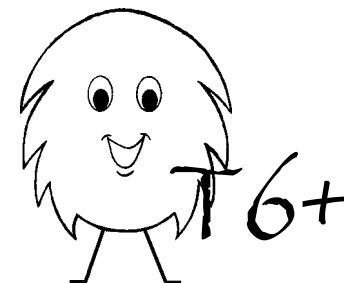


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Analog I/O Section

NOTICE: This booklet is written specifically for the T6 *plus* control system. Analog sections are not compatible with a standard T6 MCU or programmer.

Air-Oil Systems, Inc. www.airoil.com



Installation booklet for part numbers:

- 5/4-80A-115
- 5/4-90A-115
- 5/4-80A-1224
- 5/4-90A-1224



Specifications

Part No: 5/4-80A-115, 5/4-90A-115, 5/4-80A-1224, 5/4-90A-1224

Power Requirements

models xx-115: 115VAC \pm 10% @ .04A, 50 or 60 Hz
 models xx-1224: 12 to 24VDC @ .30A

Outputs

4 solid state NPN open collector, 28v zener protected
 500 ma. intermittent load, 300 ma. continuous
 24vdc (max) operating voltage
 Duty cycle programmable in 1% increments
 PWM frequency of 1khz

Inputs

5, capable of reading a positive 0 to10 volt signal
 20k input impedance, pulled down (bias toward 0v)
 Programmed in 0.040 volt resolution (total of 255 steps)
 User selectable polling speed 10 to 2550ms (see page 14)
 Input indicator light intensity reflects the input's voltage

Auxiliary Input power supply

10.0vdc @ 100ma., thermal overload protected

Physical

Size 2.9" (75mm) x 2.2" (55mm) x 4.3" (110 mm)
 Mounting DIN rail or panel (with two #6 screws)
 Weight 14 oz. (400 grams)
 Temp -20 to 140° F, 90% r. humidity (non cond.)

Origin

Designed and assembled in the USA.

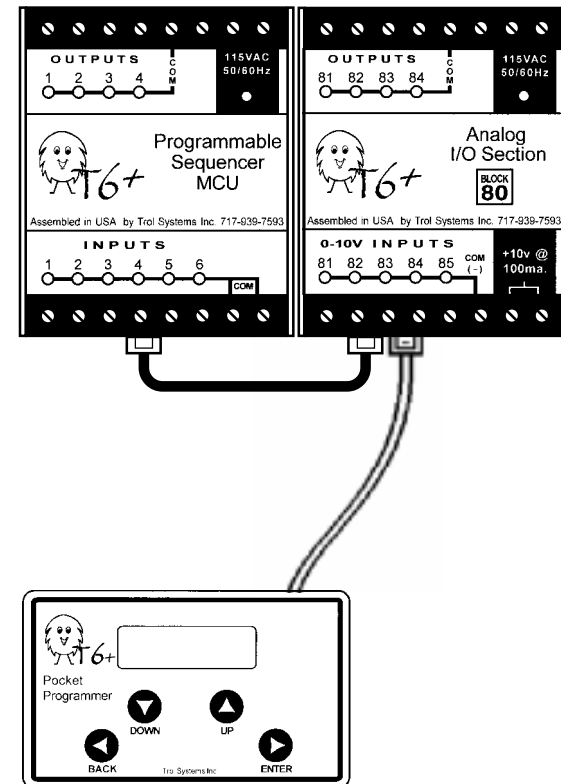
Performance

Timing Output timing \pm 1 ms repeatability
 Communication Input and output data is sent to/from the MCU
 within 850 us (typ) / line
 Data Port Dual Iic bus @ 100khz

Installation

Expansion sections can be either DIN rail mounted or panel mounted using two #6 screws. They should be mounted beside the T6 MCU as shown below. If more than one expansion section is being added; install them in block number order from left to right.

Connect the supplied cable to the data port of MCU and to the left data port of the I/O unit. Be sure to fully insert the plug so they lock into position. The programmer can be connected to the right data port.



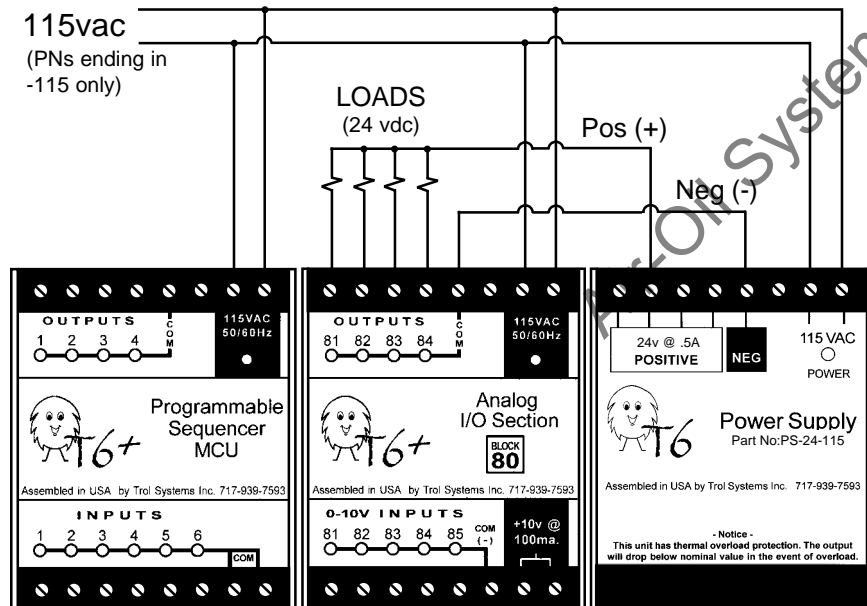
Wiring the supply

I/O sections with part numbers ending in “115” require a 115VAC supply as shown below. Part numbers ending in “1224” require a DC supply and would be connected to the power supply instead of the power line (note polarity).

Wiring the outputs

The outputs share a common terminal marked “COM” which is connected to the negative side of a DC supply. The positive side of the supply is connected to each load device. Use only a **regulated** (preferably linear type) DC power supply, measuring 24 volts or lower. The supply must be rated for the total current of all load devices that may be on at any point in the program. T6 power supply sections can be connected in parallel (pos to pos, neg to neg) to increase the total load current.

CAUTION: Load devices must not consume more than 1/2 amp of output current. Therefore, the load must not measure less than 48 ohms @ 24v or 24 ohms @ 12v. Output damage as a result of excessive voltage or current overload is not covered under warranty.



Glossary of analog terms

Analog - properties of electricity that vary continuously and smoothly rather than switching suddenly between levels.

Auxiliary input power supply - The 10 volt dc power supply that can be used to power dc input devices up to 100ma.

Current - the amount of electrical flow measured in amperes.

K - kilo ohms or 1000 ohms- ie: 10k = 10,000 ohms

Linear - an analog change in one variable that results in a proportional change to the other variable. A linear supply does not use a switching method of voltage regulation.

Milli - 1/1000th of something. ie: 1 second = 1000ms, 1amp = 1000ma

Overshoot - any unwanted voltage above the nominal value.

Polling - when an analog input is being checked, the MCU must periodically ask for input information from the analog section. This process is called polling. The T6 has an adjustable polling rate that is factory set to poll the analog section every 20ms. (see page 14)

Pull down - the resistive bias toward negative or common (0v).

Pull up - the resistive bias toward the positive supply.

PWM - pulse width modulation. Using a digital signal to create an effective dc (rms) voltage.

Resolution - the measurement of the smallest increment.

Sinking - a device that is able to pull a positive source of current toward negative or 0v. Often devices of this type are referred to as “NPN”.

Sourcing - a device that is able to supply a positive source of current. Often devices of this type are referred to as “PNP”.

Switching supply - a type of power supply that uses high speed electronics to reproduce a regulated dc source. Unlike a linear supply, they often require a minimum continuous load current to prevent overshoot.

Uf - microfarads of capacitance.

Ω - ohms. The measuring unit of electrical resistance.

Setting the input polling rate

Analog I/O sections can be programmed to perform a duty cycle on several outputs at one time. This results in a heavy work load for the microprocessor. When the MCU needs to check on an analog input, it may poll the section many times before the input voltage matches the threshold. Each time the MCU polls the analog section, it interrupts the microprocessor from performing its normal duties. If it's interrupted too many times per second, output duty cycle error will occur. Therefore, the MCU has a "Polling Rate" setting that is stored in its BIOS. This setting tells the MCU how long it should wait before requesting analog input information.

The Poll Rate is factory set at 20ms. This means that the analog section cannot be polled by the MCU greater than 50 times per second. You may adjust the rate higher (up to 2550ms) to ensure the highest amount of output duty cycle stability. Settings of less than 10ms are not advisable.

To change the polling rate for the analog section:

1. From the Main menu, choose "Setup T6 Options"
2. In the Setup menu choose "Change BIOS".
3. Scroll to the register number that corresponds to the block number of the analog section and press Enter. (ie; register 80 = Block 80).
4. Scroll until the register number is followed by the letter "D" and press Enter. The current polling rate of the section (time in milliseconds $\times 10$) is now displayed.
5. Adjust the setting as necessary (number displayed is $\times 10$ milliseconds), then press Enter to record the new setting.
6. Press the Back key twice to exit to the Main menu.
7. At the Main Menu, select "Send T6 New Program" to update the BIOS settings in the MCU.

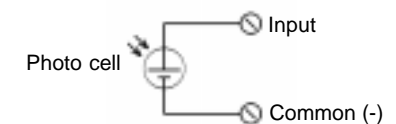
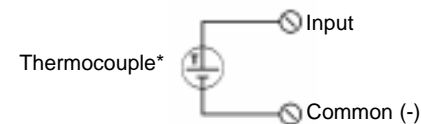
Operation of Analog Inputs

Analog inputs differ from standard (digital) inputs because they can be programmed for a particular voltage, instead of a status (on or off). They operate with a positive signal that measures from 0 to 10 volts. You program a line of the T6 for the Check Input function to see if an input is above or below a selected voltage. The same input can be checked for various voltage settings throughout the program.

Analog devices have a variable output which offers greater versatility than a switch closure device. For example; if a thermostat closes its contacts when it reaches 100 degrees, we would not be able to tell how much above or below 100 degrees the temperature is. Therefore, we couldn't program the T6 to respond as the temperature got closer to the nominal setting or to react to an overshoot in temperature. An analog temperature sensor would give us that ability.

Analog devices generally fall into two categories: those that have resistive properties and those that generate voltage. This will determine how they are connected to the input of the analog section.

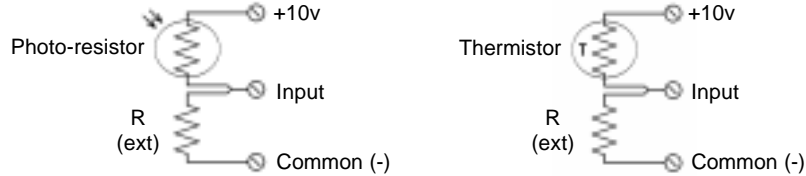
Sensors that generate their own voltage



Thermocouple: Used like a thermistor but usually in high temperature applications. It will generate voltage, usually less than 1/10 volt, instead of changing resistance. Due to their limited voltage generating abilities, thermocouples may require an amplifier in order to increase the resolution for finer temperature control applications.

Photo cell: Also called a Solar cell. A photocell generates its own voltage instead of changing resistance. Note: photo resistors and photo-transistors are often mistakenly referred to as the less popular photo cell.

Sensors that change their resistance

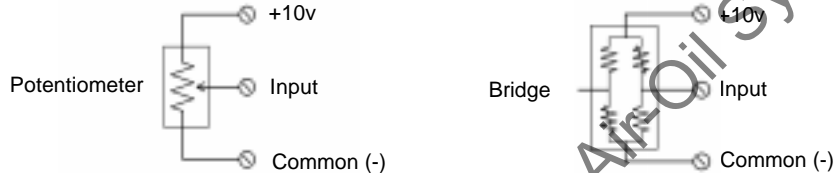


Thermistor: Used to measure temperature. The most common type, NTC, decrease in resistance with an increase in temperature. A thermistor of the PTC type will increase resistance with an increase in temperature. Typically, the response curve of resistance versus temperature is not linear.

Photo-resistor & Photo-transistor: Most often used to detect ambient light or a break in a light beam. Decrease in resistance with an increase in light. Photo-resistors are more sensitive to the yellow/green spectrum while photo transistors are more sensitive to infrared.

Note: a single element sensor requires an external resistor (R ext) connected as shown. The ideal value of this resistor should be equal to the average resistance of the sensor when operating. For example: If a thermistor is to operate from 0 to 100 degrees, its resistance at 50 degrees would be the best value for the external resistor.

Sensors that change resistive ratio



Potentiometer: This is the most popular type of configuration used on a wide variety of sensors. Linear potentiometers are often used to determine the position of a slide, cylinder or actuator. Due to their voltage dividing capability, no additional external resistors are required. Bridge type sensors have 4 wires, but only 3 are used.

Note: Pot. values under 500 ohms should not be used with the 10 volt supply due to current drain limitations. Avoid pot. values over 25K due to the influence of the input's impedance.

Removal of I/O Programming Procedure

This procedure is used only when the pocket programmer needs to be used on a differently configured system or if the system is being dismantled.

Note: Adding and removing I/O using the Setup menu procedure does not change the program within the T6 MCU. The program of a MCU must not contain any line that depends I/O that is not connected to the system.

BEGIN A NEW PROGRAM?

Power up the programmer (by MCU or optional power pack) and enter the Main menu.

SETUP T6 OPTIONS?

At the Main menu choose "setup T6 options", then press the Enter key.

SETUP MENU ERASE PROGRAM?

SETUP MENU REMOVE I/O?

In the Setup menu choose "remove I/O", then press the Enter key.

REMOVE I/O WHICH ONE? 20

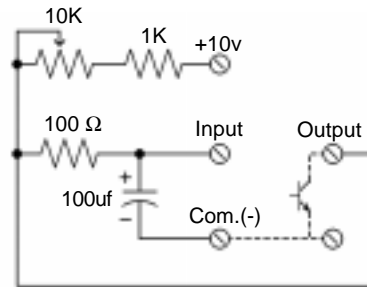
Select the Block number of the I/O section you want to remove. The Block number is printed in a box on top of the unit and is also in the middle of the part number. Once the proper block number is displayed, press the Enter key.

SETUP MENU ERASE PROGRAM?

Press the Back key to return to the Main menu. The I/O selections of this block are now removed from Program menu.

Analog Timing Configurations

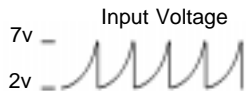
Often machine applications require periodic adjustment to timers. An analog input and output can be configured to operate with some inexpensive external components to build an adjustable timer. Up to four timing circuits can be configured to operate with this analog section.



How it works:

Current flows through all three resistors and into the 100µf capacitor. The voltage of the input begins to rise as the capacitor charges. The rate of charge depends on the setting of the external 10K potentiometer. Once the voltage of the input crosses the programmed threshold, the output is turned on. The capacitor is discharged rapidly through the 100 ohm resistor until it goes below the next programmed threshold. This process is repeated for the programmed number of times. Then the time cycle has completed, and the program will continue with the next line of the page.

30 Output S1 - Off
 31 Check Input S1 - Above 7.0V
 32 Output S1 - On
 33 Check Input S1 - Below 2.0V
 34 Repeat from line 30 - 10 times
 35 Output S1 - Off



Selecting Values:

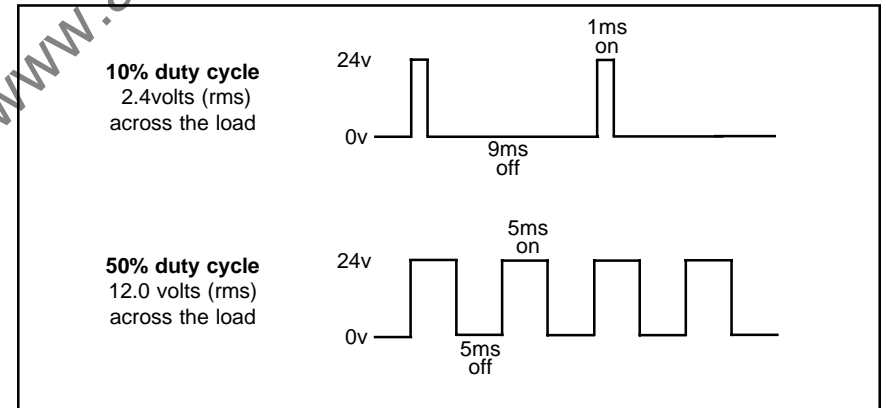
The nominal value of the potentiometer is 10K ohms with a series resistor of 1K. The discharge resistor can be any value between 50 to 200 ohms. The capacitor value can be any value above 1µf, but must be rated for at least 10v. The charge time of the capacitor determines the number of times that it should be repeated in order to build the timer suited for your needs. The formula is: **Uf X K ohms = milliseconds.** (approx.)

In the example above, if the pot is set to maximum, the equation would be $100\mu\text{f} \times 11\text{K} = 1100 \text{ ms}$, or ~ 1.1 seconds. If the pot is set to minimum, the equation would be $100\mu\text{f} \times 1\text{K} = 100 \text{ ms}$, or $\sim .1$ seconds. This gives us a charge time range of 1.1 to 0.1 second. Line 34 repeats the cycle 10 times, which results in a timer that operates with a 1 to 11 second range. If line 34 were set to 250, the range would be 25 to 275 seconds.

Operation of Analog Outputs

Analog outputs are solid-state switches which can be programmed to turn on or off just like standard relay outputs. But they can also be programmed to turn on and off at a particular ratio, called a duty cycle. This creates an effective amount of voltage across the load. For example; if the load is connected to a 24 volt supply and the output is set to a duty cycle of 50%, the effective load voltage would be $(.5 \times 24)$ or 12 volts.

Instead of a pure DC voltage level, the load receives pulses that effectively perform the same amount of work. The effective work value is called the "Root Mean Square" equivalent to the DC voltage, or RMS voltage. This digital method of creating an effective DC voltage is often referred to as pulse width modulation (PWM). It is the most energy efficient means of creating an effective DC value. Below is what a PWM signal may look like.



PWM voltage can be measured with a conventional analog meter (the type with a moving pointer). However, a digital DC volt meter should not be used unless it is of a "true RMS" type (a feature offered on newer meters). To measure the PWM voltage, connect the voltmeter across the load device.

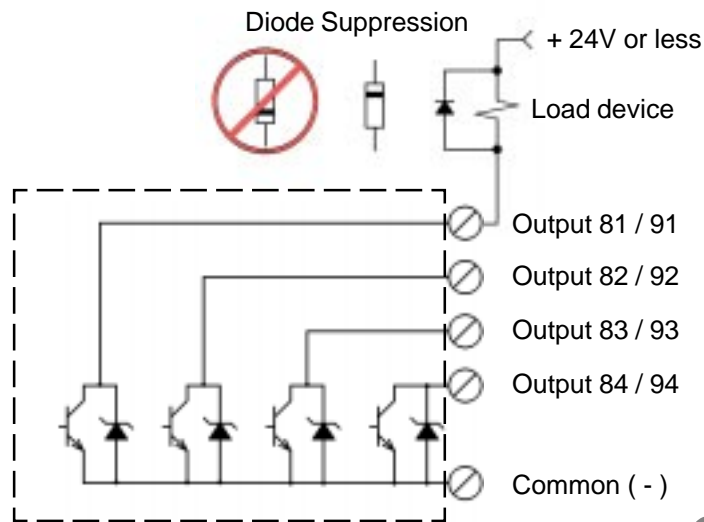
Load devices such as solenoid coils, light bulbs, heating elements and dc motors operate well with PWM signals. The frequency of the signal is so fast that the load responds only the effective DC value.

High speed devices such as electronic control circuits and instruments require a stable DC signal and may not interpret a PWM signal correctly.

Output Specifics

Each output consists of a open collector transistor that can operate load devices up to 24 volts and can sink up to 1/2 amp (500ma). The outputs are internally zener diode protected from load transients that exceed 28v.

Additional diode suppression may be connected across an inductive load as shown below. Note: Do not use capacitive load suppression because they will cause a change in the DC rms voltage.

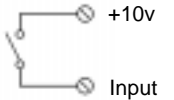


Caution: Exceeding 24 volts or 1/2 amp will damage the output transistor and is not covered under warranty. Therefore; be sure that a 24v load device does not measure less than 48 ohms or a 12v load device does not measure less than 24 ohms. Also be sure that the DC supply used for the loads is of a regulated type that will not exceed 24 volts unloaded. Avoid using switching power supplies that require a minimum load current.

Do not connect outputs together to increase current; the output signals are not synchronized. If more than 500 ma. of output current is required, an external high speed amplifier must be used (see Optional Equipment booklet). A standard solid state AC relay cannot be used as an amplifier due to their "zero cross switching" characteristics.

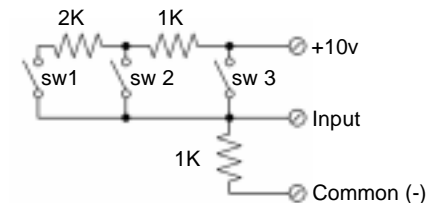
Using Switches

Analog inputs can also be used as digital inputs to detect a switch closure. Normally, no external resistor is required because each input is internally pulled down (biased toward common) with a 20k resistor. When the switch is open, the voltage of the input drops to zero. However, when you program the Check Input function, refrain from setting extreme thresholds such as 10 and 0. For example; set the threshold as "above 7 volts" to detect a closed switch and "below 3 volts" to detect an open switch.



Using Multiple Switches

Analog inputs have the ability to detect multiple switches when a "resistive ladder" is used. A specific voltage will occur based on which switch is closed. In this example;



Switch #1 will cause ~ 2.5 volts
 Switch #2 will cause ~ 5 volts.
 Switch #3 will cause ~ 10 volts.

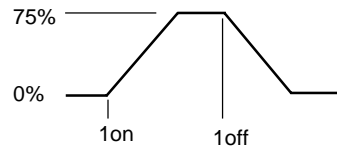
This arrangement can be used for applications where only one switch is closed at a time or when switch closure is always sequential. Such as switches located on a reciprocating slide. For example; #1, then #2, then #3, then #2, and #1. If switch #3 is closed, the other switches have no effect. Likewise; if switch #2 is closed, switch #1 has no effect.

Analog Examples

Ramping an Output

Analog outputs can be ramped up or down to a predetermined duty cycle using the Increase & Decrease options of the Output function. The Repeat lines function is used to determine the final duty cycle.

In this example; when input 1 is on, output 81 is ramped up to 75% duty cycle. When input 1 goes off, the output is ramped back down to 0%. The Wait functions are used to control the rate that the output changes. In this case it will take 7.5 seconds (75 x .1) to ramp up and 7.5 seconds to ramp down.



Example Program

- 10 Output 81, set to 0% *
- 11 Check Input 1- On
- 12 Output 81, Increase 1%
- 13 Wait 0.1 Sec.
- 14 Repeat from line 12- 75 times
- 15 Check Input 1- Off
- 16 Output 81, Decrease 1 %
- 17 Wait 0.1 Sec.
- 18 Repeat from line 16- 75 times

An output cannot be Increased above 100% duty cycle, or decreased below 0% duty cycle. In other words the output setting will not “wrap around” from 100% and begin incrementing from zero.

*Note: line 10 is used in this example only to assure that output 81 had begun at 0%, since the entire program is not shown.

Installation Programming Procedure

Once the I/O unit is installed, the pocket programmer must be informed that the system has been expanded. This is done using the Setup menu as described below. Note: If you added more than one I/O unit repeat the setup procedure for each block.

BEGIN A NEW PROGRAM?

Power up the programmer (by MCU or optional power pack) and enter the Main menu.

SETUP T6 OPTIONS?

At the Main menu choose “setup T6 options”, then press the Enter key.

SETUP MENU ADD I/O?

In the Setup menu choose “add I/O”, then press the Enter key.

ADD I/O WHICH ONE? 80

Select the Block number of the I/O section you have added. The Block number is printed on top of the unit. Once the proper block number is displayed, press the Enter key.

ADD I/O #80 ANALOG I/O?

Since this section is analog capable, choose “ANALOG I/O” then press the Enter key.

ADD I/O #80 # OF INPUTS? 5

Select the number of inputs that the I/O unit has (5), then press the Enter key.

ADD I/O #80 # OF OUTPUTS? 4

Select the number of outputs that the I/O unit has (4), then press the Enter key.

The Setup Menu will reappear. Press the Back key to return to the Main menu. The input and output selections of this block will now appear in the Program menu.

Programming the Analog I/O

After the analog section is successfully installed, some new selections will appear on the Program menu for inputs and outputs setup as being analog capable. These additional selections will appear when programming the following functions.

CHECK INPUT

Checks an input to make sure it meets the selected threshold voltage.

The selected analog input is checked to see if its voltage is above or below the threshold setting. When it is, the function is completed and the next line of the page is executed. If the input does not meet the selected threshold, the function can be set to move the page to a specific line number.

Selections for this function are:

1. Which input is to be checked (must be within analog section).
2. Whether the voltage should be Above or Below the threshold.
3. The threshold setting in full volts (0 to 10 volts). The voltage of the threshold in millivolts (.000 to .960) in .040 volt increments.
4. If the voltage of the input did not meet the threshold, what line should this page be moved to? (If you're only concerned about meeting the threshold, just press enter at the default selection of "NO").

CHECK OUTPUT

Checks an output to see if it's on or off.

This function can be used on an analog output the same way that it operates on a regular (digital) output. However, any analog output that is performing a duty cycle (no matter how low) is considered to be On.

COMPARE INPUTS

This function will not include selection of the analog inputs.

OUTPUT

Turns an output on, off, on for a period of time, or will set it to operate at a set duty cycle.

The selected analog output can be used the same way as a normal (digital) output by turning it on, off, or on for a selected amount of time. It can also perform analog options by setting the duty cycle of the output, causing a proportionate voltage across the load device. The analog choices include the ability to increase or decrease the duty cycle, allowing an output to be "ramped up and down". The Output function is completed and the next line of the page will begin. Once an output is set to a particular duty cycle, it will remain at that setting until the Output function is used to change it.

Selections for this function are:

1. Which output is to be controlled (must be within analog section).
2. Whether the output should:

Turn on - sets the output to be on at 100% duty cycle.

Turn off - sets the output to be on at 0% duty cycle.

Limit on time - sets the output to be on at 100% duty cycle, for a selected amount of time (select full seconds, then milliseconds).

Set to % - sets the output to a particular duty cycle (0 to 100%)

Increase % - adds to the current duty cycle of the output*.

Decrease % - lowers the current duty cycle of the output*.

* Note: When using the Increase or Decrease options, the duty cycle will change by the amount selected. For example: if the output is currently at 50% and the function increases it by 10%, the duty cycle will become 60%. The function can increase the output up to 100%, or decrease it to 0%.

CAUTION: When using the output function, be careful not to program the MCU so that it repetitively controls an output in the analog section (many times a second). This will cause an error in outputs that are performing a duty cycle, resulting in load voltage fluctuations. The amount of error is proportional to the number of times per second that outputs of the analog section are controlled by the MCU. If you need to repetitively control analog outputs, consider programming a line with the Wait function set for a tenth of a second. This will greatly reduce the amount of duty cycle error.