

# ADC-16 ANALOG TO DIGITAL CONVERTER

## TECHNICAL REFERENCE

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## SPECIFICATIONS

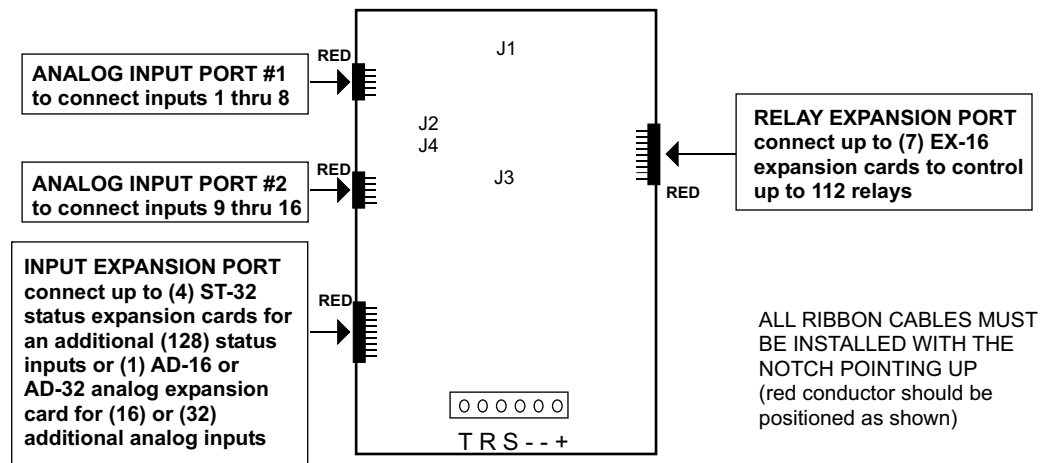
Power Supply.....	9 to 14 volts DC (300MA)
Operating Temp. Range.....	-40° C to +85° C
Serial Data Protocol.....	50 to 19,200 baud (defaults to 8 data bits, no parity & 1 or 2 stop bits) Full duplex operation
Maximum Sampling Rate.....	1,700 samples per second (single channel, 8 bit at 19,200 baud)
Analog Inputs.....	16 single-ended inputs (standard 8 bit resolution or optional 10 bit resolution) (8 bit resolution will divide your measurement range into 256 different increments) (10 bit resolution will divide your measurement range into 1,024 different increments)
Expansion Capability.....	up to 112 relays (with up to (3) EX-32 or up to (7) EX-16 expansion cards) up to 128 status inputs (with up to (4) ST-32 expansion cards) up to 32 analog inputs (with (1) AD-16 expansion card) up to 32 temperature inputs (with (1) AD-16 and temperature input options) up to 8 keypads (with KY-12 M keypads)
Weight.....	5 ounces
Size.....	7 inches by 5 inches
Options Available.....	10 Bit Resolution Temperature Input TransZorb and Resetting Fuse RS-422, RS-423 & RS-485 Serial Interface Standards

## WARRANTY AND CARE OF THE ADC-16

The ADC-16 Analog to Digital Converter is warranted against factory defects for a period of 90 days from the date of purchase. The ADC-16 has proven to be extremely reliable in actual operation during field tests. We recommend that the ADC-16 and associated hardware be installed in a suitable enclosure (4 mounting holes are provided on the circuit board) and that reasonable precautions be taken to protect the circuit from static discharge. The most likely damage to occur is that caused by lightning discharge through the power supply or serial I/O lines. The best way to prevent this type of damage is to install a Power Protector (Part # SP-120 or Radio Shack #26-1395 or Surgebuster #120K15A) in the electrical outlet which supplies power to the hardware. Shielding the analog input lines will provide additional protection. If further protection is desired, install a TransZorb across the power input to the interface card (part #SP-12K) and to the RS-232 lines (part #SP-232K).

### CONNECTION DIAGRAM

#### ADC-16 ANALOG TO DIGITAL CONVERTER



#### ADC-16 TERMINAL BLOCK CONNECTIONS

- (T) RS-232 Transmitter ( connect to green wire)
- (R) RS-232 Receiver (connect to white wire)
- (S) (+) 12 volt control signal for use with RS-232 (connect to black wire)
- (-) RS-232 signal ground (connect to red wire)
- (-) Power supply (black wire) (use caution, reversed polarity may cause damage, 9 to 14 volts DC only)
- (+) Power supply (red wire)

## POWER SUPPLY REQUIREMENTS

The ADC-16 may be powered from any DC voltage source which will supply 300 ma within a voltage range of 9 to 14 volts. The recommend power supply for use with a single ADC-16 card is the PS-GP-1 (wall transformer supply). **IMPORTANT:** Use caution when connecting the power source, reversed polarity may cause damage. The heat dissipation of the 7805 regulator on the ADC-16 will be greatly reduced with a 9 volt power source. The PS-9VDC-500 and PS-9VDC-1000 wall transformer power supplies may be used to power both the ADC-16 and expansion card(s) without the need for additional regulators. Please note that the PS-12VDC-500 and PS-12VDC-1000 are unregulated supplies and may produce voltages as high as 18 volts (see pages 7 & 8).

**POWER SUPPLY FUSING:** A 500 milliamp (.5 amp) in-line fuse should be installed in series with the (+) power supply lead to protect the power supply and the ADC-16 from damage.

### SET-UP AND TESTING

Upon receiving your ADC-16, you should connect and test the operation of the hardware to verify proper operation. Please set-up and test the ADC-16 as follows (IBM and Compatibles):

(1) Plug the serial cable into COM 1 of your computer and connect the other end to the terminal block on the ADC-16 (as shown on page 2). If you did not order a serial cable, a cable may be fabricated by soldering the wires to the proper connector as shown on the following pages. Care should be taken to prevent any static discharge on the ADC-16 by touching a metal ground before handling the ADC-16 and associated circuits. Use caution not to set the ADC-16 or associated hardware on a metal surface or damage could result.

(2) Connect the power supply (part # PS-GP-1) to the six position terminal block at the bottom of the ADC-16. Be sure to observe the (+) and (-) connections on the ADC-16 (reversed polarity may cause damage). Connect the RTC-16 terminal block to ports #1 and #2 on the ADC-16. When connecting the ribbon cable from the RCT-16 to the ADC-16, the red line on the ribbon cable should be positioned as shown on page 2. The ribbon cables for the RTC-16 should be routed underneath the ADC-16 so that the RCT-16 is on the right side of the ADC-16.

(3) The ADC-16 is set to 9,600 baud at the factory. This is the proper setting for use with the test software which is provided on CD with your order. **NOTE:** If any of the analog ports have been configured for temperature input, skip this section and complete the set-up and testing requirements which are described in the TE-8 technical reference.

Windows users should install the Windows test program (Windows 95, 98, ME, 2000, XP and Vista) Run setup.exe in the folder Windows Data Acquisition Program (on CD supplied). If prompted about an older file, keep your newer file. Once installed, run the ADC-16 program. The program defaults to Com 1. Other Com ports may be selected if required.

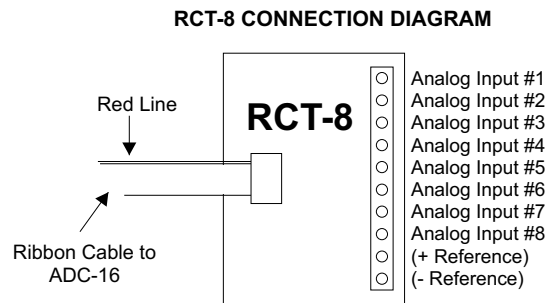
Your screen should show a row of eight or sixteen numbers. The top 8 numbers represent the analog inputs for port #1 and the bottom 8 numbers represent the analog inputs for port #2. The numbers may be fluctuating as a result of noise on the analog inputs (this is normal).

(4) Test each analog input by connecting each input (one at a time) to the reference (-) terminal on the RCT-8 or RCT-16 (see page 4). Your screen should show a "0" for that input. After this is completed, connect each input (one at a time) to the reference (+). Your screen should show a "255" for 8 bit inputs or "1023" for 10 bit inputs for each input. If

additional testing is desired, connect a 10k ohm 20 turn potentiometer to each input (one at a time) as shown on page 12, figure B. The input shown on the screen should increment from 0 to 255 (8 bit) or 0 to 1023 (10 bit). The number shown for each input should increment by one (in 256 increments for 8 bit inputs) or (in 1024 increments for 10 bit inputs) as the potentiometer is slowly adjusted from 0 to 20 turns.

(5) To exit the test program, press any key. If you exit the program abnormally, you may use CUR-ON.EXE to turn the cursor back on. If operation of the analog inputs are normal, then testing is now complete and your ADC-16 may be placed in service. If problems are encountered during testing, proceed to the trouble-shooting procedures shown below.

**NOTE:** The (S) terminal on the ADC-16 is provided for use as an RS-232 control signal for use with the RS-232 control lines CTS, DSR and DCD. If the ADC-16 does not function with your software, connect the (S) terminal (black wire) to all three control lines (CTS, DSR and DCD). The pins for these control lines on a DB-25 connector are pins 5, 6 and 8. The (S) terminal may also be used to supply a signal to one of the RS-232 control lines for use as a supervisory signal to sound an alarm with your software when the ADC-16 has lost power or has been disconnected (see utilities).



**NOTE:** The RCT-16 will have the same connections as two RCT-8

**TROUBLE-SHOOTING THE ADC-16**

(1) Verify power to the ADC-16 by checking for 5 volts DC on the 2200 mf capacitor (low voltage may indicate an overload). Verify that the ADC-16 is set to the same baud rate as what appears on the test software screen. Check for a minimum of 9 volts DC at the ADC-16 power input (on the 6 position terminal block) and check for correct polarity. The RS-232 driver on the ADC-16 requires a minimum of 9 volts for proper operation. A voltage over 14 volts will cause damage to the RS-232 driver.

(2) Verify proper operation of the COM 1 serial port (RS-232 port) on your computer. You may do this by connecting a serial printer to COM 1 and using a short Basic program (shown below) to send an ASCII code to your printer. The following example should print a "0" on your printer. The protocol is set for a printer using 1200 baud, no parity, 8 data bits and 2 stop bits. The ASCII code for "0" is 48.

```
10 OPEN "COM1:1200,N,8,2,DS,CD,CS" AS #1
20 PRINT #1, CHR$(48);
```

If your serial port is not transmitting the ASCII code, check to make sure that you have the cable connected to COM 1 (many PCs are incorrectly marked) and check the dip switch settings on your RS-232 serial card. If you are still unable to transmit the ASCII code from COM 1, check for possible software conflicts or failure of your RS-232 card. Some programs may disable your serial port (such as terminate and stay resident programs, fax drivers, etc.).

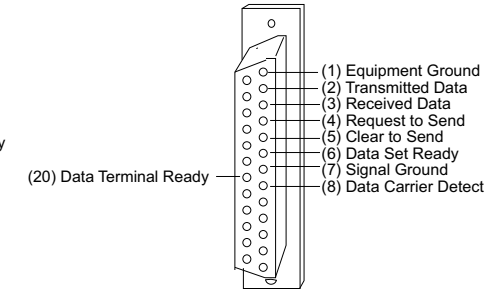
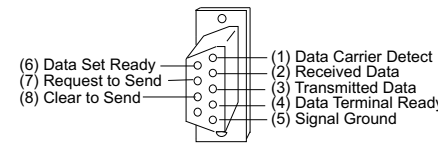
**NOTE:** Using a data probe to detect a change in logic level does not necessarily mean that the correct codes are being transmitted. Your software may be transmitting a data stream to configure a modem, mouse or other device. If your printer does print the "0" but the ADC-16 does not function, contact us at (614) 464-4470 for technical support.

(3) If erratic operation is experienced, check for loose connections at the ribbon cable connections and terminal block (tug on each wire going into the terminal block), check for power supply interruptions or short circuits caused by metal contact to the ADC-16 circuit areas or other connected hardware. When more than three EX-16 cards are connected

to the ADC-16, an external power feed is required (see EX-16 manual).

(4) The input voltage to any of the analog inputs must not exceed the reference voltage (nor should the input go negative with respect to the reference) or erratic data may be generated on one or more of the analog channels. When an external reference is used, the reference voltage must be within 100 millivolts of the supply voltage to the ADC0809 IC (approximately 5 volts DC) when operating in a MODE (2) jumper configuration (see pages 10 & 11). When operating in a MODE (3) jumper configuration (8 bit only), the reference voltage must be a minimum of 1.2 volts and the reference voltage must be centered about the supply voltage to the ADC0809 IC. When operating in a MODE (3) jumper configuration, the input voltage to any of the analog inputs must not exceed the reference voltage (nor should the input go negative with respect to the reference) or erratic data may be generated on one or more of the analog channels. If after checking thoroughly you are still unable to correct the problem, contact us at (614) 464-4470 for technical support.

**CONNECTOR PIN-OUTS**



**DB-9 Pins Connection**

- (1) Data Carrier Detect\* (connect to black wire or terminal (S) on the ADC-16)  
NOTE: This connection is not needed on most computers.
- (2) Received Data (connect to green wire or terminal (T) on the ADC-16)
- (3) Transmitted Data (connect to white wire or terminal (R) on the ADC-16)
- (5) Signal Ground (connect to red wire or terminal (-) on the ADC-16)

The following pins are optional and may be used as needed for specific applications.

- (4) Data Terminal Ready (DTR) output from your PC.
- (6) Data Set Ready (DSR) input to your PC.
- (7) Request To Send (RTS) output from your PC.
- (8) Clear To Send (CTS) input to your PC.

**DB-25 CONNECTOR...SOCKET (female)**  
(rear view/solder side)

**DB-25 Pins Connection**

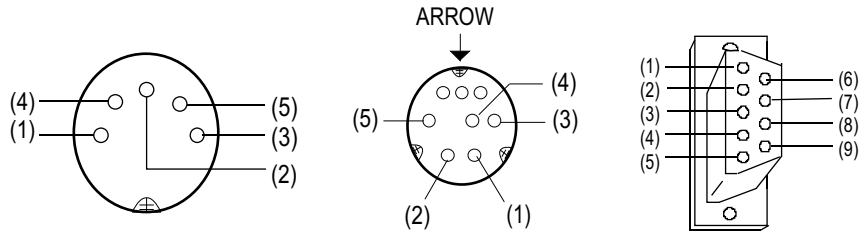
- (2) Transmitted Data (connect to white wire or terminal (R) on the ADC-16)
- (3) Received Data (connect to green wire or terminal (T) on the ADC-16)
- (7) Signal Ground (connect to red wire or terminal (-) on the ADC-16)
- (8) Data Carrier Detect\* (connect to black wire or terminal (S) on the ADC-16)  
NOTE: This connection is not needed on most computers.

The following pins are optional and may be used as needed for specific applications.

- (4) Request to Send (RTS) output from your PC.
- (5) Clear to Send (CTS) input to your PC.
- (6) Data Set Ready (DSR) input to your PC.
- (20) Data Terminal Ready (DTR) output from your PC.

\* On some types of computers, the Data Carrier Detect must be held high (+12 volts) before the RS-232 port is enabled. The (S) terminal on the ADC-16 will provide the +12 volts.

### ADDITIONAL CONNECTOR PIN-OUTS



5 PIN DIN  
(Apple)

Pin #	Connection
(1)	DTR
(2)	Signal Ground
(3)	DSR
(4)	Transmitted Data
(5)	Received Data

8 PIN MINI-DIN  
(Mac & IBM)

Pin #	Connection
(1)	DTR
(2)	DSR, DCD & CTS
(3)	Transmitted Data
(4)	Signal Ground
(5)	Received Data

RS-422  
(DB-9 plug)

Pin #	Connection
(2)	Transmitter (+)
(3)	Equipment Ground
(4)	Receiver (+)
(7)	Transmitter (-)
(8)	Receiver (-)

**NOTE:** The above connector illustrations are viewed from the rear (solder side).

### CONNECTION OF THE ADC-16 DIRECTLY TO A MODEM

The ADC-16 may be connected directly to a modem at a remote location without the need for a PC at the remote site. The modem at the remote site is then considered DCE equipment (Data Communications Equipment) and requires that the serial transmitter and receiver lines be reversed (pins 2 & 3 on a DB-25 and DB-9) when connecting to the ADC-16. When the ADC-16 is connected directly to a computer, the computer is considered to be DTE equipment (Data Terminal Equipment) and the pin-outs shown on the preceding page are correct.

### OPTIONAL TEMPERATURE INPUTS FOR THE ADC-16 AND ADC-8

The ADC-16 may be configured for temperature input by specifying the E and/or F options when ordering the ADC-16. The inputs are converted to temperature in groups of eight. The ADC-16 may be ordered with 8 temperature inputs and 8 analog inputs or with all 16 channels converted for temperature input. The 8 bit inputs require that a voltage reference and several additional components be installed on the ADC-16 card. Once the 8 bit inputs have been converted for temperature input, the analog input port (all 8 channels) will be dedicated for use as temperature input only. When the ADC-16 or ADC-4 is equipped with 10 or 12 bit inputs, additional components are not required for temperature input. The 10 bit inputs are converted to temperature input by connecting the TE-8 temperature input card to the 10 bit analog input port (removal of the TE-8 from the ADC-16 allows the inputs to be used for conventional analog input). The temperature error of the TE-8 is typically less than 1 degree F. Greater accuracy may be obtained with the use of the extended range temperature sensors. The temperature input ranges for 8 and 10 bit inputs are as follows:

(8 bit inputs)	temperature range -40° F to 146° F (-40° C to 64° C)	standard sensors
(10 bit inputs)	temperature range -40° F to 212° F (-40° C to 100° C)	standard sensors
(10 bit inputs)	temperature range -67° F to 302° F (-55° C to 150° C)	extended range sensors

### EXPANSION PORTS

The ADC-16 provides two expansion ports for additional I/O operations using a single COM port. The Relay Expansion Port allows up to (112) relays (or other output devices) to be controlled by software or keyboard input (using EX-16 or EX-32 relay expansion cards). Each EX-16 expansion card will provide control for 16 additional relays. A total of seven EX-16 expansion cards may be connected to the AR-16, ADC-4(8)(16) or STA-8(16). The first EX-16 expansion card is connected to the relay expansion port on the AR-16, ADC-16 or STA-16 using the RC-20 ribbon cable. Additional EX-16 expansion cards connect to the preceding EX-16 with the RC-20 ribbon cable. The relay output ports on the EX-16 are identical to those on the AR-16 and accept the same relay cards and other accessories as the AR-16. Shunts on the EX-16 are used to select the relay output port desired. A variety of relay cards with various contact configurations are available for connection to the EX-16 expansion cards. Relays are controlled by transmitting a relay code (32 thru 255). Each relay is assigned 2 codes, one to energize the relay and the other to de-energize the relay. The relay code is determined by using the following formula: RELAY CODE = (RELAY # times 2) - 1...to energize the relay or RELAY CODE = (RELAY # times 2) - 2...to de-energize the relay. Additional information is provided with the EX-16 relay expansion card.

### ADDING ADDITIONAL INPUTS

The Input Expansion Port allows up to (128) additional status inputs or (32) additional analog inputs to be read by software (using up to (4) ST-32 status expansion cards or (1) AD-16 or AD-32 analog expansion card). Each ST-32 expansion card will provide an additional 32 status inputs. The first ST-32 card connects to the input expansion port on the ADC-16. Additional ST-32 cards connect to the preceding ST-32 card. One AD-16 or AD-32 analog expansion card can be connected to the ADC-16 in place of the ST-32 expansion cards to provide an additional 16 or 32 analog inputs. If more than 48 analog inputs are required, contact technical support for customized hardware. The software channel codes for the AD-16 analog inputs are 16 to 31. The additional analog inputs are identical to those described on pages 9, 10 & 11 for the ADC-16 and the software is handled in the same manner with the exception of the channel codes. The status inputs are read by transmitting a single byte status port code to the ADC-16. Transmitting a 16 would request information for the first 8 status inputs on the ST-32 status expansion card. The ADC-16 would then transmit a single byte number (each bit representing one status input). Additional information is provided with the ST-32 status expansion card.

For applications requiring more than 32 analog inputs/128 status inputs or applications requiring more than 112 relays, the PS-4 or PS-8 port selector may be used as a bank selector to select one bank of 32 analog inputs/128 status inputs and 112 relays. In this manner, up to 4,096 analog inputs or up to 16,384 status inputs may be connected and 14,336 relays may be controlled (128 banks times 112 relays and 128 status inputs or 32 analog inputs). An example of this method is shown on page 9 using four banks to provide 128 analog inputs and control of 448 relays.

### USE OF UNREGULATED WALL TRANSFORMERS

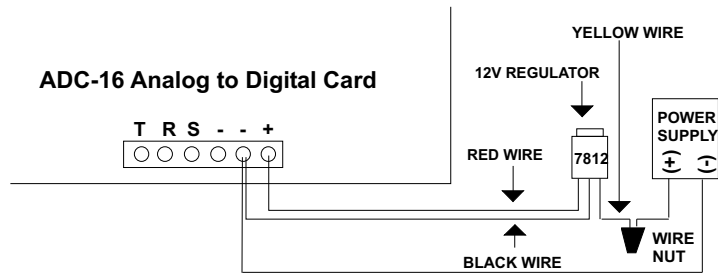
The PS-12VDC-1000 and PS-12VDC-500 power supplies are unregulated and may produce voltages substantially higher than the 12 volts DC that is labeled on the device. The 7805 regulator on the ADC-16 and any relays powered by the higher voltage may produce an excessive (and undesirable) amount of heat which may require additional air flow or ventilation to prevent overheating. Voltages over 14 volts DC may damage the Maxim IC on the ADC-16. The 7812 regulator (supplied with the power supply) may be used to regulate voltage to the ADC-16 and relay card(s). Connect the 7812 regulator as shown below and on the following page:

**BLACK WIRE:** connect to the (-) terminal on the ADC-16 and to the (-) wire coming from the power supply.

**RED WIRE:** connect to the (+) terminal on the ADC-16.

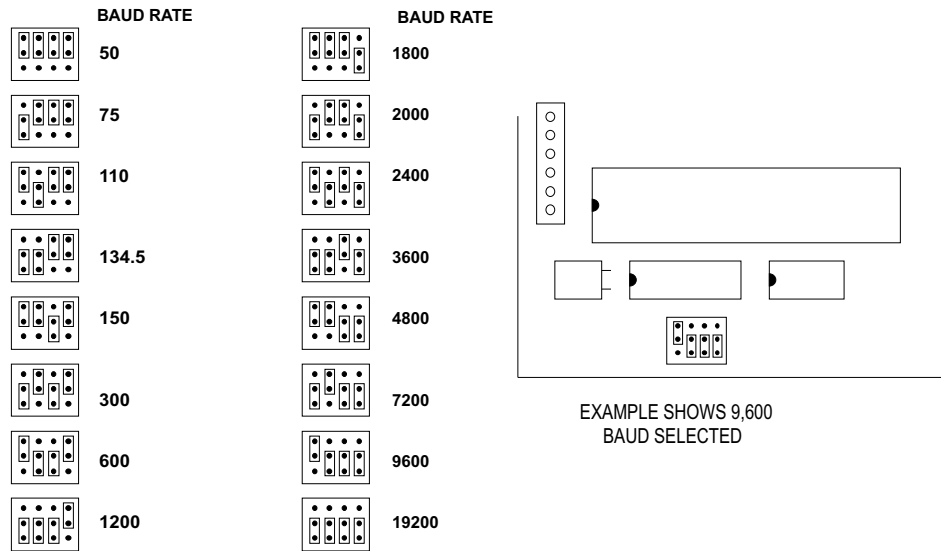
**YELLOW WIRE:** connect to the (+) wire coming from the power supply.

**USE CAUTION:** The metal tab on the regulator is electrically connected to the (-) wire (black). Before connecting the red & black wires to the ADC-16, check for 12 volts DC across the wires (red should equal (+)).



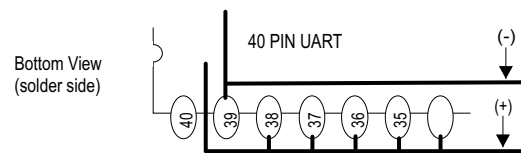
**BAUD RATE SELECTION FOR THE ADC-16**

Select the desired baud rate by placing the removable shunts in the positions which correspond to the desired baud rate. All four of the shunts must be in place for the ADC-16 to operate properly.



**CHANGING PROTOCOL SETTINGS**

PARITY, WORD LENGTH and STOP BITS: These functions are selected using pins 35, 36, 37, 38 and 39 on the 40 pin UART IC on the ADC-16. Connect the pins to the (+) 5 volt or (-) ground power feed (located above and below pins 35 thru 39) as shown in the chart on the following page to select the desired protocol. Be sure to cut the existing circuit track using a knife (if different).

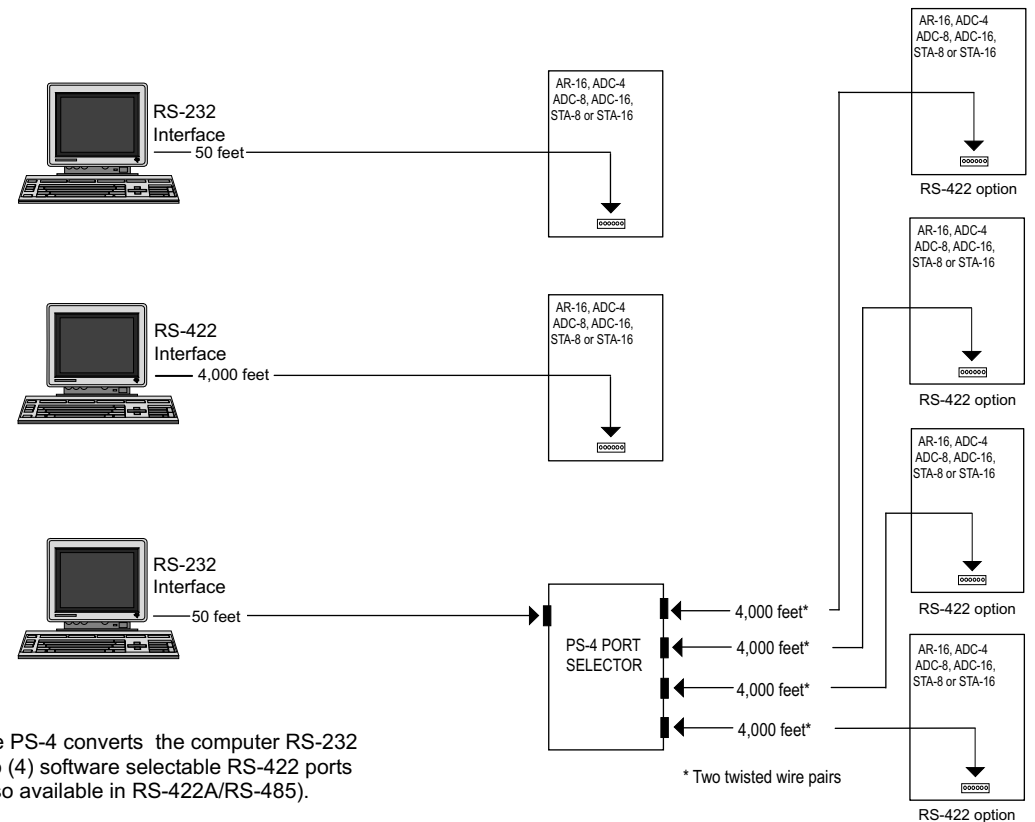


PIN 39 (EPE)	WLS1	WLS2	SBS (PINS 38, 37, 36)	PIN 35 (PI)
0 = Odd Parity	0	0	0 (5 data bits, 1 stop bit)	0 = Parity On
1 = Even parity	0	0	1 (5 data bits, 1.5 stop bits)	1 = Parity Off
	1	0	0 (6 data bits, 1 stop bit)	
	1	0	1 (6 data bits, 2 stop bits)	
	0	1	0 (7 data bits, 1 stop bit)	
	0	1	1 (7 data bits, 2 stop bits)	
	1	1	0 (8 data bits, 1 stop bit)	
	1	1	1 (8 data bits, 2 stop bits)	

NOTE: 1=(+5 VDC), 0=(ground (-))  
All pins must be connected to 5 volts or ground. Do not allow any pins to float (pins left unconnected).

**RS-422 INTERFACING AND RS-232 DISTANCE LIMITATIONS**

The RS-232 interface will allow the AR-16, ADC-4(8)(16) or STA-8(16) interface cards to be located up to 50 feet from the computer using a single 2 or 3 conductor wire. When distances need to be greater, the RS-422, RS-423 and the RS-422A, RS-485 interfaces will allow the Interface card to be located up to 4,000 feet from the computer using a 1 or 2 paired communications cable (2 or 4 conductor/1 or 2 twisted pairs of wire). The PS-4 or PS-8 port selector may be used to select one port (1 of 4 or 1 of 8) to control up to 8 interface cards (ADC-16, STA-16 or AR-16) at various locations up to 4,000 feet from the port selector, providing up to 256 analog inputs, up to 1,152 status inputs and providing control of up to 1,024 relays. A total of up to (16) PS-8 port selectors may be connected to a single RS-232 port, allowing for a total of 4,096 analog inputs, 18,432 status inputs and 16,384 relays.



The PS-4 converts the computer RS-232 into (4) software selectable RS-422 ports (also available in RS-422A/RS-485).

## VOLTAGE INPUT AMPLIFICATION AND SIGNAL CONDITIONING

The ADC-16 defaults to a 0 to 5 volt input range (installation of a voltage reference will allow input ranges as low as 0 to 1.2 volts when using 8 bit inputs). When the input voltage range is required to be lower, (such as with a watt transducer or load cell) an external instrumentation amplifier must be used to amplify the input signal to the 0 to 5 volt input range of the ADC-16.

Several general purpose instrumentation amplifiers are available to amplify lower signal levels to the 0 to 5 volt range required by the ADC-16 (for use with 8, 10 and 12 bit inputs). The VA-1 is a single channel amplifier for connection to the ADC-4, ADC-8 or ADC-16. The VA-2, VA-4 and VA-8 amplifiers are two, four and eight channel versions of the VA-1. The VA-1, VA-2, VA-4 and VA-8 all provide 15 turn potentiometer(s) for gain adjustment (amplification level). The amplification level is adjusted for a 0 to 100 millivolt input at the factory. The amplification level may be adjusted for signal inputs as low as 0 to 5 millivolts or as high as 0 to 5 volts. Lower signal levels (such as the output signal from a watt transducer, pressure transducer, load cell, etc.) with typical full scale voltages of only 20 to 100 millivolts will require the addition of the VA-1 instrumentation amplifier. Signal levels this low will require shielded wire in place of a twisted pair. The shield should be left disconnected at the source and grounded to an earth electrical ground at the VA-1.

**CONNECTION OF DIFFERENTIAL SIGNALS:** The ADC-16 inputs are single-ended. If differential inputs are required, the VA-1 may be used to convert a differential signal into a 0 to 5 volt signal for connection to the ADC-16. The VA series amplifiers have a reference input (for connection to the ADC-16 reference) which is used to generate a 2.5 volt offset. The gain adjustment on the VA series amplifiers may be adjusted to allow for differential signals as low as (+) and (-) 5 millivolts or as high as (+) and (-) 5 volts.

**ANALOG LINEAR OPTOCOUPERS:** The VI-11 or VI-81 linear optocoupler instrumentation amplifiers may be used when the analog input signal must be electrically isolated (such as with some types of pressure transducers, signals with ground referenced offsets or for signals which must be isolated for safety).

### VOLTAGE REFERENCE INPUT

Each 8 channel analog input port has a separate voltage reference input and each port may be selected to function in any of the following three modes. **NOTE:** 10 bit inputs are limited to a 5 volt reference.

**MODE (1).....**Voltage reference equals power supply. With the factory jumpers installed, the reference (+) and reference (-) will be equal to the power supply voltage (5 volts and ground, plus or minus .25 volts). The voltage input scale will be 0 to 5 volts (20 millivolt resolution with 256 increments for 8 bit inputs or 5 millivolt resolution with 1,024 increments for 10 bit inputs). The ADC-16 will then transmit (255)\* with a 5 volt input, (0) for a 0 volt input, (128) for a 2.5 volt input and other values corresponding to the following formula: voltage times (51) = X, where X = the integer value transmitted. EXAMPLE: 1.9 volts times 51 = 96.9. The ADC-16 would then transmit (97) decimal (in binary) to represent a 1.9 volt analog input. The use of the power supply for the voltage reference will be adequate for most applications. MODE (1) is selected when both jumpers are installed (J1 and J2 for port #1, or J3 and J4 for port #2), all 8 channels of the analog port will then function in the MODE (1) configuration. \*binary number represented in decimal

**MODE (2).....**Voltage reference equals calibrated external voltage reference equal to power supply voltage. This method will provide a greater degree of accuracy for analog inputs which need to be referenced to the actual volt (use of the power supply for actual volt reference may introduce small errors due to variations in the power supply caused by activity of the ADC-16 functions). To select the MODE (2) configuration cut the (+) reference voltage jumper (J1 for port #1 or J3 for port #2). The jumpers to the (-) reference voltage should be left in place (J2 for port #1 or J4 for port #2). A calibrated voltage equal to the ADC-16 power supply (plus or minus .1 volt) should be applied to the voltage reference input (terminal #9 (+) and #10 (-) on the RCT-8). The voltage input may be any well regulated power supply which can be adjusted to the desired voltage without drift (for greater stability a temperature compensated power supply may be used). To determine the proper voltage, measure the ADC-16 power supply voltage on the 28 pin 0809 chip (pins #11 and #13). The resolution will be equal to the reference voltage input divided by 256. All 8 channels of the analog input port will then function in the MODE (2) configuration with J1 (port #1) or J3 (port #2) cut and the external voltage reference connected. The ADC-16 has the capability of providing an on-board voltage reference by installing a

317 adjustable voltage regulator, 500 ohm trimmer, 240 ohm and 390 ohm resistors on the top right side of the ADC-16.

**MODE (3).....**(8 bit only) Adjusted voltage reference input. In this mode of operation the voltage input level may be adjusted to allow input of lower analog voltages (down to about 1.2 volts full scale). The MODE (3) configuration is selected by removing the voltage reference jumpers (J1 and J2 for port #1 or J3 and J4 for port #2) and installing a limiting resistor (3K typical) in place of both jumpers. It is important that both resistors be installed because the reference voltage must be centered about the supply voltage of the 0809 chip. Conversion errors may occur (due to the design of the 0809 chip) if the center of the reference voltage is not equal to the center of the supply voltage (plus or minus .1 volt). The voltage reference device is then connected to the voltage reference input (terminal #9 (+) and #10 (-) on the RCT-8). The voltage reference may be soldered directly to pins #12 (+) and #16 (-) on the 0809 chip for greater stability. The voltage reference device may be a simple zener diode or LED for less critical applications (use (2) 180 ohm resistors in place of jumpers for LED). When the voltage reference is 2.5 volts or less, the installation of a 470 mf capacitor on the ADC-16 is recommended (holes are provided near the center of the card above J3 with the positive lead marked). The use of a temperature compensated voltage reference will result in greater accuracy and less drift. You may contact our technical support staff for more information on the voltage references which we stock.

**NOTE:** The analog voltage input must not be higher than the ADC0809 power supply voltage for modes 1 and 2 or the rated voltage of the voltage reference device for mode 3. In all cases the input voltage must not go negative (or negative with respect to the reference in the case of MODE (3) operation). Failure to observe these voltage input restrictions may result in erratic or incorrect conversion results on one or more of the analog channels.

### ANALOG VOLTAGE INPUTS

Voltages up to hundreds of volts may be divided down to the 5 volt range by using a simple resistance divider as shown on the following page (the signal source must be capable of driving a 1 ma load). To determine the value transmitted by the ADC-16 for a specific voltage applied to the divider circuit use the following formula: (VI divided by DF) times 51 = TV (where TV = transmitted value sent by the ADC-16, VI = voltage input to divider, DF = divider factor) DF = full scale voltage divided by 5 volts. EXAMPLE: 100 volts full scale divided by 5 = 20 = DF. A 60 volt input to the divider divided by 20 multiplied by 51 = 153 = TV, the value transmitted by the ADC-16.

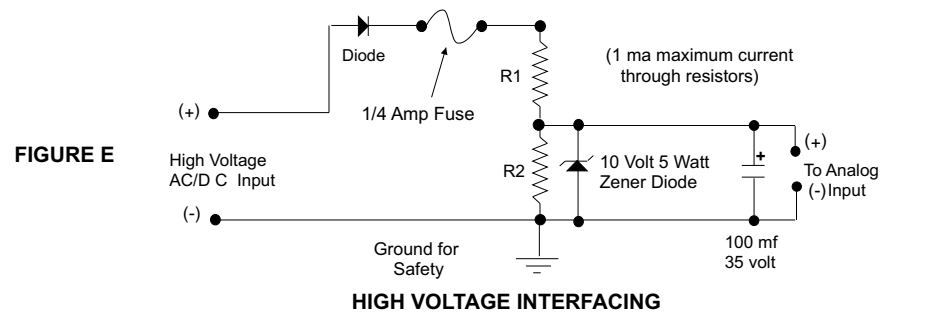
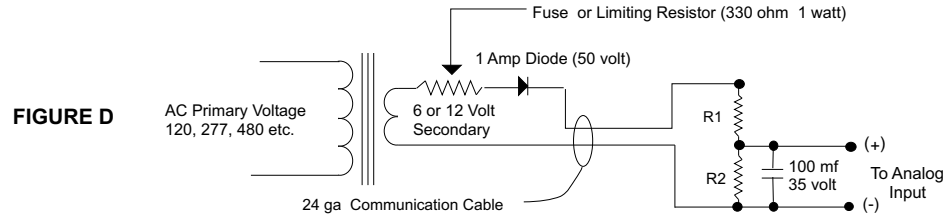
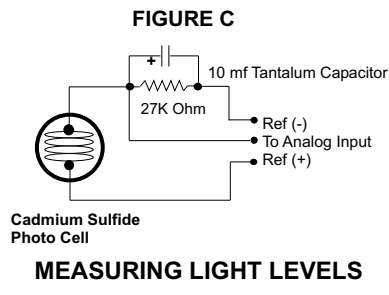
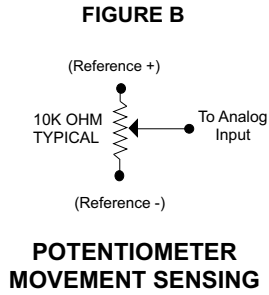
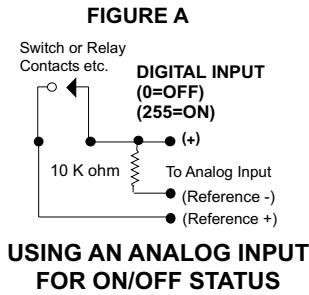
The voltage input source may be located up to several hundred feet from the ADC-16. The RCT-8, RCT-16 or RCP-8 are used to make the wire connections. The wire which connects the RCT-8 to the signal source should be a twisted pair to reduce possible input noise (22 or 24 gauge communication cable typical). Shielded cable may be used to further protect against EMI or lightning noise (the shield should be left disconnected at the source and connected to an earth ground/equipment ground at the ADC-16).

Lower millivolt signal levels (such as the output signals from a watt transducer, pressure transducer, load cell, etc.) with typical full scale voltages of only 20 to 100 millivolts will require the addition of the VA-1, VA-2, VA-4 or VA-8 instrumentation amplifier. The VA-1 connects to any of the analog inputs and will convert a millivolt signal input to a 0 to 5 volt output for input into the ADC-16. Signal levels this low will require shielded wire in place of the twisted pair. An adjustment on the VA-1 will set the input scale. The shield should be left disconnected at the source and grounded to an earth ground at the VA-1. Applications requiring isolated analog inputs require the VI-81 linear optocoupler amplifier.

**NOTE:** When the analog inputs are left floating, (no connection) the ADC-16 will transmit fluctuating numbers as a result of noise present at the inputs. We recommend that any unused inputs be connected to reference (-) to prevent possible errors on other channels.

**FILTERING INPUT NOISE:** A .01 mf filter capacitor installed on the ADC-16 card (one for each channel) will significantly reduce errors and fluctuation as a result of input noise (if noise is a problem). Holes are provided on the ADC-16 for the installation of the .01 mf capacitors (specify part # CAP-16 to order a package of (16) .01 mf filter capacitors). A 2.7 mf or 10 mf tantalum capacitor may be added for additional filtering (input response time will be slower).

Shown on the following page in figures A, B & C are methods for reading contact closure, potentiometer movement & light levels.



**CAUTION:** When working with high voltages, the potential for fire, explosion, electrocution, eye injury or blindness and life threatening injuries or death exists. If you are not familiar with the precautions needed when working with high voltages, do not attempt to connect high voltage up to these circuits. To prevent the danger of a high voltage feeding back to the ADC-16 and the fire/injury/electrocution hazard caused by an open or short circuit, a 10 volt 5 watt zener diode and 1/4 amp fuse should be connected as shown in figure E. Wire used to interconnect a high voltage input must be rated for use with the higher voltage. When connecting the ADC-16 to high voltage AC equipment the method shown in figure D above is recommended.

The following method is used to divide a high voltage down to the 5 volt range needed for input into the ADC-16. This method involves the use of two resistors (R1 and R2) which together add up to Rt (total resistance). The total resistance is determined by using the Ohms Law to compute the resistance needed for a 1 milliamp current flow through the resistors. **EXAMPLE:** If your full scale voltage is 100 volts (R = E divided by I) 100 volts divided by .001 amp = 100,000 ohms (100K ohm). To determine the proper ratio, divide 5 volts by the full scale voltage. 5 divided by 100 volts = .05. Multiple this ratio by the total resistance to determine the value of R2. R1 is then equal to the difference between the total resistance and R2. **EXAMPLE:** ratio .05 times total resistance 100,000 ohms = 5,000 ohms (the value of R2). Total resistance 100,000 ohms less R2 5,000 ohms = 95,000 ohms (the value of R1). To determine the power rating needed for the resistor, use the following formula: P = I squared times R. **EXAMPLE:** .001 squared = .000001 times R1 95,000 ohms = .095 watts. A 1/8 or 1/4 watt resistor would be sufficient.

**IMPORTANT:** The full scale voltage used should be the highest possible voltage that could be present at the high voltage input.

AC voltages may be applied to the high voltage input if a diode is connected in series and a filter capacitor (100 mf, 35 volt typical) is connected between the ADC-16 analog input and the ADC-16 reference (-). AC voltages over 24 volts or great enough to create an electrical shock hazard or fire should be connected to the ADC-16 analog input using a step-down transformer to reduce the high voltage down to the 5 volt range as shown in figure D. A diode and filter capacitor must be connected on the secondary side of the transformer (a common low current power transformer may be used).

**10 BIT ANALOG INPUTS**

The 10 bit option of the ADC-16 functions very similar to its 8 bit counterpart with the exception of the following:

- (1) Input voltage range should be maintained at 0 to 5 volts DC (5.0 volts across the voltage reference inputs).
- (2) The ADC-16 will transmit in two byte format as opposed to the single byte format of the 8 bit. The first byte received will be the most significant digits (all eight bits are used). The second byte received will be the least significant two digits (the first 6 bits will always be zero and are not used).
- (3) The sampling rate of the 10 bit version will be less than half that of the 8 bit as a result of the two byte format of the 10 bit converter (approximately 500 samples per second for a single channel at 19,200 baud).

Listed below is a software example in GW Basic/Quickbasic. Program examples in GW Basic, Quickbasic and Turbo C are provided on the disk supplied with your order. To test the 10 bit converter, insert the disk in your disk drive and enter the following:

ADC-8G	(ADC-8 port #1 = 10 bit)
ADC-16G	(ADC-16 port #1 = 10 bit, port #2 = 8 bit)
ADC-16GH	(ADC-16 port #1 = 10 bit, port #2 = 10 bit)

```

10 '-----10 BIT ANALOG TO DIGITAL----- 2-11-93
20 CLS
30 ON ERROR GOTO 330
40 OPEN "COM1:19200,N,8,2,DS,CD,CS" AS #1 'set protocol
50 FOR A=0 TO 8
60 B=A
70 IF A=8 THEN B=0 'synchronize
80 PRINT #1,CHR$(A+15); 'start conversion
90 GOSUB 290:X$ = INPUT$(1,1) 'clear buffer
100 PRINT #1,CHR$(B); 'transmit channel code
110 GOSUB 290:A$ = INPUT$(1,1) 'receive MS byte
120 PRINT #1,CHR$(B); 'transmit channel code
130 GOSUB 290:B$ = INPUT$(1,1) 'receive LS byte
140 Z=ASC(A$)*4 'position MS byte
150 Y=ASC(B$) AND 128 'check bit 8 on LS byte
160 X=ASC(B$) AND 64 'check bit 7 on LS byte
170 IF Y>0 THEN Z=Z+2 'position bit 1
180 IF X>0 THEN Z=Z+1 'position bit 0
190 Z(A)=Z 'store data in array
200 NEXT A
210 IF EOF(1) = -1 THEN 230 'byte in buffer?
220 X$=INPUT$(1,1):CLOSE:GOTO 40 'clear buffer

```

```

230 LOCATE 1,1
240 FOR X=1 TO 8
250 PRINT Z(X);" " 'print on screen
260 NEXT X
270 GOTO 50 'repeat
280 '-----subroutine to check for byte-----
290 C=0
300 IF C>25000 THEN CLOSE:CLS:LOCATE 1,1:PRINT"MALFUNCTION":RETURN 40
310 IF EOF(1) = -1 THEN C=C+1:GOTO 300 'byte received?
320 RETURN
330 CLOSE:CLS:LOCATE 1,1:PRINT "MALFUNCTION":RESUME 40

```

**8 BIT CONTROL SOFTWARE**

Analog information is transmitted from the ADC-16 upon receipt of a channel code which must be transmitted by the computer. The channel code is equal to the channel number - 1. To acquire the analog information on channel 1 the computer must first transmit a (0). Because of the delay which is required for the 0809 chip on the ADC-16 to make the conversion, the analog data transmitted will be for the previous channel requested. If information from just one analog input is desired, it will be necessary for the channel code to be transmitted twice. The data transmitted by the ADC-16 after the first transmission will be invalid. The following transmission by the ADC-16 will be the analog data on that channel at the time that the first channel code was received. The data byte transmitted by the ADC-16 will be a binary number equal to 0 to 255 decimal (0 = 0 voltage at the analog input, 255 = full scale voltage, 128 = half scale voltage, etc.). The ADC-16 will only recognize channel codes 0 to 15 (or 0 to 31 with the AD-16 or ST-32 connected). The ADC-16 passes all higher codes to the EX-16 (if connected) for relay control functions.

**PROGRAMMING IN BASIC**

The following program has been written for IBM or compatible computers using GW Basic or QuickBasic. Program examples in GW BASIC, QUICKBASIC, VISUAL BASIC, TURBO C and TURBO ASSEMBLY are provided on the disk supplied with your order. The program will continuously display the analog information for all 16 analog inputs. The screen is continuously updated so that new analog information is displayed at intervals only a few milliseconds apart. This program is intended to illustrate the fundamentals needed to develop your own software for specific applications. All values are decimal, the protocol is set as follows: 9600 baud, 8 data bits, 2 stop bits and no parity. To stop program execution, press Ctrl break. If the following program does not run on the first attempt, change the on error statement (line 30) to ON ERROR GOTO 0 while trouble-shooting the software. NOTE: In the software example shown on the following page, we are using GW Basic statements. If you are using another type of Basic, this software will still work in most cases, but minor changes may be necessary (consult your Basic manual and the sections concerning serial communications). All example programs may be loaded from disk using the test disk supplied with your order. An example of a Basic Program using an assembly language subroutine for IBM and compatibles (not shown) may be loaded and listed from GW Basic (file name ADC-16S.BAS).

NOTE: When using baud rates below 4,800 baud on high speed processors, it may be necessary to increase the number of times that your program checks for the received byte before giving up (see line 100 in the Basic program on the following page). For example, if you are on a 486 operating at 66 MHZ, you will need to increase the number of loops to 20,000 (in place of the 5,000 on line 100 of the Basic program) when operating at 75 baud.

ERROR TRAPPING: The programs in these examples include an error trapping feature to prevent problems as a result of serial transmission errors when the program is left running for long periods of time. Serial errors may be created when fluctuations in power occur, if electro mechanical interference is encountered, when strong radio signals are nearby, if lightning is in the immediate area or if other types of noise are picked up on the serial transmission lines (much of the noise can be eliminated by using a shielded serial cable). It is important to stress, however, that serial transmission errors are fairly remote and may only occur once in every 20,000 hours of operation. If your application requires 24 hour operation, 365 days a year (such as in energy management) an error which could cause a computer lock-up is unacceptable.

**GW BASIC or QUICKBASIC PROGRAM EXAMPLE**

```

10 CLS
20 DIM A$(20) 'Specify array
30 ON ERROR GOTO 220 'Re-start program if error
40 OPEN "COM1:9600,N,8,2,DS,CD,CS" AS #1 'Set protocol
50 FOR X= 0 TO 16 'Channel codes
60 IF X=8 THEN Z=0:GOTO 90 'Synchronize
70 IF X=16 THEN Z =15:GOTO 90 'Transmit last code twice
80 Z=X
90 PRINT #1,CHR$(Z); 'Transmit
100 IF Y>5000 THEN 140 'Check up to 5,000 times for the received byte
110 IF EOF(1) = -1 THEN Y=Y+1:GOTO 100 'Wait for byte
120 A$(X) = INPUT$(1,1) 'Receive
130 NEXT X
140 Y=0 'Clear wait count
150 IF EOF(1) = -1 THEN 170 'Check for error byte in COM port buffer
160 A$ = INPUT$(1,1):CLOSE #1:GOTO 40 'Clear error
170 LOCATE 1,1
180 FOR X=1 TO 16
190 PRINT ASC(A$(X));" " 'Print data on screen
200 NEXT X
210 GOTO 50 'Repeat
220 RESUME 'Start over if error (error subroutine can go here)

```

**PROGRAMMING EXAMPLES IN ASSEMBLY & C**

To view the assembly or C listing for IBM and compatibles, insert the test disk in drive A and at the A> prompt enter:

```

TYPE ADC-16.ASM or TYPE ADC-16.C To line print the listing, enter: PRINT ADC-16.ASM

```

NOTE: PRINT is an external DOS command. The assembly code was assembled and linked on an IBM XT using MS DOS 3.3 and TURBO ASSEMBLER (Borland in Scotts Valley, CA). The I/O ports for COM 1 through COM 4 are shown below.

**SYSTEMS LEVEL PROGRAMMING CONSIDERATIONS**

In Basic and other high level programming languages, the Line Status Register is automatically checked for incoming and outgoing bytes and handles the data flow as needed. When reading or writing to the COM port registers directly (such as in Assembly, C or using the OUT command in Basic), it will be necessary to check the Line Status Register before reading or writing the incoming or outgoing byte.

**BEFORE TRANSMITTING...** check BIT 5 of the Line Status Register before sending byte (bit must be high)

**BEFORE RECEIVING...** check BIT 0 of the Line Status Register before accepting byte (bit must be high)

**I/O PORT REGISTER LOCATIONS FOR THE LINE STATUS REGISTER**

COM 1	COM 2	COM 3	COM 4	
3FD	2FD	3ED	2ED	(hex values)

## COMMERCIAL USE OF THE ADC-16

### IBM BAUD RATE SELECTION

The baud rate for IBM & compatibles may be selected by turning on the baud rate latch (bit 7 of the line control register) and setting the registers as shown to the right. Basic programmers may use the OPEN COM command to set the baud rate for COM 1 & 2 in place of this method. The baud rate and protocol for COM 3 & 4 should be selected from Basic by using the above procedure and the OUT command. An example is provided on the test disk using COM 3 & 4 from Basic.

Baud Rate	MSB	LSB (decimal)
300	1	128
600	0	192
1200	0	96
9600	0	12
19200	0	6

Other standard baud rates may be selected by adjusting the given values. EXAMPLE: 4800 baud = 1/2 of 9600 = 24

NOTE: When using baud rates below 4,800 baud on high speed processors, it may be necessary to increase the number of times that your program checks for the received byte before giving up (see line 100 in the Basic program on the preceding page). For example, if you are on a 486 operating at 66 MHZ, you will need to increase the number of loops to 20,000 (in place of the 5,000 on line 100 of the Basic program) when operating at 75 baud.

The COM port register locations for COM 1 through COM 4 are shown below.

COM 1	COM 2	COM 3	COM 4	(hex values shown)
3F8	2F8	3E8	2E8	Transmitter/Receiver
3F8	2F8	3E8	2E8	Baud Latch LSB
3F9	2F9	3E9	2E9	Baud Latch MSB
3FB	2FB	3EB	2EB	Line Control

#### LINE CONTROL

(Bit 0)	(Bit 1)	Word Length
0	0	5 data bits
1	0	6 data bits
0	1	7 data bits
1	1	8 data bits

(Bit 2) 0 = 1 stop bit  
1 = 2 stop bits

(Bit 3) 0 = no parity  
1 = parity enabled

(Bit 4) 0 = even parity  
1 = odd parity

(Bit 5) 0 = logical 1  
1 = logical 0

(Bit 6) 1 = break command

(Bit 7) 0 = baud latch off  
1 = baud latch on

NOTE: The ADC-16 will function with any RS-232 COM port (or RS-422 & RS-485 with option). The test disk has test programs for use with the standard IBM COM ports (COM 1 through COM 4). Software examples in Basic & C are also provided for using COM 1 through COM 4. Non-standard COM ports may be used by substituting the COM port register values shown for those required.

When the ADC-16 is to be used in a commercial/industrial environment, additional action must be taken to insure long term reliability and trouble free operation of the hardware. In general, the most serious threat to the hardware will be electrical transients (most often caused by electrical storm activity). The following steps are strongly encouraged to protect the hardware and are listed in the order of highest priority:

(1) Install a voltage surge/spike protector in the 120 volt AC outlet which supplies power to the ADC-16 and to your hardware. Be sure that the electrical outlet has a third prong electrical ground and that it is correctly wired. Install a TransZorb on the power input to the ADC-16 (specify the /T option).

(2) Install the ADC-16 (and any expansion cards) in a metal enclosure and ground the enclosure to a reliable earth ground (an electrical system ground using the third prong on an electrical outlet will usually be sufficient). Connect a TransZorb from the (-) terminal to the metal enclosure. An in-line 1/2 amp fast-acting fuse should be installed prior to the transZorbs (the fuse will blow and prevent damage to the ADC-16 in the event of a major electrical surge). When the installation site is at higher elevations, in areas that are subject to increased electrical storm activity, the installation of gas-tube discharge devices and other action may be necessary (contact technical support for more information).

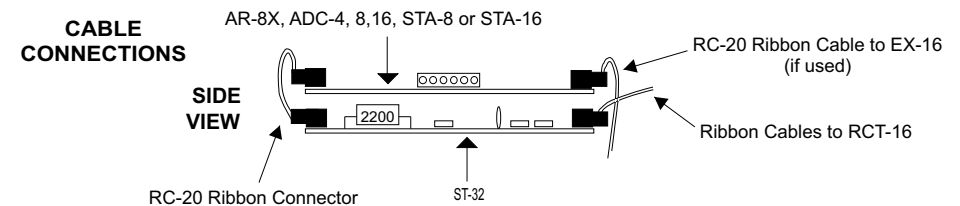
(3) Order the EX-16 with the /C Opto Isolator option. The opto isolators significantly reduce the possibility of voltage transients back-feeding to the ADC-16 & EX-16 through the relay output lines.

(4) Power the ADC-16 from a 9 volt regulated DC power supply. The regulation will provide additional protection from voltage transients. A 9 volt power source will significantly reduce the heat produced by the ADC-16 and will also reduce the energy consumption of the ADC-16. If the ADC-16 is to be operated continuously in elevated room temperatures (above 85° F), additional steps should be taken to reduce heating of the ADC-16. Install a larger heat sink on the ADC-16 regulator and install the ADC-16 in a larger metal enclosure.

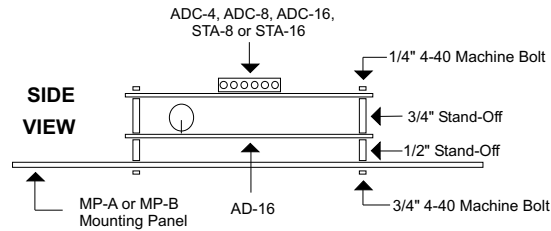
### RACK MOUNTING

The ADC-16 may be rack mounted with any of the 5" by 7" cards in the CH series card holder racks. The CH-2 will hold up to (2) of the 5" by 7" cards, the CH-4 will hold up to (4) of the 5" by 7" cards and the CH-8 will hold up to (8) of the 5" by 7" cards. The interface card (AR-16, ADC-16 or STA-16) should be installed in the top slot of the card holder rack. The expansion cards (EX-16, ST-32 or AD-16) should be installed in the slots below the interface card. All ribbon connectors should be plugged in with the ribbon cable pointing up (see diagram). The RC-20 ribbon connectors are used to connect the ADC-16 to expansion cards and when connecting expansion cards to additional expansion cards. The use of an extended length RC-20 ribbon cable will be necessary when the AD-16 or ST-32 expansion cards are used with the EX-16 or EX-32 expansion cards (add one inch for each AD-16 or ST-32 card).

#### TYPICAL MOUNTING CONFIGURATION (using the CH series card holder rack)



**MOUNTING A STAND ALONE UNIT...**A single interface card may be mounted in an enclosure or on a metal mounting panel using the MT-1 stand-off mounting hardware. The ADC-16 will attach to the 4 stand-off spacers using 4-40 machine screws (4 mounting holes are provided on the ADC-16). The ADC-16 with an expansion card attached may be mounted in an enclosure or on a metal mounting panel using the MT-2 stand-off mounting hardware. The ADC-16/AD-16 (or other combination) will attach to the 4 stand-off spacers using 4-40 machine screws as shown below (4 mounting holes are provided on the ADC-16 & AD-16). Contact technical support for more information on mounting panels and custom made distribution boards for use with the ADC-16, STA-16, EX-16, AD-16 and ST-32.



### REPAIR SERVICE

In the event that the ADC-16 is damaged from an inadvertent short circuit or other mishap, repair service is available through us by shipping your ADC-16 to the address on the rear cover of this manual. The charge for minor repair is \$15.00 and takes about 3 business days (not including shipping).

### TECHNICAL SUPPORT

Technical support for our products is available by calling (614) 464-4470. If a technical adviser is not available, please leave your name, phone number and a time that you can be reached. Your call will be returned as soon as possible and within 24 hours. Before contacting technical support be sure that you have your PC and interface hardware powered up with a telephone at hand. The interfacing hardware (ADC-16, ST-32, etc.) should not be inside an enclosure and should be immediately accessible. A multimeter should be available for checking voltage levels and the test software provided with your hardware should be ready to run.