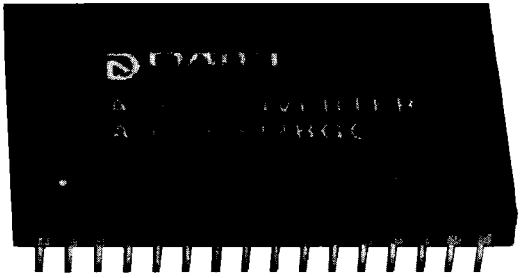
ADC-HX, ADC-HZ Series
12-Bit, Analog-to-Digital Converters

FEATURES

- **12-Bit resolution**
- **8-or 20-Microseconds conversions**
- **5 Input ranges**
- **Internal high Z buffer**
- **Short-cycle operation**



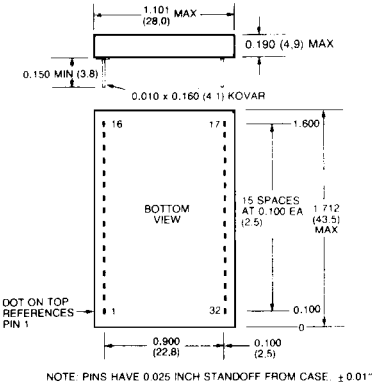
GENERAL DESCRIPTION

The ADC-HX12B and ADC-HZ12B are self-contained, high performance, 12-bit A/D converters manufactured with thick-and thin-film hybrid technology. They use the successive approximation conversion technique to achieve a 12-bit conversion in 20 and 8 microseconds respectively. Five input voltage ranges are programmable by external pin connection: 0 to +5V, 0 to +10V, ±2.5V, ±5V, and ±10V. An internal buffer amplifier is also provided for applications where 100 megohm input impedance is required.

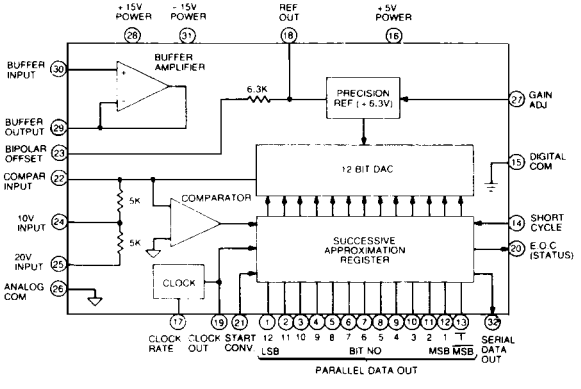
These converters utilize a fast 12-bit monolithic DAC which includes a precision zener reference source. The circuit also contains a fast monolithic comparator, a monolithic 12-bit successive approximation register, a clock and a monolithic buffer amplifier. Nonlinearity is specified at ±½ LSB maximum.

Both models have identical operation except for conversion speed. They can be short-cycled to give faster conversion in lower resolution applications. Use of the internal buffer amplifier increases conversion time by 3 microseconds, the settling time of the amplifier. Output coding is complementary binary, complementary offset binary, or complementary two's complement. Serial data is also brought out. The package is a 32-pin ceramic case.

MECHANICAL DIMENSIONS INCHES (MM)



NOTE: PINS HAVE 0.025 INCH STANDOFF FROM CASE. ±0.01"



INPUT/OUTPUT CONNECTIONS

PIN	FUNCTION	PIN	FUNCTION
1	BIT 12 OUT (LSB)	17	CLOCK RATE
2	BIT 11 OUT	18	REF OUT
3	BIT 10 OUT	19	CLOCK OUT
4	BIT 9 OUT	20	E.O.C. (STATUS)
5	BIT 8 OUT	21	START CONVERT
6	BIT 7 OUT	22	COMPAR INPUT
7	BIT 6 OUT	23	BIPOLAR OFFSET
8	BIT 5 OUT	24	10V RANGE
9	BIT 4 OUT	25	20V RANGE
10	BIT 3 OUT	26	ANALOG COM
11	BIT 2 OUT	27	GAIN ADJ
12	BIT 1 OUT (MSB)	28	+15V POWER
13	BIT 1 OUT (MSB)	29	BUFFER OUTPUT
14	SHORT CYCLE	30	BUFFER INPUT
15	DIGITAL COM	31	-15V POWER
16	+5V POWER	32	SERIAL OUTPUT

FUNCTIONAL SPECIFICATIONS

Typical at 25°C, ±15V and +5V supplies unless otherwise noted.

INPUTS	ADC-HX12B ADC-HZ12B
Analog Input Ranges, unipolar	0 to +5V, 0 to +10V FS
Analog Input Ranges, bipolar	±2.5V, ±5V, ±10V FS
Input Impedance	2.5K (0 to +5V, ±2.5V) 5K (0 to +10V, ±5V) 10K (±10V)
Input Impedance with Buffer	100 Megohms
Input Bias Current of Buffer	125 nA typical, 250 nA max.
Input Overvoltage	±15V
Start Conversion	2V min. to 5.5V max. positive pulse with duration of 100 nsec. min. Rise and fall times <30 nsec. Logic "1" to "0" transition resets converter and initiates next conversion. Loading: 2 TTL loads
OUTPUTS[1]	
Parallel Output Data	12 parallel lines of data held until next conversion command. V_{OUT} ("0") ≤ +0.4V V_{OUT} ("1") ≥ +2.4V
Coding, unipolar	Complementary Binary
Coding, bipolar	Complementary Offset Binary Complementary Two's Complement
Serial Output Data	NRZ successive decision pulses out, MSB first. Compl. Binary or Compl. Offset Binary Coding
End of Conversion (Status)	Conversion status signal. Output is logic "1" during reset and conversion and logic "0" when conversion complete.
Clock Output	Train of positive going +5V 100 nsec. pulses. 600 kHz for ADC-HX12B and 1.5 MHz for ADC-HZ12B (pin 17 grounded).
PERFORMANCE	
Resolution	12 bits (1 part in 4096)
Nonlinearity	±½ LSB max.
Differential Nonlinearity	±¾ LSB max.
Gain Error, before adjustment	±0.1%
Zero Error, unipolar, before adj.	±0.05% of FSR[3]
Offset Error, bipolar, before adj.	±0.1% of FSR[3]
Temp. Coeff. of Gain	±20 ppm/°C max.
Temp. Coeff. of Zero, unipolar	±5 ppm/°C of FSR max.[3]
Temp. Coeff. of Offset, bipolar	±10 ppm/°C of FSR max.[3]
Diff. Nonlinearity Tempco	±2 ppm/°C of FSR[3]
No Missing Codes	Over oper. temp. range
Conversion Time[2], 12 bits	20 µsec. max. 8.0 µsec. max.
10 bits[4]	15 µsec. max. 6.0 µsec. max.
8 bits[4]	10 µsec. max. 4.0 µsec. max.
Buffer Settling Time, 10V step	3.0 µsec. to 0.01%
Power Supply Rejection	0.004%/% Supply max.
POWER REQUIREMENTS	
Power Supply Voltage	+15V dc ±0.5V dc at 20 mA −15V dc ±0.5V dc at 25 mA + 5V dc ±0.25V dc at 85 mA

PHYSICAL/ENVIRONMENTAL	
Operating Temperature Range	0 to +70°C or −55 to +125°C
Storage Temperature Range	−65°C to +150°C
Package Size	1.700 x 1.100 x 0.160 inches
Package Type	32 pin ceramic
Pins	0.010 x 0.018 inch Kovar
Weight	0.5 ounces (14 grams)

FOOTNOTES:

1. All digital outputs can drive 2 TTL loads.
2. Without buffer amplifier used. ADC-HZ12B may require external adjustment of clock rate.
3. FSR is full scale range and is 10V for 0 to +10V or ±5V input and 20V for ±10V input.
4. Short cycled operation.

TECHNICAL NOTES

1. It is recommended that the ±15V power input pins both be bypassed to ground with a 0.01 µF ceramic capacitor in parallel with a 1 µF electrolytic capacitor and the +5V power input pin be bypassed to ground with a 10 µF electrolytic capacitor as shown in the connection diagrams. In addition, pin 27 should be bypassed to ground with a 0.01 µF ceramic capacitor. These precautions will assure noise free operation of the converter.

2. Digital Common (pin 15) and Analog Common (pin 26) are not connected together internally, and therefore must be connected as directly as possible externally. It is recommended that a ground plane be run underneath the case between the two commons. Analog ground and ±15V power ground should be run to pin 26 whereas digital ground and +5V dc ground should be run to pin 15.

3. External adjustment of zero or offset and gain are provided for by trimming potentiometers connected as shown in the connection diagrams. The potentiometer values can be between 10K and 100K ohms and should be 100 ppm/ °C cermet types. The adjustment range is ±0.2% of FSR for zero or offset and ±0.3% for gain. The trimming pots should be located as close as possible to the converter to avoid noise pickup. In some cases, for example 8 bit short-cycled operation, external adjustment may not be necessary.

4. Short-cycled operation results in shorter conversion times where the conversion can be truncated to less than 12 bits. This is done by connecting pin 14 to the output bit following the last bit desired. For example, for an 8-bit conversion, pin 14 is connected to bit 9 output. Maximum conversion times are given for short-cycled conversions of 8 or 10 bits. In these two cases the clock rate is also speeded up by connecting the clock rate adjust (pin 17) to +5V dc (10 bits) or +15V dc (8 bits). The clock rate should not be arbitrarily speeded up to exceed the maximum conversion rate at a given resolution, however, or missing codes will result.

DATEL, Inc. 11 Cabot Boulevard, Mansfield, MA 02048-1194/TEL (508) 339-3000/TLX 174388/FAX (508) 339-6356

5. Note that output coding is complementary coding. For unipolar operation it is complementary binary and for bipolar operation it is complementary offset binary or complementary 2's complement. In cases where bipolar coding of offset binary or 2's complement is required, this can be achieved by inverting the analog input to the converter (using an op amp connected for gain of −1.0000). The converter is then calibrated so that −FS analog input gives an output code of 0000 0000 0000, and +FS − 1 LSB gives 1111 1111 1111.
6. These converters dissipate 1.7 watts maximum of power. The case to ambient thermal resistance is approximately 25°C per watt. For ambient temperatures above 50°C, care should be taken not to restrict air circulation in the vicinity of the converter.
7. These converters can be operated with an external clock. To accomplish this, a negative pulse train is applied to START CONVERT (Pin 21). The rate of the external clock must be lower than the rate of the internal clock as adjusted (see clock rate adjustment diagram) for the converter resolution selected. The pulse width of the external clock should be between 100 nanoseconds and 300 nanoseconds. Each N-bit conversion cycle requires a pulse train of N + 1 clock pulses for completion, e.g., an 8-bit conversion requires 9 clock pulses for completion. A continuous pulse train may be used for consecutive conversions, resulting in an N-bit conversion every N + 1 pulses, or the E.O.C. output may be used to gate a continuous pulse train for single conversions.
8. When the input buffer amplifier is used, a delay equal to its settling time must be allowed between the input level change, such as a multiplexer channel change, and the negative-going edge of the START CONVERSION pulse. If the buffer is not required, its input (pin 30) should be tied to ANALOG GROUND (pin 26). This prevents the unused amplifier from introducing noise into the converter. For applications not using the internal buffer, the converter must be driven from a source with an extremely low input impedance.

CONNECTIONS AND CALIBRATION

Input Connections

INPUT VOLT. RANGE	WITHOUT BUFFER			WITH BUFFER			
	INPUT PIN	CONNECT THESE PINS TOGETHER		INPUT PIN	CONNECT THESE PINS TOGETHER		
0 to +5V	24	22 & 25	23 & 26	30	22 & 25	23 & 26	29 & 24
0 to +10V	24	—	23 & 26	30	—	23 & 26	29 & 24
±2.5V	24	22 & 25	23 & 22	30	22 & 25	23 & 22	29 & 24
±5V	24	—	23 & 22	30	—	23 & 22	29 & 24
±10V	25	—	23 & 22	30	—	23 & 22	29 & 25

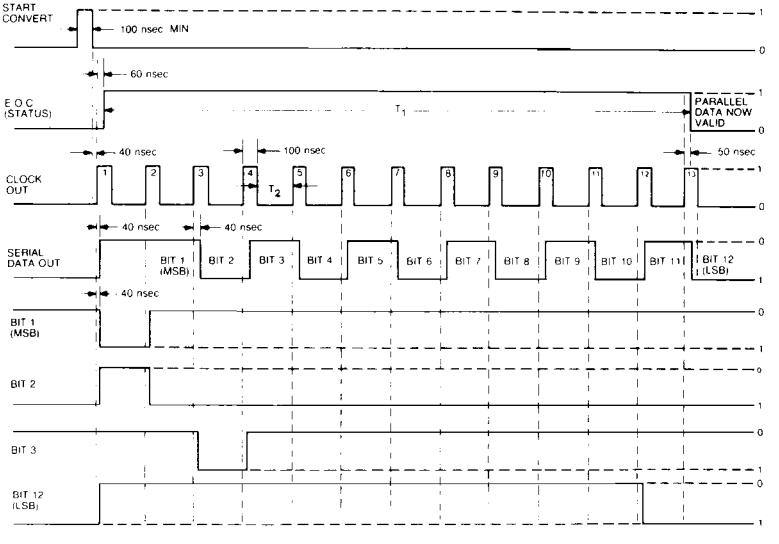
CALIBRATION PROCEDURE

1. Connect the converter for bipolar or unipolar operation. Use the input connection table for the desired input voltage range and input impedance. Apply Start Convert pulses of 100 nanoseconds minimum duration to pin 21. The spacing of the pulses should be no less than the maximum conversion time.
2. **Zero and Offset Adjustments**
   Apply a precision voltage reference source between the selected analog input and ground. Adjust the output of the reference source to the value shown in the Calibration Table for the unipolar zero adjustment (zero +½ LSB) or the bipolar offset adjustment (−FS + ½ LSB). Adjust the trimming potentiometer so that the output code flickers equally between 1111 1111 1111 and 1111 1111 1110.
3. **Full Scale Adjustment**
   Change the output of the precision voltage reference source to the value shown in the Calibration Table for the unipolar or bipolar gain adjustment (+FS − 1½ LSB). Adjust the gain trimming potentiometer so that the output code flickers equally between 0000 0000 0001 and 0000 0000 0000.

TIMING DIAGRAM OPERATING PERIODS

	ADC-HX12B	ADC-HZ12B
T_1	20 μsec.	8.0 μsec.
T_2	1.56 μsec.	0.56 μsec.

TIMING DIAGRAM FOR ADC-HX12B, ADC-HZ12B OUTPUT: 101010101010



Calibration Table

UNIPOLAR RANGE	ADJUST.	INPUT VOLTAGE
0 to +5V	ZERO	+0.6 mV
	GAIN	+4.9982V
0 to +10V	ZERO	+1.2 mV
	GAIN	+9.9963V
BIPOLAR RANGE		
±2.5V	OFFSET	−2.4994V
	GAIN	+2.4982V
±5V	OFFSET	−4.9988V
	GAIN	+4.9963V
±10V	OFFSET	−9.9976V
	GAIN	+9.9927V

Coding Table, Unipolar Operation

INPUT RANGE		COMP. BINARY CODING	
0 TO +10V	0 TO +5V	MSB	LSB
+9.9976V	+4.9988V	0000	0000 0000
+8.7500	+4.3750	0001	1111 1111
+7.5000	+3.7500	0011	1111 1111
+5.0000	+2.5000	0111	1111 1111
+2.5000	+1.2500	1011	1111 1111
+1.2500	+0.6250	1101	1111 1111
+0.0024	+0.0012	1111	1111 1110
0.0000	0.0000	1111	1111 1111

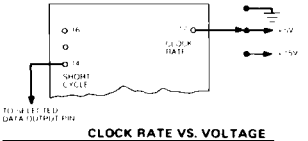
Coding Table, Bipolar Operation

INPUT VOLTAGE RANGE			COMP. OFFSET BINARY		COMP. TWO'S COMPLEMENT	
±10V	±5V	2.5V	MSB	LSB	MSB	LSB
+9.9951V	+4.9976V	+2.4988V	0000 0000	0000	1000 0000	0000
+7.5000	+3.7500	+1.8750	0001 1111	1111	1001 1111	1111
+5.0000	+2.5000	+1.2500	0011 1111	1111	1011 1111	1111
0.0000	0.0000	0.0000	0111 1111	1111	1111 1111	1111
5.0000	2.5000	1.2500	1011 1111	1111	0011 1111	1111
7.5000	3.7500	1.8750	1101 1111	1111	0101 1111	1111
9.9951	4.9976	2.4988	1111 1111	1110	0111 1111	1110
10.0000	5.0000	2.5000	1111 1111	1111	0111 1111	1111

SHORT CYCLE OPERATION

Refer to Technical Note 4 for methods of reducing the ADC-HX or ADC-HZ conversion times.

CONNECTIONS



TO SELECTED DATA OUTPUT PIN

CLOCK RATE VS. VOLTAGE

PIN 17 VOLTAGE	CLOCK RATE ADC-HX12B	CLOCK RATE ADC-HZ12B
0V	600 kHz	1.5MHz
+5V	720 kHz	1.8MHz
+15V	880 kHz	2.2MHz

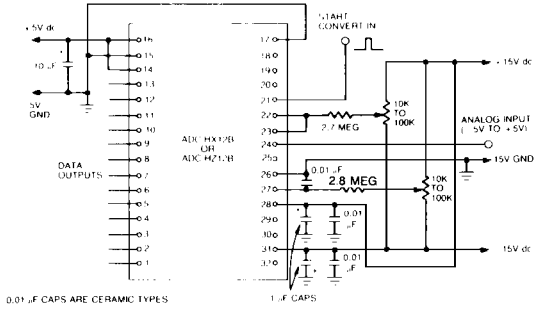
8, 10, & 12 BIT CONVERSION

RESOLUTION	12 BITS	10 BITS	8 BITS
ADC-HX12B CONV. TIME	20 µsec.	15 µsec.	10 µsec.
ADC-HZ12B CONV. TIME	8 µsec.	6 µsec.	4 µsec.
CONNECT THESE PINS TOGETHER	17 & 15	17 & 16	17 & 28
	14 & 16	14 & 2	14 & 4

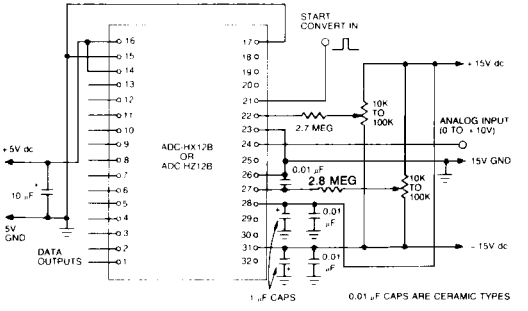
PIN 14 CONNECTION

RES. (BITS)	PIN 14 TO	RES. (BITS)	PIN 14 TO
1	PIN 11	7	PIN 5
2	PIN 10	8	PIN 4
3	PIN 9	9	PIN 3
4	PIN 8	10	PIN 2
5	PIN 7	11	PIN 1
6	PIN 6	12	PIN 16

BIPOLAR OPERATION, −5V TO +5V



UNIPOLAR OPERATION, 0 TO +10V



ORDERING INFORMATION

MODEL	TEMP. RANGE	SEAL
ADC-HX12BGC	0 to +70 °C	Epoxy
ADC-HX12BMC	0 to +70 °C	Hermetic
ADC-HX12BMM	-55 to +125 °C	Hermetic
ADC-HX/883B	-55 to +125 °C	Hermetic
ADC-HZ12BGC	0 to +70 °C	Epoxy
ADC-HZ12BMC	0 to +70 °C	Hermetic
ADC-HZ12BMM	-55 to +125 °C	Hermetic
ADC-HZ/883B	-55 to +125 °C	Hermetic

MIL-STD-883B units are available under DESC Drawing Number 5962-88508.

DATEL, Inc. 11 Cabot Boulevard, Mansfield, MA 02048-1194/TEL (508) 339-3000/TLX 174388/FAX (508) 339-6356