



DAC-HZ Series

T-51-09-12 12-Bit Hybrid
Digital-to-Analog Converters

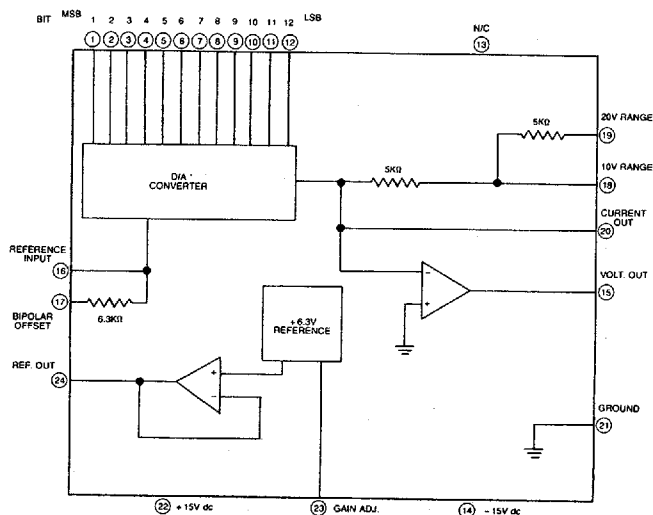
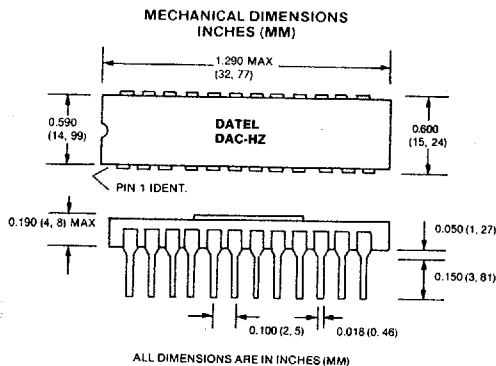
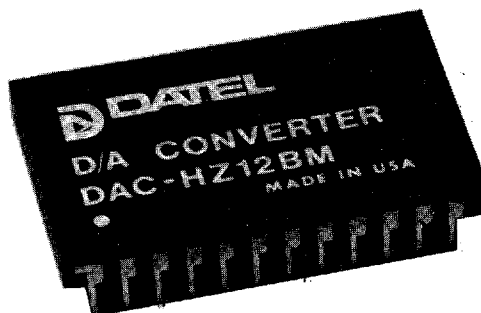
FEATURES

- 12-Bit binary
- 5 Output ranges
- 3 Microseconds settling time
- Internal reference and output amplifier
- High performance

GENERAL DESCRIPTION

The DAC-HZ Series are high performance, hybrid 12-bit binary digital-to-analog converters. These converters are manufactured using thin- and thick-film technology. They are complete and self-contained with a precision internal reference and fast output operational amplifier. Pin-programmable output voltage ranges are provided for a high degree of application flexibility; the output voltage ranges are 0 to $\pm 5V$ dc, 0 to $+10V$ dc, $\pm 2.5V$ dc, $-5V$ dc, and $\pm 10V$ dc. Current output is also provided.

The DAC-HZ Series contains a precision zener reference circuit. This eliminates code-dependent ground currents by routing current from the positive supply to the internal ground node as determined by the R-2R ladder network. The internal feedback resistors for the on-board amplifier track the ladder network resistors, enhancing temperature performance. The excellent tracking of the resistors results in a differential nonlinearity tempo of 2 ppm/ $^{\circ}C$ maximum. The temperature coefficient of gain is 20 ppm/ $^{\circ}C$ maximum and tempo of zero is ± 3 ppm/ $^{\circ}C$ maximum.



INPUT/OUTPUT CONNECTIONS

PIN	FUNCTION	PIN	FUNCTION
1	BIT 1 IN	13	NO CONNECTION
2	BIT 2 IN	14	-15V dc
3	BIT 3 IN	15	VOLT. OUT
4	BIT 4 IN	16	REFERENCE IN
5	BIT 5 IN	17	BIPOLAR OFFSET
6	BIT 6 IN	18	10V RANGE
7	BIT 7 IN	19	20V RANGE
8	BIT 8 IN	20	CURRENT OUT
9	BIT 9 IN	21	GROUND
10	BIT 10 IN	22	+15V dc
11	BIT 11 IN	23	GAIN ADJUST
12	BIT 12 IN	24	REFERENCE OUT

DAC-HZ Series



FUNCTIONAL SPECIFICATIONS

Typical at 25°C and $\pm 15V$ supplies unless otherwise noted.

INPUTS	DAC-HZ12B (Binary)	DAC-HZ12D (BCD)
Resolution	12 Binary bits	3 BCD Digits
Coding, unipolar output....	Comp. Binary	Comp. BCD
Coding, bipolar output....	Comp. Off. Binary	—
Input Logic Level, bit ON ("0")	0V to +0.8V at -1 mA	—
Input Logic Level, bit OFF ("1")	+2.4V to +5.5V at +40 μA	—
Logic Loading	1 TTL load	—
OUTPUTS		
Output Current, unipolar....	0 to -2 mA, $\pm 20\%$	0 to -1.25 mA, $\pm 10\%$
Output Current, bipolar....	± 1 mA, $\pm 20\%$	—
Voltage Compliance, Iout....	$\pm 2.5V$	—
Output Impedance, Iout, unipolar	5 k ohms	—
Output Impedance, Iout, bipolar	2.8 k ohms	—
Output Voltage Ranges, unipolar	0V to +5V 0V to +10V	0 to +2.5V 0 to +5V 0 to +10V
Output Voltage Ranges, bipolar	$\pm 2.5V$ $\pm 5V$ $\pm 10V$	— — —
Output Current, Vout.....	± 5 mA min.	—
Output Impedance, Vout....	0.05 ohm	—
PERFORMANCE		
Voltage Output Nonlinearity	$\pm \frac{1}{2}$ LSB max.	$\pm \frac{1}{4}$ LSB max.
Differential Nonlinearity....	$\pm \frac{3}{4}$ LSB max.	$\pm \frac{1}{4}$ LSB max.
Gain Error, before trimming..	$\pm 0.1\%$ of FSR ¹	—
Zero Error, before trimming..	$\pm 0.05\%$ of FSR ¹	—
Gain Tempco, max.....	± 20 ppm/°C	—
Zero Tempco, unipolar, max..	± 3 ppm/°C of FSR ¹	—
Offset Tempco, bipolar, max..	± 10 ppm/°C of FSR ¹	—
Diff. Nonlinearity Tempco, max.....	± 2 ppm/°C of FSR ¹	—
Monotonicity	Over oper. temp. range	—
Settling Time, Iout to $\frac{1}{2}$ LSB ²	300 nsec.	—
Settling Time, Vout to $\frac{1}{2}$ LSB	3 μ sec. ³	—
Slew Rate	20V/ μ sec.	—
Power Supply Rejection.....	$\pm 0.002\%$ FSR/% Supply ¹	—
POWER REQUIREMENTS		
Power Supply Voltage	+15V dc, $\pm 0.5V$ dc at 10 mA -15V dc, $\pm 0.5V$ dc at 16 mA $\pm 12V$ dc operation ⁴	—
PHYSICAL/ENVIRONMENTAL		
Operating Temperature Ranges	0°C to +70°C and -55°C to +125°C -65°C to +150°C	—
Storage Temperature Range.	1300 x 0.800 x 0.160 inches	—
Package Size	24 Pin Ceramic DIP	—
Package Type	Kovar 0.010 x 0.018 inches	—
Pins	0.22 ounces (63 grams)	—
Weight	—	—
*Specifications same as first column		
FOOTNOTES:		
1. FSR is full scale range and is 10V for 0 to +10V or -5V to +5V output; 20V for $\pm 10V$ output, etc.		
2. Current output mode.		
3. For 2.5k or 5k feedback. For 10k feedback the settling time is 4 microseconds.		
4. For $\pm 12V$ dc operation, contact factory.		

TECHNICAL NOTES

1. The DAC-HZ12 series converters are designed and factory calibrated to give $\pm \frac{1}{2}$ LSB linearity (binary version) with respect to a straight line between end points. This means that if zero and full scale are exactly adjusted externally, the relative accuracy will be $\pm \frac{1}{2}$ LSB everywhere over the full output range without any additional adjustments.
2. These converters must be operated with local supply by-pass capacitors from +15V to ground and -15V to ground. Tantalum type capacitors of 1 μF are recommended and should be mounted as close as possible to the converter. If the converters are used in a high frequency noise environment a 0.01 μF ceramic capacitor should be used across each tantalum capacitor.
3. When operating in the current output mode the equivalent internal current source of 2 mA must drive both the internal source resistances and the external load resistor. A 300 nanosecond output settling time is achieved for the voltage across a 100 ohm load resistor; for higher value resistors the settling time becomes longer due to the output capacitance of the converter. For fastest possible voltage output for a large transition, an external fast settling amplifier such as DATEL's AM-500 should be used in the inverting mode. Settling time of less than 1 microsecond can be achieved. See application diagram.

CALIBRATION PROCEDURE

1. Select the desired output range and connect the converter up as shown in the Output Range Selection table and the Standard Connection diagrams.
2. To calibrate, refer to the Coding Tables. Note that complementary coding is used.
3. **Zero and Offset Adjustments**
For unipolar operation set all digital inputs to "1" (+2.0 to +5.5V) and adjust the ZERO ADJ. potentiometer for zero output voltage or current. For bipolar operation set all digital inputs to "1" and adjust the OFFSET ADJ. potentiometer for the negative full scale (for voltage out) or positive full scale (for current out) output value shown in the Coding Table.
4. **Gain Adjustment**
Set all digital inputs to "0" (0V to +0.8V) and adjust the GAIN ADJ. potentiometer for the positive full scale (for voltage out) or negative full scale (for current out) output value shown in the Coding Table.

OUTPUT RANGE SELECTION

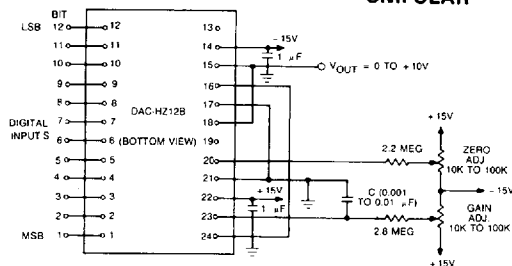
BIN. RANGE	CONNECT THESE PINS TOGETHER				
$\pm 10V$	15 & 19	17 & 20	—	16 & 24	
$\pm 5V$	15 & 18	17 & 20	—	16 & 24	
$\pm 2.5V$	15 & 18	17 & 20	19 & 20	16 & 24	
+10V	15 & 18	17 & 21	—	16 & 24	
+5V	15 & 18	17 & 21	19 & 20	16 & 24	
± 1 mA	—	17 & 20	—	16 & 24	
-2 mA	—	17 & 21	—	16 & 24	

VOLTAGE OUTPUT IS AT PIN 15.
CURRENT OUTPUT IS AT PIN 20.

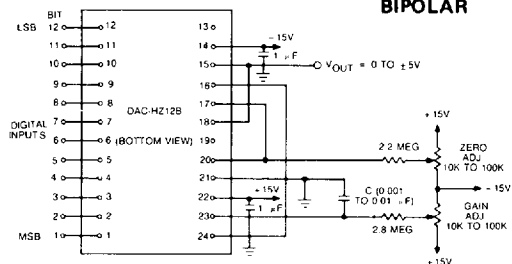
VOLTAGE OUTPUT CONNECTIONS

(FOR DIFFERENT OUTPUT SCALING REFER TO OUTPUT RANGE SELECTION TABLE)

UNIPOLAR

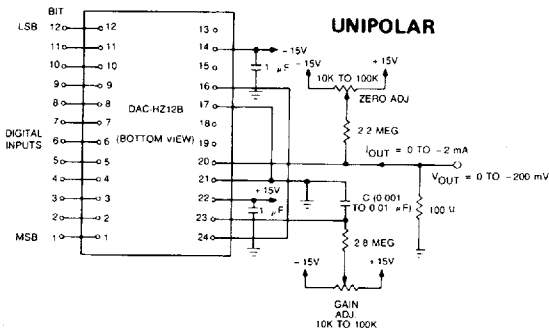


BIPOLAR

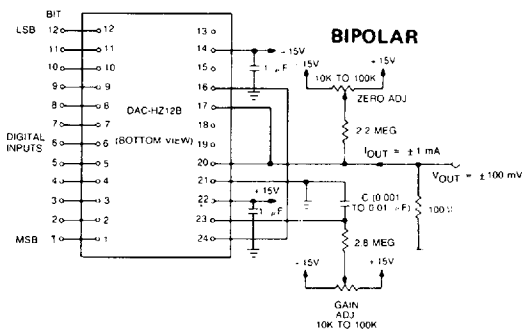


CURRENT OUTPUT CONNECTIONS

UNIPOLAR



BIPOLAR



CODING TABLES

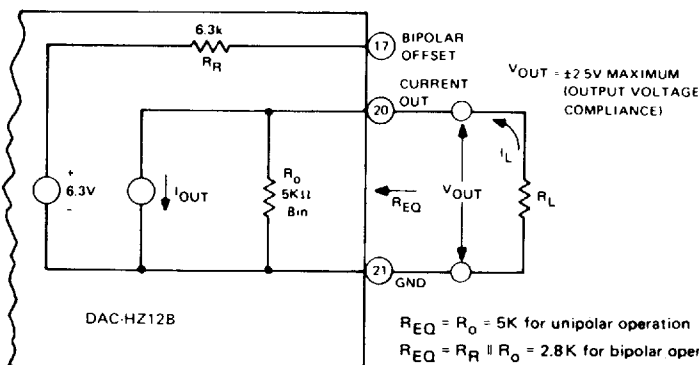
UNIPOLAR OUTPUT — COMPLEMENTARY BINARY

BINARY INPUT CODE			UNIPOLAR OUTPUT RANGES		
MSB	LSB		0 TO +10V	0 TO +5V	0 TO -2 mA
0000	0000	0000	+9.9976V	+4.9988V	-1.9995 mA
0011	1111	1111	+7.5000	+3.7500	-1.5000
0111	1111	1111	+5.0000	+2.5000	-1.0000
1011	1111	1111	+2.5000	+1.2500	-0.5000
1111	1111	1110	+0.0024	+0.0012	-0.0005
1111	1111	1111	0.0000	0.0000	0.0000

BIPOLAR OUTPUT — COMPLEMENTARY OFFSET BINARY

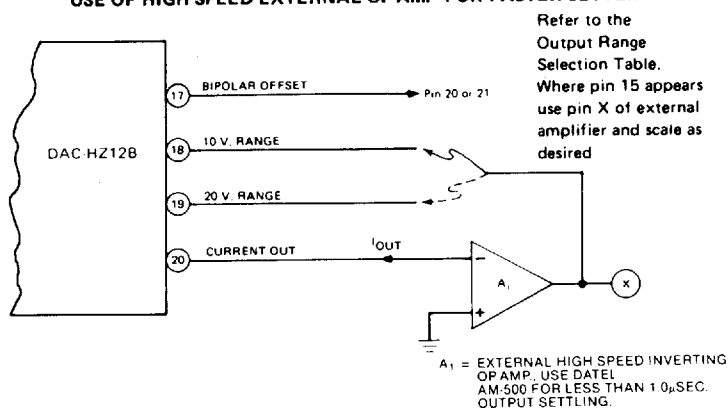
INPUT CODE			BIPOLAR OUTPUT RANGES			
MSB	LSB		±10V	±5V	±2.5V	±1 mA
0000	0000	0000	+9.9951V	+4.9976V	+2.4988V	-0.9995 mA
0011	1111	1111	+5.0000	+2.5000	+1.2500	-0.5000
0111	1111	1111	0.0000	0.0000	0.0000	0.0000
1011	1111	1111	-5.0000	-2.5000	-1.2500	+0.5000
1111	1111	1110	-9.9951	-4.9976	-2.4988	+0.9995
1111	1111	1111	-10.0000	-5.0000	-2.5000	+1.0000

EQUIVALENT CURRENT MODE OUTPUT CIRCUIT

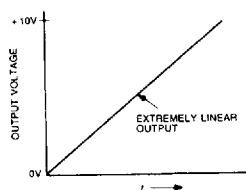
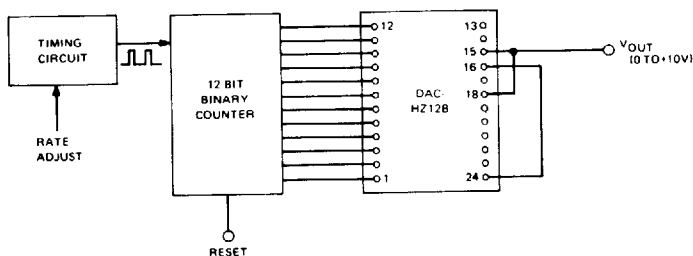
 $R_{EQ} = R_O = 5K$ for unipolar operation $R_{EQ} = R_R \parallel R_O = 2.8K$ for bipolar operation $I_{OUT} = 2mA$ binary

DAC-HZ Series

USE OF HIGH SPEED EXTERNAL OP AMP FOR FASTER SETTLING



PRECISION, LOW COST BASE LINE RAMP GENERATOR



THIS CIRCUIT DEVELOPS A HIGHLY LINEAR (0.01%) OUTPUT VOLTAGE RAMP FROM 0 TO +10V. THE RAMP CAN BE MADE AS SLOW AS DESIRED WITHOUT AFFECTING LINEARITY BY SETTING THE PULSE RATE OF THE TIMING CIRCUIT TO THE PROPER VALUE. THE OUTPUT RAMP IS GENERATED IN DISCRETE STEPS OF .024% FS (4096 STEPS FOR FS CHANGE).

ORDERING INFORMATION

MODEL NO.	OPERATING TEMP. RANGE	SEAL
DAC-HZ12BGC	0 to +70 °C	Epoxy
DAC-HZ12BMC	0 to +70 °C	Herm.
DAC-HZ12BMM	-55 to +125 °C	Herm.
DAC-HZ12DGC	0 to +70 °C	Epoxy
DAC-HZDMC	0 to +70 °C	Herm.
DAC-HZ12DMM	-55 to +125 °C	Herm.
DAC-HZ12DMM-QL	-55 to +125 °C	Herm.
DAC-HZB/883B	-55 to +125 °C	Herm.