USER'S MANUAL

MODEL 205
PULSE WIDTH MODULATION CONTROLLER

DOCUMENT NO. 00215-15 REV -

Applied Processor and Measurement, Inc.

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Applied Processor and Measurement, Inc. is pleased to provide this high quality, feature rich, and value minded test equipment for use in your laboratory. We appreciate your business and look forward to serving you for many years to come with both the Pulse Width Modulation Controller and other future equipment, equally as innovative.

Applied Processor and Measurement, Inc. is committed to customer satisfaction and continuous improvement. We welcome your comments on the product and our services. Please use the contact forms on our website for comments on the product and on this manual.

Again, thank you for purchasing and using our product.

NOTICE

The information contained within this manual has been carefully checked and is believed to be accurate and up to date.

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REVISION HISTORY

Rev	Date	Pages	Description
-	3/14/2024	All	Initial Release

SAFETY SUMMARY

THE FOLLOWING GENERAL SAFETY PRECAUTIONS MUST BE OBSERVED DURING OPERATION AND INSTALLATION OF THIS PRODUCT. FAILURE TO COMPLY WITH THESE PRECAUTIONS AND WARNINGS HERE, AND ELSEWHERE IN THIS MANUAL VIOLATES THE SAFETY STANDARDS OF DESIGN, MANUFACTURE, AND INTENDED USE OF THIS PRODUCT. APPLIED PROCESSOR AND MEASUREMENT, INC. ASSUMES NO LIABILITY FOR THE FAILURE TO COMPLY WITH THE SAFETY RECOMMENDATIONS PROVIDED IN THIS MANUAL.

INTENDED USE

The Model 205 Pulse Width Modulation Controller is intended to be used in a laboratory / industrial environment. It is not intended for use in, or in conjunction with, any medical or life support appliances, devices, or systems. Applied Processor and Measurement, Inc. assumes no liability from the use of this design in this context.

Applied Processor and Measurement, Inc. does not assume any liability for the malfunction of electronic components contained in any of its products nor any damage incurred from the improper use of the product to the user, product, or any connecting equipment.

GROUND THE SYSTEM

Even though the Pulse Width Modulation Controller requires an external DC source, care should be taken that the total system is properly grounded. Use only power supplies that have three conductor AC power cable with the grounding wire properly connected to an electrical (safety) ground. This will minimize shock hazard.

DC POWER ONLY

The Pulse Width Modulation Controller requires an external DC source of 7V DC to 28V DC. Do not connect the Pulse Width Modulation Controller directly to 120 or 240 VAC.

DO NOT SERVICE THE UNIT

Do not attempt to service the unit. NEVER open the unit while it is operating. Do not attempt to substitute parts or modify the system internally.

1.0 Introduction

This manual describes the features, operating parameters, and operating procedures for the Model 205 Pulse Width Modulation Controller (PWM Controller, PWMC-205, or PWMC).

The Model 205 Pulse Width Modulation Controller generates a pulse width modulated variable frequency and duty cycle electrical switching signal. The product is used in many industrial situations where valves, solenoids, actuators, or other magnetic / mechanical elements are applied and / or tested.

The PWM Controller contains microcomputer-based circuitry and digital Field Programmable Gate Array technology which allows for precision generation of the output frequency and duty cycle. The microcomputer also provides digital control of the output parameters via the switches on the front panel. Using the switches and the integral LCD, the output frequency and duty cycle may be adjusted digitally, from 1 to 25,000 Hz with a resolution of 0.1% duty cycle.

The PWM Controller may also be controlled via an RS-232 port. Single letter ASCII based commands allow the frequency and duty cycle to be set and displayed. This capability allows the PWM Controller to be controlled by a host computer (e.g. a PC compatible) or PLC.

The PWM Controller output is an open drain power MOSFET output. This provides low side control of the load to be pulse width modulated. An external DC power source must be provided, which may be used to power both the load and the controller. This provides maximum flexibility since the load voltage can be set by the user using any variable bench-top power supply or it can derive power directly from the system under control (provided the controller is operated within the rated specifications).

An analog input control feature is also available for the PWM Controller. This input allows the user to control the output frequency and duty cycle with analog control signals, such as 0 to 5V or 0 to 20 mA across a 250 ohm load. An external control system (for example: a PC with data acquisition cards, a laptop PC with a PCMCIA data acquisition card, or a PLC) could provide analog outputs to the PWM Controller in order to control a PWM device. In this manner, the PWM Controller is a signal conditioning element for the host computer and/or control system.

Two analog signals representing the current output waveform and the average current output of the PWM output are available on the output connector.

The controller also provides a 5V level, PWM output signal for use in in low-drive applications.

The operation of the PWM Controller is highly configurable. User programmable configuration options are available to set the power-up state of the PWM Controller and its operational state with respect to analog input operation, output frequency range and the enabling and disabling of features.

1.1 Features

The following is a summary of the feature set of the Applied Processor and Measurement, Inc. Model 205 PWM Controller.

- user / computer adjustable pulse width modulated output square wave with the following characteristics:
  - 1 to 25,000 Hz operating frequency
  - 0 to 100 % duty cycle

- frequency adjustable as follows:
  - 1 to 1000 Hz in 1 Hz steps
  - 1000 to 10000 Hz in 50 Hz steps
  - 10000 to 25000 Hz in 100 Hz steps

- duty cycle adjustable in 0.1% steps

- duty cycle polarity control

- PWM output provides low side load control

- Power MOSFET output - PWM output sinks up to 4 amps (higher pulsed)

● internally fused output - standard mini-ATO fuse, easily replaced

● controller operates from same power source that powers the load - an external power source, 7V to 28V DC must be supplied

● input power reversal protection, circuitry protected by resettable polyfuse

● built-in user interface for adjustment of frequency and duty cycle (3 switches and LCD) allows precision digital control of the output parameters

● integral backlit LCD, 4 line by 20 character, displays current frequency, duty cycle, and mode of operation

● remote operation via RS-232 interface commands:
    set frequency and duty cycle
    readout current settings
    enable/disable output
    controller configuration

● analog input control, two modes of operation
    control frequency and duty cycle output with two analog inputs
    control duty cycle only with one analog input

● opto-isolated digital input, control to enable / disable PWM output

● analog voltage output waveform proportional to the PWM output current

● analog voltage output proportional to the average PWM output current

● 5V level, low-drive (25mA), PWM output

● pluggable terminal strip connections for easy connect/disconnect

● configurable operation via the pushbutton interface on power-up, during operation and via the RS-232 port – menu driven configuration available on PWMC power-up

● capability to disable analog input operation and pushbutton interface if not used

● high reliability circuit board construction, using surface mount technology

1.2 Differences Between Model 205 PWM Controller Versions

This is the fourth generation of the Model 205 PWM Controller. There are no major differences between the Model 205 version 4 and the version 3 controller in terms of PWM output operation and specifications. The main feature diffrerences are listed below:

Feature	Model 205 version 4	Model 205 revision 3
● Display	backlit, 4 line x 20 character	2 line x 16 character
● I/O connectors	pluggable terminal strips	binding posts, IDC header
● Output fuse	mini-ATO	3AG, glass
● Analog outputs	current waveform, average current	none
● Digital output	5V level PWM output	none

The version 3 controller was availble between 2007 and 2021. Prior to 2007, version 2.x and 1.x controllers were available. The list of differences between version 3.x and version 1.x and 2.x controllers are below and are kept in this document for reference (for customers with 2.x or 1.x controllers).

Differences between the Model 205 revision 4.x and 3.x and older Model 205 versions:

● Frequency of Operation: The PWMC-205 software revision 4.x and 3.x provides for operation of the standard Model 205 PWM Controller up to 25,000 Hz. The primary operational frequency range differences between revisions 4.x, 3.x, 2.x and 1.x may be summarized as follows:

revision 4.x,3.x	1 to 1000 Hz, 1 Hz steps
revision 4.x,3.x	1000 to 10000 Hz, 50 Hz steps
revision 4.x,3.x	10000 to 25000 Hz, 100 Hz steps
revision 2.21	1 to 250 Hz, 1 Hz steps
revision 2.21	2 to 500 Hz, 2 Hz steps
revision 2.21	50 to 2500 Hz, 50 Hz steps
revision 2.0,2.1	1 to 250 Hz, 1 Hz steps
revision 2.0,2.1	2 to 500 Hz, 2 Hz steps
revision 1.x	1 to 200 Hz, 1 Hz steps
revision 1.x	2 to 400 Hz, 2 Hz steps

Additionally, it is no longer necessary to set the frequency range of operation of the PWM Controller for pushbutton interface control and RS-232 control. The frequency may be set to any value from 1 to 25000, the PWM Controller software will coerce to the nearest frequency step based on the ranges given above. The 'G' command is now used to set analog input control ranges.

● Duty Cycle of Operation: The PWM Controller has been enhanced to provide for 0.1% duty cycle resolution operation in all operational modes.

● Analog Input Control: Analog input control still requires range setting, however, additional ranges are supplied (see section 4.4 of this document) and the capability to control to higher duty cycle resolution is also provided. Duty cycle resolution via the analog input is settable to 1.0%, 0.5%, 0.2% and 0.1%. Also, the analog input port is now controlled by a 0 to 5V analog input. Finally, version 1.x and 2.x range setting and control compatibility is also provided in order to maintain backward compatibility. A new Model 205 can be configured and applied to the same test set up as any previous version (Model 205 or Model 200-01).

● Analog Input Control Options now available: The Model 205 PWM Controller may now be ordered with fully differential analog input ports. This eliminates ground loops in PLC and PC control system applications. The analog inputs may also be ordered for 5V or 10V input capability. Contact APM, Inc. for order numbers.

● External Enable Input: The analog input connector provides an optically isolated digital input to enable or disable the PWM output. This feature is configurable so that this function may be used or disabled.

The Model 205 PWM Controller may be operated in the same manner as the previous Model 205 and the Model 200-01. All remote commands, analog input operation, and the pushbutton interface are completely compatible. No changes are required for systems in place using the V2.x Model 205 or the V1.x Model 200-01 in either remote operation, or analog input operation when transitioning to the new version 3.x Model 205 or the version 4.x Model 205.

1.3 Applications

The Model 205 PWM Controller was specifically designed for product development activities, and, durability and validation testing of electromechanical devices requiring a PWM control signal (solenoids, solenoid valves, solenoid valve flow control, pumps, actuators, relays, clutches, LED modules, etc.). The PWM Controller may also be used to provide a PWM signal for driving PWM inputs on modules such as HVA/C Blower Fans, motor speed inputs, etc.

The PWM Controller may also serve as a signal conditioning element for computer control systems since it may be commanded by either analog signals or an RS-232 command.

Contact Applied Processor and Measurement, Inc. for applications assistance and regarding variations or customizations of the Model 205.

2.0 Specifications

Parameter	Description	Rating
Output Power	Open Drain Power MOSFET	Pd max = 50 watts at 25˚C
Output Current	Output Current, 100% duty cycle Power must not exceed maximum MOSFET Pd	4A maximum up to 6A pulsed
Output Voltage	Single power supply configuration (voltage within range of PWM controller PWR+/PWR- input) Dual power supply configuration (voltages not within PWM Controller PWM+/PWR- Input range)	7V minimum 28V maximum 5V minimum 32V maximum

Parameter	Description	Rating
Frequency	1 to 1000 Hz adjustable in 1Hz steps 1000 to 10000 Hz adjustable in 50 Hz steps 10000 to 25000 Hz adjustable in 100 Hz steps	max error < +/- 0.02 Hz for 1 Hz <= frequency <= 500 Hz max error < +/- 0.1 Hz for 500 Hz <= frequency <= 1000 Hz max error < +/- 10.0 Hz for 1000 Hz <= frequency <= 10000 Hz max error < +/- 50.0 Hz for 10000 Hz <= frequency <= 25000 Hz
Duty Cycle	0 to 100 %, adjustable in 0.1% steps	max error < +/- 0.01% duty over 1 Hz <= frequency <= 100 Hz max error < +/- 0.02% duty over 100 Hz <= frequency <= 1000 Hz max error < +/- 0.05% duty over 1000 Hz <= frequency <= 5000 Hz max error < +/- 0.5% duty over 10000 Hz <= frequency <= 25000 Hz
Frequency Source	Crystal Oscillator Circuit	40.0000 MHz 50 ppm stability
Input Power	7V to 28V DC, regulated or un-regulated external source. Dual supply required for operating loads outside this range.	35 mA (typical)
Operating Temp.	PWMC-205 Controller with display board (backlit LCD and switches) PWMC-205 Controller, main board only	-20 °C to 70 °C -40 °C to 85 °C

Parameter	Description	Rating
Analog Control	PWM Parameter Control Input Accuracy, Voltage Measurement	+/- 10 mV
Analog Inputs	Absolute Maximum Input Voltage Model 205, standard 5V input Model 205, 10V input option	 5.25 V 10.25V
Digital Input	Maximum Input Voltage for Output Enable Minimum Input Voltage for Output Enable Maximum Current (internal 1.65K ohm resistor)	24V 5V 15mA
Analog Outputs Filtered and Unfiltered Current Outputs	Output Voltage Transfer Function – Waveform and Average Outputs Note: Waveform Output operates over entire frequency range of the PWM output (1Hz to 25,000Hz) whereas the average voltage output is designed for operation at greater than 400Hz PWM frequencies. This is also dependent on the load inductance.	0.5V / 1A into 5KΩ load
Digital Output	Voltage Level Maximum Current	0V to 5V 15mA
RS-232	TX, RX, GND, 9600 baud, no parity, 8 data bits, 1 stop bit, DB9-M	
Size	8.66 in. x 4.33 in. x 1.76 in. height	
Display	4 Line x 20 Character Liquid Crystal with LED Backlight	

3.0 Installation

WARNING

FOLLOW THE INSTALLATION INSTRUCTIONS CAREFULLY TO AVOID POSSIBLE DAMAGE TO THE PWM CONTROLLER, TO YOUR LOAD DEVICE OR SYSTEM UNDER CONTROL. REMEMBER TO PROPERLY SELECT ALL WIRE SIZES FROM THE POWER SOURCE TO THE PWM CONTROLLER OUTPUT AND TO THE DEVICE UNDER CONTROL IN ORDER TO MINIMIZE HAZARDS AND TO PROVIDE A SUITABLE RETURN PATH FOR INDUCTIVE LOADS.

This section provides installation instructions and figures which illustrate typical connections for the PWM Controller and the device to be controlled. The table below describes the PWM Controller power input and PWM output connections.

The Model 205 has a 4 pin pluggable terminal block (TE Connectivity part number 284507-4 or equivalent) on the lower center of the controller unit for power and PWM output signal connections.

Signal	Description
PWR +	Input power positive terminal, 7 to 28 VDC
PWR -	Input power negative terminal, serves as controller ground (GND)
PWM OUT +	Voltage output to device / load
PWM OUT -	Open-Drain MOSFET output to device / load Note: the output is switched between open and GND

Table 3.0-1 Power Input and PWM Output Connections

Figure 3.0-1 illustrates the low-side drive connection of the PWM Controller to a single device using a single power supply. The power supply sources current for both the PWM Controller and the device under control.

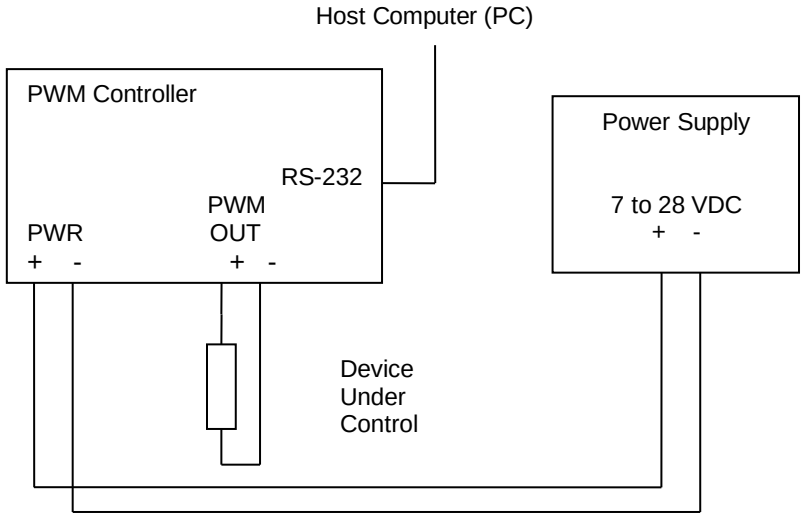


Figure 3.0-1 PWM Controller - Single Supply Connection.

NOTE: in the version 4 controller, the connection from PWR+ and PWM OUT+ is no longer necessary. An internal connection from PWR+ to PWM OUT+ is present such that the controller is able to provide a current output waveform and average current measurement. If an external connection is added from PWR+ to PWM OUT+ (as in version 3.x or older PWM Controllers), there will be no damage or effect on the PWM output. If the external connection is present, the current sensing outputs will not operate. **See Section 3.2 for further information.**

Figure 3.0-2 shows the recommended connection for a dual power supply connection. This configuration would be used for a load that is under test whose operational voltage is not in the PWM Controller operating range of 7V to 28V DC. The PWM Controller must be supplied 7V to 28V DC for its operating power. The output of the unit may operate at any voltage from 5V to 42V (within the recommended power specifications – see Section 2).

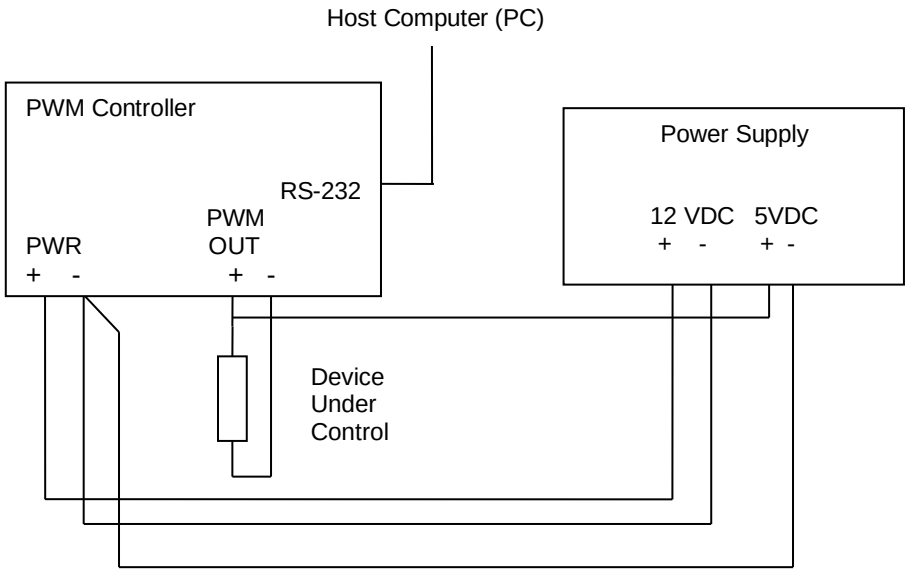


Figure 3.0-2 PWM Controller - Dual Supply Connection (see note).

In the dual supply configuration example above, the power supply has a +12 V and a +5 V output. Only 35 mA of 12V power is required to supply the PWM Controller whereas the +5V supply must be rated to accept the load under control. Note that the power supply negative output (- terminal) is commoned at the PWM Controller. This connection must be made if the power supply outputs are isolated. Some laboratory power supplies may have one common ground for +12V, -12V, and +5V outputs that are produced from the same supply, and this connection may not be required. Consult the manual from the power supply that you are using in this application to check if it is required to common the negative terminals externally. Additionally, applying the common connection at the PWM controller will assist in providing a return path for the power being "dumped" by the load when switching. This will help to keep the power for the PWM Controller cleaner especially when the power supply is a greater distance from the load and the PWM controller.

IMPORTANT NOTE: in the dual supply configuration, the connection from PWR+ and PWM OUT+ **IS** necessary. In this case, the controller internal connection **MUST** be removed. Open the back of the unit to remove the wire jumper on the terminal block on J11. In this case, the current sensing outputs will no longer be available. **See Section 3.2 for further information.**

IMPORTANT NOTE: in the dual supply configuration the power supply connection for the output load must not exceed 32V DC. The limitation is the output fuse and holder (automotive mini-ATO style). APM, Inc. can supply a PWM Controller option with up to 50V dual supply capability such that the internal connection may be maintained, the current sensing outputs will be available and the output load will operate up to 50V DC. Contact APM, Inc for further information.

For controller applications with less than 7V loads, the dual supply configuration must be used, the internal connection at J11 must be removed and the current sensing outputs will not be available.

Figure 3-0.3 illustrates another variation of the dual supply configuration. Any 12V source, even an inexpensive unregulated AC to DC adapter, may be used for the PWM Controller power. In this case, the load power is obtained from an external power supply or an external source where the device under control is applied. Note that the common connection at the PWM Controller is still required. This is the recommended configuration for applications requiring dual supply connections.

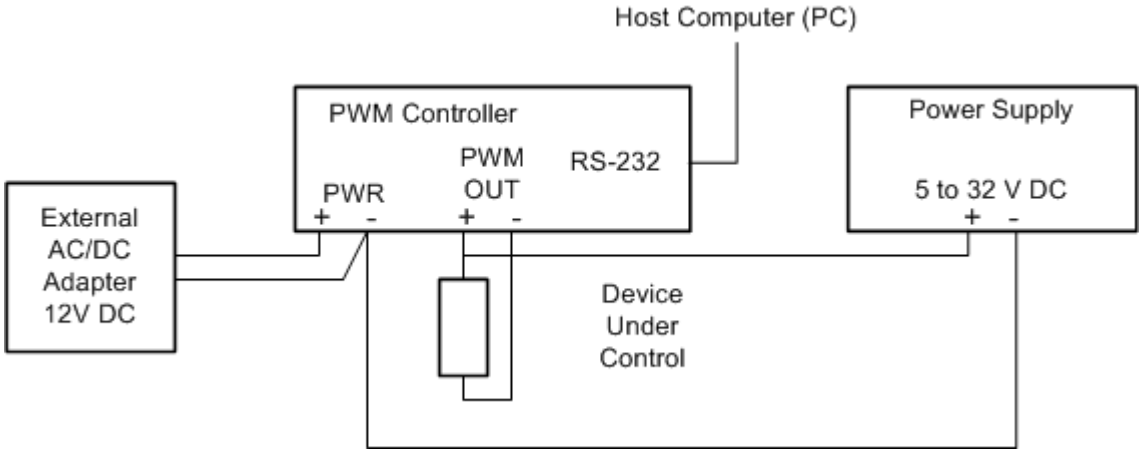


Figure 3.0-3 PWM Controller - Dual Supply Connection, Additional Example.

IMPORTANT NOTE: in the dual supply configuration, the connection from PWR+ and PWM OUT+ **IS** necessary. In this case, the controller internal connection **MUST** be removed. Open the back of the unit to remove the wire jumper on the terminal block on J11. In this case, the current sensing outputs will no longer be available. **See Section 3.2 for further information.**

Multiple loads may be tested using the PWM Controller. An example is shown in figure 3.0-4. Figure 3.0-4 illustrates the connection for controlling 3 loads with the PWM Controller. Any number of loads could be controlled provided that the total current of these devices is less than the maximum ratings defined in the PWM Controller specifications in Section 2.

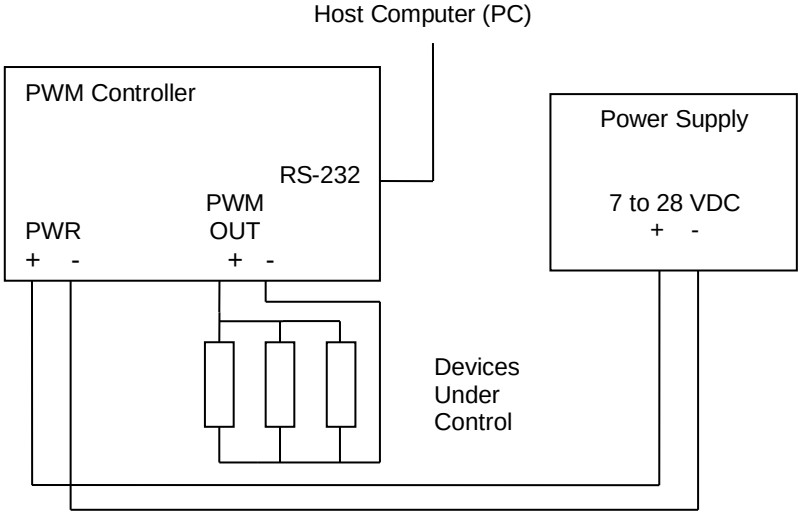


Figure 3.0-4 PWM Controller - Testing Multiple Loads.

The PWM Controller may also be used to simply supply a variable frequency and duty cycle square wave signal for a controller input. One example of this would be to connect the PWM output to a device that is driven or controlled by a PWM signal such as an HVA/C Blower Fan module or a pump speed control input.

For transmitting applications (applications where the PWM duty cycle commands a module of some type) the PWM Controller can be wired to supply an output signal (as opposed to driving a high current consuming load). Since the PWM Controller has an open drain MOSFET output, a load of some type is required to generate an output signal. A resistor at the output terminals is sufficient. The figures below show how to connect the PWM Controller as a signal generator. There are two configurations shown, depending on the configuration of signal destination (internal pull-up or not). To use the PWM Controller as a signal generator, connect the unit as shown in figure 3.0-5 or 3.0-6 for equipment with an internal pull-up.

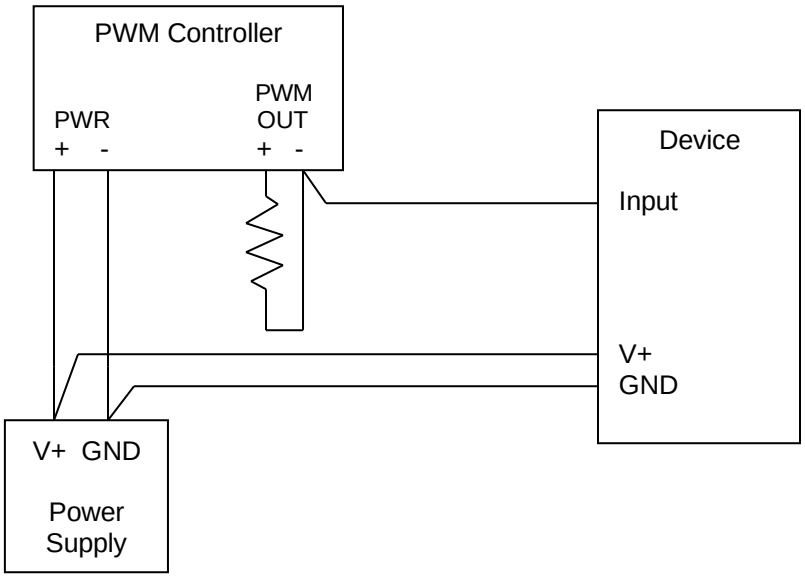


Figure 3.0-5 PWM Controller – Connecting as a Signal Generator with an added pullup resistor.

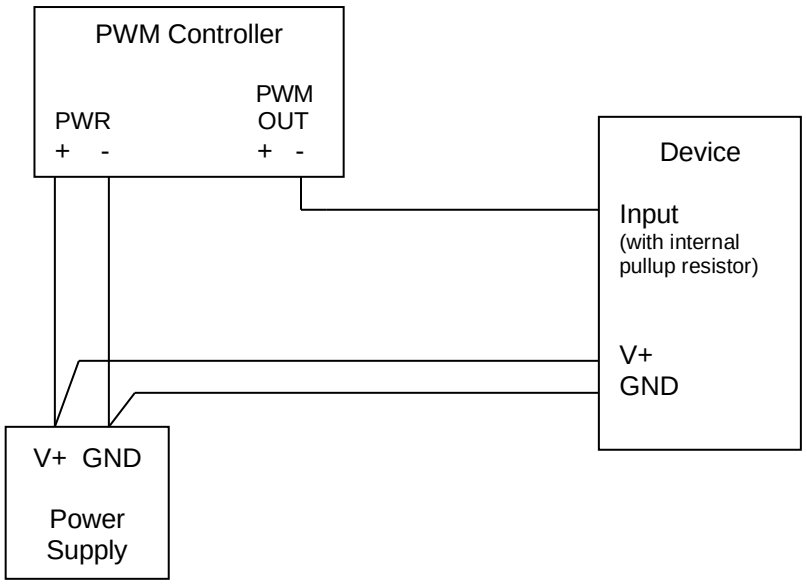


Figure 3.0-6 PWM Controller – Connecting as a Signal Generator - device contains internal pull-up.

Note that with respect to the PWM Controller, a 100% duty cycle means that the MOSFET output is on and the voltage at the device input will be 0V. At 0%, the output will be floating, or pulled up to V+ by the internal or external resistor. This 'inversion' may be compensated for in the Model 205 by using the Polarity setting function.

Finally, V+ can be any voltage within the range of the PWM Controller input voltage requirements (7 to 28V).

Note that the signal generation configuration may also be used to supply a signal which drives the gate of a higher power rated (voltage and / or current) MOSFET or a high amperage power module. This configuration allows the current and voltage ratings of the PWM Controller to be extended to any rating based on the external components available. Remember that adding another N-type MOSFET or power module in the circuit adds another level of inversion. Use the polarity function built-in to the PWM Controller to account for the desired signal level.

Finally, note that the version 4 PWM Controller has a 5V, low-drive push-pull digital output available for use as a PWM command signal. Refer to section 3.5 for further information.

Please contact APM, Inc. for more information and applications on using the PWM Controller as a signal generator / signal conditioner for control system inputs.

3.1 Fusing

WARNING

BE SURE TO FUSE THE PWM CONTROLLER PROPERLY IN ORDER TO AVOID POSSIBLE DAMAGE TO THE PWM CONTROLLER, TO YOUR LOAD DEVICE OR SYSTEM UNDER CONTROL. WHEN CHANGING THE FUSE, OR REMOVING THE BACK COVER, BE SURE THAT THE PWM CONTROLLER IS NOT CONNECTED TO ANY POWER SOURCE.

The PWM Controller contains an internal fuse for device / load protection and for the PWM Controller output MOSFET electronics itself. The input fuse is connected in series with the load and the output Power MOSFET (see the PWM Controller Block Diagram in figure 4.1-1 for details on the fuse connection) therefore the fuse will protect both the PWM output drive circuitry as well as the device / load under test.

The fuse holder is provided on the back of the PWM controller main circuit board (labeled F2). To replace the fuse in the unit, remove the back cover. Note that the circuit board need not be removed from the top of the enclosure, the fuse is completely accessible from the back of the unit by simply removing the back cover. The PWM Controller contains static sensitive circuitry, be sure to handle the unit so as to avoid touching the circuitry on the circuit board and pins on the back of the circuit board. The fuse is a standard mini-ATO style fuse. A mini-ATO type, 4 Amp fuse is installed in the unit from the factory (Littelfuse part number 297004.WXNV). Be sure to fuse the PWM Controller properly based on the current draw of the device / load under test. Also note that the mini-ATO style fuse and holder are rated up to a maximum of 32V DC.

Based on the power dissipation of the internal power MOSFET and the circuit board design in the Model 205 unit, a 4A fuse is suitable for most applications. Peak currents of relatively short durations (10's to 100's of msec) may exceed the 4A rating without blowing the fuse, damaging the output MOSFET, or damaging the circuit board. Note the plug connector on the output is rated at a maximum of 10A.

3.2 Jumpers for Internal Diode and Model 205 Current Measurement

The PWM Controller has 3 jumpers for connections for an internal inductive kickback diode, internally connecting the input power (PWR+) to the output power (PWM OUT+) and connections for the current sense resistor with respect to the kickback diode. A block diagram of the output circuit with the jumper locations is shown in figure 3.2-1.

Be sure that before any modifications are applied to the internal jumpers in the Model 205 that the unit is not connected to power (DC power input is disconnected). To change the jumper configurations, remove the back cover of the Model 205. The shunt type shorting jumpers and a wire jumper header is located at the bottom of the unit on the main circuit board. Note that the circuit board need not be removed from the top of the enclosure, the jumpers are completely accessible from the back of the unit by simply removing the back cover. Be sure to ground yourself before touching the circuit board (ESD, static discharge precaution).

Explanations on the jumpers and their functions follow in the paragraphs below.

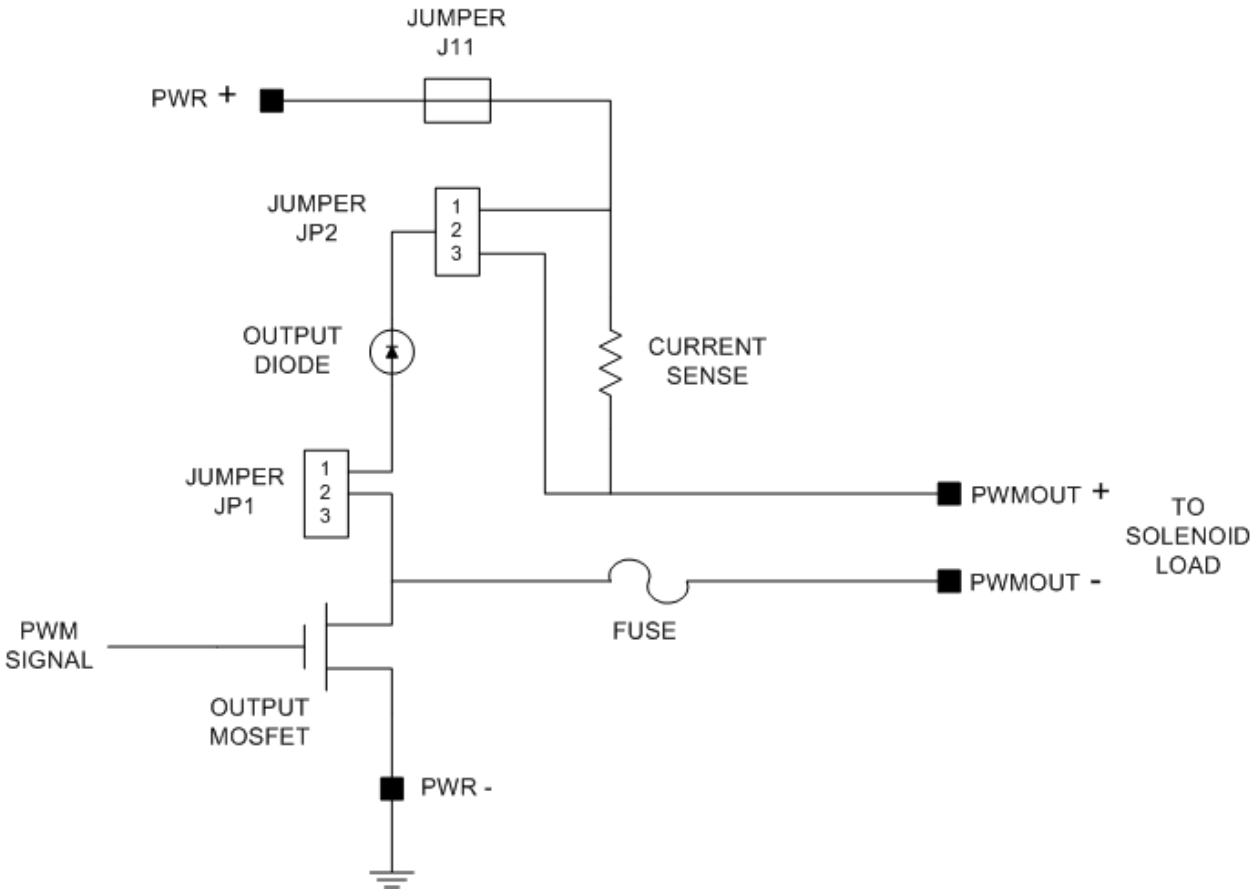


Figure 3.2-1 – PWM Controller Output Block Diagram.

3.2.1 Internal Kickback Protection Diode

The PWM Controller possesses an internal S2BA-13 diode across the output terminals to suppress inductive current kick-back from the load under test. The S2BA-13 is a general purpose diode (similar to the 1N4001) and suits most needs when working with inductive loads such as valve solenoids and relays. If your application uses another type of diode, the internal diode may be easily removed from the circuit and your diode may be installed on the PWM Controller externally, across the + and - output connections (attach cathode to +, anode to -).

To remove the internal diode from the output circuit remove the jumper JP1. The default jumper setting is to use the Model 205 internal diode with the jumper at JP1 across pins 1 and 2.

Note that a fast turnoff diode configuration option is available for the Model 205. Contact APM, Inc. for purchase of the Model 205 with this option.

3.2.2 Internal Connection from Power Input + to PWM Output +

The PWM Controller possesses and internal connection which connects the input power (PWR+) to the PWM output (PWM OUT+). The purpose of this is connection is to allow for the operation of PWM output average voltage and current waveform voltage analog outputs.

To operate with this internal connection, the input voltage (PWR +/-) must be in the range of 7V to 28V DC using a single supply connection configuration as shown in section 3.0 above.

To operate using a dual supply configuration (figures 3.0-2 or 3.0-3) above, the internal connection **MUST BE REMOVED**.

The internal connection is made with a 20AWG wire at the terminal block at J11. J11 is accessible by removing the back cover. The wire at J11 may be removed by loosening the screws on the terminal block and removing the wire.

Note that when removing this connection the analog voltage outputs for average current and waveform current will not be available for use as well as any average current output display.

The default configuration for the J11 jumper is that the wire jumper is installed.

Note that a high voltage operation option (up to 50V) is available for the Model 205. Contact APM, Inc. for purchase of the Model 205 with this option.

3.2.3 Internal Current Sensing

The Model 205 contains circuitry to measure the PWM output current to the load. Two signals are provided on the Signal Outputs terminal block: a voltage representing the average current output and a voltage representing the instantaneous current to the load (waveform). The current is converted to a voltage using a 0.025Ω non-inductive sense resistor.

Jumper JP2 selects the position of the current sense resistor with respect to the internal diode. Jumper position JP2 pins 1-2 puts the sense resistor and the diode in parallel (recirculating current), position JP2 pins 2-3 places the sense resistor in series with the input power to the diode and output load.

The default jumper setting is to use the Model 205 internal diode with the jumper at JP2 across pins 1 and 2.

Note that changing this jumper setting may change the transfer function of the current to voltage on the analog outputs.

3.3 RS-232 Connections

The PWM Controller possesses an RS-232 port for remote operation capability. The RS-232 port is available on the PWM Controller from the DB-9 connector on the upper right corner of the unit. The pinout of the DB-9 is provided in table 3.3-1. Pins not shown in the table are not connected internally within the PWM Controller.

DB-9 Pin Number	Signal
2	Transmit Data (TXD)
3	Receive Data (RXD)
5	GND

Table 3.3-1. DB-9 RS-232 Remote Port Pinout.

To connect a host computer, control system or PC to the PWM Controller, use a cable wired as defined in table 3.3-2. This table provides connections to standard RS-232 connectors for PC's or USB/RS232 DB-9 style converters. Both 9 pin and 25 pin pinout versions are shown. Note that for a PC with a DB-9, a straight through cable may be used. Consult your PC or equipment manual for proper RS-232 pinout.

PWM Controller Signal	PWM Controller DB-9 Pin	PC Signal	DB-9 Pin	DB-25 Pin
TXD	2	RXD	2	3
RXD	3	TXD	3	2
GND	5	GND	5	7

Table 3.3-2. RS-232 Cable Wiring.

The remote port communication parameters are set for the following:

Baud Rate:	9600 bps
Parity:	none
Data Bits:	8
Stop Bits:	1
Flow Control:	none.

WARNING

Note that the Model 205 RS232 port is not isolated from the controller input ground (the Model 205 GND pin is common to the PWR IN– terminal). A PC typically has signal ground connected to the chassis ground. This can potentially create a ground loop between the power source and the PC through the Model 205 which may damage the serial port or PCB traces on the Model 205.

A ground may be avoided by:

- ensuring that the PC and the power supply to the Model 205 are on the same electrical circuit
- using a commercially available RS232 isolator module.

If an RS232 isolator module is used note that a port powered module cannot be used as the Model 205 only has TX and RX pins connected. Most modules require additional pins from which to create sufficient power for the isolator module.

3.4 Analog Input Connections

WARNING

CONSULT THE SPECIFICATIONS FOR SIGNAL LIMITS ON THE ANALOG INPUT PORT. ALTHOUGH THE PWM CONTROLLER ANALOG INPUTS ARE PROTECTED, APPLYING VOLTAGES TO THESE INPUTS BEYOND THE RATINGS SPECIFIED MAY DAMAGE THE PWM CONTROLLER.

Analog input control allows control of the PWM output frequency and duty cycle, or, duty cycle only from the analog input port on the upper left side of the unit. The pinout of this port is shown in table 3.4-1. The port pins are connected via a standard, commercially available, 8 pin terminal block plug (TE Connectivity part number 284507-8 or equivalent). If analog input mode for PWM control is not required for your application, the analog input function can be disabled when configuring the unit.

Pin Number	Signal Model PWMC-205	Signal Model PWMC-205-DF only (Differential Analog Inputs)
1	Frequency Control	Frequency Control +
2	Duty Cycle Control	Frequency Control -
3	No Connection	Duty Cycle Control +
4	No Connection	Duty Cycle Control -
5	5V Output (25mA maximum)	5V Output (25mA maximum)
6	GND (common to PWR- input terminal)	GND (common to PWR- input terminal)
7	Digital Input +	Digital Input +
8	Digital Input -	Digital Input -

Table 3.4-1. Analog Input Port Pinout.

Operation using the Analog Input for control of the PWM Output Frequency and Duty Cycle is described in the Operation section of this manual, section 4.4.

Standard Model 205 PWM Controllers provide frequency and duty cycle adjust single-ended 0 to 5V analog inputs where the reference input is the controller ground, shared on pin 4. **NOTE:** a system ground loop in a single-ended connection configuration may damage the Model 205 analog input.

Model 205 PWM Controllers with the '-DF' option have 0 to 5V differential inputs for the analog inputs. The inputs are fully differential so as to protect against ground loops in control system / PLC applications. Neither '-' input is connected together internally, and, the '-' input is not connected to the controller ground. The differential input option removes the possibility of any system ground loops through the Model 205.

Operation using the Digital Input for control of the PWM Output (enable or disable) is described in the Operation section of this manual, section 4.3.3. Note that the Digital Input is optically isolated from any of the controller signals including power and ground. The input is polarized and allows for a 5 to 24V DC input which contains a series resistor to limit input current to the opto-isolator LED.

5V is available on the analog port for peripheral electronics. A potentiometer may be powered by this 5V output to control the frequency and duty cycle inputs. Do not exceed 25mA at 5V.

3.5 Signal Outputs

The Model 205 has a 6 pin pluggable terminal block (TE Connectivity part number 284507-6 or equivalent) on the lower right of the controller unit for output signal connections. Connections are as per the table below.

Pin Number	Signal	Notes
1	5V PWM Output	Low level 5V signal PWM Output (25 mA max)
2	GND	common with PWR- terminal
3	Average Current	(DC) Voltage Output Proportional to Average PWM Output Current
4	GND	common with PWR- terminal
5	Unfiltered Current Waveform	Voltage Output Waveform of PWM Output Current
6	GND	common with PWR- terminal

Table 3.5-1. Signal Output Port Pinout

The average current output and unfiltered current output voltage are scaled to provide approximately 0.5V per 1A output. The maximum output range is 4A.

Note that the average current output provides a DC average of the PWM output current. The output is intended for high frequency PWM operation (>400Hz). Frequencies below 400Hz, loads with low current (<50mA), or signal driving applications only will not provide a usable DC average signal output.

4.0 Operation

This section describes operation of the PWM Controller. All operational modes are described: pushbutton interface (front panel), remote (RS-232), analog input control, and digital input control.

4.1 Theory of Operation

All operations of the PWM Controller, including the generation of the pulse width modulated output signal, are controlled by a highly integrated microcomputer based design. A simplified block diagram of the PWM Controller is shown in figure 4.1-1.

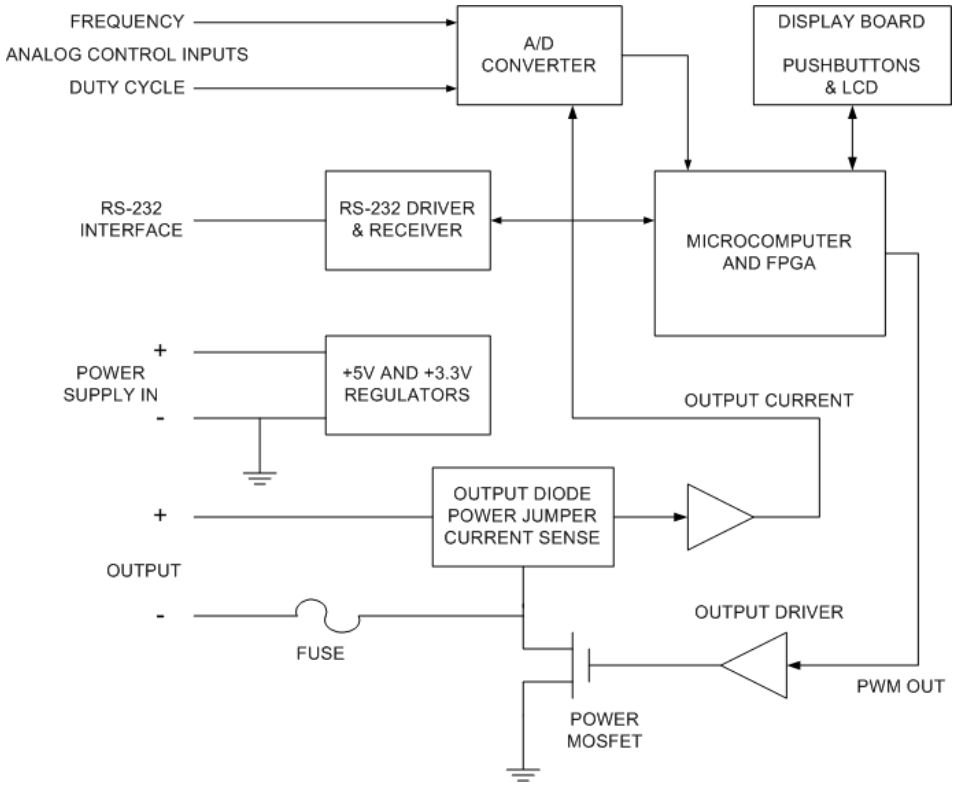


Figure 4.1-1 PWM Controller - Block Diagram.

The PWM Controller output timing is based on a crystal oscillator which drives PWM counter resources internal to the Field Programmable Gate Array (FPGA) logic. Since the PWM is hardware based, high accuracy is obtained over a wide range of frequencies and with a high resolution of the duty cycle. The user enters the output parameters into the PWM Controller via the RS-232 port or the pushbutton / LCD interface. The microcontroller calculates signal timings based on these parameters and loads the FPGA PWM counters. Note that changes to the frequency and duty cycle are updated on a cycle by cycle basis, allowing the current PWM pulse period to complete its cycle before changing. A power MOSFET output transistor provides an open drain current sink for the device under control. This MOSFET output stage is fuse protected to prevent damage to the MOSFET and / or the output load being driven. The PWM Controller includes an internal diode for suppressing back currents from inductive loads. This diode may be removed from the circuit by removing a jumper in order to easily accommodate user diode configurations (other than a S2BA-13). The output stage also possesses a current measurement circuit which allows for the Model 205 to provide voltage outputs proportional to the instantaneous PWM output current (waveform) and an average current output.

The PWM Controller analog input control capability is provided by an on board A/D converter IC. This 12-bit converter produces a digital representation of the frequency and duty cycle control inputs. The microcomputer scales the digital representation in order to produce the proper frequency and duty cycle ranges.

4.1.1 Polarity

Note the open drain output configuration with respect to the control of the load, shown in the block diagram in figure 4.1-1. When the digital output of the internal microcontroller is logic low, the MOSFET is off and the device / load receives no current. When the microcontroller bit is high, the MOSFET is turned on, allowing current to pass through the load to ground. The PWM Controller actuates the load in this manner using the MOSFET as a low side control element and is referred to in this manual as “low polarity” or “low-side drive”.

Operational capabilities within the PWM Controller include the ability to set the PWM Output polarity to either low or high. Observing the voltage from the negative terminal of the control output to ground, when the load is energized, the voltage measured will be zero. Conversely, when the load is not energized, the supply voltage will be measured across the output. This signal state and the action of the load in this manner occurs when the polarity of the PWM Controller is set to low. Setting the polarity to high will reverse the action of the PWM Output.

Consider the signal shown in figure 4.1.1-1. The figure illustrates a 10 Hz PWM signal. Using the above discussion of polarity, the signal shown represents an 80% duty cycle PWM signal with low polarity, or, 20% duty cycle at high polarity. When setting the PWM Controller to a specific duty cycle, consider the polarity setting and the effect on the load / device under control.

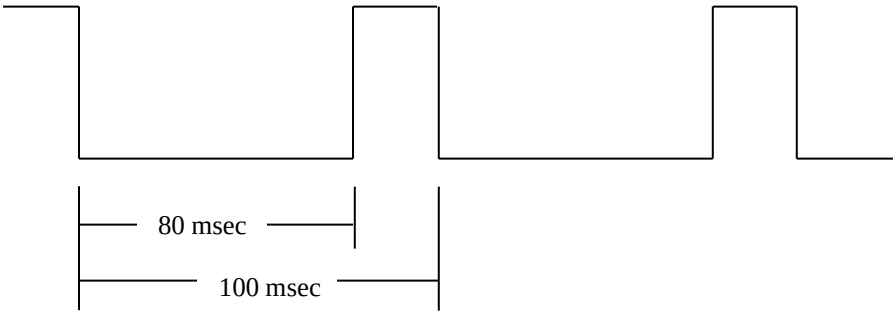


Figure 4.1.1-1 PWM Controller - Polarity Example.

4.2 PWM Controller Operation - Operational Modes

The PWM Controller operates in one of four modes: Run or Manual (Man), Analog Input Control of both Frequency and Duty Cycle (Ain), Analog Input Control of the Duty Cycle only (Adt), or Off. This is displayed as a three letter “code” by the status field on the LCD. The characteristics of the four modes are as follows:

Run / Manual (Man):

The PWM Output is operational: output frequency, duty cycle, and duty cycle polarity are displayed, and the output is operating at these settings. Both the front panel interface pushbuttons (if enabled) and the remote port are active and ready to accept commands. Changes requested by either interface shall be translated to the output and to the LCD immediately.

Analog Control of Duty Cycle (Adt):

The PWM Output is operational: output frequency, duty cycle, and duty cycle polarity are displayed, and the output is operating at these settings. Only the PWM output duty cycle is controlled by an analog input. See section 4.4 for details on the analog input voltage translation to duty cycle. In Adt mode, the front panel pushbuttons and the remote port (RS-232) control of frequency and duty cycle are disabled. Changes may be made to the duty cycle polarity and the mode of operation from either the pushbuttons or the remote port.

Analog Control of Frequency and Duty Cycle (Ain):

The PWM Output is operational: output frequency, duty cycle, and duty cycle polarity are displayed, and the output is operating at these settings. The PWM output frequency and duty cycle are controlled by the analog inputs. See section 4.4 for details on the analog input voltage translation to frequency and duty cycle. In Ain mode, the front panel pushbuttons and the remote port (RS-232) control of frequency and duty cycle are disabled. Changes may be made to the duty cycle polarity and the mode of operation from either the pushbuttons or the remote port.

Off (Off):

The PWM Output is disabled: the values of the frequency, duty cycle, and duty cycle polarity are displayed and are controlled by either the pushbuttons or the remote port (RS-232) or the analog inputs. However, these values are not translated to the output until the Man, Adt or Ain modes are enabled. The output state is set in accordance with the current polarity setting.

Note that when the Analog Input modes are not to be used, they may be disabled through configuration of the PWM Controller. In this case, only the Manual and Off modes will be available on the LCD / pushbutton interface, and via the remote interface.

4.2.1 PWM Controller Operation – Frequency Setting

The PWM Controller is able to operate from 1 to 25000 Hz. The resolution of the setting is controlled as follows:

1 to 1000 Hz in 1 Hz steps
1000 to 10000 Hz in 50 Hz steps
10000 to 25000 Hz in 100 Hz steps

The LCD / pushbutton interface or the remote port (serial port) interface will automatically coerce the value to the nearest capable setting.

Analog input resolution settings are configured separately. See section 4.4 for information on analog input control of the operating frequency.

4.3 PWM Controller Operation

4.3.1 Front Panel Interface

The PWM Controller is equipped with a front panel interface which possesses three pushbuttons for control of the PWM Output and a 4 line by 20 character backlit Liquid Crystal Display (LCD) for display of the output parameters. This section describes how to operate the PWM Controller using the front panel interface.

The PWM Controller may also be controlled using the remote port (RS-232) interface. The remote port may be used in conjunction with a PC running a terminal emulator or a custom program. All the operational capabilities of the front panel interface are available via the remote port as well. See section 4.3.2 for details on operation using the remote port.

There are three pushbuttons on the front panel interface for use in operating the PWM Controller, they are labeled: UP, DOWN and SELECT. Their function is defined as follows:

UP	- will change value by incrementing
DOWN	- will change value by decrementing
SELECT	- selects field on the display that UP or DOWN will operate on (moves cursor).

The PWM Controller front panel interface uses a 4 line by 20 character backlit alphanumeric LCD for adjustment and display of the PWM Output parameters.

When the PWM Controller is powered on, a sign on message will be displayed on the LCD. The sign-on message reports the PWM Controller Model Number, the software version, the serial number of the unit and any installed software features (see the APM, Inc. website for information on available software options). During sign on, the output will be placed in the non-engaged state based on the configured polarity setting of the unit. After sign-on, the PWM Output will begin operating at the configured settings (see section 4.6 on Configuration). After the sign on message is complete, the LCD shall display the operational screen. The main operational screen for default factory configuration is shown below, with the cursor located at the Stat field:

```
        APM PWMC-205
Freq=00001
Duty=  0.0 L
Stat=Off
```

To change any value displayed on the LCD (except the digital input control state which reports only), use the SELECT pushbutton to locate the cursor on the field to be changed, then, use the UP or DOWN pushbuttons to change the current value. The pushbuttons possess a "fast" increment or decrement feature that begins a few seconds after holding the button down. This allows large changes in the frequency or duty cycle to be accomplished quickly.

The description in the preceding paragraph provides the current values or ranges available for each parameter. For example, the duty cycle may be varied to any value between 0.0% and 100.0% (inclusive). Pressing the UP pushbutton when the value of the duty cycle is at 100.0% will no longer change the value. This is true for any maximum or minimum value for frequency and duty cycle. When using the UP or DOWN pushbuttons to change the polarity, the controller simply cycles through the values available (H or L). When the cursor is in the status position and the mode is Off, the UP pushbutton is used to enter Man mode, DOWN to enter Adt, then, Ain. When operating in either Man, or Ain mode, either pushbutton (UP or DOWN) will cause the controller to return to the off state.

The pushbutton interface may be disabled via the remote port or by configuring the PWM Controller with the pushbutton interface to be disabled. This is useful in applications where the PWM Controller is used in analog or remote control and it is desirable to prevent unwanted key presses by unauthorized personnel. See section 4.3.2 for the proper remote command and section 4.6 on configuring the PWM Controller with the pushbutton interface disabled.

4.3.2 Remote (RS-232) Interface

The PWM Controller possesses an RS-232 port for remote / computer control. All operational features are accessible via the RS-232 port using ASCII character based commands. This allows the PWM Controller to be commanded via a computer executing a terminal emulation program, or custom software, or via a PLC (Programmable Logic Controller).

When the PWM Controller is powered on, a sign on message will be transmitted out the serial interface. During this time the PWM Output will begin operating at the default or configured settings (see section 4.6 on Configuration). After the sign on message is complete, a star (*) prompt will be transmitted, signifying that the controller is ready for commands.

Features of the PWM Controller are controlled via a command set that is ASCII character based. All commands are terminated by a carriage return (Return or Enter key on your keyboard - ASCII value of 13H).

A command summary is shown in the table below. The carriage return / enter key is shown as <ENTER>. Detailed descriptions of the instructions follow. Note that in all cases spaces are ignored. No other punctuation or symbols should be used. Characters may be any combination of uppercase or lowercase characters. All numeric values shown are ASCII character representation of numbers, that is, the number 100 is actually three ASCII characters - “1”, “0”, and “0”. All numbers are represented in base 10.

A x <ENTER>	analog input mode select (x = 0) off, (x = 1) control frequency and duty cycle, (x = 2) control duty cycle only (x = F) disable
CFN <ENTER>	save configuration data
D xxx.x <ENTER>	set duty cycle to xxx.x = [0.0 ..100.0] %
+	increment duty cycle by 0.1%
-	decrement duty cycle by 0.1%
E <ENTER>	enable PWM output
F xxxxx <ENTER>	set frequency to xxxxx Hz
G xxxxx <ENTER>	set / report analog frequency control range xxxxx = 250, 500, 1000, 10000, or 25000
GV x <ENTER>	set analog input control version compatibility to 1, 2, or 3
H <ENTER>	command help
I <ENTER>	report system info - Model No., Serial No., Software rev.
K x <ENTER>	(x = 0) lock out (x = 1) enable pushbutton interface
L <ENTER>	report pushbutton and analog input lock status
M x <ENTER>	set digital input mode (x=0) off (x=1) enable/disable
P x <ENTER>	set duty cycle polarity, high (x = 1), low (x = 0)
R <ENTER>	report current frequency, duty cycle, polarity and mode
S <ENTER>	stop output
V x.x <ENTER>	set / report analog control duty cycle resolution

Table 4.3.2-1 PWM Controller Remote Port Command Summary

Command: Analog Input Control Mode Select
Syntax: A x <ENTER>
Parameters: x, where x = 0, 1, 2, or F
Description: The A command sets the mode of the PWM Controller operation using the analog input ports accessible on the 8 pin analog port connector. Use the parameter "0" for turning off analog input control. Use "1" for enabling analog input control of the duty cycle only, and "2" for enabling analog input control of both the frequency and the duty cycle. Sending frequency and duty cycle commands to a PWM Controller that is already operating in that mode will have no effect. Note that the output must be enabled with the E command for the A1 or A2 commands to control the output PWM. Sending the AF command disables the use of analog input modes entirely via the front-panel interface. This will limit the LCD display mode pushbutton selections to Manual or Off. The function is used to prevent inadvertent changes of the operating mode when the analog mode is not used. Note that this does not program the configuration memory to set the analog mode disable on power-up, this must be set using the configuration options (see section 4.6).
Example: `A 1 <ENTER>` - allows analog input control of duty cycle only

Command: Save PWM Output Configuration
Syntax: CFN <ENTER>
Parameters: none
Description: The CFN command is used to save the power on start-up settings of the PWM Controller. After a configuration is completed, the PWM Controller will start-up and operate using the last parameter settings saved in configuration memory. After the CFN command is sent, the PWM Controller will stop operation for a few seconds while saving the parameters (with the output fixed to a non-engaged state based on the current polarity setting), display "Cfn" on the LCD screen in the status field and then continue operation at its current settings. There is no need to power cycle the unit. See section 4.6 for details on the configuration process.
Example: `CFN <ENTER>` - save configuration

Command: Set the PWM Output Duty Cycle
Syntax: D xxx.x <ENTER>
Parameters: xxx.x, where xxx.x = 0.0 to 100.0, in 0.1 % increments
Description: Use the D command to remotely set the PWM output duty cycle. The value xxx.x must be in the range of 0.0 to 100.0 and represents duty cycle percentage. The minimum step resolution of the PWM Controller is 0.1%. The duty cycle value supplied may be 1, 2, 3, or 4 characters in length, leading zeroes are ignored, and the decimal is assumed to be zero when not present. This allows software formatting of the digits to be used in computer control applications. For example, a value for xxx of "004" is equivalent to "4". The percent sign is not required and should not be used.

Example: `D 34 <ENTER>` - will set the output duty cycle to 34.0%
Example: `D 0.7 <ENTER>` - will set the output duty cycle to 0.7%
Example: `D 82.5 <ENTER>` - will set the output duty cycle to 82.5%
Example: `D .2 <ENTER>` - will set the output duty cycle to 0.2%

Command: Increment the PWM Output Duty Cycle by 0.1%
Syntax: +
Parameters: none
Description: Use the '+' key to increment the PWM output duty cycle. The output duty cycle will be incremented by the minimum step resolution of the PWM Controller, which is 0.1%, every time that the '+' command is received. The PWM Controller will feedback no response (no echo) over the remote port. The value of the duty cycle on the LCD will be updated. Note that the function of this command is equivalent to using the pushbutton interface with the cursor at the duty cycle 0.1% position and pressing the UP pushbutton in the tenth place. Also note that the <ENTER> key is not required.
Example: `+` - will increase output duty cycle by 0.1%

Command: Decrement the PWM Output Duty Cycle by 0.1%
Syntax: -
Parameters: none
Description: Use the '-' key to decrement the PWM output duty cycle. The output duty cycle will be decremented by the minimum step resolution of the PWM Controller, which is 0.1%, every time that the '-' command is received. The PWM Controller will feedback no response (no echo) over the remote port. The value of the duty cycle on the LCD will be updated. Note that the function of this command is equivalent to using the pushbutton interface with the cursor at the duty cycle 0.1% position and pressing the DOWN pushbutton in the tenths place. Also note that the <ENTER> key is not required.
Example: `-` - will decrease output duty cycle by 0.1%

Command: Enable Output
Syntax: E <ENTER>
Parameters: none
Description: The E command will enable the PWM Controller output. This allows the controller to operate in the manual mode, or, the analog input modes (if enabled). Note, if the digital input enable/disable control is used the output will be controlled by the digital input.
Example: `E <ENTER>` - will enable the output

Command: Set the PWM Output Frequency
Syntax: F xxxxx <ENTER>
Parameters: xxxxx, where xxxxx = 1 to 25000 Hz
Description: Use the F command to remotely set the PWM output frequency. The value xxxxx must be in the range of 1 to 25000, otherwise an error message will be returned. The value be automatically coerced to the nearest value that is supported by the controller (see section 4.2.1). The frequency value supplied may be 1 to 5 characters in length, leading zeroes are ignored. This allows software formatting of the digits to be used in computer control applications. For example, a value for xxxxx of "00004" is equivalent to "4". The engineering units designation of "Hz" should not be typed.

Example: `F 00105 <ENTER>` - will set the output frequency to 105 Hz
`F 1040 <ENTER>` - will set the output frequency to 1050 Hz
`F 12345 <ENTER>` - will set the output frequency to 12300 Hz

Command: Set or Report the Analog Frequency Control Range
Syntax: G xxxxx<ENTER>
Parameters: xxxxx, where xxxxx =
250, 500, 1000, 10000 or 25000 for V3.x and V4.x software setting
250, 500, 2500 for V2.x software setting
200 or 400 for V1.x software setting
none to report current setting
Description: Use the G command to remotely set the PWM output frequency operating range when under analog control. See section 4.4 for the analog to frequency conversion factors that are based on the range setting. Note that the value that can be set is dependent on the software compatibility setting that is set using the GV command. The G with no parameters will report the current frequency range setting and version setting.
Example: `G 500 <ENTER>` - sets the analog freq range to 500 Hz
`G 25000 <ENTER)` - sets the analog freq range to 25000 Hz

Command: Set the Analog Frequency Control Range Version
Syntax: GV x<ENTER>
Parameters: x, where x = 3, 2, or 1
for V3.x (or V4.X software), V2.x or V1.x software setting
Description: Use the GV command to remotely set the PWM output frequency operating range software version compatibility setting when under analog control. See section 4.4 for the analog to frequency conversion factors that are based on the range setting and the software version setting. The software version setting is provided to allow for backward compatibility of the Model 205 for analog control installations that have used units with version 2 of version 1 software (and hardware). There are no differences in the range settings between version 3 and version 4 software. Use the G command with no parameters to report the version setting.
Example: `GV 1 <ENTER>` - sets the analog control ranges to version 1

Command: Command Help
Syntax: H <ENTER>
Parameters: none
Description: Use the H command to display all the remote commands of the PWM controller. A summary as shown in table 4.3.2-1 will be displayed.
Example: `H <ENTER>` - display command summary

Command: Information on System
Syntax: I <ENTER>
Parameters: none
Description: Use the I command to provide information on the PWM Controller model number, serial number and software version number. This information is useful in service calls to Applied Processor and Measurement, Inc. and maintaining your unit with respect to software upgrades. (See section 5.4). IS may also be used (version 2 or 1 software command).
Example: `I <ENTER>` - reports the system information (2 lines)

```
PWMC205 rev 4.22 (c)2024 APM,Inc.
Serial Number = 03850
```

Command: Enable / Disable the Pushbutton Interface
Syntax: K x <ENTER>
Parameters: x, where 0 = disable, 1 = enable
Description: Use the K command to remotely enable or disable the front-panel pushbutton operation. This can be used to prevent unwanted changes of the PWM Controller settings when operating in the remote or analog operation modes. When disabled, any pushbutton presses are ignored by the PWM Controller.
Example: `K 0 <ENTER>` - locks out the pushbutton interface

Command: Lockout Status
Syntax: L <ENTER>
Parameters: none
Description: Use the L command to provide the current status of the PWM Controller with respect to the state of the pushbutton, analog, and digital input interfaces
Example: `L <ENTER>` - report pushbutton and analog interface lock status (3 lines)

```
Keypad Operation = Enabled
Analog Input Modes = Disabled
Digital Input Mode = None
```

Command: Set the Digital Input Mode
Syntax: M x <ENTER>
Parameters: x, where 0 = none, 1 = enable / disable
Description: Use the M command to remotely set the digital input operational mode. Setting the mode to 0 disables the digital input feature. Setting the mode to 1 sets the digital input mode to enable / disable. When in enable / disable mode, the digital input must be asserted (see section 4.3.3) to allow the controller to PWM the output. When the digital input is not asserted, the output will be disabled. The digital input mode setting is reported via the L command.
Example: `M 1 <ENTER>` - set the digital input mode to enable / disable

Command: Set Output Polarity
Syntax: P x <ENTER>
Parameters: x, where x = 0 or 1
Description: The P command sets the PWM Controller output polarity. Use the parameter “0” to set the polarity to active low, use a “1” for active high. Sending commands to a PWM Controller that is already operating in that polarity will have no effect.
Example: `P 1 <ENTER>` - will set active high polarity

Command: Report PWM Output Parameters
Syntax: R <ENTER>
Parameters: none
Description: The R command reports the current PWM pulse parameters - the frequency, duty cycle, polarity and operational mode. Note that when operating in the Analog Input control mode, the frequency and duty cycle reported will be the settings that are derived from the analog input control signals as appropriate for the mode. If the digital input mode is set to enable / disable, a 4th line will report the state of the digital input.
Example: `R <ENTER>` - reports output parameters

```
Frequency  = 100          - PWM Controller response (3 lines)
Duty Cycle =  30.0L
Mode = Run

Frequency  = 5050         - PWM Controller response (4 lines)
Duty Cycle =  49.7L
Mode = Run
Output = Disabled
```

Command: Stop Output
Syntax: S <ENTER>
Parameters: none
Description: The S command will stop the PWM Controller output. The controller output will be forced to a permanently high or low output state depending upon the polarity setting. The PWM Controller will remain stopped until the E command is issued (or the Man, Adt, or Ain modes are enabled from the pushbutton interface).
Example: `S <ENTER>` - will stop the output

Command: Set or Report the Analog Control Duty Cycle Resolution
Syntax: V x.x <ENTER>
Parameters: x.x, where x.x = 1.0, 0.5, 0.2, or 0.1
Description: Use the V command to remotely set the pulse output duty cycle resolution when in analog control mode. Note that this command / setting is only valid when version 3 software is set. In version 2 or 1 compatibility modes, the analog duty cycle control resolution is fixed at 0.5% for backwards compatibility. The percent sign is not required and should not be used. Use the V command with no parameters to report the current setting.
Example: `V 0.2 <ENTER>` - will set the output duty resolution to 0.2% when in analog control mode

4.3.3 PWM Controller Operation - Digital Input Control

The PWM Controller allows for remote control of the PWM output via an opto-isolated digital input. This allows for the output to be enabled or disabled by an external device such as a PLC.

The digital input control is connected via 2 pins of the 8 pin connector on the front left side of the unit. (For the connector pinout, see section 3.4.)

The digital input operational feature must be set on or off using the M command, or, the start-up configuration menu (see section 4.6). When this feature is enabled, the PWM output is enabled or disabled based on the state of the digital input. Voltage (5 to 24V DC) applied to the digital input will enable the PWM output. When no voltage is applied to the digital input, the PWM output is stopped. The PWM output is enabled or disabled within 5 msec of a valid digital input state change and is asynchronous to the current PWM cycle, i.e., once the digital input is de-asserted, the output will be stopped immediately, even before the cycle is allowed to complete its period.

Note that when the digital input mode is enabled, the digital input display field will be active on the LCD (refer to section 4.3.1). The character position to the right of the “Stat” field will display “Din0” or Din1” when the digital input is enabled or disabled. This allows the user to see whether the digital input is active or stopping the PWM output. For example, if the mode is displayed as manual ‘Man’ and the digital input is 0 volts, a ‘Din0’ will be displayed on the LCD and the output will be off. When the digital input mode is not enabled (set to none), the display field for the digital input will be blank.

4.4 PWM Controller Operation - Analog Input Control

The PWM Controller operating in one of the two Analog Input Control modes provides for adjustment of the operating frequency and duty cycle via analog inputs. Note that there are two analog input control modes: one mode controls both the frequency and duty cycle, the other controls only the output duty cycle only. In the mode where only the duty cycle is controlled via the analog input, the frequency must be set in the Run (Man) mode or via configuration prior to using the analog input mode.

The analog input controls are connected via an 8 pin connector on the lower left side of the unit. (For connector pinout, see section 3.4.)

The analog control signal varies the frequency or duty cycle at a rate of mV per Hz and mV per percent duty cycle dependent on the range and resolution selected. The adjustments are also dependent upon the software compatibility setting (Version 3.x, 2.x, or 1.x). The software version compatibility setting allows for backwards compatibility for existing analog control installations using the Model 205 unit. Use the G and GV commands to set the range and compatibility settings (see section 4.3.2), or, the power-on configuration menu (see section 4.6).

The analog control mV input to output relationships are given in the equations and tables that follow:

Output Analog Control Equations – version 3.x and 4.x software compatibility

Output Freq = Voltage Input / 0.020 * 1Hz (250 Hz range)
Output Freq = Voltage Input / 0.020 * 2 Hz (500 Hz range)
Output Freq = Voltage Input / 0.020 * 5 Hz (1000 Hz range)
Output Freq = Voltage Input / 0.020 * 50 Hz (10000 Hz range)
Output Freq = Voltage Input / 0.020 * 100 Hz (25000 Hz range)

Output Duty Cycle = Voltage Input / 0.050 * 1.0 (1.0% resolution)
Output Duty Cycle = Voltage Input / 0.025 * 0.5 (0.5% resolution)
Output Duty Cycle = Voltage Input / 0.010 * 0.2 (0.2% resolution)
Output Duty Cycle = Voltage Input / 0.005 * 0.1 (0.1% resolution)

Output Analog Control Equations – version 2.x software compatibility

Output Freq = Voltage Input / 0.016 * 1 Hz (250 Hz range)
Output Freq = Voltage Input / 0.016 * 2 Hz (500 Hz range)
Output Freq = Voltage Input / 0.016 * 10 Hz (2500 Hz range)

Output Duty Cycle = Voltage Input / 0.020 * 0.5

Output Analog Control Equations – version 1.x software compatibility

Output Freq = Voltage Input / 0.020 * 1 Hz (200 Hz range)
Output Freq = Voltage Input / 0.020 * 2 Hz (400 Hz range)

Output Duty Cycle = Voltage Input / 0.020 * 0.5

Note that the control signals are limited by the operating specifications of the controller for frequency resolution. That is, the frequency output is limited to operating from 1 to 1000 Hz with a resolution of 1 Hz, 1000 to 10000 Hz, 50 Hz resolution and 10000 to 25000 Hz, with 100 Hz resolution. The example tables below quantify these values and the corresponding analog control signal values. Note that the values of frequency and duty cycle "saturate" over the maximum values. Also note that for V2.x and V1.x compatibility modes, the duty cycle resolution is fixed to 0.5%.

Analog Voltage	Frequency Setting 250 Hz Range	Frequency Setting 500 Hz Range	Frequency Setting 1000 Hz Range	Frequency Setting 10000 Hz Range	Frequency Setting 25000 Hz Range
0.0V	1 Hz	2 Hz	5 Hz	50 Hz	100 Hz
0.020V	1 Hz	2 Hz	5 Hz	50 Hz	100 Hz
0.040V	2 Hz	4 Hz	10 Hz	100 Hz	200 Hz
0.100V	5 Hz	10 Hz	25 Hz	250 Hz	500 Hz
1.000V	50 Hz	100 Hz	250 Hz	2500 Hz	5000 Hz
2.000V	100 Hz	200 Hz	500 Hz	5000 Hz	10000 Hz
3.000V	150 Hz	300 Hz	750 Hz	7500 Hz	15000 Hz
4.000V	200 Hz	400 Hz	1000 Hz	10000 Hz	20000 Hz
5.000V	250 Hz	500 Hz	1000 Hz	10000 Hz	250000 Hz

Table 4.4-1. Frequency vs. Analog Input – V3.x and V4.x Compatibility

Analog Voltage	Duty Cycle 1.0% res	Duty Cycle 0.5% res	Duty Cycle 0.2% res	Duty Cycle 0.1% res
0.0 V	0%	0%	0%	0%
0.005V	0%	0%	0%	0.1%
0.010 V	0%	0%	0.2%	0.2%
0.025 V	0%	0.5%	0.4%	0.5%
0.050 V	1%	1.0%	1.0%	1.0%
0.100 V	2%	2.0%	2.0%	2.0%
1.000 V	20%	20.0%	20.0%	20.0%
2.500 V	50%	50.0%	50.0%	50.0%
5.000 V	100%	100.0%	100.0%	100.0%

Table 4.4-2. Duty Cycle vs. Analog Input –V3.x and V4.x Compatibility

Analog Voltage	Frequency Setting (250 Hz Range)	Frequency Setting (500 Hz Range)	Frequency Setting (2500 Hz Range)
0.0V	1 Hz	2Hz	50 Hz
0.016V	1 Hz	2 Hz	50 Hz
0.160V	10 Hz	20 Hz	100 Hz
0.800V	50 Hz	100 Hz	500 Hz
1.600V	100 Hz	200 Hz	1000 Hz
2.400V	150 Hz	300 Hz	1500 Hz
3.200V	200 Hz	400 Hz	2000 Hz
4.000V	250 Hz	500 Hz	2500 Hz
5.000V	250 Hz	500 Hz	2500 Hz

Table 4.4-3. Frequency vs. Analog Input – V2.x Compatibility

Analog Voltage	Frequency Setting (200 Hz Range)	Frequency Setting (400 Hz Range)
0.0V	1 Hz	2 Hz
0.020V	1 Hz	2 Hz
0.100V	5 Hz	10 Hz
0.500V	25 Hz	50 Hz
1.000V	50 Hz	100 Hz
2.000V	100 Hz	200 Hz
3.000V	150 Hz	300 Hz
4.000V	200 Hz	400 Hz
5.000V	200 Hz	400 Hz

Table 4.4-4. Frequency vs. Analog Input – V1.x Compatibility

Analog Voltage	Duty Cycle
0.0 V	0%
0.020	0.5%
0.040 V	1%
0.400 V	10%
2.000 V	50%
4.000 V	100%
5.000 V	100%

Table 4.4-5. Duty Cycle vs. Analog Input – V2.x and V1.x Compatibility

When using the Analog Input control feature, be sure to operate the inputs within the specified limits for the analog inputs as described in Section 2.0. The system commanding the analog inputs should not exceed the voltage range of 0.0 V to 5.0 V. While the inputs are protected, command signals over 5.0 V may damage the PWM Controller internal A/D converter or the signal source. Note that 10.0 V single-ended and 5.0V differential input options are available.

The analog control input selection may be disabled via the remote port or by configuring the PWM Controller with the analog input function to be disabled. This is useful in applications where the PWM Controller is used strictly in manual mode where only the Run (Man) and Off modes are required. In situations where manual control is used, an accidental key press from the Off mode may select unwanted analog input settings for frequency and duty cycle due to the fact that the analog inputs are not connected. Disabling the analog input feature will prevent this situation. See section 4.3.2 for the proper remote command and section 4.6 on configuring the PWM Controller with the analog inputs disabled.

4.5 PWM Controller Operation - Precedence

The PWM Controller software uses rules of precedence with respect to its modes of operation. Dependent on the operational mode selected, the rules of precedence within the PWM Controller software govern how the controls affect the PWM Controller output.

The following paragraphs outline the operation of the PWM Controller with respect to its current mode of operation.

Mode: Man (Manual)
Controls Effected: no restrictions
Summary: commands to change mode, frequency, duty cycle and polarity via the pushbuttons or the RS-232 interface are accepted and implemented immediately (on the output).

Mode: Ain or Adt (either analog input mode)
Controls Effected: Front Panel Pushbuttons, RS-232
Summary: changes to the frequency and duty cycle via the pushbuttons and remote port (RS-232) are disabled, analog inputs translate to action on the frequency and duty cycle of the output based on the analog input mode selected, mode and polarity can be controlled with RS-232 and / or pushbuttons. Note that it is also possible for the analog inputs to control the frequency and duty cycle while the output is off if Ain or Adt is applied using RS232 commands.

Mode: Off
Controls Effected: no restrictions
Summary: values of frequency, duty cycle and polarity may be changed from any source, output does not reflect it until re-enabled by entering Manual (Man), Adt, or Ain mode.

Note that commands (from any source: remote port or pushbuttons) that change the mode of operation are always allowable (except when the pushbutton interface is disabled). Only commands that change the frequency and the duty cycle are subject to the rules of precedence.

Finally, when enabled, the digital input enable / disable state overrules the output state.

4.6 PWM Controller Configuration

When the PWM Controller is powered on, the parameters of PWM output are initialized to settings contained within the reprogrammable FLASH configuration memory of the PWM Controller microprocessor system. The user is able to configure these initial power-up settings. This enables the PWM Controller to be set-up for operation in a fixed environment without manual / operator interaction such as a test system using the PWM Controller in one of the analog input modes.

Factory default settings for the PWM parameters are as follows:

Output frequency	1 Hz
Output duty cycle	0%
Output polarity	low
Mode	output off
Pushbutton Interface	enabled
Analog input modes	enabled
Digital input mode	none
Analog version compatibility	V3.x (same as V4.x)
Analog Control – Freq range	250 Hz
Analog Control – Duty resolution	0.5%

The factory default settings guarantee a non-energized condition on the output (assuming an active low polarity). If your device is opposite polarity, the default settings may be changed to insure a non-energized condition for that device.

Configuration may be accomplished using either the front panel pushbutton / LCD interface, or the RS-232 remote port.

To change the power on settings of the PWM Controller, connect the unit to a power source as shown in the installation instructions.

WARNING

IT IS RECOMMENDED NOT TO HAVE THE OUTPUT DEVICE (LOAD) CONNECTED DURING CONFIGURATION. IF YOUR SYSTEM CANNOT TOLERATE A FULL ON OR OFF OUTPUT STATE, THE LOAD SHOULD NOT BE CONNECTED DURING CONFIGURATION. DURING THE INTERNAL PROGRAMMING OF THE CONFIGURATION SETTINGS, THE PWM CONTROLLER WILL DE-ENERGIZE THE OUTPUT TO THE CURRENTLY CONFIGURED POLARITY. IF YOUR SYSTEM CANNOT TOLERATE THIS, DISCONNECT IT AND RE-CONNECT AFTER CONFIGURATION IS COMPLETE.

There are two methods to configure the PWM Controller from the front-panel interface. One method sets the configuration parameters while operating, the other accesses a menu driven start-up sequence which is able to configure all aspects of the PWM Controller. The configuration may also be saved via the CFN command on the remote port. This is also performed during normal operation. Note that enabling and disabling of the pushbutton, digital input, and analog interfaces and setting the analog input control frequency range, may only be configured from the menu driven sequence and the remote port command for configuration. This is because there is no way to change the enable and disable of the pushbuttons and analog interfaces or the operating frequency range from the normal pushbutton user interface. In order to set all parameters from the pushbutton interface, the start-up menu must be used.

To configure during normal operation, power on the PWM Controller, wait for the initial messages, and let the system start-up. If you are doing this for the first time, the system will initialize to the factory default settings shown above. Adjust the frequency, duty cycle, and polarity to the desired settings using either the front panel interface or the RS-232 remote commands. Lastly, set the desired operational mode. Note that the mode selected shall be the operational mode that the PWM Controller will use on subsequent power up conditions. Normal rules of operational precedence apply. For example, if the Ain Analog Input operational mode is selected, the PWM Controller shall power on, and immediately measure the frequency and duty cycle analog inputs, and set the output parameters accordingly.

The configuration can now be saved such that the PWM Controller will power on in this state for all subsequent power cycles until re-configured by the user. The settings are stored in the PWM Controller internal FLASH memory and may be reprogrammed at any time using this procedure. The parameters can be saved by using one of two methods. Using the front panel interface, place the cursor on the “Stat” field using the SELECT pushbutton. Simultaneously press the UP and DOWN pushbuttons until the LCD displays “Cfn” in the status field. “Cfn” will be displayed briefly, and the PWM Controller will return to the operational mode that it was in prior to the configuration command. The parameters may also be saved using the remote command interface (RS-232) and typing CFN <Enter>. The display will also show “Cfn” on the display using this method as well. During configuration, the PWM controller will de-energize the output to the currently selected polarity. The PWM controller is now reconfigured.

A start-up sequence is also available via the pushbutton user interface that allows setting of all the PWM Controller parameters in the list above. This is the recommended method for PWM controller configuration.

In order to access the menu, hold down the SELECT pushbutton while applying power to the PWM Controller. The start-up messages will be displayed followed by a message prompting to release the SELECT pushbutton to begin configuration. All settings will be individually displayed for adjustment in the following order:

Enable/Disable Analog Inputs
Analog Control Version Compatibility
Analog Control Frequency Range / Step
Analog Control Duty Cycle Resolution
Start-up Mode
Start-up Frequency
Start-up Duty Cycle
Start-up Output Polarity
Digital Input Mode
Keypad Enable

Note that settings in the beginning shall determine whether later displays are accessed. For example, if Analog Inputs are disabled, the only choices for start-up mode will be Run (Manual) and Off. Similarly, if Adt is chosen as a start-up mode, the start-up duty cycle menu item will not be displayed for setting.

Adjust the setting by using the UP and DOWN pushbuttons, press SELECT when adjustment is complete. This will cause the menu to go to the next parameter to be set.

After completion of the menu list, the final choice will be to save the settings and exit, save the default (factory) settings and exit, or exit without saving. The default settings are shown above. Use the UP and DOWN pushbuttons to display the choice and press SELECT to complete the configuration. After completion of the menu sequence the start-up screen shall be displayed and the PWM Controller will operate with the reconfigured settings.

Note that the start-up configuration menu is accessible by holding down the SELECT key even when the pushbutton interface is disabled using a previous configuration setting.

It is recommended that after configuration the user re-verify the power up settings prior to connection to the output device in order ensure the settings and prevent any possible damage to the device under control.

5.0 Warranty, Service, Maintenance, Product Options

5.1 Warranty

The Model 205 PWM Controller is warranted for 90 days from the time of purchase. This includes workmanship and manufacturer defects. It does not include failures caused by misuse.

5.2 Service

WARNING

OTHER THAN FUSE REPLACEMENT OR DIODE JUMPERING THERE ARE NO USER SERVICEABLE PARTS INTERNAL TO THE PWM CONTROLLER. DO NOT ATTEMPT TO SERVICE THE UNIT. COMPONENTS INTERNAL TO THE PWM CONTROLLER ARE STATIC SENSITIVE AND MAY BE DAMAGED WITHOUT PROPER HANDLING.

If you detect a malfunction with your unit, you must contact Applied Processor and Measurement, Inc. to obtain a Return Authorization (RA) Number. You must obtain an RA number for either warranty or non-warranty service. This number must appear on the outside of a suitable shipping carton or on the packing list. Applied Processor and Measurement, Inc. will repair or replace the boards or the unit at its option. If the return is for non-warranty repair, you will be notified of any applicable charges prior to work being performed. Please refer to our website for further information and to contact us for returns / servicing.

PWM Controller Model 205

Serial Number _____

Applied Processor and Measurement, Inc. may be contacted as follows:

e-mail:	support@appliedprocessor.com
website form:	appliedprocessor.com/customer-support/
phone	716-741-1141

5.3 Diagnostics

There are steps that may be taken to diagnose problems within the unit and verify its operation as stand-alone (as opposed to operating in your application).

If the unit is typically operated using the front panel interface, connect the serial port to a PC as described in section 3.3. It is possible that the LCD has failed, in which case, the remote port interface may be used to operate the controller until the unit may be serviced. If the unit is still not operable, observation of the messages on the remote port may assist in diagnosing the unit.

Basically, the PWM Controller is a signal generator, therefore, any test equipment used to detect or measure signals may be used to check the PWM Output. If it appears that you are still in control of your PWM Controller, but you are in doubt of the PWM Output, simulate your load by connecting a resistor (for example: 100 ohms, 5W) across the output (PWM OUT +/1 terminals). Connect your test equipment across the negative terminal on the PWM Output to ground (the negative terminal on the power input). Depending on the level of diagnosis desired, any of the following methods may be used to determine whether the PWM Controller is generating an output signal.

Oscilloscope - best method of observing the output. The change in frequency and duty cycle may be observed and measured on the oscilloscope.

Frequency Counter - will be able to measure the output frequencies. Some DMM's have frequency and duty cycle measurement capability.

DMM (voltage reading) – at higher PWM frequencies a DMM on DC Voltage will average the voltage reading. Varying the duty cycle will change the average voltage read on the DMM. For example, it the operating voltage is 12V DC, the PWM frequency is set to 100Hz and the duty cycle is set to 25% (low polarity), the DMM should read approximately 9.0V (25% of the power input).

Note that when measuring the PWM output using a scope, frequency counter, or DMM the signal is present on the PWM OUT '-' terminal and is referenced to the power supply ground which is the PWR '-' terminal.

LED and resistor - placing an LED with a current limit resistor on the output will provide an easy diagnostic tool. The LED should visibly flash up to approximately 25 Hz. A variance in intensity should be discernible at higher frequencies by varying the duty cycle.

5V Level Output – note that there is a 5V output level signal available on the Signal Outputs connector (pin 1 = signal, pin 2 = ground). This output can be checked using an oscilloscope or DMM as described above. This output can be used to determine that the controller is operating and either the output MOSFET failed or the output fuse is blown.

If there is no PWM output seen then first check the output fuse – the output fuse may have been blown. See section 3.1 on replacing the internal fuse.

In conclusion, do not attempt to service the PWM Controller internally. The methods provided above give a visual indication of operation of the unit. This indication is intended to isolate problems with your application of the PWM Controller to the unit itself or the system connection.

5.4 Replacement Parts

The following replacement parts are available from APM, Inc. for your Model 205. Fuses, jumpers and connector plugs are available from industrial parts distribution. For information on replacing an internal circuit board, please contact APM, Inc. support.

Description	Ratings	Manufacturer	Part Number
Output Fuse (default installed)	4A, 32V DC	Littelfuse	297004.WXNV
Output Fuse	2A, 32V DC	Littelfuse	297002.WXNV
Output Fuse	5A, 32V DC	Littelfuse	297005.WXNV
Power In, PWM Out Plug (4 pin)	8A max	TE Connectivity Phoenix	284507-4 1803594
Control I/O Plug (8 pin)	n/a	TE Connectivity Phoenix	284507-8 1803633
Signal Outputs Plug (6 pin)	n/a	TE Connectivity Phoenix	284507-6 1803617
Jumper / Shunt	1A	Kobiconn	151-8010-E
Main Circuit Board	n/a	APM, Inc.	AY00140-xx
Display Circuit Board	n/a	APM, Inc.	AY00139-xx

5.5 Calibration

The Model 205 PWM output is generated using Field Programmable Gate Array digital logic. The source is a 40MHz +/- 50ppm crystal oscillator rated for the industrial temperature range (-40°C to +85°C) providing high stability over temperature. The digital PWM generation circuitry is not able to be calibrated.

The 0 to 5V analog inputs used for frequency and duty cycle control may be calibrated using the procedure below:

1. Connect a power source (12V DC) to the Power input on the Model 205.

2. Connect to the Model 205 using a PC serial port (see section 3.3 for details on connecting the RS232 interface to the Model 205) and terminal emulation program. Start the terminal emulation program.

3. Connect a voltage source to the frequency analog input. If a non-metered source is used, then a DMM or benchtop multimeter on DC V measurement may also be connected in parallel.

   For single-ended analog inputs, add a ground connection between Control I/O pin 6 (Model 205 ground) and the voltage source ground.

   For differential analog inputs, the +/- connections from the voltage source may be directly connected to the +/- inputs on the Model 205 Control I/O connector.

   NOTE: Be sure that the PC, power supply and voltage source are all on the same electrical circuit. PC's typically have the signal ground connected to the chassis ground (protective earth connection on the AC power cord). If not, a ground loop may occur causing errors in the analog measurements and possible damage to the Model 205.

4. Power on the Model 205 and the voltage source.

5. Set the voltage source to 0.0V. Read the analog input using the 'CALV <ENTER>' command with the terminal emulator. Verify that the response for the A/D input is 00000. This cannot be adjusted.

6. Set the voltage source to 5.00V. Read the analog input. The voltage reading should be within +/-10mV of the source voltage. Use the equation below to calculate the calibration factor.

   calibration factor = ((A/D_input * 10000) / source_voltage(mV)

7. Set the calibration factor using the following command

   calxx,yyyyy

   where xx = 15 for the frequency analog input
   xx = 14 for the duty cycle analog input
   yyyyy = calibration factor (integer portion only)

   NOTE: the calibration factor is saved in EEPROM using this command

8. Retest the analog input readings to ensure that the voltage is reading correctly. Calibration factors may be displayed by using the 'CAL' command.

9. Repeat the procedure for the duty cycle analog input.

The analog outputs cannot be calibrated. The output is approximately 0.5V per 1A PWM output. The PWM frequency, load inductance and resistance may affect the actual output voltage obtained.

It is recommended that the analog input calibration be checked once per year.

5.6 LCD Contrast Adjustment

There is a contrast adjustment on the display board for the LCD display. A potentiometer (R3) on the display board is accessible by opening the back cover of the unit. Carefully adjust the contrast potentiometer with the Model 205 powered on to the desired level. It is recommended that the only the Model 205 power is applied, no output load should be connected and no other connections (I/O, signal connectors or the serial port) should be present.

Note: be sure not to touch other components while the unit is powered on. Parts are susceptible to ESD discharge damage.

5.7 Software Upgrades / Updates

Applied Processor and Measurement, Inc. is committed to supplying a high-quality product and will issue new software releases which will enhance capability and maintain the software. New releases with enhanced capability may incur a charge, releases for bug-fixes will be provided at no charge. Consult the support page at www.appliedprocessor.com for information on new software releases, new features and how to support your unit.

5.8 Model 205 PWM Controller Options

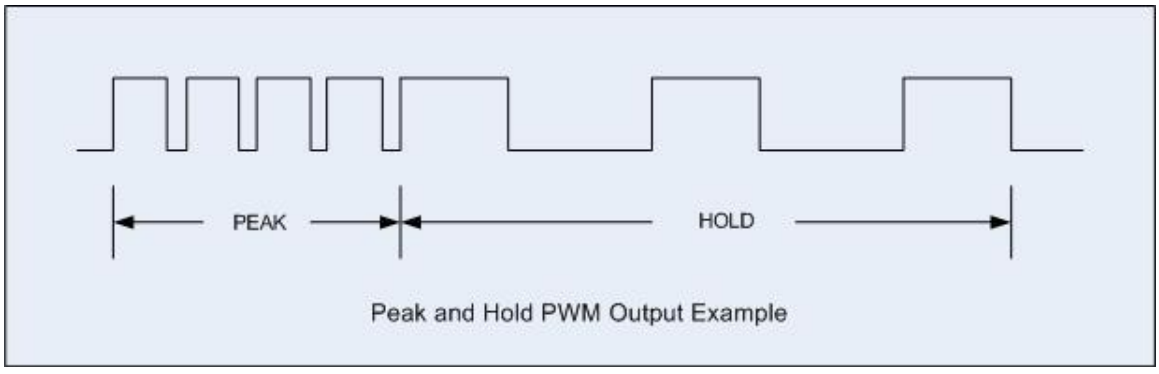
The Model 205 has options for features, analog input connections, etc. See the table below for a description of Model 205 PWM Controller options and the order number. Contact APM, Inc for pricing and availability.

The base unit order number is PWMC-205 which includes the 4 line x 20 character backlit display, pushbutton interface, RS232 interface and analog input controls in a benchtop style enclosure with pluggable terminal strip I/O connections.

Option / Description	Order Number Suffix
Differential Analog Inputs	-DF
10V Analog Inputs	-10
Board Only – Main Board PWM Controller, RS232 and Analog Control	-BD
Fast Diode Turn-Off Configuration	-FS
High DC Voltage Operation (to 50V DC)	-HV
Peak and Hold Waveform Capability (see below)	-PH
Proportional Control – Control to a Constant Average Output Current Setpoint	-CC

Model 205 options:

Peak and Hold waveform generation:



Peak and Hold PWM Output Example

5.9 Customization

The Model 205 main circuit board allows for various I/O configurations. Additionally, the unit is software controlled and the PWM output FPGA (programmable logic based). Therefore, the unit may be readily customized to suit your application. Call and discuss your requirements with one of our engineers. Our engineering staff has extensive experience in solenoid drive applications, test system applications and embedded system applications. Applied Processor and Measurement, Inc. will respond quickly with a quotation upon your request.

Applied Processor and Measurement, Inc. engineers have been designing microprocessor based instrumentation and embedded control systems since 1980. We welcome inquiries on custom designs, variations on this design, as well as customized software for your application. Call and discuss your engineering needs with one of our engineers.

5.10 Contact Information

For further information and controller purchase contact:

Applied Processor and Measurement, Inc.
8201 Old Post Rd. E., E. Amherst, NY 14051, USA
716.741.1141 ph
email: sales@appliedprocessor.com
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