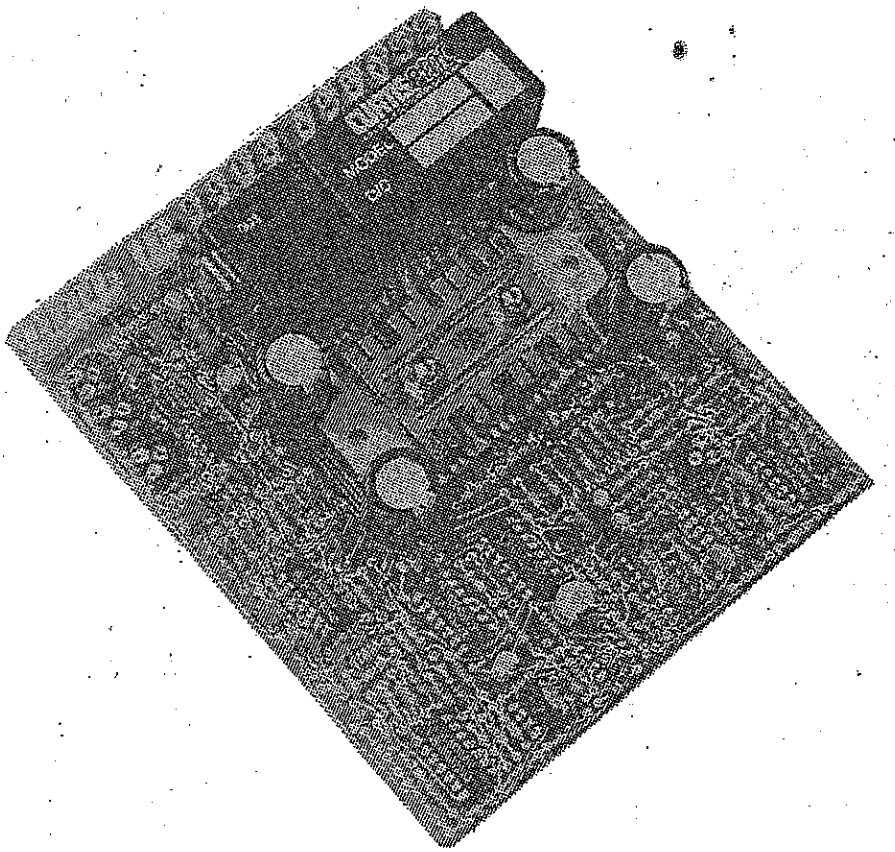
INSTALLATION/OPERATION MANUAL

FOR

CURTIS PMC 1203A

TRANSISTORIZED MOTOR CONTROLLERS



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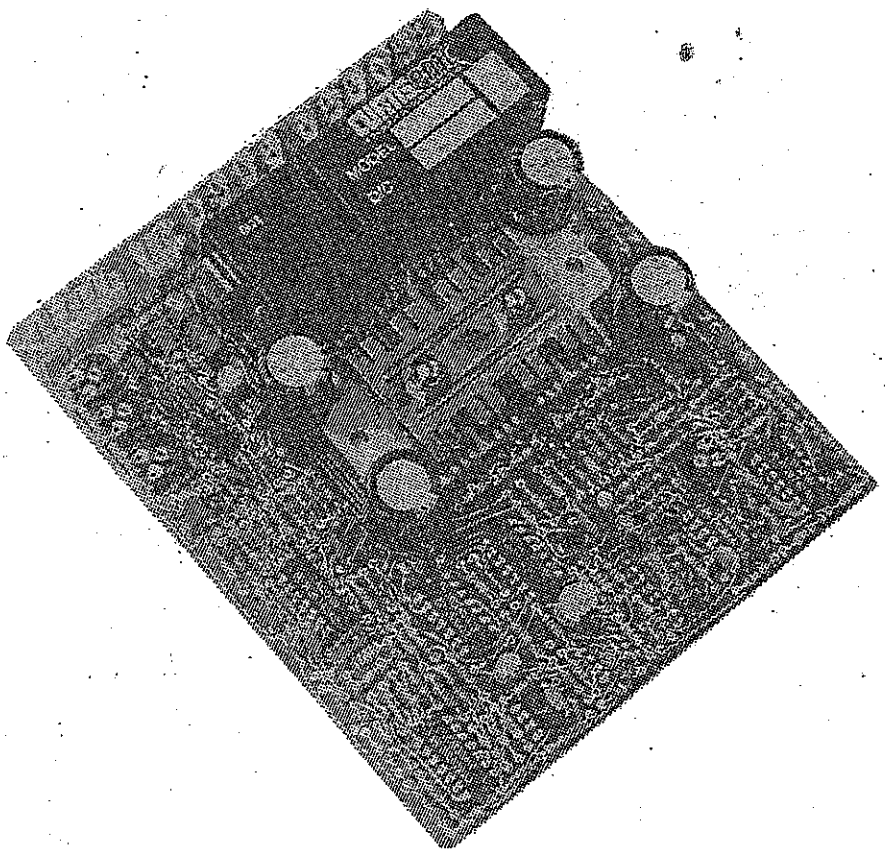

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INSTALLATION/INSTRUCTION MANUAL FOR
MODEL 1203A MOTOR SPEED CONTROLLERS
8-88, REV. 1

INTRODUCTION

The 1203A motor controllers are complete, efficient, simple to use DC motor speed controllers for heavy duty 12V, 24V and 36V permanent magnet motor applications including small vehicles, wheelchairs, scrubbers, sweepers, AGV's, conveyor belts and power steering. True regenerative and dynamic braking provide complete downhill and deceleration speed control. The only external parts needed for a complete motor control system (besides motor and battery) are an on/off switch, a throttle control potentiometer and a forward/reverse switch (single ended throttle only). All forward, reverse and power contactors are "on board" thus greatly simplifying external power wiring. Extra battery connections are provided on board for convenient wiring points for battery charger input or power output to accessories. Quick connects and plug type connectors allow easy controller installation and removal.

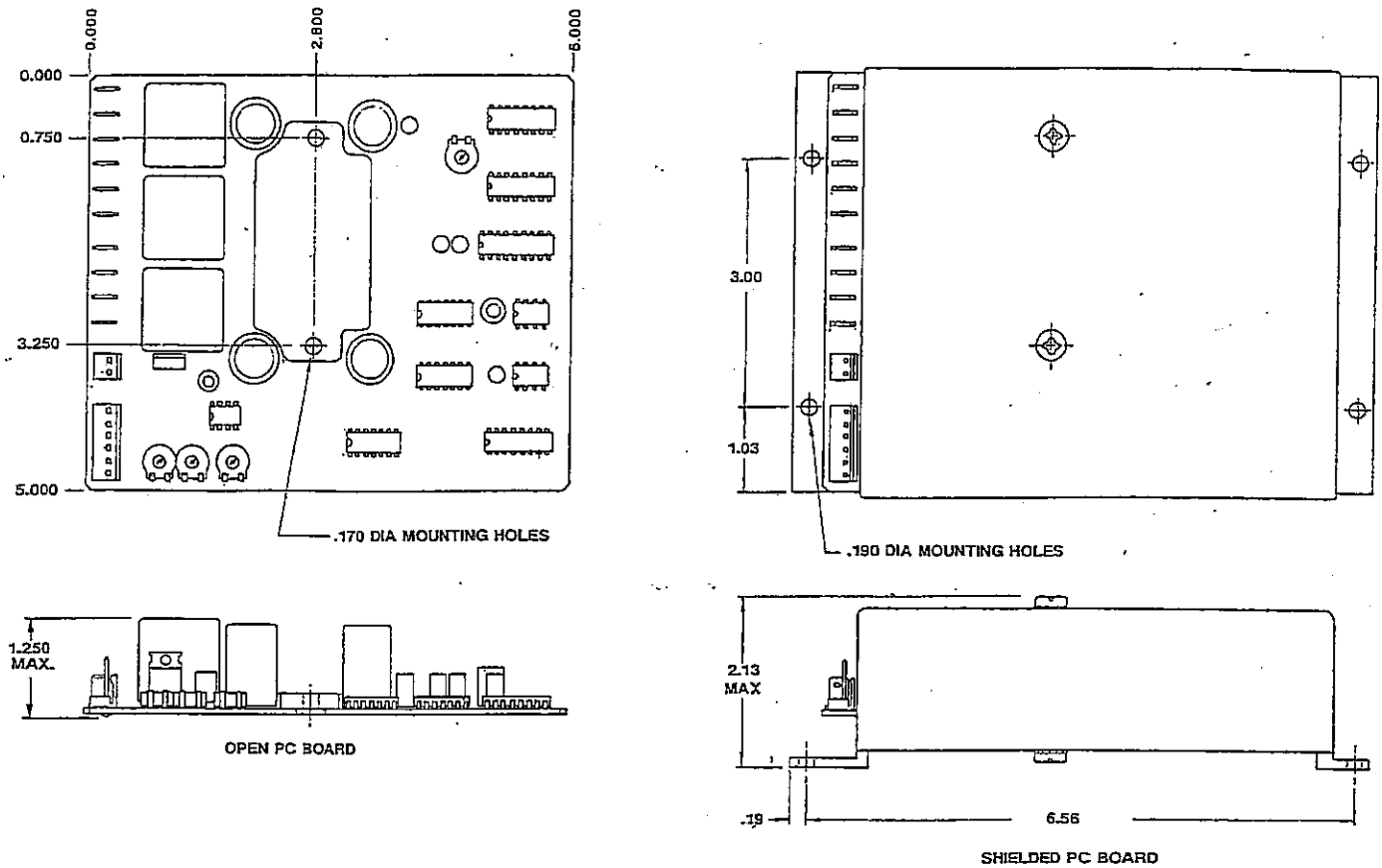
FEATURES

* Infinitely variable drive and regenerative brake control.
* Power MOSFET design provides:
  - high frequency (silent) operation with excellent low end torque.
  - high efficiency (reduces controller heating, motor and battery losses).
  - ultra smooth low speed performance.
* Available for single-ended or center off (wig-wag) throttle control. Single-ended throttle systems consist of a speed control potentiometer (with full off being at one end of rotation and full on at the other end) and a separate direction control switch. Wig-wag throttle systems consist only of a single potentiometer which controls both speed and direction with the center of rotation being off. Movement in one direction gives zero to full speed forward and movement in the other direction gives zero to maximimum set reverse speed.
* Dual ramp automatic reversing provides a smooth deceleration/acceleration transition when switching from forward to reverse or reverse to forward with throttle applied.
* Independently adjustable acceleration/braking rates may be set with on board trimpots.
* Adjustable reduced reverse speed may be set with on board trimpot.
* Externally programmable top speed may be set with an external potentiometer or a switch and resistor.

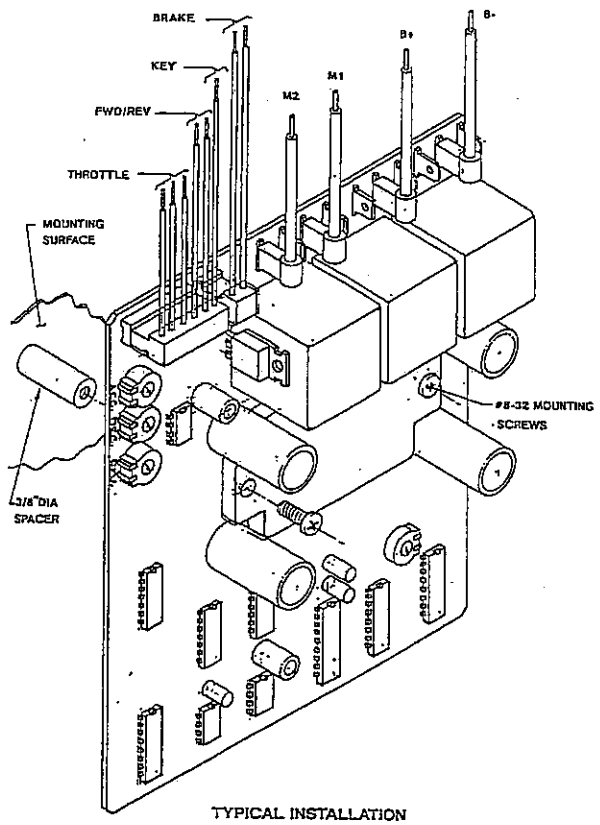
* Motor current limiting in both drive and braking modes protects both motor and controller against over currents and makes the 1203A compatible with most motors (see Appendix A for minimum allowable motor resistance).
* Potentiometer fault detection shuts off the controller in the event of any potentiometer lead or wiper breakage.
* Polarity protection prevents the controller from being turned on if the battery wires are reversed during installation. The controller will not be harmed from this battery wire reversal.
* Thermal Protecton reduces maximum available controller current if the controller is over heated. Reset is automatic when the controller cools.
* Hi-pedal disable circuitry forces the controller to remain in neutral if powered up with throttle applied (operator applying throttle, stuck throttle or broken return spring).
* Under-voltage protection reduces motor current when the batteries discharge to about two-thirds their nominal voltage. This allows the controller to operate on low batteries, with reduced performance, but will not allow the batteries to discharge below the two-thirds voltage level.
* Neutral throttle/default braking brakes motor during hands off or power off.
* A delayed auxiliary electromagnetic brake output is provided to drive a spring set brake. Brake is applied (power off) upon throttle return to neutral for one second.
* Simple installation with factory preset adjustments.
* Front or back mountable.
* Protective heatsink/housing available.

INSTALLATION

Figure 1 shows outline and mounting dimensions for the 1203A controllers. The circuit board may be front or back mounted (Figure 2) using aluminum spacers to conduct heat from the on-board mounting plate to the installation heatsink (wall, bulkhead, etc). Minimum required heatsink is a 4" x 5" aluminum plate 1/8" thick mounted with 3/8" diameter, 1" long (maximum) spacers to meet the data sheet current/time and continuous current ratings. If it is desired to mount the controller to a non-heatsinking mount (steel, fiberglass etc) a separate aluminum plate (4"x5"x1/8") should be provided and mounted on either side of the controller via aluminum standoffs. The controller may be oriented in any position but care should be taken to locate in an area protected against dirt, water, mechanical abuse, etc. A cover should be provided for complete protection from contaminants. A shielded version of the 1203A is also available from Curtis PMC if desired. No further heatsinking is required on the shielded version.



1203A MOUNTING DIMENSIONS
FIGURE 1

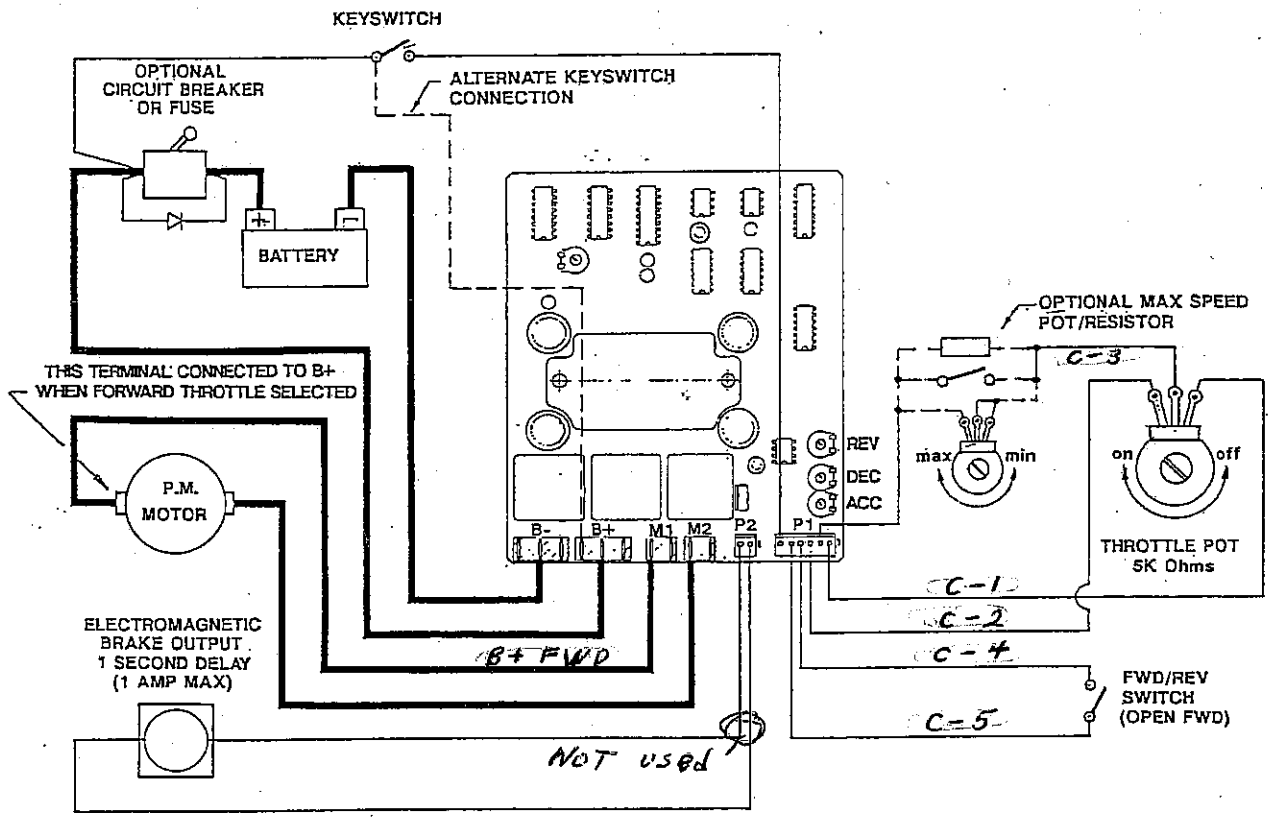


TYPICAL INSTALLATION
(BACK MOUNTED)

FIGURE 2

WIRING

All electrical connections to the controller use .250" quick connects for power connections and .156" centers connectors for control connections. Several manufacturers connectors will mate with the on board connectors with options of crimp or insulation displacement type terminals with wires straight out or at right angles to the connector bodies (see Appendix B). All connections are on one end of the PC board to help simplify wiring. Figure 2 shows a typical installation with all wires routed in the same direction using right angle style connectors.



Controller Wired as per This Diagram.

1203A WIRING DIAGRAM
(SINGLE-ENDED THROTTLE)

Highlited numbers are my own cable ID numbers.

FIGURE 3

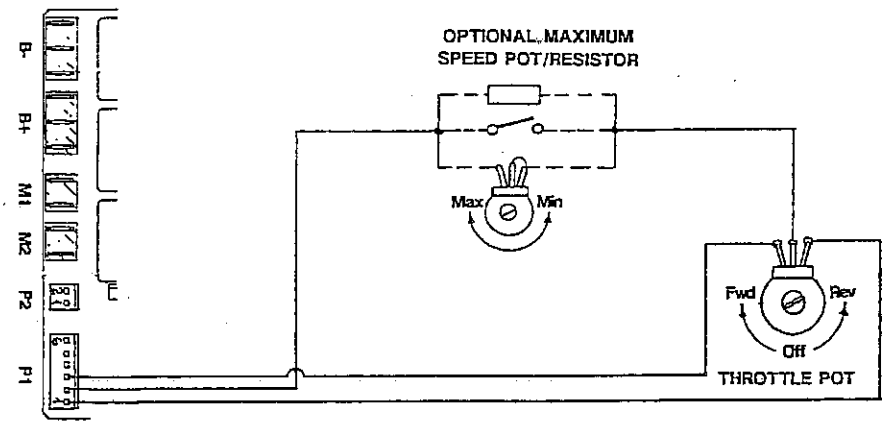
A complete wiring diagram is shown in Figure 3 using the standard 5K ohm throttle control potentiometer in single-ended configuration. Wig-wag thottle wiring (center off) is shown in Figure 4. If voltage input is used for throttle control a 5.1K ohm, 1/4W resistor must be added (Fig. 5) to keep pot fault from shutting down the controller due to the open throttle input connections. This resistor may be mounted at the PC board connector if desired. The control voltage input should be connected between B- and pot wiper connections as shown. If the voltage input wire breaks, the controller will return to neutral. For any type of throttle input, maximum controller ouptut may be limited using an external resistor and switch or a potentiometer.

Ouptut will be reduced in forward and reverse according to this resistor value as shown in Figure 9.

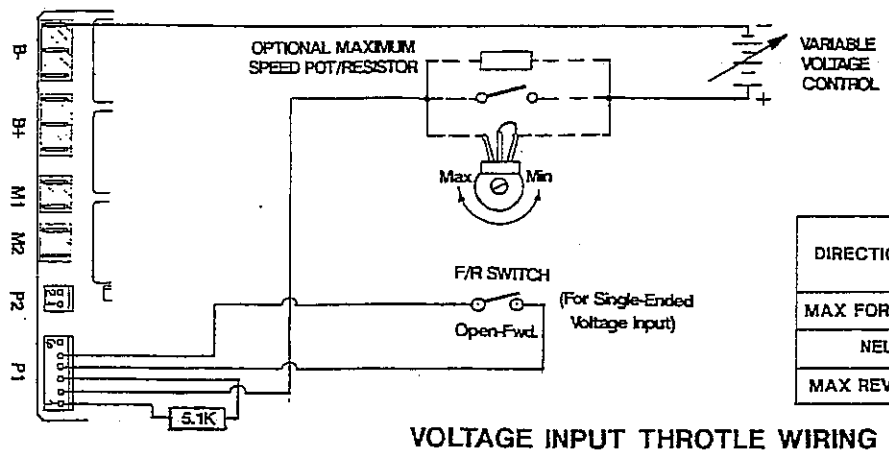
The circuit breaker (or fuse), if used, should be located to interrupt all power to the controller (B+ and keyswitch connections). A diode must be connected across the circuit breaker to shunt regenerative motor current back to the battery if the circuit breaker opens while the vehicle is in motion.

Two extra quick connects are provided for additional tie points for B+ and B- wiring. These can be used for the keyswitch connection (Fig.3) or extra vehicle wiring, accessories, battery charger, etc.

The electromagnetic brake output (connector P2 in Figure 3) immediately switches battery voltage to the brake when going from neutral to forward or reverse. Brake power is removed after a one second delay after returning throttle to neutral from forward or reverse. Other delay times are optionally available. Continuous current rating is 1 amp at nominal battery voltage.



WIG-WAG THROTTLE WIRING
FIGURE 4

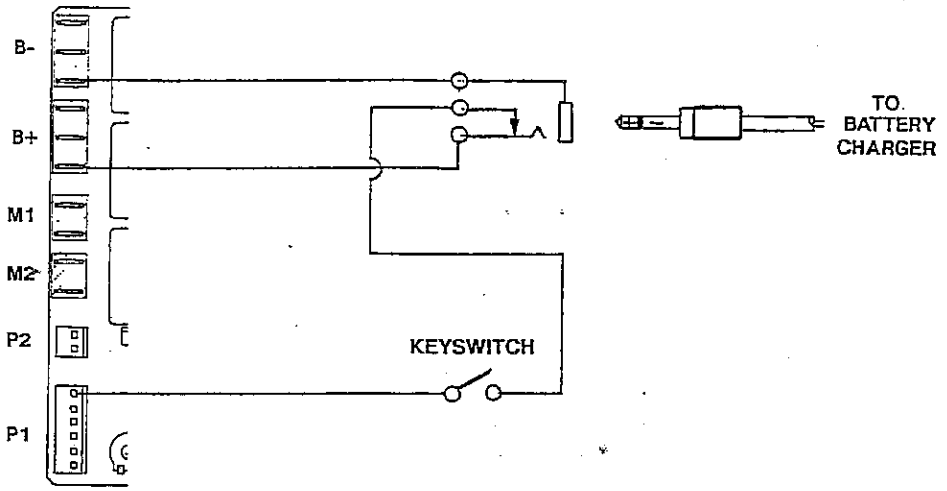


DIRECTION	VOLTAGE	
	WIG-WAG	SINGLE-ENDED
MAX FORWARD	≥ 4.7V	≥ 4.7V F/R Open
NEUTRAL	2.5 ±.3V	≤ 0.3V
MAX REVERSE	≤ 0.3V	≥ 4.7V F/R Closed

VOLTAGE INPUT THROTLE WIRING
FIGURE 5

CHARGER INTERLOCK WIRING (OPTIONAL)

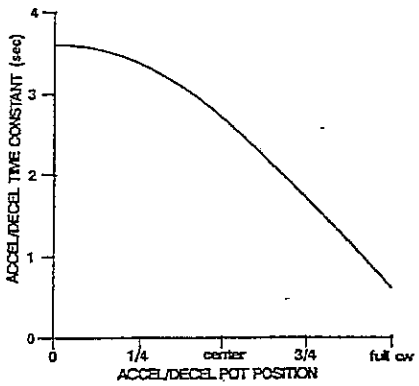
A battery charger interlock may be wired as shown in Figure 6. Power to the keyswitch will be interrupted when the battery charger is plugged in.



CHARGER INTERLOCK WIRING
FIGURE 6

ADJUSTMENTS

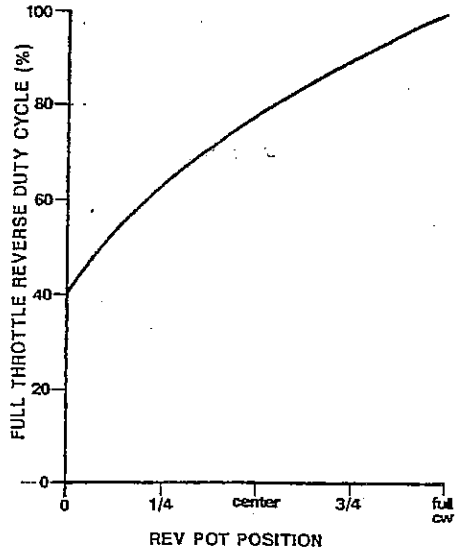
Throttle acceleration and deceleration rates may be independently adjusted by the **ACC** and **DEC** trimpots over a range of about 1/2 to 3 1/2 seconds. Acceleration time is the time to go from neutral to full forward or full reverse with a sudden throttle increase from zero to full throttle. Deceleration time is the time to return to neutral from full forward or reverse when releasing the throttle. Figure 7 shows these time constants in relation to the trimpot positions.



ACCELERATION/DECELERATION TIME CONSTANTS

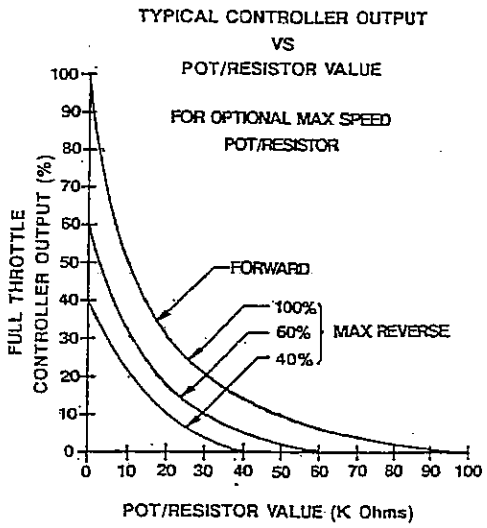
FIGURE 7

Maximum reverse duty cycle may be user adjusted with the **REV** trimpot over a range of about 40 to 100%. Duty cycle vs. trimpot position is shown in Figure 8. Maximum forward duty cycle is always 100% when no throttle limiting resistor is used at the throttle input terminals.



FULL THROTTLE REVERSE DUTY CYCLE
FIGURE 8

Vehicle top speed can be externally programed by use of the optional maximum speed pot/resistor shown in Figures 3, 4, 5. This control will reduce the top speed in both forward and reverse according to the chart shown in Figure 9.



MAXIMUM SPEED LIMITING
FIGURE 9

APPENDIX A

1203 A SPECIFICATIONS

MODEL NUMBER 1203A-	1XX,4XX	2XX,5XX	3XX,6XX
Nominal Input Voltage	12V	24V	36V
Operating Voltage Range	9-15V	18-30V	27-45V
Current Limit (15 sec rating)	90A	90A	60A
2 Minute Rating*	45A	45A	30A
1 Hr Rating*	30A	30A	20A
Regen Braking Current Limit	45A	45A	30A
Minimum Motor Resistance	.040Ω	.080Ω	.180Ω

ALL MODELS

Typical Voltage Drop	.25V @20A
Frequency of Operation	15 kHz
Speed Control Signal:	
1XX,2XX,3XX (single ended throttle)	5000Ω pot:200Ω =off, 4800Ω=full on **or** 0-5V: 0.3V=off, 4.7V=full on. Reverse operation when F/R input is high
4XX,5XX,6XX center off (wig-wag throttle)	5000Ω pot:200Ω =max REV, 2500Ω +/- 300Ω = neutral, 4800Ω =max FWD **or** 0-5V: 0.3V=max REV, 2.5V +/- 0.3V= neutral, 4.7V=max FWD
Electromagnetic Brake Output	1 amp @ nominal battery voltage
Brake Timing	Power applied to brake as throttle is applied, power off after throttle is in neutral 1 second.
Operating Ambient Temp Range	-10 to 45 C
Over Temperature Cutback Point	90 C at mounting plate (automatic reset)
Weight	10 ounces
Dimensions	5.00" x 6.00" x 1.25" h

* 2 Minute and 1 hr current ratings are mounting dependent. Controller will meet this specification when mounted to a 1/8" x 4" x 5" vertical aluminum plate via 3/8" x 1" aluminum spacers.

Model Number Code - First digit indicates voltage & throttle input type
Voltage--1,4 = 12V 2,5 = 24V 3,6 =36V
Throttle Input--1,2,3, = single ended throttle w/separate F/R input
4,5,6 = center off (wig-wag) throttle

APPENDIX B

1203A MOTOR CONTROLLER

CONTROL AND BRAKE CONNECTOR COMPATIBILITY

CONTROL CONNECTOR (P1):

PC board - Methode #3100-8-106-02 6 pin .156" centers header (locking)

Mating connectors - all available for 18-26 AWG wire

Methode #3300-106-218 (locking, insulation displacement, 18 AWG)
AMP #640426-6 (locking, insulation displacement, 18 AWG)
Molex #09-50-3061 (locking, crimp terminals)
Panduit #CE156F18-6 (locking, insulation displacement, wires at right angle, 18 AWG)

BRAKE CONNECTOR (P2):

PC board - Methode #3100-8-102-02 2 pin .156" centers header (locking)

Mating connectors - All available for 18-26 AWG wire

Methode #3300-102-218 (locking, insulation displacement, 18 AWG)
AMP #640426-2 (locking, insulation displacement, wires at right angle, 18 AWG)
Molex #09-50-3021 (locking, crimp terminals)
Panduit #CE156F18-2 (locking, insulation displacement, wires at right angle, 18 AWG)

APPENDIX C

MODEL 1203A DC MOTOR SPEED CONTROLLER FUNCTIONAL DESCRIPTION

The model 1203A series controllers are high-frequency, pulse width modulated, Power FET DC motor speed controllers. The half bridge FET configuration plus two direction relays result in full four quadrant motor operation (drive and regenerative braking in forward and reverse). The totem pole drive FET/regen FET output stage provides true bidirectional speed control for all vehicle operating conditions. Motor current is always positively controlled so there is never a condition where the motor can free wheel (coast).

During normal level ground operation, hill climbing or acceleration, motor current goes through the lower drive FET when it is on and through the internal diode of the regen FET when both FET's are off (during the sequencer dead times). When the regen FET turns on, its internal diode gets shunted by the FET turn on, thus further reducing voltage drop and power dissipation across the device (being used as a freewheel diode). During deceleration and downhill operation (regenerative braking), motor current goes through the regen FET when it is on and through the internal diode of the drive FET during the dead times. When the drive FET turns on, this diode drop again gets reduced by the FET turn on, thus making the "free-wheel diode" losses much smaller. In regenerative braking mode currents built up in the motor (to cause braking) are cycled back to the battery. In neutral, the For/Rev relays return to neutral and the motor is dynamically braked by the shorted relay contacts. Motor speed is adjusted by varying the duty cycle of the Power FET half-bridge output stage according to the throttle control input signal. Motor drive and regen current limiting, broken control wire detection, high-pedal disable, polarity protection, precharge turn-on detection and low battery voltage detection are some of the additional features to also be described in the following discussion (refer to block diagram).

Controller operation commences with turning on of the keyswitch. Polarity protection is provided here so that a reversal of the battery connections (B+, B-) will not allow the controller to be turned on. Once the keyswitch is turned on, the precharge control circuit takes care of the orderly turn on of the controller.

Filter capacitors in the power section provide the instantaneous current pulses required by the pulse-width modulated Power FET output stage and also prevent voltage spikes from disrupting the control or power circuitry. These capacitors would normally require a large current surge (to charge them up to the battery voltage) from the keyswitch and main power relay when first turning on the controller. The precharge circuit eliminates this surge by slowly charging the capacitors at turn-on. Only when

the capacitors charge up to about two-thirds nominal battery voltage does the precharge circuit allow the main power relay to turn on. The resulting current flow is low and well controlled, thus resulting in maximum keyswitch and power relay life. The precharge sensing circuit also acts as an undervoltage cut-out and provides other safety features. If battery voltage is too low, the controller will not turn on. Also, if the FET's, sequencer or drive circuits have failed, the controller will not turn on because the capacitor voltage can never rise far enough to allow the precharge circuit to turn on the main power relay. Turning the keyswitch off immediately removes all power from the controller and brakes the motor to a stop through the normally closed relay contacts.

Once the controller is on, battery voltage is fed directly to some of the control circuitry while the voltage control circuit reduces, filters and current limits the battery voltage for operating the rest of the control circuitry.

Duty cycle control for the pulse width modulator (PWM) is derived from the throttle input signal which may be provided from two possible sources:

1. 5K ohm, three wire potentiometer
2. 0-5V voltage input

Maximum speed in either case may be externally limited using the series resistor shown. This resistor restricts the input voltage swing which results in a limited duty cycle for both forward and reverse operation.

Problems caused by broken throttle potentiometer, wiper element or wires are eliminated by the pot fault detection circuit. If any of these conditions occur, the controller returns to neutral throttle conditions (zero duty cycle).

Throttle control by the 5K ohm potentiometer or 0-5V voltage input may be one of two possible configurations:

1. Single-ended throttle
2. Wig-wag (center-off) throttle

Forward and reverse direction for single-ended throttle is determined by the external FWD/REV switch. Switch open is forward and switch closed is reverse. If either of the switch wires breaks, the controller will default to forward operation. Neutral throttle is 200 ohms or less for the 5K ohm potentiometer or 0.3V or less for the voltage input. Full throttle is 4.8K ohm for potentiometer input or 4.7V for voltage input.

Forward or reverse detect for wig-wag throttle is determined by sensing the level of the throttle input signal. Neutral throttle is center-off for the 5K ohm potentiometer or 2.5 volts for the voltage input. A (+/-).3V neutral dead band allows adequate tolerance for accommodating variations in centering of the

throttle potentiometer. Throttle inputs greater than 2.8 volts select forward operation and the forward direction relay. Inputs less than 2.2. volts select reverse operation and the reverse direction relay.

Forward/reverse logic controls the dual ramp automatic reversing to provide smooth speed transistions when rapidly changing vehicle direction (for slow direction changes the duty cyle will follow the throttle input signal unless any current limit conditions occur). The forward/reverse logic determines if the controller direction needs to be changed by comparing the direction input sigal (FWD/REV switch for single-ended throttle or internal FWD/REV detect for wig-wag throttle) with the direction the controller is currently operating. If these two signals agree, no action is taken and the controller operates normally in the direction it is currently going. If these inputs disagree (by changing direction with the external FWD/REV switch for single-ended throttle or with the throttle pot for wig-wag throttle) the logic causes ramp down to smoothly pull the throttle towards neutral through the deceleration time constant. If throttle is still applied when the controller reaches neutral, the logic will then allow the throttle to smoothly increase to the speed determined by the throttle input through the acceleration time constant. This dual ramp reversing may be delayed if drive or regen current limiting occurs during acceleration or deceleration.

If rapid vehicle deceleration creates excessive regenerative motor currents, regen current limit will operate and will not allow the duty cycle to decrease to neutral until the vehicle has slowed down enough to reduce regenerative current below the limit level (typ. 45A). Once the controller is out of regen current limit, the duty cycle can decrease to zero as the controller goes into neutral. Then, if throttle is still applied, the duty cycle will begin increasing. If excessive motor currents occur during acceleration, drive current limit will keep the duty cycle from increasing until the over-current condition is removed.

Abrupt vehicle starting problems are eliminated by the high-pedal disable function. High-pedal detect determines if the throttle is depressed (on) when the keyswitch is turned on. If this condition occurs, the controller will be forced to remain in neutral until the throttle is reduced to a low level. The controller will then operate normally and high-pedal detect will not look again until the keyswitch is turned off and back on again.

In standard controller configurations, forward speed range is from 0 to 100% (zero to max speed) and reverse speed range is from zero to a nominal 60% as set during manufacturing. Reverse speed scaling may be set in the range of about 40-100% duty cycle (percent of maximum speed) during manufacturing or may be set by the user by adjusting the REVerse speed potentiometer.

Vehicle acceleration and deceleration rates may be independently set during manufacturing or may be set by the customer. These rates may be symmetrical (acceleration/deceleration rates the same) or asymmetrical (acceleration/deceleration rates different) and are set by adjusting the ACC/DEC potentiometers. These pots set RC time constants which limit the rate of change of the throttle control input signal.

After accel/decel control, the throttle control signal then passes through the limit integrator which performs these functions:

1. scales the control signal for the PWM
2. **reduces** controller output duty cycle in response to motor drive over-current or battery undervoltage conditions
3. **increases** duty cycle in response to motor regen over-current condition.

The resulting conditioned throttle input signal from the limit integrator then directly determines the output duty cycle of the FET switches via the PWM, sequencer and drive circuits.

An integrated circuit pulse-width modulator converts the conditioned throttle input signal into a smoothly varying fixed frequency duty cycle control signal for the power FET output stage. This variable duty cycle signal is modified by the sequencer to properly drive the power output stage and the drive and regen current limit disablers.

The sequencer provides interlaced drive waveforms from the PWM to assure that both the lower drive FET's and the upper regen FET's are never turned on at the same time. The sequencer inserts a dead time (all FET's off) between when the drive FET's turn off and the regen FET's turn on and vice versa. The drive circuits amplify and level shift the sequencer waveforms to the appropriate levels to drive the output stage power FET's.

Motor drive current limiting is accomplished by sensing the voltage drop across the drive FET when the FET is on. This sensed FET voltage is compared to a reference voltage which sets the controller current limit. When this reference voltage is exceeded, the current limit comparator forces the limit integrator to reduce the controller output duty cycle to hold the output current at the limit level until the over-current conditon is removed. When the drive FET is off, the current limit signal is not valid (controller output is high or drive FET is acting as a free wheel diode). During this time the current limit disabler keeps these false signals from getting to the current limit comparator.

Motor regenerative current limiting operates in the same fashion as drive current limiting. Regen FET voltage drop is sensed when the regen FET is on. This voltage drop is compared with a reference which sets maximum regenerative current. When the

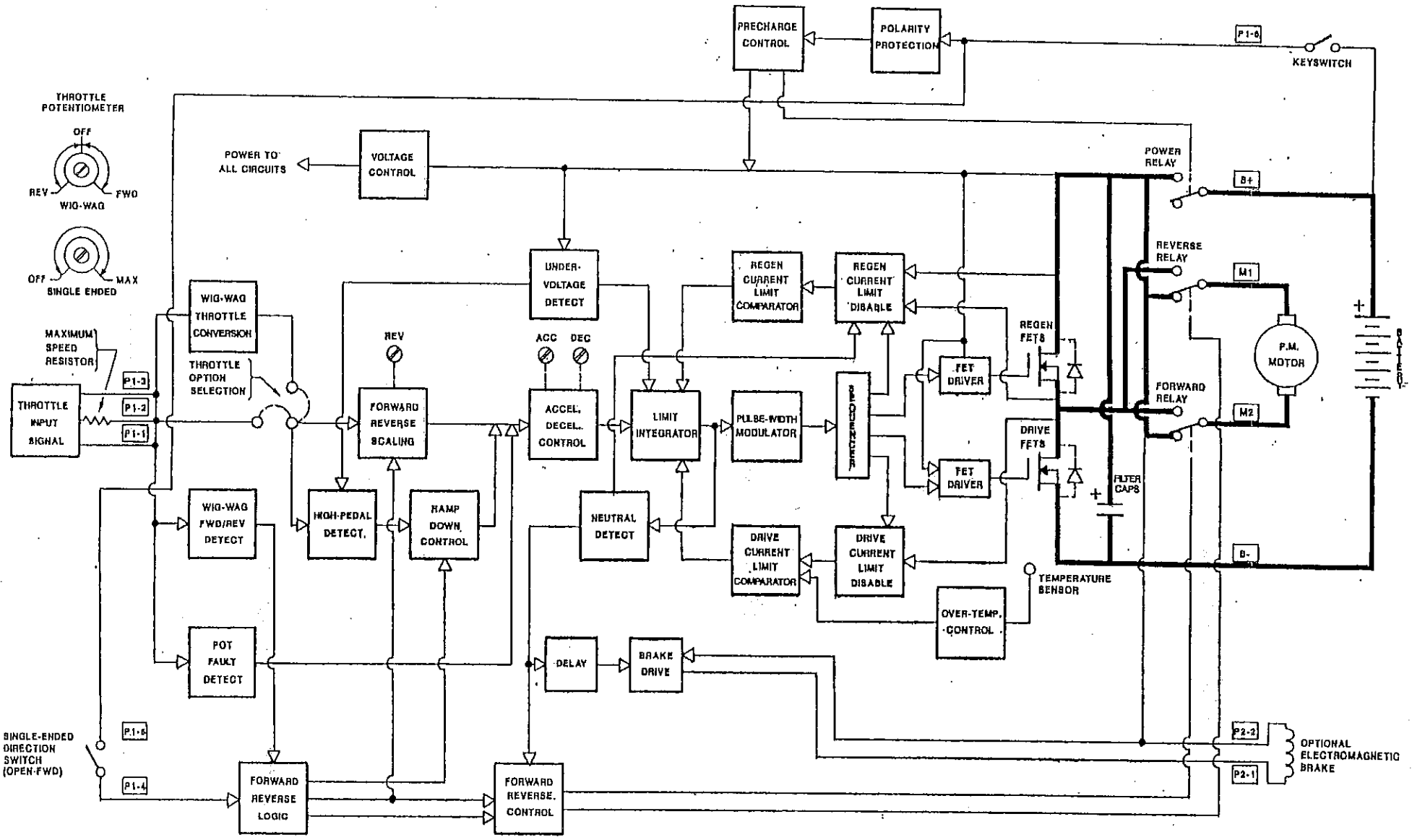
reference level is exceeded, the regen current limit comparator forces the limit integrator to **increase** the controller output duty cycle to keep the regen current absorbed by the controller at the limit level until the over-current condition is removed. When the regen FET is off, the current limit signal is disabled by the current limit disabler. This regenerative current limit feature allows the use of relatively large, low resistance motors (see specification sheet) without the problem of excessive regenerative currents causing harm to the controller or motor while maintaining relatively large braking current (typ. 45A).

Motor voltage polarity will be as follows. When forward operation is selected, terminal M1 is connected to B+ via the reverse relay and terminal M2 is connected to the pulse-width modulated controller output via the forward relay. As the throttle is increased, M2 is modulated a larger percentage of the time towards B-. At full throttle M2 is connected to B- 100% of the time so that full battery voltage is applied to the motor. In reverse operation the functuions of terminals M1 and M2 are reversed. M2 is connected to B+ while M1 is modulated by the controller. Maximum reverse duty cycle will be as set by the REV trimpot.

Thermal protection circuitry reduces controller output drive current in response to an over-temperature condition. This feature protects both motor and controller from exscessive heating. Normal current output is returned once the controller cools back down below the thermal cut-back temperature.

When the batteries discharge in normal operation to about two-thirds of nominal battery voltage, the under-voltage detect circuit forces the limit integrator to cut back motor current to maintain battery voltage at the cut-back voltage. This allows the vehicle to be operated on low batteries, with reduced performance, but will not allow the batteries to discharge beyond this cut-back voltage.

A spring set motor brake may be operated by the optional electro-magnetic brake circuit. The circuit operates by detecting neutral throttle and by providing a unidirectional time delay to drive the brake. When increasing throttle from neutral to forward or reverse, the brake coil is immediately energized to allow the vehicle to operate. The delay operates when returning from forward or reverse back to neutral. This delay allows time to go from forward to reverse, or vice versa, without the brake operating as the throttle passes through neutral. Nominal brake delay is one second but may optionally be changed.



BLOCK DIAGRAM 1203A SERIES CONTROLLERS

CURTIS PMC

PMC-B-526

1203A SERVICE POLICY

From Curtis PMC to You

This agreement is extended by Curtis PMC to the OEM who purchased the controller.

Curtis PMC expressly states that its standard product will be free of defects in workmanship or materials under normal use for twelve months. To allow for the delay between shipments and production, the warranty period is extended to fifteen months from the Date Code (D/C) date. The D/C can be found on the controller ID label.

What is Covered

We will, at our option, repair or replace any qualified 1203A Curtis PMC motor speed controller at no charge.

What is not Covered

We will not cover damages caused by misuse, abuse, contamination or faulty installation. Controllers whose Date Code has exceeded fifteen months will not be covered under this agreement.

What You must Do

The motor speed controller must be installed according to the outlined installation instructions in the 1203A Installation/Operations Manual. You must adequately protect the controller from environmental contamination that could damage the controller. The controller must be used in an application suitable for its intended design.

How to Obtain Service

Manufacturers purchasing Curtis PMC products, may obtain service by contacting the Curtis PMC Customer Service Department at 415-828-5001.

Ship to: *Customer Service Department*
Curtis PMC
6549 Sierra Lane
Dublin, CA 94568