Weeder Technologies

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WTX4

Isolated / Stackable DAQ Module

Built from 4 sub units with different I/O types each

FEATURES

- Up to 32 wide-range digital input channels with high voltage transient protection. User programmable pull-up or pull-down resistors for use with either NPN or PNP sensors.
- Up to 32 dry-contact input channels with automatic debounce and typematic repeat with adjustable delay.
- Up to 32 counter inputs, 24-bits each. Count up or down with adjustable rollover limits.
- Up to 16 quadrature encoder inputs, 24-bits each. With adjustable rollover limits.
- Up to 16 tachometer inputs which read the speed of a rotating shaft and convert to RPM.
- Up to 32 high-current open-collector output channels with automatic overload shutdown and pull-ups to 5V for TTL level outputs.
- Up to 32 timer outputs that span from 1 mS to 65,535 mS each. Re-loadable on the fly.
- Up to 4 PWM 1-Amp output channels. Duty cycle adjustable using 0.1% increments.
- Up to 16 differential analog input channels with user programmable gain and offset. 20-bit A/D converter provides resolutions down to 1.4µV. Inputs protected to ±40V.
- Up to 16 analog output channels that span ±10.00V each using 12-bit D/A converter.
- Up to 16 thermocouple input channels for types J,K,T,E thermocouples. Selectable for Deg-F or Deg-C. Built-in cold junction reference. Inputs protected to ±40V.
- Connects to a host PC, Laptop, or Single Board Computer via an RS-232 port, or a standard USB port using the included cable.
- DIP switch addressable. Connect up to 8 units together which will share the same communications port of the host using an anti-collision transmission protocol.
- Wide power supply range (10 to 30 VDC).
- Incorporates full electrical isolation between each sub unit, the power supply rails, the communications bus, and RS-232 / USB port.

SPECIFICATIONS

MAIN UNIT	
Temperature	-10°C to +70°C
Power	10 to 30 VDC, 500 mA
RS-232	Connects to host using TD, RD, and GND. Electrically isolated from power supply and data bus. (USB converter cable included)
BAUD	9600 Baud, N, 8, 1
Upstream	Data bus to upstream unit. (opto-isolated current loop)
Downstream	Data bus to downstream unit. (opto-isolated current loop)
Address	Sets digital address of sub units. (see Table 1, page 4)
DIGITAL INPUTS	
Channels	8 inputs each sub unit.
V_{IH}	+4V to +40V
V_{IL}	-40V to +0.8V
Counter & Quadrature	Range = 24-bits Min pulse width = 75µS
Tachometer	200 to 400,000 RPM Accuracy = ±0.005%
Protection	High voltage transient protection on each input channel.
Isolation	Electrically isolated from power supply and data bus.
DIGITAL OUTPUTS	
Channels	8 outputs each sub unit.
V_{OH}	Open-Collector floating with weak pull-ups to 5V for TTL.
V_{OL}	Open-Collector pulled to GND. Can sink up to 1.0 Amps.
PWM	Frequency = 20 KHz Resolution = 0.1%
Timers	1 to 65,535 mS
Protection	Resettable fuse on each output channel.
Isolation	Electrically isolated from power supply and data bus.

SPECIFICATIONS (continued)

ANALOG INPUTS	
Channels	4 inputs each sub unit.
Resolution	20-bit
2 Input Ranges	-8V to +10V -0.6V to +0.6V
Calibration	Factory calibrated, or user calibrated gain and offset.
Accuracy	±(0.05% + 20µV) of full scale
Input Impedance	10 MΩ
CMR	80 dB
Sample Rate	60 sps total each sub unit.
Protection	Each input protected to ±40V.
Isolation	Electrically isolated from power supply and data bus.
ANALOG OUTPUTS	
Channels	4 outputs each sub unit.
Resolution	12-bit
Output Range	-10V to +10V
Accuracy	±2 LSB (10mV)
Min Load	1KΩ total all channels.
Isolation	Electrically isolated from power supply and data bus.
THERMOCOUPLE INPUTS	
Channels	4 inputs each sub unit.
Resolution	1°C or 1°F selectable
Input Ranges	-210°C to +1372°C -346°F to +2502°F
Accuracy	±(0.1% + 2 deg)
Types	J, K, T, E
Sample Rate	15 sps total each sub unit.
Cold Junction	Built-in cold junction reference.
Protection	Each input protected to ±40V.
Isolation	Electrically isolated from power supply and data bus.

DESCRIPTION

The WTX4 is a Data Acquisition and Control module that is available in various different versions that provide a wide assortment of input and output combinations. Each WTX4 unit is comprised of four individual sub units which can be a mix of the following different types of I/Os.

DIGITAL INPUT – Used to read the on/off states of dry contacts for switches, proximity sensors, optical encoders, TTL level pulses, NPN or PNP sensor outputs, etc. Can also count event pulses, measure the RPM of a rotating shaft, or track the position of a quadrature encoder.

DIGITAL OUTPUT – Used for TTL level outputs, or high current open-collector outputs to control the on/off states of relays, solenoids, magnetic latches, flow valves, DC motors, etc. Provides PWM control signals as well as Timer outputs.

ANALOG INPUT – Used to read the voltages from pressure transducers, load cells, strain gauges, temperature sensors, 4-20 mA devices, potentiometer positions, etc.

ANALOG OUTPUT – Used to output DC control voltages to machinery that requires a ±10V control signal. Includes an internal automatic ramp generator with trapezoidal or S-curve shaped slope profiles.

THERMOCOUPLE INPUT – Used to read the voltages from types J, K, T, E thermocouples and convert it to absolute temperature using a built-in high-order polynomial equation.

SOFTWARE

The ModCom HMI software package, which is a free download from the www.weedtech.com web site, was specifically designed to communicate with the WTX4 series. It comes with a multitude of pre-built screen objects that can automatically poll the WTX4 for data, convert the data using mathematical formulas, and log the data to file, chart recorder graph, or web site. The data can even be sent automatically in an email or text message for notification purposes.

The ModCom screen layout can be easily setup by the novice with little or no programming skills, and those advanced programmers can use ModCom to write complex scripts, conditional statements, and control logic that will run in the background.

ELECTRICAL ISOLATION

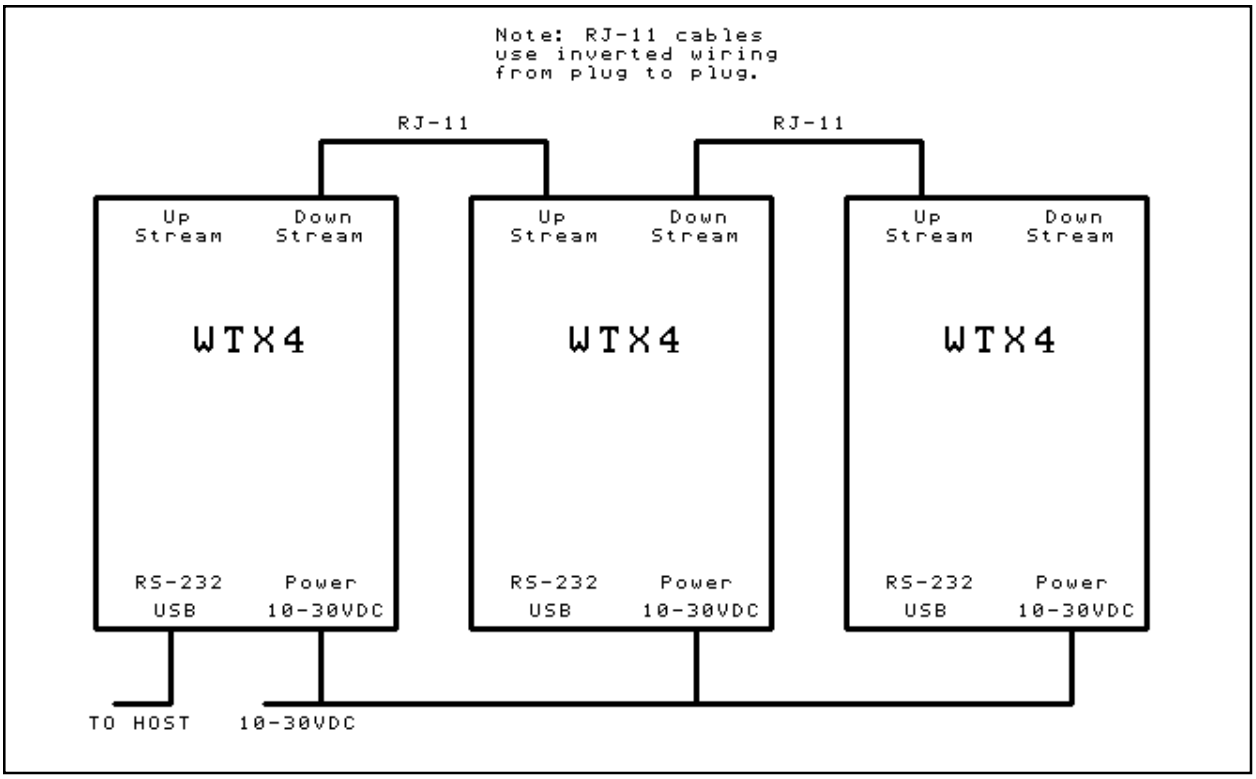
Each of the four WTX4 sub units are electrically isolated from each other, the power supply rails, the communications bus, and the RS-232 / USB port. This allows for the use of sensors which are mounted to machinery with conflicting ground potentials as well as preventing ground loops between the WTX4 and the host PC. This also protects both the host PC and the WTX4 network from accidental ground surges which can be very damaging.

ADVANTAGES OF ISOLATION

Any large machine or equipment that is drawing a significant amount of electrical current will have a ground potential that is completely different than the ground (or negative side) of the power supply that is delivering current to it. This is because the current drawn by the machine will create a voltage drop across the power supply cable and in turn, cause the voltage potential of the machine ground to be raised up to a level which is equal to this voltage drop. It will no longer be at the same voltage potential as the power supply ground even though they are directly connected together. If you have a sensor mounted to the machine that is outputting a TTL level pulse, for instance, and tied to the machine ground, the signal coming from this sensor will also be raised up with respect to the power supply ground.

For example, suppose you have a machine that is drawing 10A of current and the power supply cable is long enough that the resistance of the wire equals 0.2 ohms. This will create a 2V drop across the ground wire of the power supply cable and a sensor which is outputting a 0-5 volt pulse will now be seen as a 2-7 volt pulse with respect to the power supply ground. And this will be above the low side trigger threshold of a typical pulse counting measurement device which is usually around 1V.

Fortunately, since the WTX4 and its' sub units are fully isolated from power supply ground, the COM terminal of the sub unit can be connected to the machine ground as apposed to the power supply ground and the pulses coming from the sensor will be seen as a true 0-5 volt signal. And each one of the WTX4 sub units can be connected to separate machines which have completely different ground potentials.



CONNECTING MULTIPLE UNITS

Up to eight WTX4 units can be connected together via the RJ-11 modular jacks at the top of the unit and share the same communications link with the host. The RJ-11 ports are constructed using a pair of optically isolated current loops creating a multi-drop bus which is virtually immune to noise and can be extended hundreds of feet over common 4-conductor wire. Use standard inverted wiring from plug to plug.

The communications bus between each WTX4 unit as well as their four sub units uses a stratagem based on the Carrier Sense Multiple Access (CSMA/CD) protocol. Carrier Sense (CS) is the monitoring of the data bus for a period of inactivity before a sub unit is allowed to begin its own transmission. Multiple Access (MA) means that once the bus is free, every sub unit has an equal opportunity to transmit a frame. And Collision Detection (CD) uses non-destructive bit wise arbitration to preserve the integrity of a data frame when two or more sub units try to transmit at the exact same time.

SUB UNIT ADDRESSING

To communicate with the WTX4 DAQ module, commands are sent to the individual sub units. Each command string includes a header character at the beginning (the address) so that the command can be routed to the appropriate sub unit. If using multiple WTX4 units connected together, the DIP switch for each unit should be set to a different position so that its' sub units will be assigned a different set of header characters. Table 1 shows the header character (address) of each sub unit based on this DIP switch setting.

TABLE 1: ADDRESS SETTING

DIP SWITCH SETTING	SUB UNIT HEADER CHARACTER			
1=on, 0=off	#1	#2	#3	#4
0 0 0	A	B	C	D
0 0 1	E	F	G	H
0 1 0	I	J	K	L
0 1 1	M	N	O	P
1 0 0	a	b	c	d
1 0 1	e	f	g	h
1 1 0	i	j	k	l
1 1 1	m	n	o	p

Note: To identify the sub unit installed at each address position, transmit the header character plus the "#" sign.

DIGITAL INPUT (sub unit)

The host PC communicates with the Digital Input sub unit using a command set comprised of standard ASCII character strings as shown below. Each of these commands must be preceded with the header character which is determined by the sub unit number and the DIP switch setting of the WTX4 unit (see Table 1).

A typical command string looks like this:

HCNV{cr}

H = Header Character

C = Command Character

N = Channel Number (if applicable)

V = Value (if applicable)

{cr} = Carriage Return

COMMAND SET

TITLE	COMMAND	DESCRIPTION
READ	R *chn*	Read the current logic state of an input channel. *chn* = A-H. Returns "*chn* H" or "*chn* L". If *chn* omitted, read input channels A-H as an 8-bit port in binary notation. 1 = high, 0 = low. Channel A = MSB.
SWITCH	S *chn*	Configures a specific input channel to respond to switch transitions. *chn* = A-H. Returns "*chn* L" or "*chn* H" when switch is toggled. (Note 3)
BUTTON	B *chn delay*	Configures a specific input channel to respond to button presses. *chn* = A-H. Returns "*chn* L" when button is pressed. If button is held closed, response will be repeated at *delay* rate. *delay* = 1 to 15 listed in 1/10 of a second. If *delay* is omitted, no repeat will be used. (Note 3)
COUNTER	C *chn value*	Modifies the event counter of a specific input channel which will then begin counting the pulses applied to its input. *chn* = A-H, *value* = 0 to 16,777,215. (Note 3) If *value* is omitted, reads the current event count.
QUADRATURE	Q *pair value*	Modifies the position counter of a specific input channel pair which will then track a quadrature encoder. *pair* = AB, CD, EF, GH. *value* = 0 to 16,777,215. (Note 3) If *value* is omitted, reads the current position.
TACHOMETER	T *chn*	Measures the pulse rate (in RPM) from a tachometer sensor attached to a specific input channel. *chn* = E-H. Returns 0 to 400000.
PULL-UP	P *value*	Configures the internal 20K pull-up or pull-down resistors attached to the input channels. *Value* = H or L. H = all inputs pulled to +5V for NPN sensors, L = all inputs pulled to GND for PNP sensors. (Note 3, 4)
DIRECTION	D *chn dir*	Sets the counting direction which is used for the COUNTER function of a specific input channel. *chn* = A-H. *dir* = U or D. U = count up, D = count down. The count will roll over when reaching limits. The lower limit = 0, the upper limit is set by the LIMIT command. (Note 3, 4)
LIMIT	L *chn value*	Sets the upper limit of the registers used in the COUNTER and QUADRATURE functions of a specific input channel. *chn* = A-H for a counter, A,C,E,G for a quadrature. *value* = 0 to 16,777,215. (Note 3, 4)
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 WTX4 sub unit should be preceded with the header character (see Table 1), and terminated with a carriage return. All responses from the sub unit 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 WTX4 sub unit.

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

Note 4: If the setting is omitted, reads the current setting which will be returned to the host in the same format as above.

READ - Can be used to poll the current logic state of a specific digital input channel. Each channel can be read individually, or all of the input channels can be read simultaneously as an 8-bit port in binary notation. Channel A is the most significant bit (left side of string), channel H is the least significant bit (right side of string).

SWITCH - Configures the specified digital input channel to sense and respond to a logic transition without being polled. The transition can be produced by the dry contacts of a switch or proximity sensor wired between the channel input and the COM terminal. A built-in debounce feature is used to mask multiple transitions produced by contact bounce. This configuration differs from BUTTON in that it reports both low to high, and high to low transitions, and does not incorporate the typematic repeat function.

BUTTON - Configures the specified digital input channel to sense and respond to a low-going transition without being polled. The transition can be produced by the dry contacts of a normally-open button or proximity sensor wired between the channel input and the COM terminal. A built-in debounce feature is used to mask multiple transitions produced by contact bounce. If the button is held closed, the response character string will be re-transmitted at a rate determined by the *delay* field if used.

COUNTER - Reads or modifies the event counter assigned to a specific digital input channel. Once activated by this command, the falling edge of each pulse will cause the count value to increment or decrement depending on the setting of the DIRECTION command. The count value will roll over when reaching the high limit which is set by the LIMIT command, or when reaching the low limit of 0. If another command (other than READ) is issued and uses this same input channel, the event counter will be cleared and the COUNTER function canceled.

QUADRATURE - Reads or modifies the position counter assigned to a specific digital input channel pair. Once activated by this command, the counter will then be continuously updated by the pulse stream output of a quadrature encoder connected to its input channel pair. The count value will roll over when reaching the high limit which is set by the LIMIT command, or when reaching the low limit of 0. If another command (other than READ) is issued and uses either one of these input channels, the QUADRATURE function for this pair will be canceled.

TACHOMETER - Reads the pulse rate of a signal applied to a specific digital input channel and converts it to RPM. The pulse rate must be within the range of 200 to 400,000 RPM. A rate below 200 will return 0, a rate above 400,000 will be inaccurate because some pulses may be missed by the sampling window.

PULL-UP – Configures the internal 20K pull-up or pull-down resistors attached to the digital input channels. If set to “H”, all input channels will be pulled up to +5V for NPN type sensors or dry contacts. If set to “L”, all input channels will be pulled down to ground for PNP type sensors or TTL level pulses.

DIRECTION – Sets the counting direction which is used for the COUNTER function of a specific digital input channel. If set to “U”, the counter will count up on the falling edge of each input pulse. If set to “D”, the counter will count down on the falling edge of each input pulse.

LIMIT – Sets the upper limit of the 24-bit register used in the COUNTER and QUADRATURE functions of a specific digital input channel. This limit will be the point of rollover during all counting operations of the specified input channel. Note, if issuing the COUNTER or QUADRATURE command that contains a new value which is above the limit set here, the error symbol will be returned.

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, each sub unit present in the network will transmit this indicator to the host. If the WTX4 encounters an unintentional reset due to a power disruption or brown-out, all current functions of the Digital Input sub unit will be canceled. Therefore, upon reception of this indicator, the host should re-transmit any initialization commands as if the WTX4 had been powered up for the first time.

SWITCH CONTACT DEBOUNCE

A typical switch or button uses metal plates (called contacts) which can be moved together or apart in order to make or break the current path. During switch closure, when these plates first make contact with each other they will bounce several times before coming to rest. This bouncing of the contacts will appear as multiple

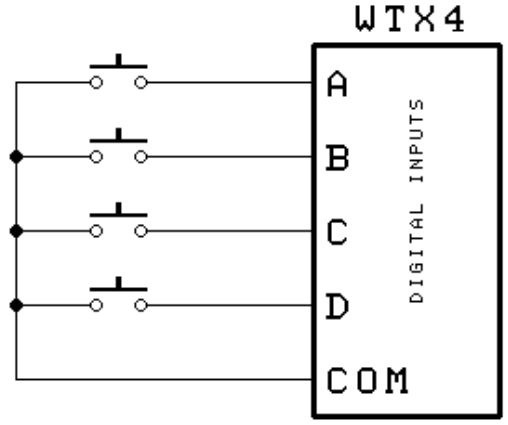
transitions to a digital input monitoring system, and in most cases, not be desirable.

Each of the input channels of the Digital Input sub unit incorporates its' own de-bounce timer used to mask these multiple transitions by disabling the input for a short period of time after each logic state change. If an input channel is setup for SWITCH or BUTTON and it detects a change of state, the action is immediately reported to the host, its de-bounce timer is loaded with a value equal to 100 mS, and the input is disabled until this time period has lapsed. Because each input channel's timer operates independently of each other, the Digital Input can still report actions on additional inputs while it's waiting for this timer to expire.

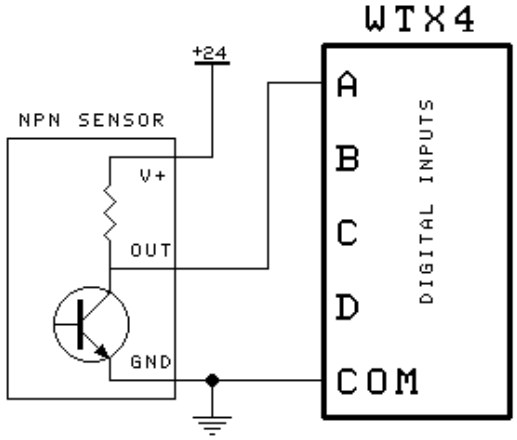
RPM SCANNING FUNCTION

If an input channel is configured to read RPM by issuing the TACHOMETER command, the pulse rate of the applied signal will be continuously sampled in the background, converted to RPM, and stored in memory. Each time that the TACHOMETER command is issued, the latest results will be returned to the host without any acquisition delay. However, although the results returned to the host will always be immediate, the update rate may be much slower depending on the frequency of the input signal. The lower the RPM, the more time it takes to sample and get an accurate reading. And since the Digital Input sub unit can only sample one input channel at a time, a low RPM signal applied to one channel will slow down the update rate of any other channels of this sub unit which are configured to read RPM.

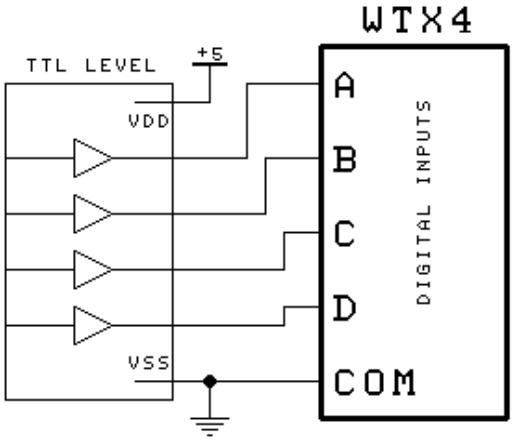
CONNECTING TO SWITCHES
(pull-ups set to high)



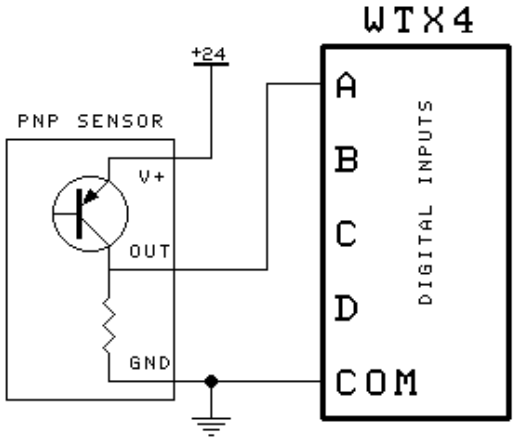
CONNECTING TO NPN SENSORS
(pull-ups set to high)



CONNECTING TO TTL LEVELS
(pull-ups set to low)



CONNECTING TO PNP SENSORS
(pull-ups set to low)



DIGITAL OUTPUT (sub unit)

The host PC communicates with the Digital Output sub unit using a command set comprised of standard ASCII character strings as shown below. Each of these commands must be preceded with the header character which is determined by the sub unit number and the DIP switch setting of the WTX4 unit (see Table 1).

A typical command string looks like this:

HCNV{cr}

H = Header Character

C = Command Character

N = Channel Number (if applicable)

V = Value (if applicable)

{cr} = Carriage Return

COMMAND SET

TITLE	COMMAND	DESCRIPTION
WRITE	W *data*	Write *data* to output channels A-H as an 8-bit port in binary notation. *data* = 00000000 to 11111111. 1 = high, 0 = low. Chn A = MSB.(Note 3)
HIGH	H *chn time*	Set a specific output channel high (open-collector floating) for a period equal to *time*. *chn* = A-H, *time* = 1 to 65535 and is listed in milliseconds. If *time* omitted, output channel remains high. (Note 3)
LOW	L *chn time*	Set a specific output channel low (open-collector pulled to GND) for a period equal to *time*. *chn* = A-H, *time* = 1 to 65535 and is listed in milliseconds. If *time* omitted, output channel remains low. (Note 3)
PWM	P *value*	Configures output channel H for pulse-width-modulation using *value* to set duty cycle. *value* = 0 to 1000 listed in 0.1% increments. If *value* omitted, reads the current setting. (Note 3)
READ	R *chn*	Read the current logic state of an output channel. *chn* = A-H. Returns "*chn* H" or "*chn* L". If *chn* omitted, read the output channels A-H as an 8-bit port in binary notation. 1 = high, 0 = low. Channel A = MSB.
DEFAULT	D *chn state*	Sets the default logic state of a specific output channel which will be loaded upon power-up or brown-out. *chn* = A-H, *state* = H or L. Default = H. If *state* omitted, reads the current setting. (Note 3)
ECHO	X *value*	Turns on or off the reception confirmation echo. *Value* = 0 or 1. 0 = off, 1 = on, default = 1. If *value* omitted, reads the current setting.
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 WTX4 sub unit should be preceded with the header character (see Table 1), and terminated with a carriage return. All responses from the sub unit 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 WTX4 sub unit.

Note 3: If ECHO is on, after successful execution, this command will be echoed back to the host in the same format as received.

WRITE - Writes data to all output channels simultaneously as an 8-bit port in binary notation. Data consists of an eight character ASCII string whose digits represent the high/low state of each output channel. Channel A is the most significant bit (left side of string), channel H is the least significant bit (right side of string).

HIGH - Set a specific output channel high with the open-collector floating and pull-up resistor to +5V. The output channel can be instructed to remain high until a further command, or return low after a user defined time-out period in the range of 1 to 65,535 mS. Note, the count down timer will operate in the background allowing other functions to be executed during this period, and it can also be re-loaded at any time before it expires using this same command.

LOW - Set a specific output channel low with the open-collector pulled to ground which can sink up to 1.0 amps. The output channel can be

instructed to remain low until a further command, or return high after a user defined time-out period in the range of 1 to 65,535 mS. Note, the count-down timer will operate in the background allowing other functions to be executed during this period, and it can also be re-loaded at any time before it expires using this same command.

PWM - Puts output channel "H" into pulse-width-modulation mode. While in this mode, the duty cycle value can be changed on the fly. If another command (other than READ) is issued, and uses this same output channel, the PWM function will be canceled.

READ - Can be used to poll the current logic state of a specific output channel. Each channel can be read individually, or all eight output channels can be read simultaneously as an 8-bit port in binary notation. Channel A is the most significant bit (left side of string), channel H is the least significant bit (right side of string).

DEFAULT – Sets the default logic state of a specific output channel which will be loaded upon power-up or brown-out. The factory setting is set to high (open-collector floating) with pull-up resistor to +5V.

ECHO - Turns on or off the confirmation echo which is used to verify reception of a command. If reception confirmation is not needed, turning ECHO off will increase the rate at which the host can manipulate the output channels because it won't have to wait for the confirmation before transmitting the next command.

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, each sub unit present in the network will transmit this indicator to the host. If the WTX4 encounters an unintentional reset due to a power disruption or brown-out, any ongoing functions of the Digital Output sub unit, such as the count-down timers or PWM operation, will be canceled and the outputs will be set to their default states. Use the DEFAULT command to set these values.

OUTPUT TIMERS

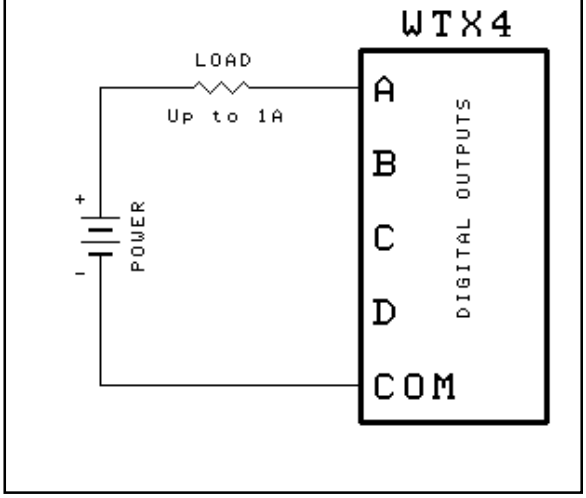
Each of the output channels of the Digital Output sub unit incorporates its' own independent count-down timer which can be used to control the length of time that a HIGH or LOW function holds the output at a specific state before returning it to the previous state. This timer can be re-loaded on the fly before it times out which provides a valuable feature. Suppose the output channel is being used to turn on a piece of machinery but ideally you would want that machine to turn back off automatically if the host PC shuts down or for any other reasons the communications has failed. By activating the channel using the HIGH or LOW command including a time value and then re-transmitting that command repeatedly at a rate faster than the timer can expire, will keep the machine active only as long as those commands are being received from the host.

This same procedure can be used to turn on an external alarm or warning light if there are any communications problems by having the host continuously transmitting a deactivation command instead of the activation command mentioned above. When using this method, the DEFAULT command should be used to make sure the output channel is set to the deactivation state at power up.

OUTPUT OVERLOAD SHUTDOWN

Each of the output channels of the Digital Output sub unit incorporates a resettable fuse which protects it from excessive current flow. If the current being sunk by an output channel exceeds 1.0 amps for an extended period of time, the output will automatically shut down to prevent damage to the output drivers. Once this happens, the current must be removed from the output channel before it will return to normal operation.

CONNECTING TO A LOAD



ANALOG INPUT (sub unit)

The host PC communicates with the Analog Input sub unit using a command set comprised of standard ASCII character strings as shown below. Each of these commands must be preceded with the header character which is determined by the sub unit number and the DIP switch setting of the WTX4 unit (see Table 1).

A typical command string looks like this:

HCNV{cr}

H = Header Character

C = Command Character

N = Channel Number (if applicable)

V = Value (if applicable)

{cr} = Carriage Return

COMMAND SET

TITLE	COMMAND	DESCRIPTION
READ	*R chn*	Read the current value of an input channel. *chn* = A-D. Returns data in format set by MODE and decimal point position set by DECIMAL.
MODE	M *chn value*	Sets the mode and voltage range for a specific input channel which will be used each time the READ command is issued. *chn* = A-D, *value* = 1-5. 1 = -8.000V to +10.000V, 2 = ±600.0mV, 3 = ±600.00mV, 4 = custom mode using -8V to +10V input range, 5 = custom mode using -0.6V to +0.6V input range. Default = 1. (Note 3, 4)
DECIMAL	D *chn value*	Sets the decimal point position for a specific input channel which will be used each time the READ command is issued. *chn* = A-D, *value* = 0-7. 0 = none, 1 = 0.0, 2 = 0.00, etc. Default = 0. (Note 3, 4)
ZERO	Z *chn*	If MODE is set to custom for a specific input channel, this command will automatically adjust the offset null so that the current voltage being applied to its input will be displayed as zero. *chn* = A-D. (Note 3)
SPAN	S *chn value*	If MODE is set to custom for a specific input channel, this command will calibrate the channel so that the current voltage being applied to its input will be displayed as *value*. *chn* = A-D, *value* = 0 to ±8388607. Use ZERO to set the offset null before using this command. (Note 3)
FACTOR	F *chn value*	If MODE is set to custom for a specific input channel, this command will calibrate the channel so that *value* will be displayed as one unit. *chn* = A-D, *value* = 0 to ±8388607 listed in mV including decimal point. Use ZERO to set the offset null before using this command. (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 WTX4 sub unit should be preceded with the header character (see Table 1), and terminated with a carriage return. All responses from the sub unit 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 WTX4 sub unit.

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

Note 4: If *value* is omitted, reads the current setting which will be returned to the host in the same format as above.

READ - Reads the current voltage applied to a specified input channel and converts it to the format which was previously set by the MODE command. The results will be returned to the host and will contain a decimal point if it was previously set by the DECIMAL command. If the voltage applied to the input channel is beyond the range of the MODE setting plus 5%, the error symbol will be returned to the host.

MODE - Sets the conversion mode and voltage range for a specific input channel. This mode will be used each time the READ command is issued for this particular channel. There are three factory calibrated modes which will return the results listed in voltage, and two user-programmable custom modes which will return the results in any direct linear engineering units of choice. If using a custom mode, the user

must set the offset null by using the ZERO command, and calibrate the channel as discussed in the section titled "USER PROGRAMMABLE MODES" later in this text.

DECIMAL - Sets the decimal point position for a specific input channel. Each time the READ command is issued for this channel, the value returned to the host will contain a decimal point at the position specified. If this setting equals 0, no decimal point will be used. Note, using a decimal point will not increase the number of digits shown on the screen, but will simply insert a decimal point within the original number.

ZERO - If an input channel is set to one of the user-programmable custom modes, this command can be used to calibrate the offset null for this particular channel. Apply the voltage to the input channel that should be displayed as zero and then issue this command. If zero volts should equal zero on the display, short the inputs together and then issue this command.

SPAN - If an input channel is set to one of the user-programmable custom modes, this command is used to generate the calibration coefficients needed to convert the current input voltage to any display reading of choice. Voltages which fall between this value and the value set with the ZERO command will be scaled linearly. For best results and accuracy, calibrate the channel using a voltage near the upper range of the measurement zone. Omitting the *value* in this command will return the channel to the factory calibration settings.

FACTOR - If an input channel is set to one of the user-programmable custom modes, this command is used to generate the calibration coefficients needed to convert one display unit to any input voltage of choice (inverse of the SPAN command). The voltage is listed in mV and may contain a decimal point. This command can also be used to set the resolution of the readings. Mode 4 can be set as small as 0.022 mV, Mode 5 can be set as small as 0.0014 mV. Omitting the *value* in this command will return the channel to the factory calibration settings.

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 and calibration data is stored in non-volatile memory. Therefore, a reset or loss of power will not corrupt or change these settings.

INPUT CHANNEL SCANNING

During normal operation, the Analog Input sub unit continuously scans all 4 channels in the background regardless of whether or not they are being polled by the host. The full 20-bit A/D results of each channel is stored in its own circular buffer which will always hold the most recent 8 samples. At any time a READ command is issued, the 8 samples associated with that particular channel are averaged together and the results will be the data which is returned to the host. This 8-times averaging smoothes out the readings and reduces the jitter shown on the computer screen.

USER PROGRAMMABLE MODES

The Analog Input sub unit incorporates a 32-bit floating point math routine which provides data conversions using calibration coefficients stored in non-volatile memory. Each of the modes selected with the MODE command has its own set of calibration coefficients. There are two modes which can be programmed by the user to display the results of each READ command in the linear engineering units preferred. The span of the A/D converter is extended across the range of each mode and determines the maximum resolution available. Mode 4 has a range of -8V to +10V and a maximum resolution of 22 µV. Mode 5 has a range of -0.6V to +0.6V and a maximum resolution of 1.4 µV. Each mode can be individually programmed using one of two methods, SPAN or FACTOR.

SPAN can be used if a known output reading can be generated by the sensor. Sensor manufacturers often include a shunt resistor for this purpose and when attached to the sensor's bridge, will cause it to output a voltage which represents a specific reading. Applying a known load or stimulus to a sensor also works well. After setting up the sensor so that it outputs the known reading, transmit the SPAN command with the *value* field containing the number that should be displayed on the screen. Multiplying the value by multiples of 10 will increase the resolution. For example, if applying a 50-lbs load to a pressure transducer, transmitting a value of 5000 in the SPAN command will set up the channel to display its readings in 0.01-lbs

increments. The DECIMAL command can then be used to set up the channel to automatically insert a decimal point in the correct position of each reading if desirable.

FACTOR can be used if the actual voltage that equals one unit of measurement can be determined. To calculate this voltage in mV, use the factory-listed output of the bridge sensor in the following equation.

value = Out * E / FS where:

Out = Output of the sensor in mV/V.

E = Excitation voltage applied to the bridge.

FS = Full scale capacity of the sensor.

For best results, the excitation voltage should be measured directly at the bridge using the same analog input channel and lead wires that will be attached to the bridge output itself. Transmit the FACTOR command with the *value* field containing the results of this equation. Dividing the value by multiples of 10 will increase the resolution displayed on the screen in the same way as multiplying the value used in the SPAN command, as discussed earlier. FACTOR can also be used to set the display resolution so that it equals 1-bit of the A/D converter by using 0.022mV for Mode 4 and 0.0014mV for Mode 5.

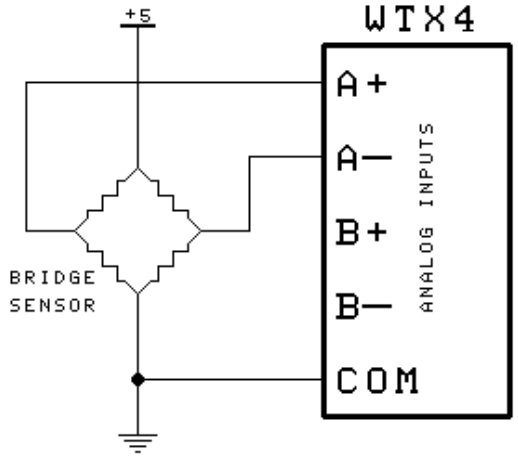
INPUT VOLTAGE RANGE

Each of the input channels of the Analog Input sub unit has a common mode range of ±10V with respect to the COM terminal regardless of the MODE it is set to or the magnitude of the differential voltage it is measuring. Both positive and negative inputs must remain inside this range at all times or conversion errors will result. If connecting to a bridge sensor for instance, the excitation voltage applied to the bridge must be less than 20V in order to keep the inputs within this common mode range. An excitation of 5V to 15V is recommended for proper operation.

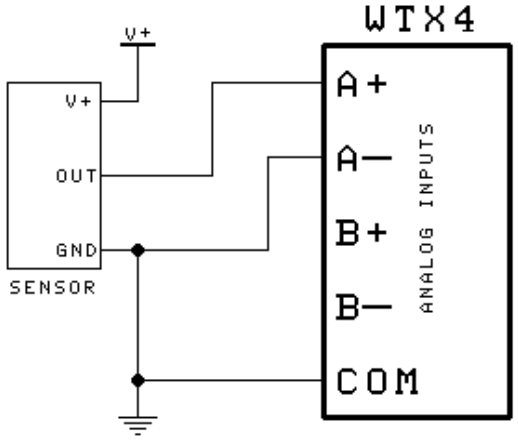
4-20 mA CURRENT TRANSMITTERS

To read the data from a 4-20 mA current transmitter, place a 100-Ohm resistor in the current loop and use an input channel to read the voltage across the resistor as shown at the right. The results returned to the host will be from 400mV to 2000mV representing the 4mA to 20mA current range. A user programmable mode can be used to automatically convert this voltage reading to any linear engineering units of choice and include a decimal point if desirable.

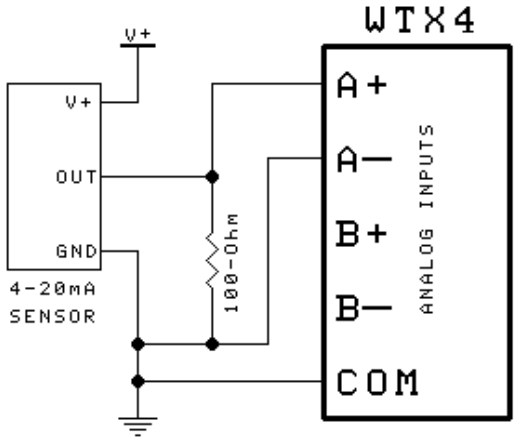
CONNECTING TO BRIDGE SENSORS



CONNECTING SINGLE-ENDED SENSORS



CONNECTING TO 4-20 mA SENSORS



ANALOG OUTPUT (sub unit)

The host PC communicates with the Analog Output sub unit using a command set comprised of standard ASCII character strings as shown below. Each of these commands must be preceded with the header character which is determined by the sub unit number and the DIP switch setting of the WTX4 unit (see Table 1).

A typical command string looks like this:

HCNV{cr}

H = Header Character

C = Command Character

N = Channel Number (if applicable)

V = Value (if applicable)

{cr} = Carriage Return

COMMAND SET

TITLE	COMMAND	DESCRIPTION
VOLTAGE	V *chn value*	Sets the voltage on an output channel. *chn* = A-D, *value* = 0 to ±1000 and is listed in 1/100 of a volt. Example: 825 = 8.25 volts. (Note 3, 4)
NUDGE	N *chn dir*	Nudge the voltage of an output channel one unit of the 12-bit D to A converter in a specific direction (*dir*). *Chn* = A-D, *dir* = + or – which indicates if the voltage should be raised or lowered. (Note 3)
TRAPEZOID	T *chn value*	Ramps the voltage on an output channel to a desired level using a trapezoidal shaped profile. Slope is determined by RAMP-RATE. *chn* = A-D, *value* = 0 to ±1000 and is listed in 1/100 of a volt. (Note 5)
S-CURVE	S *chn value*	Ramps the voltage on an output channel to a desired level using an S-curve shaped profile. Slope is determined by RAMP-RATE. *chn* = A-D, *value* = 0 to ±1000 and is listed in 1/100 of a volt. (Note 5)
PADDING	P *chn value*	Sets the magnitude of the curvature used in the S-CURVE function for a specific channel. *chn* = A-D, *value* = 1 to 3. Default = 2. (Note 3, 4)
RAMP-RATE	R *chn value*	Sets the ramp rate used in the TRAPEZOID and S-CURVE functions for a specific channel. *chn* = A-D, *value* = 1 to 255 and is listed in 1/100 of a volt/sec. Example: 125 = 1.25 V/sec. Default = 50. (Note 3, 4)
DEFAULT	D *chn value*	Sets the default voltage level for a specific output channel which will be loaded upon power-up, brown-out or an external reset. *chn* = A-D, *value* = 0 to ±1000 listed in 1/100 of a volt. Default = 0. (Note 3, 4)
CALIBRATE	C *chn v1 - v2*	Takes the actual measured values of two voltage set-points and computes the calibration coefficients for a given channel. *chn* = A-D, *v1* is the measured voltage after writing 800 to the output channel, *v2* is the measured voltage after writing -800 to the output channel. All values are listed in 1/100 of a volt. Example: 825 = 8.25 V. (Note 3, 6, 7)
ECHO	X *value*	Turns on or off the reception confirmation echo. *Value* = 0 or 1. 0 = off, 1 = on, default = 1. If *value* omitted, reads the current setting.
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 WTX4 sub unit should be preceded with the header character (see Table 1), and terminated with a carriage return. All responses from the sub unit 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 WTX4 sub unit.

Note 3: If ECHO is on, after successful execution this command will be echoed back to the host in the same format as received.

Note 4: If *value* is omitted, reads the current setting which will be returned to the host in the same format as above.

Note 5: After this function has been completed, the command will be echoed back to the host in the same format as received.

Note 6: The WTX4 sub unit has been calibrated at the factory, it is not necessary to perform this operation prior to use.

Note 7: If "*v1 - v2*" is omitted, the factory calibration coefficients for this particular channel will be restored.

VOLTAGE - Sets the voltage on a specific output channel using 0.01-volt resolution. The desired voltage can be in the range of -10.00V to +10.00V and is listed in 1/100 of a volt. The decimal point shown above is for clarity only and should not be included in the command string.

NUDGE – Raises or lowers the voltage on a specific output channel one DAC unit. This can be used in a programming loop of the host software to manually ramp the output.

TRAPEZOID - Ramps the voltage on a specific output channel to a desired voltage level using a trapezoidal shaped slope profile. After reception of this command, the voltage on the output will begin increasing or decreasing towards the target voltage at a rate determined by RAMP-RATE. When the target voltage has been reached, this command will be echoed back to the host in the same format as received. Note, communications with this sub unit will be disabled until this function completes.

S-CURVE - Ramps the voltage on a specific output channel to a desired voltage level using an S-curve shaped slope profile. After reception of this command, the voltage on the output will begin increasing or decreasing towards the target voltage at a rate determined by RAMP-RATE. Because of the curve added to the beginning and end of this slope, the total ramp time will be slightly longer then an equivalent trapezoidal slope. When the target voltage has been reached, this command will be echoed back to the host in the same format as received. Note, communications with this sub unit will be disabled until this function completes.

PADDING - Sets the magnitude of the curvature used in the S-CURVE function for a specific output channel. Select form 1 to 3, 1 being the least amount of curvature, 3 being the most.

RAMP-RATE - Sets the ramp rate used in the TRAPEZOID and S-CURVE functions for a specific output channel. Selectable range is from 0.01 V/sec to 2.55 V/sec and is listed in 1/100 of a volt/sec, The decimal point shown above is for clarity only and should not be included in the command string.

DEFAULT - Sets the default voltage level for a specific output channel which will be loaded upon power-up, brown-out, or an external reset from a switch.

CALIBRATE - Takes the actual measured values of two voltage set-points and computes the calibration coefficients for a specific output channel. To calibrate, set the output channel to 8.00 volts and measure the true voltage with a multimeter. Then set the output to -8.00 volts and measure the true voltage. Include the results in the CALIBRATE command string using the hyphen as the separator between the two numbers such as ACA800-800. The Analog Output sub unit will use this data to calculate the gain and offset coefficients particular to that channel and store it in non-volatile memory. Note, the Analog Output sub unit has been calibrated at the factory and it is not necessary to perform this operation prior to use.

ECHO – Turns on or off the confirmation echo which is used to verify reception of a command. If reception confirmation is not needed, turning ECHO off will increase the repetitive rate at which the host can manipulate the outputs.

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 and calibration data is stored in non-volatile memory. Therefore, a reset or loss of power will not corrupt or change these settings.

RESET SWITCH

One or more normally-open reset switches can be connected to these terminals for use in forcing a manual reset, or providing an emergency stop action while a TRAPEZOID or S-CURVE function is executing. Multiple switches should be wired in parallel. Upon reception of a reset from a switch, any function currently executing will immediately cease and the four output channels of this sub unit will be loaded with their default voltage settings. The RESET command character will then be transmitted to the host. This switch input uses a built-in debounce feature to mask multiple transitions caused by contact bounce.

OUTPUT CURRENT LIMITS

Each output channel of the Analog Output sub unit emits a control voltage that can be used to control equipment or machinery that accepts a ±10V control signal. These outputs do not deliver enough current to directly drive a load. If wishing to control the current driven thru a load, use the PWM output of the Digital Output sub unit instead which can deliver up to one full amp.

THERMOCOUPLE INPUT (sub unit)

The host communicates with the Thermocouple Input sub unit using a command set comprised of standard ASCII character strings as shown below. Each of these commands must be preceded with the header character which is determined by the sub unit number and the DIP switch setting of the WTX4 unit (see Table 1).

A typical command string looks like this:

HCNV{cr}

H = Header Character

C = Command Character

N = Channel Number (if applicable)

V = Value (if applicable)

{cr} = Carriage Return

COMMAND SET

TITLE	COMMAND	DESCRIPTION
READ	R *chn*	Read the current value of a thermocouple input channel. *chn* = A-D. Returns the thermocouple temperature listed in the degree units which has been selected by UNITS.
TYPE	T *chn value*	Sets the thermocouple type for a specific input channel. *chn* = A-D, *value* = J, K, T or E, listed in accordance with ANSI conventions. Default = J. If *value* omitted, reads the current setting. (Note 3)
UNITS	U *chn value*	Sets the degree units for a specific thermocouple input channel. *chn* = A-D, *value* = F or C. F = Fahrenheit, C = Celsius, default = F. If *value* omitted, reads the current setting. (Note 3)
CALIBRATE	C *chn t1 - t2*	Takes the actual measured values of two temperature points and computes the calibration coefficients for a given thermocouple input channel. *chn* = A-D, *t1* is the measured temperature when a 1000° calibration signal is applied to the input, *t2* is the measured temp when a 100° calibration signal is applied to the input. (Note 3, 4, 5)
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 WTX4 sub unit should be preceded with the header character (see Table 1), and terminated with a carriage return. All responses from the sub unit 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 WTX4 sub unit.

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

Note 4: The WTX4 sub unit has been calibrated at the factory, it is not necessary to perform this operation prior to use.

Note 5: If "*t1 - t2*" is omitted, the factory calibration coefficients for this particular channel will be restored.

READ - Reads the current value of the specified input channel. The results returned to the host will be equal to the absolute temperature of the thermocouple sensor which is attached to the input terminals of that channel. The temperature will be displayed in the degree units (Fahrenheit or Celsius) which had previously been selected by using the UNITS command.

TYPE - Sets the thermocouple type for a specific input channel. Each channel must be set to the same type as the thermocouple which is attached to its inputs. Choices are J, K, T or E and is determined by the types of metals which are used to construct the thermocouple sensor. Those metals consist of the following:

- J = Iron (+), Constantan (-)
- K = Chromel (+), Alumel (-)
- T = Copper (+), Constantan (-)
- E = Chromel (+), Constantan (-)

UNITS - Sets the degree units for a specific thermocouple input channel. Choices are Fahrenheit or Celsius and will determine the format of the temperature data which is returned to the host when issuing the READ command for that channel. Note, this also sets the degree units used in the CALIBRATE command string.

CALIBRATE - Takes the actual measured values of two temperature points and computes the calibration coefficients for a specific thermocouple input channel. To calibrate, apply a precision 1000° calibration signal to the input channel. Use the READ command to measure the temperature and record the average reading of multiple samples. Then repeat this process using a 100° calibration signal. Include the results in the CALIBRATE command string using a hyphen to separate the two numbers such as ACA1000-100. This data will be used to calculate the gain and offset coefficients particular to that channel and store it in non-volatile memory.

IMPORTANT: Before calibrating, apply power to the WTX4 unit and allow it to heat up to normal operating temperature (about 20 min), and be sure to set the TYPE and UNITS for the channel to the same as that of the calibration signal source. Once calibrated, the TYPE and UNITS can then be changed to any of the other choices without having to re-calibrate. Note, the Thermocouple Input sub unit has been calibrated at the factory, it is not necessary to perform this operation prior to use.

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 and calibration data is stored in non-volatile memory. A reset or loss of power will not corrupt these settings.

TEMPERATURE CONVERSIONS

The temperature versus voltage relationship of the output of a typical thermocouple is not linear. Therefore, simply reading the voltage and multiplying it by a scaling factor will not convert it to temperature, or at least not with any degree of accuracy over a broad range. The WTX4 Thermocouple Input sub unit however uses a different approach. The signal from the thermocouple is amplified, converted to a digital format, and then subjected to a high-order polynomial equation using 32-bit floating point math. The result is a voltage to temperature conversion with an accuracy of 0.1°C across the entire range of temperatures. Built in to the sub unit's firmware is the polynomial coefficients published by the United States National Institute of Standards (NIST) which are needed for voltage to temperature conversions for each of the four thermocouple types that the sub unit supports. When a READ command is issued by the host, the appropriate NIST coefficients are extracted and plugged into the mathematical equation mentioned above.

TEMPERATURE RANGE

The range of temperatures which can be measured by the Thermocouple Input sub unit and its thermocouple sensors is dependant on two factors, the physical limitations of the thermocouple itself, and the mathematical boundaries inherent to the polynomial equation that is used to calculate the temperature. The former specifications can be obtained from the thermocouple manufacturer and will vary depending on the form of weld used to make the junction, and the type of insulating material used to cover the wires. As for the limits of the polynomial equation used for temperature conversions, refer to the table shown below.

THERMOCOUPLE GROUNDING

Thermocouples are offered in a choice of configurations, "grounded", "ungrounded", or "exposed" junctions. If using "grounded" thermocouples, or "exposed" thermocouples which are touching ground, be sure to separate them on different sub units if the grounds they are attached to come from different sources with different voltage potentials. Using "ungrounded" thermocouples is the preferred choice because they can all share the same sub unit without causing grounding conflicts with each other.

TEMPERATURE RANGE

TYPE	CELSIUS	FAHRENHEIT
J	-210° to +1200°	-346° to +2192°
K	-200° to +1372°	-328° to +2502°
T	-200° to +400°	-328° to +752°
E	-200° to +1000°	-328° to +1832°