



© Analog Devices, Inc., 2002

DAC08—SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

(@ $V_S = \pm 15\text{ V}$, $I_{REF} = 2.0\text{ mA}$, $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ for DAC08/08A, $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$ for DAC08E and DAC08H, -40°C to $+85^\circ\text{C}$ for DAC08C, unless otherwise noted. Output characteristics refer to both I_{OUT} and I_{OUT-} .)

Parameter	Symbol	Conditions	DAC08A/H			DAC08E			DAC08C			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Resolution			8			8			8			Bits
Monotonicity			8			8			8			Bits
Nonlinearity	NL				± 0.1			± 0.19			± 0.39	% FS
Settling Time	t_S	To $\pm 1/2$ LSB, All Bits Switched ON or OFF, $T_A = 25^\circ\text{C}$ ¹		85	135		85	150		85	150	ns
Propagation Delay												
Each Bit	t_{PLH}	$T_A = 25^\circ\text{C}$ ¹		35	60		35	60		35	60	ns
All Bits Switched	t_{PHL}			35	60		35	60		35	60	ns
Full-Scale Tempco ¹	TCI_{FS}	DAC08E		± 10	± 50		± 10	± 80 ± 50		± 10	± 80	ppm/ $^\circ\text{C}$
Output Voltage												
Compliance	V_{OC}	Full-Scale Current Change $< 1/2$ LSB, $R_{OUT} > 20\text{ M}\Omega$ typ	-10		+18	-10		+18	-10		+18	V
Full Range Current	I_{FR4}	$V_{REF} = 10.000\text{ V}$ $R_{14}, R_{15} = 5.000\text{ k}\Omega$ $T_A = 25^\circ\text{C}$	1.984	1.992	2.000	1.94	1.99	2.04	1.94	1.99	2.04	mA
Full Range Symmetry	I_{FRS}	$I_{FR4} - I_{FR2}$		± 0.5	± 4		± 1	± 8		± 2	± 16	μA
Zero-Scale Current	I_{ZS}			0.1	1		0.2	2		0.2	4	μA
Output Current Range	I_{OR1} I_{OR2}	$R_{14}, R_{15} = 5.000\text{ k}\Omega$ $V_{REF} = +15.0\text{ V}$, $V_- = -10\text{ V}$ $V_{REF} = +25.0\text{ V}$, $V_- = -12\text{ V}$ $I_{REF} = 2\text{ mA}$	2.1			2.1			2.1			mA
Output Current Noise				25			25			25		nA
Logic Input Levels												
Logic “0”	V_{IL}	$V_{LC} = 0\text{ V}$			0.8			0.8			0.8	V
Logic Input “1”	V_{IH}		2			2			2			V
Logic Input Current												
Logic “0”	I_{IL}	$V_{LC} = 0\text{ V}$ $V_{IN} = -10\text{ V}$ to $+0.8\text{ V}$		-2	-10		-2	-10		-2	-10	μA
Logic Input “1”	I_{IH}	$V_{IN} = 2.0\text{ V}$ to 18 V		0.002	10		0.002	10		0.002	10	μA
Logic Input Swing	V_{IS}	$V_- = -15\text{ V}$	-10		+18	-10		+18	-10		+18	V
Logic Threshold Range	V_{THR}	$V_S = \pm 15\text{ V}$ ¹	-10		+13.5	-10		+13.5	-10		+13.5	V
Reference Bias Current	I_{I5}			-1	-3		-1	-3		-1	-3	μA
Reference Input	dI/dt	$R_{EQ} = 200\text{ }\Omega$ $R_L = 100\text{ }\Omega$ $C_C = 0\text{ pF}$ See Fast Pulsed Ref. Info Following. ¹	4	8		4	8		4	8		mA/ μs
Slew Rate												
Power Supply Sensitivity	$PSSI_{FS+}$ $PSSI_{FS-}$	$V_+ = 4.5\text{ V}$ to 18 V $V_- = -4.5\text{ V}$ to -18 V $I_{REF} = 1.0\text{ mA}$		± 0.0003	± 0.01		± 0.0003	± 0.01		± 0.0003	± 0.01	% ΔI_O /% ΔV_+ % ΔI_O /% ΔV_-
Power Supply Current	I_+ I_- I_+ I_- I_+ I_-	$V_S = \pm 15\text{ V}$, $I_{REF} = 1.0\text{ mA}$ $V_S = +5\text{ V}$, -15 V , $I_{REF} = 2.0\text{ mA}$ $V_S = \pm 15\text{ V}$, $I_{REF} = 2.0\text{ mA}$	2.3 -4.3 2.4 -6.4 2.5 -6.5	3.8 -5.8 3.8 -7.8 3.8 -7.8		2.3 -4.3 2.4 -6.4 2.5 -6.5	3.8 -5.8 3.8 -7.8 3.8 -7.8		2.3 -4.3 2.4 -6.4 2.5 -6.5	3.8 -5.8 3.8 -7.8 3.8 -7.8		mA mA mA mA mA mA
Power Dissipation	P_D	$\pm 5\text{ V}$, $I_{REF} = 1.0\text{ mA}$ $+5\text{ V}$, -15 V , $I_{REF} = 2.0\text{ mA}$ $\pm 15\text{ V}$, $I_{REF} = 2.0\text{ mA}$	33 108 135	48 136 174		33 103 135	48 136 174		33 108 135	48 136 174		mW mW mW

NOTES

¹Guaranteed by design.

Specifications subject to change without notice.

TYPICAL ELECTRICAL CHARACTERISTICS

(@ $V_S = \pm 15\text{ V}$, and $I_{REF} = 2.0\text{ mA}$, unless otherwise noted. Output characteristics apply to both I_{OUT} and I_{OUT-} .)

Parameter	Symbol	Conditions	All Grades Typical	Unit
Reference Input Slew Rate	dI/dt		8	$\text{mA}/\mu\text{s}$
Propagation Delay	t_{PLH}, t_{PHL}	$T_A = 25^\circ\text{C}$, Any Bit	35	ns
Settling Time	t_s	$T_o \pm 1/2\text{ LSB}$, All Bits Switched ON or OFF, $T_A = 25^\circ\text{C}$	85	ns

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS¹

Operating Temperature

DAC08AQ, Q	−55°C to +125°C
DAC08HQ, EQ, CQ, HP, EP	0°C to +70°C
DAC08CP, CS	−40°C to +85°C
Junction Temperature (T_J)	−65°C to +150°C
Storage Temperature Q Package	−65°C to +150°C
Storage Temperature P Package	−65°C to +125°C
Lead Temperature (Soldering, 60 sec)	300°C
V+ Supply to V− Supply	36 V
Logic Inputs	V− to V− plus 36 V
V_{LC}	V− to V+
Analog Current Outputs (at $V_S = 15\text{ V}$)	4.25 mA
Reference Input (V_{14} to V_{15})	V− to V+
Reference Input Differential Voltage (V_{14} to V_{15})	$\pm 18\text{ V}$
Reference Input Current (I_{14})	5.0 mA

Package Type	θ_{JA} ²	θ_{JC}	Unit
16-Lead Cerdip (Q)	100	16	°C/W
16-Lead Plastic DIP (P)	82	39	°C/W
20-Terminal LCC (RC)	76	36	°C/W
16-Lead SO (S)	111	35	°C/W

NOTES

¹Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.

² θ_{JA} is specified for worst-case mounting conditions, i.e., θ_{JA} is specified for device in socket for cerdip, Plastic DIP, and LCC packages; θ_{JA} is specified for device soldered to printed circuit board for SO package.

ORDERING GUIDE¹

Model	NL	Temperature Range	Package Description	Package Option	# Parts Per Container
DAC08AQ	$\pm 0.10\%$	−55°C to +125°C	Cerdip-16	Q-16	25
DAC08AQ ² /883C	$\pm 0.10\%$	−55°C to +125°C	Cerdip-16	Q-16	25
DAC08HP	$\pm 0.10\%$	0°C to 70°C	P-DIP-16	N-16	25
DAC08HQ	$\pm 0.10\%$	0°C to 70°C	Cerdip-16	Q-16	25
DAC08Q	$\pm 0.19\%$	−55°C to +125°C	Cerdip-16	Q-16	25
DAC08Q ² /883C	$\pm 0.19\%$	−55°C to +125°C	Cerdip-16	Q-16	25
DAC08RC/883C	$\pm 0.19\%$	−55°C to +125°C	LCC-20	E-20	55
DAC08EP	$\pm 0.19\%$	0°C to 70°C	P-DIP-16	N-16	25
DAC08EQ	$\pm 0.19\%$	0°C to 70°C	Cerdip-16	Q-16	25
DAC08ES	$\pm 0.19\%$	0°C to 70°C	SO-16	R-16A (Narrow Body)	47
DAC08ES-REEL	$\pm 0.19\%$	0°C to 70°C	SO-16	R-16A (Narrow Body)	2500
DAC08CP	$\pm 0.39\%$	−40°C to +85°C	P-DIP-16	N-16	25
DAC08CQ	$\pm 0.39\%$	0°C to 70°C	Cerdip-16	Q-16	25
DAC08CS	$\pm 0.39\%$	−40°C to +85°C	SO-16	R-16A (Narrow Body)	47
DAC08CS-REEL	$\pm 0.39\%$	−40°C to +85°C	SO-16	R-16A (Narrow Body)	2500
DAC08NBC	$\pm 0.10\%$	25°C	DICE		
DAC08GBC	$\pm 0.19\%$	25°C	DICE		
DAC08GRBC	$\pm 0.39\%$	25°C	DICE		

NOTES

¹Devices processed in total compliance to MIL-STD-883. Consult factory for 883 data sheet.

²For availability and burn-in information on SO and PLCC packages, contact your local sales office.

The DAC08 contains 84 transistors. Die size 63 mil x 87 mil = 5,481 square mils.

CAUTION

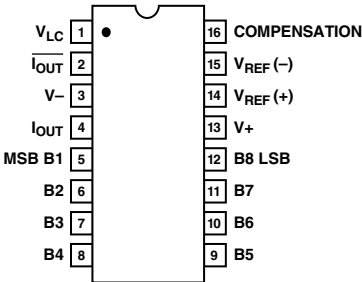
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the DAC08 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



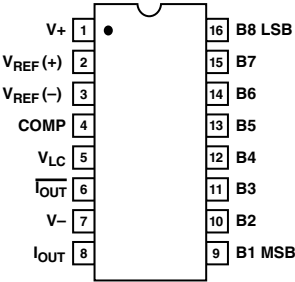
DAC08

PIN CONNECTIONS

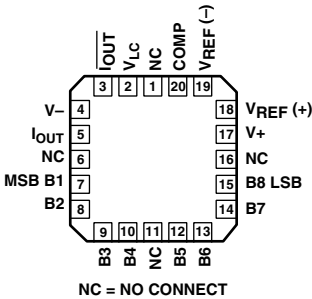
16-Lead Dual-In-Line Package (Q and P Suffix)



16-Lead SO (S Suffix)

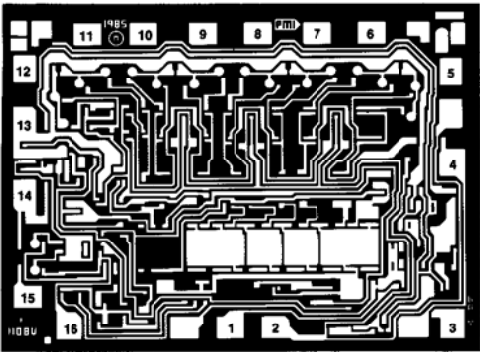


DAC08RC/883 20-Lead LCC (RC Suffix)



DICE CHARACTERISTICS

(125°C Tested Dice Available)



1. V_{LC}
2. I_{OUT}
3. V₋
4. I_{OUT}
5. BIT 1 (MSB)
6. BIT 2
7. BIT 3
8. BIT 4
9. BIT 5
10. BIT 6
11. BIT 7
12. BIT 8 (LSB)
13. V₊
14. V_{REF} (+)
15. V_{REF} (-)
16. COMP

DIE SIZE 0.087 × 0.063 inch, 5,270 sq. mils
(2.209 × 1.60 mm, 3.54 sq. mm)

WAFER TEST LIMITS (@ $V_S = \pm 15\text{ V}$, $I_{REF} = 2.0\text{ mA}$, $T_A = 25^\circ\text{C}$, unless otherwise noted. Output characteristics apply to both I_{OUT} and I_{OUT-} .)

Parameter	Symbol	Conditions	DAC08N Limit	DAC08G Limit	DAC08GR Limit	Unit
Resolution			8	8	8	Bits min
Monotonicity			8	8	8	Bits min
Nonlinearity	NL		± 0.1	± 0.19	± 0.39	% FS max
Output Voltage	V_{OC}	Full-Scale Current	+18	+18	+18	V max
Compliance		Change < 1/2 LSB	-10	-10	-10	V min
Full-Scale Current	I_{FS4} or I_{FS2}	$V_{REF} = 10.000\text{ V}$ $R_{14}, R_{15} = 5.000\text{ k}\Omega$	2.04	2.04	2.04	mA max
Full-Scale Symmetry	I_{FSS}		± 8	± 8	± 16	μA max
Zero-Scale Current	I_{ZS}		2	4	4	μA max
Output Current Range	I_{FS1} or I_{FS2}	$V_- = -10\text{ V}$, $V_{REF} = +15\text{ V}$ $V_- = -12\text{ V}$, $V_{REF} = +25\text{ V}$ $R_{14}, R_{15} = 5.000\text{ k}\Omega$	2.1	2.1	2.1	mA min
Logic Input "0"	V_{IL}		0.8	0.8	0.8	V max
Logic Input "1"	V_{IH}		2	2	2	V min
Logic Input Current		$V_{LC} = 0\text{ V}$				
Logic "0"	I_{IL}	$V_{IN} = -10\text{ V}$ to $+0.8\text{ V}$	± 10	± 10	± 10	μA max
Logic "1"	I_{IH}	$V_{IN} = +2.0\text{ V}$ to $+18\text{ V}$	± 10	± 10	± 10	μA max
Logic Input Swing	V_{IS}	$V_- = -15\text{ V}$	+18 -10	+18 -10	+18 -10	V max V min
Reference Bias Current	I_{15}		-3	-3	-3	μA max
Power Supply Sensitivity	$PSSI_{FS+}$ $PSSI_{FS-}$	$V_+ = +4.5\text{ V}$ to $+18\text{ V}$ $V_- = -4.5\text{ V}$ to -18 V $I_{REF} = 1.0\text{ mA}$	0.01	0.01	0.01	% FS/% V max
Power Supply Current	I_+	$V_S = \pm 15\text{ V}$ $I_{REF} \leq 2.0\text{ mA}$	3.8 -7.8	3.8 -7.8	3.8 -7.8	mA max μA max
Power Dissipation	P_D	$V_S = \pm 15\text{ V}$ $I_{REF} \leq 2.0\text{ mA}$	174	174	174	mW max

NOTE

Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

DAC08

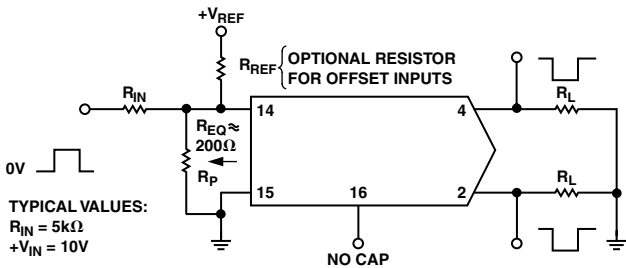


Figure 1. Pulsed Reference Operation

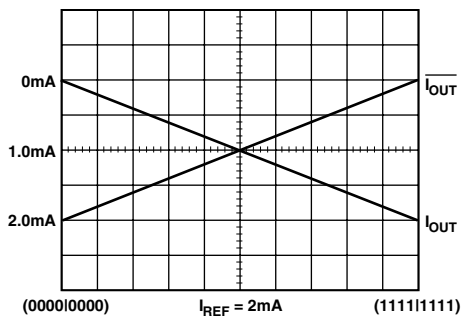


Figure 4. True and Complementary Output Operation

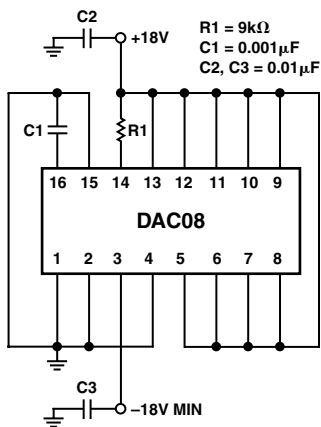


Figure 2. Burn-in Circuit

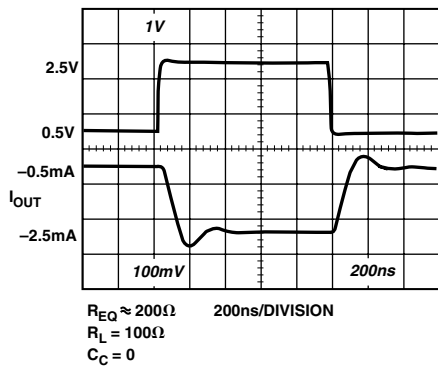


Figure 3. Fast Pulsed Reference Operation

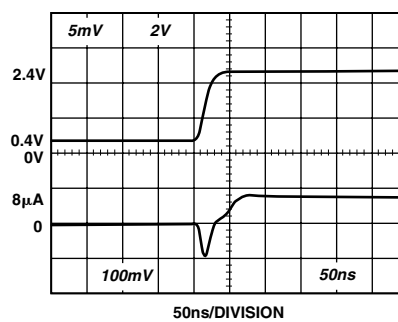


Figure 5. LSB Switching

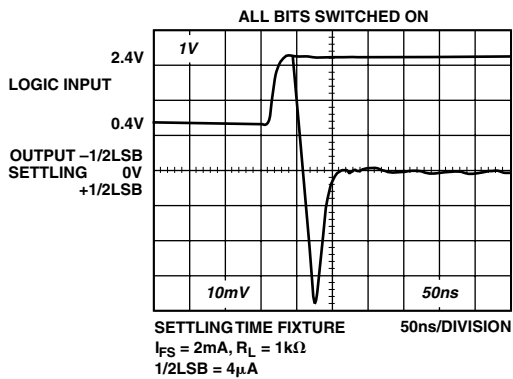
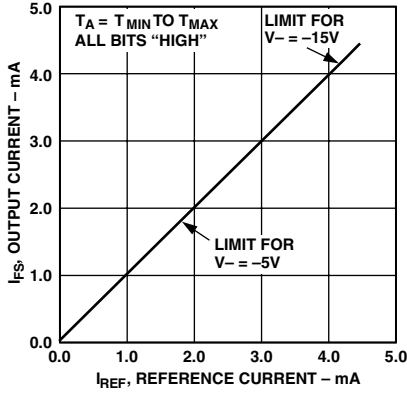
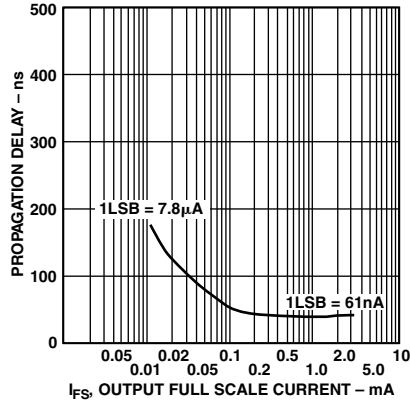


Figure 6. Full-Scale Settling Time

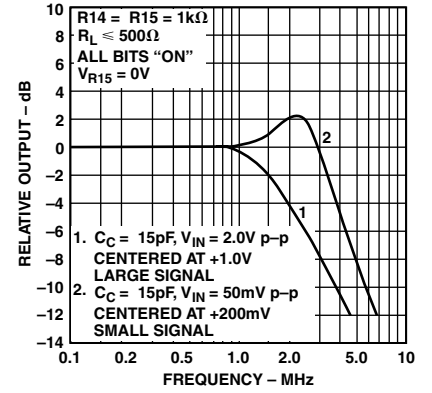
Typical Performance Characteristics–DAC08



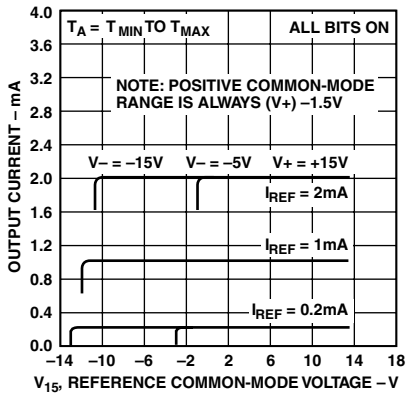
TPC 1. Full-Scale Current vs. Reference Current



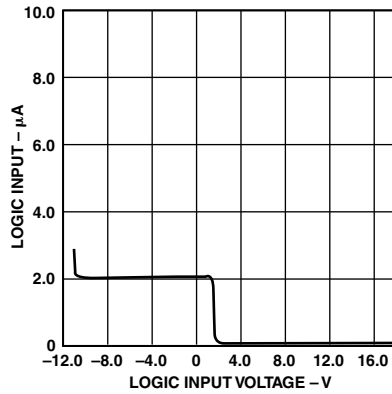
TPC 2. LSB Propagation Delay vs. I_{FS}



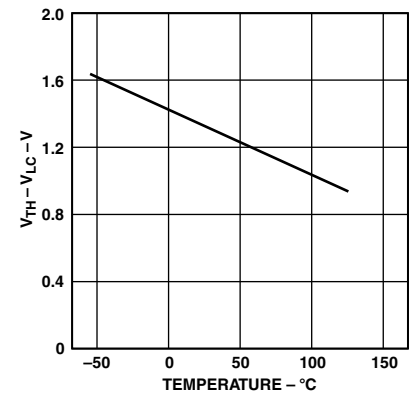
TPC 3. Reference Input Frequency Response



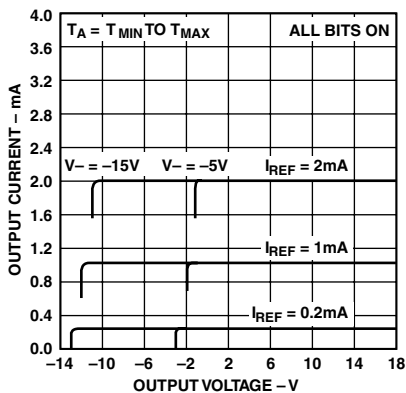
TPC 4. Reference Amp Common-Mode Range



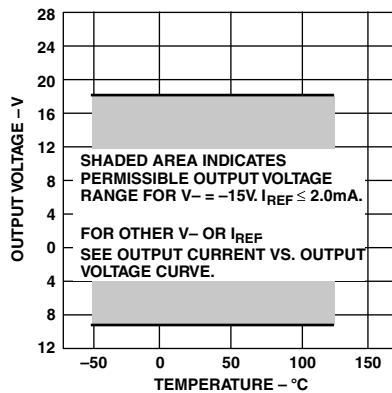
TPC 5. Logic Input Current vs. Input Voltage



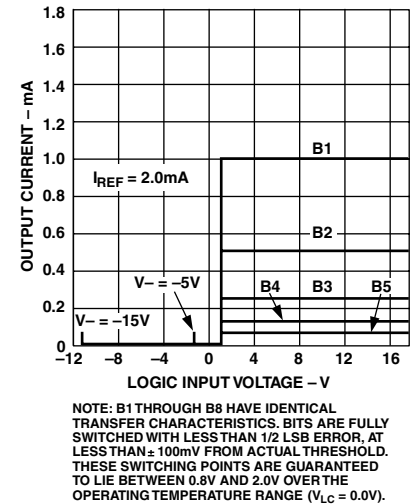
TPC 6. $V_{TH} - V_{LC}$ vs. Temperature



TPC 7. Output Current vs. Output Voltage (Output Voltage Compliance)

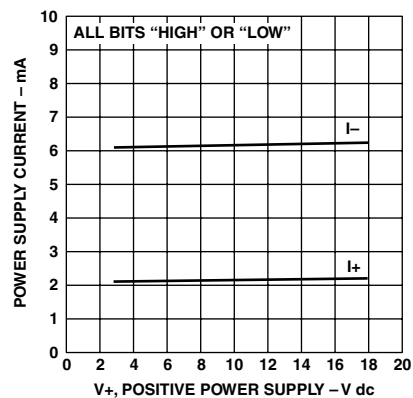


TPC 8. Output Voltage Compliance vs. Temperature

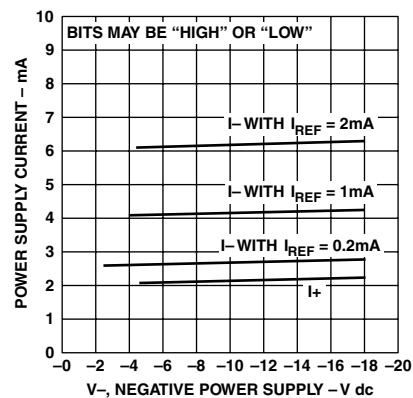


TPC 9. Bit Transfer Characteristics

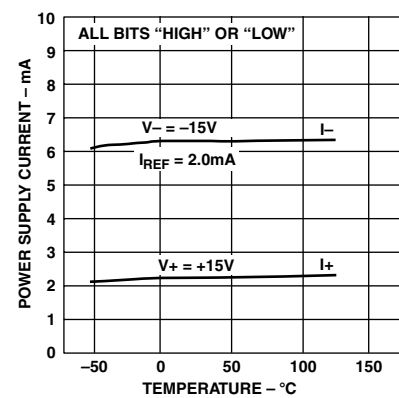
DAC08



TPC 10. Power Supply Current vs. V+



TPC 11. Power Supply Current vs. V-



TPC 12. Power Supply Current vs. Temperature

BASIC CONNECTIONS

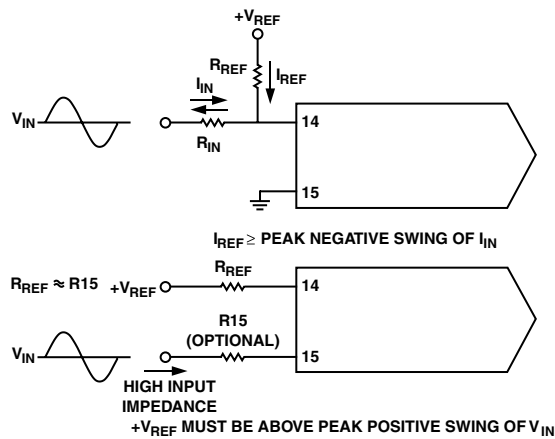


Figure 7. Accommodating Bipolar References

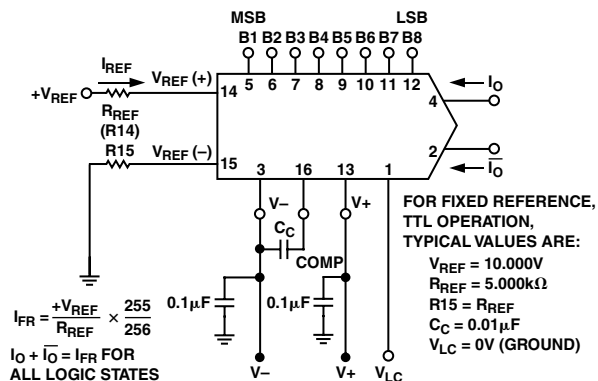


Figure 8. Basic Positive Reference Operation

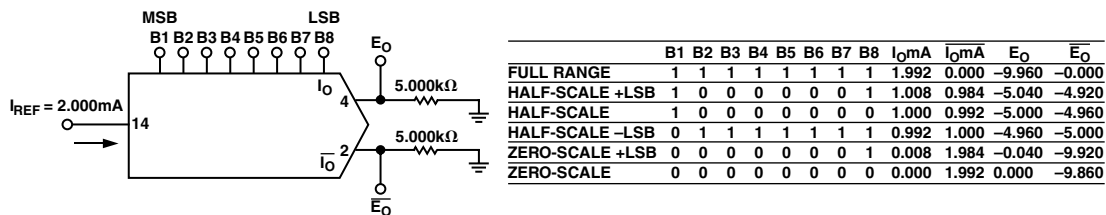


Figure 9. Basic Unipolar Negative Operation

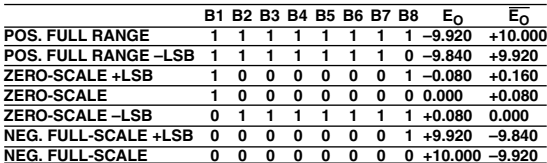


Figure 10. Basic Bipolar Output Operation

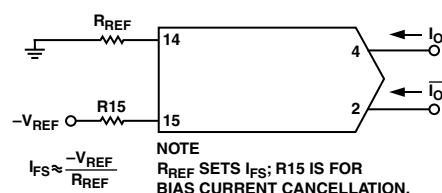


Figure 11. Recommended Full-Scale Adjustment Circuit

Figure 12. Basic Negative Reference Operation

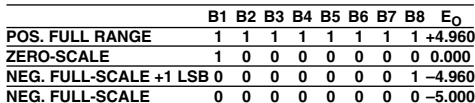
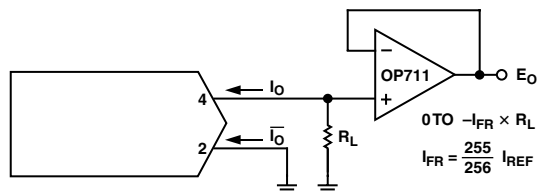


Figure 13. Offset Binary Operation



FOR COMPLEMENTARY OUTPUT (OPERATION AS A NEGATIVE LOGIC DAC),
CONNECT INVERTING INPUT OF OP AMP TO $\overline{I_0}$ (PIN 2); CONNECT I_0 (PIN 4) TO
GROUND.

**FOR COMPLEMENTARY OUTPUT (OPERATION AS A NEGATIVE LOGIC DAC),
CONNECT NONINVERTING INPUT OF OP AMP TO I_0 (PIN 2); CONNECT I_0 (PIN 4)
TO GROUND.**

Figure 14. Positive Low Impedance Output Operation

Figure 15. Negative Low Impedance Output Operation

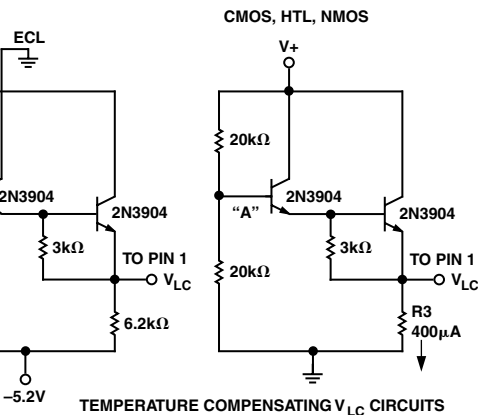


Figure 16. Interfacing with Various Logic Families

DAC08

APPLICATION INFORMATION REFERENCE AMPLIFIER SETUP

The DAC08 is a multiplying D/A converter in which the output current is the product of a digital number and the input reference current. The reference current may be fixed or may vary from nearly zero to 4.0 mA. The full-scale output current is a linear function of the reference current and is given by:

$$I_{FR} = \frac{255}{256} \times I_{REF}, \text{ where } I_{REF} = I_{14}$$

In positive reference applications, an external positive reference voltage forces current through R14 into the $V_{REF(+)}$ terminal (Pin 14) of the reference amplifier. Alternatively, a negative reference may be applied to $V_{REF(-)}$ at Pin 15; reference current flows from ground through R14 into $V_{REF(+)}$ as in the positive reference case. This negative reference connection has the advantage of a very high impedance presented at Pin 15. The voltage at Pin 14 is equal to and tracks the voltage at Pin 15 due to the high gain of the internal reference amplifier. R15 (nominally equal to R14) is used to cancel bias current errors; R15 may be eliminated with only a minor increase in error.

Bipolar references may be accommodated by offsetting V_{REF} or Pin 15. The negative common-mode range of the reference amplifier is given by: $V_{CM-} = V_-$ plus $(I_{REF} \times 1 \text{ k}\Omega)$ plus 2.5 V. The positive common-mode range is V_+ less 1.5 V.

When a dc reference is used, a reference bypass capacitor is recommended. A 5.0 V TTL logic supply is not recommended as a reference. If a regulated power supply is used as a reference, R14 should be split into two resistors with the junction bypassed to ground with a 0.1 μF capacitor.

For most applications the tight relationship between I_{REF} and I_{FS} will eliminate the need for trimming I_{REF} . If required, full-scale trimming may be accomplished by adjusting the value of R14, or by using a potentiometer for R14. An improved method of full-scale trimming which eliminates potentiometer T.C. effects is shown in the recommended full-scale adjustment circuit.

Using lower values of reference current reduces negative power supply current and increases reference amplifier negative common-mode range. The recommended range for operation with a dc reference current is 0.2 mA to 4.0 mA.

REFERENCE AMPLIFIER COMPENSATION FOR MULTIPLYING APPLICATIONS

AC reference applications will require the reference amplifier to be compensated using a capacitor from Pin 16 to V_- . The value of this capacitor depends on the impedance presented to Pin 14: for R14 values of 1.0, 2.5 and 5.0 $\text{k}\Omega$, minimum values of C_C are 15, 37 and 75 pF. Larger values of R14 require proportionately increased values of C_C for proper phase margin, so the ratio of C_C (pF) to R14 ($\text{k}\Omega$) = 15.

For fastest response to a pulse, low values of R14 enabling small C_C values should be used. If Pin 14 is driven by a high impedance such as a transistor current source, none of the above values will suffice and the amplifier must be heavily compensated which will decrease overall bandwidth and slew rate. For R14 = 1 $\text{k}\Omega$ and C_C = 15 pF, the reference amplifier slews at 4 mA/ μs enabling a transition from $I_{REF} = 0$ to $I_{REF} = 2 \text{ mA}$ in 500 ns.

Operation with pulse inputs to the reference amplifier may be accommodated by an alternate compensation scheme. This

technique provides lowest full-scale transition times. An internal clamp allows quick recovery of the reference amplifier from a cutoff ($I_{REF} = 0$) condition. Full-scale transition (0 mA to 2 mA) occurs in 120 ns when the equivalent impedance at Pin 14 is 200 Ω and $C_C = 0$. This yields a reference slew rate of 16 mA/ μs , which is relatively independent of R_{IN} and V_{IN} values.

LOGIC INPUTS

The DAC08 design incorporates a unique logic input circuit that enables direct interface to all popular logic families and provides maximum noise immunity. This feature is made possible by the large input swing capability, 2 μA logic input current and completely adjustable logic threshold voltage. For $V_- = -15 \text{ V}$, the logic inputs may swing between -10 V and $+18 \text{ V}$. This enables direct interface with 15 V CMOS logic, even when the DAC08 is powered from a 5 V supply. Minimum input logic swing and minimum logic threshold voltage are given by: V_- plus $(I_{REF} \times 1 \text{ k}\Omega)$ plus 2.5 V. The logic threshold may be adjusted over a wide range by placing an appropriate voltage at the logic threshold control pin (Pin 1, V_{LC}). The appropriate graph shows the relationship between V_{LC} and V_{TH} over the temperature range, with V_{TH} nominally 1.4 above V_{LC} . For TTL and DTL interface, simply ground pin 1. When interfacing ECL, an $I_{REF} = 1 \text{ mA}$ is recommended. For interfacing other logic families, see preceding page. For general set-up of the logic control circuit, it should be noted that Pin 1 will source 100 μA typical; external circuitry should be designed to accommodate this current.

Fastest settling times are obtained when Pin 1 sees a low impedance. If Pin 1 is connected to a 1 $\text{k}\Omega$ divider, for example, it should be bypassed to ground by a 0.01 μF capacitor.

ANALOG OUTPUT CURRENTS

Both true and complemented output sink currents are provided where $I_O + \bar{I}_O = I_{FS}$. Current appears at the "true" (I_O) output when a "1" (logic high) is applied to each logic input. As the binary count increases, the sink current at pin 4 increases proportionally, in the fashion of a "positive logic" D/A converter. When a "0" is applied to any input bit, that current is turned off at Pin 4 and turned on at Pin 2. A decreasing logic count increases \bar{I}_O as in a negative or inverted logic D/A converter. Both outputs may be used simultaneously. If one of the outputs is not required, it must be connected to ground or to a point capable of sourcing I_{FS} ; do not leave an unused output pin open.

Both outputs have an extremely wide voltage compliance enabling fast direct current-to-voltage conversion through a resistor tied to ground or other voltage source. Positive compliance is 36 V above V_- and is independent of the positive supply. Negative compliance is given by V_- plus $(I_{REF} \times 1 \text{ k}\Omega)$ plus 2.5 V.

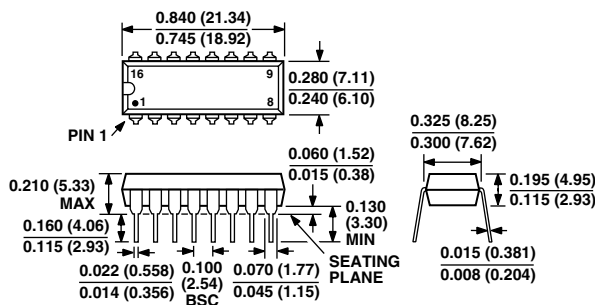
The dual outputs enable double the usual peak-to-peak load swing when driving loads in quasi-differential fashion. This feature is especially useful in cable driving, CRT deflection and in other balanced applications such as driving center-tapped coils and transformers.

POWER SUPPLIES

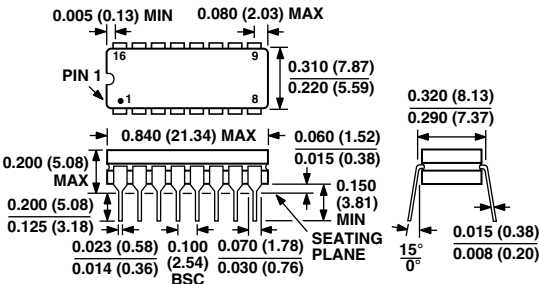
The DAC08 operates over a wide range of power supply voltages from a total supply of 9 V to 36 V. When operating at supplies of $\pm 5 \text{ V}$ or less, $I_{REF} \leq 1 \text{ mA}$ is recommended. Low reference current operation decreases power consumption and increases negative compliance, reference amplifier negative common-mode

OUTLINE DIMENSIONS
Dimensions shown in inches and (mm).

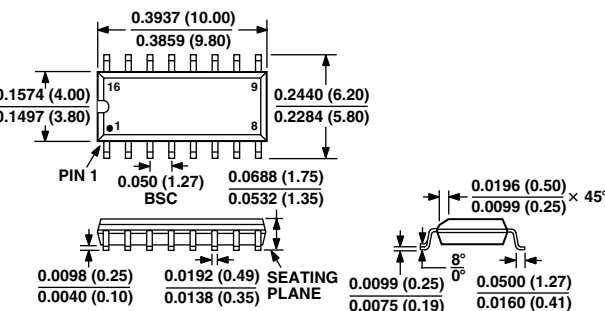
16-Lead Plastic DIP (N-16)



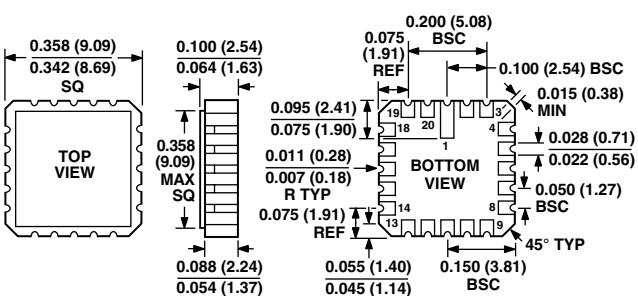
16-Lead Cerdip (Q-16)



16-Lead SO (R-16A)



20-Terminal Leadless Chip Carrier (E-20)



Revision History

Location	Page
Data Sheet changed from REV. A to REV. B.	
Edits to SPECIFICATIONS	2
Edits to ABSOLUTE MAXIMUM RATINGS	3
Edits to ORDERING GUIDE	3
Edits to WAFER TEST LIMITS	5
Edit to Figure 13	8
Edits to Figures 14 and 15	9
Replacement of SO-16 with R-16A Package Outline	12