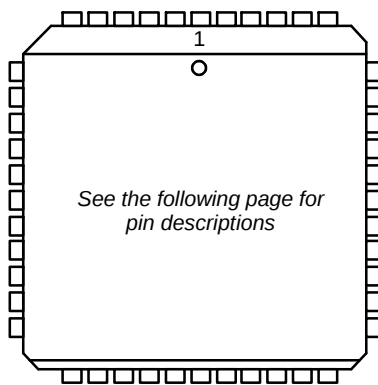


June 1998-3

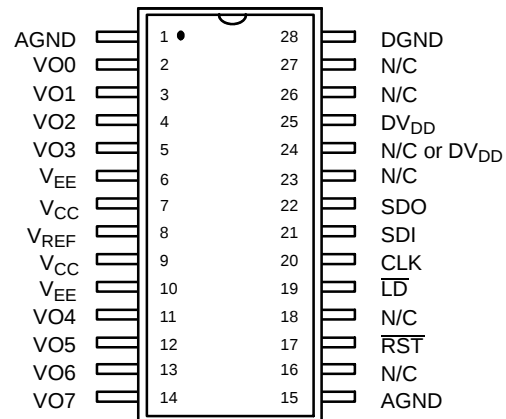
ORDERING INFORMATION

Package Type	Temperature Range	Part No.	Res. (Bits)	INL (LSB)	DNL (LSB)	FSE (LSB)
PLCC	0 to +70°C	MP7610CP	14	2	2	16
PLCC	-40 to +85°C	MP7610BP	14	4	3	24
PLCC	-40 to +85°C	MP7610AP	14	8	4	32
SOIC	0 to +70°C	MP7610CS	14	4	3	24
SOIC	-40 to +85°C	MP7610BS	14	2	2	16
SOIC	-40 to +85°C	MP7610AS	14	8	4	32

PIN CONFIGURATIONS



44 Pin PLCC



28 Pin SOIC (Jedec, 0.346")

PIN DESCRIPTION

SOIC Pin #	PLCC Pin #	Symbol	Description
1	2	AGND	Analog Ground
2	3	VO0	DAC 0 Output
3	4	VO1	DAC 1 Output
4	5	VO2	DAC 2 Output
5	6	VO3	DAC 3 Output
6	7	V _{EE}	Analog Negative Power Supply (–12 V)
7	9	V _{CC}	Analog Positive Power Supply (+12 V)
8	12	V _{REF}	Voltage Reference Input (+5 V)
9	13	V _{CC}	Analog Positive Power Supply (+12 V)
10	15	V _{EE}	Analog Negative Power Supply (–12 V)
11	18	VO4	DAC 4 Output
12	19	VO5	DAC 5 Output
13	20	VO6	DAC 6 Output
14	21	VO7	DAC 7 Output
15	24	AGND	Analog Ground
16		N/C	No Connection
17	26	$\overline{\text{RST}}$	Reset all DACs to 0 V Output
18		N/C	No Connection
19	29	$\overline{\text{LD}}$	Load Signal; Load Data to Selected DAC
20	31	CLK	Serial Data Clock
21	32	SDI	Serial Data Input
22	34	SDO	Shift Register Serial Output
23		N/C	No Connection
24	37	N/C	No Connection or DV _{DD}
25	40	DV _{DD}	Digital Positive Power Supply (+5 V)
26		N/C	No Connection
27	1, 8, 10, 11, 14, 16, 17, 22, 23, 25, 27, 28, 30, 33, 35, 36, 38, 39, 41, 42, 43	N/C	No Connection
28	44	DGND	Digital Ground

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	Min	25°C Typ	Max	Tmin to Tmax Min Max	Units	Test Conditions/Comments
STATIC PERFORMANCE							
Resolution (All Grades)	N	14				Bits	End Point Linearity Spec
Integral Non-Linearity (Relative Accuracy)	INL					LSB	
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		0°C to 85°C
B			16	24	24		
C			12	16	16		
Positive Full Scale Error Temperature Coefficient	Δ+FSE/ ΔT		4			ppm/°C	
Negative Full Scale Error	−FSE					LSB	
A			24	32	32		0°C to 85°C
B			16	24	24		
C			12	16	16		
Negative Full Scale Error Temperature Coefficient	Δ−FSE/ ΔT		4			ppm/°C	
Bipolar Zero Offset	ZOFS					LSB	
A				16	16		0°C to 85°C
B				12	12		
C				12	12		
Bipolar Zero Offset Temperature Coefficient	ΔZOFS/ ΔT		2			ppm/°C	
INL Matching	ΔINL					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	ΔZOFS					LSB	
A				16	16		
B				12	12		
C				12	12		
Full Scale Error Matching	ΔFSE					LSB	
A				16	16		
B				12	12		
C				12	12		

ELECTRICAL CHARACTERISTICS (CONT'D)

Parameter	Symbol	Min	25°C Typ	Max	Tmin to Tmax Min Max	Units	Test Conditions/Comments
DYNAMIC PERFORMANCE							
Voltage Settling from $\overline{\text{LD}}$ to VDAC Out ¹	t_{sd}		30	50		50 μs	ZS to FS (20 V Step) 5k, 50pF load
Channel-to-Channel Crosstalk ⁶	CT		0.04			LSB	DC
Digital Feedthrough ^{1, 6}	Q		-70			dB	CLK and Data to V_{OUTi}
Power Supply Rejection Ratio	PSRR			5		ppm/%	ΔV_{EE} & $\Delta V_{CC} = \pm 5\%$, ppm of FS
REFERENCE INPUTS							
Impedance of V_{REF}	REF	350	700	1.05k	350 1.05k	Ω	See Application Hints for Driving the reference input
V_{REF} Voltage ^{1, 2}	V_{REF}	3.5		6		V	
DIGITAL INPUTS³							
Logic High	V_{IH}	2.4				V	
Logic Low	V_{IL}			0.8		V	
Input Current	I_L			± 10		μA	
Input Capacitance ¹	C_L			8		pF	
ANALOG OUTPUTS							
Output Swing		$-V_{EE} + 1.4$	$V_{CC} - 1.4$			V	
Output Drive Current		-5		5		mA	
Output Impedance	R_O		1			Ω	
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}
DIGITAL OUTPUTS							
Output High Voltage	V_{OH}		4.5			V	
Output Low Voltage	V_{OL}		0.5			V	
POWER SUPPLIES							
V_{CC} Voltage ⁵	V_{CC}	$V_{REF} + 1.5$	12	12.75	$V_{REF} + 1.5$ 12.75	V	
V_{EE} Voltage ⁵	V_{EE}	-12.75	-12	-5	-12.75 -5	V	
DVDD Voltage	DVDD	4.5	5	5.5	4.5 5.5	V	
Positive Supply Current	I_{CC}		8	10		mA	Bipolar zero
Negative Supply Current	I_{EE}		15	20		mA	Bipolar zero
Digital Supply Current	I_{DD}			2		mA	Bipolar zero
Power Dissipation	PD_{ISS}		320	420		mW	Bipolar zero
ANALOG GROUND CURRENT							
Per Channel ¹	I_{AGND}		± 60			μA	See Application Notes
DIGITAL TIMING SPECIFICATIONS^{1,4}							
Input Clock Pulse Width	t_{CH}, t_{CL}	60				ns	$V_{IL} = 0, V_{IH} = 5.0, C_L = 20 \text{ pF}$
Data Setup Time	t_{DS}	15				ns	
Data Hold Time	t_{DH}	15				ns	
CLK to SDO Propagation Delay	t_{PD}			40		ns	
DAC Register Load Pulse Width	t_{LD}	45				ns	
Preset Pulse Width	t_{PR}	65				ns	
Clock Edge to Load Time	t_{CKLD1}	140				ns	
	t_{CKLD2}	0				ns	
$\overline{\text{LD}}$ Falling Edge to SDO Tri-state Enable	t_{HZ1}	50				ns	Note: t_{LD} and t_{CKLD2} cannot both be min. since $t_{CKLD1} = t_{CKLD2} + t_{LD}$

ELECTRICAL CHARACTERISTICS (CONT'D)

Parameter	Symbol	Min	25°C Typ	Max	Tmin to Tmax Min Max	Units	Test Conditions/Comments
DIGITAL TIMING SPECIFICATIONS ^{1, 4} (CONT'D)							
$\overline{\text{LD}}$ Rising Edge to SDO Tri-state Disable	t _{HZ2}	50				ns	
$\overline{\text{LD}}$ Rising Edge to CLK Enable	t _{LDCK}	50				ns	
$\overline{\text{LD}}$ Set-up Time with Respect to CLK	t _{LDSU}	45				ns	

NOTES:

- ¹ Guaranteed; not tested.
- ² Specified values guarantee functionality.
- ³ Digital inputs should not go below digital GND or exceed DV_{DD} supply voltage.
- ⁴ See Figures 2 and 3. All digital input signals are specified with $t_{\text{R}} = t_{\text{F}} = 10 \text{ ns}$ 10% to 90% and timed from a 50% voltage level.
- ⁵ For power supply values $< \frac{1}{2} 2E_{\text{VREF}}$ the output swing is limited as specified in Analog Outputs.
- ⁶ 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)^{1, 2}

V_{CC} to AGND	+16.5 V	Analog Inputs & Outputs	Indefinite Shorts to V_{CC} , V_{EE} , DV_{DD} , AGND, DGND (provided that power dissipation of the package spec is not exceeded)
V_{EE} to AGND	-16.5 V	Operating Temperature Range	
DV_{DD} to DGND	+6.5 V	Extended Industrial	-40°C to +85°C
V_{REF} to DGND	+7.0 V	Maximum Junction Temperature	-65°C to 150°C
AGND to DGND	$\pm 1 \text{ V}$	Storage Temperature	150°C
(Functionality guaranteed for $\frac{1}{2} 0.5 \text{ V}$ only)		Lead Temperature (Soldering, 10 sec)	+300°C
Digital Input & Output Voltage		Package Power Dissipation Rating @ 75°C	
to DGND	-0.5 to $DV_{\text{DD}} + 0.5 \text{ V}$	SOIC, PLCC	1150mW
		Derates above 75°C	15mW/°C

NOTES:

- ¹ 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.
- ² 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 $\frac{1}{2} 300 \text{ mV}$ to assure normal operation. If there is any chance that the AGND to DGND can be greater than $\frac{1}{2} 1 \text{ V}$, 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.

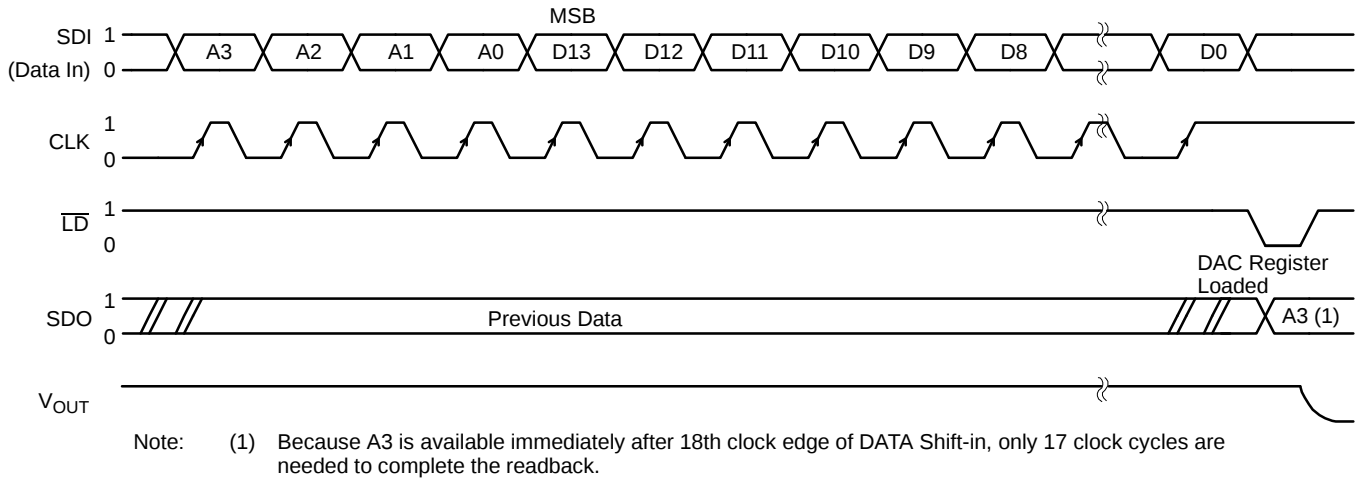


Figure 1. Serial Data Timing and Loading

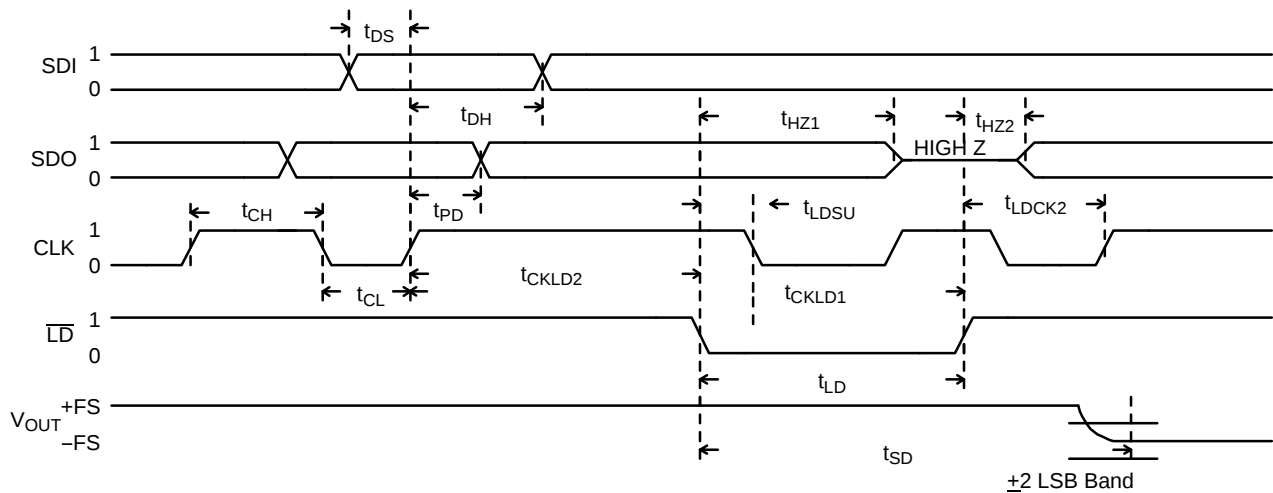


Figure 2. Serial Data Input Timing (RST = "1")

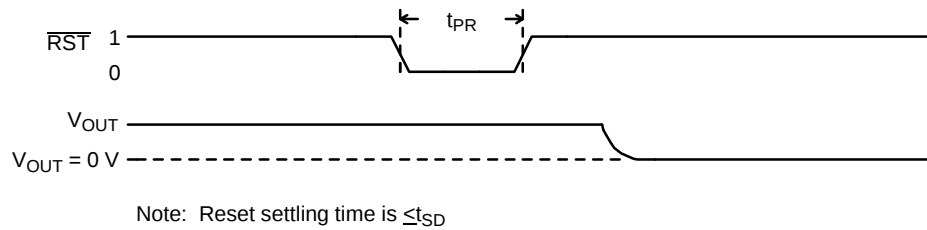


Figure 3. Reset Operation

The MP7610 is equipped with a serial data (3-wire standard) μ -processor logic interface to reduce pin count, package size, and board wire (space). If the $\overline{\text{LD}}$ signal is high, the CLK signal loads the digital input bits (SDI) into the shift register (4 bits address A3 to A0 plus 14 bits data D13 to D0 for the MP7610). The $\overline{\text{LD}}$ signal going low loads the data into the selected DAC. The

$\overline{\text{LD}}$ signal going low also disables the serial data (SDI), output (SDO tri-stated) and the CLK input. This design tremendously reduces digital noise and glitch transients into the DACs due to free running CLK and SDI. Note also that the preset signal ($\overline{\text{RST}}$) resets all analog outputs to 0 volt regardless of digital inputs.

Function	A3	A2	A1	A0	$\overline{\text{LD}}$	CLK	$\overline{\text{RST}}$	SDI	SDO
Shift Data In and Out	X	X	X	X	1	0 $\rightarrow$ 1 Repeat	1	Data Input Valid	Data Output Valid
Stop Shifting Data In and Out	X	X	X	X	0	X	1	X	Hi-Z
Load DACs	0	0	0	0	No Operation				
DAC 0	0	0	0	1	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 1	0	0	1	0	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 2	0	0	1	1	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 3	0	1	0	0	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 4	0	1	0	1	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 5	0	1	1	0	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 6	0	1	1	1	1 $\rightarrow$ 0	X	1	X	Hi-Z
DAC 7	1	0	0	0	1 $\rightarrow$ 0	X	1	X	Hi-Z
⋮	⋮	⋮	⋮	⋮	No Operation	X	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	X	⋮	⋮	⋮
⋮	1	1	1	0	No Operation	X	1	X	Hi-Z
⋮	1	1	1	1	No Operation	X	1	X	Hi-Z
Reset all DACs to 0 V	X	X	X	X	X	X	0	X	X

**Table 1. Digital Function Truth Table
Serial In/Serial Out**

Note: For timing information See Electrical Characteristics.

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. MP7610 Ideal DAC Output vs. Input Code

Note: See Electrical Characteristics for real system accuracy

SERIAL INTERFACE DIAGRAMS

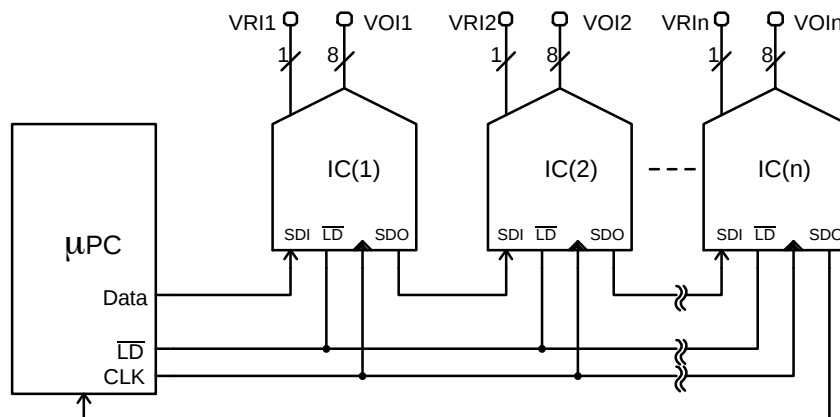


Figure 4. Simplified Diagram

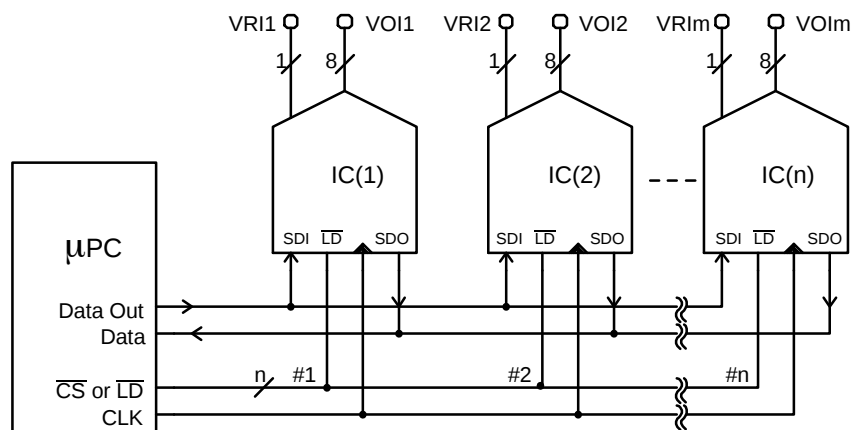


Figure 5. Simplified Diagram

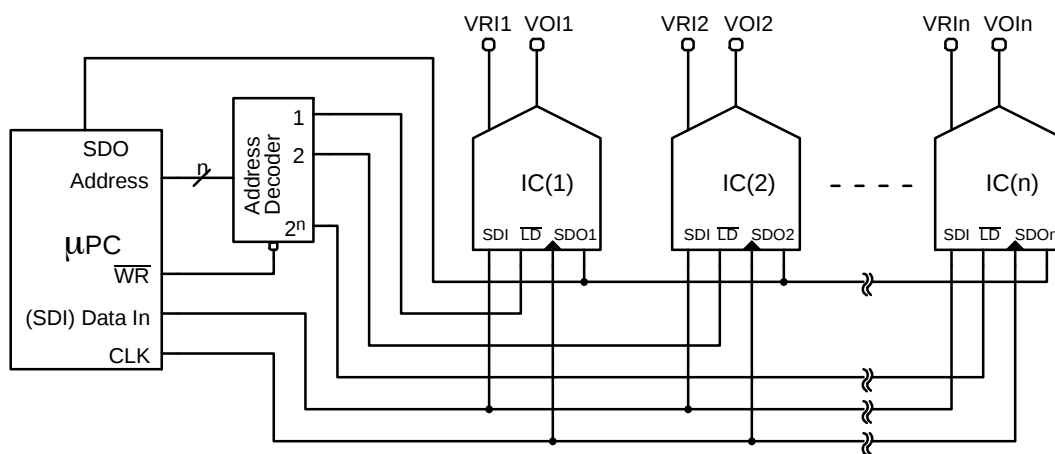
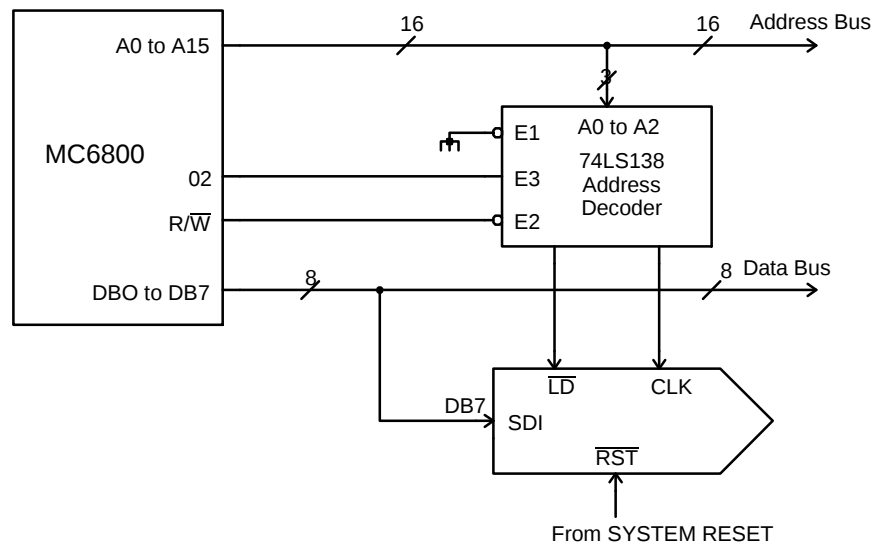


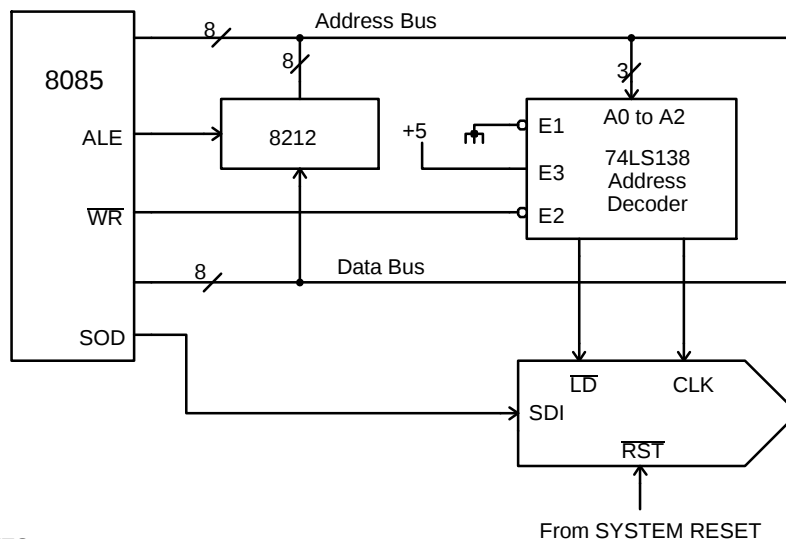
Figure 6. Simplified Diagram



NOTES

1. Execute consecutive memory write instructions while manipulating the data between WRITES so that each WRITE presents the next bit.
2. The serial data loading is triggered by the CLK pulse which is asserted by a decoded memory WRITE to memory location 2000, R/W, and 02. A WRITE to address 4000 transfers data from input shift register to DAC register.

Figure 7. MC6800 Interface

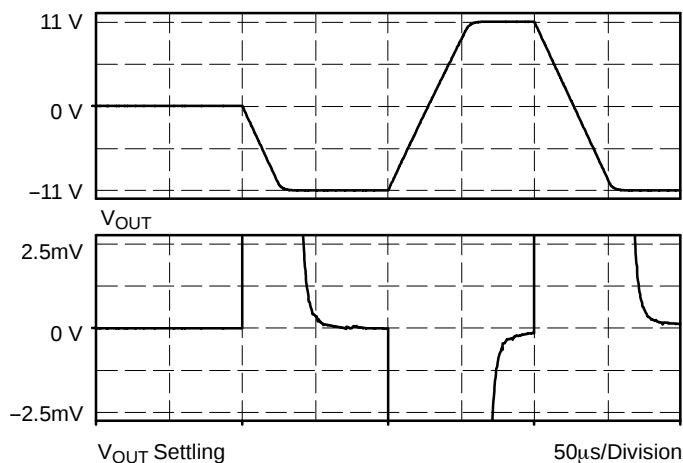


NOTES:

1. Clock generated by $\overline{WR}$ and decoding address 8000.
2. Data is clocked in the DAC shift register by executing memory write instructions. The clock input is generated by decoding address 8000 and WR. Data is then loaded into the DAC register with a memory write instruction to address 4000.
3. Serial data must be present in the right justified format in registers H & L of the microprocessor.

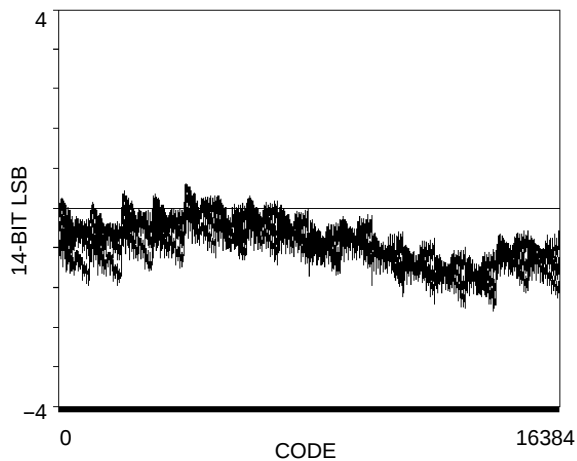
Figure 8. 8085 Interface

PERFORMANCE CHARACTERISTICS

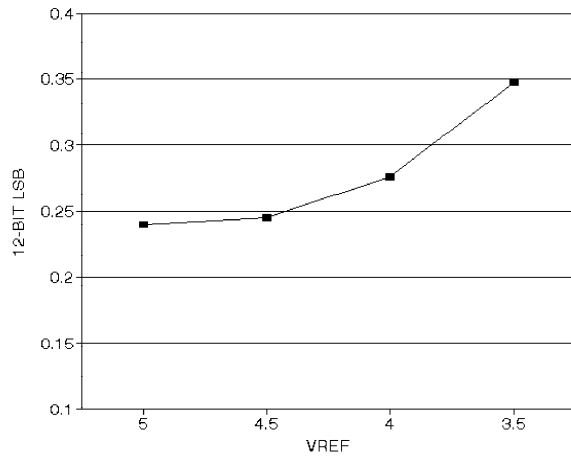


Graph 1. Typical Output Settling Characteristic
 $V_{REF} = 5\text{ V}$, $R_L = 5\text{ K}$, $C_L = 500\text{ pF}$

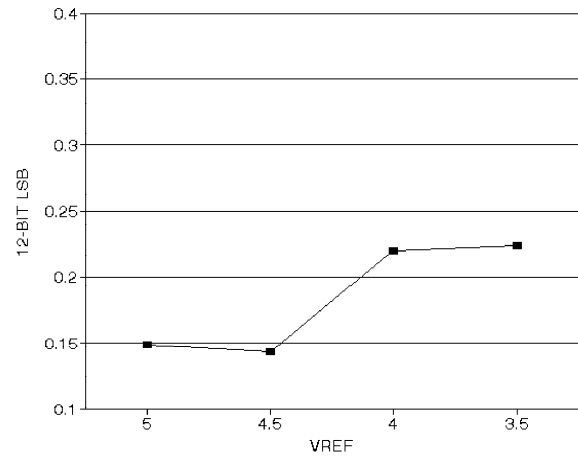
Graph 1 shows the typical output settling characteristic of the MP7610 Family for a RESET ! ZS ! FS ! ZS series of code transitions. The top graph shows the output voltage transients, while the bottom graph shows the difference between the output and the ideal output.



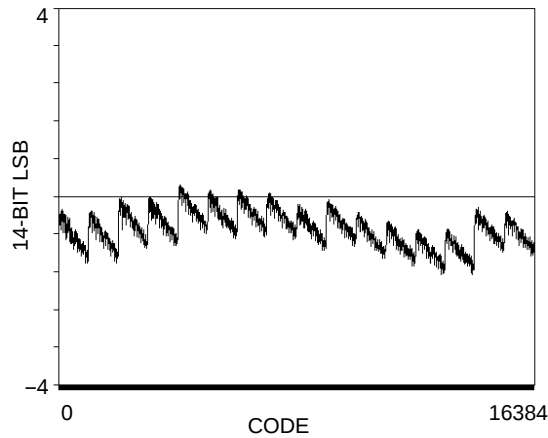
Graph 2. Linearity with
 $V_{REF} = 5\text{ V}$, All DACs, All Codes



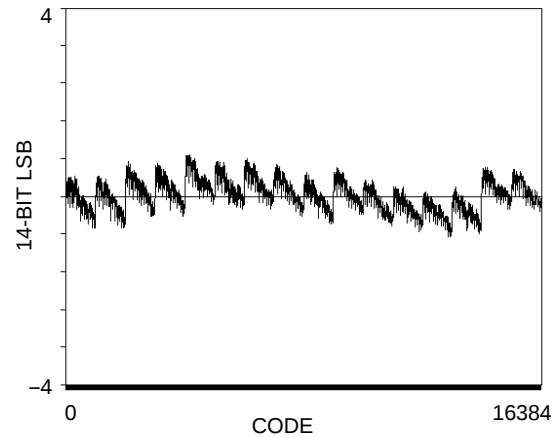
Graph 3. DAC 0 INL vs. V_{REF}



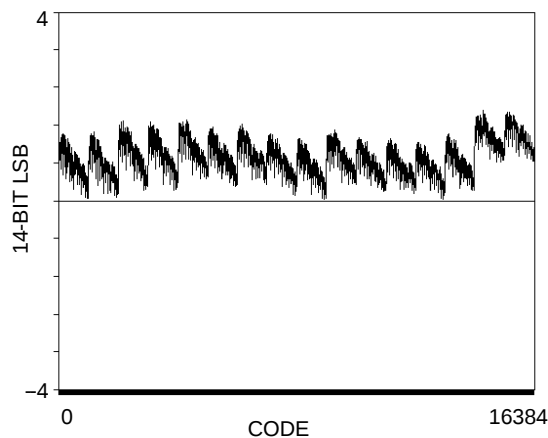
Graph 4. DAC 0 DNL vs. V_{REF}



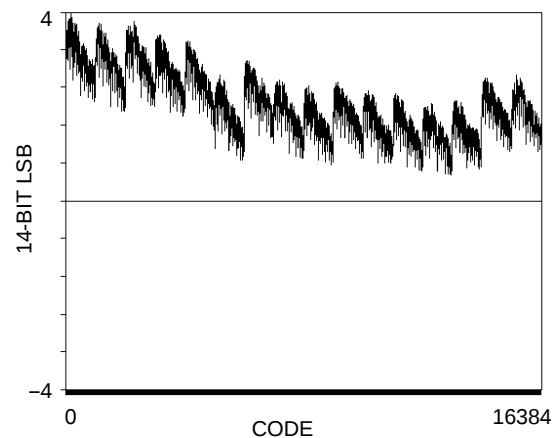
Graph 5. DAC 0 Linearity with $V_{REF} = 5\text{ V}$, $V_{OUT} = 10$



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



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



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

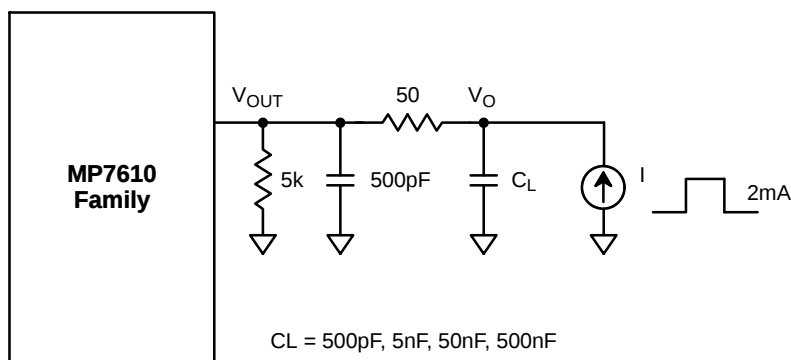
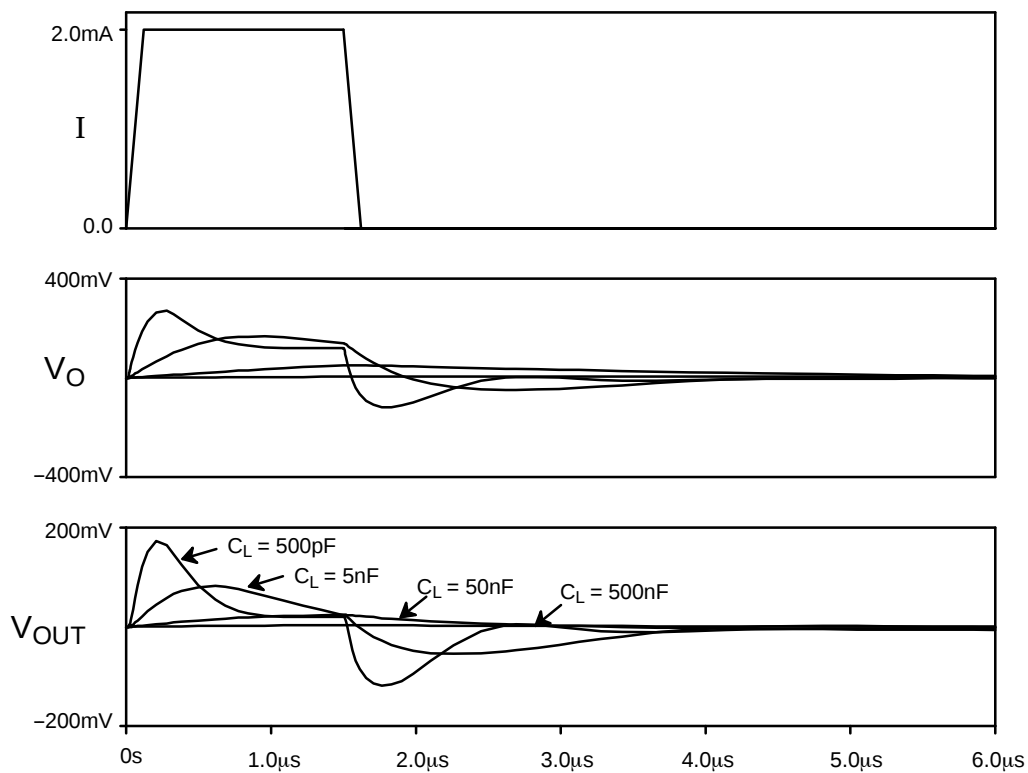


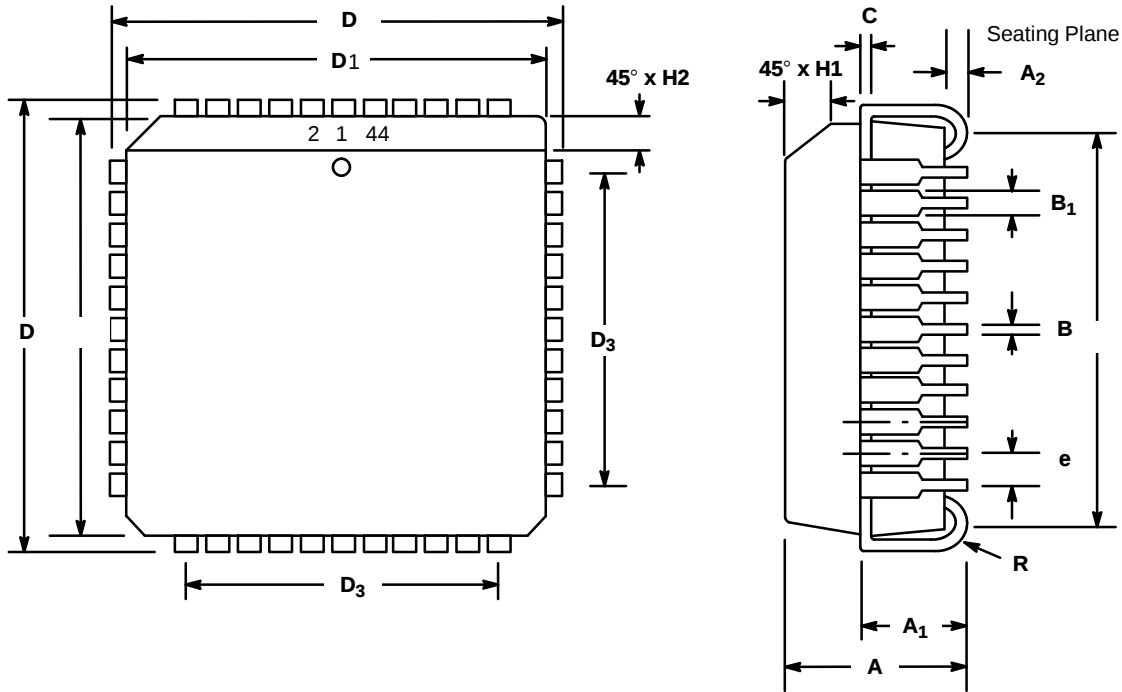
Figure 9. Circuit for Determining Typical Analog Output Pulse Response



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 LEADED CHIP CARRIER (PLCC)

Rev. 1.00

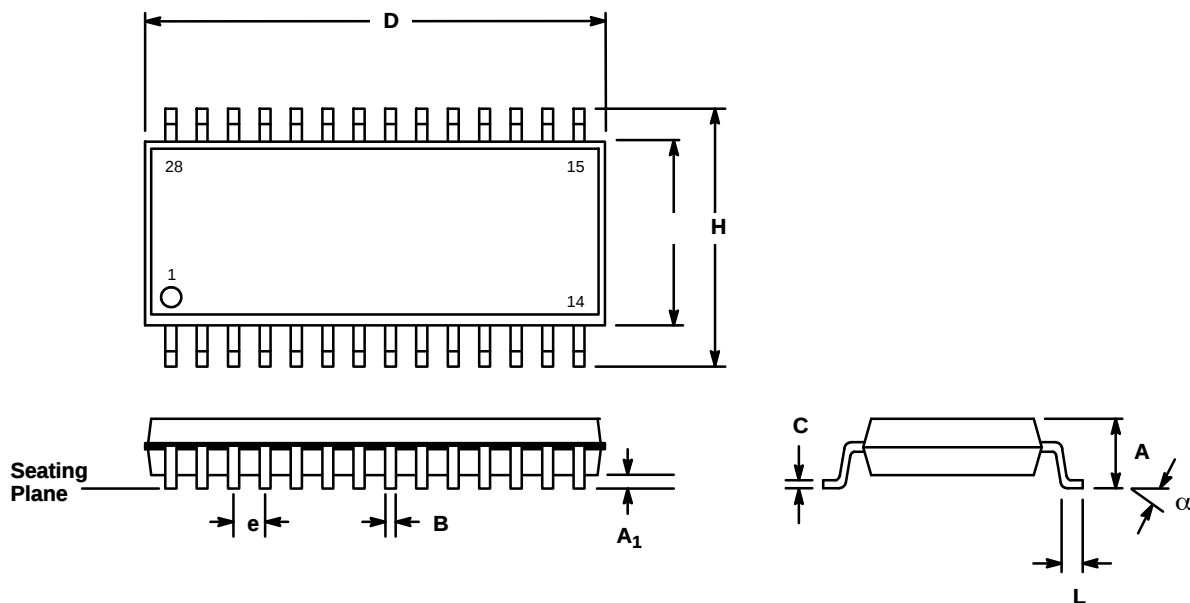


SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.165	0.180	4.19	4.57
A ₁	0.090	0.120	2.29	3.05
A ₂	0.020	---	0.51	---
B	0.013	0.021	0.33	0.53
B ₁	0.026	0.032	0.66	0.81
C	0.008	0.013	0.19	0.32
D	0.685	0.695	17.40	17.65
D ₁	0.650	0.656	16.51	16.66
D ₂	0.590	0.630	14.99	16.00
D ₃	0.500 typ.		12.70 typ.	
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

**28 LEAD SMALL OUTLINE
(350 MIL JEDEC SOIC)**

Rev. 1.00



SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.093	0.104	2.35	2.65
A ₁	0.004	0.012	0.10	0.30
B	0.013	0.020	0.33	0.51
C	0.009	0.013	0.23	0.32
D	0.706	0.718	17.93	18.24
E	0.340	0.350	8.64	8.89
e	0.050 BSC		1.27 BSC	
H	0.460	0.485	11.68	12.32
L	0.016	0.050	0.40	1.27
α	0°	8°	0°	8°

Note: The control dimension is the millimeter column

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