ANALOG DEVICES

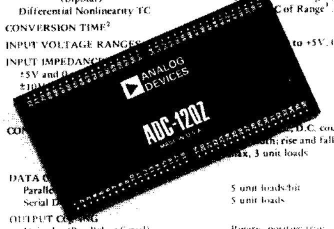
Low Cost General Purpose Analog-to-Digital Converter

ADC-12QZ

FEATURES
12 Bit Resolution and Accuracy
Very High Performance/Cost Ratio
No Missing Codes from 0 to +70°C
40μs Conversion Time
Low Profile Module
Parallel and Serial Outputs
TTL/DTL Logic Levels
User Selected Input Ranges
Input Buffer Option Available

SPECIFICATIONS
(typical @ +25°C and rated supply voltages, unless otherwise noted)

RESOLUTION	12 Bits
ACCURACY	
Error Relative to Full Scale	±½LSB max
Quantization Error	±½LSB max
Differential Nonlinearity Error	±½LSB max
Monotonicity	No missing codes from 0 to +70°C
TEMPERATURE COEFFICIENTS	
Gain TC	±30ppm/°C of Reading[1], max
Zero TC (Unipolar)	±5ppm/°C of Range[1], max
(Bipolar)	±10[illegible]°C of Range[1], max
Differential Nonlinearity TC	[illegible]C of Range[1], max
CONVERSION TIME[2]	
INPUT VOLTAGE RANGES	[illegible] to +5V, 0 to +10V
INPUT IMPEDANCE	
±5V and 0[illegible]	
±10V[illegible]	
CO[illegible]	[illegible] D.C. coupled, 100ns [illegible]th; rise and fall time 1μs [illegible]ax, 3 unit loads
DATA O[illegible]	
Parall[illegible]	5 unit loads/bit
Serial D[illegible]	5 unit loads
OUTPUT CODING	
Unipolar (Parallel or Serial)	Binary, positive true
Bipolar Parallel	Offset binary or 2's complement, positive true
Bipolar Serial	Offset binary, positive true



GENERAL DESCRIPTION
The ADC-12QZ is a 12-bit successive approximation type general purpose analog-to-digital converter that offers moderate speed and good performance at very low cost. Analog Devices' proprietary monolithic quad switches and a unique combination of thin film and hybrid technology have been incorporated in the ADC-12QZ, resulting in a converter that has the basic performance of a much higher priced unit. It has no missing codes from 0 to +70°C, and has a maximum error of ±½LSB relative to full scale at room temperature. The ADC-12QZ is packaged in a convenient, small, low profile module, and all of its logic inputs and outputs are fully TTL/DTL compatible.

EASY TO USE
The ADC-12QZ was designed specifically to make it easy to use. It contains its own temperature-compensated precision voltage reference, and any of four input ranges (0 to +10V, ±10V, 0 to +5V, ±5V) can be selected with jumpers and connections at the module terminals. If a high input impedance is required, the ADC-12QZ can be special ordered with an input buffer.

Binary output coding is used for unipolar operation, but for operation in the bipolar mode, the parallel output data can be either two's complement or offset binary at the user's option. The two codes differ only in that the MSB output (pin 72) is used for offset binary coding, while its complement, $\overline{\text{MSB}}$ (pin 70) is used for two's complement coding. STATUS, which indicates when the parallel output data is valid, and its complement, $\overline{\text{STATUS}}$, are both available.

A latched serial output having a nonreturn-to-zero (NRZ) format is taken from the output of a TTL flip-flop. The serial data is transmitted MSB first in binary code for unipolar operation and in offset binary code for bipolar operation. The STROBE output is used to clock the serial data into a receiving shift register.

TIMING
As shown in Figure 1, the leading edge ("0" to "1" transition) of the convert command pulse sets the STATUS and MSB outputs to the "1" state, and the outputs of bits 2-12 to "0". The conversion program begins on the trailing edge of the convert command pulse with the starting of the internal clock. The bit decisions are made on successive "1" to "0" clock pulse transitions, with the MSB decision occurring first. The 200ns wide strobe pulses are used to synchronize the transmission of serial data. Serial data bits are valid on successive leading edges ("0" to "1" transitions) of the strobe pulses. At the completion of the conversion, the STATUS output returns to zero, signaling that the parallel output data is valid.

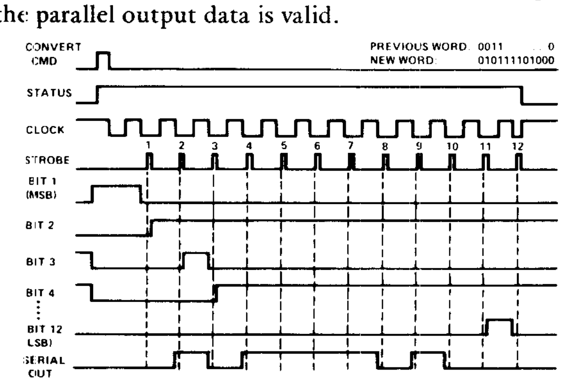


Figure 1. ADC-12QZ Timing Diagram

SPECIFICATIONS (typical @ +25°C and rated supply voltages, unless otherwise noted)

RESOLUTION	12 Bits
ACCURACY	
Error Relative to Full Scale	±½LSB max
Quantization Error	±½LSB max
Differential Nonlinearity Error	±½LSB max
Missing Codes	No missing codes from 0 to +70°C
TEMPERATURE COEFFICIENTS	
Gain TC	±30ppm/°C of Reading[1], max
Zero TC (Unipolar)	±5ppm/°C of Range[1], max
(Bipolar)	±10ppm/°C of Range[1], max
Differential Nonlinearity TC	±10ppm/°C of Range[1], max
CONVERSION TIME[2]	40μs max
INPUT VOLTAGE RANGES	±5V, ±10V, 0 to +5V, 0 to +10V
INPUT IMPEDANCE	
±5V and 0 to +10V Ranges	5k ohms
±10V Range	10k ohms
0 to +5V Range	2.5k ohms
Buffered[3]	1000 Megohms min
CONVERT COMMAND[4]	Positive Pulse, D.C. coupled, 100ns min width; rise and fall time 1μs max, 3 unit loads
DATA OUTPUTS[4]	
Parallel Data	5 unit loads/bit
Serial Data	5 unit loads
OUTPUT CODING	
Unipolar (Parallel or Serial)	Binary, positive-true
Bipolar — Parallel	Offset binary or 2's complement, positive-true
Bipolar — Serial	Offset binary, positive-true
LOGIC OUTPUTS[4]	
Status	"1" during conversion, "0" otherwise; 5 unit loads
$\overline{\text{Status}}$	"0" during conversion, "1" otherwise; 5 unit loads
Strobe	Serial data synchronization, 5 unit loads
POWER SUPPLY REQUIREMENTS	
Analog	+15V ±5% @ 20mA
	-15V ±5% @ 30mA
Digital	+5V ±5% @ 210mA
POWER SUPPLY SENSITIVITY[5]	
Gain	±20ppm/%ΔV_S
Zero	±10ppm/%ΔV_S
TEMPERATURE RANGE[6]	
Operating	0 to +70°C
Storage	-55°C to +125°C
EXTERNAL ADJUSTMENTS	
Zero	20kΩ, 20 turn potentiometer across ±15V supply with 1.5MΩ resistor connected between slider and pin 20.
Gain	20kΩ, 20 turn potentiometer across ±15V supply with 150kΩ resistor connected between slider and pin 1.
DIMENSIONS	2" x 4" x 0.4" Module, Nominal

NOTES:

[1] Range for unipolar operation ≡ +F.S.; Range for bipolar operation ≡ 2 (+F.S.). Reading for bipolar input is defined as |Actual Reading − (−F.S.)|.

[2] Conversion time is measured from trailing edge of convert command pulse to "1" to "0" transition of status output.

[3] Units with buffer available on special order only.

[4] All digital inputs and outputs are completely TTL compatible. One unit load is identical to that defined for standard 54/74 Series TTL.

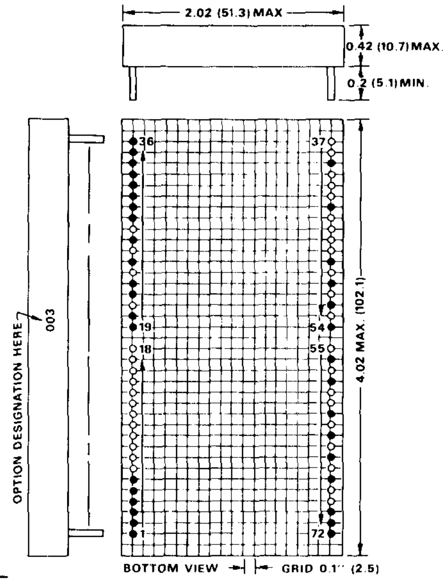
[5] For ±15V supply only, and with +15V and −15V supplies tracking.

[6] Extended operating temperature version (−55°C to +125°C) is available on special order; the extended temperature range for 12 Bit units is −25°C to +85°C.

Specifications subject to change without notice.

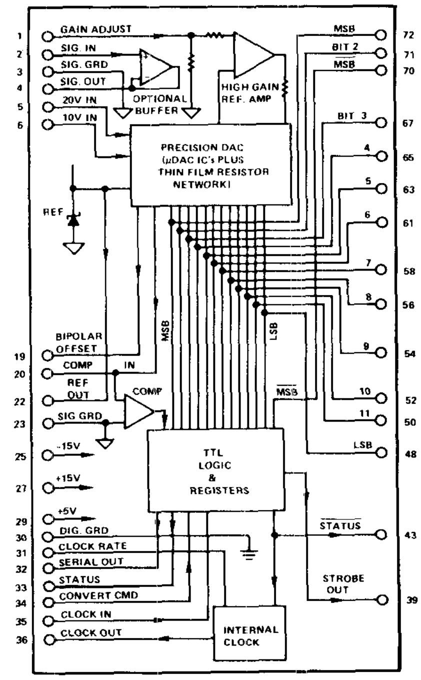
OUTLINE DIMENSIONS AND PIN DESIGNATIONS

Dimensions shown in inches and (mm).



NOTE:
Terminal pins installed only in shaded hole locations.
Module Dimensions in CM: 10.29 max by 5.11 max by 1.04 max.
All pins are gold plated rodar, (MIL-G-45 204), 0.019" ±0.001" dia., 0.2" min. length.
For plug-in mounting card, order Board No. AC1548

BLOCK DIAGRAM AND PIN DESIGNATIONS



ORDERING GUIDE*

ADC-12QZ-XXX

OPTION DESIGNATOR	INPUT BUFFER	TEMP RANGE
003	NO	STANDARD
013	NO	EXTENDED
023	YES	STANDARD
033	YES	EXTENDED

*Note: Only -003 is standard. All other variations must be special ordered.

INPUT RANGE SELECTION

Four input ranges are available; 0 to +5V, ±5V, 0 to +10V and ±10V. If the ADC-12QZ has been ordered with the optional input buffer, any of these ranges can be buffered to provide an input impedance of 1000 Megohms. The chart below shows the connections required for each of the ranges.

RANGE SETTING INSTRUCTIONS

Input Range in Volts	Buffered Input	Range and Buffer Select			Offset Select
		input to pin	Jumper pin 4 to	Jumper pin 20 to	Jumper pin 19 to
0 to +10V	NO	6	–	–	23
	YES*	2	6	–	23
±5V	NO	6	–	–	20
	YES*	2	6	–	20
±10V	NO	5	–	–	20
	YES*	2	5	–	20
0 to +5V	NO	6	–	5	23
	YES*	2	6	5	23

*Buffered input can be used only with units ordered with optional input buffer.

ZERO AND GAIN ADJUSTMENT

The ADC-12QZ is normally used with external zero and gain calibration potentiometers. However, if maximum accuracy is not required, they may be omitted. With no connections to either pin 1 or pin 20, gain calibration will be within approximately ±2LSB, and zero calibration will be within approximately ±10LSB.

If gain and zero adjustment potentiometers are used, they should be connected as shown in Figure 2. The zero control has a range of about ±20LSB, and the gain control has a range of about ±13LSB.

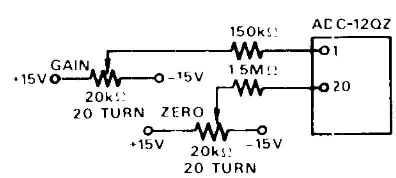


Figure 2. Zero and Gain Potentiometers

Proper gain and zero calibration requires great care and the use of extremely sensitive and accurate instruments. The voltage source used as a signal input must be very stable. It also should be capable of being set to within 1/10LSB at both ends of its range.

The ADC-12QZ's zero and gain adjustments are independent of each other if the zero (or offset) adjustment is made first. These adjustments are not made with zero and full scale input test signals, and it may be helpful to appreciate why. An analog-to-digital converter has a given digital output code for a small range of input signals (the nominal width of the range being one LSB). If properly adjusted, the converter will switch from one output code to the adjacent output code when the analog input signal is halfway between the two. With the input test signal set at that halfway point, the potentiometer can be adjusted until the converter does switch at just that point. By using this technique with a high speed convert command rate and a visual display of the output code, zero and gain adjustments can be performed in a very sensitive and accurate manner.

ZERO ADJUSTMENT PROCEDURE

1. For unipolar ranges:
   a) Set input voltage precisely to +½LSB.
   b) Adjust zero control until converter is just barely switching from 000000000000 to 000000000001.
2. For bipolar ranges:
   a) Set input voltage precisely to ½LSB above – F.S.
   b) Adjust zero control until converter is just barely switching from 000000000000 to 000000000001.

GAIN ADJUSTMENT PROCEDURE

1. Set input voltage precisely to ½LSB less than "all bits on" value. Note that this is 1½LSB less than nominal full scale.
2. Adjust gain control until converter is just barely switching from 111111111110 to 111111111111.

The table below summarizes the zero and gain adjustment procedure, and shows the proper input test voltages used in calibrating the ADC-12QZ.

CALIBRATION DATA

Input Voltage Range	Adjustment	Input Voltage	Adjust control to point where converter is just on the verge of switching between the two codes shown*
0 to +5V	ZERO	0.61mV	000000000000 000000000001
	GAIN	4.9982V	111111111110 111111111111
0 to +10V	ZERO	1.22mV	000000000000 000000000001
	GAIN	9.9963V	111111111110 111111111111
±5V	ZERO	-4.9988V	000000000000 000000000001
	GAIN	4.9963V	111111111110 111111111111
±10V	ZERO	-9.9976V	000000000000 000000000001
	GAIN	9.9927V	111111111110 111111111111

*Codes shown are natural binary for unipolar input ranges and offset binary for bipolar input ranges.

OUTPUT CODE

When using a unipolar input range the ADC-12QZ's parallel output data is in natural binary code. When using a bipolar input range, the parallel output data can be either two's complement or offset binary code at the user's option. The only difference between the two codes is the state of the most significant bit. $\overline{\text{MSB}}$, pin 70, is used for two's complement coding. MSB, pin 72, is used for offset binary coding.

GROUNDING PRACTICE AND POWER SUPPLY BYPASSING

The ADC-12QZ's digital and analog grounds are not tied together internally. A connection must therefore be provided externally. It is recommended that the two grounds be connected with a jumper at the module terminals from SIGNAL GROUND (pin 23) to DIGITAL GROUND (pin 30).

The ADC-12QZ's +5V, +15V and -15V power inputs are each internally bypassed to ground with 0.1μF capacitors. Further power supply noise suppression can be achieved by adding additional bypass capacitors externally. Such capacitors would typically be 2μF (or greater) tantalum types. For best results they should be located near the module's power input terminals.

CONNECTING THE CLOCK

Although the ADC-12QZ contains its own internal clock oscillator, connection to it is accomplished with an external jumper between pins 35 and 36 of the module. This jumper between CLOCK OUT (pin 36) and CLOCK IN (pin 35) must be installed because unless otherwise specified, the ADC-12QZ is intended to operate only with the internal clock. If operation with an external clock is required, contact the factory for further information.

The internal clock is set to run at the maximum permissible rate. Although running it at a slower rate will not improve the converter's accuracy, in some applications a slower conversion time may permit synchronization or compatibility with interfacing equipment. This may be accomplished by connecting a capacitor externally between CLOCK OUT (pin 36) and CLOCK RATE ADJ (pin 31). The conversion time can be extended to at least 35ms in this manner. The capacitor's value is determined by the formula:

$$\text{Conversion Time (in } \mu s) \approx 35\left(1 + \frac{C_{ext}}{2200}\right)$$

where C_{ext} = external capacitance in pF.

SERIAL DATA OUTPUT

A latched serial output (taken from the output of a TTL flip-flop) is brought out to pin 32. The data is transmitted MSB first, and is coded positive-true binary for unipolar input ranges, or positive-true offset binary for bipolar input ranges. Prior to the beginning of a conversion this output will match the state of the twelfth bit (LSB) of the previous conversion (assuming the previous conversion was allowed to go to completion). In most applications the state of the serial output prior to the beginning of a conversion will be of no consequence.

Figure 3, shown below, indicates one method for transmitting data serially to a remote location using only three wires (plus a digital ground). The data is clocked into a receiving shift register using the ADC-12QZ's strobe output as a clock source for the shift register.

The Timing Diagram (Figure 1) shows that the serial data bits are valid on successive strobe pulse leading edges ("0" to "1" transitions). This allows the strobe pulse to clock the shift register directly, since the shift register transfers information on "0" to "1" transitions of the clock input. The first bit, which is the MSB, is valid on the first strobe pulse's leading edge. Each complete conversion has exactly twelve strobe pulses, one for each bit.

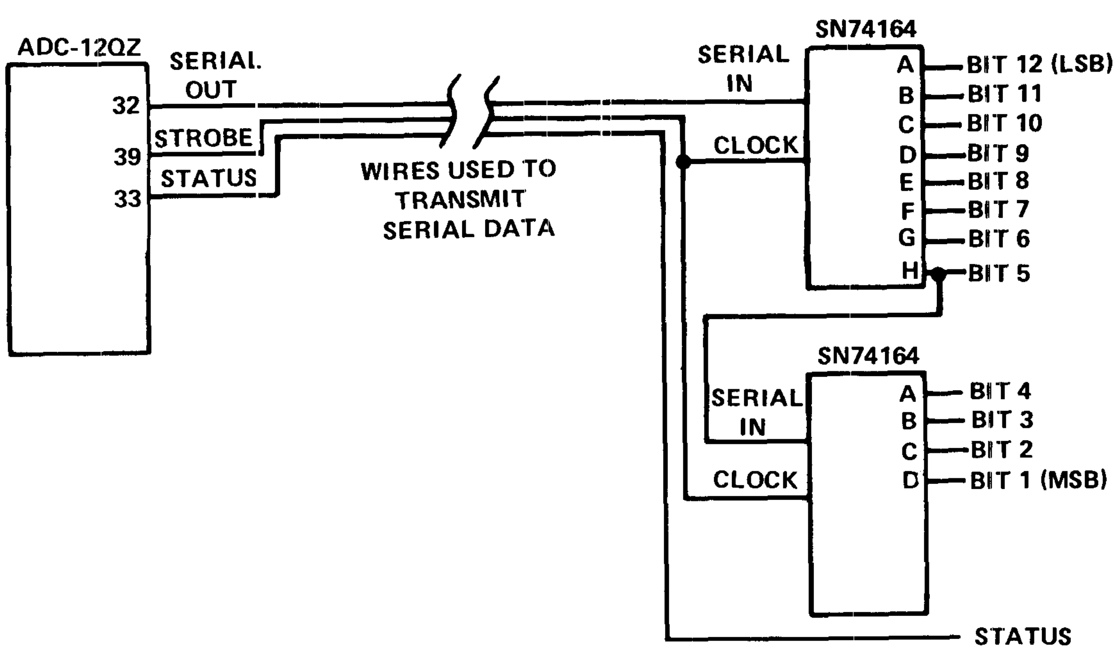


Figure 3. Block Diagram – Serial Data Transfer