +125°C
Infinite Shorts to $V_{CC}$ , $V_{EE}$ , $DV_{DD}$ , AGND and DGND		Maximum Junction Temperature	150°C
(provided that power dissipation of the package spec is not exceeded)		Storage Temperature Range	-65°C to +150°C
AGND to DGND	$\pm 1$ V	Lead Temperature (Soldering, 10 sec)	+300°C
(Functionality guaranteed for $\pm 0.5$ V only)		Package Power Dissipation Rating to 75°C	
Digital Input & Digital Output Voltage to:		PQFP, PGA, PLCC	800mW
		Derates above 75°C	11mW/°C

### 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.

## APPLICATION NOTES

NOTE: When using these DACs to drive remote devices, the accuracy of the output can be improved by utilizing a remote analog ground connection. The difference between the DGND and AGND should be limited to  $\pm 300$  mV to assure normal operation. If there is any chance that the AGND to DGND can be greater than  $\pm 1$  V, we recommend two back-to-back diodes be used between DGND and AGND to clamp the voltage and prevent damage to the DAC. Using a buffer between the remote ground location and AGND may help reduce noise induced from long lead or trace lengths.

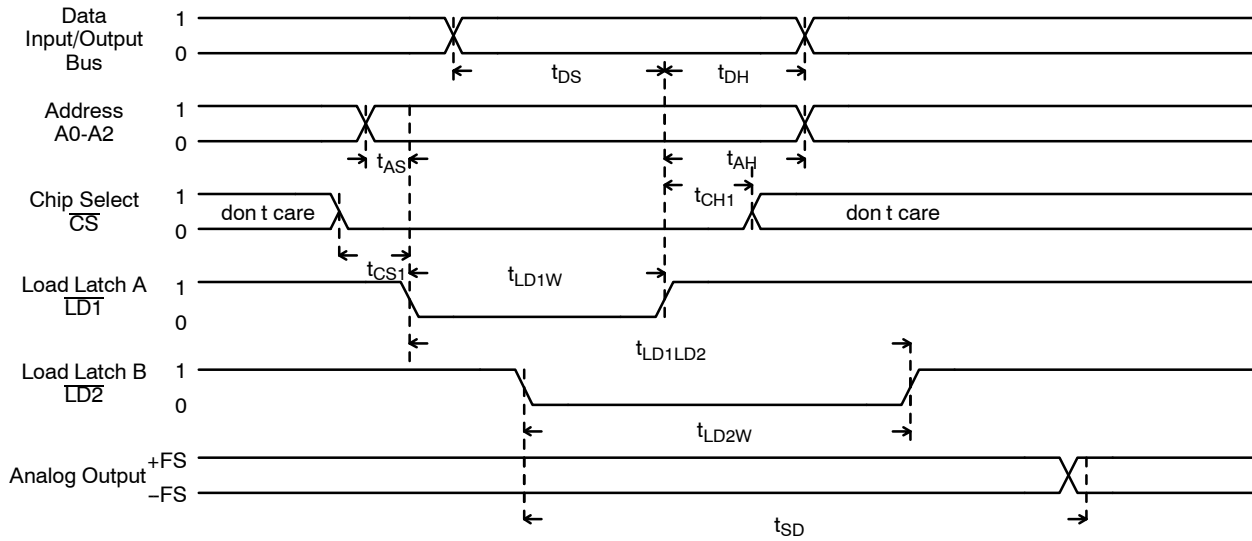


Figure 1. Loading Latch A and Updating Latch B

Notes:

- (1) Chip Select (CS) and Load LATCHA (LD1) Signals follow the same timing constraints and are interchangeable in the above diagram.
- (2)  $R1 = R2 = 1$ .
- (3) For the case where LD2 is in the low state, analog output would respond to the falling edge of LD1 (transparent mode).

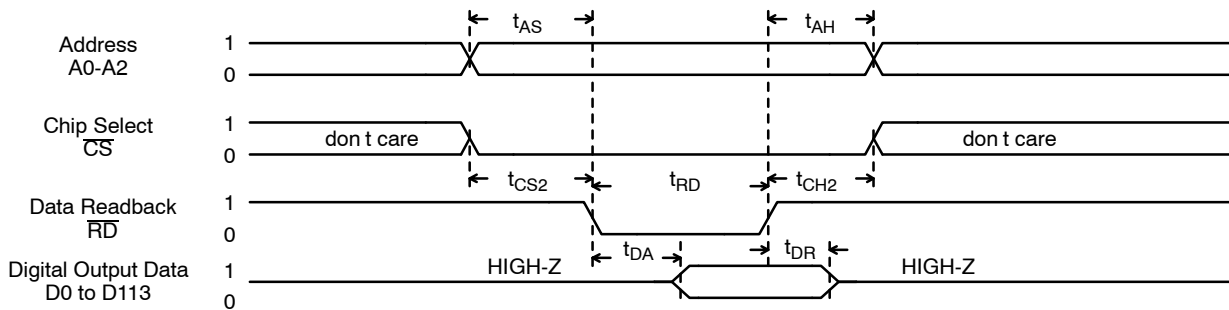


Figure 2. Read Back First Latch Bank of One DAC

Notes:

- (1) Chip Select (CS) and Data Readback (RD) Signals follow the same timing constraints and are interchangeable in the above diagram.
- (2)  $R1 = R2 = 1$ .

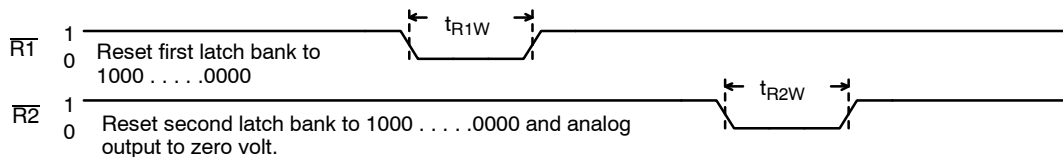


Figure 3. Reset Operations

A standard  $\mu$ -processor and TTL/CMOS compatible input data port loads the data into the pre-selected DACS. If  $\overline{CS} = 0$ , the chip accesses digital data on the bus. Then address bits A0 to A2 select the appropriate DAC and  $\overline{LD1}$  loads the data into the first-latch-bank. When all 8-channels first-latch-banks are loaded, then  $\overline{LD2}$  enables the second-latch-bank and updates

all 8-channels simultaneously. The selected DAC becomes transparent (activity on the digital inputs appear at the analog output) when both  $\overline{LD1} = \overline{LD2} = 0$ .

$\overline{R1} = 0$  resets the first-latch-bank.  $\overline{R2} = 0$  resets the second-latch-bank which sets the analog output to zero volts (data = 100...00), regardless of digital inputs.

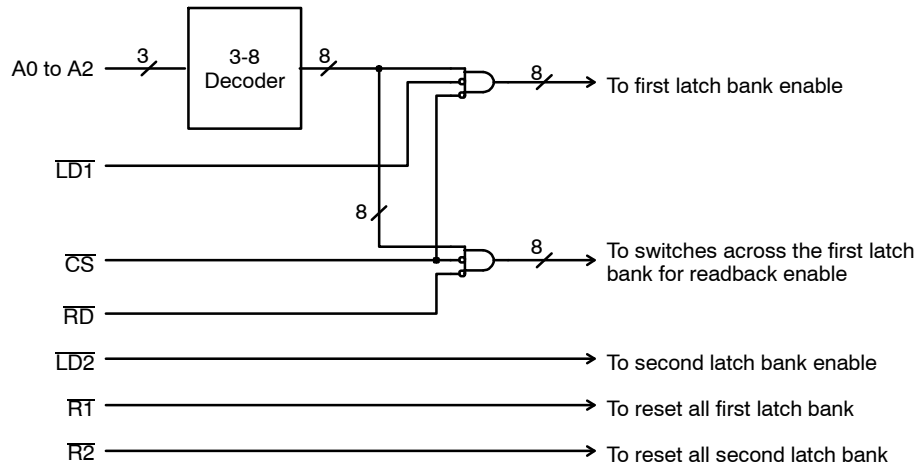
Function	A2	A1	A0	$\overline{RD}$	$\overline{LD1}$	$\overline{LD2}$	$\overline{CS}$	$\overline{R1}$	$\overline{R2}$
Load Latch 1 of DAC1	0	0	0	1	0→1	1	0	1	1
Load Latch 1 of DAC2	0	0	1	1	0→1	1	0	1	1
Load Latch 1 of DAC3	0	1	0	1	0→1	1	0	1	1
Load Latch 1 of DAC4	0	1	1	1	0→1	1	0	1	1
Load Latch 1 of DAC5	1	0	0	1	0→1	1	0	1	1
Load Latch 1 of DAC6	1	0	1	1	0→1	1	0	1	1
Load Latch 1 of DAC7	1	1	0	1	0→1	1	0	1	1
Load Latch 1 of DAC8	1	1	1	1	0→1	1	0	1	1
Load Latch 2 of DAC1→8	X	X	X	1	1	0→1	X	1	1
Read Latch 1 of DAC1	0	0	0	0	1	1	0	1	1
Read Latch 1 of DAC2	0	0	1	0	1	1	0	1	1
Read Latch 1 of DAC3	0	1	0	0	1	1	0	1	1
Read Latch 1 of DAC4	0	1	1	0	1	1	0	1	1
Read Latch 1 of DAC5	1	0	0	0	1	1	0	1	1
Read Latch 1 of DAC6	1	0	1	0	1	1	0	1	1
Read Latch 1 of DAC7	1	1	0	0	1	1	0	1	1
Read Latch 1 of DAC8	1	1	1	0	1	1	0	1	1
Reset Latch 1 of DAC1→8	X	X	X	X	X	X	X	0	1
Reset Latch 2 of DAC1→8	X	X	X	X	X	X	X	1	0

Note: 1: High, 0: Low, X: Don't Care

**Table 1. Octal Parallel Data Input 14-Bit DAC Truth Table**

**Note:** For timing information see *Electrical Characteristics*





**Figure 4. Simplified Parallel Logic Port**

Hex Code	Binary Code	Output Voltage = $2 \cdot V_r \left(-1 + \frac{2 \cdot D}{16384}\right)$ ( $V_r = +5\text{ V}$ )
0 0 0 0	00000000000000	$10 \cdot (-1 + 0) = -10$
⋮	⋮	⋮
1 F F F	01111111111111	$10 \cdot \left(-1 + \frac{16382}{16384}\right) = -1.22\text{ mV}$
2 0 0 0	10000000000000	$10 \cdot \left(-1 + \frac{16384}{16384}\right) = 0$
2 0 0 1	10000000000001	$10 \cdot \left(-1 + \frac{16386}{16384}\right) = 1.22\text{ mV}$
⋮	⋮	⋮
3 F F F	11111111111111	$10 \cdot \left(-1 + \frac{32766}{16384}\right) = 9.99878$

**Table 2. MP7611  
Ideal DAC Output vs. Input Code**

*Note: See Electrical Characteristics for real system accuracy*

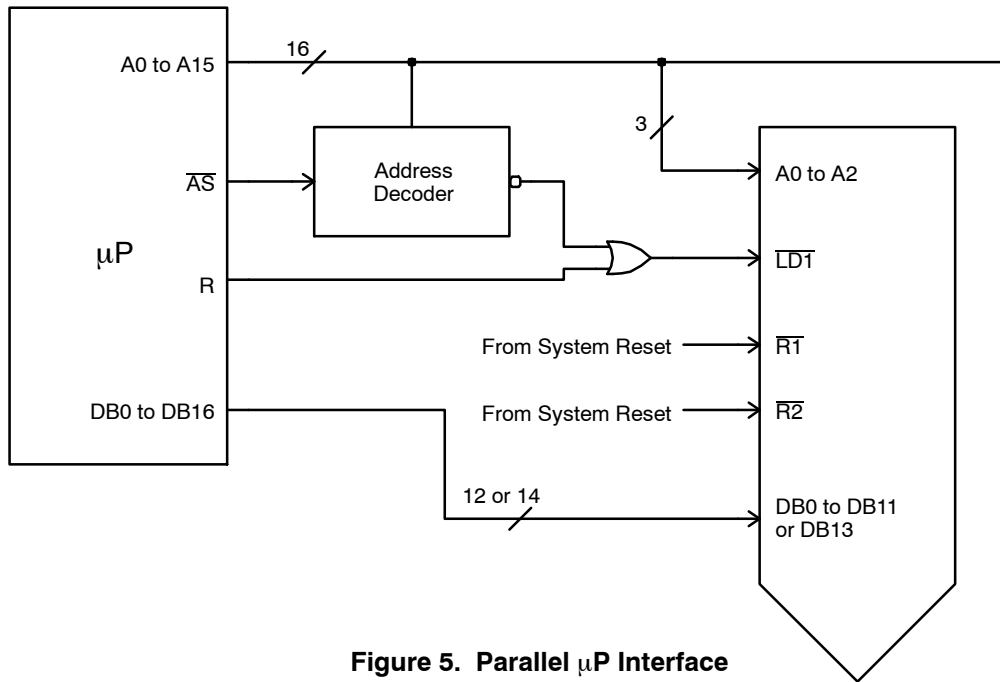
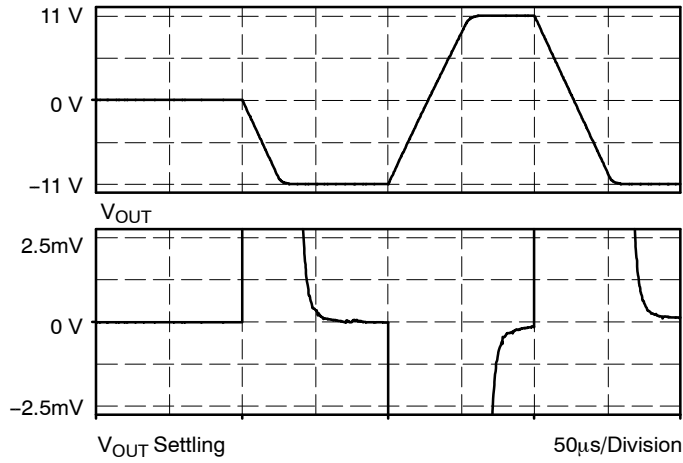


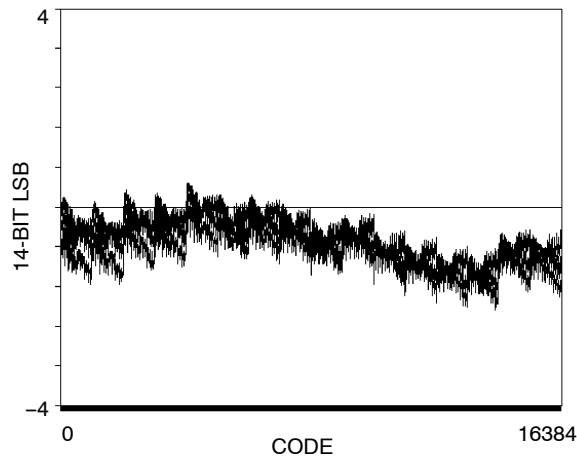
Figure 5. Parallel  $\mu$ P Interface

**PERFORMANCE CHARACTERISTICS**

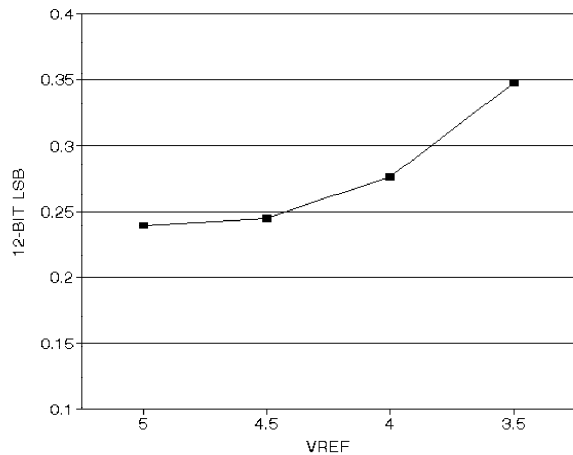


**Graph 1. Typical Output Settling Characteristic**  
 $V_{REF} = 5\text{ V}$ ,  $R_L = 5\text{ K}$ ,  $C_L = 500\text{ pF}$

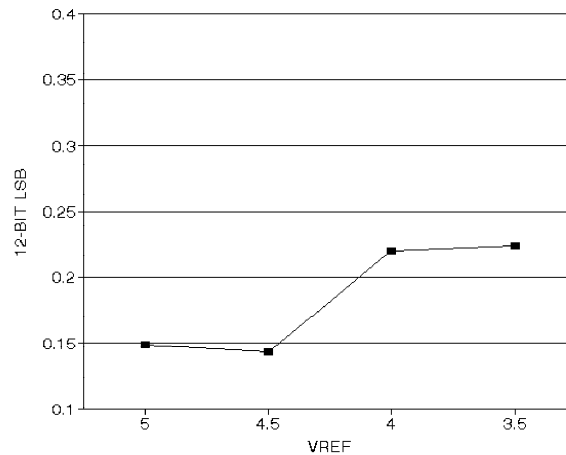
Graph 1 shows the typical output settling characteristic of the MP7610 Family for a RESET →ZS→FS→ZS series of code transitions. The top graph shows the output voltage transients, while the bottom graph shows the difference between the output and the ideal output.



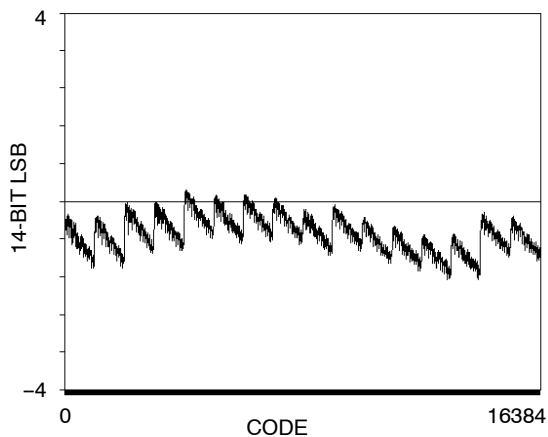
**Graph 2. Linearity with**  
 $V_{REF} = 5\text{ V}$ , All DACs, All Codes



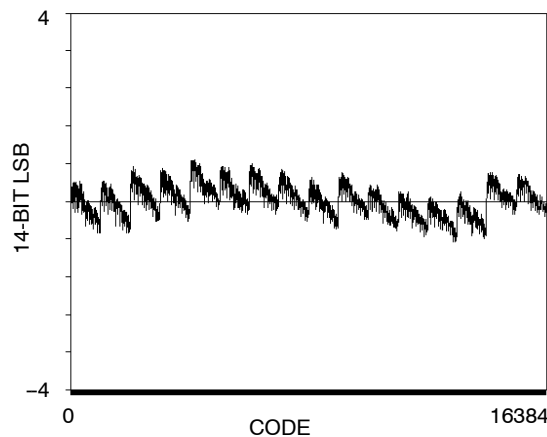
**Graph 3. DAC 0 INL vs.  $V_{REF}$**



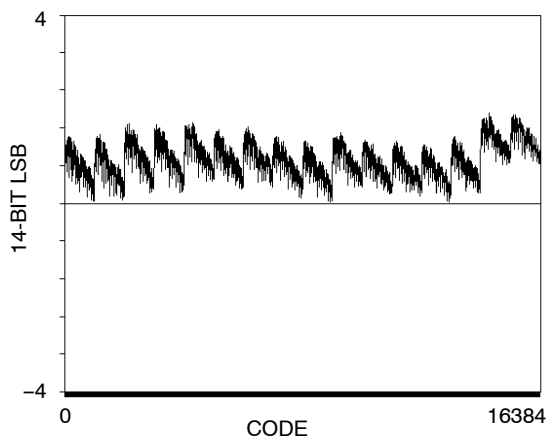
**Graph 4. DAC 0 DNL vs.  $V_{REF}$**



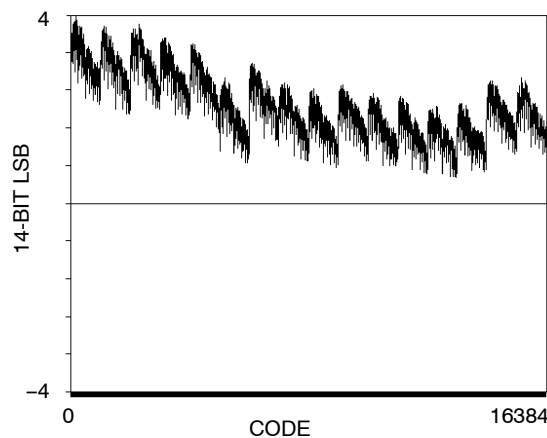
**Graph 5. DAC 0 Linearity with  $V_{REF} = 5\text{ V}$ ,  $V_{OUT} = \pm 10$**



**Graph 6. DAC 0 Linearity with  $V_{REF} = 4.5\text{ V}$ ,  $V_{OUT} = \pm 9$**



**Graph 7. DAC 0 Linearity with  $V_{REF} = 4\text{ V}$ ,  $V_{OUT} = \pm 8$**



**Graph 8. DAC 0 Linearity with  $V_{REF} = 3.5\text{ V}$ ,  $V_{OUT} = \pm 7$**

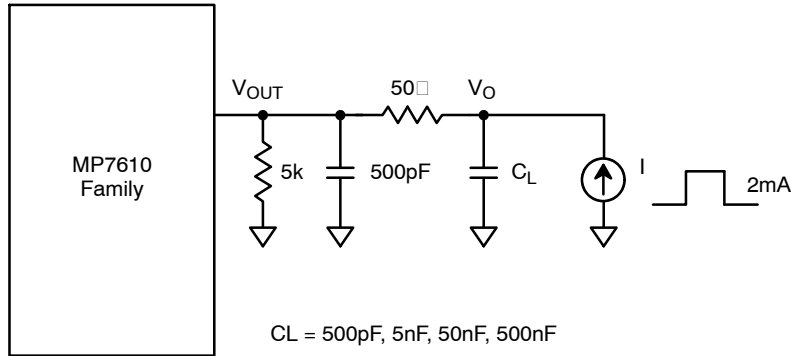
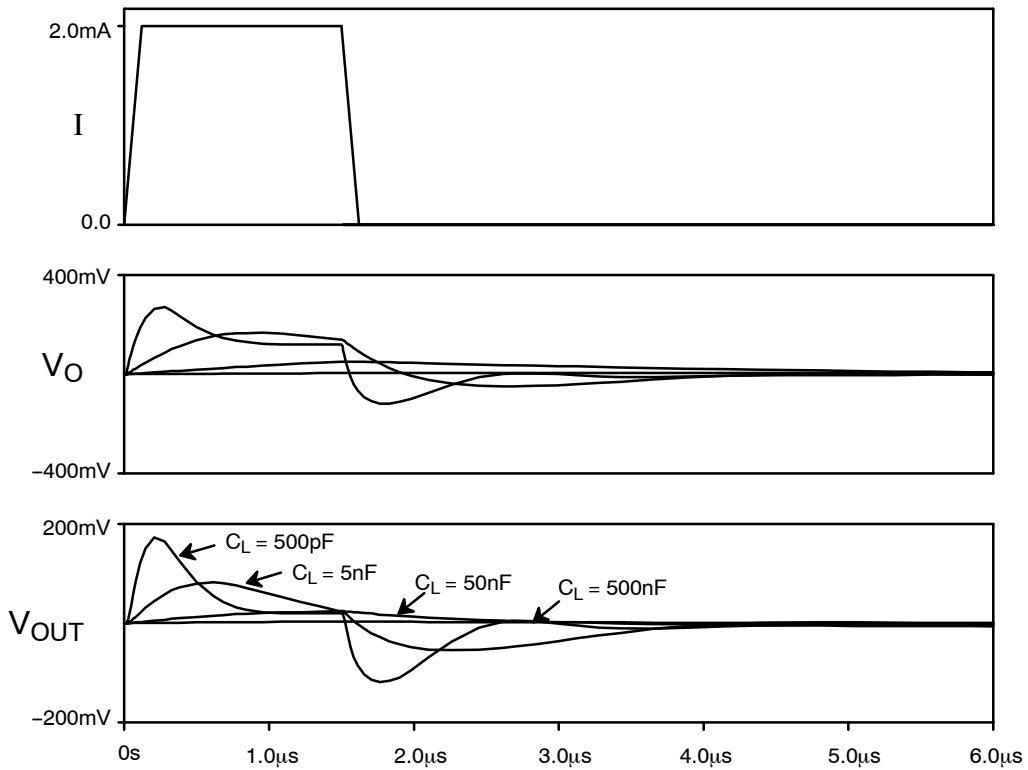


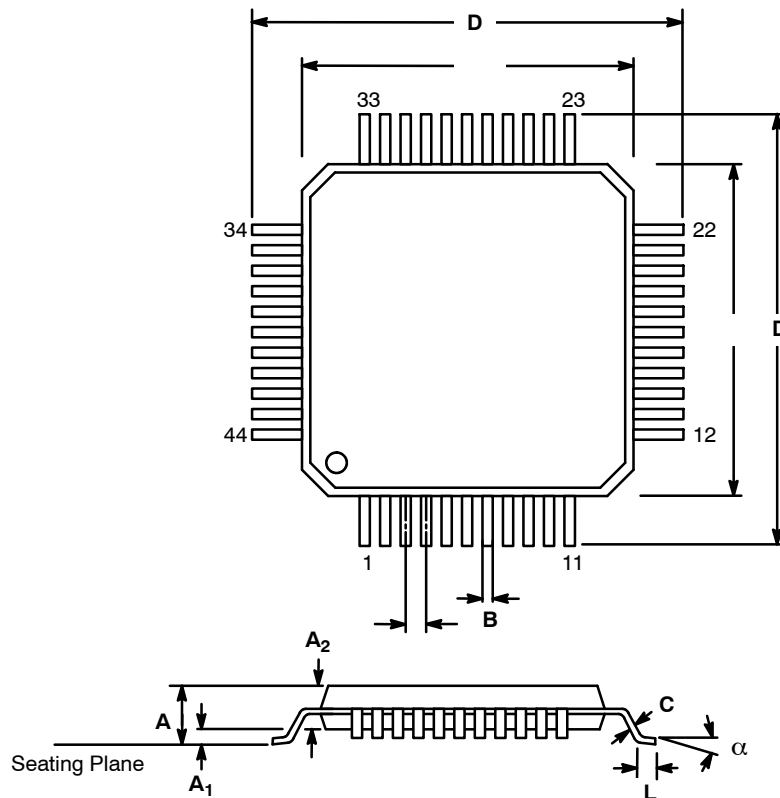
Figure 6. Circuit for Determining Typical Analog Output Pulse Response



Graph 9. Typical Response of the MP7610 Family Analog Output to a Current Pulse with  $C_L=500\text{pF}, 5\text{nF}, 50\text{nF}, 500\text{nF}$   
(See Figure 9. above)

## 44 LEAD PLASTIC QUAD FLAT PACK (14 mm x 14 mm QFP)

Rev. 1.00

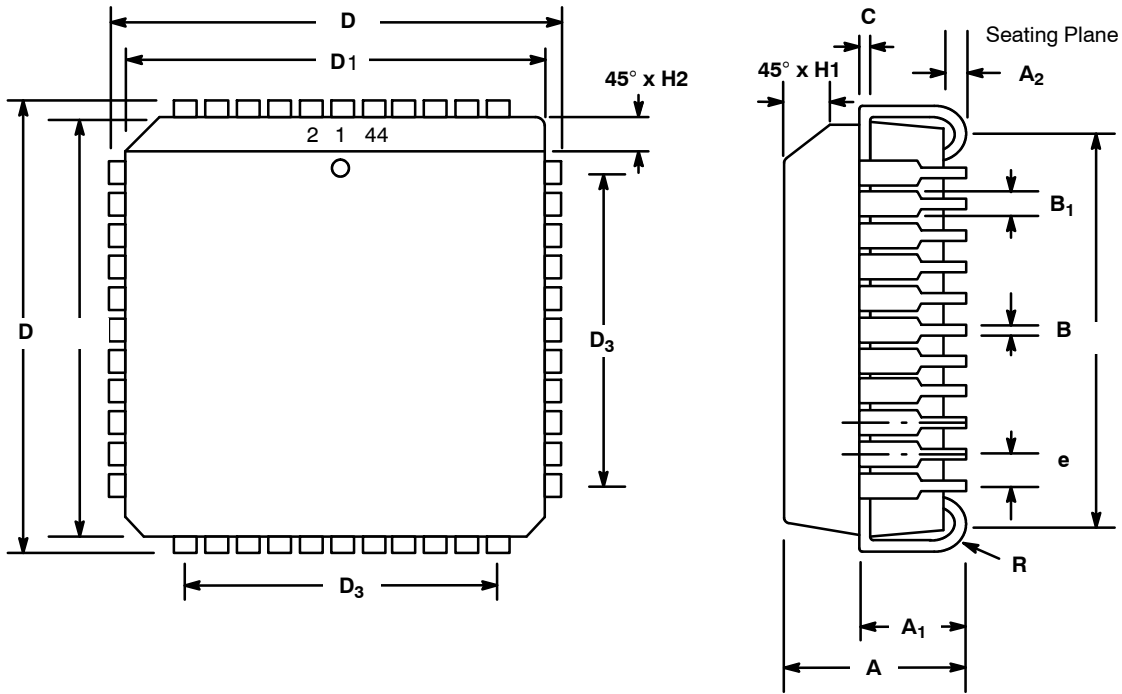


SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.110	0.134	2.80	3.40
A <sub>1</sub>	0.010	0.014	0.25	0.35
A <sub>2</sub>	0.100	0.120	2.55	3.05
B	0.014	0.020	0.35	0.50
C	0.005	0.009	0.13	0.23
D	0.667	0.687	16.95	17.45
D <sub>1</sub>	0.547	0.555	13.90	14.10
e	0.039 BSC		1.00 BSC	
L	0.026	0.37	0.65	0.95
α	0°	7°	0°	7°

Note: The control dimension is the millimeter column

**44 LEAD PLASTIC LEADED CHIP CARRIER  
(PLCC)**

*Rev. 1.00*



SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.165	0.180	4.19	4.57
A <sub>1</sub>	0.090	0.120	2.29	3.05
A <sub>2</sub>	0.020	---	0.51	---
B	0.013	0.021	0.33	0.53
B <sub>1</sub>	0.026	0.032	0.66	0.81
C	0.008	0.013	0.19	0.32
D	0.685	0.695	17.40	17.65
D <sub>1</sub>	0.650	0.656	16.51	16.66
D <sub>2</sub>	0.590	0.630	14.99	16.00
D <sub>3</sub>	0.500 typ.		12.70 typ.	
e	0.050 BSC		1.27 BSC	
H1	0.042	0.056	1.07	1.42
H2	0.042	0.048	1.07	1.22
R	0.025	0.045	0.64	1.14

*Note: The control dimension is the inch column*

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