

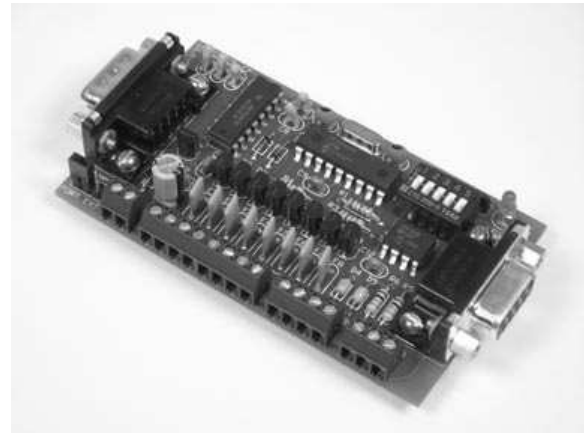
## Digital Output Module

### FEATURES

- 8 high-current open-collector output channels with automatic overload shutdown.
- 2 wide-range digital input channels with high voltage transient protection.
- DIP switch addressable; stack up to 32 modules on the same serial port to provide 256 outputs and 64 inputs.
- 2 event counter inputs with 24-bits each.
- 1 quadrature encoder input with 24-bits.
- 2 tachometer inputs which read the speed of a rotating shaft from 200 to 400,000 RPM.
- Turn on/off relays, solenoids, DC motors, etc., including PWM drive-current control.
- Each output incorporates a delay timer to allow momentary on/off or off/on activation.
- An output can be used as a watchdog timer to reset the host in case of lockup.
- Each input incorporates a pull-up resistor to 5-volts, simplifying hookup to switch contacts.
- Responds to button presses and switch transitions using automatic debounce and typematic repeat with adjustable delay.
- Wide power supply range (8 to 30 VDC).

### DESCRIPTION

Connects to the RS-232 serial port of a PC, laptop, or other host and provides 8 open-collector digital outputs for control, and 2 digital inputs for dry contacts, TTL level signals, or NPN type sensors. The digital outputs are robust enough to directly control the on/off states of other electrical equipment of up to a full ampere in current. The wide range digital inputs not only provide power for dry contacts, but in many cases can be wired directly to contacts which have external voltages already present.



### SPECIFICATIONS

Digital Outputs	Open-collector type. Sink up to 1.0 Amps. Overload protected.
Digital Inputs	Low = -40V to +0.8V High = +4V to +40V Transient protected.
Counter/Quadrature	Range = 24-bits Min pulse width 75 $\mu$ S
Tachometer	200 to 400,000 RPM Accuracy = $\pm 0.005\%$
PWM	Resolution = 10-bits Freq = 19.53 KHz
Processor	PIC16F628
Clock	20 MHz
Communications	9600 Baud, N, 8, 1
Power Requirements	+8 to +30 VDC
Current Draw	14 to 20 mA
Operating Temperature	-20°C to +70°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 than 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 Digital Output Module using a command set comprised of standard ASCII character strings as shown 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.

**WRITE** - Writes data to all output channels simultaneously as a 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. High state sets the output floating, low state pulls the output to ground.

**HIGH** - Set a specific output channel high (open collector floating). The output channel can be instructed to remain high until a further command, or return low after a user defined

**TABLE 2: COMMAND SET**

TITLE	COMMAND	DESCRIPTION
WRITE	W <i>data</i>	Write <i>data</i> to output channels A-H as an 8-bit port in binary notation. <i>data</i> = 00000000 to 11111111. 1 = high, 0 = low. Chn A = MSB.(Note 3)
HIGH	H <i>chn time</i>	Set a specific output channel high (open-collector floating) for a period equal to <i>time</i> . <i>chn</i> = A-H, <i>time</i> = 1 to 65535 and is listed in milliseconds. If <i>time</i> omitted, output channel remains high. (Note 3)
LOW	L <i>chn time</i>	Set a specific output channel low (open-collector pulled to GND) for a period equal to <i>time</i> . <i>chn</i> = A-H, <i>time</i> = 1 to 65535 and is listed in milliseconds. If <i>time</i> omitted, output channel remains low. (Note 3)
PWM	P <i>value</i>	Configures output channel H for pulse-width-modulation using <i>value</i> to set duty cycle. <i>value</i> = 0 to 1024. 0 = 0% duty cycle, 1024 = 100% duty cycle. If <i>value</i> omitted, reads the current setting. (Note 3)
READ	R <i>chn</i>	Read the current logic state of an input or output channel. <i>chn</i> = A-J. Returns " <i>chn</i> H" or " <i>chn</i> L". If <i>chn</i> omitted, read input channels I-J as a 2-bit port in binary notation. 1 = high, 0 = low. Channel I = MSB.
SWITCH	S <i>chn</i>	Configures a specific input channel to respond to switch transition. <i>chn</i> = I-J. Returns " <i>chn</i> L" or " <i>chn</i> H" when switch is toggled. (Note 3)
BUTTON	B <i>chn delay</i>	Configures a specific input channel to respond to button presses. <i>chn</i> = I-J. Returns " <i>chn</i> L" when button is pressed. If button is held down, response will be repeated at <i>delay</i> rate. <i>delay</i> = 1 to 15 listed in 1/10 of a second. If <i>delay</i> omitted, no repeat will be used. (Note 3)
COUNTER	C <i>chn value</i>	Modifies the event counter of a specific input channel which will then begin counting the pulses applied to its input. <i>chn</i> = I-J, <i>value</i> = 0 to 16,777,215. (Note 3) If <i>value</i> omitted, reads the current event count.
QUADRATURE	Q <i>pair value</i>	Modifies the position counter of a specific input channel pair which will then begin tracking a quadrature encoder. <i>pair</i> = IJ. <i>value</i> = 0 to 16,777,215. (Note 3) If <i>value</i> omitted, reads the current position.
TACHOMETER	T <i>chn</i>	Measures the pulse rate (in RPM) from a tachometer sensor attached to a specific input channel. <i>chn</i> = I-J. Returns 0 to 400000.
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.
<p><b>Note 1:</b> 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.</p> <p><b>Note 2:</b> 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.</p> <p><b>Note 3:</b> To verify a valid reception, this command will be echoed back to the host in the same format as received.</p>		

**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.
A – H	Screw Term	Open-Collector Type Sink up to 1.0 Amps each Automatic Overload Shutdown	Digital output channels. If a channel is set high, the output will be floating, if set low, the output will be pulled to ground.
I – J	Screw Term	$V_{IL} = -40V$ to $+0.8V$ $V_{IH} = +4V$ to $+40V$ High Volt Transient Protection	Digital input channels. All channels incorporate a pull-up resistor to 5 volts which will hold it high if left open.
V+	Screw Term	Tied to Power Supply Input	Used as source supply for digital outputs.
GND	Screw Term	Tied to Power Supply Ground	Used as return path for digital Inputs.
<b>Note 1:</b> 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.			

time-out period in the range of 1 to 65,535 mS. Note, the timer will operate in the background allowing other functions to be initiated during this period. This function can also be used as a watchdog timer as discussed later in this text.

**LOW** - Set a specific output channel low (open collector pulled to ground). 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 timer will operate in the background allowing other functions to be initiated during this period. This function can also be used as a watchdog timer as discussed later in this text.

**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 input or output channel. Each

channel can be read individually, or both of the input channels can be read simultaneously as a 2-bit port in binary notation.

**SWITCH** - Configures the specified input channel to sense and respond to a logic transition without being polled. The transition can be produced by an SPST toggle switch wired to ground. 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 input channel to sense and respond to a low-going transition without being polled. The transition can be produced by a normally-open button wired to ground. A built-in debounce feature is used to mask multiple transitions produced by contact bounce. If the button is held down, 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 input channel. Once activated by this command, the counter will increment on the falling edge of each input pulse. 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 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. If another command (other than READ) is issued, and uses either one of these input channels, the position counter will be cleared and the QUADRATURE function canceled.

**TACHOMETER** - Reads the pulse rate of a signal applied to a specific 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 may cause a communications malfunction, see the section titled "RPM SCANNING FUNCTION" for a very important note.

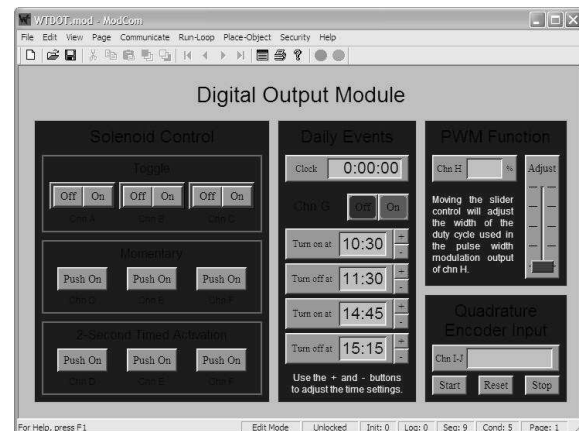
**ERROR** - Any data string sent from the host containing the correct header character but an invalid command or variable will be responded to with this error indicator.

**RESET** - Upon power-up or any other reset condition, this indicator is transmitted to the host. If the Digital Output Module encounters an unintentional reset due to a power disruption or brown-out, all setup information will be lost. Therefore, upon reception of this indicator, the host should retransmit setup information as if the module had been powered up for the first time.

## 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.

**FIGURE 1: MODCOM APPLICATION**



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](http://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.

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 operate the Digital Output Module, start with the sample application "WTDOT.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 screen. At this point you can use the mouse to click on the Push Buttons and control the on/off states of output channels A thru F. Channel G has been set aside for a daily event function which you can modify on the fly, and cause the output to turn on and off depending on the time of day. Channel H is set up for PWM mode and uses a Slider Control to adjust the magnitude of its output. Input channels I and J can track the position of a quadrature encoder.

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 pull up its properties dialog box. Also, go to the <Run-Loop> menu item to view the Scripts and Conditionals which make some of these functions operate. Refer to the help files for more information.

## 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 system, and in most cases, not be desirable.

Each of the input channels of the WTDOT incorporates its own debounce 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 debounce 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 WTDOT can still report actions on additional inputs while its waiting for one or more debounce timers to expire.

## RPM SCANNING FUNCTION

If an input channel is configured to read RPM by issuing the TACHOMETER command, the channel will be continuously scanned in the

background and the results stored in memory. Each time that the TACHOMETER command is issued, the latest results will be returned to the host without any acquisition delay. Note however, that the first time the TACHOMETER command is issued, the results returned to the host will be 0 because the RPM scanning function had not yet been enabled for that particular channel.

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 acquire. And since the WTDOT can only scan one input channel at a time, a low RPM signal applied to one channel will slow down the update rate of any other channels which are configured to read RPM.

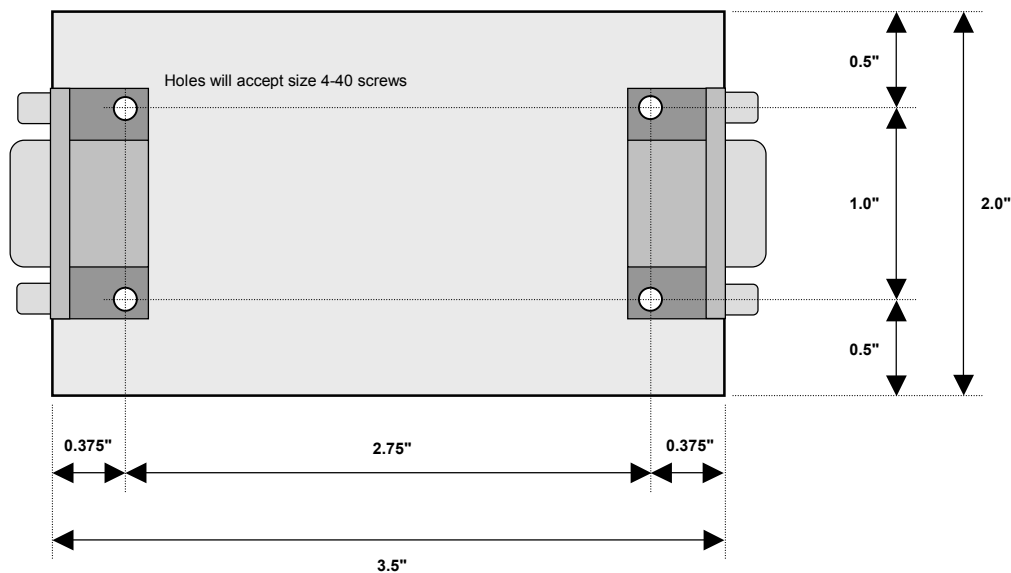
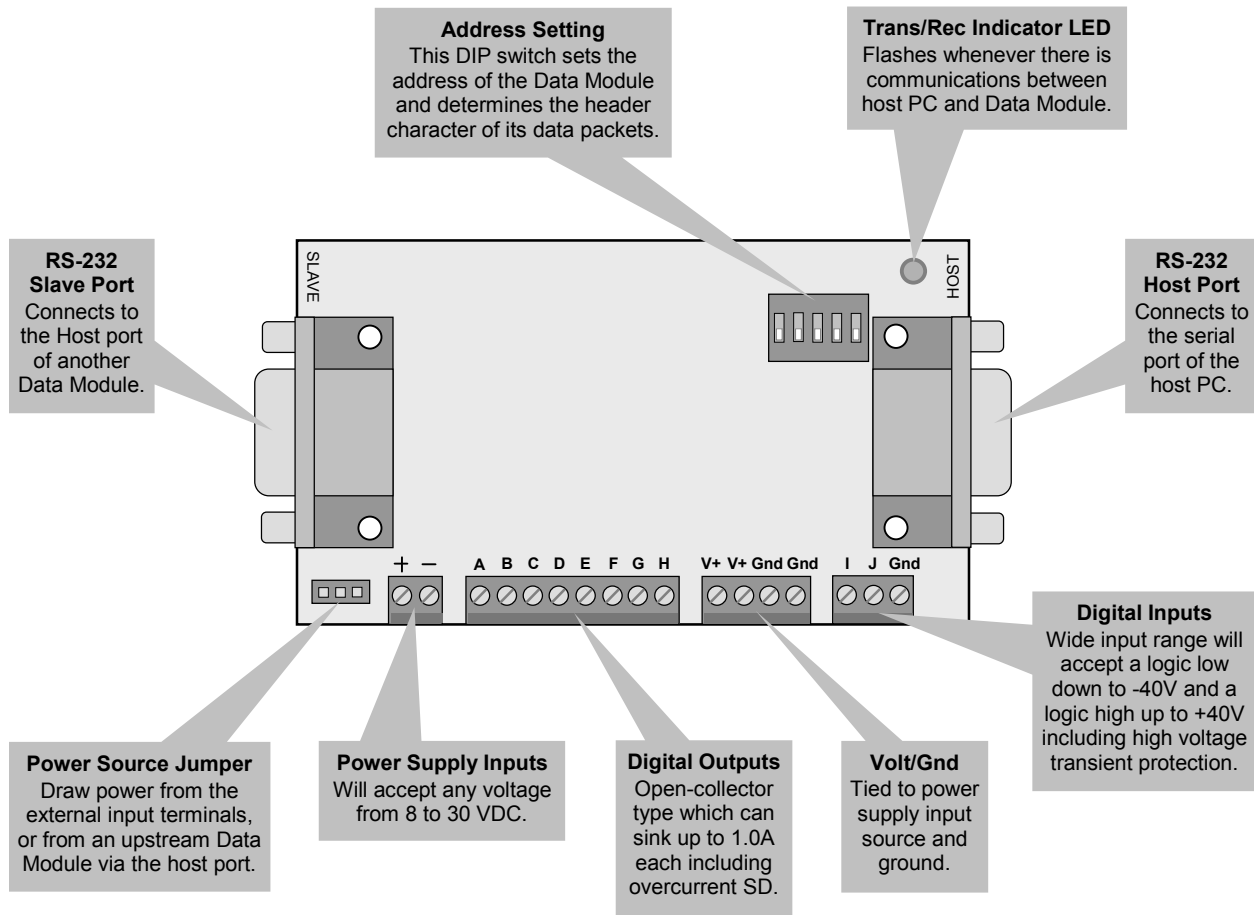
IMPORTANT, if one or more of the inputs are configured to read RPM, and a high frequency signal above 400,000 RPM is applied to any one of the other tachometer input channels, whether enabled for RPM or not, it will cause interference with the communications from the host.

## WATCHDOG TIMER FUNCTION

An output channel may be set up as a watchdog timer to reset the host in case of lockup. To do this, have the host transmit a HIGH or LOW command repetitively at a rate faster than the time period used in the command. This procedure causes the output channel to go into watchdog timer mode. From this point on, if anything prevents the WTDOT from receiving this command, the time period will expire and the output will automatically emit a two-second pulse at the opposite state. This pulse can be used to reset the host or other equipment in the system. Note, this two-second pulse is only produced during watchdog timer mode, normally when a HIGH or LOW time period expires, the output will change back to the opposite state and remain there.

## OUTPUT OVERLOAD SHUTDOWN

Each output channel 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, current must be removed from the output channel before it will return to normal operation.



DIGITAL OUTPUT MODULE  
WTDOT-M

