GENERAL DESCRIPTION

The [redacted]Z is a low cost 10 bit successive approximation type analog-to-digital converter intended for general purpose applications. It offers performance and features previously found only in much more expensive converters. The ADC-10Z is monotonic over its entire operating temperature range, and has a maximum relative accuracy error of ±½LSB. The unit is packaged in a convenient, small, low profile module. All of its logic inputs and outputs are fully TTL/DTL compatible.

USER FLEXIBILITY

The ADC-10Z is designed for flexibility and ease of use. It contains an internal temperature-compensated precision voltage reference, eliminating the problem of supplying an external reference voltage. Any of four calibrated input ranges (two unipolar and two bipolar) can be selected with jumpers and connections to the module terminals. A direct input allows the input range to be set to any desired value by selecting the value of an external series resistor. If a high input impedance is required, the ADC-10Z can be special ordered with an input buffer.

Binary output coding is used for unipolar operation, but the user selects either two's complement or offset binary coding when operating in the bipolar mode. The two codes differ only in that their MSB's are in complementary states. The MSB output is used for offset binary coding, and $\overline{\text{MSB}}$ gives 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 with a nonreturn-to-zero type (NRZ) format is taken from the output of a TTL flip-flop. The serial data output pulse train is transmitted MSB first in binary code for unipolar operation, or in offset binary code for bipolar operation. The STROBE output is used to synchronize the serial data with a receiving shift register.

TIMING

As shown in the timing diagram below, 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 2-10 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 strobe pulse is used to synchronize the transmission of serial data because the serial data bits are valid on successive "1" to "0" strobe pulse transitions. At the completion of the conversion, the STATUS output returns to zero, signaling that the parallel output data is valid.

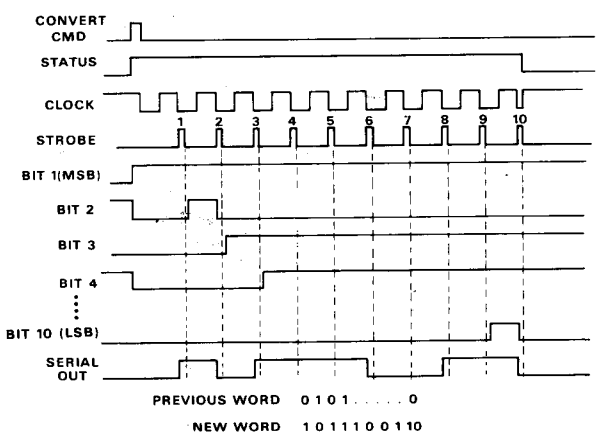
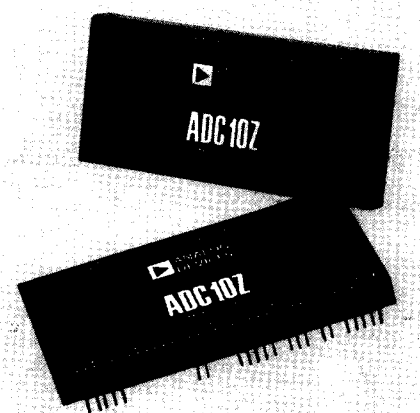


Figure 1. ADC-10Z Timing Diagram

[redacted]

FEATURES

- **10 Bit Resolution and Accuracy**
- **Very High Performance/Cost Ratio**
- **Monotonic Over Temperature**
- **20μs Conversion Time**
- **Low Profile Module**
- **Parallel and Serial Outputs**
- **Simplified Serial Data Transfer**
- **TTL/DTL Logic Levels**
- **User Selected Input Ranges**
- **Input Buffer Option Available**



Ceramic Pkg.

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ROUTE ONE INDUSTRIAL PARK
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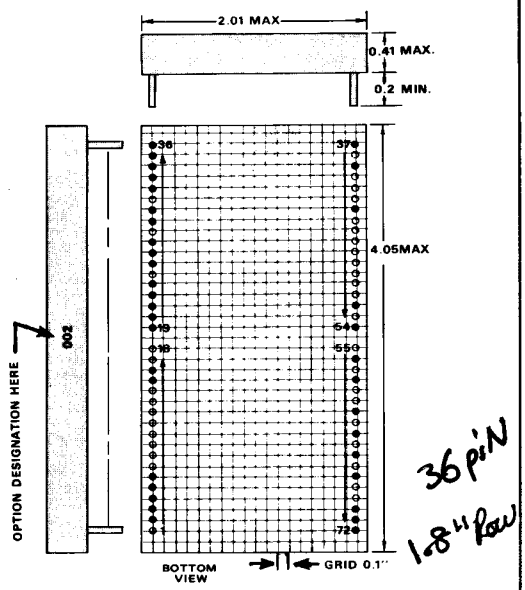
RESOLUTION	10 Bits
ACCURACY	
Relative to Full Scale	±½LSB max.
Quantization Error	±½LSB max.
Differential Nonlinearity Error	±½LSB max.
Differential Nonlinearity TC	±10ppm/°C of Range[1] max.
Monotonicity	Monotonic from 0°C to +70°C
TEMPERATURE COEFFICIENTS	
Gain TC	±40ppm/°C of Reading[1], max.
Zero TC (Unipolar)	±25ppm/°C of Range[1], max.
(Bipolar)	±30ppm/°C of Range[1], max.
CONVERSION TIME[2]	20µs max.
INPUT VOLTAGE RANGES	±5V, ±10V, 0 to +5V, 0 to +10V Direct (±1.2V ±5%, 0 to +1.2V ±5%)
INPUT IMPEDANCE	
±5V and 0 to +5V Ranges	6.0k ohm min.
±10V and 0 to +10V Ranges	12.0k ohm min.
Direct	1.6k ohm min.
Buffered[3]	1000 Meg ohm min.
LOGIC INPUTS[4]	
Convert Command	Positive pulse, D.C. coupled, 100ns min. width; rise and fall times 1µs max., 3 unit loads.
Clock Input	2 unit loads
Clock Inhibit	1 unit load
DATA OUTPUTS[4]	
Parallel Data	4 unit loads/bit
Serial Data	NRZ, 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, 10 unit loads
$\overline{\text{Status}}$	"0" during conversion, 6 unit loads
Strobe	Serial data synchronization; 3 unit loads
POWER SUPPLY REQUIREMENTS	
Analog	+15V ±3% @ 18mA −15V ±3% @ 25mA
Digital	+5V ±5% @ 170mA
POWER SUPPLY SENSITIVITY[5]	
Gain	±0.01% of Reading[1]/%ΔV_S
Zero	±0.01% of Range[1]/%ΔV_S
TEMPERATURE RANGE[6]	
Operating	0°C to +70°C
Storage	−55°C to +125°C
EXTERNAL ADJUSTMENTS	
Zero	20kΩ, 20 turn potentiometer across ±15V supply with slider to pin 20
Gain	20 turn potentiometer in series with input
DIMENSIONS	2" x 4" x 0.4" Module, Nominal
PRICES (for -002 option)	
100+	$67.
1-9	$99.

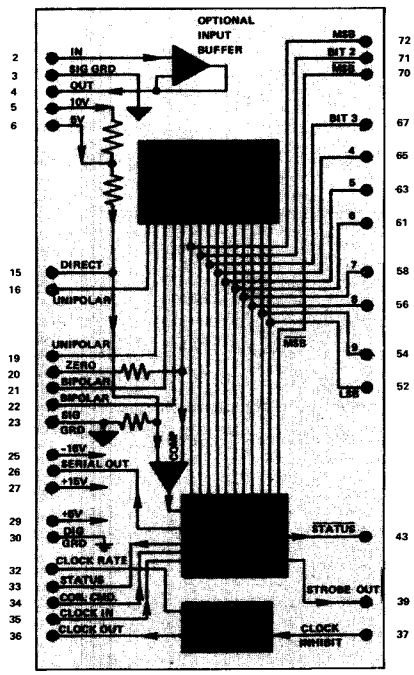
Notes:
[1] Range for unipolar operation ≡ +F.S.; Range for bipolar operation ≡ 2 (+F.S.). Reading for bipolar input is defined as |Actual Reading − (−F.S.)|.
[2] Conversion time is measured from trailing edge of convert command pulse to "1" to "0" transition of status output.
[3] Units with buffer available on special order only. In small quantities (1-9) add $20 to price.
[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.
[6] Extended operating temperature version (−55°C to +125°C) is available on special order.
Specifications subject to change without notice.

OUTLINE DIMENSIONS
(In Inches)



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 half-hard brass, (MIL-G-45 204) 0.02" dia., 0.2" min. length.
For ADC-10Z plug-in mounting card with printed circuit edge connector, order Board No. AC1504 @ $25.00.

BLOCK DIAGRAM AND PIN DESIGNATIONS



ORDERING GUIDE*

ADC-10Z-XXX

OPTION DESIGNATOR	INPUT BUFFER	TEMP RANGE
002	NO	STANDARD
012	NO	EXTENDED
022	YES	STANDARD
032	YES	EXTENDED

*Note: Only -002 is standard. All other variations must be special ordered.

INPUT RANGE SELECTION

There are four fixed input voltage ranges available; 0 to +5V, ±5V, 0 to +10V, and ±10V. The desired range is determined according to the Range Setting Instructions shown below. In addition, a direct input allows the user to set the input range to any value greater than approximately +1.2 volts with an external series resistor. The values of the series resistor and gain trim potentiometer used with the direct input can be determined from information in the DIRECT INPUT section below.

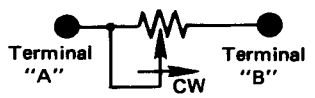
Although an analog-to-digital converter input is frequently preceded by a sample-and-hold amplifier, it isn't necessarily a requirement. If the input signal remains constant, or changes by an amount equivalent to no more than ½LSB during a conversion, then a sample-and-hold amplifier probably isn't needed. For example, an input signal applied to the ADC-10Z could slew at a rate of up to 0.25 volts/ms and still change no more than ½LSB during a conversion (assuming a 10 volt input range and a 20μs conversion time).

RANGE SETTING INSTRUCTIONS

0 to +5V	X	X	100Ω	* Pin 2	— *	Pin 6	Pin 16	—
±5V	X	X	200Ω	* Pin 2	— *	Pin 6	—	Pin 22
0 to +10V	X	X	200Ω	* Pin 2	— *	Pin 5	Pin 16	—
±10V	X	X	500Ω	* Pin 2	— *	Pin 5	—	Pin 22

*Gain Adjustment Potentiometer, Terminal "A".

[1]Buffered Input can be used only with units ordered with optional input buffer.



DIRECT INPUT

In applications where a transducer output (or similar signal) is to be fed directly into the ADC-10Z's input, it may be desirable to be able to set the gain, or scale factor, between the transducer output and A/D converter input. This would ordinarily be done with a separate gain adjustable operational amplifier, but the ADC-10Z's direct input (pin 15) makes such an amplifier unnecessary.

The ADC-10Z provides a full-scale digital output (all 1's) for an input of +1.2 volts ±5% applied to its direct input. The range of input signals when using the direct input is 0 to +1.2V in the unipolar configuration, or −1.2V to +1.2V in the bipolar configuration. (Jumper pin 16 to pin 19 for unipolar, or pin 21 to pin 22 for bipolar.)

By using an external resistor in series with the direct input, it is possible to set the full-scale input voltage to any value desired greater than +1.2 volts. The approximate value of the external series resistance is given by:

$$\text{SERIES RESISTOR (in k}\Omega) \approx \frac{\text{+F.S. Voltage} - 1.2 \text{ Volts}}{0.75\text{mA}}$$

The exact value resistor required must be determined experimentally. A gain adjustment potentiometer is connected in series with the series resistor, as shown in Figure 2. Its resistance should be approximately 2% of the value of the series resistor for a unipolar input and 4% for a bipolar input.

When using the direct input, the input impedance seen by the signal source is equal to the resistance of the series resistor plus 1.6kΩ. If this offers too low an input impedance, the input signal can be applied to the buffered input, pin 2 (if the ADC-10Z has been special ordered with a buffer). The buffer output (pin 4) would then be connected through the series resistor and gain adjustment potentiometer to the direct input. Signals applied to the buffer input must be kept within the span of −10V to +10V.

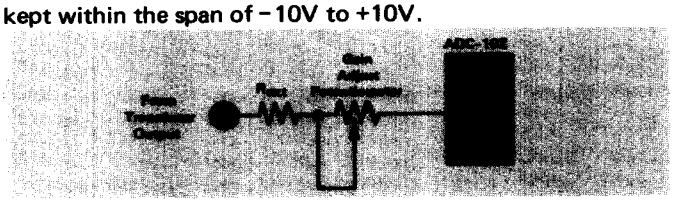


Figure 2. Using the Direct Input

GROUNDING PRACTICE AND POWER SUPPLY BYPASSING

The ADC-10Z's digital and analog grounds are not tied together internally. A connection must 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-10Z's +5V, +15V, and −15V power busses 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

To use the internal clock, two jumpers must be installed. One goes from CLOCK OUT (pin 36) to CLOCK IN (pin 35). The other connects CLOCK INHIBIT (pin 37) to $\overline{\text{STATUS}}$ (pin 43). The second jumper keeps the clock from running except during a conversion, and also is used in synchronizing the starting of the clock cycle at the beginning of a conversion.

The internal clock is factory 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 ADJUST (pin 32). The conversion time can be extended to at least 20ms in this manner. The capacitor's value is determined by the formula:

$$\text{Conversion Time (in } \mu\text{s)} \approx 20\mu\text{s} \left(1 + \frac{C_{ext}}{1200}\right)$$

where C_{ext} = external capacitance in pF.

INSTRUCTIONS FOR ADJUSTMENT OF ZERO AND GAIN

The ADC-10Z is normally used with external zero and gain calibration potentiometers. However, if maximum accuracy is not required, they may be omitted. With ZERO ADJ (pin 20) jumpered to SIGNAL GROUND (pin 23), the converter's zero offset will be ±6.5LSB maximum. If the gain adjust potentiometer is replaced with a fixed resistor equal in value to half the maximum gain pot resistance, the gain calibration error will be ±4LSB maximum (on the four calibrated ranges).

If the gain and zero potentiometers are used, an accurate voltage source is required for calibration. It must be very stable, and should be capable of being set to within ±1/10LSB at both ends of its range. The zero adjustment pot has a range of approximately ±16LSB, and the gain adjust pot has a range of approximately ±7LSB (on the calibrated ranges).

The zero and gain calibrations are independent of each other if the zero adjustment is made first. These adjustments are not made with zero and full scale input test signals, and it may be helpful to understand why. An analog-to-digital converter has a given digital output code for a small range of input signals (the average width of that 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. If the input test signal is set at that halfway point, where the converter should be on the verge of switching to the next value, the potentiometer can be adjusted until the converter does switch at exactly that point. Using a high speed convert command rate and a visual display of the output code, these adjustments can be made in a very sensitive and accurate way with this technique.

ZERO ADJUSTMENT

1. Set input voltage precisely to ½LSB above zero.
2. Adjust zero control such that:
   a. for unipolar connections; converter is just barely switching from 0000000000 to 0000000001.
   b. for bipolar connections; converter is just barely switching from 1000000000 to 1000000001 (offset binary coding).

GAIN ADJUSTMENT

1. For unipolar connections:
   a. Set input voltage precisely to ½LSB less than "all bits on" input. Note that this is 1½LSB less than nominal full scale.
   b. Adjust gain control to the point where converter is just barely switching from 1111111110 to 1111111111.
2. For bipolar connections:
   a. Set input voltage precisely to ½LSB above nominal negative full scale.
   b. Adjust gain control to the point where converter is just barely switching from 0000000000 to 0000000001 (offset binary coding).

The table below summarizes the zero and gain adjustment instructions, and lists the proper input test voltages used in calibrating the ADC-10Z on any of its fixed ranges:

CALIBRATION DATA

0 to +5V	Zero	2.44mV	0000000000 0000000001
	Gain	4.9927V	1111111110 1111111111
0 to +10V	Zero	4.88mV	0000000000 0000000001
	Gain	9.9854V	1111111110 1111111111
±5V	Zero	4.88mV	1000000000 1000000001
	Gain	-4.9951V	0000000000 0000000001
±10V	Zero	9.77mV	1000000000 1000000001
	Gain	-9.9902V	0000000000 0000000001

*Output coding shown is binary for unipolar ranges and offset binary for bipolar ranges.

SERIAL DATA OUTPUT

A latched serial output (taken from the output of a TTL flip-flop) is brought out to pin 26. 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 tenth 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 at 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 strobe pulse output as a clock source for the shift register. Note that a logic inverter precedes the shift registers' clock inputs. This is needed because the SN7496 transfers data on the positive-going edge of its clock pulse.

The Timing Diagram (Figure 1) shows that the serial data bits are valid on successive trailing edges ("1" to "0" transitions) of the strobe pulses. The first bit, which is the MSB, is valid on the first strobe pulse's trailing edge. Each complete conversion has exactly ten strobe pulses, one for each bit.

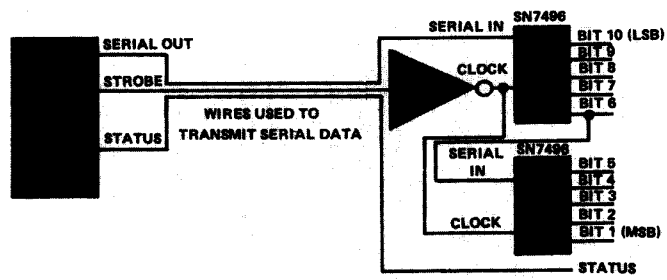


Figure 3. Block Diagram — Serial Data Transfer