ANALOG DEVICES

High Speed Analog to Digital Converter

ADC1109

FEATURES
High Speed: 10 Bits in 4μs Max
Error Relative to Full Scale: ±½LSB
User Choice of Unipolar or Bipolar Input
Small 2" x 3" x 0.4" Module

GENERAL DESCRIPTION

The ADC1109 is a high speed analog-to-digital converter packaged in a compact 2" x 3" x 0.4" module. It uses the successive approximations technique to perform complete 10 bit conversion in less than 4μs with ±½LSB relative accuracy.

The ADC1109 can be configured by the user to accept either unipolar or bipolar input signals and to produce Binary, Offset Binary, or Two's Complement coded outputs. The data outputs are fully DTL/TTL compatible and are available in both parallel and serial form.

TIMING

As shown in Figure 1, the "0" to "1" transition of the CONVERT COMMAND input sets the MSB output to logic "0" and the STATUS, $\overline{\text{MSB}}$, and BIT 2 through BIT 10 outputs to logic "1". Nothing further happens until the CONVERT COMMAND returns to logic "0", at which time the conversion proceeds.

With the MSB in the logic "0" state, the internal digital-to-analog converter's output is compared with the analog input. If the D/A output is less than the analog input, the first "0" to "1" clock transition resets the MSB to logic "1". If the D/A output is greater than the analog input, the MSB remains at logic "0".

The first "0" to "1" clock transition also sets the BIT 2 output to logic "0" and another comparison is made. This process continues through each successive bit until the BIT 10 (LSB) comparison is completed. At this time the STATUS output returns to logic "0" and the conversion cycle ends.

The SERIAL DATA output is of the non-return-to-zero (NRZ) type. The data is available, MSB first, 40ns after each of the ten "0" to "1" clock transitions.

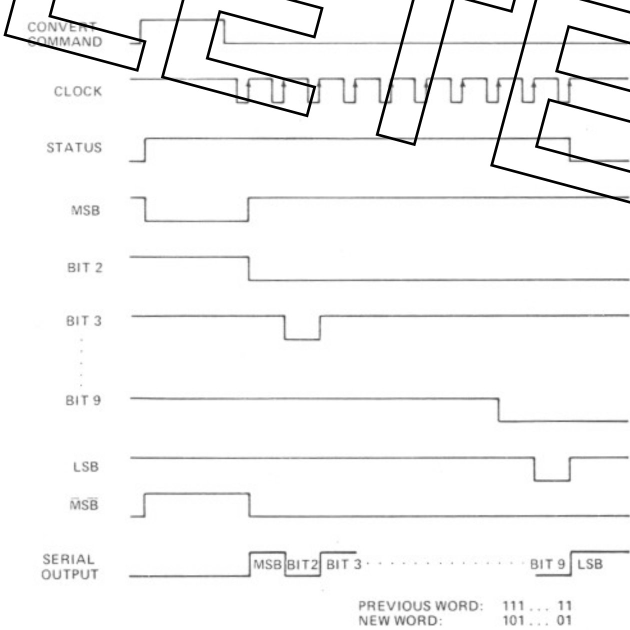

Figure 1. Timing Diagram

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Tel: 617/329-4700 **TWX: 710/394-6577**

West Coast	Mid-West	Texas
213/595-1783	312/894-3300	214/231-5094

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

MODEL	ADC1109
RESOLUTION	10 Bits
CONVERSION TIME[1]	3.8μs (4μs Max)
ACCURACY[2]	
Error Relative to Full Scale	±½LSB
Quantization Error	±½LSB
Differential Nonlinearity Error	±½LSB
TEMPERATURE COEFFICIENTS	
Gain	±30ppm/°C of Reading (±50ppm/°C Max)
Zero (Unipolar Inputs)	±200μV/°C (±500μV/°C Max)
Offset (Bipolar Inputs)	±200μV/°C (±500μV/°C Max)
Differential Nonlinearity	±7ppm/°C (±11ppm/°C Max)
INPUT VOLTAGE RANGES	±5V, 0 to +10V
INPUT IMPEDANCE	10kΩ
CONVERT COMMAND	Positive Pulse, TTL Compatible, 100ns Min Width
PARALLEL DATA OUTPUT	
Unipolar Inputs	Positive True Binary
Bipolar Inputs	Positive True Offset Binary or Two's Complement
SERIAL DATA OUTPUT	
Unipolar Inputs	Positive True Binary
Bipolar Inputs	Positive True Offset Binary
	TTL Compatible, NRZ Format, MSB First
STATUS OUTPUT	Logic "1" During Conversion, TTL Compatible
CLOCK OUTPUT	TTL Compatible, 190ns Width
LOGIC FANOUTS AND LOADING	
Convert Command	1TTL Load
Parallel Data Outputs	5TTL Loads/Bit
Status Output	8TTL Loads
Serial Data Output	6TTL Loads
Clock Output	10TTL Loads
ADJUSTMENT RANGES	
Gain	±5LSB
Zero	±10LSB
Offset	±10LSB
POWER REQUIREMENTS	+5VDC ±5% @ 125mA (135mA, Max) +15VDC ±3% @ 35mA (40mA, Max)[3] -15VDC ±3% @ 35mA (40mA, Max)
POWER SUPPLY SENSITIVITY	
Gain (to +15V Supply)	±7.5mV/V (±15mV/V, Max)
Zero (to +15V Supply)	±15mV/V (±20mV/V, Max)
(to -15V Supply)	±5mV/V (±10mV/V, Max)
Offset (to +15V Supply)	±400mV/V (±500mV/V, Max)
(to -15V Supply)	±5mV/V (±10mV/V, Max)
TEMPERATURE RANGE	
Operating	0 to +70°C
Storage	-55°C to +85°C
PRICE (1-9)	$159

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

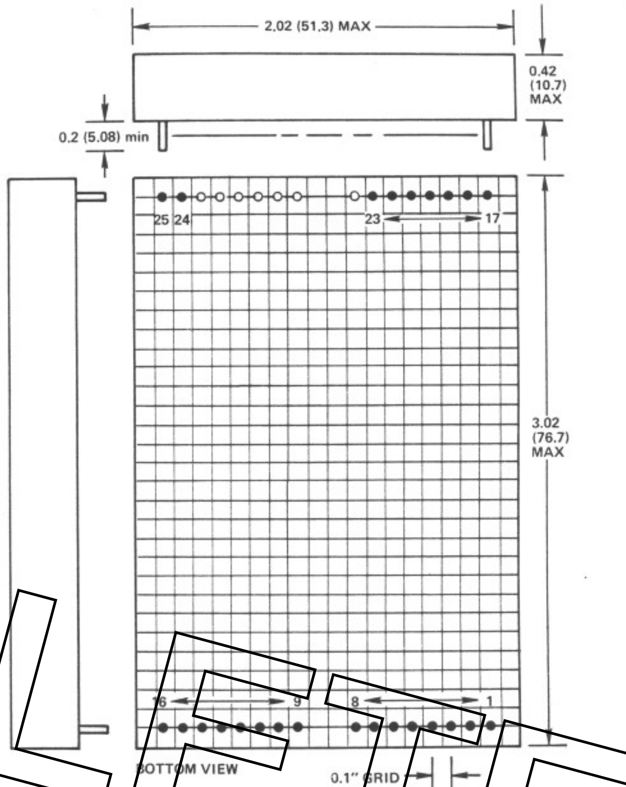
[2] Warmup time to rated accuracy is 5 minutes.

[3] Values shown are for the unipolar mode; values for the bipolar mode are 45mA (50mA, Max).

Specifications subject to change without notice.

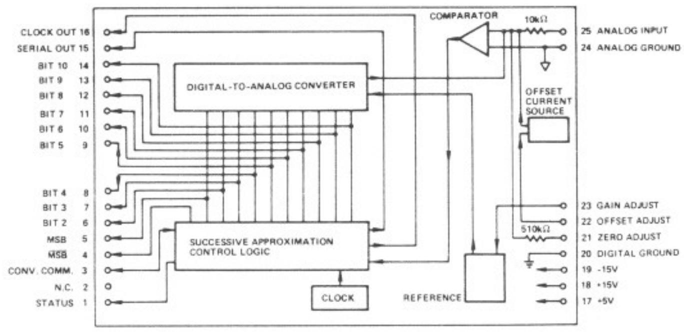
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



Pins are installed only in shaded hole locations.
Pins are half hard brass, gold plated per MIL-G-45204B, Class I, Type II.
Pin Diameter is 0.019" (0.483mm) ±0.001" (0.025mm).
For plug-in mounting card, order Board No. AC-1520 @ $25.00.

BLOCK DIAGRAM AND PIN DESIGNATIONS



ANALOG INPUT CHARACTERISTICS

The input circuit of the ADC1109 is shown below in block diagram form.

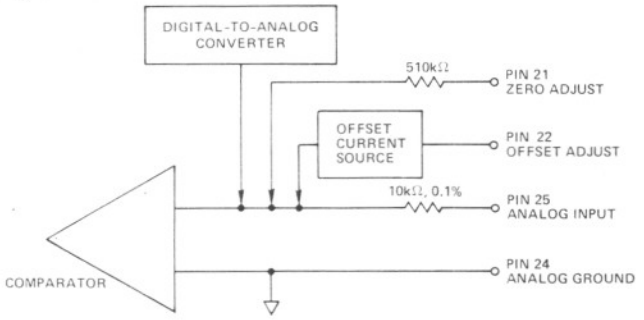


Figure 2. Input Circuit Block Diagram

When the ADC1109 is connected as a unipolar device, Pin 22 is left open circuit disabling the offset current source. The 0 to +10V input signal develops a 0 to +1mA current which is compared to the 0 to −1mA output of the D/A converter. A voltage between +15V and −15V can be applied to Pin 21 by means of a 20kΩ potentiometer to adjust the zero point by at least ±10LSB.

With a 250Ω variable resistor connected between +15V and Pin 22, the bipolar offset current source provides ½mA to the comparator input. The ADC1109 will then accept bipolar (±5V) inputs, and compare the 0 to +1mA sum of the offset and input signal currents to the 0 to −1mA D/A converter output. The 250Ω variable resistor provides for a minimum adjustment of ±10LSB in the offset. Pin 21 is left open circuit in this mode of operation.

If an input impedance of greater than 10kΩ is required, an operational amplifier input buffer can be used. Analog Devices' model 48 fast settling differential amplifier, packaged in a small 1.125" x 1.125" x 0.4" module, is an ideal choice.

PARALLEL DATA OUTPUT

The ADC1109 produces natural Binary coded outputs when configured as a unipolar device; as a bipolar device it can produce either Offset Binary or Two's Complement output codes. The most significant bit is represented by pin 5 (MSB output) for Binary and Offset Binary codes and by pin 4 ($\overline{\text{MSB}}$ output) for the Two's Complement code. Table I and II below illustrate the relationship between the analog input and digital output for all three codes.

The LSB output is typically valid 5ns before the "1" to "0" transition of the STATUS output. However, under worst case conditions, the LSB might not be valid until 10ns after the STATUS change. If this is not accounted for in the design of external circuits, the LSB might always appear as a "0" to the system.

ANALOG INPUT	DIGITAL OUTPUT
	BINARY CODE
+9.9902V	1111111111
+5.0000V	1000000000
+1.2500V	0010000000
+0.0098V	0000000001
+0.0000V	0000000000

Table I. Nominal Unipolar Input-Output Relationships

ANALOG INPUT	DIGITAL OUTPUT	
	OFFSET BINARY	TWO'S COMPLEMENT
+4.9902	1111111111	0111111111
+2.5000	1100000000	0100000000
0.0000	1000000000	0000000000
−2.5000	0100000000	1100000000
−5.0000	0000000000	1000000000

Table II. Nominal Bipolar Input-Output Relationships

SERIAL DATA OUTPUT

The serial data output, available on pin 15, is of the non-return-to-zero format. The data is transmitted MSB first and is Binary coded for unipolar units and Offset Binary coded for bipolar units.

Figure 3, shown below, indicates one method for transmitting data serially using only three wires (plus a digital ground). The data is clocked into a receiving shift register using the delayed clock output of the ADC1109.

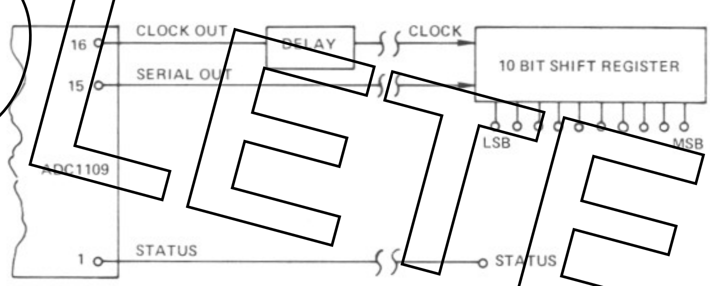


Figure 3. Serial Data Transmission

The timing diagram presented in Figure 4 shows that the converter's clock output must be delayed by an amount of time greater than or equal to the sum of the receiving shift register setup time plus the 40ns maximum clock output to serial output delay.

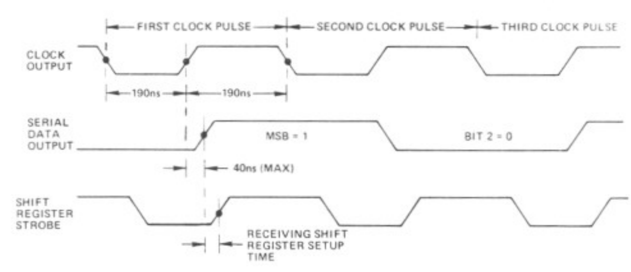


Figure 4. Serial Data Timing Diagram

The data appearing in the shift register will be valid a period of time, equal to the shift register propagation delay, after the "0" to "1" transition of the last shift register strobe pulse.

GAIN, ZERO, AND OFFSET ADJUSTMENTS

The potentiometers used for making gain and offset or zero adjustments are connected as shown in Figure 5 for unipolar, and Figure 6 for bipolar units.

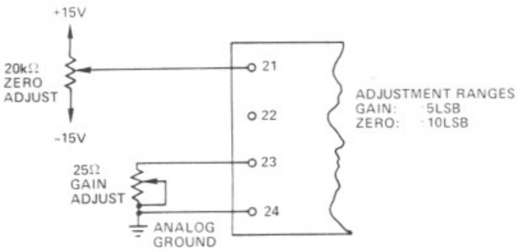


Figure 5. Unipolar Adjustment Connections

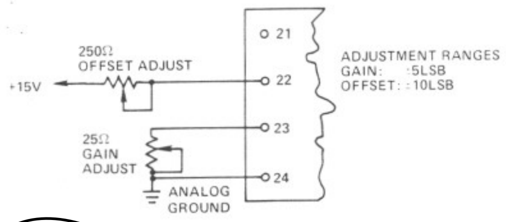


Figure 6. Bipolar Adjustment Connections

Proper gain and offset/zero calibration requires great care, and the use of extremely sensitive and accurate reference instruments. The voltage standard used as a signal source must be very stable. It should be capable of being set to within 1mV of the desired value at both ends of its range.

The gain and offset/zero calibrations will be independent of each other if the offset/zero adjustment is made first. These adjustments are not made with zero and full scale input signals, and it may be helpful to understand why. An A/D converter will produce a given digital word output for a small range of input signals, the nominal width of the range being one LSB. If the input test signal is set at a point where the converter should be on the verge of switching to the next value, the unit can be calibrated so that it does switch to the next value at just that point. With a high speed convert command rate and a visual display, these adjustments can be performed in a very accurate and sensitive way. Analog Devices' Conversion Handbook gives more detailed information on testing and calibrating A/D and D/A converters.

ZERO AND OFFSET CALIBRATION

For unipolar units set the input voltage precisely to +0.0049V and adjust the 20kΩ zero potentiometer until the converter is just on the verge of switching from 0000000000 to 0000000001.

For bipolar units set the input voltage precisely to -4.9951V and adjust the 250Ω variable offset resistor until Offset Binary coded units are just on the verge of switching from 0000000000 to 0000000001, and Two's Complement coded units are just on the verge of switching from 1000000000 to 1000000001.

GAIN CALIBRATION

Set the input voltage precisely to +9.9853 for unipolar units or +4.9853V for bipolar units. Note that these values are 1½LSB's less than nominal full scale. Adjust the 25Ω variable gain resistor until binary and offset binary coded units are just on the verge of switching from 1111111110 to 1111111111 and Two's Complement coded units are just on the verge of switching from 0111111110 to 0111111111.

POWER SUPPLY AND GROUNDING CONNECTIONS

The ADC1109 requires power supplies of -15V, +15V, and +5V which are connected to pins 19, 18, and 17 respectively. The +5V power supply and digital returns are connected to **DIGITAL GROUND (pin 20)** while the ±15V supplies and analog signal returns are connected to ANALOG GROUND (pin 24). Analog ground and digital ground are tied together internally, but it is important that no digital ground signals be present in a path serving as an analog ground return.

The +5V and ±15V power inputs are internally bypassed, but it is recommended that additional bypass capacitors be added externally. The capacitors should be located as near to the module pins as possible. The +5V bypass capacitor should be connected between the +5V input (pin 17) and DIGITAL GROUND (pin 20). The ±15V bypass capacitors should be connected between pin 19 and ANALOG GROUND, and between pin 18 and ANALOG GROUND. The capacitors would typically be 10μF (or greater) tantalum types.

REPETITIVE CONVERSIONS

When making repetitive conversions in the parallel output mode, at least 100ns must be allowed between the completion of one conversion and the beginning of the next. This results in a typical throughput rate of 238kHz. When operating in the serial output mode, an additional period of time may be necessary to assure that the data from one conversion has been completely entered in the receiving shift register before the next conversion is initiated.

The ADC1109 can be interrupted during a conversion with a new convert command. The unit will reset and begin a new conversion as long as the 100ns minimum convert command pulse width requirement is met.

THE AC1520 MOUNTING CARD

The AC1520 mounting card is available to assist in the application of the ADC1109. This 4.5″ x 4.0″ printed circuit card, shown below in Figure 7, has sockets that allow an ADC1109 to be plugged directly onto it. The card includes gain, offset, and zero adjustment potentiometers and power supply bypass capacitors. It mates with a Cinch 251-22-30-160 (or equivalent) edge connector which is supplied with every card. Jumpers can be installed on the printed circuit card to program the analog input range.

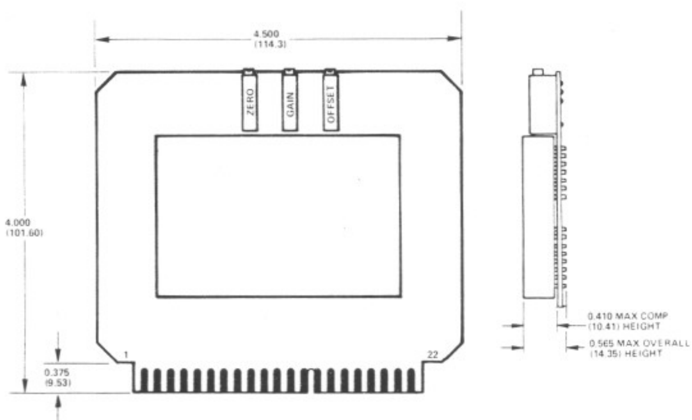


Figure 7. AC1520 mounting card outline dimensions in inches and (mm)

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