Weeder Technologies

WTPCT-M

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Pulse Counter/Timer Module

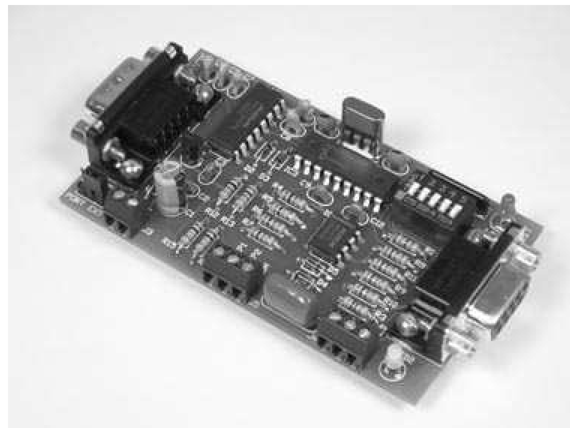
FEATURES

- Reads frequency from 0.50000 to 1,400,000 Hz using 5 digit resolution throughout range.
- Reads period from 0.71429 to 2,000,000 µS using 5 digit resolution throughout range.
- Reads RPM from a single or multiple toothed shaft/pickup using 1 RPM resolution.
- Measures duty cycle of input signal.
- High speed 24-bit pulse counter including quadrature encoder position tracking.
- Measures high or low pulse durations using 1 µS resolution.
- Calculate velocity of a projectile using two trip-wire inputs.
- Use trip-wire inputs of multiple units to plot acceleration/deceleration graphs.
- 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. Manages those precise timing-related functions and calculations needed in many laboratory testing applications. Simple command strings sent from the host will evoke the necessary series of self-timed measurements and conversions required to obtain the result. Data will be returned in direct engineering units for ease of interpretation.

Because of its autonomous execution, the module is not restrained by typical interface and/or data bus limitations, nor does it place any timing critical demand on the host's processor. And since it is stackable, the host can initiate multiple timing-related acquisitions which will process concurrently.



SPECIFICATIONS

Max Input Freq	1.4 MHz
Resolution	5-digit (Freq / Period)
Accuracy	±0.005%
Gate Time	0.2 to 2.3 seconds, continuously variable
Input Impedance	2 KW
Input Sensitivity	500 mVpp @ 100 KHz
Input Range	Protected to 160 VAC
Min Pulse Width	54 µS (count / quadrature)
Processor	PIC16F628
Clock	20 MHz
Communications	9600 Baud, N, 8, 1
Power Requirements	+8 to +30 VDC
Current Draw	22 to 26 mA
Operating Temperature	0°C to +70°C
Board Dimensions	3.5" x 2.0" x 0.7"
Weight	1.7 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 host PC communicates with the Pulse Counter/Timer Module using a command set comprised of standard ASCII character strings as depicted in Table 2. Each of these commands must be preceded with the header character which is determined by the DIP switch setting on the circuit card (see Table 1), and terminated with a carriage return.

FREQUENCY - Reads the frequency of the input signal using a 5-digit resolution. Unlike most frequency counters which merely count the number of cycles that occur within an exact predetermined gated time-period, the WTPCT instead measures the exact time it takes for a significant number of cycles to complete, then plugs the results into the following equation:

freq = count / time

This method greatly increases the precision, and resolutions of .00001 Hz can be achieved at the low end of the frequency spectrum. The number of cycles sampled is continuously variable and is determined by the input frequency. Acquisition time will be between 0.2 and 2.3 seconds.

PERIOD - Reads the period of the input signal using a 5 digit resolution. This is accomplished by measuring the exact time it takes for a significant number of cycles to complete, then plugging the results into the following equation:

period = time / count

TABLE 2: COMMAND SET

TITLE	COMMAND	DESCRIPTION
FREQUENCY	F	Reads frequency of the input signal in hertz using 5 digit resolution. Returns 0.50000 to 1400000 with floating decimal point.
PERIOD	P	Reads period of the input signal in microseconds using 5 digit resolution. Returns 0.71429 to 2000000 with floating decimal point.
RPM	R *teeth*	Reads rate-per-minute of the input signal using 1 RPM resolution. Returns 0 to 99999. *teeth* = number of teeth per revolution. If *teeth* is omitted, uses default of 1.
DUTY	D	Measures duty cycle of the input signal as a percentage of pulse time to period. Returns 0.1 to 99.9.
COUNT	C *value*	Modifies the pulse count accumulator; which will then begin counting the pulses of the input signal. *value* = 0 to 16,777,215. (Note 4) If *value* is omitted, reads the current pulse count. Returns 0 to 16,777,215.
QUADRATURE	Q *value*	Modifies the position counter; which will then begin tracking the output of a quadrature encoder. *value* = 0 to 16,777,215. (Note 4) If *value* is omitted, reads the current position. Returns 0 to 16,777,215.
TIME	T *state*	Measures the duration of the next pulse using 1 µS resolution. Returns 10 to 3355443. *state* = H or L, which selects the logic state. If *state* omitted, measures the very next pulse, high or low. (Note 3)
VELOCITY	V	Measures time between the rising edge of TRIP1 and the rising edge of TRIP2 using 1 µS resolution. Returns 10 to 3355443. (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 brown out.

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 receiving this command from the host, the yellow LED will light to indicate that the module is ready to receive a trip or pulse-trigger. The COM port will be disabled and remain so until the acquisition is complete.

Note 4: After successful execution, this command will be echoed back to the host in the same format as received.

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.
SIG +	Screw Term	Sens = 500 mVpp @ 100KHz Max input = 160 VAC Impedance = 2 KΩ	Signal input to counter/timer circuit.
SIG -	Screw Term	GND	Signal input ground.
SHLD	Screw Term	Shield	Connected to RS-232 cable shield.
TRIP (1-2)	Screw Term	V_{IL} = 0 to 0.8V V_{IH} = 2.0 to 5V Protected to ±20V	Trip inputs used in VELOCITY function, or signals A and B from a quadrature encoder.
COM	Screw Term	GND	TRIP1 and TRIP2 ground return.

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

The number of cycles sampled is continuously variable and is determined by the input frequency. Acquisition time will be between 0.2 and 2.3 seconds.

RPM - Reads the rate-per-minute of the input signal using a 1 RPM resolution. This is accomplished by measuring the exact time it takes for a significant number of cycles to complete, then plugging the results into the following equation:

rpm = ((count / time) x 60) / teeth

The number of cycles sampled is continuously variable and is determined by the input frequency. Acquisition time will be between 0.2 and 2.3 seconds. The lower limit is restricted to the result of dividing 27 by the number of teeth being used in the command string.

DUTY - Measures the duty cycle of the input signal as a percentage using 0.1 percent resolution. This is accomplished by measuring both the pulse time and period of the input signal and then plugging the results into the following equation:

duty = (pulsetime / period) x 100.

COUNT - Reads or modifies the pulse count accumulator, selectable between 0 and 16,777,215. The accumulator will then increment on the falling edge of each input pulse. Note that once another function is initiated, the accumulator will be reset to zero and remain there until the next COUNT command is issued.

QUADRATURE - Reads or modifies the position counter, selectable between 0 and 16,777,215. The position counter will then be continuously updated by a quadrature encoder connected to the TRIP1 and TRIP2 inputs. Note that once another function is initiated, the position counter will be reset to zero and remain there until the next QUADRATURE command is issued.

TIME - Measures the duration of the next pulse using a 1 µS resolution. The trigger edge (rising or falling) is selected via the *state* field. "H" is a high going pulse, "L" is a low going pulse. If *state* is omitted, the trigger edge is dependent on the logic level of the input line when this command is issued and will be the next immediate logic transition. Pulse length can be in the range of 10 to 3,355,443 µS. Due to the internal setup time, pulse lengths shorter then 10 µS may be missed.

VELOCITY - Measures the time interval between the rising edge of TRIP1 and the rising edge of TRIP2 using a 1 µS resolution. Interval can be in the range of 10 to 3,355,443 µS. Due to the internal setup time, intervals shorter then 10 µS may be missed. If both trip inputs are not properly pulled low prior to issuing this command, 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, this indicator is transmitted to the host.

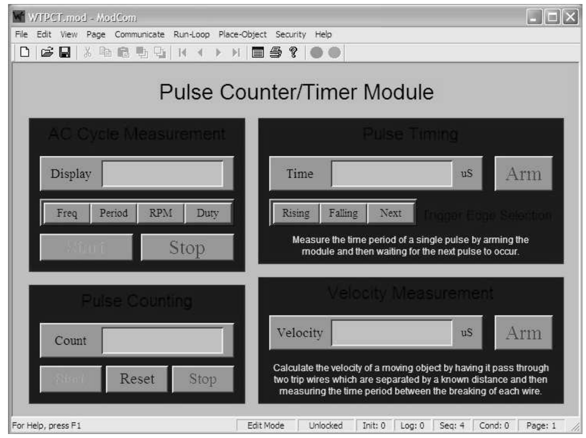
OPERATION

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. It is highly recommended to use an ungrounded AC adapter such as that which is available from Weeder Technologies. This will provide isolation and prevent ground loops which are commonly created if the power supply and computer are grounded at different points.

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 its 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 www.weedtech.com. This program will allow the user to quickly set up buttons which transmit commands, dials and meters which automatically poll for data, and a variety of other screen objects such as slider controls, event counters and timers, chart recorders that plot the data from any screen object, and more. In addition, conditional statements can be set up to watch for and act upon specific conditions, program scripts can be written by the user to perform complex tasks in the background, and data can be logged to a file or web page at user-defined intervals.

FIGURE 1: MODCOM APPLICATION



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 acquire data from the Pulse Counter/Timer module, start with the sample application "WTPCT.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, which is required to operate the different functions of this application, click on the green toolbar button at the top of the screen. The toolbar button will turn gray once the run-loop is activated.

To read frequency, period, RPM, etc., click on the "Start" button in the "AC Cycle Measurement" section of the screen. This button will first clear all windows and then run a program Script called "CycleMeasure" which will continuously poll the data module using a command string which is selected by the Button Array. The Display window will show the measurement results coming back from the module. You can change the Button Array selection (hence the polling command) at any time to view the data in different formats.

The other sections of the screen allow you to track position using a quadrature encoder, time pulse lengths, or measure the velocity of a projectile. To understand how this application works, first halt the run-loop by clicking on the red toolbar button at the top of the screen, then right-click on any screen object to view its properties. Note that each operation uses a program Script to poll for data. This is so the user can choose which operation to perform at any given time. If wishing to perform a single function, like measuring frequency, it would be easier to simply place one Data Window on the screen and have it automatically poll for data. To view or edit the Scripts, go to the <Run-Loop> menu item at the top of the screen.

TRIP INPUT TERMINALS

These input terminals incorporate internal pull-up resistors to 5-volts, therefore a simple trip wire connected from each input to the COM terminal is all that’s needed when measuring the velocity of a projectile. Alternately, a photo transistor detector can be wired to the TRIP inputs allowing the beam from a LASER to be used as the trip source. Simply connect the emitter to the COM terminal, and the collector to the TRIP terminal.

To plot acceleration/deceleration graphs, two or more modules must be used. Connect the TRIP1 terminal of the second module to the same trip source as the TRIP2 terminal of the first, and so forth down the line. In this way, it is possible to measure the velocity of the projectile at multiple points along its travel path. Note, always set up the hardware apparatus so that TRIP1 will occur before TRIP2 on each module.

TRIP/TRIGGER READY LED

When issuing the TIME or VELOCITY command, the yellow LED on the module will light. This is to indicate that the module is ready for either a trigger (start of a new pulse when using TIME), or a trip (positive transition on TRIP1 when using VELOCITY). During this time, communications with the host is suspended. The module will not hear any other commands sent from the host.

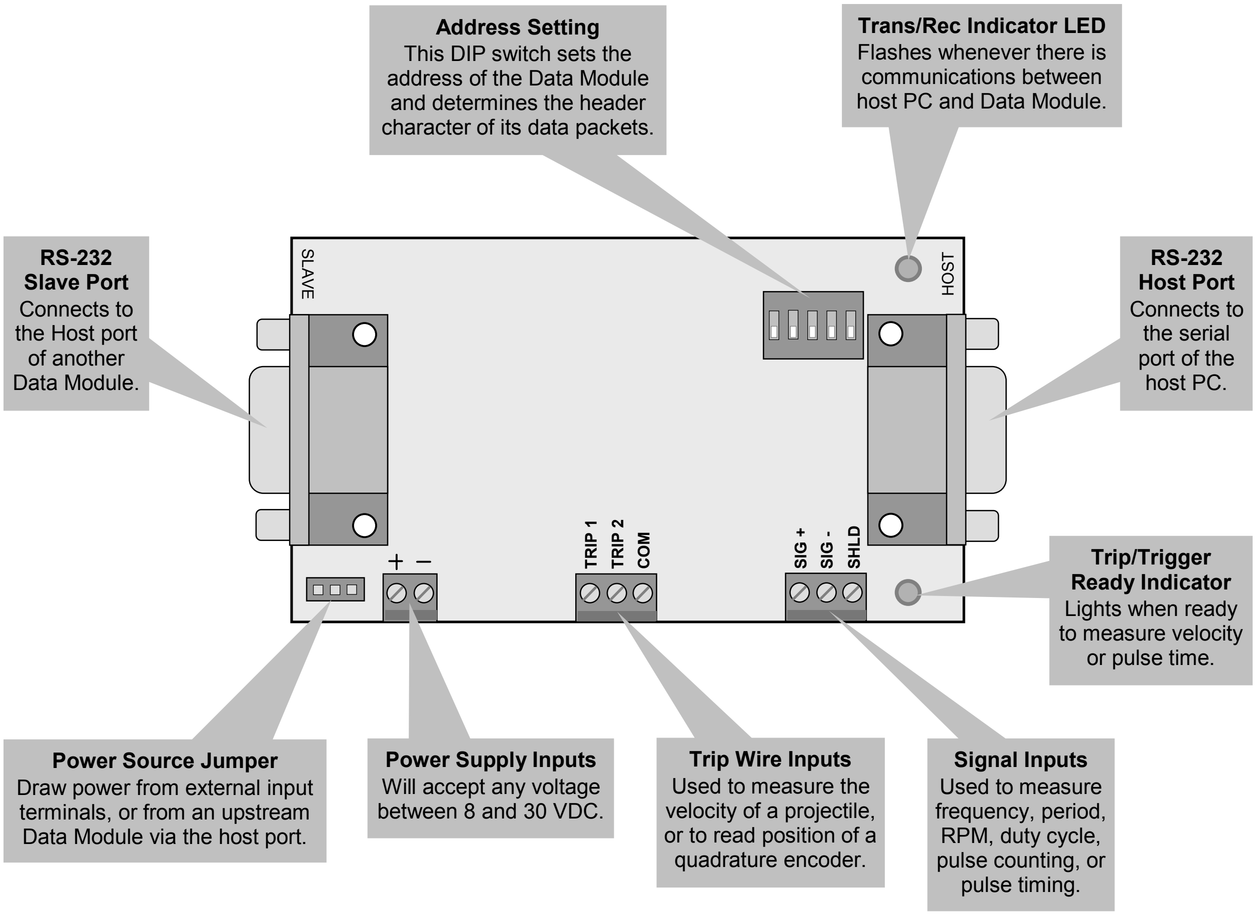
Once a valid trip or pulse-trigger is received, the LED will turn off and acquisition will commence. The communications port will not be reactivated until the acquisition has been completed which is determined by the end of the pulse, or a positive transition on TRIP2 respectively. In either case, if the valid measurement range is exceeded prior to receiving this termination, the error code is transmitted to the host.

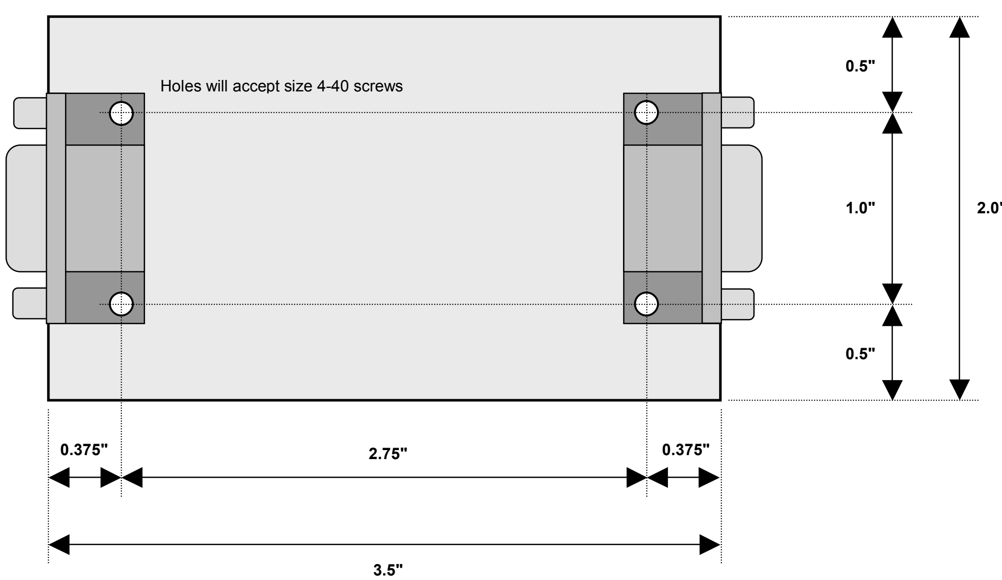
INPUT SIGNAL CONDITIONING

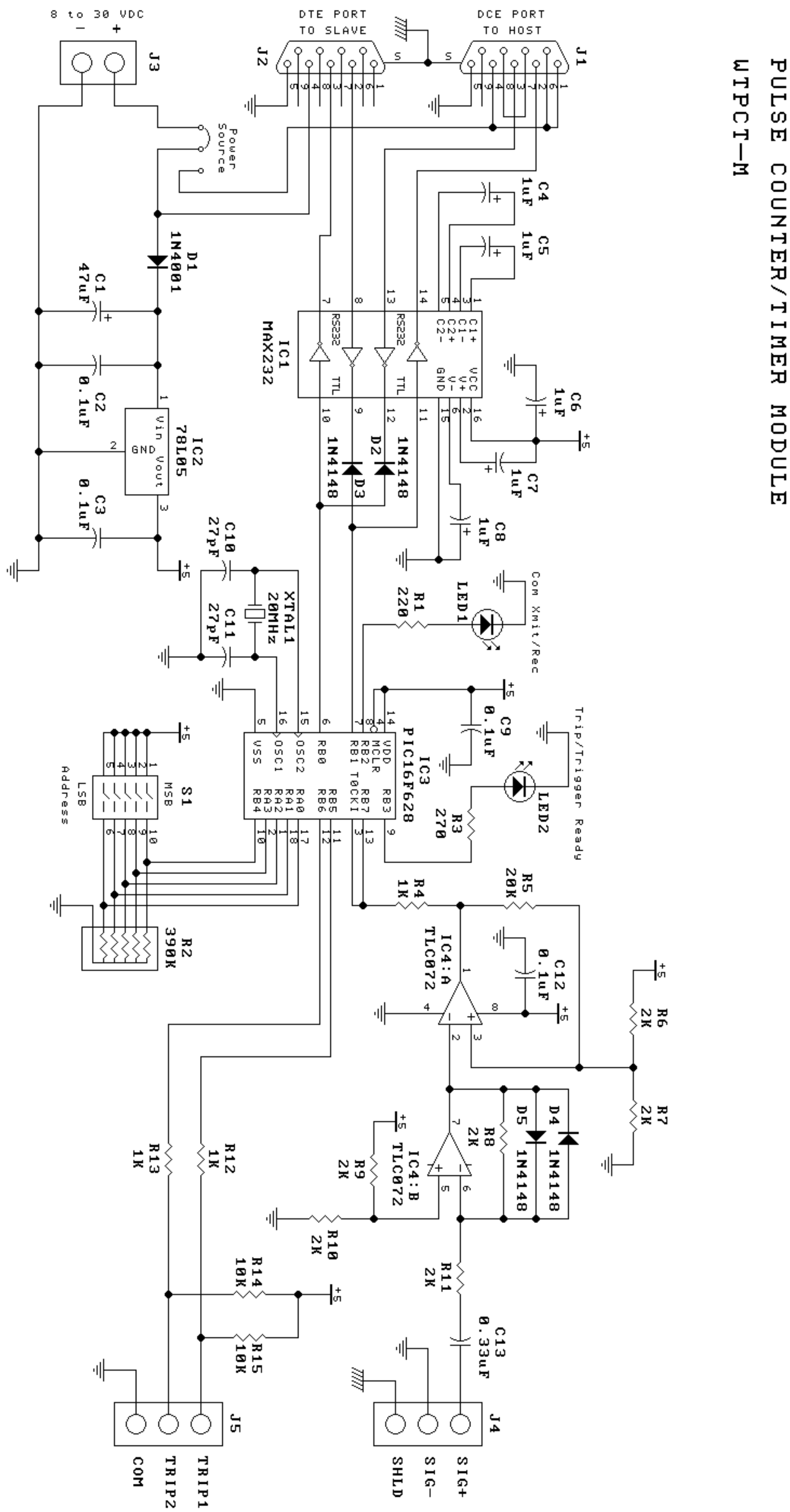
The input terminal uses capacitive coupling to correct for any DC offset voltages which may be present. In cases of measuring long pulse times, particularly when using the TIME command, the input signal may remain at one logic level for an extended period. If this occurs, the input capacitor will eventually charge to the mid point of the hysteresis used in the signal conditioning amplifier. Because of this hysteresis, the amplifier’s output will remain at the logic level produced by the last transition of the input signal and thus be ready to sense the next change of state. Note, that upon power-up or brown out, the amplifier’s logic state will be unknown.

Input sensitivity is determined by the hysteresis mentioned above and is selected as a trade off between two factors. It must be sensitive enough to allow the sampling of weak signals, but coarse enough to prevent any signal bounce from triggering extra pulse counts. Low duty cycle signals, such as the output of a rotating-shaft pickup, will bounce several times after the initial pulse which is produced when one of the teeth passes by the pickup. These extra ripples in the waveform must not transcend the thresholds created by the hysteresis or a count error will result. Should this be evident, a resistor divider network can be used to attenuate the signal at the input to the WTPCT to keep it below this limit.

The first stage of the signal conditioning amplifier contains a pair of clamping diodes in its’ feedback path which limits the voltage applied to the inverted input pin to less then 1Vp-p regardless of the amplitude of the input signal. This is used to protect the operational amplifier from voltages greater then standard TTL levels, and also to reduce large signals to a point where they can be processed by the counter/timer circuit.


Address Setting
This DIP switch sets the address of the Data Module and determines the header character of its 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.
RS-232 Host Port
Connects to the serial port of the host PC.
SLAVE
HOST
+ –
TRIP 1
TRIP 2
COM
SIG +
SIG -
SHLD
Trip/Trigger Ready Indicator
Lights when ready to measure velocity or pulse time.
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.
Trip Wire Inputs
Used to measure the velocity of a projectile, or to read position of a quadrature encoder.
Signal Inputs
Used to measure frequency, period, RPM, duty cycle, pulse counting, or pulse timing.


Holes will accept size 4-40 screws
0.5"
1.0"
0.5"
2.0"
0.375"
2.75"
0.375"
3.5"


PULSE COUNTER/TIMER MODULE
WTPCT-M
8 to 30 VDC
J3
DTE PORT
TO SLAVE
J2
DCE PORT
TO HOST
J1
Power
Source
D1
1N4001
C1
47uF
C2
0.1uF
IC2
78L05
C3
0.1uF
C4
1uF
C5
1uF
IC1
MAX232
C6
1uF
C7
1uF
C8
1uF
D2
1N4148
D3
1N4148
C10
27pF
C11
27pF
XTAL1
20MHz
R1
220
LED1
Com Xmit/Rec
IC3
PIC16F628
C9
0.1uF
LED2
Trip/Trigger Ready
R3
270
S1
MSB
LSB
Address
R2
390K
R4
1K
R5
20K
IC4:A
TLC072
C12
0.1uF
R6
2K
R7
2K
D4
1N4148
D5
1N4148
R8
2K
IC4:B
TLC072
R9
2K
R10
2K
R11
2K
C13
0.33uF
R12
1K
R13
1K
R14
10K
R15
10K
J4
SIG+
SIG-
SHLD
J5
TRIP1
TRIP2
COM