

## DAC0800/DAC0802

### 8-Bit Digital-to-Analog Converters

#### General Description

The DAC0800 series are monolithic 8-bit high-speed current-output digital-to-analog converters (DAC) featuring typical settling times of 100 ns. When used as a multiplying DAC, monotonic performance over a 40 to 1 reference current range is possible. The DAC0800 series also features high compliance complementary current outputs to allow differential output voltages of 20 V<sub>p-p</sub> with simple resistor loads as shown in *Figure 1*. The reference-to-full-scale current matching of better than  $\pm 1$  LSB eliminates the need for full-scale trims in most applications while the nonlinearities of better than  $\pm 0.1\%$  over temperature minimizes system error accumulations.

The noise immune inputs of the DAC0800 series will accept TTL levels with the logic threshold pin, V<sub>LC</sub>, grounded. Changing the V<sub>LC</sub> potential will allow direct interface to other logic families. The performance and characteristics of the device are essentially unchanged over the full  $\pm 4.5V$  to  $\pm 18V$  power supply range; power dissipation is only 33 mW with  $\pm 5V$  supplies and is independent of the logic input states.

The DAC0800, DAC0802, DAC0800C and DAC0802C are a direct replacement for the DAC-08, DAC-08A, DAC-08C, and DAC-08H, respectively.

#### Features

- Fast settling output current: 100 ns
- Full scale error:  $\pm 1$  LSB
- Nonlinearity over temperature:  $\pm 0.1\%$
- Full scale current drift:  $\pm 10$  ppm/ $^{\circ}C$
- High output compliance:  $-10V$  to  $+18V$
- Complementary current outputs
- Interface directly with TTL, CMOS, PMOS and others
- 2 quadrant wide range multiplying capability
- Wide power supply range:  $\pm 4.5V$  to  $\pm 18V$
- Low power consumption: 33 mW at  $\pm 5V$
- Low cost

#### Typical Applications

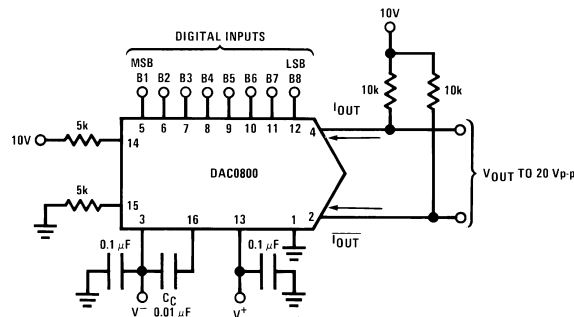


FIGURE 1.  $\pm 20$  V<sub>p-p</sub> Output Digital-to-Analog Converter (Note 5)

#### Ordering Information

Non-Linearity	Temperature Range	Order Numbers				
		J Package (J16A) (Note 1)		N Package (N16E) (Note 1)		SO Package (M16A)
$\pm 0.1\%$ FS	$0^{\circ}C \leq T_A \leq +70^{\circ}C$	DAC0802LCJ	DAC-08HQ	DAC0802LCN	DAC-08HP	DAC0802LCM
$\pm 0.19\%$ FS	$-55^{\circ}C \leq T_A \leq +125^{\circ}C$	DAC0800LJ	DAC-08Q			
$\pm 0.19\%$ FS	$0^{\circ}C \leq T_A \leq +70^{\circ}C$	DAC0800LCJ	DAC-08EQ	DAC0800LCN	DAC-08EP	DAC0800LCM

Note 1: Devices may be ordered by using either order number.

## Absolute Maximum Ratings (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ( $V^+ - V^-$ )	$\pm 18V$ or $36V$
Power Dissipation (Note 3)	500 mW
Reference Input Differential Voltage (V14 to V15)	$V^-$ to $V^+$
Reference Input Common-Mode Range (V14, V15)	$V^-$ to $V^+$
Reference Input Current	5 mA
Logic Inputs	$V^-$ to $V^-$ plus $36V$
Analog Current Outputs ( $V_S^- = -15V$ )	4.25 mA
ESD Susceptibility (Note 4)	TBD V

Storage Temperature	$-65^\circ\text{C}$ to $+150^\circ\text{C}$
Lead Temp. (Soldering, 10 seconds)	
Dual-In-Line Package (plastic)	$260^\circ\text{C}$
Dual-In-Line Package (ceramic)	$300^\circ\text{C}$
Surface Mount Package	
Vapor Phase (60 seconds)	$215^\circ\text{C}$
Infrared (15 seconds)	$220^\circ\text{C}$

## Operating Conditions (Note 2)

	Min	Max	Units
Temperature ( $T_A$ )			
DAC0800L	$-55$	$+125$	$^\circ\text{C}$
DAC0800LC	0	$+70$	$^\circ\text{C}$
DAC0802LC	0	$+70$	$^\circ\text{C}$

## Electrical Characteristics

The following specifications apply for  $V_S = \pm 15V$ ,  $I_{REF} = 2\text{ mA}$  and  $T_{MIN} \leq T_A \leq T_{MAX}$  unless otherwise specified. Output characteristics refer to both  $I_{OUT}$  and  $I_{OUT-}$ .

Symbol	Parameter	Conditions	DAC0802LC			DAC0800L/ DAC0800LC			Units
			Min	Typ	Max	Min	Typ	Max	
	Resolution		8	8	8	8	8	8	Bits
	Monotonicity		8	8	8	8	8	8	Bits
	Nonlinearity				$\pm 0.1$			$\pm 0.19$	%FS
$t_s$	Settling Time	To $\pm 1/2$ LSB, All Bits Switched "ON" or "OFF", $T_A = 25^\circ\text{C}$ DAC0800L DAC0800LC		100	135		100 100	135 150	ns ns ns
$t_{PLH}$ , $t_{PHL}$	Propagation Delay Each Bit All Bits Switched	$T_A = 25^\circ\text{C}$		35 35	60 60		35 35	60 60	ns ns
$TC_{FS}$	Full Scale Tempco			$\pm 10$	$\pm 50$		$\pm 10$	$\pm 50$	ppm/ $^\circ\text{C}$
$V_{OC}$	Output Voltage Compliance	Full Scale Current Change $< 1/2$ LSB, $R_{OUT} > 20\text{ M}\Omega$ Typ	$-10$		18	$-10$		18	V
$I_{FS4}$	Full Scale Current	$V_{REF} = 10.000V$ , $R14 = 5.000\text{ k}\Omega$ $R15 = 5.000\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$	1.984	1.992	2.000	1.94	1.99	2.04	mA
$I_{FSS}$	Full Scale Symmetry	$I_{FS4} - I_{FS2}$		$\pm 0.5$	$\pm 4.0$		$\pm 1$	$\pm 8.0$	$\mu\text{A}$
$I_{ZS}$	Zero Scale Current			0.1	1.0		0.2	2.0	$\mu\text{A}$
$I_{FSR}$	Output Current Range	$V^- = -5V$ $V^- = -8V$ to $-18V$	0 0	2.0 2.0	2.1 4.2	0 0	2.0 2.0	2.1 4.2	mA mA
$V_{IL}$ $V_{IH}$	Logic Input Levels Logic "0" Logic "1"	$V_{LC} = 0V$			0.8			0.8	V V
$I_{IL}$ $I_{IH}$	Logic Input Current Logic "0" Logic "1"	$V_{LC} = 0V$ $-10V \leq V_{IN} \leq +0.8V$ $2V \leq V_{IN} \leq +18V$		$-2.0$ 0.002	$-10$ 10		$-2.0$ 0.002	$-10$ 10	$\mu\text{A}$ $\mu\text{A}$
$V_{IS}$	Logic Input Swing	$V^- = -15V$	$-10$		18	$-10$		18	V
$V_{THR}$	Logic Threshold Range	$V_S = \pm 15V$	$-10$		13.5	$-10$		13.5	V
$I_{I5}$	Reference Bias Current			$-1.0$	$-3.0$		$-1.0$	$-3.0$	$\mu\text{A}$
$dI/dt$	Reference Input Slew Rate	(Figure 11)	4.0	8.0		4.0	8.0		mA/ $\mu\text{s}$
$PSSI_{FS+}$ $PSSI_{FS-}$	Power Supply Sensitivity	$4.5V \leq V^* \leq 18V$ $-4.5V \leq V^- \leq 18V$ $I_{REF} = 1\text{ mA}$		0.0001	0.01		0.0001	0.01	%/% %/%

## Electrical Characteristics (Continued)

The following specifications apply for  $V_S = \pm 15V$ ,  $I_{REF} = 2 \text{ mA}$  and  $T_{MIN} \leq T_A \leq T_{MAX}$  unless otherwise specified. Output characteristics refer to both  $I_{OUT}$  and  $\overline{I_{OUT}}$ .

Symbol	Parameter	Conditions	DAC0802LC			DAC0800L/ DAC0800LC			Units
			Min	Typ	Max	Min	Typ	Max	
I+ I-	Power Supply Current	$V_S = \pm 5V$ , $I_{REF} = 1 \text{ mA}$		2.3	3.8		2.3	3.8	mA
				-4.3	-5.8		-4.3	-5.8	mA
		$V_S = 5V$ , $-15V$ , $I_{REF} = 2 \text{ mA}$		2.4	3.8		2.4	3.8	mA
				-6.4	-7.8		-6.4	-7.8	mA
I+ I-	Power Supply Current	$V_S = \pm 15V$ , $I_{REF} = 2 \text{ mA}$		2.5	3.8		2.5	3.8	mA
				-6.5	-7.8		-6.5	-7.8	mA
P <sub>D</sub>	Power Dissipation	$\pm 5V$ , $I_{REF} = 1 \text{ mA}$		33	48		33	48	mW
		$5V, -15V$ , $I_{REF} = 2 \text{ mA}$		108	136		108	136	mW
		$\pm 15V$ , $I_{REF} = 2 \text{ mA}$		135	174		135	174	mW

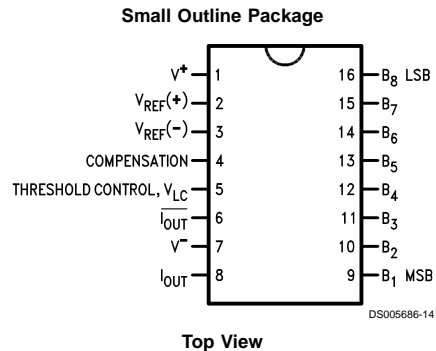
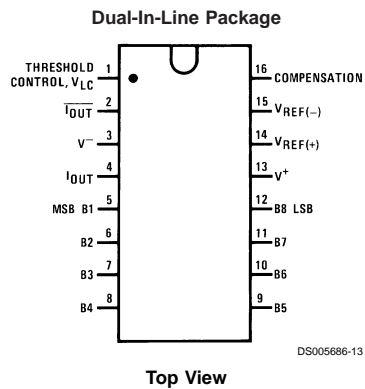
**Note 2:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating conditions.

**Note 3:** The maximum junction temperature of the DAC0800 and DAC0802 is 125°C. For operating at elevated temperatures, devices in the Dual-In-Line J package must be derated based on a thermal resistance of 100°C/W, junction-to-ambient, 175°C/W for the molded Dual-In-Line N package and 100°C/W for the Small Outline M package.

**Note 4:** Human body model, 100 pF discharged through a 1.5 kΩ resistor.

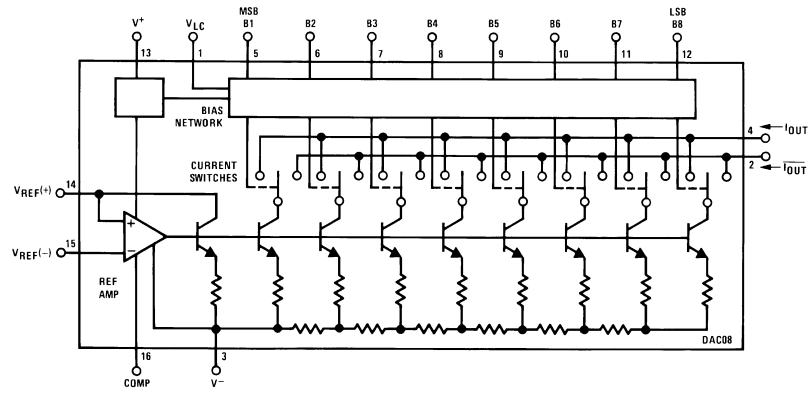
**Note 5:** Pin-out numbers for the DAC080X represent the Dual-In-Line package. The Small Outline package pin-out differs from the Dual-In-Line package.

## Connection Diagrams



See Ordering Information

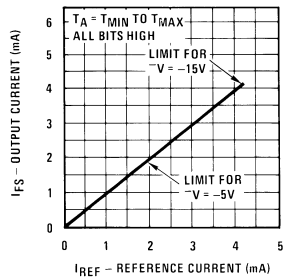
## Block Diagram (Note 5)



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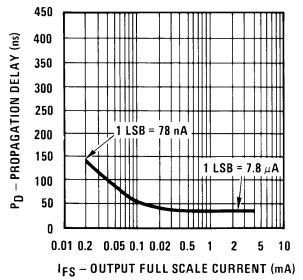
## Typical Performance Characteristics

### Full Scale Current vs Reference Current



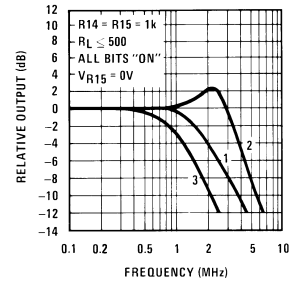
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### LSB Propagation Delay vs I<sub>FS</sub>



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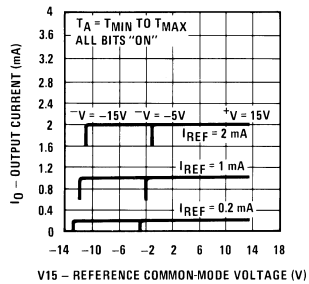
### Reference Input Frequency Response



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- Curve 1:**  $C_C = 15$  pF,  $V_{IN} = 2$  Vp-p centered at 1V.
- Curve 2:**  $C_C = 15$  pF,  $V_{IN} = 50$  mVp-p centered at 200 mV.
- Curve 3:**  $C_C = 0$  pF,  $V_{IN} = 100$  mVp-p centered at 0V and applied through 50Ω connected to pin 14.2V applied to R14.

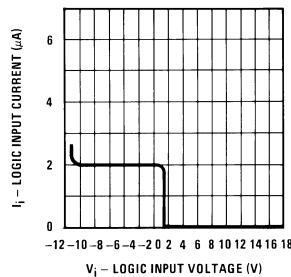
### Reference Amp Common-Mode Range



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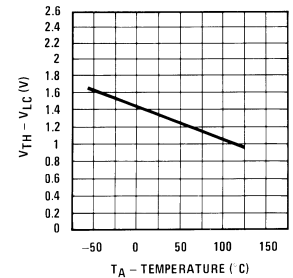
Note. Positive common-mode range is always  $(V+) - 1.5V$ .

### Logic Input Current vs Input Voltage



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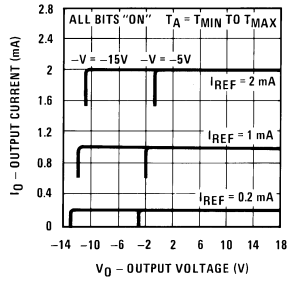
### V<sub>TH</sub> - V<sub>LC</sub> vs Temperature



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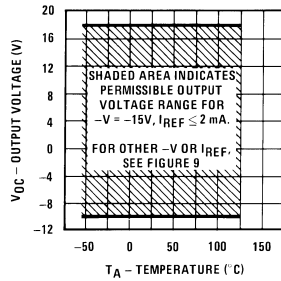
## Typical Performance Characteristics (Continued)

**Output Current vs Output Voltage (Output Voltage Compliance)**



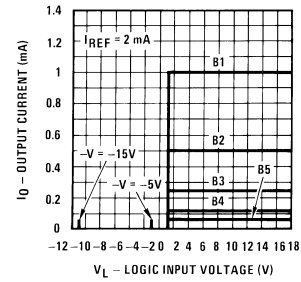
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**Output Voltage Compliance vs Temperature**



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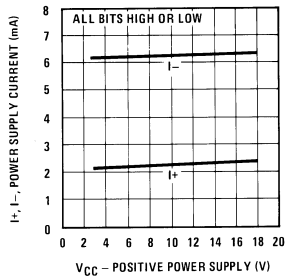
**Bit Transfer Characteristics**



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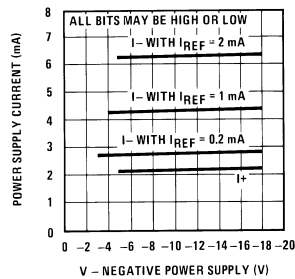
Note. B1-B8 have identical transfer characteristics. Bits are fully switched with less than 1/2 LSB error, at less than ±100 mV from actual threshold. These switching points are guaranteed to lie between 0.8 and 2V over the operating temperature range ( $V_{LC} = 0V$ ).

**Power Supply Current vs +V**



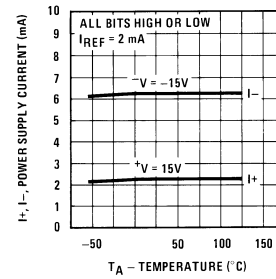
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**Power Supply Current vs -V**



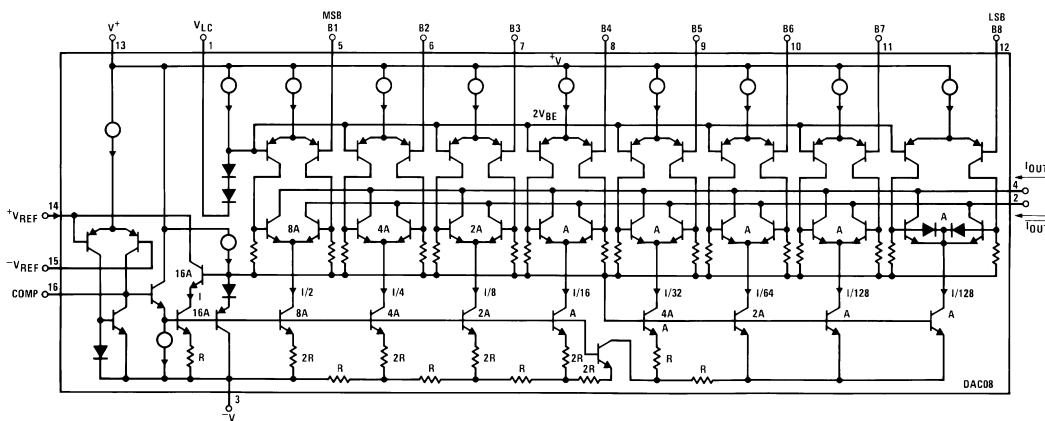
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**Power Supply Current vs Temperature**



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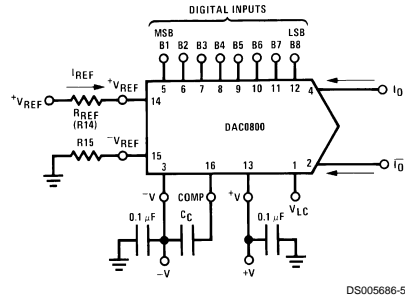
## Equivalent Circuit



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FIGURE 2.

## Typical Applications



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$$I_{FS} \approx \frac{+V_{REF}}{R_{REF}} \times \frac{255}{256}$$

$I_O + \bar{I}_O = I_{FS}$  for all logic states

For fixed reference, TTL operation, typical values are:

$V_{REF} = 10.000V$

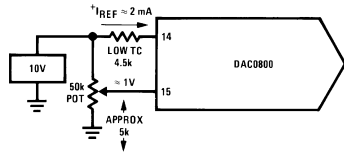
$R_{REF} = 5.000k$

$R15 = R_{REF}$

$C_C = 0.01 \mu F$

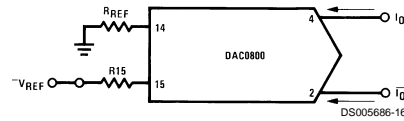
$V_{LC} = 0V$  (Ground)

FIGURE 3. Basic Positive Reference Operation (Note 5)



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FIGURE 4. Recommended Full Scale Adjustment Circuit (Note 5)

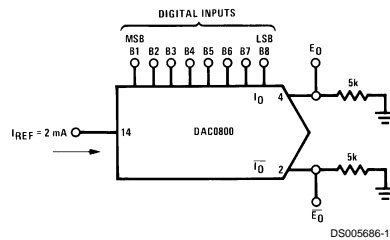


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$$I_{FS} \approx \frac{-V_{REF}}{R_{REF}} \times \frac{255}{256}$$

Note.  $R_{REF}$  sets  $I_{FS}$ ;  $R15$  is for bias current cancellation

FIGURE 5. Basic Negative Reference Operation (Note 5)

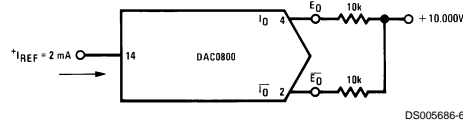


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	B1	B2	B3	B4	B5	B6	B7	B8	$I_O$ mA	$\bar{I}_O$ mA	$E_O$	$\bar{E}_O$
Full Scale	1	1	1	1	1	1	1	1	1.992	0.000	-9.960	0.000
Full Scale-LSB	1	1	1	1	1	1	1	0	1.984	0.008	-9.920	-0.040
Half Scale+LSB	1	0	0	0	0	0	0	1	1.008	0.984	-5.040	-4.920
Half Scale	1	0	0	0	0	0	0	0	1.000	0.992	-5.000	-4.960
Half Scale-LSB	0	1	1	1	1	1	1	1	0.992	1.000	-4.960	-5.000
Zero Scale+LSB	0	0	0	0	0	0	0	1	0.008	1.984	-0.040	-9.920
Zero Scale	0	0	0	0	0	0	0	0	0.000	1.992	0.000	-9.960

FIGURE 6. Basic Unipolar Negative Operation (Note 5)

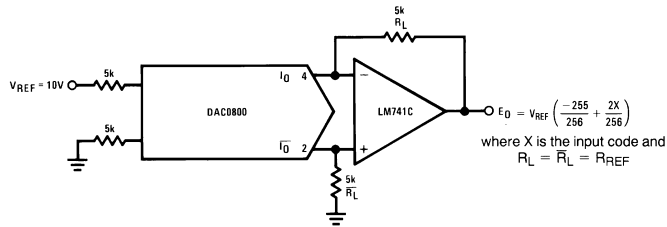
## Typical Applications (Continued)



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	B1	B2	B3	B4	B5	B6	B7	B8	$E_O$	$\bar{E}_O$
Pos. Full Scale	1	1	1	1	1	1	1	1	-9.920	+10.000
Pos. Full Scale-LSB	1	1	1	1	1	1	1	0	-9.840	+9.920
Zero Scale+LSB	1	0	0	0	0	0	0	1	-0.080	+0.160
Zero Scale	1	0	0	0	0	0	0	0	0.000	+0.080
Zero Scale-LSB	0	1	1	1	1	1	1	1	+0.080	0.000
Neg. Full Scale+LSB	0	0	0	0	0	0	0	1	+9.920	-9.840
Neg. Full Scale	0	0	0	0	0	0	0	0	+10.000	-9.920

FIGURE 7. Basic Bipolar Output Operation (Note 5)

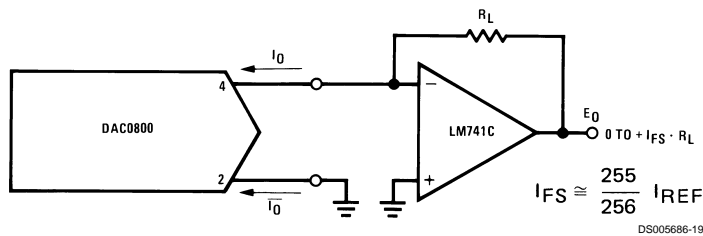


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If  $R_L = \bar{R}_L$  within  $\pm 0.05\%$ , output is symmetrical about ground

	B1	B2	B3	B4	B5	B6	B7	B8	$E_O$
Pos. Full Scale	1	1	1	1	1	1	1	1	+9.960
Pos. Full Scale-LSB	1	1	1	1	1	1	1	0	+9.880
(+)Zero Scale	1	0	0	0	0	0	0	0	+0.040
(-)Zero Scale	0	1	1	1	1	1	1	1	-0.040
Neg. Full Scale+LSB	0	0	0	0	0	0	0	1	-9.880
Neg. Full Scale	0	0	0	0	0	0	0	0	-9.960

FIGURE 8. Symmetrical Offset Binary Operation (Note 5)

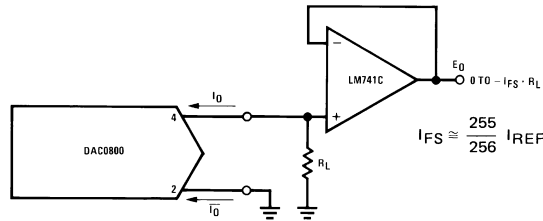


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For complementary output (operation as negative logic DAC), connect inverting input of op amp to  $\bar{I}_O$  (pin 2), connect  $I_O$  (pin 4) to ground.

FIGURE 9. Positive Low Impedance Output Operation (Note 5)

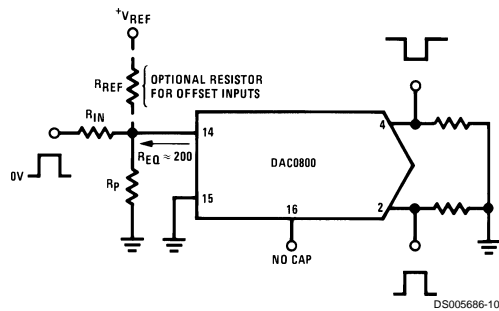
Typical Applications (Continued)



DS005686-20

For complementary output (operation as a negative logic DAC) connect non-inverting input of op am to  $\bar{I}_O$  (pin 2); connect  $I_O$  (pin 4) to ground.

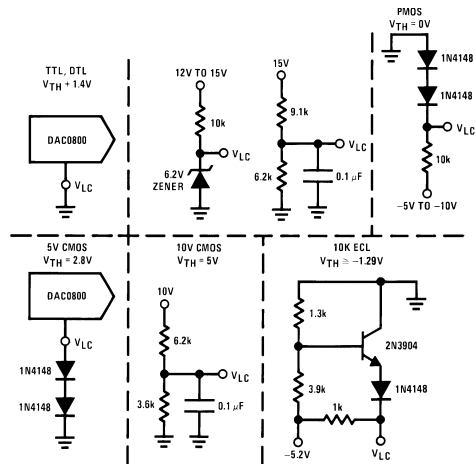
FIGURE 10. Negative Low Impedance Output Operation (Note 5)



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Typical values:  $R_{IN}=5k$ ,  $+V_{IN}=10V$

FIGURE 11. Pulsed Reference Operation (Note 5)

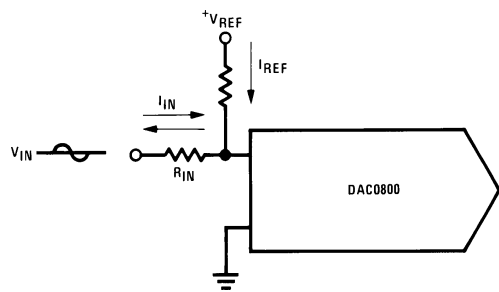


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$V_{TH} = V_{LC} + 1.4V$   
15V CMOS, HTL, HNIL  
 $V_{TH} = 7.6V$

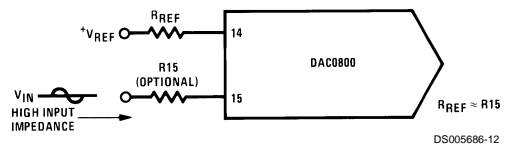
Note. Do not exceed negative logic input range of DAC.

FIGURE 12. Interfacing with Various Logic Families



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(a)  $I_{REF} \geq$  peak negative swing of  $I_{IN}$



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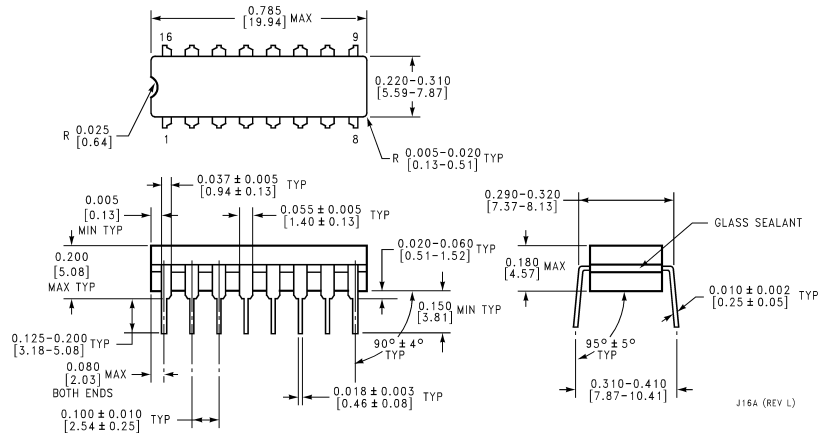
(b)  $+V_{REF}$  must be above peak positive swing of  $V_{IN}$

FIGURE 13. Accommodating Bipolar References (Note 5)

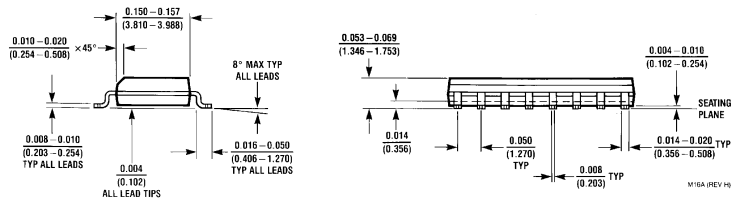
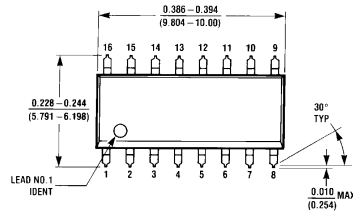




**Physical Dimensions** inches (millimeters) unless otherwise noted

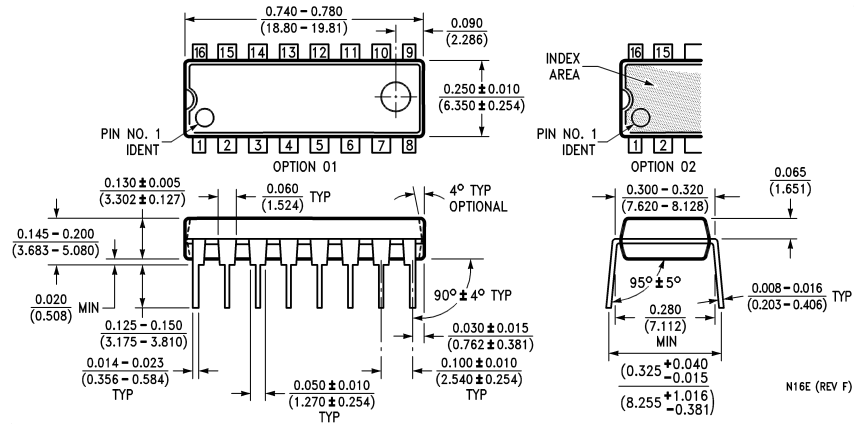


**Molded Small Outline Package (SO)**  
**Order Numbers DAC0800LCM,**  
**or DAC0802LCM**  
**NS Package Number M16A**



**Molded Small Outline Package (SO)**  
**Order Numbers DAC0800LCM,**  
**or DAC0802LCM**  
**NS Package Number M16A**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



**Molded Dual-In-Line Package**  
**Order Numbers DAC0800, DAC0802**  
**NS Package Number N16E**

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