



# Am6080

Microprocessor System Compatible 8-Bit High-Speed  
Multiplying D/A Converter

## DISTINCTIVE CHARACTERISTICS

- 8-bit D/A with 8-bit Input data latch
- Compatible with most popular microprocessors including the Am8086 and the Am2900 Families
- Write, Chip Select and Data Enable logic on chip
- DAC appears as memory location to microprocessor
- MSB inversion under logic control
- Differential current output
- Choice of six coding formats
- Fast settling current output—160 ns
- Nonlinearity to  $\pm 0.1\%$  max over temperature range
- Full scale current pre-matched to  $\pm 1$  LSB
- High output impedance and voltage compliance
- Low full scale current drift— $\pm 5$  ppm/ $^{\circ}\text{C}$
- Wide range multiplying capability—2.0 MHz bandwidth
- Direct interface to TTL, CMOS, NMOS
- High-speed data latch—80 ns min write time

## GENERAL DESCRIPTION

The Am6080 is a monolithic 8-bit multiplying Digital-to-Analog converter with an 8-bit data latch, chip select and other control signal lines used for direct interfacing with microprocessor buses.

The converter allows a choice of six different coding formats. The most significant bit ( $D_7$ ) can be inverted or non-inverted under the control of the code-select input. The code control also provides a zero differential current output for two's complement coding. A high-voltage compliance, complementary current output pair is provided. The data latch is very high speed which makes the Am6080 capable of interfacing with high-speed microprocessors.

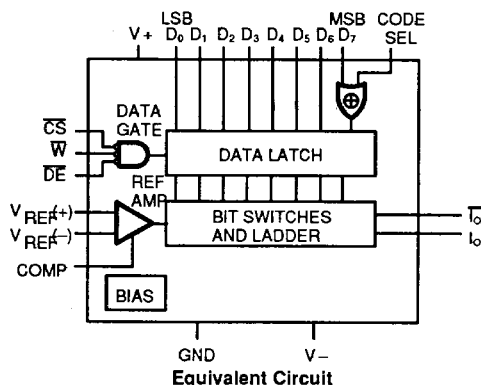
Monotonic multiplying performance is maintained over a more than 40-to-1 reference-current range. Matching

within  $\pm 1$  LSB between reference and full-scale current eliminates the need for full-scale trimming in most applications.

The Am6080 guarantees full 8-bit monotonicity. Non-linearities as tight as 0.1% over the entire operating temperature range are available. Device performance is essentially unchanged over the full power-supply voltage and temperature range.

Applications for the Am6080 include microprocessor-compatible data-acquisition systems and data-distribution systems, 8-bit A/D converters, servo-motor and pen drivers, waveform generators, programmable attenuators, analog-meter drivers, programmable power supplies, CRT-display drivers and high-speed modems.

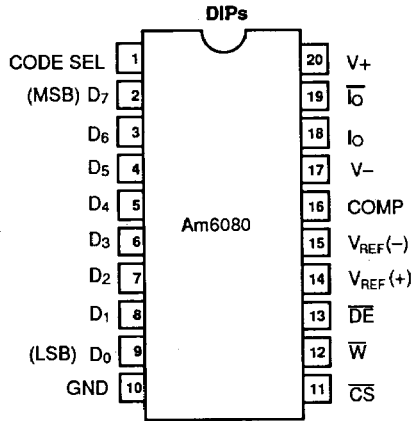
## BLOCK DIAGRAM



03941-001C

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# CONNECTION DIAGRAM Top View



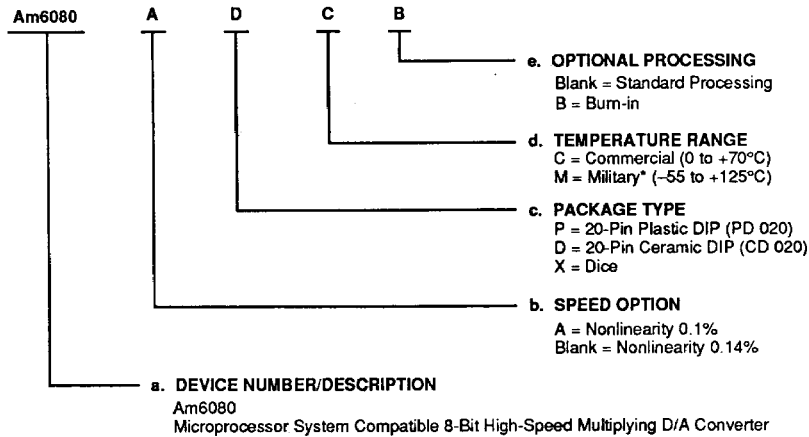
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## ORDERING INFORMATION

### Standard Products

AMD standard products are available in several packages and operating ranges. The ordering number (Valid Combination) is formed by a combination of:

- a. **Device Number**
- b. **Speed Option (if applicable)**
- c. **Package Type**
- d. **Temperature Range**
- e. **Optional Processing**



Valid Combinations	
Am6080	DC, DCB, PC, DMB
Am6080A	XM, XC

\*Military temperature range products are "NPL" (Non-Compliant Products List) or Non-Mil-STD-883C Compliant products only.

### Valid Combinations

Valid Combinations list configurations planned to be supported in volume for this device. Consult the local AMD sales office to confirm availability of specific valid combinations, to check on newly released combinations, and to obtain additional data on AMD's standard military grade products.

### Group A Tests

Group A tests consist of subgroups 1, 2, 3, 4, 5, 6.

**PIN DESCRIPTION****D<sub>0</sub>-D<sub>7</sub>**

D<sub>0</sub>-D<sub>7</sub> are the input bits 1–8 to the input data latch. Data is transferred to the data latch when  $\overline{CS}$ ,  $\overline{DE}$ , and  $\overline{W}$  are active and is latched when any of the enable signals go inactive.

 **$\overline{CS}$** **Chip Select**

This active low input signal enables the Am6080. Writing into the data latch occurs only when the device is selected.

**CODE SEL****Code Select**

When CODE SEL = 0, the MSB (D<sub>7</sub>) is inverted and 1 LSB balance current is added to the  $\overline{I_0}$  output.

**COMP****Compensation**

Frequency compensating terminal for the reference amplifier.

 **$\overline{DE}$** **Data Latch Enable**

This active low input is used to enable the data latch. The  $\overline{CS}$ ,  $\overline{DE}$ , and  $\overline{W}$  must be active in order to write into the data latch.

 **$I_0$ ,  $\overline{I_0}$** 

These are high-impedance complementary current outputs. The sum of these currents is always equal to  $I_{FS}$ .

 **$V_{REF(+)}$ ,  $V_{REF(-)}$** 

Positive and negative reference voltage to the reference bias amplifier. These differential inputs allow the use of positive, negative and bipolar references.

 **$\overline{W}$** **Write**

This active low control signal enables the data latch when the  $\overline{CS}$  and  $\overline{DE}$  inputs are active.

**FUNCTIONAL TABLES****DATA LATCH CONTROL**

$\overline{CS}$	$\overline{W}$	$\overline{DE}$	Data Latch
0	0	0	Transparent
X	X	1	Latched
X	1	X	Latched
1	X	X	Latched

X = Don't Care

**CODE SELECT**

CODE SEL	Function
0	MSB Inverted (Note 1)
1	MSB Non-Inverted

Note 1. LSB balance current is added to the  $\overline{I_0}$  output.

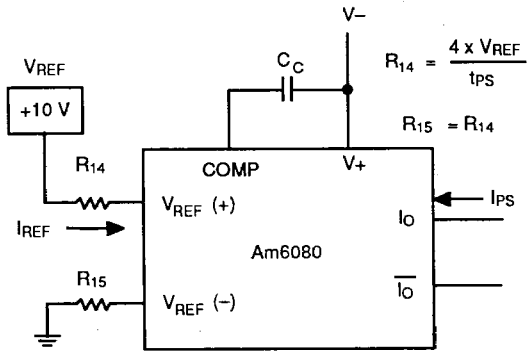
**APPLICATIONS**

**APPLICATION HINTS:**

**1. Reference current and reference resistor.**

There is a 1-to-4 scale up between the reference current ( $I_{REF}$ ) and the full-scale output current ( $I_{FS}$ ). If  $V_{REF} = +10$  V and  $I_{FS} = 2$  mA, the value of the  $R_{14}$  is:

$$R_{14} = \frac{4 \times 10 \text{ Volts}}{2 \text{ mA}} = 20 \text{ k}\Omega$$



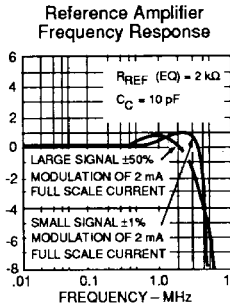
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**2. Reference amplifier compensation.**

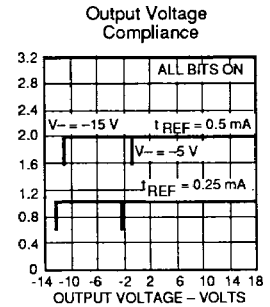
For AC Reference applications, a minimum value compensation capacitor ( $C_C$ ) is normally used. The value of this capacitor depends on  $R_{15}$ . The minimum values to maximize bandwidth without oscillation are as follows:

**TABLE 2.**  
**COMPENSATION CAPACITOR**  
( $I_{FS} = 2$  mA,  $I_{REF} = 0.5$  mA)

$R_{REF}$ (k $\Omega$ )	$C_C$ (pF)
10	50
5	25
2	10
1	5
.5	0



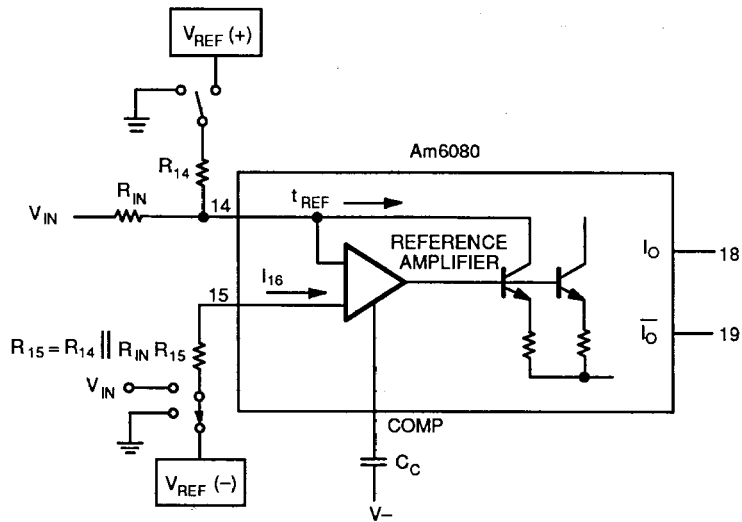
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A 0.01- $\mu$ F capacitor is recommended for the fixed reference operation.

**APPLICATIONS (continued)**



**Reference Amplifier Biasing**

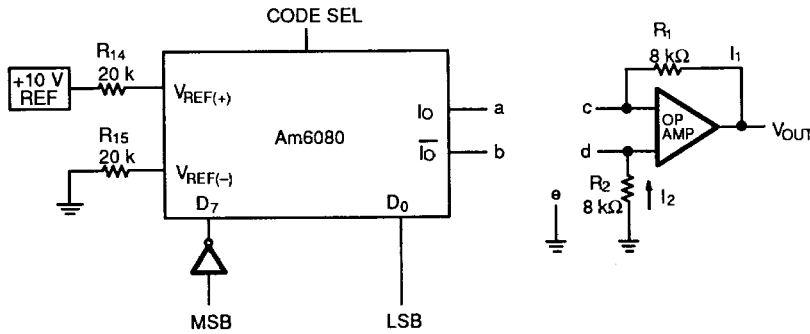
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Reference Configuration	$R_{14}$	$R_{15}$	$R_{IN}$	$C_C$	$I_{REF}$
Positive Reference	$V_{R+}$	0V	N/C	.01 $\mu$ F	$V_{R+}/R_{14}$
Negative Reference	0V	$V_{R-}$	N/C	.01 $\mu$ F	$-V_{R-}/R_{14}$
Low Impedance Bipolar Reference	$V_{R+}$	0V	$V_{IN}$	(Note 1)	$(V_{R+}/R_{14}) + (V_{IN}/R_{IN})$ (Note 2)
High Impedance Bipolar Reference	$V_{R+}$	$V_{IN}$	N/C	(Note 1)	$(V_{R+} - V_{IN})/R_{14}$ (Note 3)
Pulsed Reference (Note 4)	$V_{R+}$	0V	$V_{IN}$	No Cap	$(V_{R+}/R_{14}) + (V_{IN}/R_{IN})$

**Notes:**

1. The compensation capacitor is a function of the impedance seen at the  $+V_{REF}$  input and must be at least  $C = 5$  pFX  $R_{14}(eq)$  in k $\Omega$ . For  $R_{14} < 800 \Omega$  no capacitor is necessary.
2. For negative values of  $V_{IN}$ ,  $V_{R+}/R_{14}$  must be greater than  $-V_{IN} Max/R_{IN}$  so that the amplifier is not turned off.
3. For positive values of  $V_{IN}$ ,  $V_{R+}$  must be greater than  $V_{IN} Max$  so that the amplifier is not turned off.
4. For pulsed operation,  $V_{R+}$  provides a DC offset and may be set to zero in some cases. The impedance at pin 14 should be 800  $\Omega$  or less and an additional resistor may be connected from pin 14 to ground to lower the impedance.

APPLICATIONS (continued)



03941-008C

CODE FORMAT	CODE SEL	CONNECTIONS	OUTPUT SCALE	OUT SEL	MSB D7	D6	D5	D4	D3	D2	D1	LSB D0	I <sub>1</sub> (mA)	I <sub>2</sub> (mA)	V <sub>OUT</sub>	
UNIPOLAR	1	a-c b-e	Positive full scale	1	1	1	1	1	1	1	1	1	1.9929	0	9.9606	
			Positive full scale - LSB	1	1	1	1	1	1	1	0	0	1.964	0	9.9201	
			Zero scale	0	0	0	0	0	0	0	0	0	0	0	0	
	Complementary binary; one polarity with complementary input code, true zero output.	1	a-e b-c	Positive full scale	0	0	0	0	0	0	0	0	0	1.992	0	9.9606
Positive full scale - LSB				0	0	0	0	0	0	0	1	1	1.964	0	9.9201	
Zero scale				1	1	1	1	1	1	1	1	1	1	0	0	
SYMMETRICAL OFFSET	1	a-c b-d	Positive full scale	1	1	1	1	1	1	1	1	1	1.992	.008	9.9606	
			Positive full scale - LSB	1	1	1	1	1	1	1	0	0	1.984	.008	9.9807	
			(+) Zero scale	1	0	0	0	0	0	0	0	0	1.000	.992	.040	
			(-) Zero scale	0	1	1	1	1	1	1	1	1	.992	1.008	-.0404	
	1's complement; offset half scale symmetrical about zero, no true zero output. MSB complemented (need inverter at B <sub>7</sub> ).	1 (Note 1)	a-c b-d	Positive full scale	0	1	1	1	1	1	1	1	1	1.992	.008	9.9606
				Positive full scale - LSB	0	1	1	1	1	1	1	0	0	1.964	.008	9.9807
				(+) Zero scale	0	0	0	0	0	0	0	0	0	1.000	.992	.040
				(-) Zero scale	1	1	1	1	1	1	1	1	1	.992	1.008	-.040
Offset binary; offset half scale, true zero output. MSB complemented remainder add to I <sub>0</sub> (need inverter at D <sub>7</sub> ).	0 (Note 1)	a-c b-d	Positive full scale	1	1	1	1	1	1	1	1	1	1.992	.008	9.920	
			Positive full scale - LSB	1	1	1	1	1	1	1	0	0	1.984	.016	9.840	
			+ LSB	1	0	0	0	0	0	0	0	1	1	1.008	.992	.080
			Zero scale	1	0	0	0	0	0	0	0	0	1.000	1.000	.000	
OFFSET WITH TRUE ZERO	0	a-c b-d	- LSB	0	1	1	1	1	1	1	1	1	1.992	1.008	-.080	
			Negative full scale + LSB	0	0	0	0	0	0	0	0	1	1	.008	1.992	-9.920
			Negative full scale	0	0	0	0	0	0	0	0	0	0	2.000	-10.000	
			Positive full scale	0	1	1	1	1	1	1	1	1	1	1.992	.008	9.920
2's complement; offset half scale, true zero output. MSB complemented.	0	a-c b-d	Positive full scale - LSB	0	1	1	1	1	1	1	0	0	1.984	.016	9.840	
			+1 LSB	0	0	0	0	0	0	0	0	1	1	1.008	.992	.080
			Zero scale	0	0	0	0	0	0	0	0	0	1.000	1.000	.000	
			-1 LSB	1	1	1	1	1	1	1	1	1	.992	1.008	-.080	
Negative full scale + LSB	1	0	0	0	0	0	0	0	0	1	1	.008	1.992	-9.920		
															Negative full scale	1

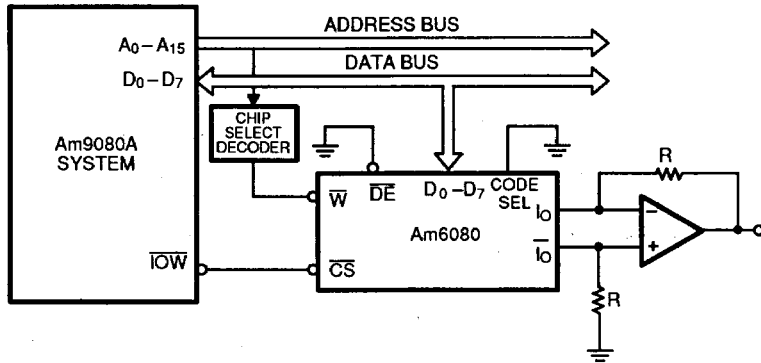
Note:

1. An external inverter is necessary since the code select inverts the MSB and adds a 1 LSB balance current to I<sub>0</sub>. Only one of these features is desired for this code.

ADDITIONAL CODE MODIFICATIONS

1. Any of the offset binary codes may be complemented by reversing the output terminal pair.

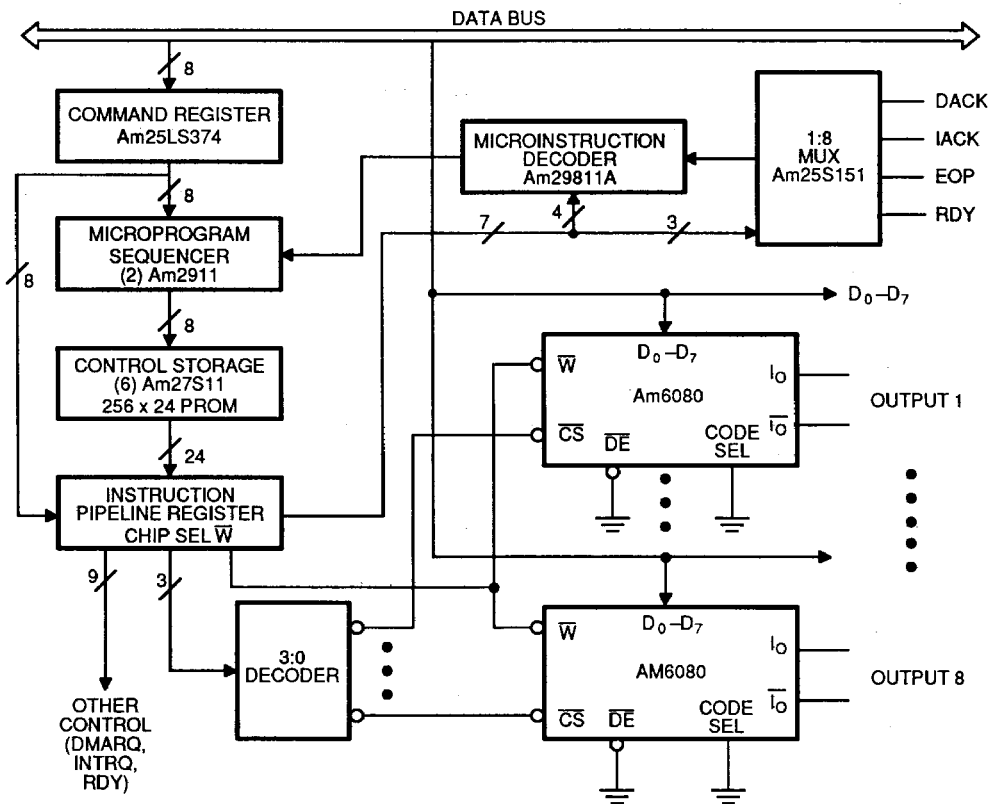
**APPLICATIONS (continued)**



**WRITING DATA INTO THE Am6080 (2's Complement)**  
 PORT 1 :EQU OOH OUTPUT PORT ADDRESS  
 MOV A, M :GET DATA FROM MEMORY  
 OUT 0 PORT 1; :SEND DATA

**Am9080A Data System**

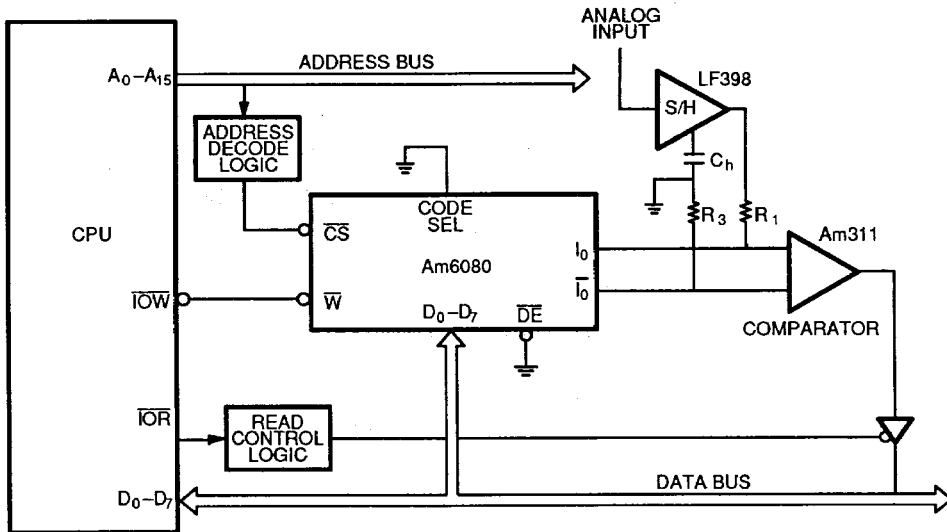
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**APPLICATIONS (continued)**

**ANALOG/DIGITAL CONVERTER  
UNDER  
SOFTWARE CONTROL**



03941-011C

**Am6080A SOFTWARE FOR A/D CONVERSION USING Am6080**

SEQ	SOURCE	STATEMENT	SEQ	SOURCE	STATEMENT
0	PORT1 EQU 00H	;6080 A/O PORT ADDRESS	13	IN PORT3	;INPUT FROM COMP
1	PORT3 EQU 02H	;COMPARATOR ADDRESS	14	CRA A	;SET SIGN FLAG
2	ORG 3E50H		15	JM NEXT	;IF SMALLER GO TO NEXT BIT
3	START: LXI SP, STAKS-16	;INITIAL STAKS POINTER	16	MOV D,E	;SAVE RESULT
4	SAMPLE: CALL ADCON	;CALL A/D CONVERSION	17	NEXT: MOV A,B	;GET NEXT TRIAL BIT
5	JMP SAMPLE	;NEXT SAMPLE	18	RAR	;SHIFT RIGHT ONCE
6	ADCON: XRA A	;CLEAR ACC	19	RC	;RETURN ON CARRY
7	MOV D,A	;CLEAR D REG	20	MOV B,A	;STORE TEST BIT
8	STC	;SET CARRY	21	ADD D	;ACCUMULATE RESULT
9	RAR	;SET BIT 7 TO 1	22	JMP LOOP	;TRY NEXT BIT
10	MOV B,A	;STORE TEST BIT AT B REGISTER	23	STAKS: DS 16	
11	LOOP: MOV E,A	;STORE TEST WORD	24	END START	
12	OUT PORT1	;OUTPUT TO A/D			

**Instrumentation and Control**

- Data Acquisition
- Data Distribution
- Function Generation
- Servo Controls
- Programmable Power Supplies
- Digital Zero Scale Calibration
- Digital Full Scale Calibration
- Digitally Controlled Offset Null

**Audio**

- Music Distribution
- Digitally Controlled Gain
- Potentiometer Replacement
- Digital Recording
- Speech Digitizing

**Signal Processing**

- CRT Displays
- IF Gain Control
- 8 x 8 Digital Multiplication
- Line Driver

**A/D Converters**

- Ratiometric ADC
- Differential Input ADC
- Microprocessor Controlled ADC

**D/A Converters**

- Signal Quadrant Multiplying DAC
- Two Quadrant Multiplying DAC
- Four Quadrant Multiplying DAC



**MAXIMUM RATINGS**

Storage Temperature	-65 to +150°C
Lead Temperature	
(Soldering, 60 sec)	300°C
Logic Inputs	-5 to +18 V
Analog Current Outputs	-12 to +18 V
Reference Inputs (V <sub>14</sub> , V <sub>15</sub> )	V- to V+
Reference Input	
Differential Voltage (V <sub>14</sub> to V <sub>15</sub> )	±18 V
Reference Input Current (I <sub>14</sub> )	1.25 mA

Stresses above those listed under MAXIMUM RATINGS may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

**OPERATING RANGES**

Military	-55 to +125°C
Commercial	0 to +70°C
Power Supply Voltage	±18 V
Die Size	0.083 x 0.121 in.

Operating ranges define those limits between which the functionality of the device is guaranteed.

**DC CHARACTERISTICS**

These specifications apply for  $V_+ = +5\text{ V}$ ,  $V_- = -15\text{ V}$ ,  $I_{\text{REF}} = 0.5\text{ mA}$ , over the operating temperature range unless otherwise specified. Output characteristics refer to all outputs.

Included in Group A Subgroup. 1, 2, 3, 4, 5, 6 unless otherwise noted.

Parameter	Description	Test Conditions	Am6080A			Am6080			Unit	
			Min	Typ	Max	Min	Typ	Max		
	Resolution		8	8	8	8	8	8	bits	
	Monotonicity		8	8	8	8	8	8	bits	
DNL	Differential Nonlinearity		—	—	$\pm 0.19$	—	—	$\pm 0.39$	%FS	
NL	Nonlinearity		—	—	$\pm 0.1$	—	—	$\pm 0.19$	%FS	
$I_{\text{FS}}$	Full Scale Current	$V_{\text{REF}} = 10.000\text{ V}$ $R_{1,4} = R_{1,5} = 20.000\text{ k}\Omega$ $T_A = 25^\circ\text{C}$	1.984	1.992	2.000	1.976	1.992	2.008	mA	
$\text{TCI}_{\text{FS}}$	Full Scale Tempco		—	$\pm 5$	$\pm 20$	—	$\pm 10$	$\pm 40$	ppm/ $^\circ\text{C}$	
			—	.0005	$\pm 0.002$	—	.001	$\pm 0.004$	%FS/ $^\circ\text{C}$	
$V_{\text{OC}}$	Output Voltage Compliance		-10	—	+18	-10	—	+18	V	
$I_{\text{FSS}}$	Full Scale Symmetry	$I_{\text{FS1}} - \overline{I_{\text{FS1}}}$	—	$\pm 0.1$	$\pm 1.0$	—	$\pm 0.2$	$\pm 2.0$	$\mu\text{A}$	
$I_{\text{ZS}}$	Zero Scale Current			0.01	1.0		0.01	2.0	$\mu\text{A}$	
$I_{\text{RR}}$	Reference Current Range	$V_- = -5\text{ V}$	0	0.5	0.55	0	0.5	0.55	mA	
		$V_- = -15\text{ V}$	0	0.5	1.1	0	0.5	1.1		
$V_{\text{IL}}$	Logic Input Levels	Logic "0"	—	—	0.8	—	—	0.8	V	
$V_{\text{IH}}$		Logic "1"	2.0	—	—	2.0	—	—		
$I_{\text{IN}}$	Logic Input Current	$V_{\text{IN}} = -5\text{ V to } +18\text{ V}$	—	—	40	—	—	40	$\mu\text{A}$	
$V_{\text{IS}}$	Logic Input Swing	$V_- = -15\text{ V}$	-5	—	+18	-5	—	+18	V	
$I_{\text{IS}}$	Reference Bias Current		0	-0.5	-2.0	0	-0.5	-2.0	$\mu\text{A}$	
d/dt	Reference Input Slew Rate	$R_{1,4(\text{REQ})} = 800\ \Omega$ (Note 2) $C_C = 0\text{ pF}$	4.0	8.0	—	4.0	8.0	—	mA/ $\mu\text{s}$	
$\text{PSSI}_{\text{FS}+}$	Power Supply Sensitivity	$V_+ = +4.5\text{ V to } +5.5\text{ V}$ , $V_- = -15\text{ V}$	—	$\pm 0.0003$	$\pm 0.01$	—	$\pm 0.0005$	$\pm 0.01$	%FS/%	
$\text{PSSI}_{\text{FS}-}$		$V_- = -13.5\text{ V to } -16.5\text{ V}$ , $V_+ = +5\text{ V}$	—	$\pm 0.0005$	$\pm 0.01$	—	$\pm 0.0005$	$\pm 0.01$		
$V_+$ $V_-$	Power Supply Range	$I_{\text{REF}} = 0.5\text{ mA}$ $V_{\text{OUT}} = 0\text{ V}$	$V_- = -15\text{ V}$	4.5	—	18	4.5	—	18	V
			$V_+ = +5\text{ V}$	-18	—	-12	-18	—	-12	
$I_+$ $I_-$	Power Supply Current	$V_+ = +5\text{ V}$ , $V_- = -15\text{ V}$	—	9.8	14.7	—	9.8	14.7	mA	
			—	-7.4	-9.9	—	-7.4	-9.9		
$I_+$ $I_-$	Power Supply Current	$V_+ = +15\text{ V}$ , $V_- = -15\text{ V}$	—	9.8	14.7	—	9.8	14.7	mA	
			—	-7.4	-9.9	—	-7.4	-9.9		
$P_D$	Power Dissipation (Note 1)	$V_+ = +5\text{ V}$ , $V_- = -15\text{ V}$	—	160	222	—	160	222	mW	
		$V_+ = +15\text{ V}$ , $V_- = -15\text{ V}$	—	258	369	—	258	369		

**Notes:**

- Derate Hermetic DIP 10 mW/ $^\circ\text{C}$  above 100 $^\circ\text{C}$ . Plastic package 6.8 mW/ $^\circ\text{C}$ . Leadless 10 mW/ $^\circ\text{C}$  above 100 $^\circ\text{C}$ .
- Not tested. Guaranteed by characterization.

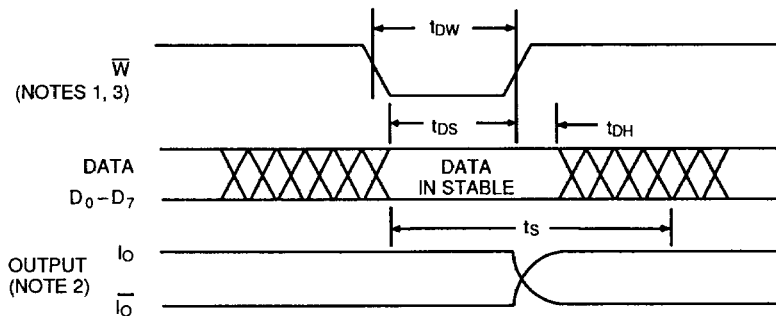
**AC CHARACTERISTICS**

$V_+ = +5\text{ V}$ ,  $V_- = -15\text{ V}$ ,  $I_{REF} = 0.5\text{ mA}$ ,  $R_L < 500\ \Omega$ ,  $C_L < 15\text{ pF}$  over the operating temperature range unless otherwise specified.

Parameter	Description		Conditions	Commercial			Military			Unit
				Min.	Typ.	Max.	Min.	Typ.	Max.	
$t_s$	Setting Time, All Bits Switched (Note 4)		$T_A = 25^\circ\text{C}$ Settling to $\pm 1/2$ LSB		160			160		ns
$t_{PLH}$	Propagation	Each bit	$T_A = 25^\circ\text{C}$ 50% to 50%		80	160		80	160	ns
$t_{PHL}$	Delay (Note 4)	All bits switched			80	160		80	160	
$t_{DH}$	Data Hold Time (Note 4)		See timing diagram	10	-30		10	-30		ns
$t_{DS}$	Data Set Up Time (Note 4)		See timing diagram	80	35		100	35		ns
$t_{DW}$	Data Write Time (Note 4)		See timing diagram	80	35		100	35		ns

**Notes:**

- $t_{DW}$  is the overlap of  $\overline{W}$  LOW,  $\overline{CS}$  LOW, and  $\overline{DE}$  LOW. All three signals must be LOW to enable the latch. Any signal going inactive latches the data.
- $t_s$  is measured with the latches open from the time the data becomes stable on the inputs to the time when the outputs are settled to within  $\pm 1/2$  LSB. All bits switched on or off.
- The internal time delays from  $\overline{CS}$ ,  $\overline{W}$ , and  $\overline{DE}$  inputs to the enabling of the latches are all equal.
- Not tested. Guaranteed by characterization.

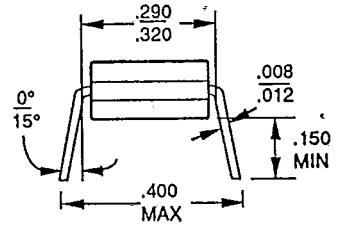
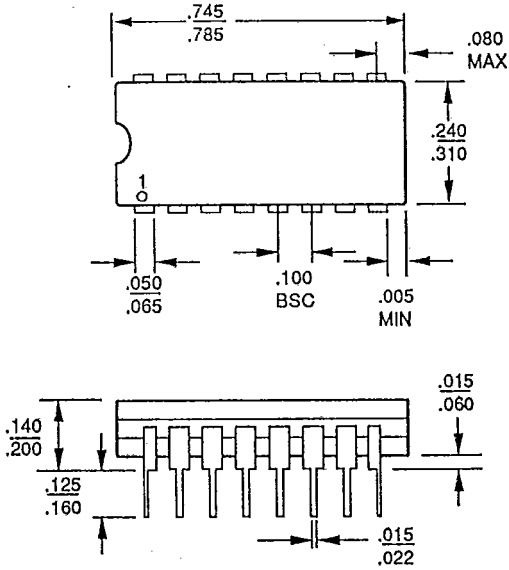
**Timing Diagram**

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# PHYSICAL DIMENSIONS CD 016

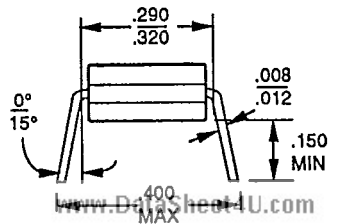
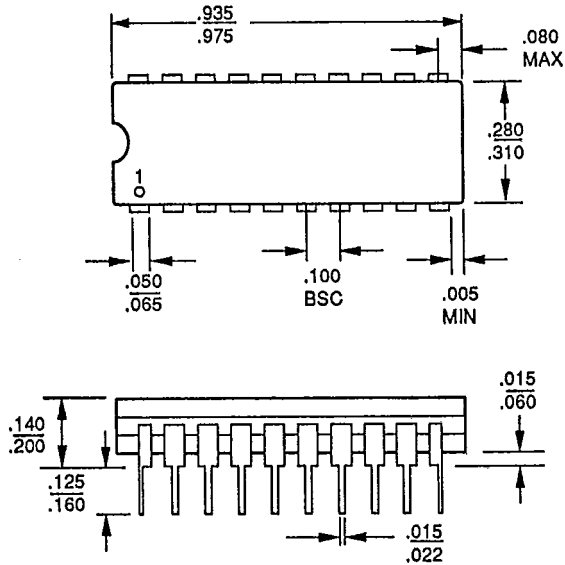
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T-90-20



07319B

# CD 020

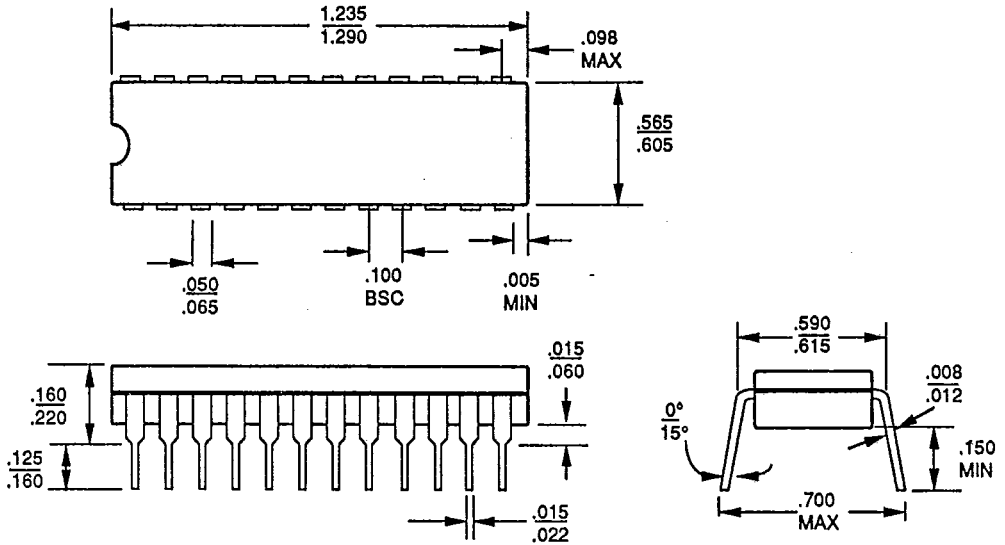


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PHYSICAL DIMENSIONS (continued)  
CD 024

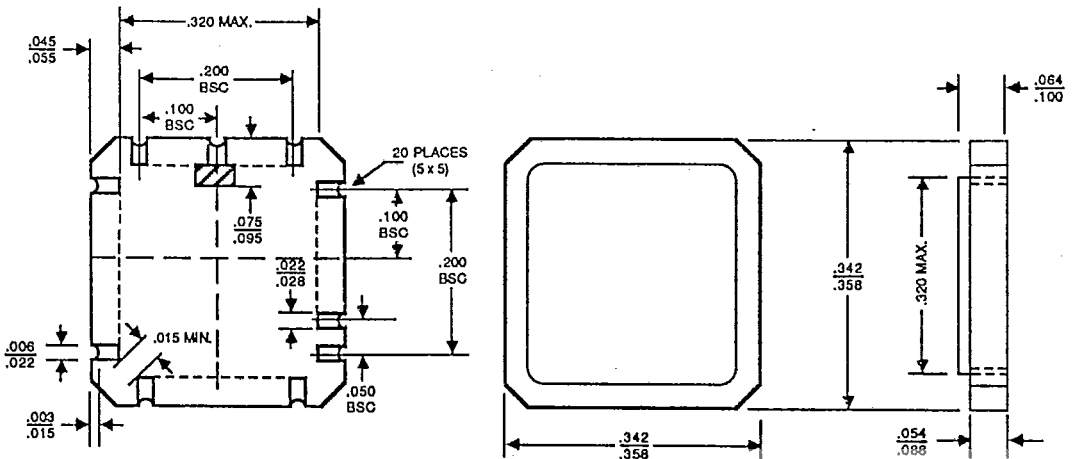
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CL 020

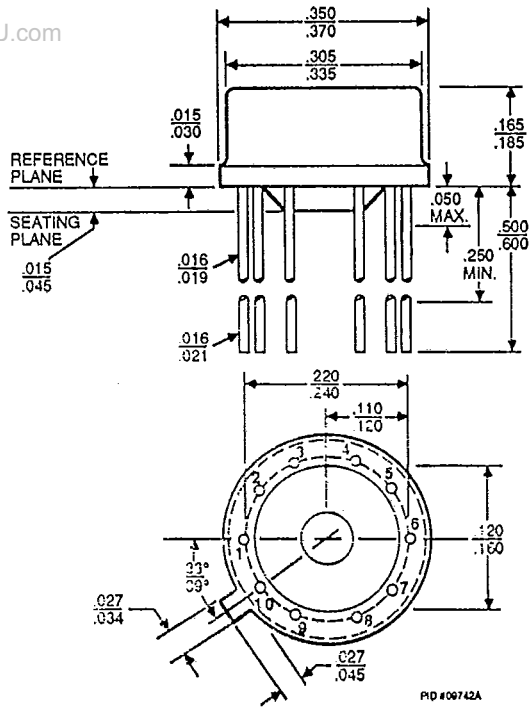


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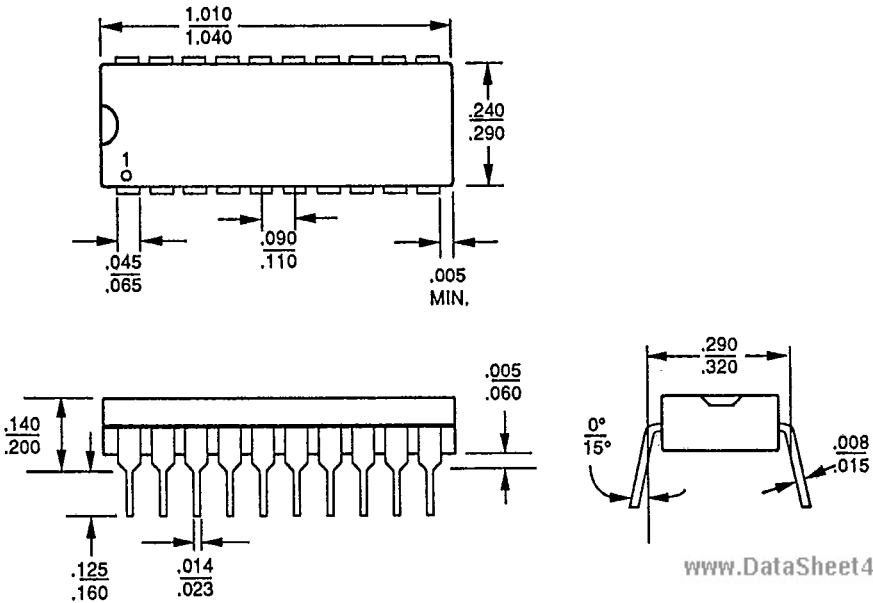
PID #07318C

PHYSICAL DIMENSIONS (continued)  
MC 010

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PD 020



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