

CTD – TRANSAXLE DRIVE SYSTEM

DESCRIPTION:

The transaxle drive system is a 24Volt DC powered motorized traction drive system that uses a differential style axle to propel various wheeled carts. This system utilizes a state of the art electronic motor controller to control several parameters of the motor. While these parameters are programmable, they are set at the factory and can not be changed by the customer. However, if parameters need to be changed, the customer can remove the controller off the cart and send it back to Vestil for changes to be made.

OPERATION:

The traction drive system utilizes a twist throttle type speed input device to control the forward and reverse speeds of the cart. The throttle position is proportional to the speed of the cart, if the throttle is at half open position, the cart is moving at half the speed.

To use the traction drive system, turn the system on with the toggle switch (red cap) located in the upper right corner of the twist throttle. Slowly twist the throttle back towards the operator. To reverse directions, push the toggle switch located on the throttle assembly (black switch). Always allow the cart to come to a full stop before reversing directions. When turning, make turns slowly as the differential drive system will increase speeds on turns

If the traction drive system is left on and not used for several minutes, the unit will go into a sleep mode and shut off. To reset the system, simply turn the on/off switch off and back on again. Then twist the throttle several times and it will reset. It is recommended to shut the unit off when not in use to save battery life. Never ride on the cart. Always be aware of objects or personnel around you. Never use the cart in wet environments, the motor and controller are not sealed and water will damage these components.

MAINTENANCE:

The transaxle drive is greased from the factory and comes ready to use. In most cases, service should never be required for the transaxle drive. However, in extremely high duty, dirty environments, service of the differential case may be required annually. Carefully separate the differential and clean the case out with clean mineral spirits and dry with compressed air. Repack the unit with any good quality bearing grease and reassemble.

Batteries should be kept at full charge when stored for prolonged periods of time. It is recommended that the charger be plugged in when the cart is not in use. Always turn the drive unit (red toggle switch) off when not in use, leaving the unit on will drain the batteries. The supplied battery charger is designed to be left hooked to the batteries without risk of overcharging and damaging the batteries. Once the charger is plugged in, the charger can be left on for an indefinite amount of time. The charger will bring the batteries up to full charge and shutoff once

the batteries have reached full charge. The charger will then periodically monitor the battery state and recharge the batteries if necessary. If storing unit for longer than 3 months, remove battery from cart and store in a cool, dry place.

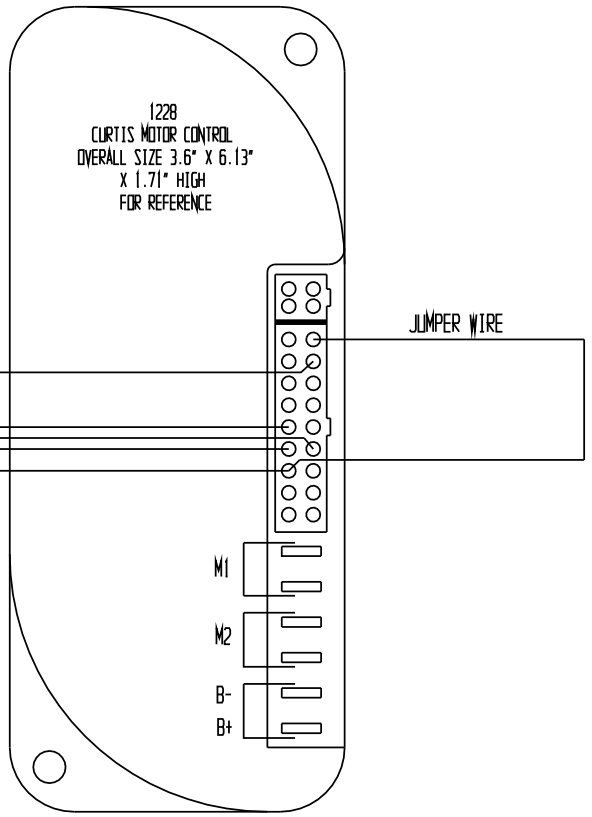
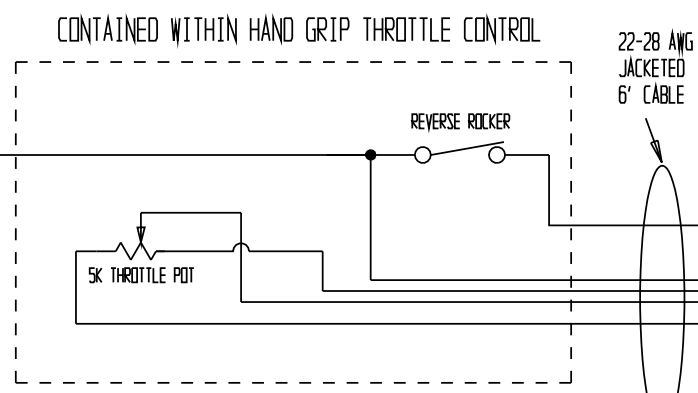
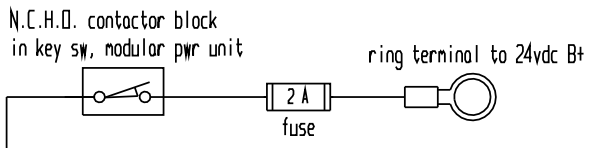
TROUBLE SHOOTING:

<u>Problem-</u>	<u>Cause-</u>	<u>Solution-</u>
When twisting the throttle Nothing happens	Switch is in off position	Turn switch on
	Unit is in sleep mode	Turn switch off and back on And twist the throttle several times
	Low voltage	Plug charger in and bring batteries to full charge
	Drive wheel is not contacting ground	push cart until wheel touches ground
	Batteries terminals are corroded	Clean both sets of terminals
	In line fuse is blown	Replace fuse
Unit goes forward but will Not reverse or vice-versa	Toggle switch is defective	Replace toggle switch
	Controller is bad	Consult factory
Unit takes off to Quickly or slows down to Quickly	Controller needs programmed	Consult factory

For any additional information or questions please contact Vestils' technical service department at (260)665-7586

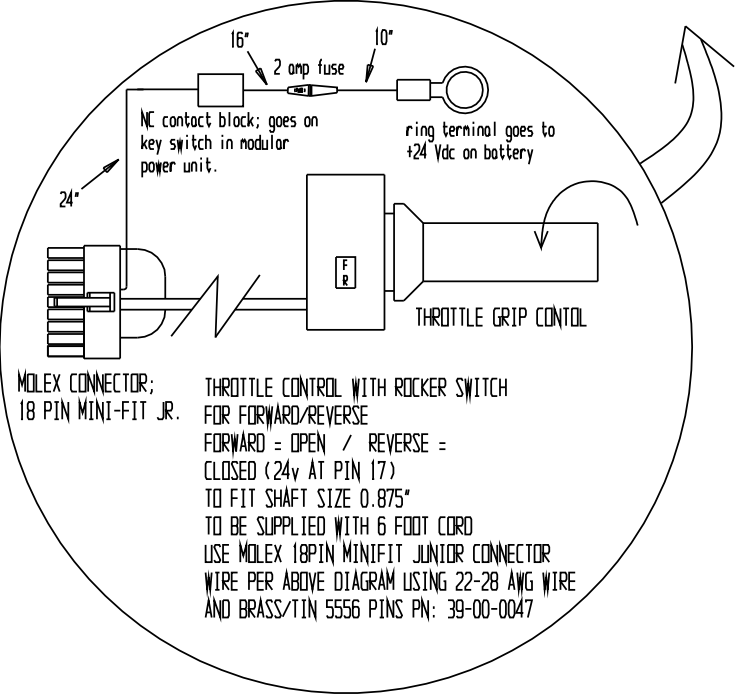
DRAWING NUMBER
21-124-029
REV.
B

REV.	DATE	REVISIONS	INITIAL
B	21-124-029		
A	07/18/01	UPDATE PIN OUT; ECR# 01-064	TG
B	02/25/09	Move on/off sw to mod pwr unit	TG



18-PIN CONNECTOR DETAIL
MINI-FIT JR.
P/N 39-01-2180 WITH
5556 PINS
FOR REFERENCE

NC	9	18	SPEED POT
NC	8	17	REVERSE
NC	7	16	NC (NO CONNECTION)
NC	6	15	NC
ON/OFF KSI	5	14	NC
POT WIPER	4	13	POT LO
POT HI	3	12	NC
NC	2	11	NC
NC	1	10	NC

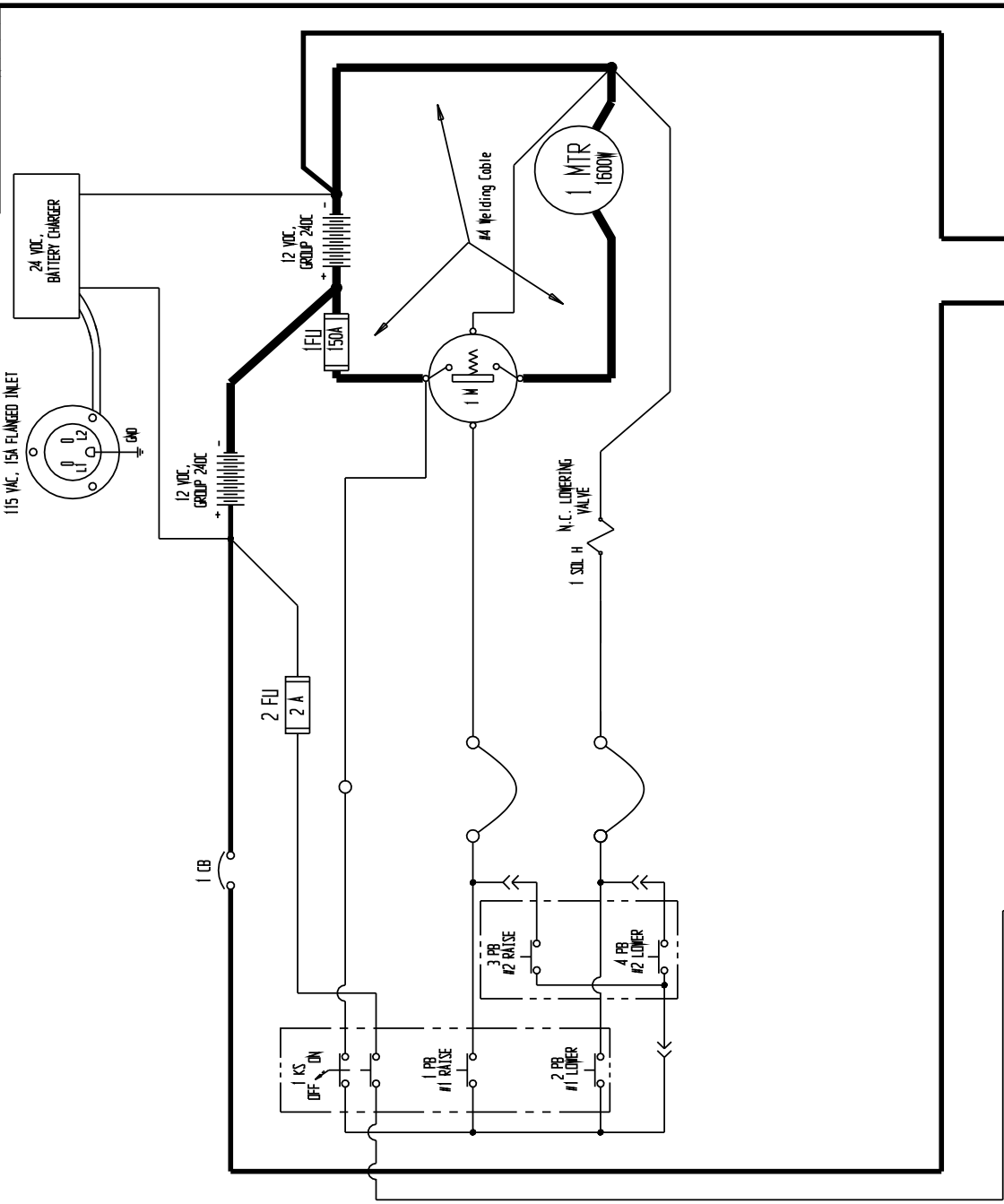


VESTIL MANUFACTURING CO.

SCALE: N/A	APPROVED BY:	DRAWN BY: T. GORRELL
DATE: 04/06/01		SIZE: B
SCHEMATIC, ELECTRICAL, THROTTLE CONTROL, PWD LIFT CART		
MATERIAL: N/A	QTY. #: 21-124-029	REV: B

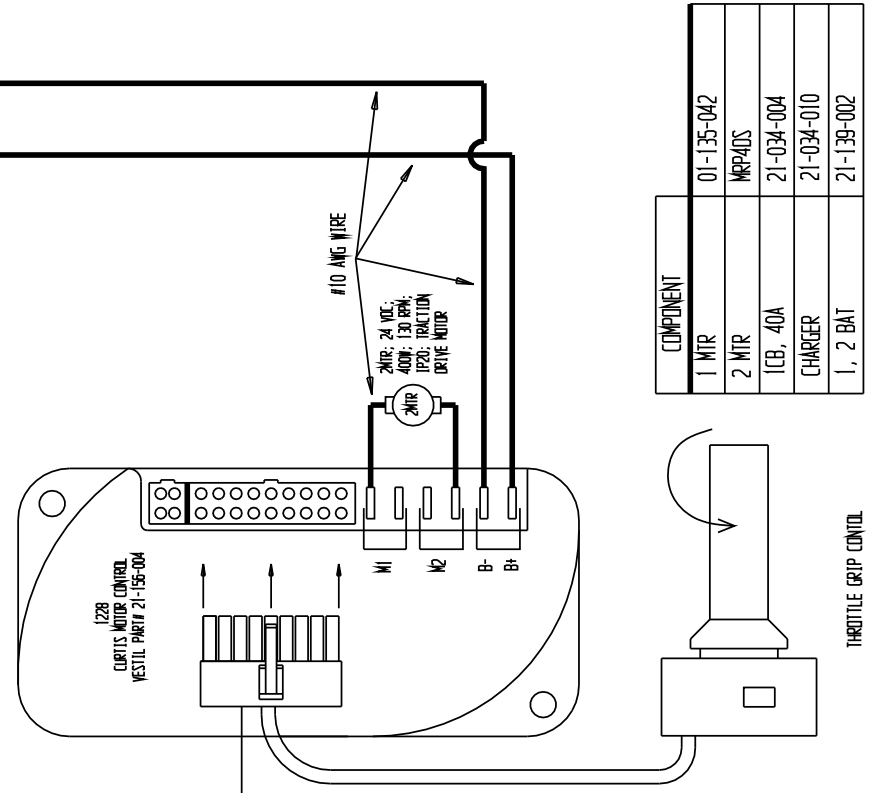
DRAWING NUMBER
21-124-030

REV.
C



REV. C
DATE: 21-124-030

REV.	DATE	REVISIONS	INITIAL
A	7/16/03	CORRECT CB PN; ECR 03-087	TG
B	4/26/06	UPDATE FOR MOD. PWR. UNIT	TG
C	2/27/09	REMOVE SMART START	TG



COMPONENT	PN
1 MTR	01-135-042
2 MTR	MRP40S
1 CB, 40A	21-034-004
CHARGER	21-034-010
1, 2 BAT	21-139-002

VESTIL MANUFACTURING CO.

SCALE: N/A	APPROVED BY:	DRAWN BY: T. GORRELL
DATE: 05/15/01		SIZE: B
SCHEMATIC, ELECTRICAL, PWD LIFT CART, CTD		
MATERIAL: N/A	DRAWING NUMBER: 21-124-030	REV: C

INSTRUCTIONS FOR : Troubleshooting CTD Throttle Grip

VESTIL MFG. CO. / T&S EQPT. CO.

PRODUCTS USED ON:
CTD

The attached print shows the basic throttle grip assembly as it connects to the Curtis motor controller. These instructions are a guide to troubleshooting the throttle grip.

READ ALL INSTRUCTIONS BEFORE PROCEEDING!
Only trained and qualified service personnel should work on this equipment!
Lock out all potential energy sources before attempting this installation!

WARNING: Some conditions could cause the CTD to run out of control. Jack the wheels of the CTD off the ground before attempting any work on the motor control circuitry.

To verify the throttle grip is working properly, first unplug the connector from the controller and measure the resistance on the following pins. The values should be as indicated. If the unit is under warranty, do not disassemble the grip. If the unit is under warranty, just make the following measurements to verify operation...if the unit is found defective, contact Vestil for a replacement.

Note: The pin out shown to the right of the motor controller on the diagram is for the motor controller... looking at it. So when testing the throttle grip, it must be held in the same orientation as it would be when plugging it into the controller. The contacts can then be probed from the back side of the molex connector.

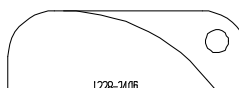
All values should be within +/- 10%

- 1) Pin 3 to 13 = 5,000 ohms...if not, then the throttle pot may be defective, or have bad wiring connections.
- 2) Pin 13 to 4 < 500 ohms...if not, verify the throttle grip is not bound up and at home position. If the grip has been disassembled, verify it has been put back together properly. The gear from the potentiometer has to be at "home" position ("zero" ohms) at neutral. If the potentiometer will not go to zero (even after the throttle grip has been disassembled), then it may be defective, or have bad wiring connections.
- 3) Pin 13 to 4 = 5,000 ohms with throttle twisted to "maximum speed."...if not, then check for the same problems as in 2).
- 4) Pin 5 to 10 = zero ohms with on/off switch in the on (down) position; and "open" (no value) when the switch is in the off (up) position...if not, verify switch operation and/or connections.
- 5) Pin 5 to 17 = zero ohms with the forward/reverse switch in the reverse direction; and "open" when in the forward direction...if not, then verify switch operation and/or connections.

Related documents:

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REV.	ENG #:	REV.	DATE	REVISIONS	INITIAL
	21-124-029	A	07/18/01	UPDATE PIN OUT; ECR# 01-064	TAG



MODEL 1228 CONTROLLER (Rev. L) WORKSHEET

APPLICATION PARAMETERS						UNITS		
VEHICLE TYPE	Material Handling Equipment						Type of vehicle: Cart Traction Drive CTD	
VEHICLE GROSS WEIGHT	NA					kg/lbs	Vehicle weight plus Max load	
VEHICLE SPEED	NA					MPH	Maximum vehicle speed	
E/M BRAKES	NA					Amps	Electro-mechanical brake current, if used	
MOTOR POWER	1/3 HP					KW/HP	Size of motor and power rating	
MOTOR RESISTANCE (COLD)	250					m Ohm	Resistance of the motor when cold	
CONTROLLER PARAMETERS		RANGE	DEFAULT	DESIRED	*	ACCESS	UNITS	
MAIN C/L SETTING	30A to 70A/110A	70A / 110A	70	0	O		Amps	Maximum current limit in drive or regen braking.
MOTOR R	0 - 625	200 for 70A, 130 for 110A	125	0	O		m Ohm	Sets motor resistance used for speed estimation. This param amount is determined by another parameter, IR COMP COEFF
IR COMP COEFF	0 - 100	50	50	0	O		%	The value of motor compensation the controller uses to acco
KEY OFF DECEL	0.2 - 4.0	0.6	0.2	0	U		Sec.	Time to reach zero output from full output only after the key s1
TREMOR COMP	1 - 5	3	1	0	U		-	Controls vehicle response to sharp throttle movements. Large
ACCEL MAX SPEED	0.2 - 4.0	1.4	0.6	u	U		-	Sets the forward acceleration rate with the speed potentiomet
ACCEL MIN SPEED	0.2 - 8.0	4.0	0.4	u	U		-	Sets the forward acceleration rate with the speed potentiomet
DECEL MAX SPEED	0.2 - 4.0	1.4	0.4	0	O		-	Sets the forward deceleration rate from high speeds. Smaller
DECEL MIN SPEED	0.2 - 8.0	4.0	0.4	0	O		-	Sets the forward deceleration rate from low speeds. Smaller
ESTOP	0.2 - 4.0	0.6	0.2	0	O		Sec.	Sets the emergency stop deceleration rate. Emergency stop
REVERSE ACCEL MAX	0.2 - 8.0	2.0	0.6	u	U		-	Sets the reverse acceleration rate with the speed potentiomet
REVERSE ACCEL MIN	0.2 - 8.0	5.0	0.6	u	U		-	Sets the reverse acceleration rate with the speed potentiomet
REVERSE DECEL MAX	0.2 - 4.0	1.8	0.4	0	O		-	Sets the reverse deceleration rate from high speeds. Smaller
REVERSE DECEL MIN	0.2 - 8.0	3.8	0.4	0	O		-	Sets the reverse deceleration rate from low speeds. Smaller
M1 MAX SPEED	0 - 100	60	100	u	U		%	The speed requested in forward with the throttle and speed lir
M2 MAX SPEED	0 - 100	100	100	u	U		%	The speed requested in forward with the throttle and speed lir
M1 MIN SPEED	0 - 100	20	30	0	U		%	The speed requested in forward with the throttle set to maxim
M2 MIN SPEED	0 - 100	15	38	0	U		%	The speed requested in forward with the throttle set to maxim

CONTROLLER PARAMETERS	RANGE	DEFAULT	DESIRED	*	ACCESS	UNITS	
M1 REVERSE MAX SPEED	0 - 100	40	60	U	U	%	The speed requested in reverse with the throttle pot and speed
M2 REVERSE MAX SPEED	0 - 100	40	100	U	U	%	The speed requested in reverse with the throttle pot and speed
REVERSE MIN SPEED	0 - 100	15	30	U	U	%	The speed requested in reverse with the throttle set to maximum
GEAR SOFTEN	0 - 100	10	0	O	O	-	Softens the bump associated with gear slack in the transaxle take up.
SOFT START	0 - 100	0	0	O	U	-	Softens the bump associated with gear slack in the transaxle take up.
RAMP SHAPE	20.0 - 70.0	50.0	50.0	U	U	%	Adjusts desired speed request at 50% throttle to vary throttle
BDI FULL VOLTAGE	23.4 - 25.0	24.6	24.6	O	O	Volts	Voltage at or above which 100% BDI is displayed.
BDI EMPTY VOLTAGE	19.0 - 24.0	20.8	20.8	O	O	Volts	Voltage at or above which 0% BDI is displayed.
BDI RESET VOLTAGE	0.0 - 40.0	27.0	27.0	O	O	Volts	Reset voltage where the BDI resets to full.
SLEEP DELAY	0 - 60	30	20	O	U	Min.	Sets the delay time since last throttle request until the controller
BRAKE DELAY	0.0 - 1.0	0.2	0.2	O	O	Sec.	Maximum time delay for brake engagement in the event that the
CREEP SPEED	0.0 - 10.0	8.0	8.0	O	U	%	The speed requested when the throttle is just outside the neutral
THROTTLE TYPE	0 - 5	0 (Wig-Wag)	2	O	O	-	Type of throttle input: (0) wig-wag 5 kOhm or Volt, (1) inverted 5 kOhm, (4) single-ended 0-5 volt, (5) inverted single-ended 5-
THROTTLE DEADBAND	6.0 - 25.0	10.0	15.0	O	O	-	The range of throttle travel that represents neutral.
THROTTLE GAIN	1.0 - 10.0	1.1	1.4	O	O	-	The multiplier that represents full scale throttle travel. 1 = 5k t
THROTTLE AUTOCAL	ON/OFF	OFF	OFF	O	O		Tool for centering wigwag throttle pot. A horn must be connected
SPEED SCALER	20.0 - 28.0	24.0	24	O	O	Volts	Maximum motor output voltage at 100% throttle to stabilize motor
HIGH PEDAL DISABLE	ON/OFF	ON	ON	O	O	-	Disables controller if throttle is applied before the KSI input. If
FAULT BEEP	ON/OFF	ON	OFF	O	O	-	Controller provides a signal to the horn driver circuit when a fault
SEAT LIFT	ON/OFF	OFF	OFF	O	O		Enables/disables seat lift mode.
BRAKE FAULTS	ON/OFF	ON	OFF	O	O	-	Enables/disables brake faults.
SEAT LIFT BRAKE FAULTS	ON/OFF	OFF	OFF	O	O	-	Enables/disables brake faults in seat lift mode.
PUSH SPEED	25 - 50	35	35	O	O	%	Limits the speed at which the vehicle can be pushed in push r

MANUAL

CURTIS PMC

MODEL **1 2 2 8**

MultiMode™
MOTOR CONTROLLER

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DESIGN OF CURTIS PMC 1200 SERIES
CONTROLLERS PROTECTED BY U.S.
PATENT NO. 4626750.

CURTIS

CURTIS PMC

235 East Airway Boulevard
Livermore, California 94550 USA
Tel: 925-961-1088
Fax: 925-961-1099
www.curtisinst.com

Draft #4
30 Nov. 2000

1228 Manual, p/n 36148
Rev. B: November 2000

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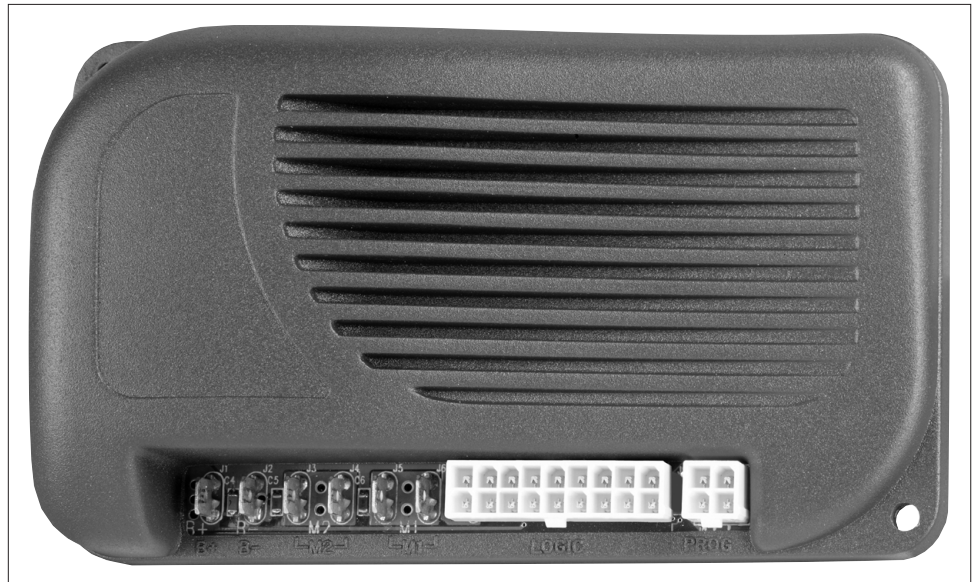
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OVERVIEW

The Curtis PMC 1228 MultiMode™ controller is a permanent magnet motor speed controller designed for use in mobility aid scooters and other small electric vehicles, such as sweeper/scrubbers. It offers smooth, silent, cost effective control of motor speed and torque. A four quadrant, full bridge power output stage provides for solid state motor reversing and full braking power without additional relays or contactors.

The 1228 controller is fully programmable by means of the Curtis PMC 1307 handheld programmer.* Use of the programmer offers diagnostic and test capability as well as configuration flexibility.

Fig. 1 Curtis PMC 1228 MultiMode™ electronic motor controller.



Like all Curtis PMC motor controllers, the 1228 offers superior operator control of the vehicle's motor drive speed. In addition, the 1228 controls the seat lift motor if one is used. **Features include:**

- ✓ Full bridge power MOSFET design, providing
 - infinitely variable forward, reverse, drive, and brake control
 - silent high frequency operation
 - high efficiency
- ✓ Programmability through the Curtis PMC handheld programmer
- ✓ Complete diagnostics through the handheld programmer and an OEM-supplied status LED
- ✓ Full compliance with all applicable international standards

* Other Curtis PMC programmers may also be applicable.

More Features ➞

- ✓ Available for single-ended or wigwag 5k Ω potentiometer throttles and 0–5V throttles (both standard full stroke and restricted range)
- ✓ MultiMode™ input selects between two different operating modes, thus allowing optimization of vehicle characteristics for different driving conditions (for example, indoor/outdoor)
- ✓ Speed limit input provides linear variable speed limiting when an external speed limit pot is used
- ✓ Current limiting in both driving and regenerative braking modes
- ✓ Load compensation stabilizes speed on ramps and over obstacles
- ✓ Speed scaler eliminates variations in maximum speed that would otherwise result from variations in battery charge levels
- ✓ High pedal disable (HPD) function with lockout monitors status of the throttle during turn-on and prevents operation until the throttle has been returned to neutral
- ✓ Key-off deceleration function provides a controlled deceleration if the keyswitch is turned off while driving
- ✓ “E Stop” provides a faster deceleration for emergency stops
- ✓ Seat lift function simplifies the wiring required to implement seat lift in DME scooter applications
- ✓ Comprehensive fault detection monitors main contactor, output stage, throttle demand vs. output, etc., and disables the drive functions if any conditions are outside specified limits
- ✓ ISO 7176 compliant throttle fault detection circuitry inhibits driving if throttle pot signal goes out of range for any reason
- ✓ Missing/shorted brake detection forces neutral in the event of an open or shorted brake circuit
- ✓ Anti-rollback/anti-roll-forward function sets brake delay according to speed and direction for improved braking response and minimized rollback on hills, etc.
- ✓ Reverse beeper option can be used to drive an OEM-supplied low current dc horn when vehicle is in reverse
- ✓ “Push” input electrically releases brake for key-on pushing (requires that the vehicle be stopped first)
- ✓ “Push-Too-Fast” feature guards against unpowered vehicle runaway by powering up and regulating motor voltage to limit vehicle speed
- ✓ Inhibit input disables the controller and puts the vehicle in a safe state during charging, etc.

- ✓ Power saver deactivates the main relay after 25 seconds of non-operation and deactivates the entire controller after the programmed sleep delay has elapsed
- ✓ BDI output can be used to provide data to a voltmeter; the BDI output can be “stuffed” (optional) in order to display the battery state of charge during battery charging even while the keyswitch is turned off
- ✓ Undervoltage cutback function protects against operation at low battery voltage
- ✓ Overvoltage protection shorts the motor and disables driving in the event of excessive battery voltage
- ✓ Thermally protected and compensated for stable output
- ✓ Reverse polarity protection (battery input)

Familiarity with your Curtis PMC controller will help you install and operate it properly. We encourage you to read this manual carefully. If you have questions, please contact the Curtis office nearest you.



Working on electric vehicles is potentially dangerous. You should protect yourself against runaways, high current arcs, and outgassing from lead acid batteries:

RUNAWAYS — Some conditions could cause the vehicle to run out of control. Disconnect the motor or jack up the vehicle and get the drive wheels off the ground before attempting any work on the motor control circuitry. NOTE: If the wrong combination of throttle and switch styles is selected with the handheld programmer, the vehicle may suddenly begin to move.

HIGH CURRENT ARCS — Electric vehicle batteries can supply very high power, and arcs can occur if they are short circuited. Always open the battery circuit before working on the motor control circuit. Wear safety glasses, and use properly insulated tools to prevent shorts.

LEAD ACID BATTERIES — Charging or discharging generates hydrogen gas, which can build up in and around the batteries. Follow the battery manufacturer’s safety recommendations. Wear safety glasses.

2

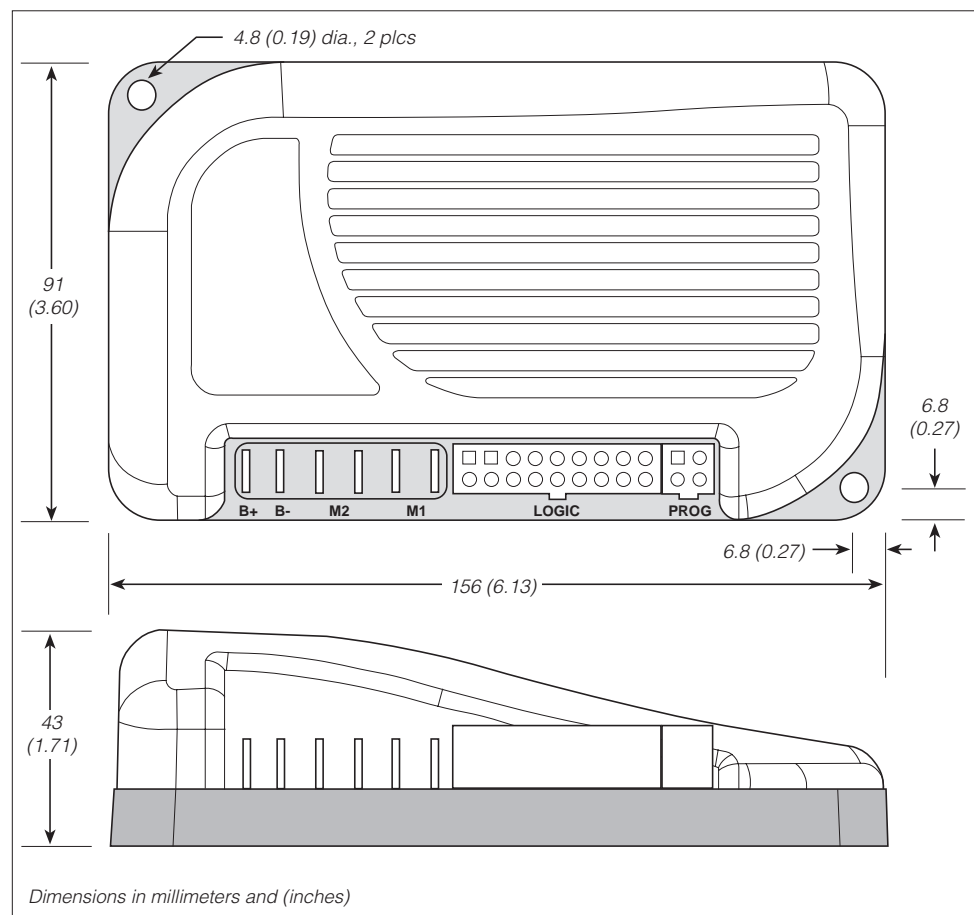
INSTALLATION AND WIRING

MOUNTING THE CONTROLLER

The 1228 controller can be oriented in any position, but **the location should be carefully chosen to keep the controller clean and dry. If a clean, dry mounting location cannot be found, a cover must be used to shield the controller from water and contaminants.**

The outline and mounting hole dimensions are shown in Figure 2. The controller should be mounted by means of the two mounting holes at the opposing corners of the heatsink, using M4 × 20 mm (#8 × 0.75") screws. This will give 6 mm (0.25") of exposed screw, which can be increased according to the thickness of the mounting site.

Fig. 2 *Mounting dimensions, Curtis PMC 1228 controller.*



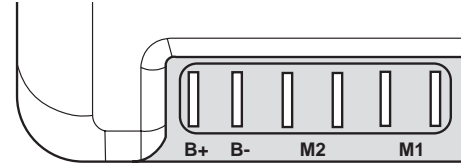
You will need to take steps during the design and development of your end product to ensure that its EMC performance complies with applicable regulations; suggestions are presented in Appendix C.

The 1228 controller contains **ESD-sensitive components**. Use appropriate precautions in connecting, disconnecting, and handling the controller. See installation suggestions in Appendix C for protecting the controller from ESD damage.



CONNECTIONS: High Current

Six 1/4" quick-connect terminals are provided for the high current connections. Two terminals each are provided for the motor **M1** and **M2** connections. The battery connections (**B+**, **B-**) have one terminal each.

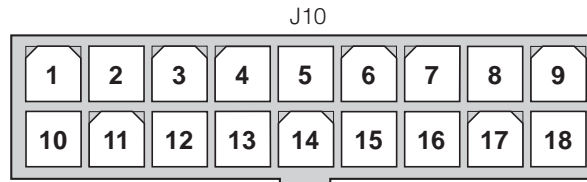


CONNECTIONS: Low Current

The low current logic control connections are provided by an 18-pin connector (see pin list below). Two identical sets of B+/B- pins are provided; they are electrically connected to the controller's **B+**, **B-** terminals and are rated at 9 amps. The mating connector is an 18-pin Molex Mini-Fit Jr., p/n 39-01-2180, with type 5556 pins; see chart at left for part numbers.

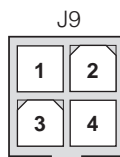
Molex Type 5556 Pins	
<i>Brass / Tin</i>	
AWG	P/N
16	39-00-0078
18–24	39-00-0039
22–28	39-00-0047
<i>Phosphor Bronze / Tin</i>	
AWG	P/N
16	39-00-0080
18–24	39-00-0060
22–28	39-00-0066

NOTE: 16 AWG wire and pins are recommended for the battery charger circuit.



J10 Pin 1	B- (for logic circuit or battery charger)
J10 Pin 2	B- (for logic circuit or battery charger)
J10 Pin 3	pot high output
J10 Pin 4	pot wiper input
J10 Pin 5	keyswitch input (KSI)
J10 Pin 6	electromagnetic brake input (brake -)
J10 Pin 7	push switch input
J10 Pin 8	mode switch input—M1 (open), M2 (closed)
J10 Pin 9	status LED output
J10 Pin 10	B+ (for logic circuit or battery charger)
J10 Pin 11	B+ (for logic circuit or battery charger)
J10 Pin 12	inhibit input
J10 Pin 13	pot low input
J10 Pin 14	electromagnetic brake output (brake +)
J10 Pin 15	BDI output
J10 Pin 16	horn input
J10 Pin 17	reverse switch input
J10 Pin 18	speed limit pot wiper input

J9 Pin 1	receive data (+5V)
J9 Pin 2	ground (B-)
J9 Pin 3	transmit data (+5V)
J9 Pin 4	+15V supply (100mA)



A 4-pin low power connector is provided for the programmer. This connector is also used to implement the seat lift feature. When you want to use the programmer, unplug the seat lift connector and plug in the programmer.

WIRING: STANDARD INSTALLATION

Applications with Seat Lift Feature

The wiring diagram presented in Figure 3a shows a typical installation. This installation has a single-ended, 3-wire 5kΩ potentiometer throttle, which is used with a reverse switch. With a wigwag throttle, a reverse switch is not used and Pin 17 is left unconnected. In the installation shown, Pin 18 is wired to a speed limit pot.

In this example, one set of B+/B- pins is left unused because the logic circuit is wired directly to the vehicle's battery pack.

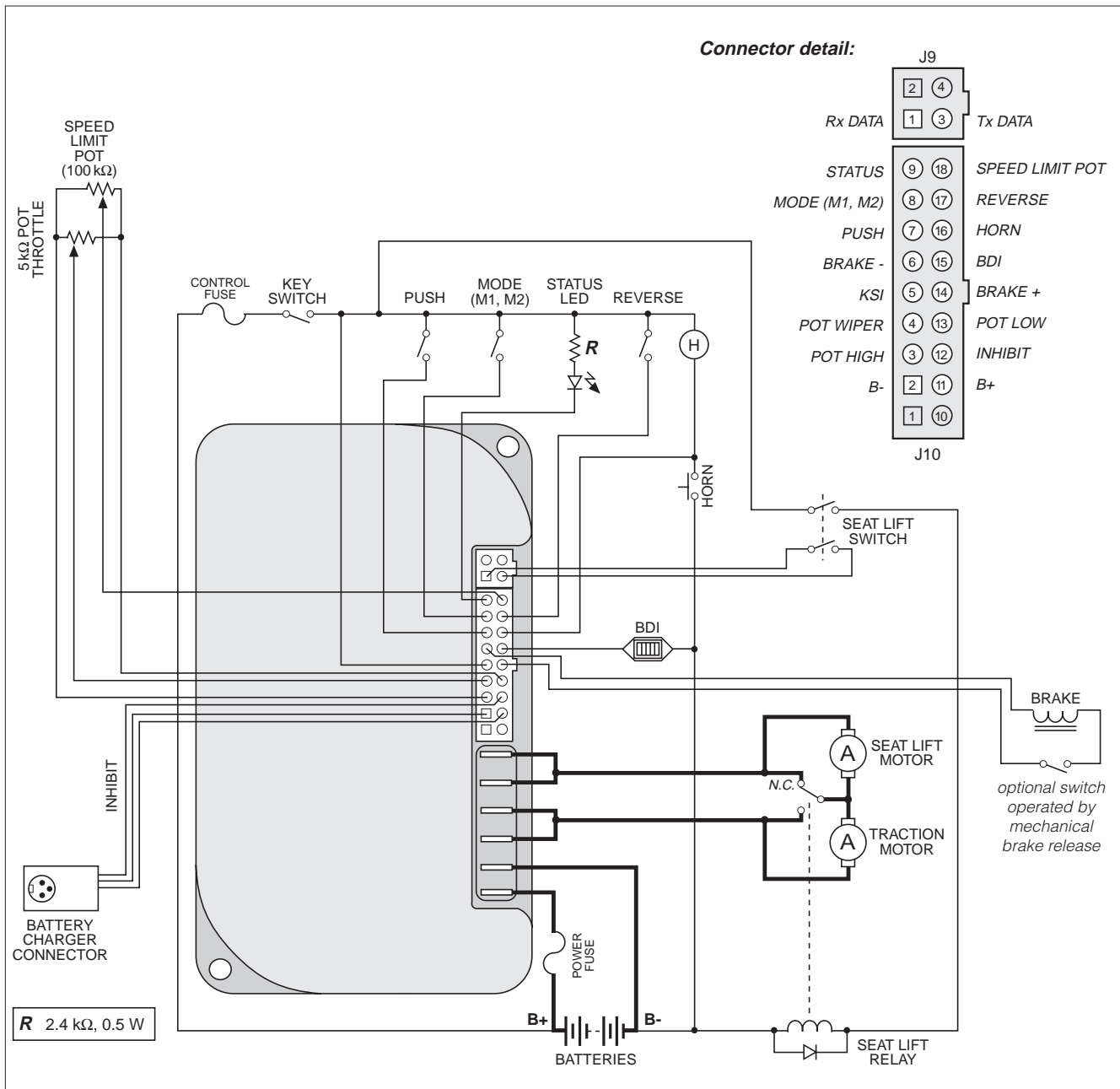


Fig. 3a Standard wiring configuration, Curtis PMC 1228 controller.

Blue Ox draft #4+ [4 December 2000]

The wiring diagram presented in Figure 3b illustrates an alternative wiring that can be used in some applications. Here the control circuit is connected to the B+ and B- pins (in this example, Pins 10 and 1) instead of to the battery pack. All four of the B+ and B- pins (Pins 10, 11, 1, 2) are connected directly to the controller's B+ and B- terminals. The pins are rated at 9 amps, so this configuration is appropriate only for applications where accessory power drawn from these pins will never exceed 9 amps.

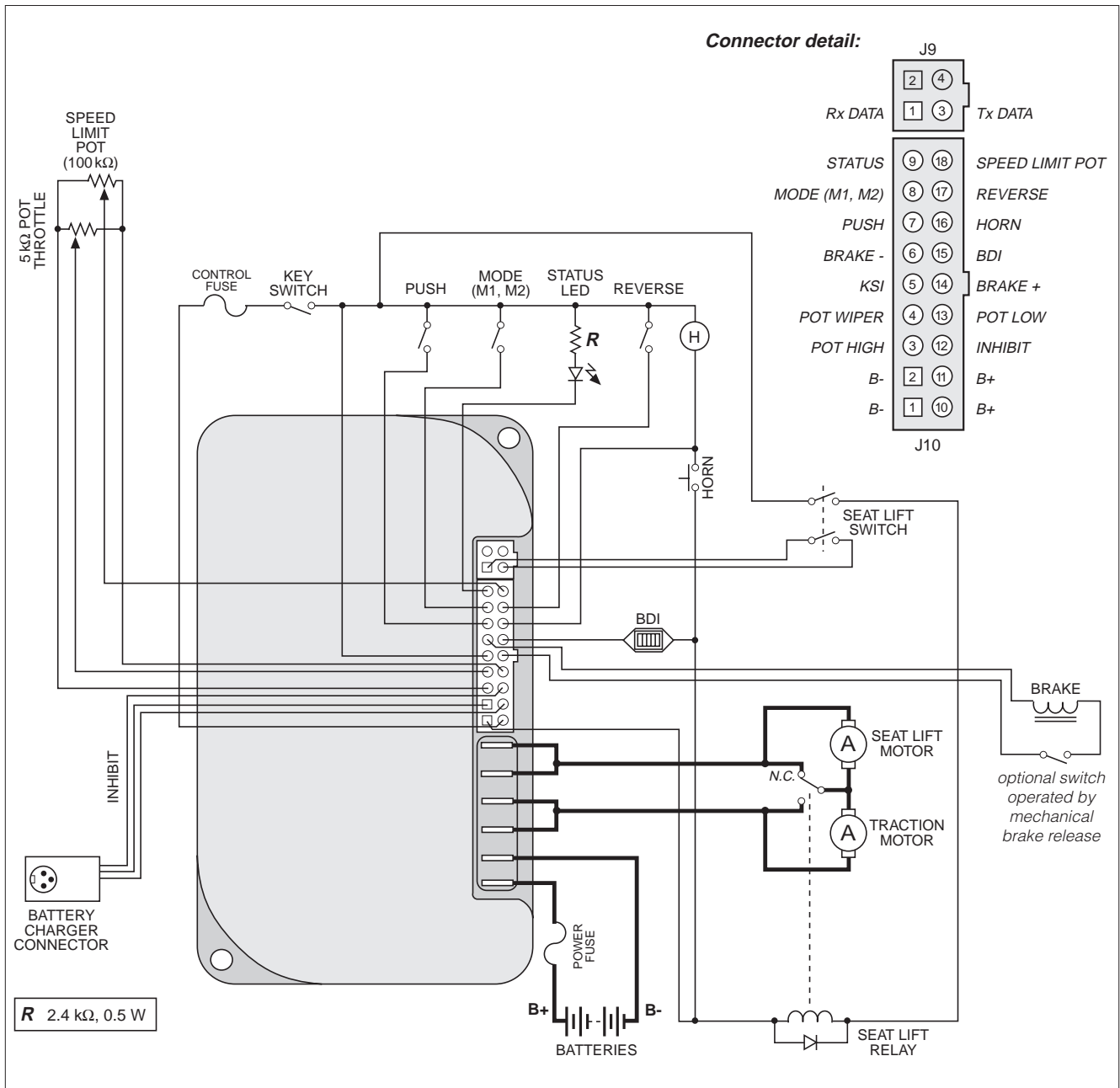


Fig. 3b Alternative wiring configuration, for low current ($\leq 9 A$) applications.

Blue Ox draft #4+ [4 December 2000]

Applications without Seat Lift Feature

The wiring presented in Figures 4a and 4b is the same as in Figures 3a and 3b, except the components and wiring used to implement the seat lift feature have been removed. This simpler configuration is applicable to vehicles such as sweepers/scrubbers and scooters that do not have seat lift motors.

This installation has a single-ended, 3-wire 5kΩ potentiometer throttle, which is used with a reverse switch. With a wigwag throttle, a reverse switch is not used and Pin 17 is left unconnected. In the installation shown, Pin 18 is wired to a speed limit pot.

In this example, one set of B+/B- pins is left unused because the logic circuit is wired directly to the vehicle's battery pack.

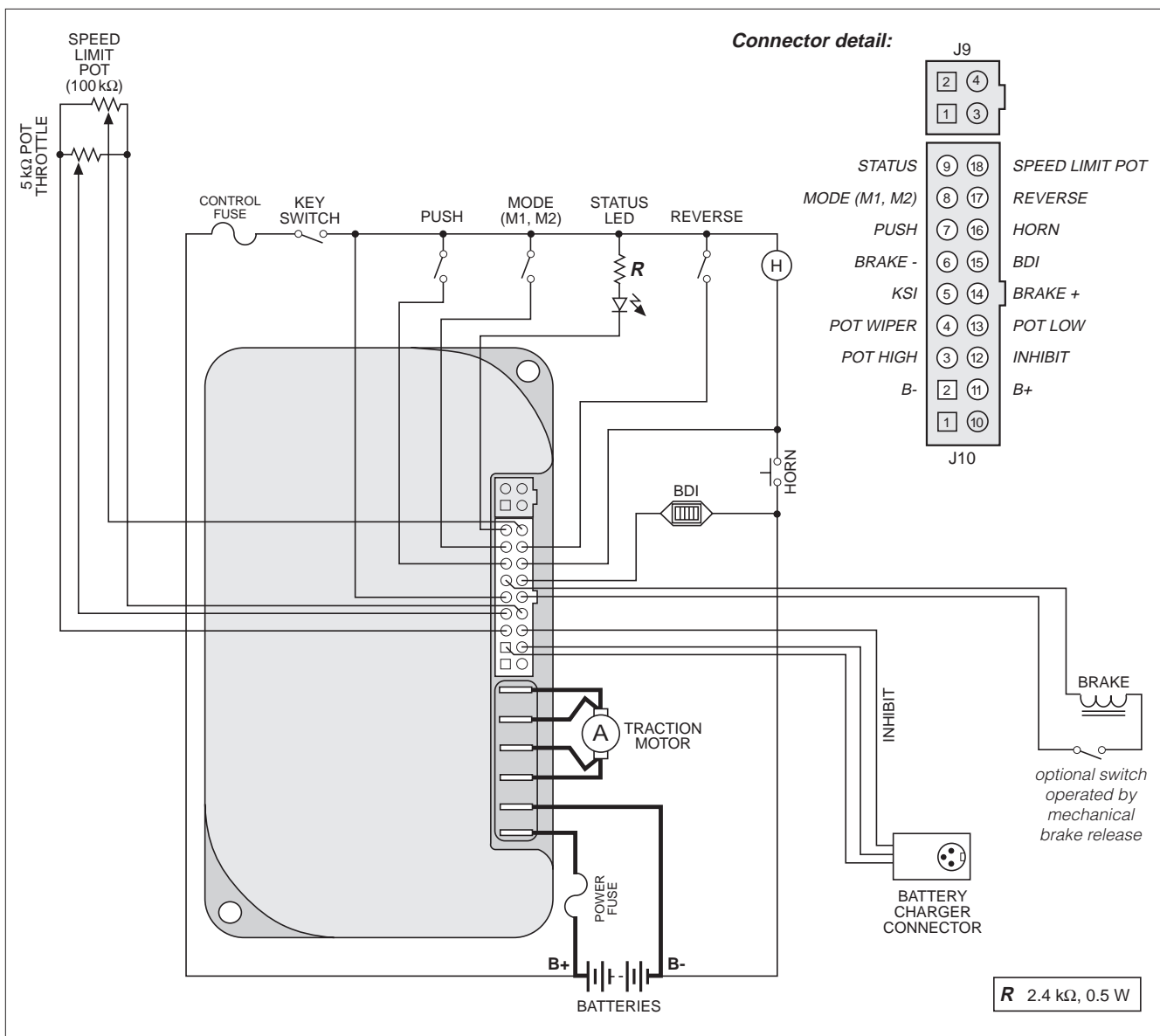


Fig. 4a Standard wiring configuration, Curtis PMC 1228 controller, in applications with no seat lift.

Blue Ox draft #4+ [4 December 2000]

The wiring diagram presented in Figure 4b illustrates an alternative wiring that can be used in some applications. Here the control circuit is connected to the B+ and B- pins (in this example, Pins 10 and 1) instead of to the battery pack. All four of the B+ and B- pins (Pins 10, 11, 1, 2) are connected directly to the controller's B+ and B- terminals. The pins are rated at 9 amps, so this configuration is appropriate only for applications where accessory power drawn from these pins will never exceed 9 amps.

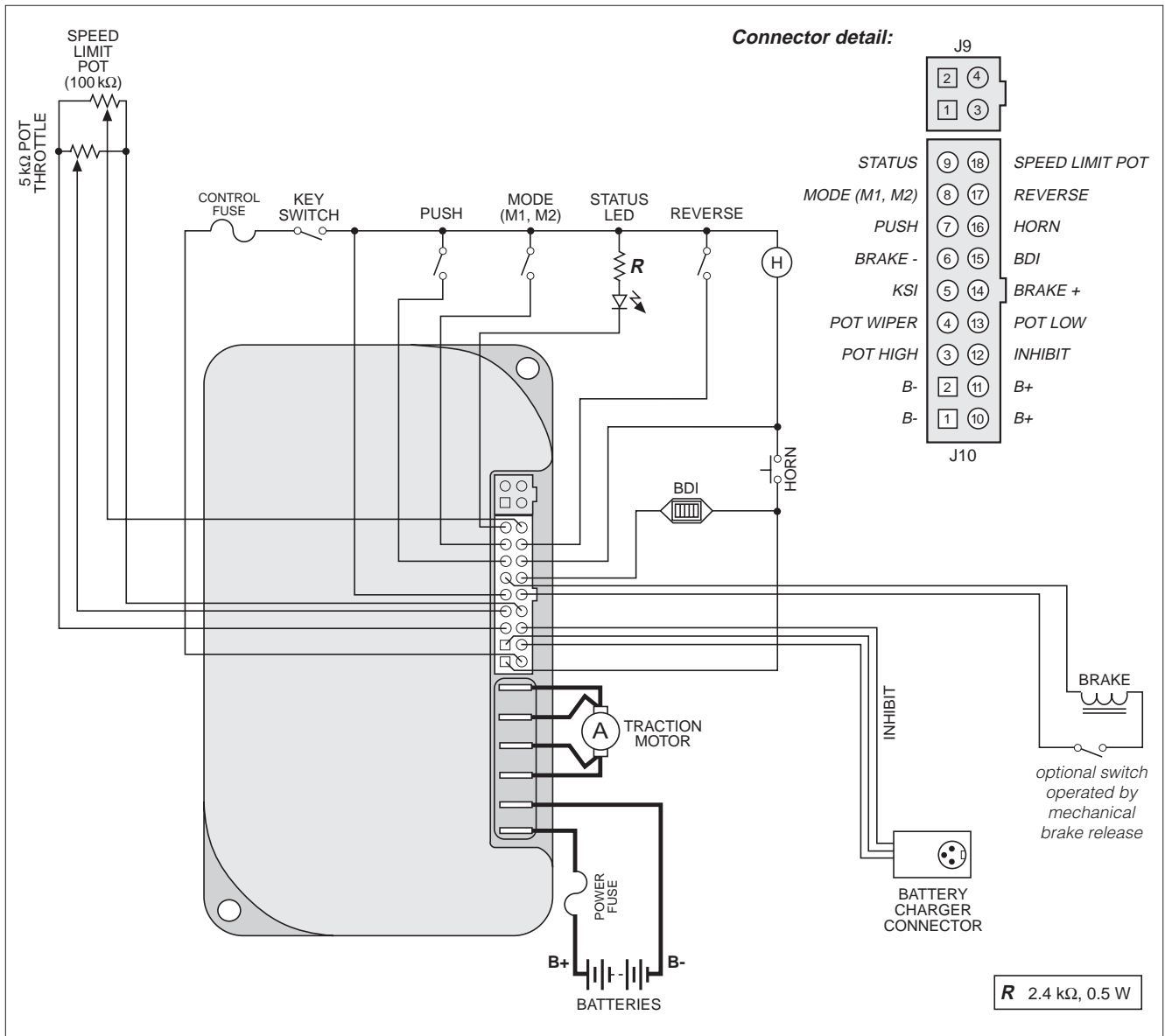


Fig. 4b Alternative wiring configuration, for low current ($\leq 9 A$) applications, with no seat lift.

Blue Ox draft #4+ [4 December 2000]

THROTTLE WIRING

The 1228 controller is programmable to suit a variety of throttles. If the throttle you are planning to use is not covered, contact the Curtis office nearest you.

Mounting dimensions are provided in Appendix B for all the applicable Curtis throttles, including the standard 5k Ω , 3-wire throttle potentiometer; several potboxes; the footpedal FP-2; the potentiometer throttle WP-45 CP; and the electronic throttle ET-XXX.

For information on the various throttle parameters, see Section 3: Programmable Parameters; the throttle parameters are on pages 24–29.

5k Ω , 3-Wire Potentiometer

A 5k Ω , 3-wire potentiometer is the standard throttle, and is shown in the basic wiring diagrams (Figures 3a/3b and 4a/4b). The controller can be programmed to be compatible with single-ended, wigwag, or inverted wigwag throttles (see page 24). These throttle styles are defined in Table 1. NOTE: The standard 10% neutral deadband and 1-to-1 throttle gain are assumed in the definitions; resistance is measured between pot low and pot wiper.

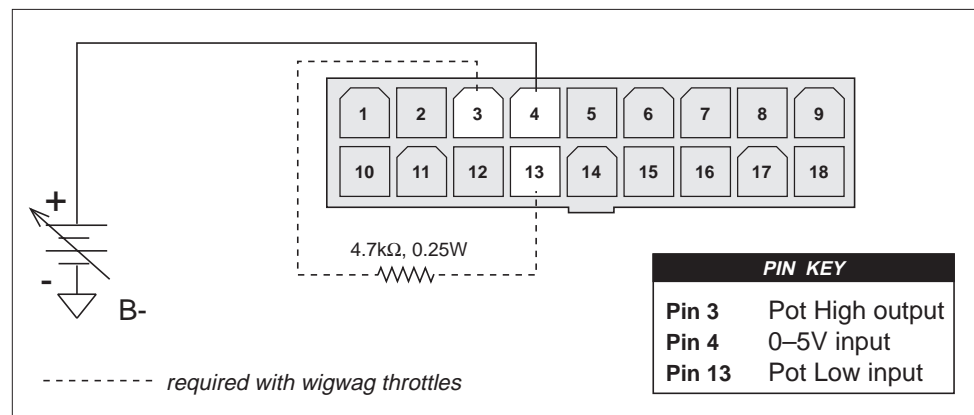
For wigwag and inverted wigwag applications, the pot can be correctly centered within the controller's neutral band by using the throttle autocalibration feature (see page 25). Pots with less than 5 k Ω total resistance change over the throttle's full stroke can be accommodated by programming the controller for reduced-range throttle inputs, via the throttle gain parameter (see page 27).

The controller provides full pot fault protection against open or shorted wires anywhere in the throttle assembly. The overall pot resistance can range from 4.5 k Ω to 7 k Ω . Values outside this range will trigger a fault condition. If a pot fault occurs while the vehicle is moving, the controller will decelerate the vehicle to neutral through its normal deceleration curve. If the fault is corrected while the throttle is still applied, the vehicle will accelerate to the requested speed.

0–5V Throttle

A 0–5V throttle input can be used instead of a pot, as shown in Figure 5. The controller can be programmed to be compatible with single-ended, wigwag, or

Fig. 5 *Wiring for 0–5V throttle.*



inverted wigwag style throttles (see page 24). These throttle styles are defined in Table 1. With a wigwag or inverted wigwag 0–5V input, the throttle output voltage must be 2.5 V (\pm deadband) in neutral and a 4.7k Ω , 0.25W resistor must be added between the pot high and pot low pins. A resistor is not required with a single-ended 0–5V input.

Voltage throttles with less than 5 V total voltage change over the full stroke can be accommodated by programming the controller for reduced-range throttle inputs, via the throttle gain parameter (see page 27).

Because the throttle input voltage is referenced to B- and no throttle connections are made to the pot high and pot low pins, throttle fault protection is lost with 0–5V throttles. The controller will not recognize out-of-range throttle inputs as faults, and applying excessive voltages to the throttle wiper input may damage the controller. **It is the responsibility of the vehicle manufacturer to provide throttle fault detection for 0–5V throttles.**

Table 1 THROTTLE STYLES for 3-wire, 5k Ω pots (and 0–5V throttles)

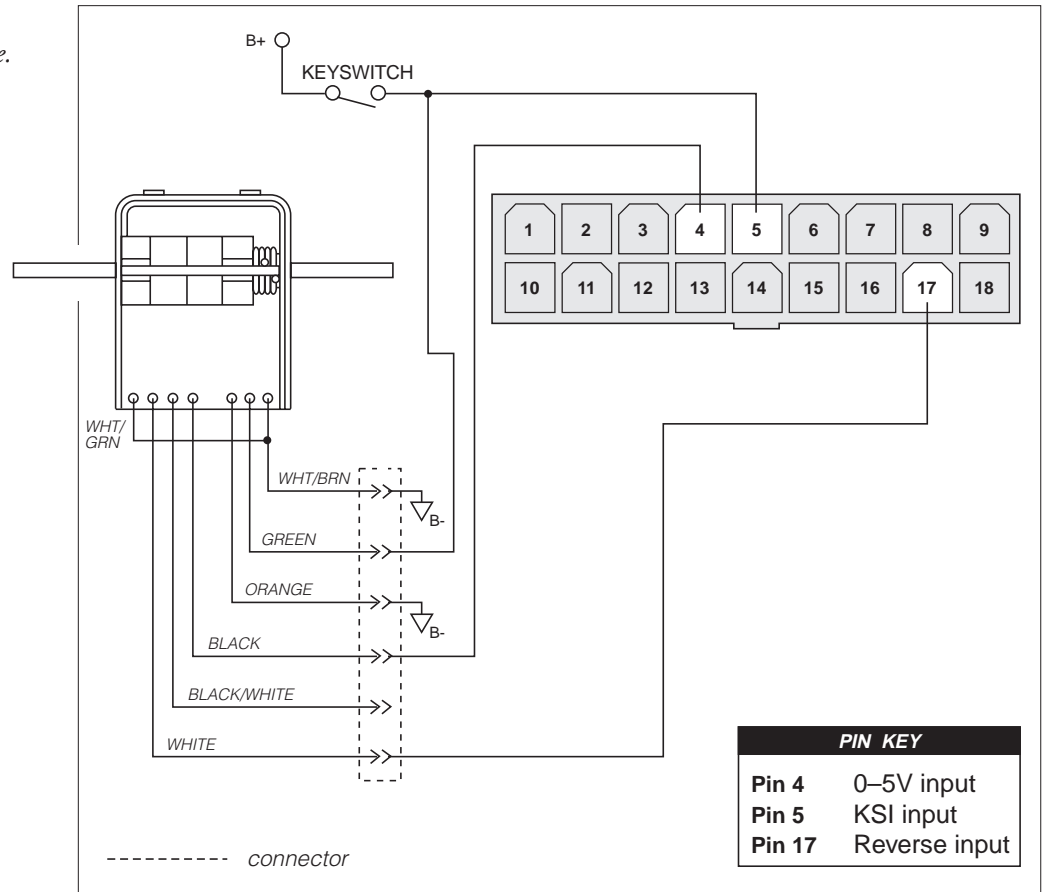
THROTTLE STYLE	DESCRIPTION OF OPERATION
<i>Single-Ended</i>	Zero speed at any resistance (or voltage, in the case of voltage throttles) less than the programmed deadband threshold. Controller output increases as resistance (or voltage) increases in the selected direction.
<i>Inverted Single-Ended</i>	Zero speed at any resistance (or voltage) greater than the programmed throttle gain threshold. Controller output increases as resistance (or voltage) decreases in the selected direction.
<i>Wigwag</i>	Zero speed at the throttle midrange, which is defined by the programmed deadband value. Controller output increases in the forward direction as resistance (or voltage) increases. Output increases in the reverse direction as this resistance (or voltage) decreases.
<i>Inverted Wigwag</i>	Same as wigwag, with the exception that increasing the resistance (or voltage) increases controller output in the <u>reverse</u> direction, and decreasing resistance (or voltage) increases output in the <u>forward</u> direction.

Curtis ET-XXX Electronic Throttle

The recommended wiring for the Curtis ET-XXX electronic throttle is shown in Figure 6. The ET-XXX throttle provides a single-ended 0–5V throttle signal and a signal indicating whether it is in forward or reverse. NOTE: The controller must be programmed as a Type 4 throttle for use with the ET-XXX.

As with any voltage throttle, there is no fault detection built into the ET-XXX. It is the responsibility of the vehicle manufacturer to provide throttle fault detection when using the ET-XXX.

Fig. 6 *Wiring for Curtis ET-XXX electronic throttle.*



Speed Limit Pot

A speed limit pot allows the operator to adjust the speed of the vehicle at full throttle. The speed limit pot should be sized so that it does not affect throttle input resistance and thus the throttle response; a 100k Ω pot is recommended. Wiring is shown in the basic wiring diagrams (Figures 3a/3b and 4a/4b).

The speed limit pot is at its maximum speed setting when its wiper is shorted to the throttle pot's pot high connection (Pin 3). When the speed limit pot is in its maximum speed position, the vehicle's speed at full throttle corresponds to the programmed maximum speed setting.

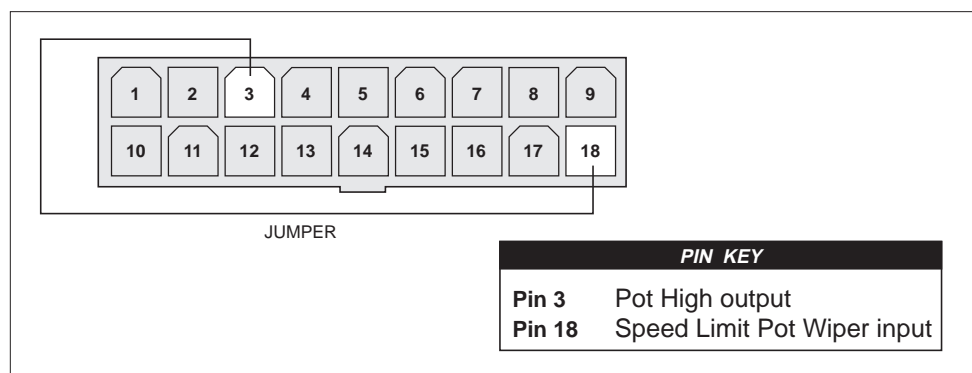
The speed limit pot is at its minimum speed setting when its wiper is shorted to the throttle pot's pot low connection (Pin 13). When the speed limit pot is in its minimum speed position, the vehicle's speed at full throttle corresponds to the programmed minimum speed setting. For information on the programmable speed parameters, see Section 3.

The speed limit pot varies the vehicle's speed linearly over the range between the minimum and maximum speed settings in each mode.

The speed limit pot also limits the vehicle's reverse speed. Reverse speed is linearly proportional to the speed limit pot setting and is adjustable from the programmed maximum reverse speed (maximum reverse speed with speed limit pot in its maximum speed position) to the programmed minimum reverse speed (maximum reverse speed with speed limit pot in its minimum speed position).

If a speed limit pot is not used, the speed limit input (Pin 18) should be jumpered to the pot high output (Pin 3), as shown in Figure 7. In this configuration, the vehicle speed at full throttle is defined by the programmed maximum speed. If no jumper is used, the vehicle speed at full throttle will be limited to the programmed minimum speed, and the controller will register a speed limit pot fault.

Fig. 7 *Wiring of speed limit input to enable maximum speed when no speed limit pot is used.*



SWITCHES AND OTHER HARDWARE

Keyswitch

The vehicle should have an OEM-supplied master on/off switch to turn the system off when not in use. The keyswitch provides logic power for the controller and for the other control input switches. It must be sized to carry the 150 mA quiescent logic current plus the current necessary to drive the precharge function (1.5 A for 0.5 seconds) and the status LED, horn, and any other accessories powered from the keyswitch circuit.

Push Switch

An OEM-supplied push switch can be used to release the electromagnetic brake electrically, thus precluding the necessity for a mechanical brake release. Activating the push input inhibits the controller's drive functions until the push switch is turned off. **NOTE:** The controller must be connected to the batteries and the keyswitch must be turned on in order to use the push feature.

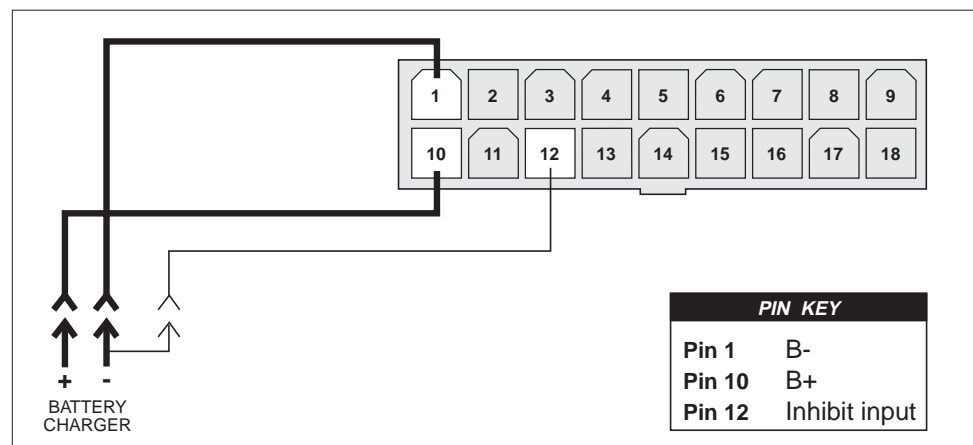
Brake Release Switch (Brake Coil Disable Switch)

If a brake release lever is used to release the electromagnetic brake mechanically, an OEM-supplied brake coil disable switch is recommended. This switch opens the electromagnetic brake coil circuit when the mechanical brake release lever releases the brake from the motor shaft. The open brake coil circuit will register as a fault, inhibiting controller operation if an operator attempts to drive the vehicle with the brake mechanically released. This safety feature ensures that the vehicle cannot be driven when the brake cannot be engaged.

Inhibit

The inhibit input can be used to inhibit operation during battery charging. The inhibit input overrides all other controller inputs and is active when low (i.e., when shorted to B-). The input can be left floating when not engaged; it does not need to be pulled high. Typically, battery chargers have a dedicated third terminal that automatically provides inhibit. If your battery charger does not have this third terminal, inhibit can be wired as shown in Figure 8.

Fig. 8 *Wiring to inhibit operation during battery charging (for battery chargers without a dedicated inhibit terminal).*



Status LED

The 1228 controller has the capability to drive an OEM-supplied panel indicator LED, which can be used to tell the operator, at a glance, the controller's status. This LED always indicates whether the controller is powered on or off. The status LED will also provide diagnostics information via flash codes (see Section 7).

If a status LED is used, it should be installed with the proper resistor in series. The controller's LED driver is capable of a maximum current of 15 mA. The recommended resistor—designed to limit driver current to 15 mA when active—is 2.4 k Ω , 0.5 W. Alternatively, an LED with a built-in resistor can be used; it should be rated for 24V operation. NOTE: A status LED mounted on the dashboard is required to meet most international standards.

Battery Discharge Indicator (BDI)

The 1228 controller can drive an OEM-supplied 0–5V panel meter to show the battery pack's state of charge as a percentage of the amp-hour capacity of the batteries. The BDI resets to full charge when the battery voltage rises above the programmed threshold value (see page 31). The batteries must be put through a full charge cycle with the controller installed before the BDI will begin operation.

The controller must be powered on for the BDI to monitor battery charging. One way to do this is by turning on the keyswitch. Alternatively, the controller can be factory-configured with the BDI output “stuffed” to automatically power up the controller during charging. With this option, you don't run the risk of forgetting to turn on the keyswitch and thus not getting accurate information from the BDI. NOTE: In order for the stuffed BDI output to power up the controller, the charger must be connected to the inhibit input; see page 14.

Horn

The controller's horn driver—Pin 16—is designed to drive an OEM-supplied low current dc horn at 1 Hz. The horn sounds a warning when the reverse direction is selected (a series of beep tones) and when the throttle autocalibration feature is being used (a constant tone). The horn driver sinks a maximum current of 15 mA. Using a horn with a higher current requirement will damage and disable the driver.

Circuitry Protection Devices

To protect the control wiring from accidental shorts, an OEM-supplied low current fuse (appropriately sized for the maximum control circuit current draw) should be connected in series with the B+ logic supply. A fuse is also recommended for use in the high power connection from the battery to the controller's B+ terminal. This fuse will protect the power system from external shorts and should be sized appropriately for the maximum rated current of the controller.

Seat Lift Switch

An OEM-supplied seat lift switch can be used to short Pins 1 and 3 of the 4-pin connector (J9), thus activating the throttle-controlled seat lift function. The mating connector for J9 is a 4-pin Molex Mini-Fit Jr., p/n 39-01-2045.

3

PROGRAMMABLE PARAMETERS

The 1228 controller has a number of parameters that can be programmed by means of the handheld programmer. These programmable parameters allow the vehicle's performance characteristics to be customized to fit the needs of individual vehicle operators. Programmer operation is described in the Curtis PMC programmer manual.

Each controller is either a generic model or an OEM-specified model. Generic controllers are shipped with the default parameter settings shown in Table D-1. The generic controllers have model numbers ending in the digits "20" (1228-2420, 1228-2720). OEM-specified controllers are shipped with the default parameter settings designated by the OEM. The last two digits of the model number on these custom controllers identify a particular configuration of default parameter settings.

In addition to specifying parameter values, the OEM can designate whether a parameter will have User or OEM-only access rights. Accordingly, Curtis PMC offers two versions of its programmers. The User programmer can adjust only those parameters with User access rights, while the OEM programmer can adjust all the parameters.

The MultiMode™ feature of the 1228 controller allows operation in two distinct modes: "Mode 1" and "Mode 2." These modes can be programmed to provide two different sets of operating characteristics, which can be useful for operation in different conditions. For example, Mode 1 could be programmed such that the vehicle moves slowly for precise, indoor maneuvering and Mode 2 programmed for higher speed, long distance travel outdoors.

Three parameters can be configured independently in the two modes:

- maximum speed (M1, M2)
- minimum speed (M1, M2)
- maximum reverse speed (M1, M2).

The controller is in Mode 2 when the mode switch is in the On position (input connected to B+). Leaving the mode input floating or actively switching it Off (pulling it to B-) puts the controller in Mode 1.

The programmable parameters are described in the following order. They are listed in the text by the abbreviated names that appear in the programmer's Program Menu. Not all of these parameters are displayed on all controllers; the list for any given controller depends on its specifications.

Motor Parameters

Main Current Limit
Motor Resistance

Acceleration Parameters

Maximum-Speed Forward Acceleration Rate
Minimum-Speed Forward Acceleration Rate
Maximum-Speed Reverse Acceleration Rate
Minimum-Speed Reverse Acceleration Rate
Gear Soften
Soft Start

Braking Parameters

Maximum-Speed Forward Deceleration Rate
Minimum-Speed Forward Deceleration Rate
Emergency Stop Deceleration Rate
Maximum-Speed Reverse Deceleration Rate
Minimum-Speed Reverse Deceleration Rate
Key-Off Deceleration Rate
Brake Delay

Speed Parameters

Maximum Speed, M1/M2
Minimum Speed, M1/M2
Maximum Reverse Speed, M1/M2
Minimum Reverse Speed
Creep Speed
Push Speed
IR Compensation
Speed Scaler

Throttle Parameters

Throttle Input Signal Type
Throttle Autocalibration
Throttle Deadband
Throttle Gain
Ramp Shape (Static Throttle Map)

Fault Parameters

High Pedal Disable (HPD)
Brake Faults
Seat Lift Brake Faults
Fault Beep

Other Parameters

Seat Lift
Virtual Seat Lift
Ampere Hours
BDI Reset Voltage
Sleep Delay
Tremor Compensation

Motor Parameters

MAIN C/L [default access, generic models: OEM]

The **main current limit** parameter allows adjustment of the maximum current the controller will supply to the motor during both drive and regenerative braking operation. This parameter can be limited to protect the motor from excessive (potentially damaging) currents or to reduce the maximum torque applied to the drive system by the motor. It is adjustable from 30 amps to 100% of the controller's full rated current. (The full rated current depends on the controller model; see 15-minute ratings in Table E-1.)

MOTOR R [default access, generic models: OEM]

The **motor resistance** parameter is crucial to proper vehicle operation. The control system performance depends on this value being set correctly. The motor resistance parameter is adjustable between 0 and 200 milliohms. It must be set to the actual cold motor resistance. For instructions, see Section 6, tuning procedure #2, on page 38.

Acceleration Parameters

ACCEL MAX SPD [default access, generic models: User]

The **maximum-speed forward acceleration rate** defines the time it takes the controller to accelerate from zero to 100% output during forward travel at full throttle with the speed limit pot in its maximum speed position. Larger values represent a longer acceleration time and gentler starts, while smaller values represent faster acceleration. The maximum-speed forward acceleration rate is adjustable from 0.2 to 4.0 seconds. Acceleration rates under 0.5 second provide abrupt acceleration and should only be used under special circumstances.

The maximum-speed and minimum-speed forward acceleration rates are scaled linearly to provide appropriate response throughout the speed limit pot's range. The reverse acceleration rates are similarly scaled.

ACCEL MIN SPD [default access, generic models: User]

The **minimum-speed forward acceleration rate** defines the time it takes the controller to accelerate from zero to 100% output during forward travel at full throttle with the speed limit pot in its minimum speed position. Larger values represent a longer acceleration time and gentler starts, while smaller values represent faster acceleration. The minimum-speed forward acceleration rate is adjustable from 0.2 to 8.0 seconds. Acceleration rates under 0.5 second provide abrupt acceleration and should only be used under special circumstances.

REV ACCEL MAX [default access, generic models: User]

The **maximum-speed reverse acceleration rate** defines the time it takes the controller to accelerate from zero to 100% output while traveling in reverse at full throttle with the speed limit pot in its maximum speed position. Larger values represent a longer acceleration time and gentler starts, while smaller values represent faster acceleration. The maximum-speed reverse acceleration rate is adjustable from 0.2 to 8.0 seconds. Acceleration rates under 0.5 second provide abrupt acceleration and should only be used under special circumstances.

REV ACCEL MIN [default access, generic models: User]

The **minimum-speed reverse acceleration rate** defines the time it takes the controller to accelerate from zero to 100% output while traveling in reverse at full throttle with the speed limit pot in its minimum speed position. Larger values represent a longer acceleration time and gentler starts, while smaller values represent faster acceleration. The minimum-speed reverse acceleration rate is adjustable from 0.2 to 8.0 seconds. Acceleration rates under 0.5 second provide abrupt acceleration and should only be used under special circumstances.

GEAR SOFTEN [default access, generic models: OEM]

The **gear soften** feature allows smooth pickup of gear slack in the transmission when torque is reversed; it affects all accelerations except those from zero speed. The effect of this feature is most noticeable when reapplying the throttle from neutral after decelerating from high speed but before coming to a stop. (See soft start parameter, below, for softening torque endpoints for accelerations from a complete stop.)

The gear soften parameter is adjustable from 0% to 100%, with 100% providing a great deal of softening and 0% eliminating the feature. The trade-off in increasing the gear soften value is that acceleration response may be slowed somewhat, especially at higher values.

SOFT START [default access, generic models: OEM]

The **soft start** feature allows softened torque endpoints for forward/reverse accelerations from a complete stop. When accelerating from a stop, some users prefer the softened gear slack transitions this parameter can provide, while others prefer the vehicle to respond instantly.

The soft start parameter is adjustable from 0% to 100%, with 100% providing a great deal of softening and 0% eliminating the feature. The trade-off in increasing the soft start value is that acceleration response may be slowed somewhat, especially at higher values.

Braking Parameters

DECEL MAX SPD [default access, generic models: OEM]

The **maximum-speed forward deceleration rate** determines the time it takes the controller to decelerate from its present output to zero when the throttle is released to neutral during forward travel with the speed limit pot in its maximum speed position. Larger values represent a longer deceleration time and gentler stops. Smaller values will reduce the stopping distance required. The maximum-speed deceleration rate should be set at a value that will ensure the vehicle stops within a safe distance when traveling at full speed. The maximum-speed deceleration rate is adjustable from 0.2 to 4.0 seconds. Deceleration rates under 0.5 second provide abrupt stops and should only be used under special circumstances.

DECEL MIN SPD [default access, generic models: OEM]

The **minimum-speed forward deceleration rate** defines the time it takes the controller to decelerate from its present output to zero when the throttle is released to neutral during forward travel with the speed limit pot in its minimum speed position. Larger values represent a longer deceleration time and gentler stops. Smaller values will reduce the stopping distance required. The minimum-speed deceleration rate is adjustable from 0.2 to 8.0 seconds. Deceleration rates under 0.5 second provide abrupt stops and should only be used under special circumstances.

E STOP [default access, generic models: OEM]

The **emergency stop deceleration rate** defines the time it takes the vehicle to stop when a reverse throttle command >80% is given while the vehicle is moving forward. This gives the operator a way to stop more quickly when unexpected conditions arise.

When the E Stop feature is invoked the E Stop deceleration rate becomes the new forward deceleration rate. Therefore it makes sense to set it to a value lower (faster stop) than the fastest forward deceleration rate (DECEL MAX SPEED). The E Stop deceleration rate is adjustable from 0.2 to 4.0 seconds.

REV DECEL MAX [default access, generic models: OEM]

The **maximum-speed reverse deceleration rate** defines the time it takes the controller to decelerate from its present output to zero when the throttle is released to neutral during reverse travel with the speed limit pot in its maximum speed position. Larger values represent a longer deceleration time and gentler stops. Smaller values will reduce the stopping distance required. The maximum-speed reverse deceleration rate should be set at a value that will ensure the

vehicle stops within a safe distance when traveling in reverse at full speed. The maximum-speed deceleration rate is adjustable from 0.2 to 4.0 seconds. Deceleration rates under 0.5 second provide abrupt stops and should only be used under special circumstances.

REV DECEL MIN [default access, generic models: OEM]

The **minimum-speed reverse deceleration rate** defines the time it takes the controller to decelerate from its present output to zero when the throttle is released to neutral during reverse travel with the speed limit pot in its minimum speed position. Larger values represent a longer deceleration time and gentler stops. Smaller values will reduce the stopping distance required. The minimum-speed reverse deceleration rate is adjustable from 0.2 to 8.0 seconds. Deceleration rates under 0.5 second provide abrupt stops and should only be used under special circumstances.

KEY OFF DECEL [default access, generic models: OEM]

The **key-off deceleration rate** defines the time it takes the vehicle to stop after the keyswitch has been turned off while the vehicle is in motion. The key-off deceleration rate is independent of the normal programmed deceleration rate, the selected mode, and the speed and direction of travel when KSI is switched off. It is adjustable from 0.2 to 4.0 seconds.

BRAKE DELAY [default access, generic models: OEM]

The **brake delay** parameter specifies when the controller engages the electromagnetic brake after the vehicle's speed command has reached zero. This time delay is adjustable from 0.0 to 1.0 seconds. It should be set low enough to minimize rolling downhill when stopping on ramps, yet long enough to allow for a smooth stop on flat surfaces.

Speed Parameters

M1/M2 MAX SPD [default access, generic models: User]

The **maximum speed** parameter defines the maximum allowed speed at full forward throttle with the speed limit pot in its maximum speed position. For example, if Mode 1 Maximum Speed is set at 60% and the speed limit pot is in its maximum speed position, the controller will adjust its output to achieve 60% speed at full throttle in Mode 1. NOTE: If a speed limit pot is not used in your application, see page 13.

M1/M2 MIN SPD [default access, generic models: User]

The **minimum speed** parameter defines the maximum allowed speed at full forward throttle with the speed limit pot in its minimum speed position. For example, if Mode 1 Minimum Speed is set at 20% and the speed limit pot is in its minimum speed position, the controller will adjust its output to achieve 20% speed at full throttle in Mode 1. NOTE: If a speed limit pot is not used in your application, see page 13.

M1/M2 REV MAX SPD [default access, generic models: User]

The **maximum reverse speed** parameter defines the maximum allowed speed in reverse at full throttle with the speed limit pot in its maximum speed position. For example, if Mode 1 Maximum Reverse Speed is set at 40% and the speed limit pot is in its maximum speed position, the controller will adjust its output to achieve 40% reverse speed at full throttle in Mode 1. NOTE: If a speed limit pot is not used in your application, see page 13.

REV MIN SPD [default access, generic models: User]

The **minimum reverse speed** parameter defines the maximum allowed speed in reverse at full throttle with the speed limit pot in its minimum speed position. Reverse speed is not affected by which mode (Mode 1, Mode 2) is selected. NOTE: If a speed limit pot is not used in your application, see page 13.

CREEP SPD [default access, generic models: OEM]

Creep speed helps to prevent vehicle rollback on inclines when the brake is released with very little throttle applied. It is activated when the throttle request exceeds the throttle's deadband threshold. The throttle response is rescaled so that the controller's output is adjustable over the full throttle range, but starting at the programmed creep speed value. Creep speed is programmable from 0% to 20% of the maximum available speed.

PUSH SPD [default access, generic models: OEM]

When the push switch is switched to the On position, the push feature releases the electromagnetic brake and allows the vehicle to be manually pushed. The maximum speed at which the vehicle can be pushed is defined by the **push speed** parameter. It is programmable from 25% to 60% of the maximum available speed. This parameter also sets the "push-too-fast" speed, which is the maximum speed at which the vehicle can be pushed when it is unpowered and the brake is mechanically released.

IR COMP COEFF [default access, generic models: OEM]

IR compensation is a method by which the controller maintains a constant vehicle speed despite changes in motor loading. The **IR compensation** parameter adjusts how aggressively the controller tries to maintain constant speed under changing load conditions. The parameter is scaled 0–100%, and defines the percentage of compensation applied.

SPD SCALER [default access, generic models: OEM]

The **speed scaler** parameter sets the maximum voltage that can be applied to the motor. It can be used to eliminate variations in maximum speed that would otherwise result when driving with a fully charged battery vs. a partially discharged battery. If the speed scaler is set at 23 volts, for example, the maximum vehicle speed will be the same whether the actual battery voltage is 28 volts or 23 volts or any value in between.

The speed scaler parameter is programmable between 20.0 V and 28.0 V.

*Throttle Parameters***THRTL TYPE** [default access, generic models: OEM]

The controller can be programmed to accept single-ended, wigwag, or inverted wigwag signals from a 5k Ω , 3-wire pot or from a 0–5V voltage source. These throttle styles are described in Table 1, page 11.

The **throttle input signal type** options—Types “0” through “5” in the Throttle Type programming menu—are listed in Table 2.

THROTTLE TYPE	APPLICABILITY		DESCRIPTION
	5k Ω 3-wire Pot	0–5V Throttle	
0	✓	✓ *	wigwag pot or voltage throttle
1	✓	✓ *	inverted wigwag pot or voltage throttle
2	✓		single-ended pot; maximum speed = 5k Ω
3	✓		inverted single-ended pot; maximum speed = 0
4		✓	single-ended voltage throttle; maximum speed = 5V
5		✓	inverted single-ended voltage throttle; maximum speed = 0

* Requires resistor; see Figure 5, page 10.

THRTL AUTOCAL [default access, generic models: OEM]

The **throttle autocalibration** parameter provides a means of easily and reliably centering wigwag throttle pots. To use this method, a horn must be connected to the horn driver. The horn assists the technician in accurately centering the pot in the throttle assembly. The controller inhibits driving while in autocalibration mode, enabling the technician to adjust the throttle potentiometer safely.

Throttle centering is accomplished as follows:

1. Jack the vehicle drive wheels off the ground or disconnect the motor leads.
2. Completely assemble the throttle mechanism but do not tighten the clamping mechanism that secures the potentiometer shaft to the throttle lever.
3. Plug the programmer into the controller, and turn on the keyswitch.
4. Select the program mode and scroll down to the throttle autocalibration parameter.
5. Set the throttle autocalibration to On. At this point, the horn will probably sound, indicating that the throttle pot is out of adjustment. If the horn does not sound, the pot is already centered and further adjustment is not necessary.
6. With the throttle lever at the neutral position, adjust the potentiometer in one direction until the horn turns off. Note this position. Adjust the pot in the other direction until the horn turns off. Note this position. Set the pot halfway between the two noted positions. The pot is now adjusted to the proper value for neutral.
7. Tighten the clamping mechanism that secures the throttle lever to the potentiometer shaft. Depress and release the throttle to verify the mechanical return to neutral; the horn should turn off with the same amount of motion in both directions.
8. Set the throttle autocalibration parameter to Off, or cycle the keyswitch to reset it to Off. The vehicle will not drive if the throttle autocalibration parameter is left On.

THRTL DEADBAND [default access, generic models: OEM]

The **throttle deadband** parameter defines the throttle pot wiper voltage range that the controller interprets as neutral. Increasing the throttle deadband setting increases the neutral range. This parameter is especially useful with throttle assemblies that do not reliably return to a well-defined neutral point, because it allows the deadband to be defined wide enough to ensure that the controller goes into neutral when the throttle mechanism is released.

Examples of two deadband settings (25%, 10%) are shown in Figure 9, along with the equations used to determine the wiper voltage range (with respect to B-) that the controller will interpret as neutral.

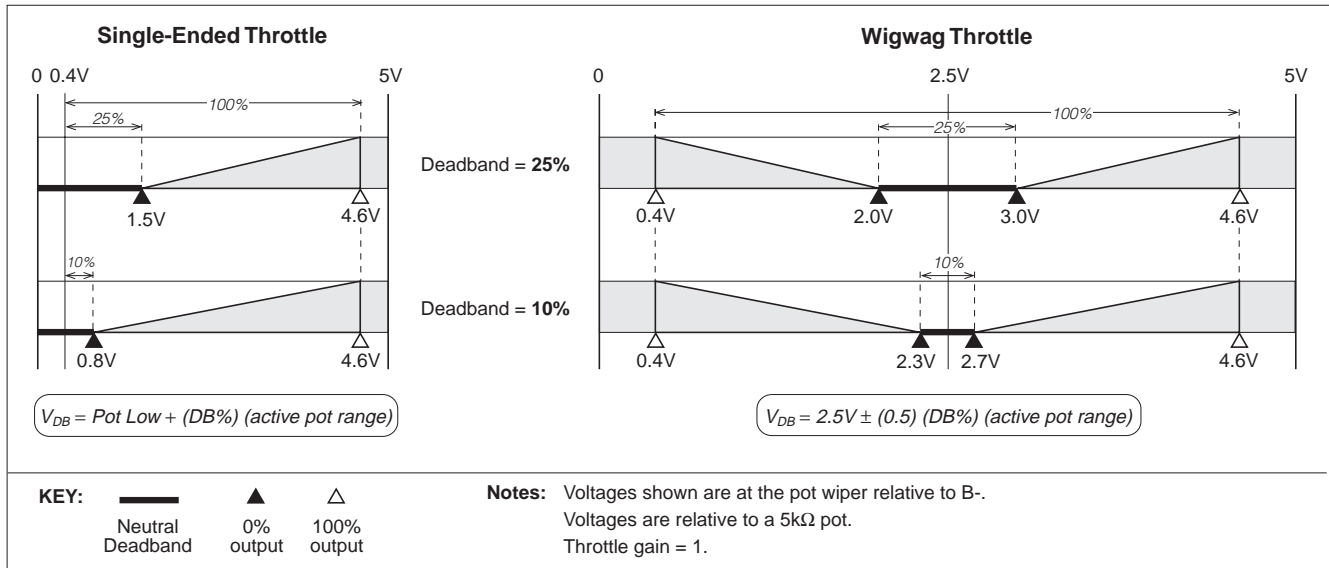


Fig. 9 Effect of adjusting the neutral deadband parameter.

The programmer displays the throttle deadband parameter as a percentage of the wiper voltage range and is adjustable from 5% to 25%. The default deadband setting is 10%.

The throttle wiper voltage range is approximately 4 volts, measured relative to B-. This is true regardless of whether a single-ended or wigwag throttle is used. When a single-ended throttle is used, the deadband parameter sets a single threshold wiper voltage—that is, a wiper voltage (relative to B-) at which the controller will begin to modulate. When a wigwag throttle is used, the deadband parameter sets two threshold wiper voltages, one on either side of the 2.5 V centerpoint, for forward and reverse.

Depending on the individual pot, the values for Pot Low and Pot High (and hence for the deadband, which is a percentage of the range defined by Pot Low and Pot High) vary. The values listed below can be used with the equations provided in Figure 9 to calculate the actual deadband threshold(s) for any given deadband setting:

POT	POT LOW	POT HIGH	POT RANGE
4 kΩ	0.5 V	4.5 V	4.0 V
5 kΩ	0.4 V	4.6 V	4.2 V
7 kΩ	0.3 V	4.7 V	4.4 V

Detailed guidelines for adjusting the throttle deadband parameter are presented in Section 6.

THRTL GAIN [default access, generic models: OEM]

The **throttle gain** parameter sets the wiper voltage required to produce 100% controller output. Increasing the throttle gain setting reduces the wiper voltage required, and therefore the full stroke necessary to produce full output is reduced. This feature allows reduced-range throttle assemblies to be used.

Examples are shown in Figure 10 to illustrate the effect of three different throttle gain settings (1, 1.5, and 2) on full-stroke wiper voltage. Adjusting the throttle gain also affects the neutral deadband, which is a percentage of the throttle's active range. NOTE: The deadband values shown in the bottom two examples are the same due to rounding; the actual deadband in the bottom example is somewhat narrower than in the example above it.

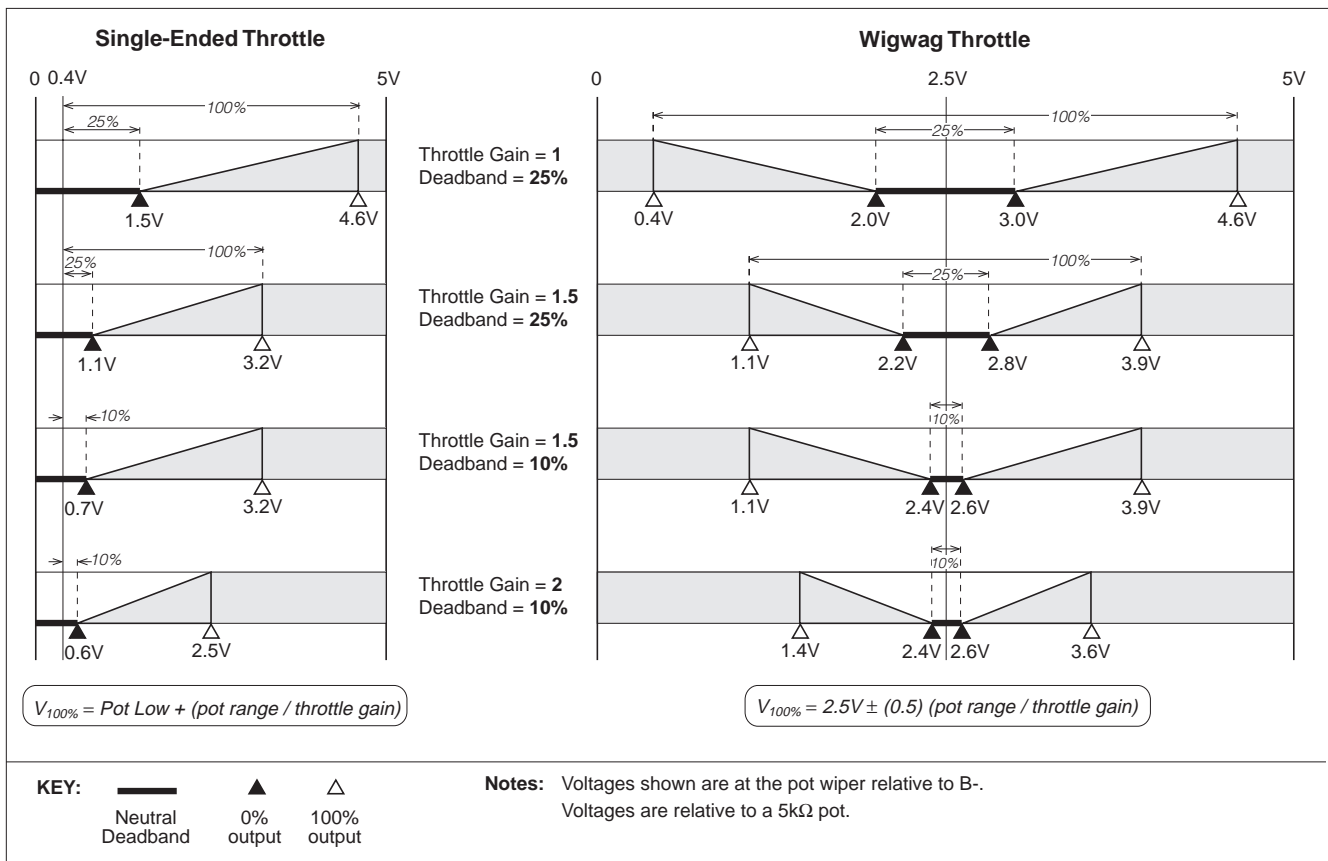


Fig. 10 Effect of adjusting the throttle gain parameter.

When a single-ended throttle is used, the throttle gain parameter sets the maximum pot wiper voltage required to produce 100% output. When a wigwag throttle is used, the throttle gain parameter sets the pot wiper resistance required to produce 100% output in both forward and reverse: the wiper voltage required for full forward output is decreased, and the wiper voltage required for full reverse output is increased.

The throttle gain parameter can be set with values from 1 to 10. The throttle gain value is the ratio of the pot's full 5kΩ to the resistance of the throttle's range of travel ($G = R_{\text{pot}} / R_{\text{travel}}$). A setting of 1 thus represents a one-to-one

ratio—in other words, no throttle gain adjustment. A setting of 10 would allow use of a pot with a range of only 1/10th of 5k Ω , i.e., 500 ohms. For most applications, throttle gain settings between 1 and 2 will work best.

NOTE: The throttle characteristics are defined in terms of wiper voltage rather than throttle pot resistance because of the range of pot values that can be used and the variation between pots of the same value.

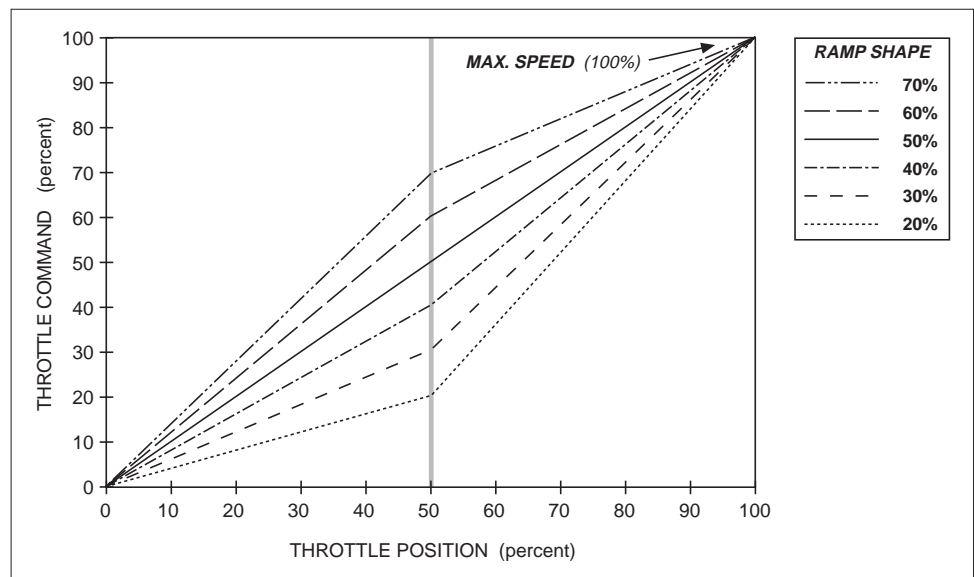
Detailed guidelines for adjusting the throttle gain parameter are presented in Section 6.

RAMP SHAPE [default access, generic models: User]

The **ramp shape** parameter determines the static throttle map of the controller. This parameter modifies the throttle input to the controller, and hence the vehicle's response. Setting the ramp shape parameter at 50% provides a linear response to throttle position. Values below 50% reduce the throttle command at low throttle positions, providing enhanced slow speed maneuverability. Values above 50% give the vehicle a faster, jumpier feel at low throttle positions.

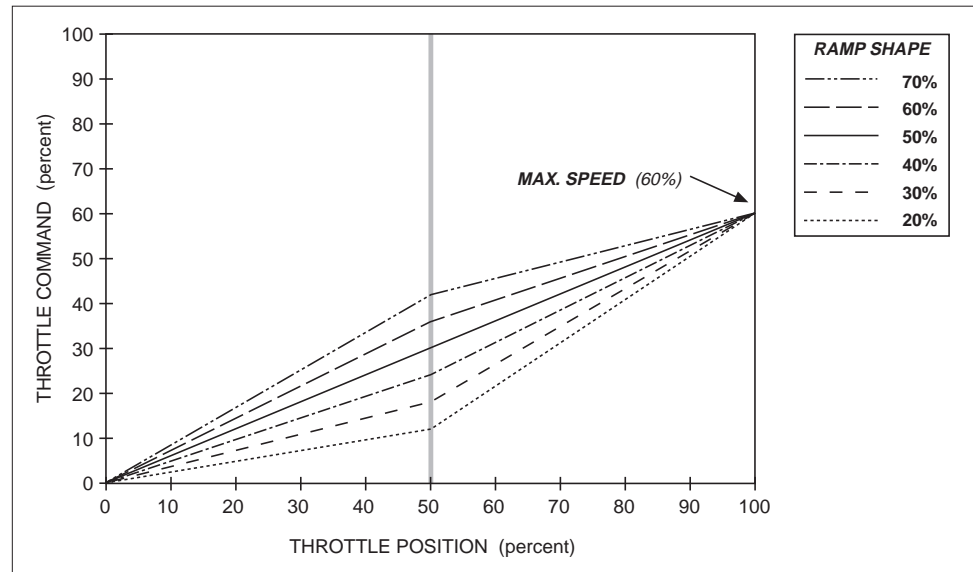
The ramp shape can be programmed to values between 20.0% and 70.0%. The ramp shape number refers to the throttle command at half throttle. For example, if maximum speed is set at 100%, a ramp shape of 40% will result in a 40% throttle command at half throttle. The 50% ramp shape corresponds to a linear response. Six ramp shapes (20, 30, 40, 50, 60, and 70%) are shown as examples in Figure 11.

Fig. 11 Ramp shape (throttle map) with maximum speed set at 100%.



Changing the maximum speed setting changes the throttle command range, and hence the ramp shape. Ramp shapes with the maximum speed setting dropped from 100% to 60% are shown in Figure 12.

Fig. 12 Ramp shape (throttle map) with maximum speed set at 60%.



In all cases, the ramp shape number is the throttle command at half throttle. In Figure 12, for example, the 50% ramp shape results in a 30% throttle command at half throttle (i.e., a command that is halfway between 0% and 60%). The 20% ramp shape results in a 12% command at half throttle (20% of the range from 0% to 60%).

Fault Parameters

HIGH PEDAL DIS [default access, generic models: OEM]

The primary function of the **high pedal disable (HPD)** feature is to prevent the vehicle from moving if the controller is turned on with the throttle already applied. HPD also serves as the interlock to prevent the vehicle from starting up with the push or inhibit feature active, and to prevent driving if Inhibit is activated during operation.

When the HPD parameter is programmed On, HPD is active and controller output is inhibited (1) if a throttle input greater than the throttle deadband exists when the controller is turned on, (2) if the push switch is On when the controller is turned on, (3) after the vehicle reaches a stop if the push switch is activated while the vehicle is being driven, or (4) if the inhibit switch is activated while the vehicle is being driven. If HPD is programmed Off, this protection feature is disabled. NOTE: All DME scooter applications must have the HPD feature programmed On to satisfy the industry's safety requirements.

BRAKE FLTS [default access, generic models: OEM]

The **brake faults** parameter enables (“On”) or disables (“Off”) all the electromagnetic brake driver and wiring fault detection. All DME scooter applications must have this parameter programmed On to satisfy the industry’s safety requirements.

In non-DME applications such as sweeper/scrubbers, where there is no electromagnetic brake, the brake faults parameter can be programmed Off, thus eliminating the need for the 200Ω, 5W bias resistor on the controller’s brake driver output that would otherwise be necessary.

SL BRAKE FLTS [default access, generic models: OEM]

The **seat lift brake faults** parameter enables (“On”) or disables (“Off”) the brake coil open and shorted brake driver fault detection in seat lift mode.

The seat lift brake faults parameter is only active when the standard brake faults parameter is also programmed On. If the standard brake faults parameter is programmed Off, there will be no fault detection in seat lift mode even if the seat lift brake faults parameter is programmed On.

NOTE: If you are installing the 1228 controller in an existing scooter system that uses a brake disable relay in its seat lift circuit, you should program the seat lift brake faults parameter Off. Systems designed to be used with the new 1228 do not require this second relay, which was required by earlier versions.

FAULT BEEP [default access, generic models: OEM]

The **fault beep** parameter enables the horn during controller faults, in order to make the fault codes audible. It beeps only the fault codes; it does not precede the fault code with a level-of-seriousness code (as does the status LED, with its slow/fast flash preceding the fault code). If this audible alarm is not wanted, the fault beep parameter should be programmed Off.

*Other Parameters***SEAT LIFT** [default access, generic models: OEM]

DME scooter systems typically use the 1228 controller to drive the seat lift motor as well as the traction motor. The power path is determined by a relay that routes motor drive power from the controller to either the traction motor or the seat lift motor depending on whether the seat lift switch is open or closed; see Figures 3a/3b. When the seat lift feature is active, the controller disables the electromagnetic brake driver (i.e., sets the brake), and operates in Mode 1, regardless of mode switch position.

The seat lift switch connector plugs into J9 (the 4-pin connector). The controller transitions from traction mode to seat lift mode when the seat lift switch is closed.

To use the programmer, you must remove the seat lift switch connector from J9 in order to plug in the programmer; both connectors use J9. When you have finished using the programmer, the seat lift switch connector can be plugged back into J9.

The **seat lift** parameter enables (“On”) or disables (“Off”) seat lift mode. Programming the seat lift parameter On enables the controller to recognize seat lift switch inputs at J9. If the seat lift parameter is programmed Off, the controller will not respond to the seat lift switch, even when it is plugged into J9.

VSL [default access, generic models: OEM]

The handheld programmer and the seat lift switch input share the same 4-pin connector (J9) on the controller—see Figures 3a/3b. Therefore some provision must be made to put the controller into seat lift mode when the programmer—rather than the seat lift switch input—is plugged in. The **virtual seat lift** parameter accomplishes this. Setting this parameter On with the programmer plugged in transitions the controller from traction mode to seat lift mode. The controller disables the electromagnetic brake driver (i.e., sets the brake), and operates in Mode 1, regardless of mode switch position. If the seat lift switch is then activated, the motor drive power is routed to the seat lift motor.

The VSL parameter is accessible by the OEM only while the programmer is being used. The parameter is factory-programmed to automatically reset to Off when the keyswitch is cycled. This prevents the system from being frozen in seat lift mode if the VSL parameter is not reset to Off before the programmer is removed.

AMPERE HOURS* [default access, generic models: OEM]

The **ampere hours** parameter provides a means of tailoring a battery discharge indicator (BDI) to the battery pack on a particular vehicle. The ampere hours parameter should be set to the amp-hour capacity of the battery pack.

NOTE: The amp-hour capacity will be affected by the ambient temperature, the age of the batteries, etc.

BDI RESET [default access, generic models: OEM]

The **BDI reset voltage** parameter sets the threshold at which the battery discharge indicator (BDI) will show full charge. It should be set to the voltage level of the fully-charged battery pack.

* This parameter is available on 1228 controllers with Rev. 06 software, but has been removed from the Rev. 07 software.

SLEEP DLY [default access, generic models: OEM]

The controller powers down completely if the throttle request remains at neutral beyond the time specified by the **sleep delay** parameter; to resume operation, the keyswitch must be cycled. The sleep delay can be set from 1 to 60 minutes. Setting this parameter to zero disables the sleep delay.

TREMOR COMP [default access, generic models: OEM]

The **tremor compensation** parameter allows adjustment to limit the controller's response to sharp throttle movements, such as might result from hand tremors. The tremor compensation parameter can be set to values of 1 through 5, with 1 providing no compensation, and 5 providing the most. Although larger values provide steadier response, they also result in more sluggish response to throttle requests. There is thus a trade-off between crispness of response (low tremor compensation settings) and steady speed in the presence of tremors (high tremor compensation settings).

This effect of tremor compensation is most noticeable when the throttle is moved quickly from full to very low requests. **NOTE:** this function is bypassed if the throttle moves into the neutral deadband.

Although designed primarily to help end users with hand tremor problems, this parameter can be used more generally to smooth out overall vehicle responsiveness for steadier driving.

4

INSTALLATION CHECKOUT

Before operating the vehicle, carefully complete the following checkout procedure. If you find a problem during the checkout, refer to the diagnostics and troubleshooting section (Section 7) for further information.

The installation checkout can be conducted with or without the handheld programmer. The checkout procedure is easier with a programmer. Otherwise, observe the status LED for diagnostic codes. (The codes are listed in Section 7.)



Put the vehicle up on blocks to get the drive wheels off the ground before beginning these tests.

Do not stand, or allow anyone else to stand, directly in front of or behind the vehicle during the checkout.

Make sure the keyswitch is off, the throttle is in neutral, and the forward/reverse switches are open.

Wear safety glasses and use well-insulated tools.

Maintain proper grounding for ESD protection.

1. If a programmer is available, connect it to the programmer connector.
2. Turn on the keyswitch. The programmer should power up with an initial display, and the status LED should light steadily. If neither happens, check for continuity in the keyswitch circuit and controller ground.
3. If you are using a programmer, plug it in, wait until it has initialized, and then put it into the diagnostic mode. The display should indicate “No Known Faults.”

If there is a problem, the status LED will flash a diagnostic code and the programmer will display a diagnostic message. If you are conducting the checkout without a programmer, look up the status LED diagnostic code in Section 7: Diagnostics and Troubleshooting.

When the problem has been corrected, it may be necessary to cycle the keyswitch in order to clear the fault.
4. Select a direction and operate the throttle. The motor should begin to turn in the selected direction. If it does not, verify the wiring to the throttle and motor. The motor should run proportionally faster with increasing throttle. If not, refer to Section 7.
5. If you are using a programmer, put it into the test mode. Scroll down to observe the status of the switches: mode, reverse, and push. Plug in

the battery charger to verify the Inhibit input status. Cycle each input in turn, observing the programmer. The programmer should display the correct status for each input.

Similarly, check the throttle and speed limit pot inputs. The programmer should display the correct value for each input.

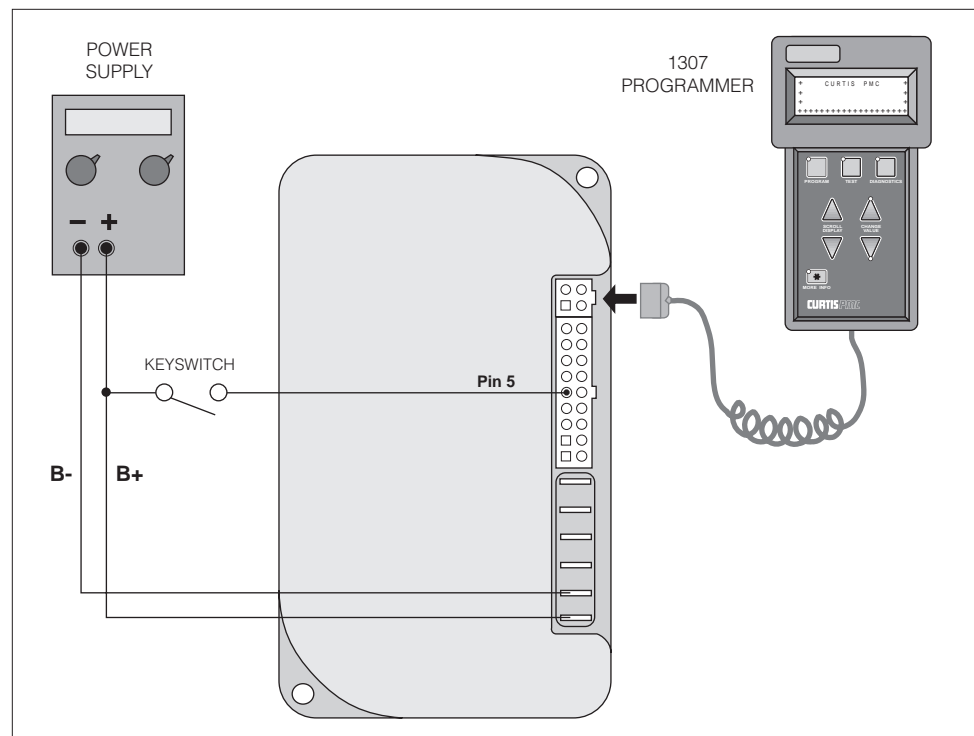
6. Verify that all options, such as high pedal disable (HPD) and seat lift, are as desired. If you are using a programmer, put it into the program mode and set the VSL parameter On to check out the seat lift.
7. Take the vehicle down off the blocks and drive it in a clear area. It should have smooth acceleration and good top speed.
8. Test the deceleration and regenerative braking of the vehicle. Verify that the deceleration and braking response is as desired.
9. If you used a programmer, disconnect it when you have completed the checkout procedure.

BENCH TESTING WITH THE PROGRAMMER

With the simple bench test setup shown in Figure 13, the controller parameters can be verified or adjusted without the controller being wired into a vehicle. The wiring can be expanded to conduct a complete functional test on the bench; if you want to do this, contact Curtis for further information.

The complete in-vehicle installation checkout, as described in Steps 1–9, should still be conducted before the vehicle is operated.

Fig. 13 Bench test setup for verifying and adjusting the controller's parameters.



5

PROGRAMMER MENUS

Curtis PMC's universal handheld programmers allow you to program, test, and diagnose Curtis PMC programmable controllers. For further information about programmer operation, consult the programmer manual or call the Curtis office closest to you.

There are five programmer menus:

- **Program Menu**
- **Test Menu**
- **Diagnostics Menu**
- **Special Diagnostics (Diagnostic History File)**
- **Special Program Menu.**

The first four menus are controller-specific, and are presented below. The items are listed in these menus in the order in which they appear in the actual menus displayed by the 1307 programmer. Depending on the specific 1228 model you have, some of the items may not appear.

The “special” program menu is generic to the various controllers, and is therefore not included here; see the programmer manual.

1228 PROGRAM MENU *(not all items available on all controllers)*

MAIN C/L	Main current limit for drive and regen. braking, in amps
MOTOR R	Cold resistance of traction motor, in milliohms
IR COMP COEFF	IR compensation factor: 0–100%
KEY OFF DECEL	Deceleration rate when keyswitch is turned off, in seconds
TREMOR COMP	Tremor compensation: 1–5
ACCEL MAX SPD	Acceleration rate at maximum throttle requests, in seconds
ACCEL MIN SPD	Acceleration rate at minimum throttle requests, in seconds
DECEL MAX SPD	Deceleration rate at maximum throttle requests, in seconds
DECEL MIN SPD	Deceleration rate at minimum throttle requests, in seconds
E STOP	Emergency deceleration rate, in seconds
REV ACCEL MAX	Reverse accel rate at maximum throttle requests, in seconds
REV ACCEL MIN	Reverse accel rate at minimum throttle requests, in seconds
REV DECEL MAX	Reverse decel rate at maximum throttle requests, in seconds
REV DECEL MIN	Reverse decel rate at minimum throttle requests, in seconds
M1 MAX SPD	Mode 1 max. speed with speed pot at max, as % available
M2 MAX SPD	Mode 2 max. speed with speed pot at max, as % available
M1 MIN SPD	Mode 1 max. speed with speed pot at min, as % available
M2 MIN SPD	Mode 2 max. speed with speed pot at min, as % available
M1 REV MAX SPD	Mode 1 max. reverse speed with speed pot at max, as % available
M2 REV MAX SPD	Mode 2 max. reverse speed with speed pot at max, as % available

REV MIN SPD	Maximum reverse speed with speed pot at min, as % available
GEAR SOFTEN	Softened torque reversals for accel/decel while moving: 0–100%
SOFT START	Softened torque endpoints for accel from zero speed: 0–100%
RAMP SHAPE	Throttle map: 20–70%
AMPERE HOURS	Battery pack capacity, in amp-hours ¹
BDI RESET	Battery pack full charge level, in volts
SLEEP DLY	Delay before sleep mode, in minutes
BRAKE DLY	Delay before engaging electromagnetic brake, in seconds
CREEP SPD	Creep speed, as % available speed
THRTL TYPE	Throttle type ²
THRTL DEADBAND	Neutral deadband adjustment, as % of active range
THRTL GAIN	Restricted range throttle adjustment: 1–10
THRTL AUTOCAL	Wigwag throttle centering utility: On/Off
SPD SCALER	Maximum voltage that can be applied to motor, in volts
HIGH PEDAL DIS	High pedal disable (HPD): On/Off
FAULT BEEP	Horn if HPD or brake fault: On/Off
SEAT LIFT	Seat lift enable: On/Off
BRAKE FLTS	Electromagnetic brake driver/wiring fault check: On/Off
SL BRAKE FLTS	Electromagnetic brake fault check in seat lift mode: On/Off
VSL	Virtual seat lift enable: On/Off ³
PUSH SPD	Push speed, as % available speed

Program Menu Notes

¹ The ampere-hours parameter is available on controllers with Rev. 06 software; it has been removed from the Rev. 07 software.

² Throttle types (see Throttle Wiring in Section 2)

Type 0: wigwag (5k Ω pots or 5V throttles)

Type 1: inverted wigwag (5k Ω pots or 5V throttles)

Type 2: single-ended pots (0–5k Ω)

Type 3: inverted single-ended pots (5k Ω –0)

Type 4: single-ended voltage throttles (0–5V)

Type 5: inverted single-ended voltage throttles (5V–0)

³ VSL is factory programmed to reset to Off when the keyswitch is cycled.

1228 TEST MENU (not all items available on all controllers)

HEAT SINK TEMP	Heatsink temperature, in °C
THROTTLE %	Throttle request: 0–100% of range
SPD LIMIT POT	Speed limit pot rotation: 0–100%
BATT VOLTAGE	Battery voltage across the capacitors
MODE INPUT A	On = Mode 1; Off = Mode 2
REVERSE INPUT	On = reverse is selected
INHIBIT IN	On = operation is inhibited
EM BRAKE DRVR	On = electromagnetic brake is mechanically released
MAIN CONT	On = voltage is applied to main relay coil
MOTOR R	Cold motor resistance, in mΩ
PUSH ENABLE IN	On = push enable switch is closed

1228 DIAGNOSTICS AND DIAGNOSTIC HISTORY

This is a list of the possible messages you may see displayed when the programmer is operating in either of the Diagnostics modes. The messages are listed here in alphabetical order for easy reference.

BRAKE ON FAULT	Electromagnetic brake coil open or driver short
BRAKE OFF FAULT	Electromagnetic brake coil short or driver open
CURRENT SENSE FAULT	A/D current sense voltage out of range
EEPROM FAULT	Error in reading EEPROM locations
HPD	High pedal disable (HPD) fault
HW FAILSAFE	Motor voltage fault
LOW BATTERY VOLTAGE	Battery voltage too low (<17 volts)
MAIN CONT FLTS	Main contactor did not close or did not open
MAIN ON FAULT	Main contactor driver failed short
MAIN OFF FAULT	Main contactor driver failed open
NO KNOWN FAULTS	No known faults
OVERVOLTAGE	Battery voltage too high (>36 volts)
POWER SECTION FAULT	MOSFET driver fault, or shorted motor wiring
PRECHARGE FAULT	Capacitor bank voltage < minimum operating voltage
PROC/WIRING FAULT	HPD fault present >10 seconds
SPD LIMIT POT FAULT	Speed limit pot input voltage out of range
THERMAL CUTBACK	Cutback, due to over-/under-temperature
THROTTLE FAULT 1	Throttle input voltage out of range

6

VEHICLE PERFORMANCE ADJUSTMENT

The 1228 controller is a very powerful vehicle control system. Its wide variety of adjustable parameters allow many aspects of vehicle performance to be optimized. Once a vehicle/motor/controller combination has been tuned, the parameter values can be made standard for that system or vehicle model. Any changes in the motor, the vehicle drive system, or the controller will require that the system be tuned again to provide optimum performance.

The tuning procedures should be conducted in the sequence given, because successive steps build upon the ones before. It is important that the effect of these programmable parameters be understood in order to take full advantage of the 1228 controller's powerful features. Please refer to the descriptions of the applicable parameters in Section 3 if there is any question about what any of them do.

Instructions are provided for the following seven tuning steps.

1. **Verifying the default parameters**
2. **Determining motor resistance**
3. **Tuning the throttle's active range**
4. **Setting the maximum speeds**
5. **Setting the acceleration and deceleration rates**
6. **Adjusting load compensation**
7. **Fine-tuning the vehicle's response smoothness.**

1. Verifying the default parameters

Set the throttle type parameter to match the type of throttle being used. Verify that all other parameters are at or reasonably near their default values before beginning the tuning exercise. Because much of the tuning must be done while driving the vehicle at high speed, it is important that you start with reasonable values or control may become difficult.

If your controller is a generic model, use the standard default parameter values listed in Appendix D. For OEM-specified controllers, use the default values for your customized controller.

2. Determining motor resistance

If the cold resistance of the traction motor in your application is known, you can enter this value, in milliohms, for the motor resistance (MOTOR R) parameter, and proceed to Step 3. However, we strongly recommend that instead of using the theoretical value provided by the motor manufacturer you use the actual value as determined in the following procedure. It is very important that the motor resistance parameter be set accurately. The correct value for MOTOR R is determined as follows.

- 2-a. Position the vehicle up against a wall, high curb, or some other immovable object.
- 2-b. Plug the programmer into the controller and turn on the keyswitch.
- 2-c. In the programmer's Program Menu, set the MAIN C/L parameter to "30" (30 amps).
- 2-d. In the Test Menu, scroll down to display the Motor R field.
- 2-e. With the speed limit pot set at maximum, apply the throttle full forward, driving the vehicle against the immovable object.
- 2-f. Observe the Motor R value displayed in the Test Menu.
- 2-g. Select the Program Menu, where MOTOR R will appear near the top of the display. Program the MOTOR R parameter to the Motor R value that was displayed in the Test Menu.
- 2-h. Before moving on to Step 3, be sure to set the MAIN C/L back to its default setting.

3. Tuning the throttle's active range

Before attempting to optimize any specific vehicle performance characteristics, it is important to ensure that the controller output is operating over its full range. The procedures that follow will establish the throttle deadband and throttle gain parameter values that correspond to the absolute full range of your particular throttle mechanism.* It is advisable to include some buffer around the absolute full range of the throttle mechanism to allow for throttle resistance variations over time and temperature as well as variations in the tolerance of potentiometer values between individual throttle mechanisms.

Tuning the throttle deadband

- 3-a. Jack the vehicle wheels up off the ground so that they spin freely.
- 3-b. Plug the programmer into the controller and turn on the keyswitch.
- 3-c. When the programmer instructs you to select a menu, select the Test Menu. The Throttle % field should be visible in the display. You will need to reference the value displayed here.
- 3-d. Slowly apply the throttle until you hear the electromagnetic brake disengage. Use care with this step as it is important to identify the threshold throttle position at which the brake is disengaged.
- 3-e. Without moving the throttle, read the value shown in the Throttle % field. This value should be zero. If the Throttle % value is zero, proceed to Step 3-f. If it is greater than zero, the throttle deadband parameter must be

* If you are using a wigwag throttle, you should center it before proceeding with the throttle tuning procedures. Instructions for wigwag throttle centering (using the Throttle Autocalibration parameter) are presented on page 25.

increased. Select the Program Menu, scroll down to display the THRTL DEADBAND field, and enter a larger THRTL DEADBAND value. Select the Test Menu and repeat the procedure from Step 3-d until the Throttle % is zero at the electromagnetic brake disengagement point.

- 3-f. While observing the Throttle % value displayed in the programmer's Test Menu, continue to increase the throttle past the electromagnetic brake disengagement point. Note where the Throttle % value begins to increase, indicating that the controller has begun to supply drive power to the motor. If the throttle had to be moved further than desired before the Throttle % value began to increase, the throttle deadband parameter must be decreased. In the Program Menu, scroll down to the THRTL DEADBAND field, and enter a smaller THRTL DEADBAND value. Select the Test Menu and repeat the procedure from Step 3-d. When the amount of travel between the point at which the brake is disengaged and the Throttle % value begins to increase is acceptable, the throttle deadband is properly tuned.
- 3-g. If a bidirectional (wigwag) throttle assembly is being used, the procedure should be repeated for the reverse direction. The THRTL DEADBAND value should be selected such that the throttle operates correctly in both forward and reverse.

Tuning the throttle gain

- 3-h. Jack the vehicle wheels up off the ground so that they spin freely.
- 3-i. Plug the programmer into the controller and turn on the keyswitch.
- 3-j. When the programmer instructs you to select a menu, select the Test Menu. The Throttle % field should be visible in the display. You will need to reference the value displayed here.
- 3-k. Apply full throttle and observe the Throttle % value. This value should be 100%. If it is less than 100%, the throttle gain must be decreased to attain full controller output at the maximum throttle position. Select the Program Menu, scroll down to the THROTTLE GAIN field, and enter a smaller THROTTLE GAIN value. Select the Test Menu and repeat this step until the Throttle % value is 100%.
- 3-l. Now that the full throttle position results in a 100% value for Throttle %, slowly reduce throttle until the Throttle % value drops below 100% and note the throttle position. This represents the extra range of motion allowed by the throttle mechanism. If this range is large, you may wish to decrease it by increasing the throttle gain. This will provide a larger active throttle range and more vehicle control. Select the Program Menu, scroll down to the THROTTLE GAIN field, and enter a smaller THROTTLE GAIN value. Select the Test Menu and repeat this step until an appropriate amount of extra range is attained.
- 3-m. If a wigwag throttle is being used, repeat the procedure for the reverse direction. The THROTTLE GAIN value should be selected such that the throttle operates correctly in both forward and reverse.

4. Setting the maximum speeds

The four maximum speeds with the speed limit pot in its maximum speed position (maximum forward speed in Mode 1 and in Mode 2, and maximum reverse speed in Mode 1 and in Mode 2) are set by the speed parameters containing the word MAX. The three maximum speeds with the speed limit pot in its minimum speed position (maximum forward speed in Mode 1 and in Mode 2, and the single maximum reverse speed for both M1/M2) are set by the speed parameters containing the word MIN. Each of the maximum speeds is set as a percentage of the maximum possible speed. Set each of the seven maximum speed parameters to give the desired performance.

- 4-a. Use M1 MAX SPD to set the maximum forward speed in Mode 1 when the speed limit pot is in its maximum speed position.
- 4-b. Use M2 MAX SPD to set the maximum forward speed in Mode 2 when the speed limit pot is in its maximum speed position.
- 4-c. Use M1 MIN SPD to set the maximum forward speed in Mode 1 when the speed limit pot is in its minimum speed position.
- 4-d. Use M2 MIN SPD to set the maximum forward speed in Mode 2 when the speed limit pot is in its minimum speed position.
- 4-e. Use M1 REV MAX SPD to set the maximum reverse speed in Mode 1 when the speed limit pot is in its maximum speed position.
- 4-f. Use M2 REV MAX SPD to set the maximum reverse speed in Mode 2 when the speed limit pot is in its maximum speed position.
- 4-g. Use REV MIN SPD to set the maximum reverse speed for both modes when the speed limit pot is in its minimum speed position.

5. Setting the acceleration and deceleration rates

After adjusting the maximum speed parameters per Step 4 (or leaving them at their default settings per Step 1), proceed with setting the acceleration and deceleration rates to give the desired performance.

The acceleration and deceleration functions have been designed to provide smooth throttle response when maneuvering at low speeds and snappy throttle response when traveling at high speeds. This is accomplished by defining acceleration/deceleration rates at each end of the speed limit pot's range. The rates are scaled linearly between these two endpoints. Four pairs of parameters define the endpoints of the acceleration/deceleration curves:

Forward acceleration:	ACCEL MIN SPD and ACCEL MAX SPD
Forward deceleration:	DECEL MIN SPD and DECEL MAX SPD
Reverse acceleration:	REV ACCEL MIN and REV ACCEL MAX
Reverse deceleration:	REV DECEL MIN and REV DECEL MAX.

The programmed acceleration and deceleration rates are independent of mode. However, it makes sense to adjust the low speed rates under the slowest speed conditions (Mode 1) and the high speed rates under the fastest speed conditions (Mode 2). Tuning the rates under the most extreme (slowest, fastest) conditions will most likely result in good performance throughout the entire driving range.

Forward acceleration and deceleration rates

- 5-a. First, set the ACCEL MIN SPD. Select Mode 1 and set the speed limit pot to its minimum speed position. For low speed testing, we suggest that you drive in a confined area such as an office, where low speed maneuverability is crucial. Depending on how you liked the forward acceleration you experienced, increase or decrease the ACCEL MIN SPD value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's low speed forward acceleration behavior.
- 5-b. Now adjust DECEL MIN SPD, the low speed forward deceleration characteristic. Driving at full throttle with the speed limit pot still in its minimum speed position, release the throttle to neutral. Depending on how you liked the deceleration you experienced, increase or decrease the DECEL MIN SPD value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's low speed forward deceleration behavior.
- 5-c. Next, set the ACCEL MAX SPD. Select Mode 2 and set the speed limit pot to its maximum speed position. Apply full throttle. Depending on how you liked the forward acceleration you experienced, increase or decrease the ACCEL MAX SPD value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's high speed forward acceleration.
- 5-d. Driving at full throttle with the speed limit pot still in its maximum speed position, release the throttle to neutral. Depending on how you liked the deceleration you experienced, increase or decrease the DECEL MAX SPD value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's high speed forward deceleration behavior.

Reverse acceleration and deceleration rates

- 5-e. First, set the REV ACCEL MIN. Select Mode 1 and set the speed limit pot to its minimum speed position. For low speed testing, we suggest that you drive in a confined area such as an office, where low speed maneuverability is crucial. Depending on how you liked the acceleration you experienced while driving in reverse, increase or decrease the REV ACCEL MIN value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's low speed reverse acceleration behavior.

- 5-f. Now adjust REV DECEL MIN, the low speed reverse deceleration characteristic. Leaving the speed limit pot in its minimum speed position, drive in reverse at full throttle and then release the throttle to neutral. Depending on how you liked the deceleration you experienced, increase or decrease the REV DECEL MIN value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's low speed reverse deceleration behavior.
- 5-g. Next, set the REV ACCEL MAX. Select Mode 2 and set the speed limit pot to its maximum speed position. Driving in reverse, apply full throttle. Depending on how you liked the reverse acceleration you experienced, increase or decrease the REV ACCEL MAX value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's high speed reverse acceleration.
- 5-h. Leaving the speed limit pot in its maximum speed position, drive in reverse at full throttle and then release the throttle to neutral. Depending on how you liked the deceleration you experienced, increase or decrease the REV DECEL MAX value from its default setting. Smaller values provide faster response. Continue testing and adjusting this value until you are satisfied with the vehicle's high speed reverse deceleration behavior.

Fine tuning the acceleration and deceleration rates

- 5-i. Drive around in both Mode 1 and Mode 2, while varying the position of the throttle and the speed limit pot. In most cases, setting the acceleration and deceleration rates as described in Steps 5-a through 5-h will provide good performance throughout. However, you may want to make further adjustments to them.
- 5-j. In rare cases, it may be desirable to adjust the RAMP SHAPE parameter. This parameter can be used, for example, to extend the throttle's gentle acceleration range to further enhance maneuverability in confined areas. See page 28 for a detailed description of the ramp shape options.

Emergency stop deceleration rate

The E STOP function is invoked when the vehicle is moving forward and the throttle makes a fast transition through neutral to a >80% reverse throttle request. This provides a way to stop more quickly when unexpected conditions arise. When the E STOP function engages, its programmed value becomes the new forward deceleration rate, replacing the regular forward deceleration rate.

- 5-k. Drive fast and suddenly release the throttle. You will experience the deceleration behavior determined by the forward deceleration rate.
- 5-l. Return to fast speed operation, and this time throw the throttle into >80% reverse. Now you are experiencing the deceleration behavior determined by the E STOP rate.
- 5-m. Adjust the E STOP value to produce the desirable "feel" for emergency stops: typically as fast as possible without making the vehicle unstable.

- 5-n. Note that the E STOP rate should always be faster than (or equal to) the fastest forward deceleration rate, DECEL MAX SPD.

6. Adjusting load compensation

The IR COMP COEFF parameter is used to set the percentage of the maximum motor resistance that will be applied, i.e., $(\text{IR COMP COEFF}) \times (\text{MOTOR R})$, to compensate for increased load caused by uneven terrain.

The trade-off in setting this parameter is that as ability to overcome load disturbances increases, operating smoothness decreases. A high IR COMP COEFF value will allow the vehicle to continue creeping at a low speed, even though it has just contacted a bump in the threshold of a doorway. But if IR COMP COEFF is set too high, it may make the vehicle “jumpy” during normal driving. Small throttle movements in this case may no longer provide gentle linear acceleration, but instead initiate accelerations with a sharp jerk. Therefore, the tuning goal is a balance between adequate load disturbance response and normal acceleration/deceleration response.

The normal range for IR COMP COEFF is approximately 50–80%. Larger numbers provide stiffer, stronger response. If the value needs to be much larger or smaller than this range to achieve acceptable performance, the MOTOR R has probably not been set up correctly and should be checked. NOTE: Largely different settings for IR COMP COEFF will affect the maximum speeds that were set in Step 4. Therefore, if you make large changes to IR COMP COEFF, you should repeat Step 4.

Assuming that MOTOR R is set correctly (within 10–20%), some general rules of thumb apply:

- 6-a. If the vehicle rolls the other direction near the end of a stop on flat ground, IR COMP COEFF is set too high.
- 6-b. If the vehicle seems to decelerate to a stop in a nonlinear fashion, IR COMP COEFF could be set too high.
- 6-c. If the vehicle is extremely “jumpy” (i.e., responds abruptly to small throttle changes, IR COMP COEFF could be set too high.
- 6-d. If the vehicle is still moving on a modest ramp when the brake gets set, IR COMP COEFF is set too low.
- 6-e. If the vehicle speed varies dramatically when cresting a hill, IR COMP COEFF is most likely set too low.

7. Fine-tuning the vehicle’s response smoothness

Three additional functions—gear soften, soft start, and tremor compensation—are available for softening and smoothing vehicle response. In most cases, these functions can be used to maintain a high degree of responsiveness, while still providing smooth vehicle operation.

Gear soften and soft start

These two parameters can be set from 0–100%, with 100% providing a great deal of softening and 0% eliminating the function. They have by far the most noticeable effect on older, worn transaxles.

- 7-a. Make sure the GEAR SOFTEN and SOFT START parameters are set to 0%.
- 7-b. While driving at both high and low speeds, release the throttle to neutral and then reapply it before coming to a complete stop. Notice how the transaxle gears bump as you reapply the throttle.
- 7-c. Change the GEAR SOFTEN parameter from 0% to 100% and repeat the same exercise. Notice how the slop transition is softened, at the expense of a small bit of nonlinearity in the acceleration rate.
- 7-d. Adjust the GEAR SOFTEN parameter until you find a setting you like, noting that you probably won't notice much of a difference if you're using a brand new, tight transaxle. Some users prefer a softened feel, while others prefer this parameter set to zero because they want complete linearity in response. In setting this parameter, you also may want to take into consideration that softened slack take-up is easier on the transaxle gears and may extend the transaxle operating life.
- 7-e. The soft start function is the same as gear soften, except that it applies to accelerations from zero speed. Note that you'll feel a transaxle bump only if the gears are meshed in the opposite direction when torque is applied, so you may need to nudge the vehicle backwards against the brake when experimenting with this parameter. We recommend relatively small values for the SOFT START parameter (typically < 40%) to avoid excessive delay from a stop. Having separate parameters for the soft start and gear soften functions allows you to set the SOFT START parameter lower than the GEAR SOFTEN parameter. Setting the two parameters the same in effect collapses them into a single parameter.

Tremor compensation

The TREMOR COMP parameter controls vehicle response to sharp throttle movements, such as those resulting inadvertently from hand tremors. This parameter can be set from 1–5, with larger values providing steadier response. The tremor compensation function somewhat overlaps the gear softening functions. However, the tremor compensation function is active all the time, while the two gear softening functions are active only during a gear slack transition, i.e., a torque direction reversal.

Generally, we recommend that you do all your tuning with the TREMOR COMP parameter set to 4 and then either leave it at 4 or adjust it down to 3 or up to 5 as the final piece of tuning. Tremor compensation is most noticeable when the throttle is moved quickly from full to small (but non-neutral) values. The function is bypassed in the neutral state to ensure responsive linear deceleration when the driver commands a stop.

7

DIAGNOSTICS AND TROUBLESHOOTING

The 1228 controller provides diagnostics information to assist technicians in troubleshooting drive system problems. The diagnostics information can be obtained in two ways: observing the fault codes issued by the status LED or reading the appropriate display on the handheld programmer.

LED DIAGNOSTICS

During normal operation, with no faults present, the status LED is steadily on. If the controller detects a fault, the status LED provides two types of information. First, it displays a slow flash (2 Hz) or a fast flash (4 Hz) to indicate the severity of the fault. Slow-flash faults are self-clearing; as soon as the fault is corrected, the vehicle will operate normally. Fast-flash faults (“*” in Table 3) are considered to be more serious in nature and require that the keyswitch be cycled to resume operation after the fault is corrected.

After the severity indication has been active for 10 seconds, the status LED flashes a 2-digit fault identification code continuously until the fault is corrected. For example, code “1,4”—low battery voltage—appears as:

□ □ □ □ □	□ □ □ □ □	□ □ □ □ □
(1 , 4)	(1 , 4)	(1 , 4)

The codes are listed in Table 3. Refer to the troubleshooting chart (Table 4) for suggestions about possible causes of the various faults.

PROGRAMMER DIAGNOSTICS

The programmer presents complete diagnostic information in plain language, in its Diagnostics Menu. The following 4-step process is recommended for diagnosing and troubleshooting an inoperative vehicle: (1) visually inspect the vehicle for obvious problems; (2) diagnose the problem, using the programmer; (3) test the circuitry with the programmer; and (4) correct the problem. Repeat the last three steps as necessary until the vehicle is operational.

Example: A vehicle that does not operate in reverse is brought in for repair.

STEP 1: Examine the vehicle and its wiring for any obvious problems, such as broken wires or loose connections.

STEP 2: Connect the programmer, select the Diagnostics Menu, and read the displayed fault information. In this example, the display shows “No Known Faults,” indicating that the controller has not detected anything out of the norm.

Table 3 STATUS LED FAULT CODES

LED CODES		EXPLANATION	
<i>LED off</i>	████████	no power or defective controller	
<i>solid on</i>	□□□□□□	controller operational; no faults	
1,1	□ □	thermal cutback fault	
1,2	□ □□	throttle fault	
1,3	□ □□□	speed limit pot fault	
1,4	□ □□□□	undervoltage fault	
1,5	□ □□□□□	overvoltage fault	
2,1	□□ □	main contactor driver Off fault	
2,3	□□ □□	main contactor fault	
2,4	□□ □□□	main contactor driver On fault	
*	3,1	□□□ □	HPD fault present for >10 seconds
	3,2	□□□ □□	brake On fault
	3,3	□□□ □□□	precharge fault
	3,4	□□□ □□□□	brake Off fault
	3,5	□□□ □□□□□	HPD (High Pedal Disable) fault
*	4,1	□□□□ □	current sense fault
*	4,2	□□□□ □□	motor voltage fault (hardware failsafe)
* †	4,3	□□□□ □□□	EEPROM fault
*	4,4	□□□□ □□□□	power section fault

* = Must cycle keyswitch to clear.
† = Must use programmer to clear, as follows: select Program Menu, alter data value of any parameter, cycle keyswitch.

NOTE: Only one fault is indicated at a time, and faults are not queued up.

STEP 3: Select the Test Menu, and observe the status of the inputs and outputs in the reverse direction. In this example, the display shows that the reverse switch did not close when “reverse” was selected, which means the problem is either in the reverse switch or the switch wiring.

STEP 4: Check or replace the reverse switch and wiring and repeat the test. If the programmer shows the reverse switch closing and the vehicle now drives normally, the problem has been corrected.

Refer to the troubleshooting chart (Table 4) for suggestions covering a wide range of possible faults.

Table 4 TROUBLESHOOTING CHART

LED CODE	PROGRAMMER LCD DISPLAY	EXPLANATION	POSSIBLE CAUSE
1,1	THERMAL CUTBACK	over-/under-temperature cutback	<ol style="list-style-type: none"> 1. Temperature >97°C or < -25°C. 2. Excessive load on vehicle. 3. Operation in extreme environments. 4. Electromagnetic brake not releasing properly.
1,2	THROTTLE FAULT 1	throttle fault	<ol style="list-style-type: none"> 1. Throttle input wire open or shorted. 2. Throttle pot defective. 3. Wrong throttle type selected.
1,3	SPD LIMIT POT FAULT	speed limit pot fault	<ol style="list-style-type: none"> 1. Speed limit pot wire(s) broken or shorted. 2. Broken speed limit pot.
1,4	LOW BATTERY VOLTAGE	battery voltage too low	<ol style="list-style-type: none"> 1. Battery voltage <17 volts. 2. Bad connection at battery or controller.
1,5	OVERVOLTAGE	battery voltage too high	<ol style="list-style-type: none"> 1. Battery voltage >36 volts. 2. Vehicle operating with charger attached. 3. Intermittent battery connection.
2,1	MAIN OFF FAULT	main contactor driver Off fault	<ol style="list-style-type: none"> 1. Main contactor driver failed open.
2,3	MAIN CONT FLTS	main contactor fault	<ol style="list-style-type: none"> 1. Main contactor welded or stuck open. 2. Main contactor driver fault. 3. Brake coil resistance too high.
2,4	MAIN ON FAULT	main contactor driver On fault	<ol style="list-style-type: none"> 1. Main contactor driver failed closed.
3,1	PROC/WIRING FAULT	HPD fault present for >10 sec.	<ol style="list-style-type: none"> 1. Misadjusted throttle. 2. Broken throttle pot or throttle mechanism.
3,2	BRAKE ON FAULT	brake On fault	<ol style="list-style-type: none"> 1. Electromagnetic brake driver shorted. 2. Electromagnetic brake coil open.
3,3	PRECHARGE FAULT	precharge fault	<ol style="list-style-type: none"> 1. Controller failure. 2. Low battery voltage.
3,4	BRAKE OFF FAULT	brake Off fault	<ol style="list-style-type: none"> 1. Electromagnetic brake driver open. 2. Electromagnetic brake coil shorted.
3,5	HPD	HPD (High Pedal Disable) fault	<ol style="list-style-type: none"> 1. Improper sequence of throttle and KSI, push, or inhibit inputs. 2. Misadjusted throttle pot.
4,1	CURRENT SENSE FAULT	current sense fault	<ol style="list-style-type: none"> 1. Short in motor or in motor wiring. 2. Controller failure.
4,2	HW FAILSAFE	motor voltage fault (hardware failsafe)	<ol style="list-style-type: none"> 1. Motor voltage does not correspond to throttle request. 2. Short in motor or in motor wiring. 3. Controller failure.
4,3	EEPROM FAULT	EEPROM fault	<ol style="list-style-type: none"> 1. EEPROM failure or fault.
4,4	POWER SECTION FAULT	power section fault	<ol style="list-style-type: none"> 1. EEPROM failure or fault. 2. Short in motor or in motor wiring. 3. Controller failure.

8

MAINTENANCE

There are no user serviceable parts in the Curtis PMC 1228 controller. **No attempt should be made to open, repair, or otherwise modify the controller.** Doing so may damage the controller and will void the warranty. However, it is recommended that the controller's diagnostics history file be checked and cleared periodically, as part of routine vehicle maintenance.

DIAGNOSTIC HISTORY

The handheld programmer can be used to access the controller's diagnostic history file. The programmer will read out all the faults that the controller has experienced since the last time the diagnostic history file was cleared. The faults may be intermittent faults, faults caused by loose wires, or faults caused by operator errors. Faults such as HPD or overtemperature may be caused by operator habits or by overloading.

After a problem has been diagnosed and corrected, clearing the diagnostic history file is advisable. This allows the controller to accumulate a new file of faults. By checking the new diagnostic history file at a later date, you can readily determine whether the problem was indeed completely fixed.

For instructions on accessing and clearing the diagnostic history file, see the Curtis PMC programmer manual.

APPENDIX A

GLOSSARY OF FEATURES AND FUNCTIONS

Acceleration rate

The acceleration rate is the time required for the controller to increase its speed command from zero to 100% when full throttle is applied. The 1228 has four acceleration rates that can be set independently: forward acceleration with the speed limit pot in its maximum speed position and in its minimum speed position, and reverse acceleration with the speed limit pot in its maximum speed position and in its minimum speed position. The forward acceleration rates control how quickly the vehicle accelerates when it is moving forward, and the reverse acceleration rates control how quickly the vehicle accelerates when it is moving in reverse.

The acceleration rates at each end of the speed limit pot's range define the endpoints of the forward and reverse acceleration curves—see *Section 3, page 19*.

Access rights

Each programmable parameter is assigned an access level (OEM or User) that defines who is allowed to adjust it. Restricting parameter access to the OEM reduces the likelihood of important performance characteristics being changed by someone unfamiliar with the vehicle's operation. In some cases, it may be necessary to restrict a parameter's access to ensure that it is not set to a value in violation of EEC or other safety regulations.

Curtis PMC programmers are available in OEM and User models; the User programmer can adjust only those parameters with User access, while the OEM programmer can adjust all the parameters. Typically, OEMs supply User programmers to their dealers and distributors for setting the User-access parameters to each customer's liking, and also for testing and diagnostics.

Anti-rollback

The anti-rollback feature prevents a vehicle that is traveling uphill in forward or reverse from rolling back downhill when the throttle is released. It engages the electromagnetic brake before the vehicle begins to roll back down the incline.

Anti-roll-forward

The anti-roll-forward feature prevents a vehicle that is traveling downhill in forward or reverse from rolling downhill excessively when the throttle is released. This reduces "coasting" downhill when the throttle is released during low speed operation.

BDI

The 1228 controller can drive a panel battery discharge indicator (BDI) to show the battery pack's state of charge as a percentage of the amp-hour capacity of the batteries—*see Section 2, page 15*.

Brake delay time

The brake delay time specifies when the controller engages the electromagnetic brake after the controller's speed command has reached zero. This time delay should be set long enough to allow full deceleration without jerking the vehicle to a stop yet short enough so that the brake is engaged immediately after the vehicle comes to a stop.

The anti-roll-forward feature is affected by the brake delay. The brake delay parameter should therefore be adjusted while driving on both hills and flat terrain, to determine the setting that provides the most comfortable stop within the specified stopping distance.

Creep speed

Creep speed, which is activated when the throttle is first moved out of the neutral deadband, helps to prevent rollback when starting uphill on an incline with low throttle. The creep speed is programmable—*see Section 3, page 23*.

Current limiting

Curtis PMC controllers limit the motor current to a preset maximum. This feature protects the controller from damage that might result if the current were limited only by motor demand. Output from the power section is reduced until the motor current falls below the set limit level.

In addition to protecting the controller, the current limit feature also protects the rest of the system. By eliminating high current surges during vehicle acceleration, stress on the motor and batteries is reduced and their efficiency enhanced. Similarly, there is less wear and tear on the vehicle drivetrain. The current limit is programmable—*see Section 3, page 19*.

Current multiplication

During acceleration and during reduced speed operation, the Curtis PMC controller allows more current to flow into the motor than flows out of the battery. The controller acts like a dc transformer, taking in low current and high voltage (the full battery voltage) and putting out high current and low voltage.

Deceleration rate

The deceleration rate determines the time required for the controller to decelerate from its present output to zero when the throttle is released to neutral—*see Section 3, page 21*. The 1228 has four deceleration rates that can be set

independently: forward deceleration with the speed limit pot in its maximum speed position and in its minimum speed position, and reverse deceleration with the speed limit pot in its maximum speed position and in its minimum speed position. The forward deceleration rates control how quickly the vehicle slows when it is moving forward, and the reverse deceleration rates control how quickly the vehicle slows when it is moving in reverse.

NOTE: See *Emergency stop* and *Key-off deceleration* entries, below, for additional special deceleration rates.

Electromagnetic compatibility (EMC)

Electromagnetic compatibility (EMC) is regulated by various federal and international standards, which establish maximum levels of allowable emissions and minimum levels of immunity. A variety of techniques can be used to improve EMC performance; see Appendix C.

Emergency stop (“E Stop”)

The E Stop feature provides a separately programmable deceleration rate that is invoked when the vehicle is traveling forward and the throttle is thrown into >80% reverse. This provides a way to stop the vehicle quickly when unexpected conditions arise—see *Section 3, page 21*.

Electrostatic discharge (ESD)

Electrostatic discharge (ESD) can degrade sensitive electronic components within the controller. See Appendix C for suggestions on minimizing ESD.

ET-series electronic throttles

The ET-XXX is a wigwag-style throttle control assembly that provides a 0–5V signal in both the forward and reverse directions. Use of this throttle control assembly requires that the controller throttle input be configured for a single-ended Type 4 (0–5V) throttle.

Fault detection and response

An internal microcontroller automatically maintains surveillance over the functioning of the controller. When a fault is detected, the appropriate fault code is signalled via the Status LED and is also displayed on the programmer via the Diagnostics Menu. See *Section 7: Diagnostics and Troubleshooting*.

If the fault is critical, the controller is disabled. More typically, the fault is a remediable condition and temporary—for example, an HPD fault is cleared when the throttle is returned to neutral. The faults covered by the 1228 controller’s automatic fault detection system are listed in the troubleshooting chart presented as Table 4—see *Section 7, page 48*.

Fault recording

Fault events are recorded in the controller's memory. Multiple occurrences of the same fault are recorded as one occurrence.

The fault event list can be loaded into the programmer for readout. The Special Diagnostics mode provides access to the controller's diagnostic history file—the entire fault event list created since the diagnostic history file was last cleared. The Diagnostics mode, on the other hand, provides information about only the currently active faults.

Fault recovery

Some faults require cycling the keyswitch to reset the controller and enable operation after the cause of the fault has been remedied. For most faults, however, all that is required is bringing operation into compliance. For example, an overvoltage fault clears as soon as battery voltage drops within the acceptable range. For more detail about clearing faults, see Tables 3 (page 47) and 4 (page 48).

Full bridge

The 1228 controller uses a full bridge design for power switching and direction selection. This eliminates the need for external or on-board forward/reverse contactors. The result is a higher reliability product providing smoother direction transitions and a more comfortable ride.

Gear soften

The gear soften feature allows smooth pickup of gear slack in the transmission when torque is reversed; it affects all accelerations except those from zero speed (see Soft start). The gear soften feature is programmable—see *Section 3, page 20*.

Hardware failsafe *(see Motor voltage fault)*

High pedal disable (HPD)

The HPD feature prevents controller output if the controller is turned on when the throttle is not in neutral. For the vehicle to start, the controller must receive an input to KSI before receiving a throttle input. In addition to providing routine smooth starts, HPD also protects against accidental sudden starts if problems in the throttle linkage (e.g., bent parts, broken return spring) give a throttle input signal to the controller even with the throttle released.

Similarly, HPD prevents controller output if the controller is turned on when the push switch is in the On position. For the vehicle to start, the controller must receive an input to KSI before receiving a push input.

HPD also intervenes if the push switch or inhibit switch is activated while the vehicle is driving. If the inhibit switch is turned on, the vehicle goes into

HPD immediately. If the push switch is turned on, the push input is ignored until the vehicle has stopped, at which point the vehicle goes into HPD.

The HPD feature can be programmed On or Off—see *Section 3, page 29*. All DME scooter applications must have this parameter programmed On to satisfy the industry's safety requirements.

HPD lockout (procedural/wiring fault)

After 10 seconds of a continuous HPD fault, driving is inhibited until power to the controller is cycled. This feature prevents operation of a vehicle with a defective or misadjusted throttle.

Inhibit

The inhibit input is used to put the vehicle in a safe, non-drivable state during battery charging. Typically, battery chargers have a dedicated third terminal that automatically provides inhibit, as shown in the basic wiring diagrams (Figures 3a/3b and 4a/4b). If your charger does not have this third terminal, the inhibit input should be wired directly to the charger—see *Section 2, page 14*.

IR compensation

IR compensation is a technique used to provide near-constant speed control of the vehicle during varying motor loads despite resistive motor losses (IR). Internal circuitry monitors the current and voltage in the motor relative to throttle position and adjusts the controller output to maintain as constant a speed as possible during varying motor loads. The motor load varies as a function of inclines/declines in terrain or when the vehicle encounters an obstacle, such as debris on the sidewalk. The programmable IR speed compensation parameter adjusts how aggressively the controller tries to maintain constant speed under changing load conditions—see *Section 3, page 24*.

ISO pot fault

All 1228 controllers contain throttle pot fault circuitry that meets ISO 7176 requirements.

Key-off deceleration

The key-off deceleration feature provides controlled deceleration—rather than an abrupt stop—when the keyswitch is turned off for any reason while driving. The key-off deceleration rate is programmable—see *Section 3, page 22*.

KSI

KSI (Key Switch Input) provides power to the controller's logic board, initializes the microprocessor, and starts diagnostics. The keyswitch functions as a master switch for the vehicle, to turn the system off when not in use.

LED

The 1228 controller allows for the use of a Light Emitting Diode (LED) to indicate the status of the controller and provide system fault information—*see Section 2, page 15*.

Load compensation (*see IR compensation*)

Missing brake detection

If the electromagnetic brake coil circuit is open, the controller inhibits driving and shorts the motor. If a mechanical brake release lever is used, it is recommended that a switch operated by this lever be wired in series with the brake coil to inhibit driving when the brake is mechanically released, as shown in the wiring diagrams. This provides a safety feature by ensuring the vehicle cannot be driven when the brake cannot be engaged. All DME scooter applications must have this parameter programmed On to satisfy the industry's safety requirements. In non-scooter applications such as scrubbers/sweepers where there is no electromagnetic brake, the brake fault features can be turned Off.

An alternative brake fault detection protocol is used in applications with a seat lift. When a seat lift is requested, the controller disables the electromagnetic brake. This would cause a brake fault, if the special seat lift brake fault protocol were not used. In applications with a seat lift, both the standard brake faults parameter and the seat lift mode brake faults parameter should be programmed On.

The brake faults parameter and seat lift brake faults parameter are both programmable—*see Section 3, page 30*.

MOSFET

A MOSFET (metal oxide semiconductor field effect transistor) is a type of transistor characterized by its fast switching speeds and very low losses.

Motor voltage fault

The motor voltage fault check circuit verifies that the average voltage being applied to the motor corresponds to that requested by the throttle input. If there is a discrepancy between the throttle request and voltage across the motor, the controller is shut down. The motor voltage fault check appears on the programmer's Diagnostics Menu as the "Hardware Failsafe" fault.

MultiMode™

The MultiMode™ feature of these controllers allows the vehicle to be operated with two distinct sets of characteristics. The two modes can be programmed to be suitable for operation under different conditions, such as slow precise indoor maneuvering in Mode 1 and faster, long distance, outdoor travel in Mode 2.

The following parameters can be set independently in the two modes:

- maximum speed (maximum forward speed with speed pot at max)
- minimum speed (maximum forward speed with speed pot at min)
- maximum reverse speed.

OEM (= Original Equipment Manufacturer)

Output fault detection

The 1228 controller provides two types of output fault protection. The controller compares the throttle request to the controller's output voltage. If they diverge beyond specified limits, the controller shorts the motor through the low side bridge drivers, thus quickly bringing the vehicle to a stop.

Output fault protection also protects against shorts in the motor or its wiring as well as component failures within the controller that could lead to uncontrolled motor operation. If the controller detects a motor or motor wiring short, or a component failure within the controller output drivers, the controller power section opens the connection to the motor, thus allowing the vehicle to coast.

Overtemperature (*see Thermal protection*)

Overvoltage protection

The overvoltage protection feature shorts the motor and shuts down the regenerative current path to the controller if the voltage exceeds the factory-set limit. Controller operation resumes when the voltage is brought within the acceptable range. The 1228's cutoff and re-enable voltage is 36 V.

Power saver

The power saver feature minimizes battery power drain if the vehicle is left on but is not being used. The main contactor is released after 25 seconds if no throttle commands are received. Normal operation resumes when the throttle is moved. If the throttle remains at neutral beyond the programmed Sleep Delay time, the controller powers down completely; normal operation resumes when the keyswitch is cycled.

Precharge

The precharge feature soft-charges the controller's internal capacitor bank when the controller is first turned on and before the main relay is engaged. This protects the main relay's contacts from the large inrush currents that exist when battery voltage is applied to a discharged capacitor bank.

Precharge fault

The precharge fault feature keeps the main contactor from being engaged if the internal capacitor bank voltage does not rise above the minimum threshold within 500 ms after the controller is turned on. This protects the system against faults that short the controller's internal B+ bus.

Procedural/wiring fault (HPD lockout)

After 10 seconds of a continuous HPD fault, driving is inhibited until power to the controller is cycled. This feature prevents operation of a vehicle with a defective or misadjusted throttle.

Push

The push feature allows the brake to be released electrically so that the vehicle can be pushed. This is convenient when, for example, it is appropriate for an attendant to manually push a mobility aid scooter. The push feature inhibits the controller's drive function until the push switch is turned off, thus ensuring that the vehicle cannot be operated in a condition in which the electromagnetic brake cannot be engaged. To use the push feature, the batteries must be wired to the controller, the keyswitch must be on, the vehicle must be stopped, and the electromagnetic brake must be engaged.

The maximum speed at which the vehicle can be pushed is programmable—see *Section 3, page 23*. If the vehicle is pushed faster than the programmed push speed, indicating a runaway or other abnormal condition, the push-too-fast feature will intervene and limit the speed of the vehicle.

Push-too-fast

The push-too-fast feature limits the maximum speed at which the vehicle can be pushed, thus guarding against vehicle runaway with the electromagnetic brake mechanically released. The controller, even if it is powered off and there are no batteries in the system, will detect the motor voltage created by the moving vehicle. When this voltage becomes high enough, indicating that significant vehicle speed has been reached, the controller logic will power up and turn on the MOSFET power sections to regulate the motor voltage and limit the speed of the vehicle.

PWM

Pulse width modulation (PWM), also called “chopping,” is a technique that switches battery voltage to the motor on and off very quickly, thereby controlling the speed of the motor. Curtis PMC 1200 series controllers use high frequency PWM—15 kHz—which permits silent, efficient operation.

Ramp shape (static throttle map)

The ramp shape parameter determines the controller's static throttle map. Adjusting the throttle characteristics to suit your specific application can enhance your vehicle's performance. The ramp shape parameter is programmable—see *Section 3, page 28*.

Regenerative braking

The 1228 controller uses regenerative braking to slow the vehicle to a stop and to reduce speed when traveling downhill. Regenerative braking means that the energy used to slow the vehicle is channeled back into the batteries, resulting in longer vehicle range between charges.

Reverse beeper

The 1228 controller can drive an OEM-supplied low current dc horn at 1 Hz while the vehicle is backing up. This safety feature reduces the risk of injury to passersby.

Reverse polarity protection

If the B+ and B- connections are reversed to an otherwise properly wired controller, it will not allow the main contactor to be engaged. This protects the controller's power MOSFET output section from being damaged by the reverse polarity.

Seat lift

The 1228 is designed to make implementation of a seat lift function easy; see Figures 3a/3b. The 1228 can be used to drive the seat lift motor as well as the traction motor. An external power relay is required to route the motor drive power from the traction motor to the seat lift motor when seat lift is requested. The seat lift switch is plugged into the controller's 4-pin connector. The seat lift feature can be programmed On or Off—see *Section 3, page 30*.

Soft start

The soft start feature allows smooth pickup of gear slack in the transaxle when accelerating from zero speed. The soft start feature is programmable—see *Section 3, page 20*.

Speed scaler

The speed scaler feature eliminates variations in speed that would otherwise result from variations in battery charge levels from fully charged to partially discharged. The programmable speed scaler parameter allows you to set the maximum voltage that can be applied to the motor—see *Section 3, page 24*.

Speed settings

There are two upper-limit speed settings: maximum and minimum. The “maximum” speed settings define the highest controller output at full throttle with the speed limit pot in its maximum speed position. The “minimum” speed settings define the highest controller output at full throttle with the speed limit pot in its minimum speed position. The maximum and minimum speeds are programmable independently for Mode 1 and Mode 2—see *Section 3, page 22*.

The reverse upper-limit speed settings are also programmable; the maximum reverse speed is programmable independently in both modes, and the minimum reverse speed is a single setting that applies to both modes—see *Section 3, page 23*.

Temperature compensation

The 1228 controller employs temperature compensation to minimize performance variation resulting from changes in controller or ambient temperatures. There is, however, a small rolloff in the current limit value as the controller’s power section heats up. Variations of up to 10% of the specified 1-minute current limit rating may be observed in applications where the controller undergoes significant heating. Providing adequate air flow will minimize this effect.

Temperature data

The temperature displayed in the programmer’s Test Menu is the instantaneous heatsink temperature, in degrees Celsius.

Thermal protection

Because of their efficiency and thermal design, Curtis PMC controllers should barely get warm in normal operation. Overheating can occur, however, if the controller is undersized for its application or otherwise overloaded. If the internal temperature of the controller exceeds 97°C (206°F), the main current limit decreases steadily until it is reduced to zero at 134°C (273°F). At the reduced performance level, the vehicle can be maneuvered out of the way and parked. Full current limit and performance return automatically after the controller cools down.

NOTE: To prevent loss of braking effort, regenerative current limit is not cut back in overtemperature conditions. As a consequence, motor braking down a steep slope with a heavy driver for an extended period of time may cause severe overheating of the MOSFETs. If thermal cutback occurs often in normal vehicle operation, the controller is probably undersized for the application and a higher current model should be used.

The controller is similarly protected from undertemperature. Should its internal temperature fall below -25°C (-13°F), the current limit decreases to approximately one-half of the set current. When the controller warms up, full current limit and performance return automatically.

Throttle deadband (neutral deadband)

The throttle deadband is the pot wiper voltage range that the controller interprets as neutral. Increasing the neutral range can be useful with throttle assemblies that do not return reliably to a well-defined neutral point. The throttle deadband parameter is programmable—see *Section 3, page 25*.

Throttle fault protection

5k Ω , 3-wire potentiometer throttle

For 5k Ω , 3-wire potentiometer throttles, the throttle fault detection circuitry meets ISO 7176 requirements. Also, throttle pot resistances outside the range of 4.5–7 k Ω are considered to be indicative of a faulty pot or faulty wiring, in which case the controller will register a pot fault. Fault detection causes the controller to decelerate to zero output. The controller returns to normal operation when the fault has been repaired.

0–5V throttle

Because the throttle input voltage is referenced to B- and no connection is made to the pot high and pot low inputs, complete throttle pot protection is lost with 0–5V throttles. Only a broken wire fault to the pot wiper input will be detected by the controller. Therefore, **it is the responsibility of the vehicle manufacturer to provide throttle fault detection for 0–5V throttles.**

Throttle gain

The 1228 controller can be programmed for use with restricted range throttle inputs via the throttle gain parameter—see *Section 3, page 27*. This capability allows throttle pots with < 5k Ω total full stroke wiper resistance to be used.

Throttle map

The static throttle map (duty cycle as a function of throttle position) is adjustable, in order to provide the proper feel for the many types of vehicles that use the 1228 controller. The throttle map parameter is called “ramp shape,” and is programmable—see *Section 3, page 28*.

Throttle response

The dynamic throttle response (duty cycle as a function of time) is shaped by the acceleration and deceleration rate settings. The newest throttle input is mapped to the throttle map, and the controller then automatically accelerates (or decelerates) through a straight line until the new throttle demand is obtained.

Throttle types

The controller can be programmed to accept wigwag or single-ended signals from a 5k Ω , 3-wire pot or from a 0–5V voltage source—see *Section 3, page 24*.

Undertemperature (see *Thermal protection*)

Undervoltage protection

Undervoltage protection automatically cuts back the controller output if battery voltage is detected below the undervoltage point at startup, or when the battery voltage is pulled below the undervoltage point by an external load. The undervoltage cutback point is not adjustable; for the 1228 controller, it is 17 volts derated linearly to 14 volts.

During normal operation, the controller duty cycle will be reduced when the batteries discharge down to less than the undervoltage level. If the motor current is such that the batteries are being pulled below the minimum point, the duty cycle will be reduced until the battery voltage recovers to the minimum level. In this way the controller “servos” the duty cycle around the point which maintains the minimum allowed battery voltage.

If the voltage continues to drop below the undervoltage level to a severe undervoltage condition (due to battery drain or external load), the controller output is disabled.

Virtual seat lift

Because the handheld programmer and the seat lift switch input share the same 4-pin connector on the 1228 controller, they cannot both be plugged in at the same time. The virtual seat lift parameter, when programmed On, mimics the seat lift switch input signal when the programmer is plugged in. This enables the seat lift functions to be tested and programmed without the seat lift switch input being plugged in—see *Section 3, page 31*.

The virtual seat lift parameter is factory set to Off. The OEM can change this parameter to On temporarily, while the programmer is plugged in, for test purposes. It defaults to the factory setting when the keyswitch is cycled.

Watchdog (external, internal)

The external watchdog timer guards against a complete failure of the microprocessor, which would incapacitate the internal watchdog timer. This independent system check on the microprocessor meets the EEC’s requirement for backup fault detection.

The external watchdog timer safety circuit shuts down the controller (and the microprocessor) if the software fails to generate a periodic external pulse train. This pulse train can only be created if the microprocessor is operating. If not periodically reset, the watchdog timer times out after 15–20 msec and turns off the controller. The external watchdog also directly shuts down the PWM drive to the MOSFETs. It can only be reset by cycling KSI.

The internal watchdog timer must be reset periodically by correct sequential execution of the software. If not reset, the internal timer times out and the microprocessor is “warm booted.” This causes the microprocessor to shut down its outputs—thus shutting down the controller—and attempt to restart.

APPENDIX B THROTTLE MOUNTING DIMENSIONS

Fig. B-1 *Mounting dimensions, Curtis PMC standard 5kΩ, 3-wire throttle potentiometer, p/n 98191.*

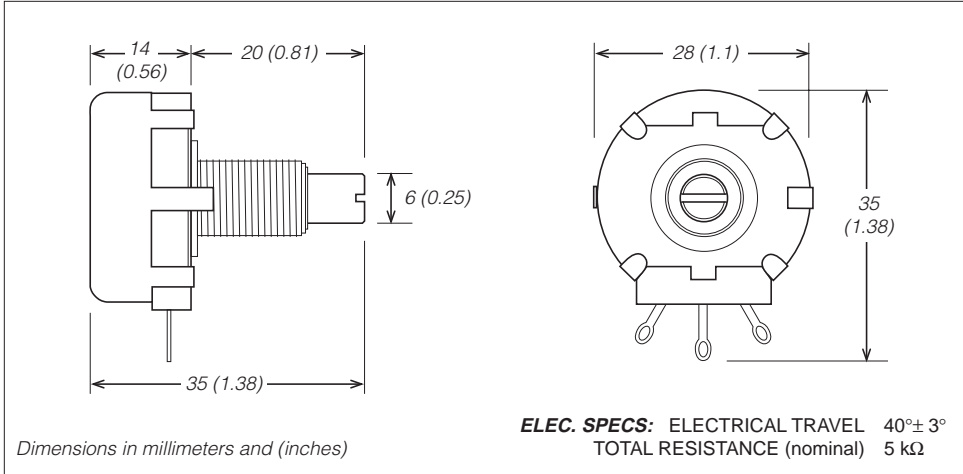
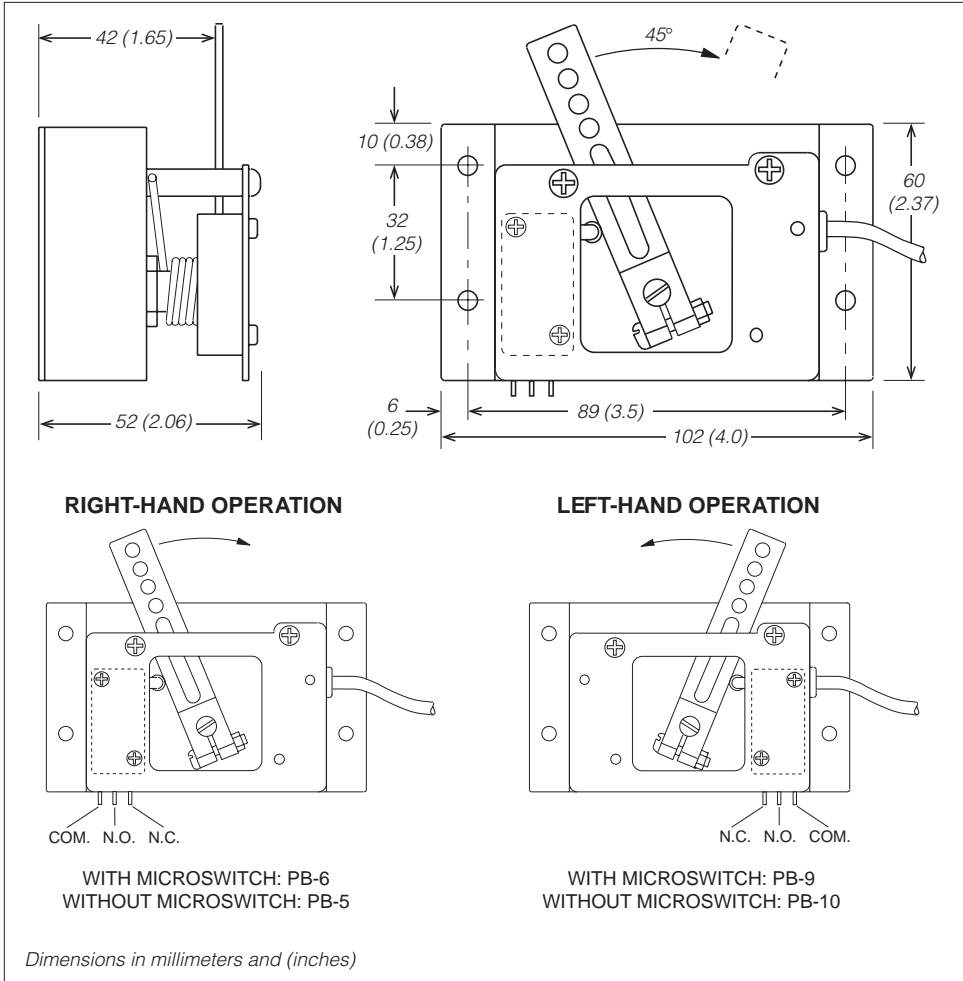


Fig. B-2 *Mounting dimensions, Curtis PMC potboxes PB-5, -6, -9, and -10.*



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Fig. B-3 Mounting dimensions, Curtis PMC footpedal FP-2.

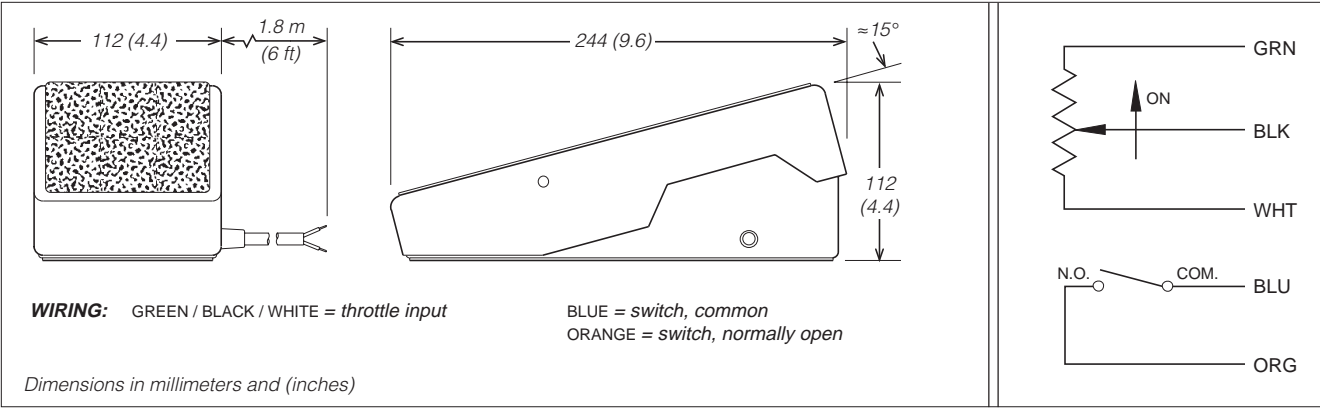
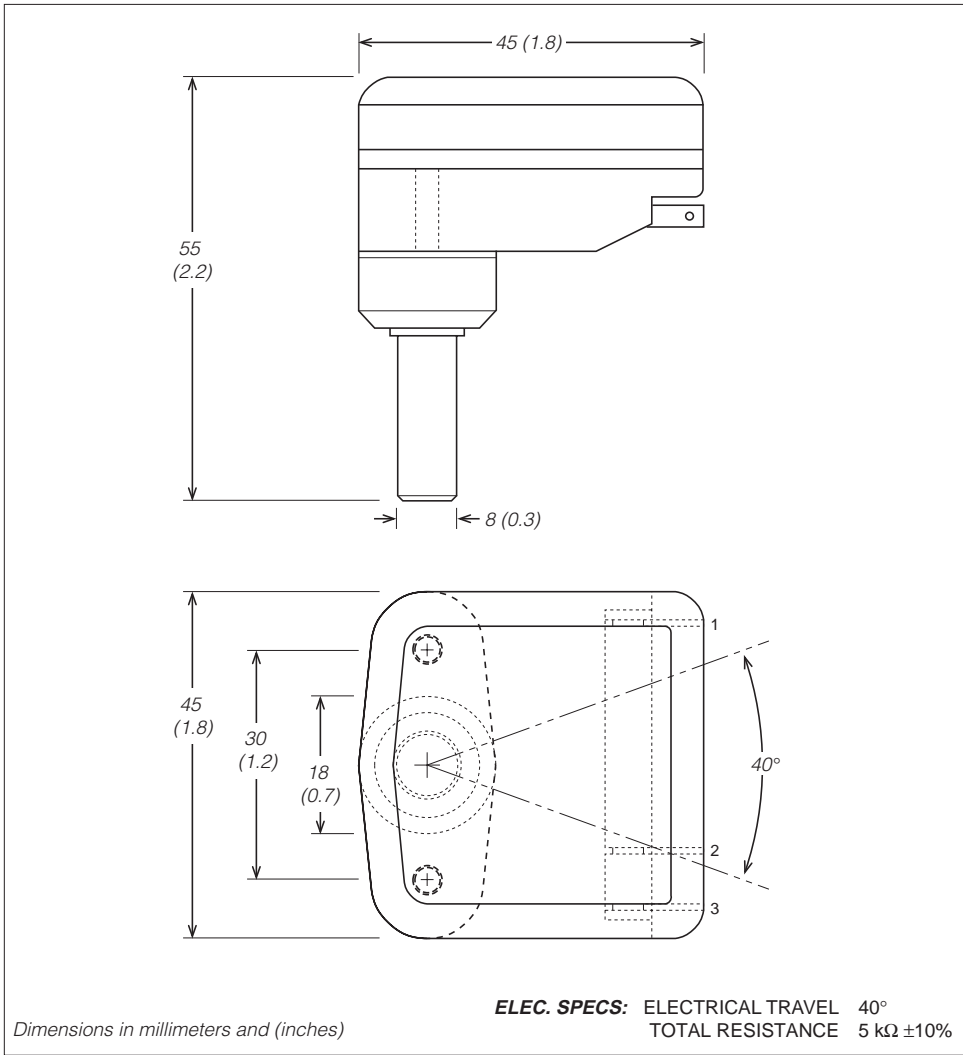
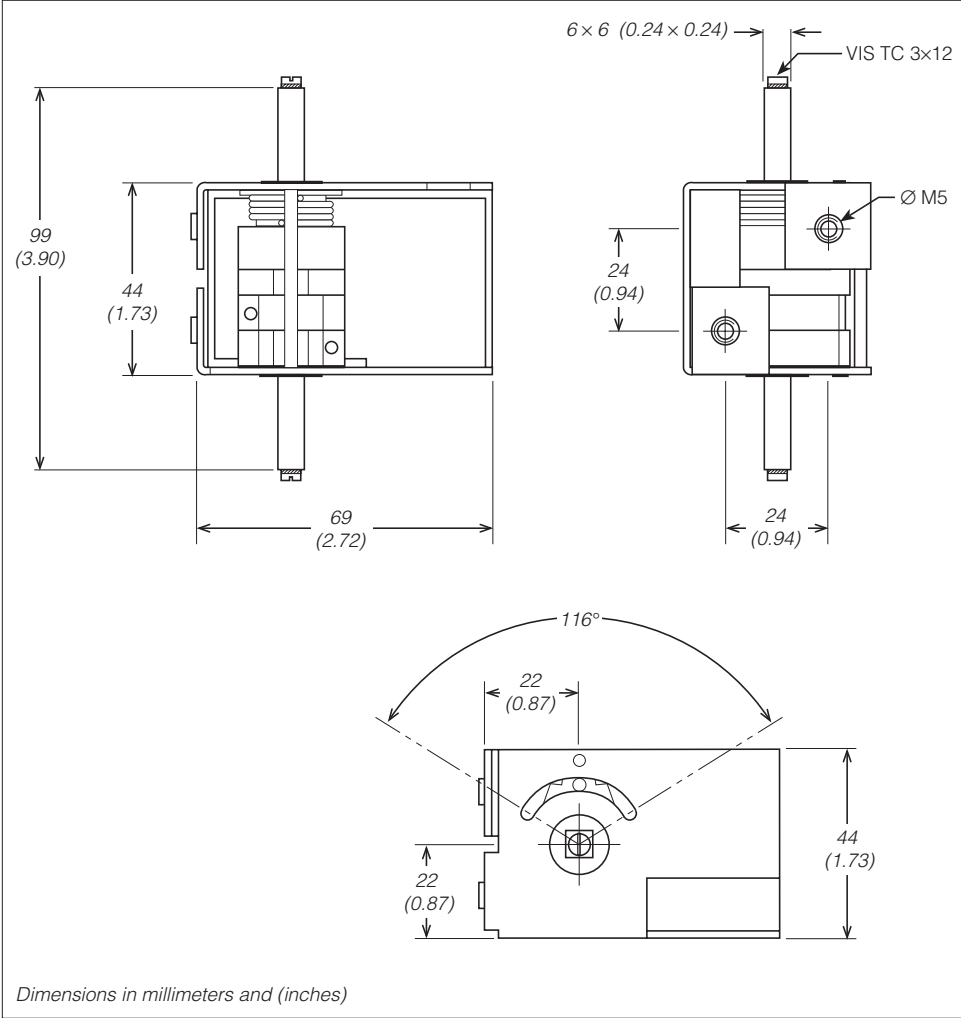


Fig. B-4 Mounting dimensions, Curtis potentiometer throttle WP-45 CP.



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Fig. B-5 *Mounting dimensions, Curtis electronic throttle (ET series).*



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APPENDIX C

VEHICLE DESIGN CONSIDERATIONS REGARDING ELECTROMAGNETIC COMPATIBILITY (EMC) AND ELECTROSTATIC DISCHARGE (ESD)

ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic compatibility (EMC) encompasses two areas: emissions and immunity. *Emissions* are radio frequency (rf) energy generated by a product. This energy has the potential to interfere with communications systems such as radio, television, cellular phones, dispatching, aircraft, etc. *Immunity* is the ability of a product to operate normally in the presence of rf energy.

EMC is ultimately a system design issue. Part of the EMC performance is designed into or inherent in each component; another part is designed into or inherent in end product characteristics such as shielding, wiring, and layout; and, finally, a portion is a function of the interactions between all these parts. The design techniques presented below can enhance EMC performance in products that use Curtis PMC motor controllers.

Decreasing Emissions

Motor brush arcing can be a significant source of rf emissions. These emissions may be reduced by installing bypass capacitors across the motor wires and/or between each motor wire and the motor frame. If the latter approach is used, the voltage rating and leakage characteristics of the capacitors must be adequate to meet any safety regulations regarding electrical connections between a battery operated circuit and the chassis. The bypass capacitor should be installed as close to the motor as possible, or even inside it, to provide the best performance. Alternatively a ferrite bead can be installed on the wires, as close as possible to the motor. In some instances, capacitors and ferrite beads may both be appropriate. Another option is to choose a motor with a brush material that will result in less arcing to the commutator. Brushes that have been run in for approximately 100 hours will typically generate lower emissions than new brushes because there is less arcing after they are properly seated.

The motor drive output from Curtis PMC controllers can also make a contribution to rf emissions. This output is a pulse width modulated square wave with rather fast rise and fall times that are rich in harmonics. The impact of these switching waveforms can be minimized by making the wires from the controller to the motor as short as possible. Ferrite beads installed on the drive wires can further reduce these emissions. For applications requiring very low emissions, the solution may involve enclosing the controller, interconnect wires, and motor together in one shielded box. The motor drive harmonics can couple to battery supply leads and throttle circuit wires, so ferrite beads may also be required on these other wires in some applications.

Increasing Immunity

Immunity to radiated electric fields can be achieved either by reducing the overall circuit sensitivity or by keeping the undesired signals away from this circuitry. The controller circuitry itself cannot be made less sensitive, since it must accurately detect and process low level signals from the throttle potentiometer. Thus immunity is generally achieved by preventing the external rf energy from coupling into sensitive circuitry. This rf energy can get into the controller circuitry via conducted paths and via radiated paths.

Conducted paths are created by the wires connected to the controller. These wires act as antennas and the amount of rf energy coupled into these wires is generally proportional to their length. The rf voltages and currents induced in each wire are applied to the controller pin to which the wire is connected. Curtis PMC motor controllers include bypass capacitors on the printed circuit board's throttle wires to reduce the impact of this rf energy on the internal circuitry. In some applications, ferrite beads may also be required on the various wires to achieve desired performance levels.

Radiated paths are created when the controller circuitry is immersed in an external field. This coupling can be reduced by enclosing the controller in a metal box. Some Curtis PMC motor controllers are enclosed by a heat sink that also provides shielding around the controller circuitry, while others are unshielded. In some applications, the vehicle designer will need to mount the controller within a shielded box on the end product. The box may be constructed of just about any metal, although steel and aluminum are most commonly used.

Most coated plastics do not provide good shielding because the coatings are not true metals, but rather a mixture of small metal particles in a non-conductive binder. These relatively isolated particles may appear to be good based on a dc resistance measurement but do not provide adequate electron mobility to yield good shielding effectiveness. Electroless plating of plastic will yield a true metal and can thus be effective as an rf shield, but it is usually more expensive than the coatings.

A contiguous metal enclosure without any holes or seams, known as a Faraday cage, provides the best shielding for the given material and frequency. When a hole or holes are added, rf currents flowing on the outside surface of the shield must take a longer path to get around the hole than if the surface was contiguous. As more "bending" is required of these currents, more energy is coupled to the inside surface, and thus the shielding effectiveness is reduced. The reduction in shielding is a function of the longest linear dimension of a hole rather than the area. This concept is often applied where ventilation is necessary, in which case many small holes are preferable to a few larger ones.

Applying this same concept to seams or joints between adjacent pieces or segments of a shielded enclosure, it is important to minimize the open length of these seams. Seam length is the distance between points where good ohmic contact is made. This contact can be provided by solder, welds, or pressure contact. If pressure contact is used, attention must be paid to the corrosion characteristics of the shield material and any corrosion-resistant processes

applied to the base material. If the ohmic contact itself is not continuous, the shielding effectiveness can be maximized by making the joints between adjacent pieces overlapping rather than abutted.

The shielding effectiveness of an enclosure is further reduced when a wire passes through a hole in the enclosure. RF energy on the wire from an external field is re-radiated into the interior of the enclosure. This coupling mechanism can be reduced by filtering the wire at the point where it passes through the boundary of the shield. Given the safety considerations involved with connecting electrical components to the chassis or frame in battery powered vehicles, such filtering will usually consist of a series inductor (or ferrite bead) rather than a shunt capacitor. If a capacitor is used, it must have a voltage rating and leakage characteristics that will allow the end product to meet applicable safety regulations.

The B+ (and B-, if applicable) wires that supply power to the throttle control panel—such as for the keyswitch—should be bundled with the remaining throttle wires so that all these wires are routed together. If the wires to the control panel are routed separately, a larger loop area is formed. Larger loop areas produce more efficient antennas which will result in decreased immunity performance.

ELECTROSTATIC DISCHARGE (ESD)

Curtis PMC motor controllers contain ESD-sensitive components, and it is therefore necessary to protect them from ESD damage. Electrostatic discharge (ESD) immunity is achieved either by providing sufficient distance between conductors and the outside world so that a discharge will not occur, or by providing an intentional path for the discharge current such that the circuit is isolated from the electric and magnetic fields produced by the discharge. In general the guidelines presented above for increasing the radiated immunity will also provide increased ESD immunity.

It is usually easier to prevent the discharge from occurring than to divert the current path. A fundamental technique for ESD prevention is to provide adequately thick insulation between all metal conductors and the outside environment so that the voltage gradient does not exceed the threshold required for a discharge to occur. However, in some scooter applications isolation may not be appropriate; in these cases, connection to chassis ground may be required. If the current diversion approach is used, all exposed metal components must be grounded. The shielded enclosure, if properly grounded, can be used to divert the discharge current; it should be noted that the location of holes and seams can have a significant impact on the ESD suppression. If the enclosure is not grounded, the path of the discharge current becomes more complex and less predictable, especially if holes and seams are involved. Some experimentation may be required to optimize the selection and placement of holes, wires, and grounding paths. Careful attention must be paid to the control panel design so that it can tolerate a static discharge.

APPENDIX D

PROGRAMMABLE PARAMETERS

The 1228's programmable parameters are listed in 1307 program menu order in Table D-1, along with the default access levels, minimum and maximum allowable values, and default settings that are standard on generic models. Cross references to the main entry in the manual are also provided.

Table D-1 PARAMETER RANGES AND DEFAULT SETTINGS
(for Generic 1228 Controllers with Rev. 06 and Rev. 07 Software):
1307 PROGRAM MENU ORDER LISTING

PARAMETER	DEFAULT ACCESS	MIN VALUE	MAX VALUE	DEFAULT SETTING	UNITS	DESCRIPTION IN MANUAL
MAIN C/L	OEM	30	70, 110	70, 110 ^(a)	amps	page 19
MOTOR R	OEM	0	400	300, 240 ^(b)	milliohms	page 19
IR COMP COEFF	OEM	0	100	70	percent	page 24
KEY OFF DECEL	OEM	0.2	4.0	0.6	seconds	page 22
TREMOR COMP	OEM	1	5	3	–	page 32
ACCEL MAX SPD	User	0.2	4.0	1.4	seconds	page 19
ACCEL MIN SPD	User	0.2	8.0	4.0	seconds	page 20
DECEL MAX SPD	OEM	0.2	4.0	1.4	seconds	page 21
DECEL MIN SPD	OEM	0.2	8.0	4.0	seconds	page 21
E STOP	OEM	0.2	4.0	0.6	seconds	page 21
REV ACCEL MAX	User	0.2	8.0	2.0	seconds	page 20
REV ACCEL MIN	User	0.2	8.0	5.0	seconds	page 20
REV DECEL MAX	OEM	0.2	4.0	1.8	seconds	page 21
REV DECEL MIN	OEM	0.2	8.0	3.8	seconds	page 22
M1 MAX SPD	User	0	100	60	percent	page 22
M2 MAX SPD	User	0	100	100	percent	page 22
M1 MIN SPD	OEM	0	100	20	percent	page 23
M2 MIN SPD	OEM	0	100	15	percent	page 23
M1 REV MAX SPD	User	0	100	40	percent	page 23
M2 REV MAX SPD	User	0	100	40	percent	page 23
REV MIN SPD	User	0	100	15	percent	page 23
GEAR SOFTEN	OEM	0	100	10	percent	page 20
SOFT START	OEM	0	100	0	percent	page 20
RAMP SHAPE	User	20.0	70.0	50.0	percent	page 28
AMPERE HOURS ^(c)	OEM	0	70, 110	33	amp-hours	page 31
BDI RESET	OEM	0.0	40.0	27.0	volts	page 31
SLEEP DLY	OEM	0	60	30	minutes	page 32
BRAKE DLY	OEM	0.0	1.0	0.2	seconds	page 22
CREEP SPD	OEM	0.0	20.0	8.0	percent	page 23
THRTL TYPE	OEM	0	5	0 ^(d)	–	page 24
THRTL DEADBAND	OEM	6.0	25.0	10.0	percent	page 25
THRTL GAIN	OEM	1.0	10.0	1.1	–	page 27
THRTL AUTOCAL	OEM			OFF	–	page 25
SPD SCALER	OEM	20.0	28.0	24.0	volts	page 24
HIGH PEDAL DIS	OEM			ON	–	page 29
FAULT BEEP	OEM			ON	–	page 30
SEAT LIFT	OEM			OFF	–	page 30
BRAKE FLTS	OEM			ON	–	page 30
SL BRAKE FLTS	OEM			ON	–	page 30
VSL	OEM			OFF	–	page 31
PUSH SPD	OEM	25	60	35	percent	page 23

^a Main C/L default setting depends on model: 1228-2420 is 70 amps, 1228-2720 is 110 amps.

^b Motor R default setting depends on model: 1228-2420 is 150 mΩ, 1228-2720 is 120 mΩ.

^c Ampere hours parameter is not included in Rev. 07 software.

^d Throttle types: 0=wigwag, 1=inverted wigwag, 2=0–5kΩ, 3=5kΩ–0, 4=0-5V, 5=5V–0.

The 1228's programmable parameters are listed in alphabetical order (by display name) in Table D-2, along with the default access levels, minimum and maximum allowable values, and default settings that are standard on generic models. Cross references to the main entry in the manual are also provided.

Table D-2 PARAMETER RANGES AND DEFAULT SETTINGS
(for Generic 1228 Controllers with Rev. 06 and Rev. 07 Software):
ALPHABETICAL LISTING

PARAMETER	DEFAULT ACCESS	MIN VALUE	MAX VALUE	DEFAULT SETTING	UNITS	DESCRIPTION IN MANUAL
ACCEL MAX SPD	User	0.2	4.0	1.4	seconds	page 19
ACCEL MIN SPD	User	0.2	8.0	4.0	seconds	page 20
AMPERE HOURS ^(a)	OEM	0	70, 110	33	amp-hours	page 31
BDI RESET	OEM	0.0	40.0	27.0	volts	page 31
BRAKE DLY	OEM	0.0	1.0	0.2	seconds	page 22
BRAKE FLTS	OEM			ON	–	page 30
CREEP SPD	OEM	0.0	20.0	8.0	percent	page 23
DECEL MAX SPD	OEM	0.2	4.0	1.4	seconds	page 21
DECEL MIN SPD	OEM	0.2	8.0	4.0	seconds	page 21
E STOP	OEM	0.2	4.0	0.6	seconds	page 21
FAULT BEEP	OEM			ON	–	page 30
GEAR SOFTEN	OEM	0	100	10	percent	page 20
HIGH PEDAL DIS	OEM			ON	–	page 29
IR COMP COEFF	OEM	0	100	70	percent	page 24
KEY OFF DECEL	OEM	0.2	4.0	0.6	seconds	page 22
MAIN C/L	OEM	30	70, 110	70, 110^(b)	amps	page 19
MAX SPD, M1	User	0	100	60	percent	page 22
MAX SPD, M2	User	0	100	100	percent	page 22
MIN SPD, M1	OEM	0	100	20	percent	page 23
MIN SPD, M2	OEM	0	100	15	percent	page 23
MOTOR R	OEM	0	400	300, 240^(c)	milliohms	page 19
PUSH SPD	OEM	25	60	35	percent	page 23
REV ACCEL MAX	User	0.2	8.0	2.0	seconds	page 20
REV ACCEL MIN	User	0.2	8.0	5.0	seconds	page 20
REV DECEL MAX	OEM	0.2	4.0	1.8	seconds	page 21
REV DECEL MIN	OEM	0.2	8.0	3.8	seconds	page 22
REV MAX SPD, M1	User	0	100	40	percent	page 23
REV MAX SPD, M2	User	0	100	40	percent	page 23
REV MIN SPD	User	0	100	15	percent	page 23
RAMP SHAPE	User	20.0	70.0	50.0	percent	page 28
SEAT LIFT	OEM			OFF	–	page 30
SL BRAKE FLTS	OEM			ON	–	page 30
SLEEP DLY	OEM	0	60	30	minutes	page 32
SOFT START	OEM	0	100	0	percent	page 20
SPD SCALER	OEM	20.0	28.0	24.0	volts	page 24
THRTL AUTOCAL	OEM			OFF	–	page 25
THRTL DEADBAND	OEM	6.0	25.0	10.0	percent	page 25
THRTL GAIN	OEM	1.0	10.0	1.1	–	page 27
THRTL TYPE	OEM	0	5	0^(d)	–	page 24
TREMOR COMP	OEM	1	5	3	–	page 32
VSL	OEM			OFF	–	page 31

^a Ampere hours parameter is not included in Rev. 07 software.

^b Main C/L default setting depends on model: 1228-2420 is 70 amps, 1228-2720 is 110 amps.

^c Motor R default setting depends on model: 1228-2420 is 150 mΩ, 1228-2720 is 120 mΩ.

^d Throttle types: 0=wigwag, 1=inverted wigwag, 2=0–5kΩ, 3=5kΩ–0, 4=0-5V, 5=5V–0.

APPENDIX E

SPECIFICATIONS

Table E-1 SPECIFICATIONS: 1228 CONTROLLER

Nominal input voltage	24 V
PWM operating frequency	15 kHz
Electrical isolation to heatsink	500 V ac (minimum)
B+, B- logic pin current (max.)	9 A (pins 10, 11 and 1, 2 on 18-pin connector)
KSI input current (typical)	50 mA without programmer; 150 mA with programmer
KSI input current (peak)	1.5 A
Logic input current (typical)	1 mA at 24 V
Horn output current (max.)	15 mA
BDI output voltage and current (max.)	0–5 V, 2 mA
LED output current (max.)	15 mA
Electromagnetic brake coil resistance	32–200 Ω
Electromagnetic brake current (max.)	1 A
Control input switch type	on/off
Speed control signal	3-wire, 0–5k Ω ; or 0–5V
Speed control type	single-ended or wigwag
Operating ambient temperature range	-25°C to 45°C (-13°F to 113°F)
Storage ambient temperature range	-40°C to 75°C (-40°F to 167°F)
Heatsink overtemperature cutback	linear cutback starts at 97°C (206°F); complete cutoff at 134°C (273°F)
Heatsink undertemperature cutback	50% armature current at -25°C (-13°F)
Package environmental rating	IP40
Weight	0.6 kg (1.3 lb)
Dimensions (L×W×H)	156 × 91 × 43 mm (6.13" × 3.60" × 1.71")
Regulatory compliance	Designed to carry the CE marking in accordance with EMC directive 89/336/EEC. EMC and EMI per PREN12184:1995; EN55011/03.91; EN61000-4.2:1996; EN61000-4.3:1997; and EN50204:1995. All software documentation needed to support 510K FDA filing is available.

MODEL NUMBER	NOMINAL BATTERY VOLTAGE (volts)	15 SEC RATING (amps)	1 MIN RATING (amps)	1 HOUR RATING (amps)	VOLTAGE DROP @ 20 AMPS (volts)	UNDER-VOLTAGE CUTBACK (volts)	OVER-VOLTAGE CUTOFF (volts)
1228-24XX	24	70	70 *	35 †	0.45	17	36
1228-27XX	24	110	75 *	35 †	0.20	17	36

* Actual value of 1-minute rating depends on MOSFET heating (see "Temperature compensation" in Appendix A: Glossary).

† Typical value; actual value depends on duty cycle and motor resistance. Higher duty cycles and higher resistances yield higher ratings.

LIMITED WARRANTY

Vestil Manufacturing Corporation (“Vestil”) warrants this product to be free of defects in material and workmanship during the warranty period. *Our warranty obligation is to provide a replacement for a defective original part if the part is covered by the warranty, after we receive a proper request from the warrantee (you) for warranty service.*

Who may request service?

Only a warrantee may request service. *You are a warrantee if* you purchased the product from Vestil or from an authorized distributor AND Vestil has been fully paid.

What is an “original part”?

An original part is a part used to make the product as shipped to the warrantee.

What is a “proper request”?

A request for warranty service is proper if Vestil receives: 1) a photocopy of the Customer Invoice that displays the shipping date; AND 2) a written request for warranty service including your name and phone number. Send requests by any of the following methods:

Mail
Vestil Manufacturing Corporation
2999 North Wayne Street, PO Box 507
Angola, IN 46703

Fax
(260) 665-1339
Phone
(260) 665-7586

Email
sales@vestil.com

In the written request, list the parts believed to be defective and include the address where replacements should be delivered.

What is covered under the warranty?

After Vestil receives your request for warranty service, an authorized representative will contact you to determine whether your claim is covered by the warranty. Before providing warranty service, Vestil may require you to send the entire product, or just the defective part or parts, to its facility in Angola, IN. The warranty covers defects in the following *original* dynamic components: motors, hydraulic pumps, electronic controllers, switches and cylinders. It also covers defects in *original* parts that wear under normal usage conditions (“wearing parts”): bearings, hoses, wheels, seals, brushes, batteries, and the battery charger.

How long is the warranty period?

The warranty period for original components is 1 year. The warranty period begins on the date when Vestil ships the product to the warrantee. If the product was purchased from an authorized distributor, the period begins when the distributor ships the product. Vestil may extend the warranty period for products shipped from authorized distributors by *up to* 30 days to account for shipping time.

If a defective part is covered by the warranty, what will Vestil do to correct the problem?

Vestil will provide an appropriate replacement for any *covered* part. An authorized representative of Vestil will contact you to discuss your claim.

What is not covered by the warranty?

1. Labor;
2. Freight;
3. Occurrence of any of the following, which automatically voids the warranty:
 - Product misuse;
 - Negligent operation or repair;
 - Corrosion or use in corrosive environments;
 - Inadequate or improper maintenance;
 - Damage sustained during shipping;
 - Collisions or other incidental contacts causing damage to the product;
 - Unauthorized modifications: DO NOT modify the product IN ANY WAY without first receiving written authorization from Vestil. Modification(s) might make the product unsafe to use or might cause excessive and/or abnormal wear.

Do any other warranties apply to the product?

Vestil Manufacturing Corp. makes no other express warranties. All implied warranties are disclaimed to the extent allowed by law. Any implied warranty not disclaimed is limited in scope to the terms of this Limited Warranty.

