

# ADC-4 ANALOG TO DIGITAL CONVERTER

(4 channel A to D with 12 bit resolution)

## TECHNICAL REFERENCE

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## SPECIFICATIONS

|                                |   |
|--------------------------------|---|
| Power Supply.....              | 9 to 14 volts DC (300MA)  |
| Protocol for Serial Data I/O.. | 50 to 19,200 baud (defaults to 8 data bits, no parity & 1 or 2 stop bits)<br>(sampling at a maximum of 850 samples per second single channel)   |
| Resolution.....                | 4 channels at 12 bit (providing 4,096 increments per channel)<br>8 channels at 8 or 10 bit with optional port #2 (256 or 1,024 increments)  |
| Input Channels.....            | 4 analog channels (12 analog channels with optional port #2)  |
| Expansion Capability.....      | up to (112) relays (using EX-16 Relay Expansion cards)<br>up to (128) status inputs (using ST-32 Status Expansion cards) or...<br>up to (24) additional 8 or 10 bit analog inputs (using AD-16 Analog Expansion)<br>up to (24) temperature inputs (using the /E and /F Temperature Input options)<br>Up to (6) keypads (using KY-12M keypads) |
| Weight.....                    | 6 ounces  |
| Size.....                      | 7 inches by 5 inches  |

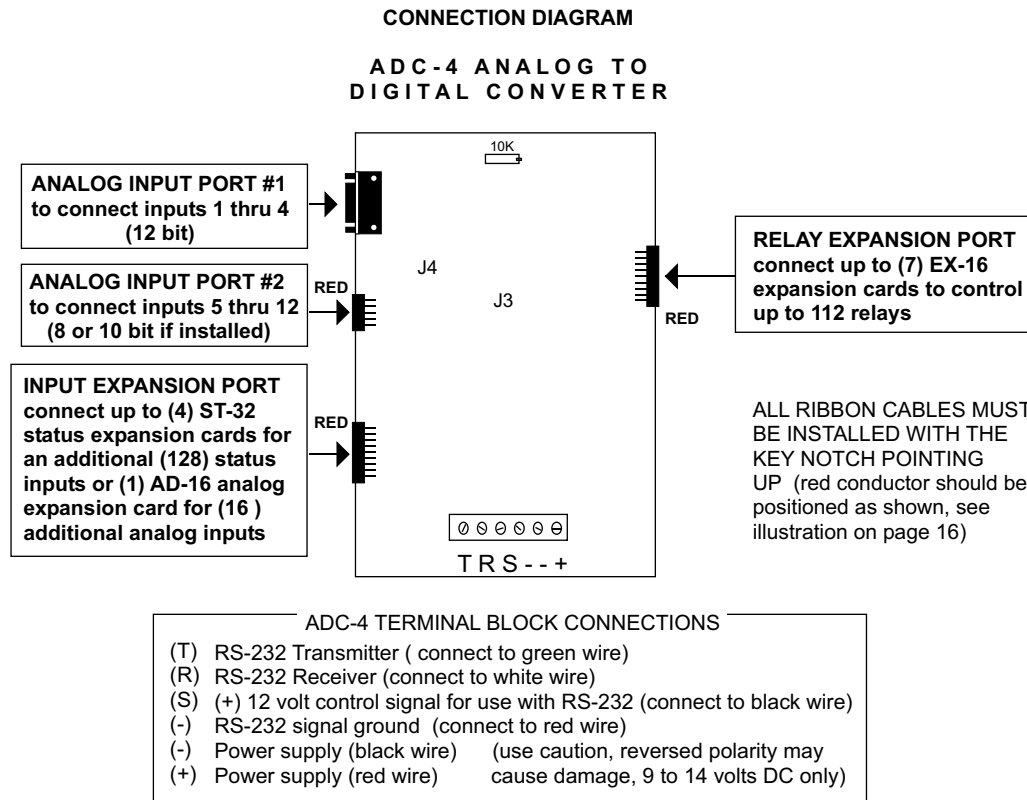
## TECHNICAL SUPPORT

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.

## WARRANTY AND CARE OF THE ADC-4

The ADC-4 Analog to Digital Converter is warranted against factory defects for a period of 90 days from the date of purchase. The ADC-4 has proven to be extremely reliable in actual operation during field tests. We recommend that the ADC-4 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) or you may add the /T option when ordering.



**POWER SUPPLY REQUIREMENTS**

The ADC-4 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-4 card is the PS-GP-1 (wall transformer supply). Use caution when connecting the power source, reversed polarity may cause damage.

The heat dissipation of the 7805 regulator on the ADC-4 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-4 and expansion card(s). If 12 volt adapters are used, the 7812 regulator which is supplied with the power supply should be used to regulate voltage to the hardware (as shown on page 8). The PS-12VDC-500 and PS-12VDC-1000 are unregulated supplies and may produce voltages as high as 18 volts.

The 12 bit converter is sensitive to power supply noise and slow power-up (as a result of the on- chip microprocessor). See the section on the following page on ADC-4 power-up.

**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-4 from damage.

**SET UP AND TESTING**

PLEASE TEST ALL YOUR HARDWARE FOR PROPER OPERATION UPON RECEIVING YOUR ORDER

(1) Connect the serial cable to COM1 of your computer and connect the other end to the ADC-4 as shown page 2. If you did not order a serial cable with your ADC-4, you may construct your own as shown on page 4. Connect the PS-GP-1 power supply to the (+) and (-) terminals on the ADC-4 terminal block and plug the power supply into a 120 VAC power source. Use caution not to set the ADC-4 card on a metal surface or the ADC-4 may be damaged. Connect a DB-9 socket with 6 wires attached to analog input port #1 (if port # 2 is installed, connect an RCT-8 terminal block with the ribbon cable up (as shown on page 16)). The ADC-4 is factory set for 19,200 baud which is the proper setting for use with the test software which is provided on disk.

Windows users should install the Windows test program provided on CD (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 test program defaults to Com 1, other Com ports may be selected if required. Open ADC-4.dat (or other) under the file pull down menu.

Your screen will show a row of 4 numbers. The top 4 numbers represent the analog inputs for port #1 (12 bit in 4,096 increments) and the bottom 8 numbers represent the analog inputs for port #2 (8 or 10 bit, 256 or 1,024 increments if installed). The numbers may be fluctuating as a result of noise on the analog inputs (this is normal). If the 12 bit analog inputs do not appear to be functional, reset the ADC-4 by removing power briefly (see below).

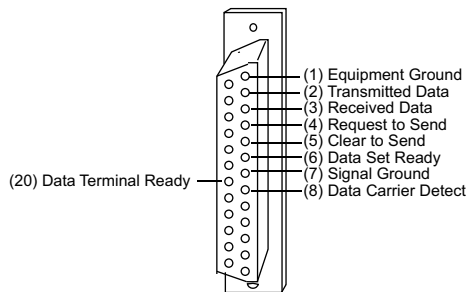
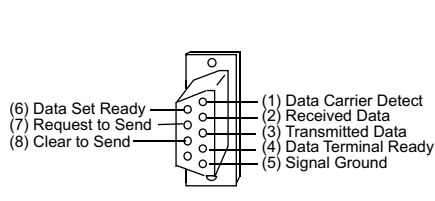
(3) Test each analog input by connecting each input (one at a time) to the reference (-) terminal on the DB-9 or RCT-8 (see page 5). Your screen should show a "0" for that input. After this is completed, connect each input (one at a time) to the reference (+). Your screen should show a "4095" for the 12 bit inputs, "1023" for 10 bit inputs or "255" for 8 bit inputs. If additional testing is desired, use a 20 turn 10K trimpot with the top terminal connected to reference (+), the bottom terminal connected to reference (-) and the middle (slider) terminal connected to the analog input. The input shown on the screen should increment from "0 to 4095" for 12 bit inputs, from "0 to 1023" for 10 bit inputs and from "0 to 255" for 8 bit inputs. The number on each input should increment by one as the trimpot is adjusted from 0 to 20 turns.

(4) To exit the test program, press any key. If you use Ctrl Break to stop the program, 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-4 may be placed in service. If problems are encountered during testing, proceed to page 5 for trouble-shooting procedures.

**ADC-4 POWER-UP**

Caution must be taken when supplying power to the ADC-4. The 12 bit converter has an on-chip microprocessor which is sensitive to power supply noise and low voltage power-up. The on-chip microprocessor may not "boot" properly if the power supply is noisy or if power is supplied to slowly. If the microprocessor does not "boot" properly, the 12 bit inputs may not function or may behave erratically. If you experience difficulty with the 12 bit inputs of the ADC-4 as a result of the microprocessor not booting properly, connect your power source as shown on the following page. The 2200 mf capacitor must be placed before the switch and fully charged before power is supplied to the ADC-4. Close the switch to power the ADC-4 and boot the 12 bit microprocessor.

**CONNECTOR PIN-OUTS**



DB-9 CONNECTOR...SOCKET (female)  
(rear view/solder side)

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

| DB-9 Pins | Connection  |
|-----------|---|
| (1)       | Data Carrier Detect* (connect to black wire or terminal (S) on the ADC-4)<br>NOTE: This connection is not needed on most computers. |
| (2)       | Received Data (connect to green wire or terminal (T) on the ADC-4)  |
| (3)       | Transmitted Data (connect to white wire or terminal (R) on the ADC-4)   |
| (5)       | Signal Ground (connect to red wire or terminal (-) on the ADC-4)  |

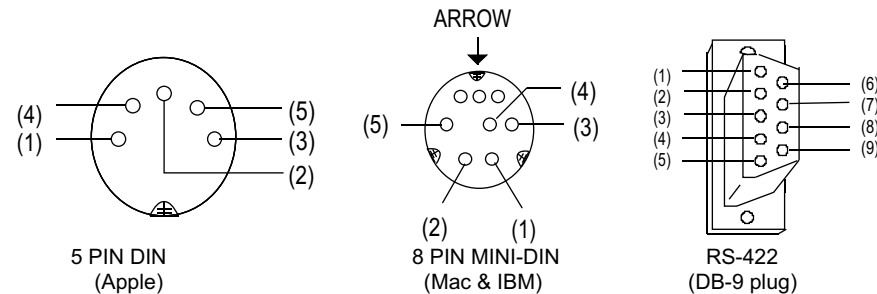
| DB-25 Pins | Connection  |
|------------|---|
| (2)        | Transmitted Data (connect to white wire or terminal (R) on the ADC-4)   |
| (3)        | Received Data (connect to green wire or terminal (T) on the ADC-4)  |
| (7)        | Signal Ground (connect to red wire or terminal (-) on the ADC-4)  |
| (8)        | Data Carrier Detect* (connect to black wire or terminal (S) on the ADC-4)<br>NOTE: This connection is not needed on most computers. |

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

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

|     |  |      |  |
|-----|--|------|--|
| (4) | Data Terminal Ready (DTR) output from your PC. | (4)  | Request to Send (RTS) output from your PC.     |
| (6) | Data Set Ready (DSR) input to your PC.         | (5)  | Clear to Send (CTS) input to your PC.          |
| (7) | Request To Send (RTS) output from your PC.     | (6)  | Data Set Ready (DSR) input to your PC.         |
| (8) | Clear To Send (CTS) input to your PC.          | (20) | Data Terminal Ready (DTR) output from your PC. |

**ADDITIONAL CONNECTOR PIN-OUTS**

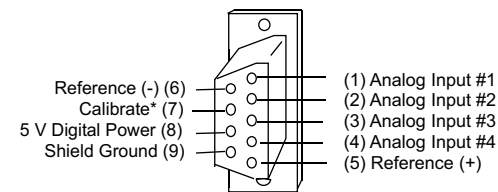
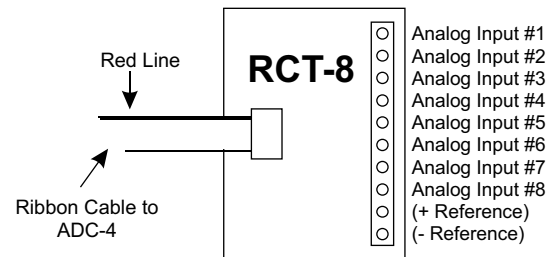


| Pin # | Connection       | Pin # | Connection       | Pin # | Connection       |
|-------|------------------|-------|------------------|-------|------------------|
| (1)   | DTR              | (1)   | DTR              | (2)   | Transmitter (+)  |
| (2)   | Signal Ground    | (2)   | DSR, DCD & CTS   | (3)   | Equipment Ground |
| (3)   | DSR              | (3)   | Transmitted Data | (4)   | Receiver (+)     |
| (4)   | Transmitted Data | (4)   | Signal Ground    | (7)   | Transmitter (-)  |
| (5)   | Received Data    | (5)   | Received Data    | (8)   | Receiver (-)     |

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

**RCT-8 TERMINAL BLOCK CONNECTIONS (8 & 10 BIT)**

**12 BIT DB-9 CONNECTIONS**



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

DB-9 SOCKET (female)  
viewed from solder side (rear)  
\*see page 9

**TROUBLE SHOOTING THE ADC-4**

(1) Verify power to the ADC-4 by checking for a minimum of 9 volts DC at the terminal block and for 5 volts DC on the 2200 mf capacitor located above the terminal block (low voltage may indicate an overload). Also check for the correct polarity of the power. Verify that the ADC-4 is set to the same baud rate as what appears on the test software screen.

(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 or terminal to COM 1 and using a short BASIC program (shown on the following page) 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-4 does not function, contact us at (614) 464-4470 for technical support.

(3) If erratic operation is experienced, check for loose or dirty connections at the terminal block and ribbon cables. Check for power supply interruptions or short circuits caused by metal contact to the ADC-4 circuit areas or other connected hardware. When more than three EX-16 cards are connected to the ADC-4, 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 A to D IC (approximately 5 volts DC) when operating in a MODE (2) jumper configuration (see page 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.

#### CONNECTION OF THE ADC-4 DIRECTLY TO A MODEM

The ADC-4 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-4. When the ADC-4 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.

#### EXPANSION PORTS

The ADC-4 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 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-4(8)(16) or STA-8(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.

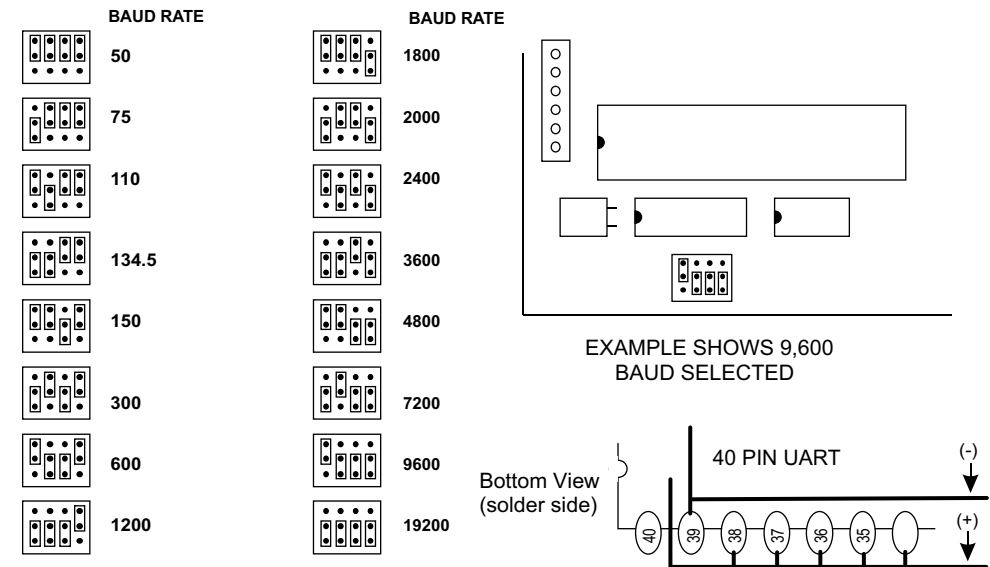
#### ADDING ADDITIONAL INPUTS

The Input Expansion Port allows up to (128) additional status inputs or (16) additional analog inputs to be connected (using up to (4) ST-32 status expansion cards or (1) AD-16 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-4. Additional ST-32 cards connect to the preceding ST-32 card. One AD-16 analog expansion card can be connected to the ADC-4 in place of the ST-32 expansion cards to provide an additional 16 analog inputs. If more than 32 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 10, 11 & 12 for the ADC-4 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-4. Transmitting a 16 would request information for the first 8 status inputs on the ST-32 status expansion card. The ADC-4 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.

#### BAUD RATE SELECTION FOR THE ADC-4

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-4 to operate properly. The default baud rate is 19,200.



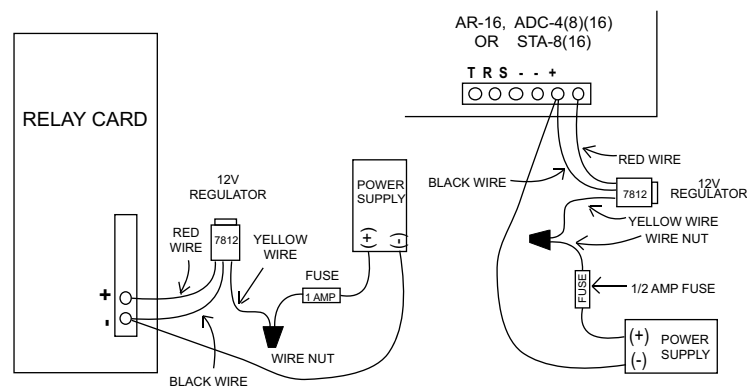
#### CHANGING PROTOCOL SETTINGS

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-4 (shown above). Connect the pins to the (+) 5 volt or (-) ground power feed (located above and below pins 35 thru 39) to select the desired protocol (as shown in the chart on the following page). Be sure to cut the existing circuit trace 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)    | NOTE: 1=(+5 VDC), 0=(ground (-))   |
|                 | 0    | 1    | 1 (7 data bits, 2 stop bits)   | All pins must be connected to 5 volts or ground. Do not allow any pins to float (pins left unconnected). |
|                 | 1    | 1    | 0 (8 data bits, 1 stop bit)    |  |
|                 | 1    | 1    | 1 (8 data bits, 2 stop bits)   |  |

### 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-4 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-4. The 7812 regulator (supplied with the power supply) may be used to regulate voltage to the ADC-4 and relay card(s). Connect the 7812 regulator as shown below:



BLACK WIRE: connect to the (-) terminal on the ADC-4 and to the (-) wire coming from the power supply.

RED WIRE: connect to the (+) terminal on the ADC-4.

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-4, check for 12 volts DC across the wires (red should equal (+)).

### VOLTAGE INPUT AMPLIFICATION AND SIGNAL CONDITIONING

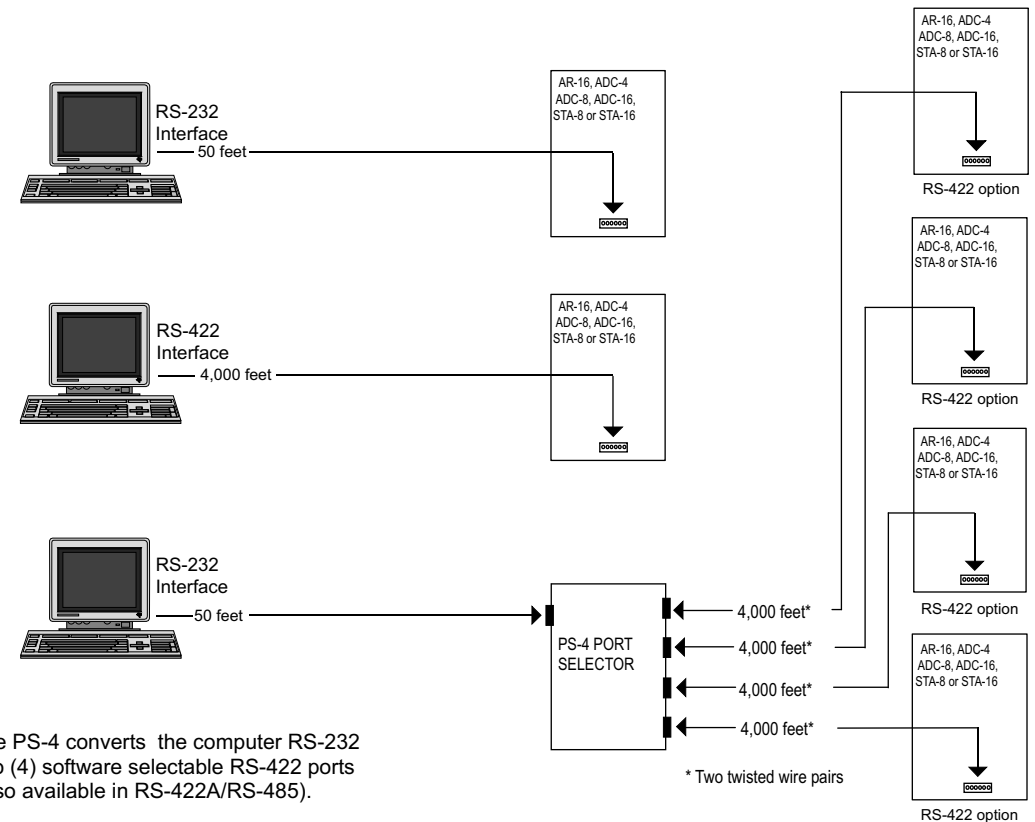
Lower signal levels (such as the output signal from a watt transducer, pressure transducer, load cell, etc.) with typical full scale voltages of only 20 to 100 millivolts will require the addition of the VA-1 instrumentation amplifier. The VA-1 connects to any of the analog inputs and will convert a millivolt signal input to a 0 to 5 volt output for connection to the ADC-4. Signal levels this low will require shielded wire in place of a twisted pair. A gain 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 an isolated analog input should use the VI-11 linear optocoupler instrumentation amplifier.

CONNECTION OF DIFFERENTIAL SIGNALS: The ADC-4 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-4. The VA-1 has a reference input (for connection to the ADC-4 reference) which is used to generate a 2.5 volt offset. The gain adjustment on the VA-1 may be adjusted to allow for differential signals as low as (+) and (-) 5 millivolts or as high as (+) and (-) 5 volts.

ANALOG LINEAR OPTOCOUPLEDERS: 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 pressure transducers, ground referenced signals or for safety).

### 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).

\* Two twisted wire pairs

### CALIBRATION AND TRIMPOT ADJUSTMENT

The calibrate terminal (pin #7 on the DB-9) is not normally used. The 12 bit inputs are automatically calibrated upon power-up. The calibrate pin may be used to force an autocalibration cycle by installing a jumper on the ADC-4 to complete the circuit to pin 26 on the 28 pin A/D IC. An autocalibration cycle will be initiated with a low trigger pulse to the pin (momentary contact of DB-9 pin #7 to ground pin #9). An autocalibration cycle may be desired to improve the accuracy of the conversions if the ADC-4 has been operated for long periods of time without a power-up (over a period of months or years, performance may degrade without an autocalibration cycle).

Installed on the ADC-4 is a trimpot (two if port #2 is configured for temperature input). All trimpots are adjusted at

the factory and normally will not need adjustment. If the voltage at the reference terminals (DB-9 pins 5 & 6) are not at exactly 5.00 volts, you may adjust the voltage as follows: The top trimpot (10K) is used to adjust the reference voltage. Adjust this voltage for exactly 5.00 volts on DB-9 pins 5 & 6. The third trimpot is only installed if port #2 is configured for temperature input and is located above the relay expansion port. Adjust as described in the TE-8 reference manual.

#### COMMERCIAL USE OF THE ADC-4

When the ADC-4 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-4 and to your hardware. Be sure that the electrical outlet has a third prong electrical ground and that it is correctly wired. Install TransZorbs on the power input to the ADC-4 or order the ADC-4 with the /T option.
- (2) Install the ADC-4 (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). Install a Transzorb across the power input to the ADC-4 (at the terminal block) and connect a Transzorb from the (-) terminal to the metal enclosure. An inline ½ amp fast-acting fuse should be installed prior to the transzorbs (the fuse will blow and prevent damage to the ADC-4 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 ADC-4/EX-16 with the /C Opto Isolator option. The opto isolators significantly reduce the possibility of voltage transients back-feeding to the EX-16 through the relay output lines. Care should be taken to prevent dust build-up on the printed circuit areas to prevent corrosion caused by condensation or airborne impurities.
- (4) Power the ADC-4 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-4 and will also reduce the energy consumption of the ADC-4. If the ADC-4 is to be operated in elevated room temperatures (above 85° F), additional steps should be taken to reduce heating of the ADC-4. Install a larger heat sink on the ADC-4 regulator and install the ADC-4 in a larger metal enclosure.

#### 12 BIT ANALOG INPUTS

The voltage input range on the 12 bit analog inputs is fixed at 0 to 5 volts DC and should not be adjusted to different voltages. For optimum accuracy, it is recommended that the reference voltage be maintained at exactly 5.00 volts DC (adjustable at the 10K trimpot).

When the analog inputs are used with ratiometric inputs (such as with potentiometer or position sensors, ratiometric transducers such as strain gauges, thermistor bridges, pressure transducers, etc.), both reference pins on the DB-9 are used (see pages 5 & 12). A 10K potentiometer is recommended for best noise immunity. Use two twisted pairs with shield when connecting the potentiometer or transducer to the DB-9 (connect ref. (+) & ref. (-) to one pair and the input & ref. (-) to the other pair). Connect unused inputs to ref. (-) and the shields to pin #9.

When the analog inputs are used for standard volt input, the reference (+) pin is not used and may be disconnected (if desired) by breaking the circuit on the ADC-4 where it merges near the 10K trimpot. The (-) side of the standard volt input should be connected to the DB-9 pin 6 (reference (-)) for all 4 channels. The (+) side of the standard volt input should connect to the desired input channel. The DB-9 cable should be no longer than necessary (to prevent noise and the resulting inaccuracy caused by the fluctuating input values). Shielded cable (a twisted pair plus shield) should be used when connecting the input to the transducer or sensing device. The twisted pair should be connected to the input and reference (-) pins on the DB-9 and the shield should be connected to the shield pin #9 on the DB-9.

#### 8 BIT ANALOG VOLTAGE INPUTS

The analog voltage input must not be higher than power supply voltage for modes 1 and 2 or the rated voltage of the voltage reference device for mode 3. 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-4 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-4, 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-4.

#### 8 BIT 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. Additional 8 or 10 bit analog ports may be added by connecting the AD-16 analog expansion card to the ADC-4.

**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). With the jumpers installed, the voltage input scale will be 0 to 5 volts (plus or minus .2 volts, 20 millivolt resolution, 8 bit). The ADC-4 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.

**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-4 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-4 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-4 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.

**MODE (3).....**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). 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.

### 10 BIT ANALOG TO DIGITAL

The 10 bit option of the ADC-4 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-4 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 half that of the 8 bit as a result of the two byte format of the 10 bit converter.

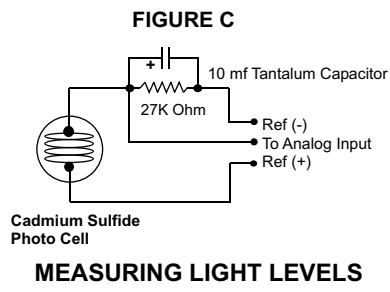
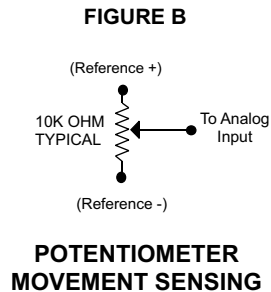
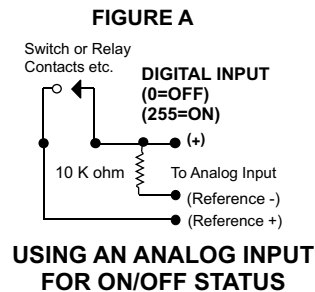
### CONNECTING TO THE ADC-4 ANALOG INPUTS

The voltage input source may be located up to several hundred feet from the ADC-4. A DB-9 and the RCT-8, RCT-16 or RCP-8 are used to make the wire connections. The wire which connects the DB-9 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-4). Always use shielded cable with the 12 bit analog inputs.

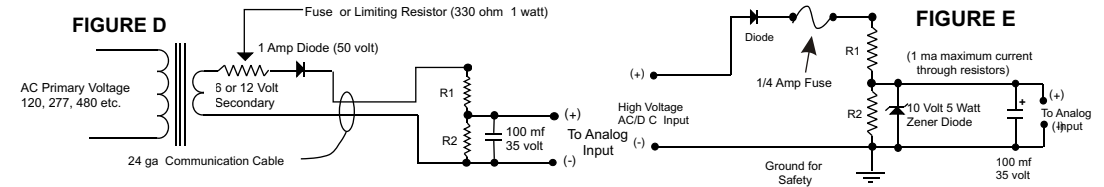
**NOTE:** When the analog inputs are left floating, (no connection) the ADC-4 will transmit fluctuating numbers as a result of noise present at the inputs. We recommend that any unused inputs be connected to reference (-) to prevent possible errors on other channels.

**FILTERING INPUT NOISE:** A .01 mf filter capacitor installed on the ADC-4 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-4 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 added for additional filtering (input response time will be slower).

Shown below in figures A, B & C are methods for reading contact closure, potentiometer movement & light levels.



### HIGH VOLTAGE INTERFACING



**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-4 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. When connecting the ADC-4 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-4. 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. Multiply 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-4 analog input and the ADC-4 reference (-). AC voltages over 24 volts or great enough to create an electrical shock hazard or fire should be connected to the ADC-4 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).

### CONTROL SOFTWARE FOR THE ADC-4

The following pages will provide software examples in GW BASIC, QUICKBASIC, VISUAL BASIC, TURBO C and TURBO ASSEMBLY. All program examples are provided on the enclosed disk. The programs are intended to demonstrate the fundamentals needed for development of your own software. The program examples may be copied to your program and used as a subroutine if desired. The Basic OUT command may also be used to transmit the channel codes. Since GW Basic/QuickBasic only supports the OPEN COM statement for COM 1 and COM 2, it will be necessary to use the OUT command when using COM 3 or COM 4. An example of this software method is provided on the test disk supplied with your order. When using the PRINT #1, command, be sure to include the semicolon (;) at the end of the command to suppress the carriage return and line feed. The VISUAL BASIC example may be viewed from the VB directory on the disk provided.

### 8 BIT CONTROL SOFTWARE

Analog information is transmitted from the ADC-4 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-4 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-4 after the first transmission will be invalid. The following transmission by the ADC-4 will be the analog data on that channel at the time that the first channel code was received by the ADC-4. The data byte transmitted by the ADC-4 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-4 will only recognize channel codes 0 to 15 (or 0 to 31 with the AD-16 or ST-32 connected). The ADC-4 passes all higher codes to the EX-16 (if connected) for relay control functions. The 8 bit software example shown below will run in G W Basic or QuickBasic. Other Basic languages may require minor changes. Change line 30 to read ON ERROR GOTO 0 while debugging your software.

```

10 CLS '-----8 BIT ANALOG TO DIGITAL----- 2-11-94
20 DIM A$(16) :Specify array
30 ON ERROR GOTO 220 :Re-start program if error
40 OPEN "COM1:9600,N,8,2,DS,CD,CS" AS #1 :Set protocol
50 FOR X= 8 TO 16 :Channel codes
70 IF X=16 THEN Z =15 ELSE Z=X :Transmit last code twice
80 PRINT #1,CHR$(Z); :Transmit
90 Y=0 :Clear wait count
100 IF Y>25000 THEN 150 :Check up to 25,000 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
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)

```

### 12 BIT CONTROL SOFTWARE

The 12 bit control software is very similar to the 8 bit control software described above except that the data is transmitted in a two byte format. The MS byte is received first, of which only the first four LS bits are used. The LS byte is received second, of which all 8 bits are used. The typical sequence of events that occur during communication with the 12 bit port of the ADC-4 is shown below. List the Basic program for a better understanding of the sequence.

Analog information on the four 12 bit analog channels is acquired by transmitting and receiving (8) single byte codes in the correct sequence as shown:

| TRANSMIT | RECEIVE | REMARKS   | (all codes are decimal) |
|----------|---------|---|-------------------------|
| 4        | byte    | This starts the conversion for channel 1 and selects the MS byte. The byte received will be the MS byte from the previous conversion for channel 4. |                         |
| 0        | byte    | This selects the LS byte. The byte received will be the LS byte from the previous conversion for channel 4.   |                         |
| 5        | byte    | This starts the conversion for channel 2 and selects the MS byte. The byte received will be the MS byte from the previous conversion for channel 1. |                         |
| 1        | byte    | This selects the LS byte. The byte received will be LS byte from the previous conversion for channel 1.   |                         |

|   |      |   |
|---|------|---|
| 6 | byte | This starts the conversion for channel 3 and selects the MS byte. The byte received will be the MS byte from the previous conversion for channel 2. |
| 2 | byte | This selects the LS byte. The byte received will be the LS byte from the previous conversion for channel 2.   |
| 7 | byte | This starts the conversion for channel 4 and selects the MS byte. The byte received will be the MS byte from the previous conversion for channel 3. |
| 3 | byte | This selects the LS byte. The byte received will be LS byte from the previous conversion for channel 3.   |

To continuously read the four 12 bit channels, repeat the above steps. If you are branching to a subroutine and wish to capture the data for just one read of the four channels, it will be necessary to transmit the last two bytes an additional time to receive the data on channel 4. To accomplish this, add the following to the data stream as shown below:

|   |      |   |
|---|------|---|
| 7 | byte | This selects the MS byte. The byte received will be the MS byte from the previous conversion for channel 4. |
| 3 | byte | This selects the LS byte. The byte received will be LS byte from the previous conversion for channel 4.     |

Listed below is a software example that will run in GW Basic or QuickBasic. Program examples in GW Basic, QuickBasic, Visual Basic and Turbo C are provided on the disk supplied with your order.

```

10 '-----12 BIT ANALOG TO DIGITAL----- 5-28-92
20 CLS
30 ON ERROR GOTO 250
40 OPEN "COM1:19200,N,8,2,DS,CD,CS" AS #1
50 FOR X=0 TO 3
60 PRINT #1,CHR$(X+4); 'start conversion/select MS byte
70 GOSUB 220:A$ = INPUT$(1,1) 'receive MS byte
80 PRINT #1,CHR$(X); 'select LS byte
90 GOSUB 220:B$ = INPUT$(1,1) 'receive LS byte
100 IF X=0 THEN Z=4 ELSE Z=X 'synchronize
110 A(Z)=ASC(A$) 'store MS byte
120 B(Z)=ASC(B$) 'store LS byte
130 NEXT X
140 C=0
150 IF EOF(1) = -1 THEN 170 'byte left in buffer?
160 X$=INPUT$(1,1):CLOSE #1:GOTO 40 'clear buffer and start over
170 LOCATE 1,1
180 FOR X=1 TO 4
190 PRINT A(X)*256+B(X);" " 'compute value and print on screen
200 NEXT X
210 GOTO 50
220 IF C>25000 THEN X=3:RETURN 130 'subroutine to wait for byte
230 IF EOF(1) = -1 THEN C=C+1:GOTO 220 'byte received?
240 RETURN
250 RESUME

```

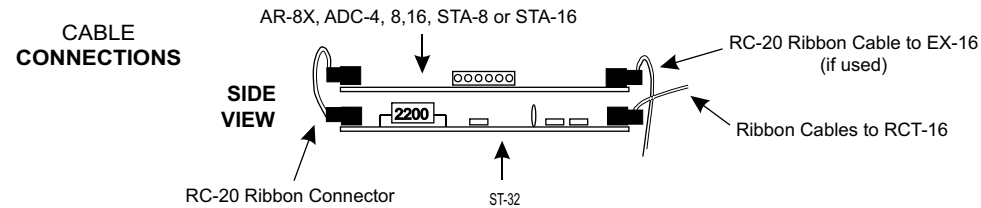
NOTE: An example of 10 bit control software may be viewed by listing the 10 bit Basic program provided on disk.

**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 220 in the Basic program on the previous 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 220 of the Basic program) when operating at 75 baud.

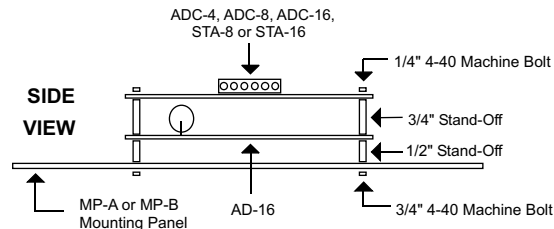
### RACK MOUNTING

The ADC-4 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-4/8/16 or STA-8/16) 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 connector should be folded over at the top connector when connecting to the interface card or 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 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-4 will attach to the 4 stand-off spacers using 4-40 machine screws (4 mounting holes are provided on the ADC-4). The ADC-4 with an expansion card attached may be mounted in an enclosure or on a metal mounting panel using the MT-1 stand-off mounting hardware. The ADC-4 with an ST-32 or EX-16 will attach to the 4 stand-off spacers using 4-40 machine screws as shown below (4 mounting holes are provided on the ADC-4, ST-32 & EX-16). Contact technical support for more information on mounting panels and custom made distribution boards for use with the ADC-4, EX-16, AD-16 and ST-32.



### REPAIR SERVICE

In the event that the ADC-4 is damaged from an inadvertent short circuit or other mishap, repair service is available through us by shipping your ADC-4 to the address on the rear of this manual. The charge for minor repair is \$15.00 and takes about 3 business days (not including shipping).