# Analog Input Module

Price $69

FEATURES

- 8 input channels; supports single-ended, differential, or pseudo-differential modes.

- 12-bit plus sign A/D converter reads voltages from 0 to 4095 mV using 1 mV resolution.

- Two software programmable alarm trip-points for each input channel.

- All user configuration data (alarm trip-points) stored in non-volatile memory.

- Automatic self-calibrating and auto-zero upon power-up.

- DIP switch addressable; stack up to 32 modules on the same serial port for 256 single-ended inputs, or 128 differential inputs.

- Industry standard RS-232 interface. Meets all EIA/TIA-232E and V.28 specifications.

- Wide power supply range (8 to 30 VDC).

- Screw-terminal connectors used on all inputs.

DESCRIPTION

Connects to the RS-232 serial port of a PC, laptop, or other host. Simple command strings sent from the host will initiate A/D conversions on the input channels, which will read the voltage present. Results will be returned in direct millivolts without translating.

Interface with temperature sensors, pressure transducers, load cells, strain gages, POT settings, etc. Input channels can be read individually, or all channels can be read as a group. The later being convenient for continuous data acquisition applications of up to 160 samples per second.

Set distinct high and low DC-level alarm trip-points for each input channel. Transition of these points will be reported to the host. Ideal for watching for over range conditions without tying up communications line.
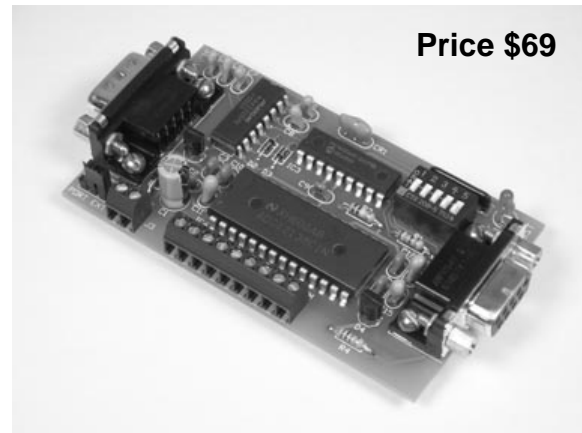
SPECIFICATIONS

Analog Inputs	8 single-ended or 4 differential channels
Input Range	0 to 4095 mV
Resolution	12-bit plus sign (1mV)
Accuracy	± (1% + 1mV)
Over Voltage Range	Each Input protected from -5V to +10V
Source Impedance	8KΩ max
Integral Linearity Error	±2 LSB max
Processor	PIC16F628
Clock	4 MHz
Communications	9600 Baud, N, 8, 1
Power Requirements	+8 to +30 VDC
Current Draw	17 to 31 mA
Operating Temperature	-20°C to +80°C
Board Dimensions	3.5" x 2.0" x 0.7"
Weight	1.9 oz

TABLE 1: ADDRESS SETTING

HEADER CHARACTER ASCII (HEX)	DIP SWITCH SETTING 1=on, 0=off 1 2 3 4 5
A (41)	0 0 0 0 0
B (42)	0 0 0 0 1
C (43)	0 0 0 1 0
D (44)	0 0 0 1 1
E (45)	0 0 1 0 0
F (46)	0 0 1 0 1
G (47)	0 0 1 1 0
H (48)	0 0 1 1 1
I (49)	0 1 0 0 0
J (4A)	0 1 0 0 1
K (4B)	0 1 0 1 0
L (4C)	0 1 0 1 1
M (4D)	0 1 1 0 0
N (4E)	0 1 1 0 1
O (4F)	0 1 1 1 0
P (50)	0 1 1 1 1
a (61)	1 0 0 0 0
b (62)	1 0 0 0 1
c (63)	1 0 0 1 0
d (64)	1 0 0 1 1
e (65)	1 0 1 0 0
f (66)	1 0 1 0 1
g (67)	1 0 1 1 0
h (68)	1 0 1 1 1
i (69)	1 1 0 0 0
j (6A)	1 1 0 0 1
k (6B)	1 1 0 1 0
l (6C)	1 1 0 1 1
m (6D)	1 1 1 0 0
n (6E)	1 1 1 0 1
o (6F)	1 1 1 1 0
p (70)	1 1 1 1 1

STACKABLE DATA MODULES

All modules in this series incorporate two EIA/TIA-232E serial ports which communicate at 9600 baud, no parity, 8 data bits and 1 stop bit. DB9 connectors are jumpered to satisfy hardware handshaking. The port labeled ''HOST'' is configured as a DCE device and should be connected to a PC's serial port. The port labeled ''SLAVE'' is a DTE device and can be left open, or connected to another module's host port. Up to 32 modules can be chained together in this fashion to form a network. Either plugged together end to end, or separated by a cable. Because a module contains two individual bi-directional ports which pass data through, it also acts as a repeater, extending the total allowable length of the RS-232 communications line.

A modem can serve as the host for remote operation, but since a modem uses a DCE port, a ''null modem'' adapter must be placed between the modem and the data module's host port. A gender changer may also be required. In addition, any hardware/software flow control must be disabled in the terminal program.

Each module in a network should be set to a different address using the on-board 32-position DIP switch. A module will only respond to data packets that begin with its' own unique header character, which is determined by this DIP switch setting. See Table 1. Data packets transmitted by a module will also begin with this header character. The host PC can use the header character to address each individual module in a network, and to identify a module which is talking.

COLLISION CONTENTION

The utilization of the communications line can be thought of more as a single, bi-directional, data bus, operated in a multi-drop mode rather then a standard RS-232 data link. A transmission from a data module travels in both directions, upstream to the host, and downstream to signal other modules that it has seized the line. Before transmitting, a module will listen to the communications line and wait for quiescence. After a silent period equal to the length of one byte, the waiting module will send its data packet using a Carrier Sense Multiple Access with Collision Detection communications protocol. See the application note (AN100) at the back of this manual for more details.

COMMAND SET

The Analog Input Module communicates with the host PC using a command set comprised of standard ASCII character strings as depicted in Table 2. Each function can be initiated by the host and then left to be independently acquired. Analog voltage data is automatically converted to decimal notation by the data module before sending back to the host.

Acquisition throughput time is calculated by the total number of characters in the receive and transmit data sets plus 2, multiplied by the byte/sec rate of the RS-232 serial communications speed which is 1.04 mS. For example, if one input channel is being polled and the results returned to the host is a full 4-digit number, the acquisition speed can be up to 80 samples per second provided the host can keep up. If more then one channel is being polled, the sample rate is divided by the number of channels. Note, if wishing to poll all channels, a higher rate/channel can be realized by using a single command string (omitting *chn*) because the overall number of characters is reduced.

An input channel can be configured as either a single-ended input, or paired up for differential mode. A description of each command and configuration follows.

SINGLE-ENDED - Performs conversion on the specified input channel using single-ended mode. The voltage present in reference to the COM terminal will be reported to the host, and can be positive or negative. The result will be formatted in millivolts. If no input channel is specified, all eight inputs will be read and reported to the host.

DIFFERENTIAL - Performs conversion on the specified input channel pair using differential mode. The voltage difference between the two

TABLE 2: COMMAND SET

TITLE	COMMAND	DESCRIPTION
SINGLE-ENDED	*S chn*	Perform conversion on a single-ended input channel. *chn* = 1-8. Returns 0 to ±4095. If *chn* is omitted, perform conversion on all eight single-ended input channels. Returns "result1 result2 result3 result4 result5 result6 result7 result8", space delimited. resultX = 0 to ±4095.
DIFFERENTIAL	*D chn*	Perform conversion on a differential input channel pair. *chn* = A-D. Returns 0 to ±4095. If *chn* is omitted, perform conversion on all four differential input channel pairs. Returns "resultA resultB resultC resultD", space delimited. resultX = 0 to ±4095.
HIGH-ALARM	H *chn value*	Set high level alarm trip-point for an input channel (or channel pair). *chn* = 1-8, or A-D. *value* = 0 to ±4095. Returns "*chn* H" when voltage at input overshoots trip-point level. (Note 3, 4, 5)
LOW ALARM	L *chn value*	Set low level alarm trip-point for an input channel (or channel pair). *chn* = 1-8, or A-D. *value* = 0 to ±4095. Returns "*chn* L" when voltage at input undershoots trip-point level. (Note 3, 4, 5)
CLEAR-ALARM	C *chn*	Clear alarm trip-points for an input channel (or pair). *chn* = 1-8, or A-D. If *chn* is omitted, clear alarm trip-points for all inputs. (Note 3)
AUTO-ZERO	Z	Perform Auto-Zero function on ADC. (Note 3)
ERROR	?	This character will be returned after an invalid command or variable.
RESET	!	This character will be returned after a power-on reset, or brownout.

Note 1: All command strings sent to the data module should be preceded with the header character (see Table 1), and terminated with a carriage return. All responses from the data module will also appear in this format.

Note 2: Any spaces shown above in the listing of the command strings are for clarity only. They should not be included in the actual transmission from the host, nor expected in a response from the data module.

Note 3: After successful execution, this command will be echoed back to the host in the same format as received.

Note 4: Setting an alarm on a differential pair (A-D) will clear any alarm previously assigned to the single-ended channels of the pair. Setting an alarm on a single-ended channel (1-8) will clear any alarm previously assigned to it's differential pair.

Note 5: If *value* is omitted, reads the current setting which will be returned to the host in the same format as above.

TABLE 3: TERMINAL / CONNECTOR DESCRIPTION

NAME	TYPE	ELECTRICAL SPECS	COMMENTS:
HOST	DB9 (female)	EIA/TIA-232E Standard	RS-232 serial port configured as DCE. Connects to host PC. Hardware handshake jumpered.
SLAVE	DB9 (male)	EIA/TIA-232E Standard	RS-232 serial port configured as DTE. Can be connected to another data module's HOST port for networking.
Power Source	Jumper	N/A	Power source selection jumper. Selects either external, or port powered. (Note 1)
+	Screw Term	+8 to +30 VDC	External unregulated power supply input.
-	Screw Term	GND	External power supply ground.
1 – 8	Screw Term	Range = 0 to 4095 mV Max = -5 to +10 V	Analog input channels. (Note 2)
COM	Screw Term	Range = 0 to 4095 mV Max = -5 to +10 V	Analog input used as pseudo ground when operating in single-ended mode.

Note 1: Selecting "port powered" will draw from the power supply source of an upstream data module. Caution, the COM port of a PC or laptop does not supply enough current to serve as the power supply source.

Note 2: If $V_{IN+} > V_{IN-}$ result will be shown as a positive number. If $V_{IN+} < V_{IN-}$ result will be shown as a negative number. V_{IN-} is COM terminal while in single-ended mode, V_{IN-} is channel number 2, 4, 6 or 8 while in differential mode.

channels will be reported to the host, and can be positive or negative. The result will be formatted in millivolts. If no input pair is specified, all four input pairs will be read and reported to the host.

HIGH-ALARM - Sets the high level alarm trip-point for a specified input channel, or channel pair. Anytime the voltage at the input overshoots this level, an indication will be reported to the host. This indicator will be re-transmitted once per second until the voltage drops back below the trip-point level. Note, any new alarm trips will be reported to the host immediately, even if one or more alarms are already in the once-per-second report mode.

LOW-ALARM - Sets the low level alarm trip-point for a specified input channel, or channel pair. Anytime the voltage at the input undershoots this level, an indication will be reported to the host. This indicator will be re-transmitted once per second until the voltage climbs back above the trip-point level. Note, any new alarm trips will be reported to the host immediately, even if one or more alarms are already in the once-per-second report mode.

CLEAR-ALARM - Clears both the high and low

alarm settings for a specified input channel, or channel pair. If no channel is specified, clears the alarm trip points for all input channels.

AUTO-ZERO - Instructs the ADC12138 to perform it's auto-zero function. This will correct for any offset errors associated with a change in ambient temperature or supply voltage. This should be initiated every so often in applications subjected to broad temperature fluctuations.

ERROR - Any data string sent from the host containing the correct header character but an invalid command or variable will be responded to with this error indicator.

RESET - Upon power-up or any other reset condition, this indicator is transmitted to the host. Note, all user configuration data such as the alarm trip-points is stored in non-volatile memory. Therefore, a reset or loss of power will not corrupt these settings.

OPERATION

To hook the data module to a host PC, use a standard RS-232 cable with male and female DB9 connectors on opposite ends. This cable

should be wired straight through (pin to pin) with no crossover of the data lines. In other words, not a null modem cable. Connect a suitable DC power source to the **+** and **-** terminals of the data module. This power source can be a simple wall mounted AC adapter or wall-wart, however, avoid adapters which were originally intended to charge a cordless device since most of these do not provide filtering. The high noise content will wreck havoc on a microcontroller based circuit.

When the data module is first powered up, the red LED will flash briefly. This indicates that the on-board microcontroller has booted up, successfully completed it's internal diagnostic test, and has transmitted the reset character to the host to signal that it is up and running. The red LED will also flash anytime the module receives or transmits any data packet, thus making it a valuable diagnostic tool when troubleshooting communications problems.

An easy-to-use Windows™ software package called "ModCom" is available and can be downloaded from Weeder Technologies' web site. This program will allow the user to quickly set up custom buttons which transmit commands, custom windows that poll for data, and a variety of other screen objects such as slider controls, event counters & timers, bar-graph level indicators, button selection arrays, and more. In addition, conditional statements can be set up to take action when specific events or conditions are met, sequences can be written and then called by other screen objects during run-time, and data can be logged to a file automatically at user-defined intervals.

Once ModCom is installed and running, go to the <Communicate> menu item at the top of the screen and click on <Send/Receive>. A dialog box will pop up which you can use to type in the commands from Table 2, transmit them directly to the data module, and see the response coming back. Use this dialog box to familiarize yourself with the command set and to experiment with the various features supported by the module. The experience gained here is significant since these are the same command strings you will use when setting up the other objects in ModCom.

To read voltages at the input channels, start with the sample application "WTADC.mod" which can be found in the ModCom subfolder called "Samples". After this file is opened, it will appear as shown in Figure 1. To start the main run-loop, click on the green toolbar button at the top of the

FIGURE 1: MODCOM APPLICATION
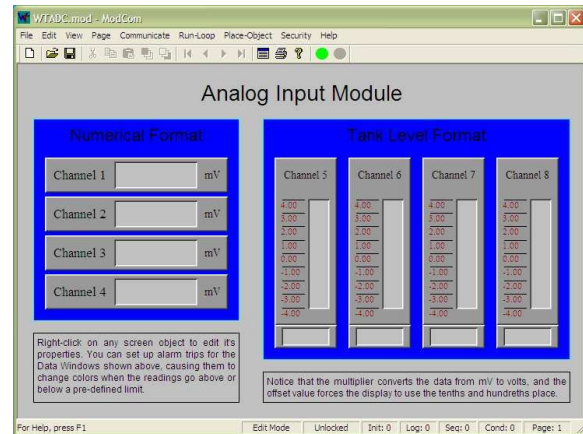
screen. At this time the Data Windows and Level Indicators will begin polling for data and show the input voltages on the screen. Note, any input channel which is left open will show a reading which will drift erratically.

Each Data Window can be set up to signal an alarm condition by changing colors if the voltage exceeds a predefined high or low limit. To do this, first halt the run-loop by clicking on the red toolbar button at the top of the screen. Then right-click on the object to pull up it's properties dialog box. Within this box are a number of options which can be modified by the user. For more details, read through the help files which can be accessed by clicking on the <Help> menu item at the top of the screen.

The voltage shown in each Data Window or Level Indicator can also be logged to a file. Go to the <Run-Loop> menu item at the top of the screen and click on <Data Logging>. Within this dialog box you can specify the data log file name, set the time interval between log events, and select those screen objects that you wish to log to file. The contents of the file can be viewed or printed by clicking on the corresponding button shown in this dialog box, or by clicking on a toolbar button at the top of the main screen.

INPUT VOLTAGE RANGE

Each input channel of the WTADC must stay within the range of 0 to +5V at all times that the module is being used to collect data. Exceeding this range, even on a channel which is not currently being used, will corrupt the readings on all the other channels. To test for input voltage range compliance, perform the following steps.

FIGURE 2: VOLTAGE SCALING
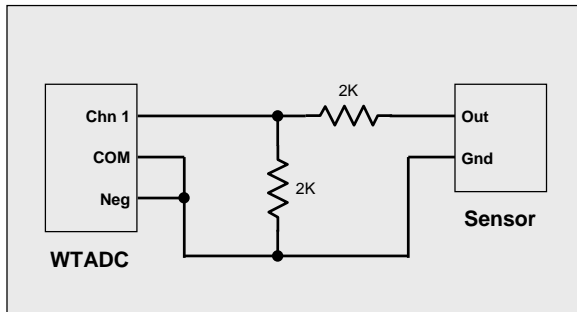
Hook up the input channels of the WTADC to any sensors or other devices that it will be reading voltages from. Apply power to the WTADC and also to all devices or external circuitry which is attached to the module's input channels. Using a voltmeter, connect the black probe to power supply ground, and the red probe directly to the screw terminals of each input channel, one by one. You should read a voltage in the range of 0 to 5 volts on all channels including the COM channel. If any channel is showing a voltage above +5 volts or below 0 volts, the WTADC will not function properly. To read the signal from a sensor which is outputting a voltage above the range of the WTADC's inputs, you must scale it down by using a pair of voltage divider resistors as shown in Figure 2. With the resistors shown here, a 0 to 8 volt signal will be scaled down to 0 to 4 volts.

READING NEGATIVE VOLTAGES

When reading voltages on the single-ended channels 1 thru 8, the most common practice is to tie the COM terminal to power supply ground. However, the module can operate in a pseudo-differential mode by tying the COM terminal to a mid-point such as 2 VDC. This will enable channels 1 thru 8 to decode both positive and negative voltage swings if required. Keep in mind that the COM terminal is not a ground, it is actually an analog input channel similar to the others which yields flexibility, but it also has the same voltage limitations and thus must be treated accordingly.

READING FLUCTUATIONS

Noise on the input lines will cause the readings reported by the WTADC to fluctuate up and down. This symptom can easily be corrected by placing a 0.1µF capacitor across the input lines near the point where they connect to the screw terminals of the WTADC board.
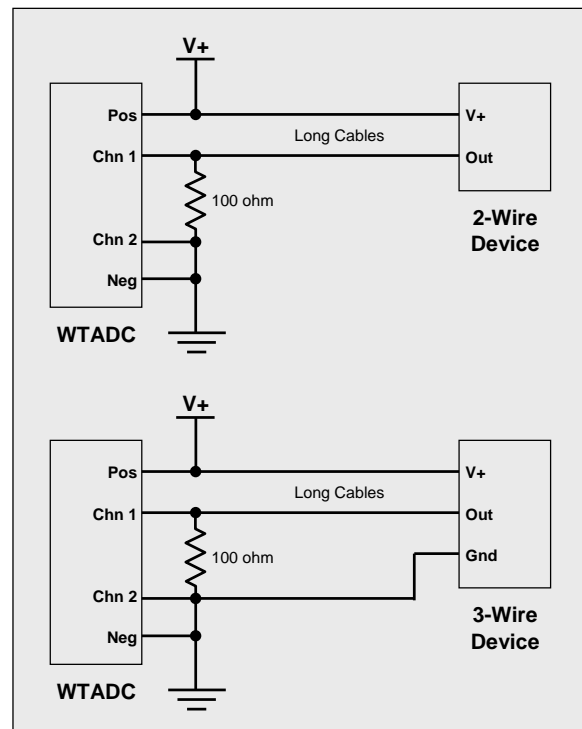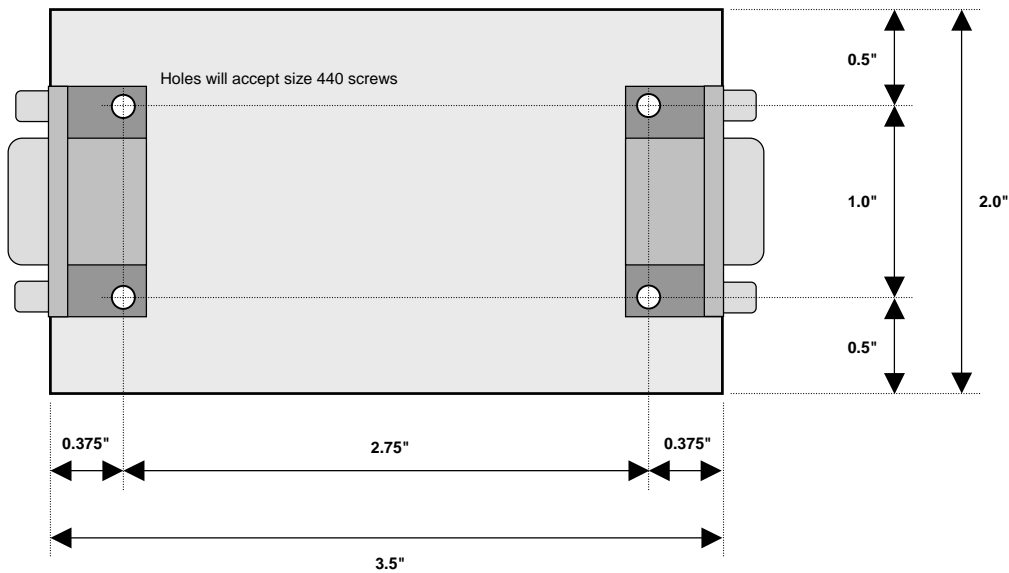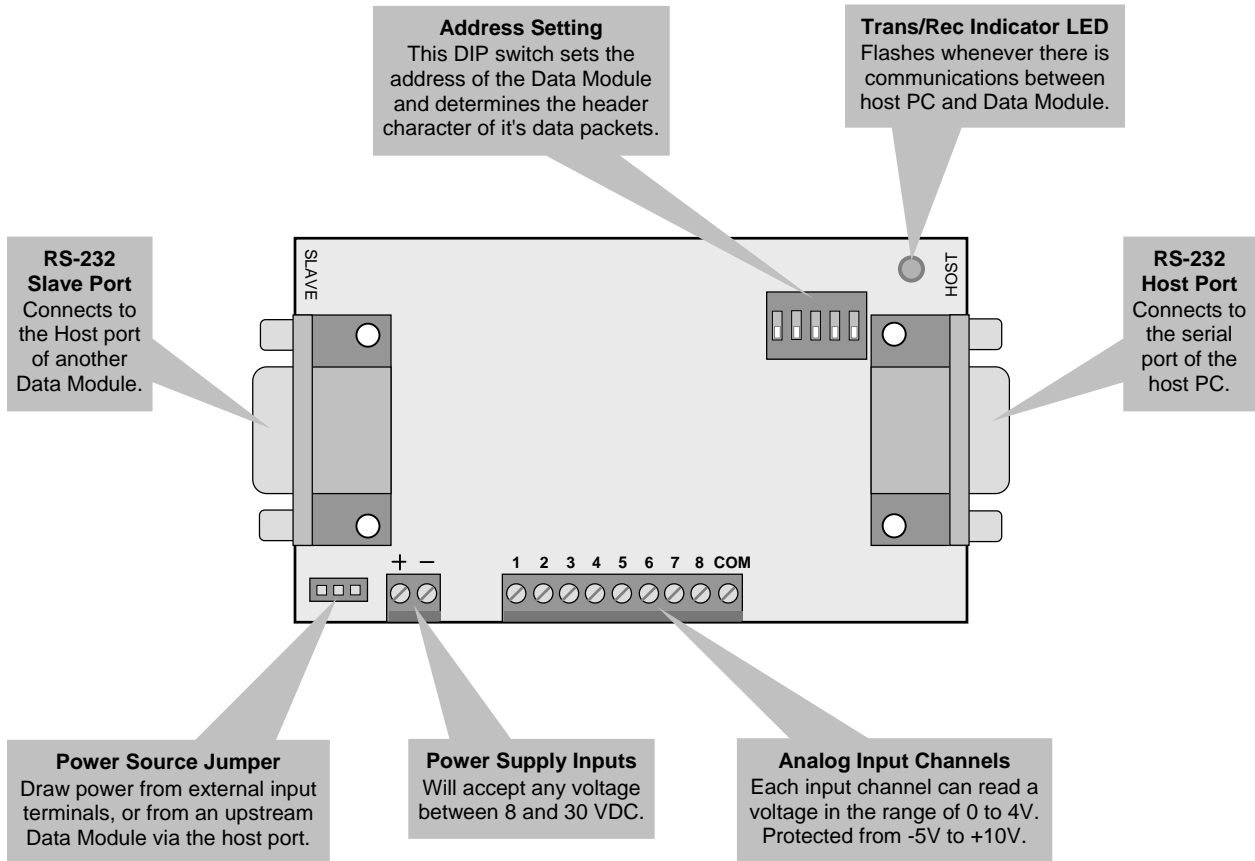
POTENTIOMETER DECODING

To read the setting of a potentiometer, connect the ''cw'' terminal to a 4-volt source, the wiper to a single-ended analog input channel, and the ''ccw'' terminal to power supply ground. The COM terminal must also be connected to power supply ground. The setting of the potentiometer can be determined by the voltage at the input channel and will span from 0 mV when turned to the full counter-clockwise position, to 4000 mV when turned fully clockwise. Note, to keep the source impedance within limits of the WTADC, it is not recommended to use a potentiometer with a value greater than 20KΩ.

4-20 mA CURRENT TRANSMITTERS

To read the data from a 4-20 mA current transmitter, simply place a 100-ohm resistor in the current loop and use a differential channel pair to read the voltage across the resistor. The results returned to the host will be from 400 to 2000 representing the 4mA to 20mA current range. Figure 3 demonstrates how to wire up a differential channel pair of the WTADC to either a 2-wire or 3-wire device. The voltage applied to V+ should be within the range of both the WTADC and the 4-20 mA current transmitter.

FIGURE 3: USING 4-20 mA DEVICES

Address Setting
This DIP switch sets the address of the Data Module and determines the header character of it's data packets.

Trans/Rec Indicator LED
Flashes whenever there is communications between host PC and Data Module.

RS-232 Slave Port
Connects to the Host port of another Data Module.

SLAVE

HOST

RS-232 Host Port
Connects to the serial port of the host PC.

+ − 1 2 3 4 5 6 7 8 COM

Power Source Jumper
Draw power from external input terminals, or from an upstream Data Module via the host port.

Power Supply Inputs
Will accept any voltage between 8 and 30 VDC.

Analog Input Channels
Each input channel can read a voltage in the range of 0 to 4V. Protected from -5V to +10V.

Holes will accept size 440 screws

0.5"

1.0"

2.0"

0.5"

0.375" 2.75" 0.375"

3.5"

ANALOG INPUT MODULE
WTADC-M