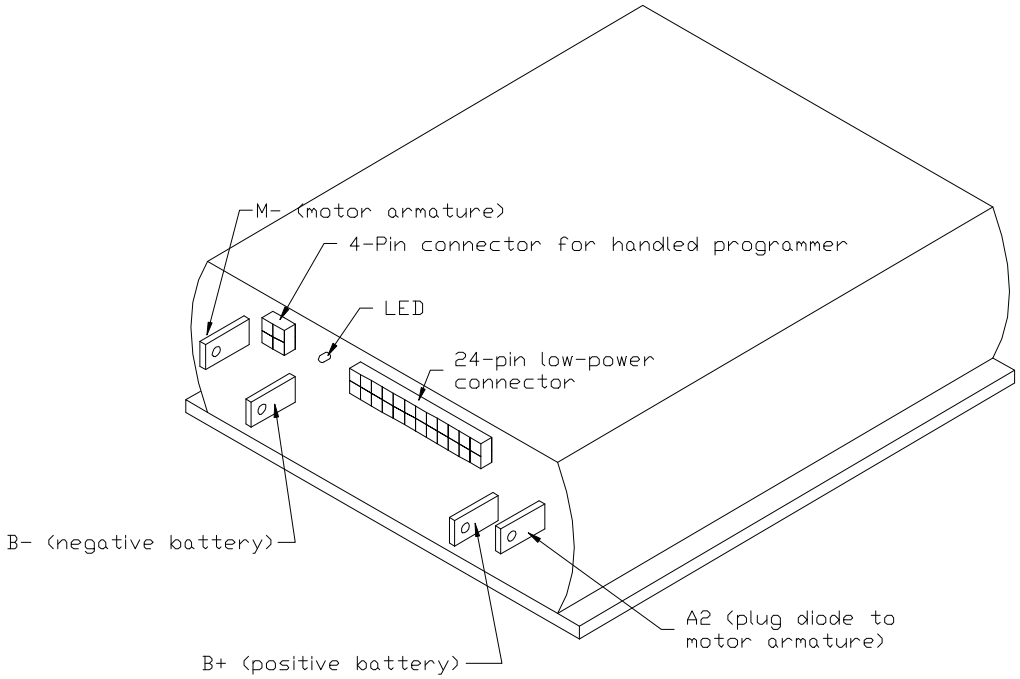
INTRODUCTION

Curtis PMC 11980169 & 11980170 programmable motor speed controllers provide efficient, cost-effective and simple to install controls for a variety of large industrial vehicles. Typical applications include walkie/rider pallet trucks, fork lifts, stackers, reach trucks and other industrial trucks.

The 1207-based microprocessor logic section combined with a Curtis PMC Mosfet power section gives the 11980169 & 11980170 controller high power and advanced features in a rugged, compact package. The optional hand held programer enables the user to set parameters, conduct tests, and obtain diagnostic information quickly and easily.

Figure 1



Like all Curtis PMC motor controllers, the 11980169 & 11980170 controller offers superior operator control of the vehicle' s motor drive speed. The key features of the controllers are:

* Infinitely variable drive and plug brake control
* Custom power MOSFET design providing high efficiency (for reduced motor and battery losses) and silent operation
* Power connections made by tin-plated copper busses with a polarized Molex connector for control signals

* Sealed package, providing environmental protection

* Thermal protection and compensating circuitry provides under-temperature cutback, constant current limit over operating range, and linear roll back in over-temperature thus preventing sudden power loss regardless of thermal conditions

* Over voltage and under voltage protection

* Intelligent hand held programmer (Curtis PMC #11980176) provides a full set of parameter and function setting

* Diagnostic and test information for the controller and other system components readily available through both an on board LED and the optional hand held programmer

* Meets or exceeds EEC fault detect requirements, with circuitry and software to detect faults in the throttle circuit, MOSFET drive circuits, MOSFET output, contactor drivers, and contactors

* Programmable input sequencing options include several combinations of neutral start and static return to off (SRO)

* Arcless contactor switching with microprocessor-controlled contactor sequencing

* Smooth, controlled plug braking with either variable (throttle-dependent) or fixed plug current limit

* High speed switch (HSS) input allows operation in two distinct speed ranges

* Anti-rollback (ramp start) provides full power for starting on ramps

* Simple contactor and switch wiring, with coil drivers monitored for shorts and open circuits thus ensuring fail-safe operation

* Flexible throttle circuitry accommodates a variety of throttle types: 5koms-0, 0-5koms, 0-5V, 0-10V, inductive, Hall, etc.

* Programmable " ramp shape" (static throttle map) provides flexible in selecting throttle response feel

Familiarity with your Curtis PMC controller will help you install and operate it properly. We encourage you to read this manual carefully.

INSTALLATION AND WIRING

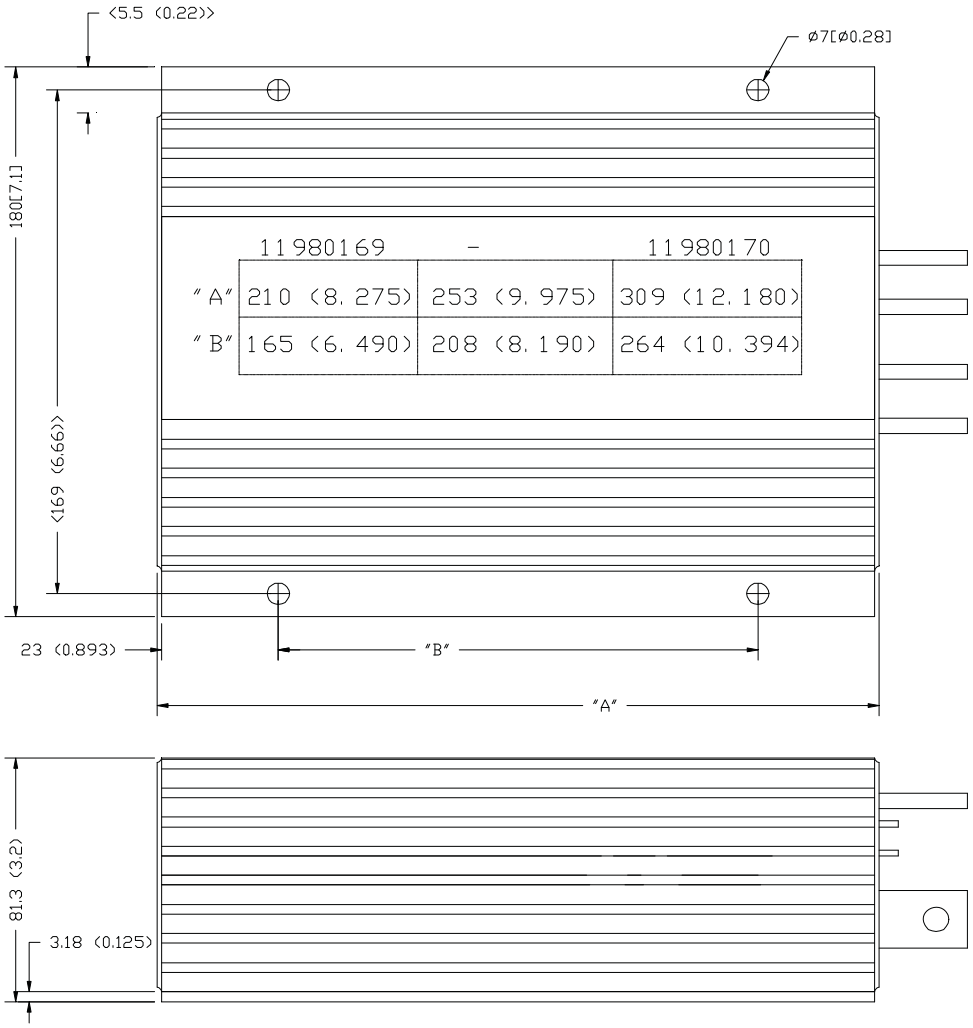
MOUNTING THE CONTROLLER

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

To ensure full rated output power, the controller should be fastened to a clean, flat metal surface with four screws. The case outline and mounting hole dimensions are shown in Figure 2. Access is needed at the front of the controller to plug the programmer into its connector, and to view the LED.

Although not usually necessary, a thermal joint compound can be used to improve heat conduction from the mounting surface.

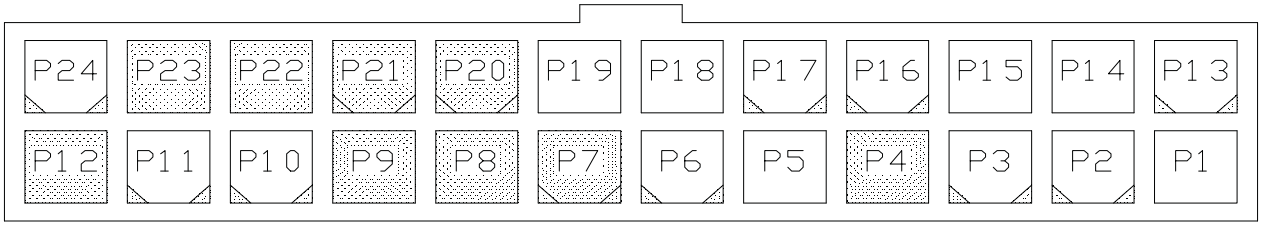
Figure 2



	11980169 –		11980170
"A"	210 (8.275)	253 (9.975)	309 (12.180)
"B"	165 (6.490)	208 (8.190)	264 (10.394)

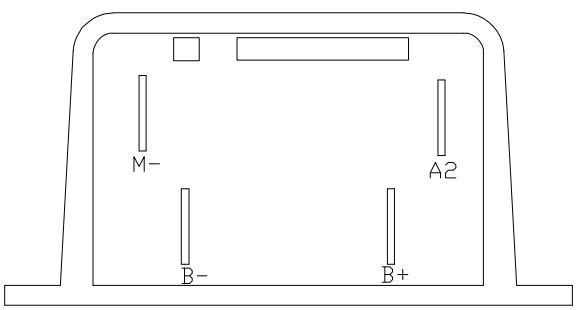
CONNECTIONS: Low Current

A 24-pin low current connector in the front of the controller provides the low current logic control connections (See pin list below). The mating connector is Molex Mini-Fit Jr., part number 11980173.



P1:	key switch input (KSI)	P13:	n/c
P2:	brake input	P14:	n/c
P3:	high speed input	P15:	n/c
P4:	n/c	P16:	throttle: 5koms-0 or 0-5ohms
P5:	throttle: 0-10V	P17:	main contactor driver output
P6:	n/c	P18:	forward contactor driver
P7:	n/c	P19:	reverse contactor driver output
P8:	n/c	P20:	n/c
P9:	n/c	P21:	n/c
P10:	forward input	P22:	n/c
P11:	reverse input	P23:	n/c
P12:	n/c	P24:	n/c

A 4-pin low power connector, also located on the front of the controller, is provided for the hand held programmer. The mating cable can be ordered as a separate part: p/n 11980172.



CONNECTIONS: High Current

Four tin-plated solid copper bus bars are provided for the high current connections to the battery and motor:

M- output to motor armature
B- negative connection to battery
B+ positive connection to battery/field

A2

Plug diode to motor armature

Cables are fastened to the bus bars by M8 (5/16") bolts. When tightening the bolts, two opposing wrenches should be used to prevent bending the bus bars and putting undue strain on the internal connections.

CAUTION

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

RUNAWAYS -- Some fault conditions could cause the vehicle to run out of control. Jack up the vehicle and get the drive wheels off the ground before attempting these procedures or any other work on the motor control circuitry.

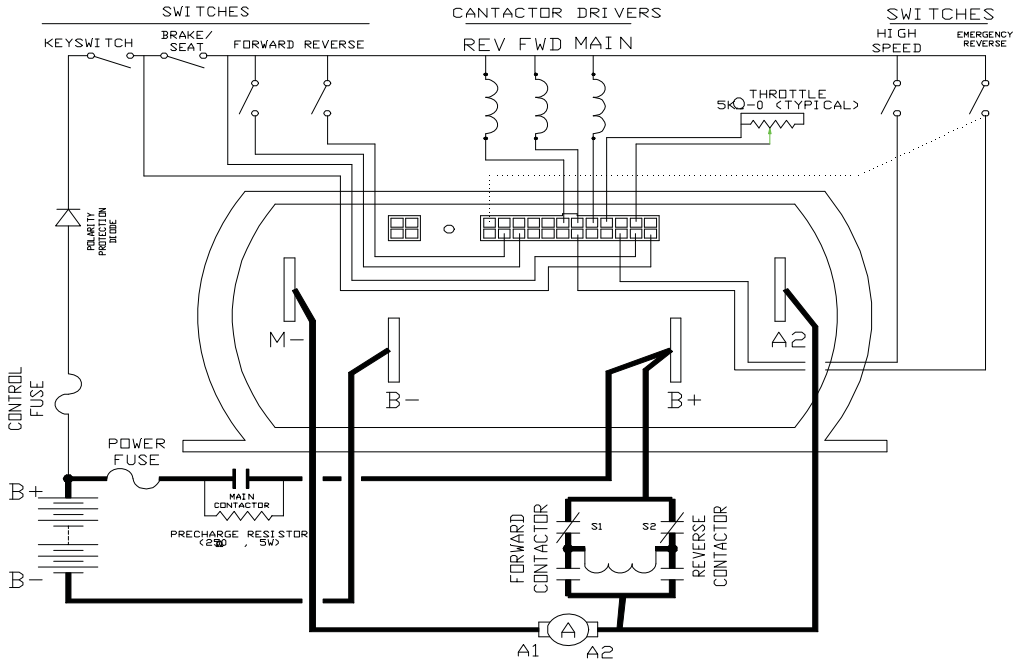
HIGH CURRENT ARCS -- Electric vehicle batteries can supply very high power, and arcs can occur if they are short circuited. Always open the battery circuit before working on the motor control circuit. Wear safety glasses, and use properly insulated tools to prevent shorts.

LEAD ACID BATTERIES -- Charging or discharging generates hydrogen gas, which can built up in and around the batteries. Follow the battery manufacturer' s safety recommendations. **Wear safety glasses.**

WIRING: Standard Configuration

The configuration shown in Figure 3 is typical arrangement for most applications. For walkie applications, the brake switch is typically activated by the tiller switch. For rider applications, the brake switch is typically a seat switch or a foot switch.

Figure 3

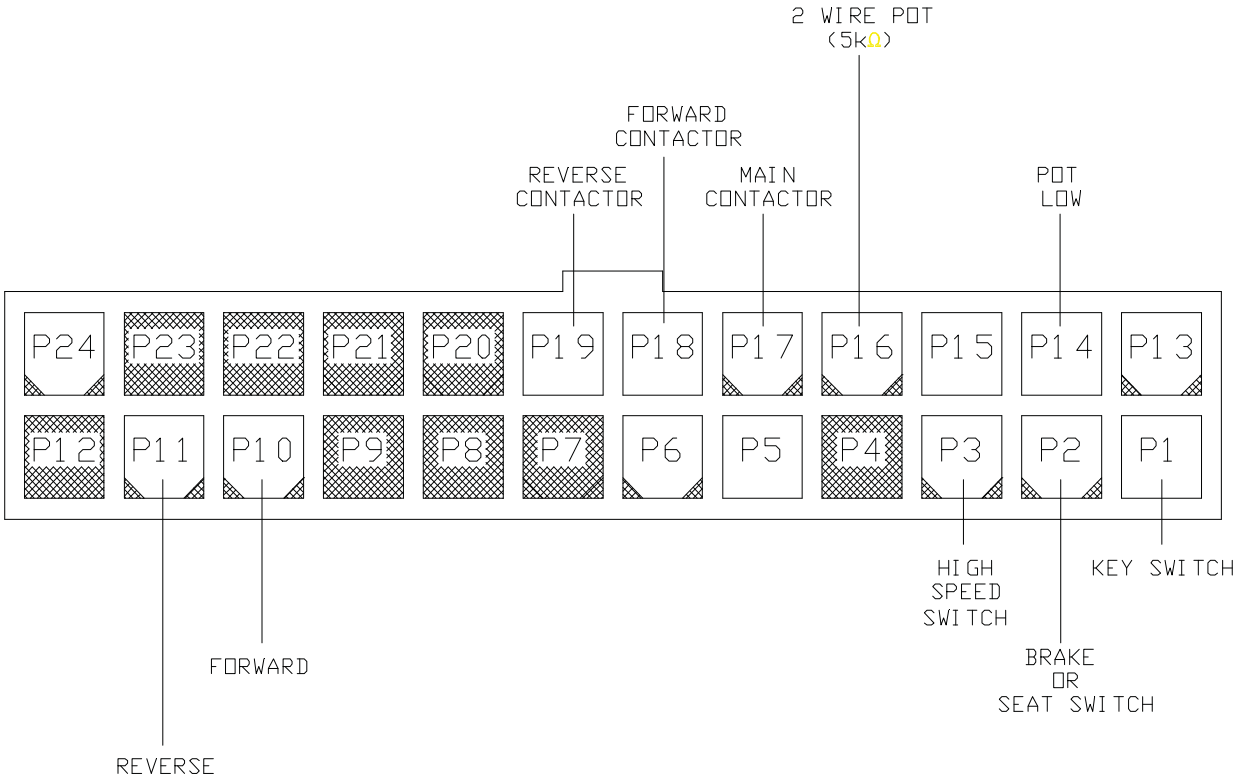


Standard Power Wiring

In every wiring configuration, it is imperative that the field be wired between B+ and A2 and that the armature be wired between M- and the A2 terminal. The internal plug diode used in the 11980169 & 11980170 is connected between M- and A2. Therefore, the armature and field positions cannot be interchanged. Reversing cantactors can be used to switch either the armature or the field.

Standard Control Wiring

Wiring for the input switches and contactors is shown in Figure 3 (see detail below). The main contactor, if one is used, is normally connected directly to the controller. Optionally, the main contactor can be switched directly by the keyswitch or brake, leaving pin P17 unconnected.



The throttle shown in Figure 3 is a 5kohm-0 type. Various other throttles can also be accommodated.

WIRING: Throttle

5kohm-0 Throttle (“ Type 1")

The 5kohm-0 throttle (called a “ Type 1" throttle in the programming menu of the hand held programmer) is a 2-wire resistive throttle that connects between the 5kohm-0/ 0-5kohm pin (P16) and the Pot Low Pin (P14). Zero speed corresponds to 5kohm and full speed corresponds to 0 ohm.

Broken wire protection is provided by the controller sensing the current flow from the 5kohm-0 input through the pot and into the Pot Low pin. If the Pot Low input current falls below 0.1 mA, a throttle fault is generated and the controller is disabled. **Note:** The Pot Low pin (P14) must not be tied to ground.

CONTACTORS, SWITCHES, AND OTHER HARDWARE

Main Contactor

A main contactor allows the controller to be disconnected from the battery. In 24V applications a main contactor is optional, but in 36-48V applications a main contactor is required. A heavy-duty single-pole, single-throw (SPST) contactor with silver-alloy contacts is recommended.

After initial closing of the contacts, inrush currents flow as the controller’ s internal filter capacitors are charged. A 250ohms, 5W resistor can be used across the contactor to precharge the capacitors and reduce the inrush current through the contacts.

A built-in coil suppression diode is connected between the main contactor coil output and the brake/seat switch input.

Forward/Reverse Contactors

For forward/reverse, a paired single-pole, double-throw (2XSPDT) contactor. With 4-terminal split field motors, two single-pole, single-throw (SPST) contactors are typically used. The coil voltage should match the vehicle voltage. The maximum allowed coil current is 1 ampere.

A built-in coil suppression diode is connected between each forward/reverse contactor coil output and the brake/seat switch input.

Forward/Reverse Switches

The direction input switches can be any type of single-pole, single-throw (SPST) switch capable of switching the battery voltage at 10 mA.

Keyswitch

The vehicle should have a master on/off switch to turn the system off when not in use. The keyswitch provides logic power or the controller, and coil current for the contactors. The keyswitch must be capable of carrying these currents.

Circuitry Protection Devices

For reverse polarity protection, a diode should be added to the control circuit. It must be sized appropriately for the maximum contactor coil currents. To protect the control wiring from accidental shorts, a low current fuse (appropriate for the maximum current draw) should be connected in series with the battery feed. These devices are both shown in the wiring diagrams.

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 for further information.

The installation checkout can be conducted with or without the hand held programmer. The checkout procedure is easier with a programmer. Otherwise, observe the LED for diagnostic codes.

CAUTION

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 key switch is off and the brake is applied (brake switch open), the throttle is in neutral, and the forward/reverse switches are open.

Wear Safety Glasses and use well-insulated tools.

1. If a programmer is available, connect it to the programmer connector.

2. Turn the key switch on. The programmer should " power up" with an initial display, and the controller' s Status LED should begin steadily blinking a single flash. If neither happens, check for continuity in the key switch circuit and controller ground.

3. If you are using a programmer, put it into the diagnostic mode by pressing the *DIAGNOSTICS* key. The display should indicate " No Faults Found" .

Close the brake/seat switch. To do this on a walkie, pull the tiller down to the operating position. The LED should continue blinking a single flash and the programmer should continue to indicate no faults. If there is a problem, the LED will flash a diagnostic code in Section 5 (Diagnostics and Troubleshooting).

When the problem has been corrected, it may be necessary to cycle the brake/seat switch in order to clear the fault code.

4. With the brake/seat switch closed, 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 forward/reverse switches, forward/reverse contactors, and motor. The motor should run proportionally faster with increasing throttle. If not, refer to Section 5.

5. If you are using a programmer, put it into the test mode by pressing the *TEST* key. Scroll down to observe the status of the forward, reverse, brake, and speed select switch (if you have one). Cycle each switch in turn, observing the programmer. Each input should show the correct state on the programmer.

6. Take the vehicle off the blocks and drive it in a clear area. It should have smooth acceleration and good speed.

7. Test the plug braking of the vehicle. Verify that the plug braking option is as desired (variable or fixed).

8. Verify that all options, such as high pedal disable (HPD), static return to off (SRO), and anti-tie down, are as desired.

9. If you used a programmer, disconnect it when you have completed the checkout procedure.

PROGRAMMING AND ADJUSTMENT

To change a parameter using the programmer, press the *PROGRAM* key, and scroll down the Program Menu until the desired parameter is the top line of the display. Press the appropriate *CHANGE VALUE* key (" up" or down") until the desired number is reached. The Parameter is now set at the desired value. All programming occurs in real time. In other words, the parameters can be changed while the vehicle is in operation.

The upper and lower limits of parameters are set at the factory. Some parameters have dependencies on other parameters. When the programmer is being used to adjust a parameter and a limit is reached, the display will stop changing. To see why the display has stopped changing, press the *MORE INFO* key. If the limit is related to another parameter, that information will be displayed; changing the value of the related parameter may allow the original parameter to be adjusted further. Otherwise, the display simply says " Max Limit" or " Min Limit" .

In addition to addition to adjusting parameters, the programmer can be used to change various options--such as throttle type, HPD, SRO, etc. Typically, the brake/seat switch must be cycled before the new options take effect.

Use of the programmer is described more fully on page 18.

MAINTENANCE

There are no user-serviceable parts inside Curtis PMC controllers. No attempt should be made to open the controller. Opening the controller may damage it and will void the warranty.

However, it is recommended that the controller exterior be cleaned periodically, and if a hand held programmer is available this periodic cleaning provides a good opportunity to check the controller' s diagnostic history file.

CAUTION

Although the 11980169 & 11980170 controller is inherently a high power device. When working around any battery powered vehicle, proper safety precautions should be taken. These include, but are not limited to: proper training, wearing eye protection, avoiding loose clothing and jewelry, and using insulated wrenches.

CLEANING

Although the 11980169 & 11980170 controller requires virtually no maintenance when properly installed, the following minor maintenance is recommended in certain applications.

1. Remove power by disconnecting the battery.

2. Discharge the capacitors in the controller by connecting a load (such as a contactor coil or a horn) across the controller' s B+ and B- terminals.

3. Remove any dirt or corrosion from the bus bar area. The controller should be wiped clean with a moist rag. Allow it to dry before reconnecting the battery.

4. Make sure the connections to the bus bars are tight. Use two wrenches for this task in order to avoid stressing the bus bars; the wrenches should be well insulated.

DIAGNOSTIC HISTORY

The hand held programmer can be used to access the controller' s diagnostic history file. Connect the programmer, press the *MORE INFO* key, and then while continuing to hold the *MORE INFO* key--press the *DIAGNOSTICS* key. 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 contactor faults may be the result of loose wires; contactor wiring should be carefully checked out. Faults such as HPD or over temperature may be caused by operator habits or by overloading.

After a problem has been diagnosed and corrected, cleaning 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 later date, you can readily determine whether the problem was indeed completely fixed.

To clear the diagnostic history file, go to the Special Program Menu (by pressing and holding the *MORE INFO* key, and then pressing the *PROGRAM* key), scroll through the menu until " Clear Diagnostic History" is the top line in the display, and then press *MORE INFO* again. The programmer will prompt you to acknowledge or cancel. See Page 18 of this manual for more detail on programmer operation.

DIAGNOSTICS AND TROUBLESHOOTING

PROGRAMMER DIAGNOSTICS

With a programmer, the diagnostics and troubleshooting process is more direct than with the LED alone. The programmer presents complete diagnostic information in plain language--no codes to decipher. Faults are displayed in the Diagnostic Menu, and the status of the controller inputs/outputs is displayed in the Test Menu.

The following 4-step process is generally used 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 " forward" 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, put it in diagnostic mode, and read the displayed fault information. In this example, the display shows " No Faults Present," indicating that the controller has not detected anything out of the norm.

STEP 3: Put the programmer in test mode, and observe the status of the inputs and outputs in the forward direction. In this example, the display shows that the forward switch did not close when " forward" was selected, which means the problem is either in the forward switch or the switch wiring.

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

Refer to the troubleshooting chart (Table 1) for suggestions covering a wide range of possible faults.

TABLE 1 TROUBLESHOOTING CHART

LED CODE	PROG. LCD DISPLAY	EXPLANATION	POSSIBLE CAUSE
1,2	HW FAILSAFE	hardware fail-safe error	1. Controller defective
1,3	M- FAULT	M- output shorted	1. M- output shorted to ground. 2. Internal motor short to ground.
1,4	SRO	SRO fault	1. Improper sequence of KSI, brake, and direction inputs. 2. Wrong SRO type selected. 3. Brake of direction switch circuit open. 4. Sequencing delay too short.
2,1	THROTTLE FAULT 1	5kohms-0 wiper fault	1. BB wire open. 2. BB check wire open.
2,3	HPD	HPD sequencing fault	1. Improper seq. of KSI, brake, throttle inputs. 2. Wrong HPD type selected. 3. Misadjusted throttle pot. 4. Sequencing delay too short.
2,4	THROTTLE FAULT 2	Pot Low broken or shorted	1. Pot Low wire open. 2. Pot Low wire shorted. 3. Wrong throttle type selected.
3,1	CONT DRVR OC	driver output over current	1. Direction contactor coil shorted.
3,2	DIR CONT WELDED	welded direction contactor	1. Direction contactor stuck closed.
3,4	MISSING CONTACT OR	missing contactor	1. Direction contactor coil open. 2. Direction contactor missing. 3. Wire to direction contactor open.
4,1	LOW BATTERY VOLTAGE	low battery voltage	1. Battery voltage <16V (24-36V models) or <21V (36-48V models). 2. Corroded or loose battery terminal. 3. Loose controller terminal.
4,2	OVER-VOLTAGE	over voltage	1. Battery voltage >48V (24-36V models) or >65V (36-48V models). 2. Vehicle operating with charger attached
4,3	THERMAL CUTBACK	over-/under-temp. cutback	1. Temperature >85 deg. C or <-25 deg. C. 2. Excessive load on vehicle. 3. Improper mounting of controller. 4. Operation in extreme environments.

LED DIAGNOSTICS

During normal operation, with no faults present, the LED on the controller' s front face flashes a single flash at approximately 1 flash/second. If the controller detects a fault, a 2-digit code (see Table 2) is flashed continuously until the fault is corrected. For Example, code " 3,2" -- welded direction contactor-- Appears As:

ooo oo	ooo oo	ooo oo
(3,2)	(3,2)	(3,2)

TABLE 2 LED Codes

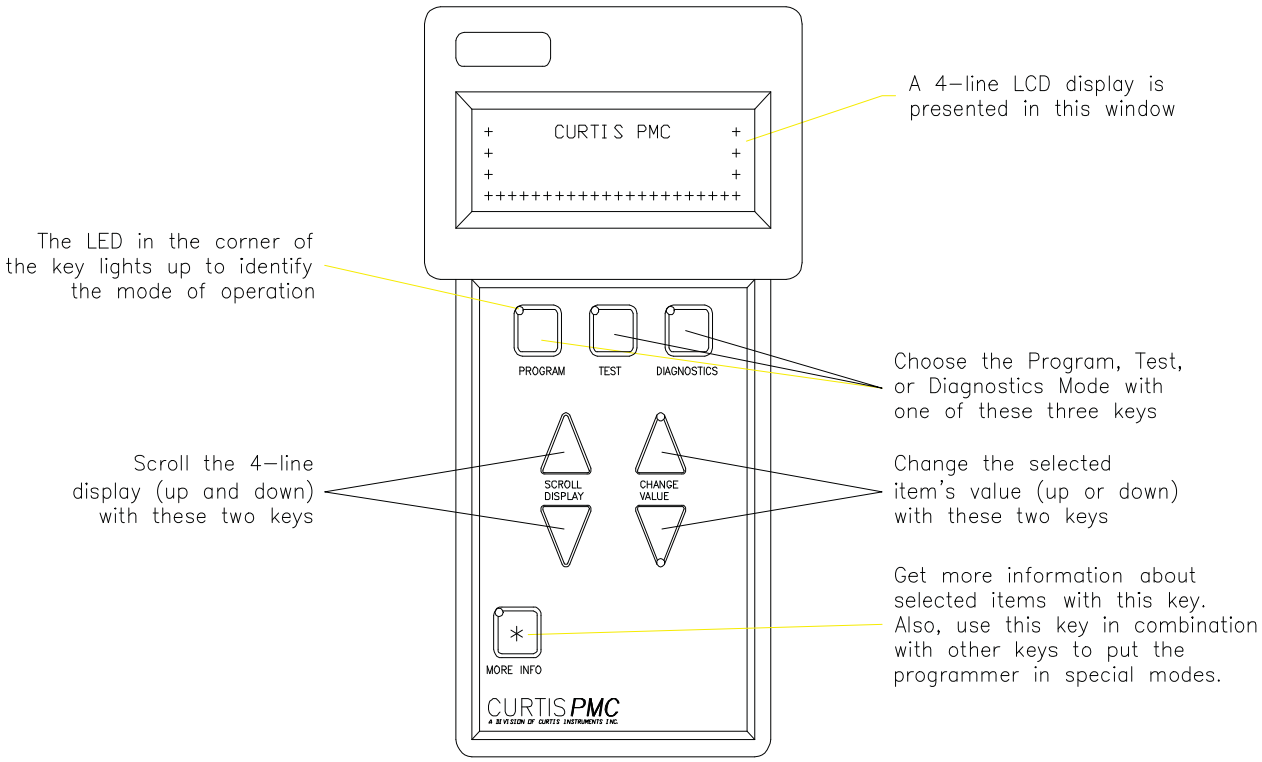
LED	CODE	EXPLANATION
LED off solid	Solid Line	no power or defective controller
on single	Clear Line	defective controller
flash	O	controller operational; no faults
1,2	O OO	hardware fail-safe error
1,3	O OOO	M-fault or motor output short
1,4	O OOOO	sequencing fault (SRO)
2,1	OO O	5kohm-0 or throttle wiper input fault
2,3	OO OOO	high-pedal-disable fault (HPD)
2,4	OO OOOO	throttle pot low open or shorted to B+ or B-
3,1	OOO O	contactor driver over current
3,2	OOO OO	welded direction contactor
3,3	OOO OOO	(reserved for future use)
3,4	OOO OOOO	missing contactor
4,1	OOOO O	low battery voltage
4,2	OOOO OO	over voltage
4,3	OOOO OOO	thermal cutback
4,4	OOOO OOOO	(reserved for future use)

NOTE: Only one fault is indicated at a time, and faults are not queued up. Operational faults--such as a fault in SRO sequencing--are cleared by cycling the brake/seat switch or Keyswitch. (See " Fault recovery" on page 27 for more information.)

PROGRAMMER OPERATION

The optional universal Curtis PMC hand held programmer allows you to program, test, and Curtis PMC programmable controllers. The programmer is powered by the host controller, via a 4-pin connector located on the front face of the controller.

When the programmer is first plugged into the controller, the programmer displays the controller' s model number, date of manufacture, and software revision code. Following this initial display, the programmer displays a prompt for further instructions.



The programmer is operated via an 8-keypad. Three keys select operating modes (Program, Test, Diagnostics), two scroll the display up and down, and two change the values of selected parameters. The eighth key, the MORE INFO key, is used to display further information about selected items within any of the three standard modes. In addition, when pressed together with the PROGRAM or the DIAGNOSTICS key, the MORE INFO key selects the Special Program mode or the Special Diagnostics mode.

The Display window presents a 4-line LCD display. The display is visible even in bright sunlight. You can adjust the display contrast in the Special Program mode.

When on of the menu keys is pressed, the LED at the corner of the key lights up, identifying the mode of programmer operation. For example, if the TEST key is pressed, the LED at the corner of the key indicates that the programmer is now in the Test mode, and the Test Menu is displayed.

Four lines of a menu are displayed at a time. The item at the top of the display window is the selected item. To select an item, scroll within the menu until the desired item is positioned at the top of the display window. The selected item is always the top line. (In the Program mode, the selected item is highlighted by a flashing arrow.) To modify a parameter or obtain more information about it, it must be scrolled to the top position in the display window.

To scroll up and down within a menu, use the two SCROLL DISPLAY arrow keys. The SCROLL DISPLAY arrow keys can be pressed repeatedly or be held down. When a key is held down, the scrolling speed increases the longer the key is held.

A small scroll bar at the lift of the display window provides a rough indication of the position of the four displayed items within the entire menu. That is, when the bar is at the top of the window, the top of the menu is displayed. As you scroll through the menu, the bar moves downward. When the bar is at the very bottom of the window, you have reached the end of the menu.

The two CHANGE VALUE arrows keys are used to increase or decrease the value of a selected menu item. Like the SCROLL DISPLAY arrow keys, the CHANGE VALUE arrow keys can be pressed repeatedly or be held down. The longer a key is held, the faster the parameter changes. This allows rapid changing of any parameter.

An LED on each CHANGE VALUE arrow key indicates whether the key is active and whether change is permissible. When the value of a parameter is being increased, the LED on the " up" CHANGE VALUE key is on until you reach the maximum value for that parameter. When the LED goes off, you cannot increase the value.

The MORE INFO key has three functions: (1) to display more information about the selected item, (2) to access the Special Program and Special Diagnostics modes (when used together with the PROGRAM and DIAGNOSTICS keys), and (3) to initiate certain commands (such as the Self Test).

" More information" is available in all of the programmer operating modes. After using the MORE INFO key to display additional information about the selected item, press the MORE INFO key again to return to the original list.

OPERATING MODES:

PROGRAM, TEST, DIAGNOSTICS, SPECIAL PROGRAM, SPECIAL DIAGNOSTICS

In the **Program** mode, accessed by pressing the PROGRAM key, all the adjustable parameters and features of the controller are displayed (four at a time), along with their present settings. The setting of the selected item--the item at the top of the display, with the flashing arrow--can be changed, using the two CHANGE VALUE keys.

The LEDs on these keys indicate whether there is still room for change. That is, when the upper limit of a parameter' s range is reached, the LED on the " up" key no longer lights up, indicating that the present value cannot be increased; when the lower limit is reached, the LED on the " down" key no longer lights up.

The MORE INFO key, when used in the Program mode, displays a bar graph along with the minimum and maximum values possible for the selected parameter. Parameters can be changed either from the main Program Menu or after the MORE INFO key has been pressed and the additional information is being displayed (see example below).

Some parameters on some controllers have dependencies on other parameters. This means that the available settings for one parameter may be dependent on the limits of another parameter. For example, your controller may not allow the main current limit to be set below some other current limit, such as the emergency reverse current limit. In this example, if you attempt to reduce the main current limit below that of emergency reverse, a message will be displayed indicating that the minimum main current limit is dependent on the emergency reverse current limit.

The Program Menu is presented at the end of this section. NOTE: Some items may not be available on all models.

In the **Test** mode, accessed by pressing the TEST key, real-time information is displayed about the status of the inputs, outputs, and controller temperature. For example, when the status of the forward switch is displayed, it should read " On/Off/On/Off/On/Off" as the switch is repeatedly turned on an off. In the Test mode, the item of interest dies not need to be the top item on the list; it only needs to be among the four items visible in the window. The Test mode is useful for checking out the operation of the controller during initial installation, and also for troubleshooting should problems occur.

The MORE INFO key, when used in the Test mode, causes additional information to be displayed about the selected item (top line in the window).

The Test Menu is presented at the end of this section. NOTE: Some items may not be available on all models.

Section F: Transistor Control
(Curtis 11980169 & 11980170)

In the **Diagnostics** mode, accessed by pressing the DIAGNOSTICS key, currently active faults detected by the controller are displayed.

The MORE INFO key, when used in the Diagnostics mode, causes additional information to be displayed about the selected item.

A list of the abbreviations used in the Diagnostics display is included at the end of this section.

The Special Program mode allows you to perform a variety of tasks, most of which are self-explanatory. Through the Special Program Menu, you can revert to earlier Settings, save controller settings into the programmer memory, load the controller settings from the programmer into a controller, clear the controller' s diagnostic history, adjust the contrast of the programmer' s LCD display, select the language to be displayed by the programmer, and display basic information (model number, etc.) about the controller and the programmer.

To access the Special Program mode, first press the MORE INFO key. Then, while continuing to hold the MORE INFO key, press the PROGRAM key. The LED on the PROGRAM key will light, just as when the programmer is in Program mode. To distinguish between the Program and Special Program modes, look at the menu items in the display.

The MORE INFO key is used initially to access the Special Program mode, and once you are within the Special Program mode, it is used to perform the desired tasks. To adjust the contrast in the display window, for example, select " Contrast Adjustment" by scrolling until this item is at the top of the screen, and then press MORE INFO to find out how to make the adjustment.

The Special Program Menu is presented at the end of this section. Pg 23

In the **Special Diagnostics** mode, the controller' s diagnostic history file is displayed. This file included a list of all faults observed and recorded by the controller since the history was last cleared. (NOTE: The maximum and minimum temperatures recorded by the controller are included in the Test Menu.) Each fault is listed in the diagnostic history file only once, regardless of the number of times it occurred.

To access Special Diagnostics, first press the MORE INFO key. Then, while continuing to hold the MORE INFO key, press the DIAGNOSTICS key. The LED on the DIAGNOSTICS key will light, just as when the programmer is in Diagnostics mode.

The MORE INFO key, when used within the Special Diagnostics mode, causes additional information to be displayed about the selected item.

To clear the diagnostic history file, put the programmer into the Special Program mode, select " Clear Diagnostic History," and press the MORE INFO key for instructions. Clearing the diagnostic history file also resets the maximum/minimum temperatures in the Test Menu.

PEACE-OF-MIND PROGRAMMING

Each time the programmer is connected to the controller, it acquires all the controller' s parameters and stores them in its temporary memory. You can revert back to these original settings at any time during a programming session via the Special Program Menu. Select " Revert to Previous Settings" by scrolling it to the top of the display window, press the MORE INFO key, and follow the instructions displayed. Any inadvertent changing of parameters can be " Undone" using this procedure--even if you can' t remember what the previous settings were- **-as long as the programmer has not been unplugged and power has not been removed from the controller**.

PROGRAMMER SELF TEST

You can test the programmer by displaying two special test screens. Press the MORE INFO key while the programmer is powering up. During the Self Test, you can toggle between the two test screens by pressing the SCROLL DISPLAY keys. The first screen turns on every LCD element, and the second screen displays all the characters used in the various menus. As part of the Self Test, you can also test the keys be pressing each one and observing whether its corner LED lights up. To exit the Self Test, unplug the programmer or turn off the controller, and then re-power it without holding the MORE INFO key.

PROGRAMMER MENUS

MAIN C/L	Main current limit
L/S MAIN C/L	Low speed main current limit
PLUG C/L	Plug current limit
L/S PLUG C/L	Low speed plug current limit
RAMP C/L	Ramp start current limit
L/S RAMP C/L	Low Speed ramp start current limit
ACCEL RATE	Acceleration rate, in seconds
CREEP SPEED	Creep speed, as percent PWM duty cycle
LOW SPEED	Low speed, as percent PWM duty cycle
RAMP SHAPE	Throttle map
ANTI-TIE DOWN	Anti-TIE DOWN: on or off
QUICK START	Quick-start throttle factor

TEST MENU (not all items available on all controllers)

FORWARD SWITCH	Forward switch: On/Off
REVERSE SWITCH	Reverse switch: On/ Off
BRAKE SWITCH	Brake Switch: On/ Off
THROTTLE %	Throttle reading, in percent of full
SPEED SWITCH	Speed switch: On/Off
FWD CONTACTOR	Forward contactor: On/Off
REV CONTACTOR	Reverse contactor: On/Off
BATT VOLTAGE	Battery voltage
HEAT SINK ©	Heat sink temperature
MAX TEMP ©	Maximum temperature seen*
MIN TEMP ©	Minimum temperature seen*

*Maximum/minimum temperatures recorded since Diagnostic History was last cleared.

SPECIAL PROGRAM MENU

RESET ALL SETTINGS	Revert to original settings
CONT SETTINGS PROG	Save controller settings in programmer
PROG SETTINGS CONT	Load programmer settings in controller
CLEAR DIAG HISTORY	Clear diagnostic history memory
CONTRAST ADJUSTMENT	Adjust display contrast
LANGUAGE SELECTION	Select displayed language
PROGRAMMER INFO	Display programmer information
CONTROLLER INFO	Display controller information

DIAGNOSTICS AND SPECIAL DIAGNOSTICS "MENU"

This is not a menu as such, but simply 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 in alphabetical order for easy reference.

BB WIRING CHECK	BB wiring check failed
CONT DRVR OC	Contactor driver over current
DIR CONT WELDED	Direction contactor welded
HPD	high-pedal-disable activated
HW FAILSAFE	Hardware failsafe activated
LOW BATTERY VOLTAGE	Battery voltage to low *
M - FAULT	M- output fault
MISSING CONTACTOR	Missing contactor
NO KNOWN FAULTS	No known faults
OVERVOLTAGE	Battery voltage too high **
SRO	Static-return-to-off activated
THERMAL CUTBACK	Thermal cutback due to temperature
THROTTLE FAULT 1	Throttle input fault
THROTTLE FAULT 2	Throttle low input fault

APPENDIX

GLOSSARY OF FEATURES AND FUNCTIONS

Acceleration/deceleration rate

The acceleration rate (the time required for the controller to increase from 0% to 100% duty factor) is adjustable via the hand held programmer. The deceleration rate is fixed, and cannot be adjusted. The shape of the acceleration/deceleration curves is controlled by the ramp shape parameter, which is programmable (see Ramp shape).

Anti-rollback *(see Ramp start)*

Anti-TIE DOWN

Before enabling high speed operation, the anti-TIE DOWN function checks that the high speed switch (HSS) has been released after the last cycling of the brake switch. This feature discourages operators from taping or otherwise " tying down" the high speed switch. If high speed mode is already selected before the brake/seat switch is closed, the controller remains in low speed mode until the HSS is released and pressed again.

Arcless contactor switching

The controller output duty factor is quickly reduced to zero any time a direction is de-selected, so that the controller current will be reduced to zero before the direction contactor drops out.

Brake/seat switch

This is a controller-enable input connected to the brake on a walkie or to the seat of a rider. The brake/seat switch must be closed for the controller to operate. This safety interlock is used on most material handling vehicles. Cycling the brake/seat switch or KSI clears most faults and enables operation.

Contactor drivers and circuits

The controller can accommodate three external contactors: forward, reverse, and main. Some vehicles may have no main contactor, or the main contactor may be wired directly to the KSI or brake signal, bypassing the controller.

Various protections provided for the contactor drivers ensure that the contactors operate correctly; *see "Fault detection" below.*

Creep speed at first throttle

Creep speed is activated when a direction is first selected. The output maintains creep speed until the throttle is rotated out of the throttle dead band (typically 10% of throttle). Creep speed is adjustable from 0 to 25% PWM duty cycle.

Current Limiting

Current limiting reduces the PWM output to the power section until the motor current falls below the set limit level. Reduction of output is done smoothly.

The current limit depends on the operating mode; for example, the limit is typically higher in high speed than in slow speed. The main and plug braking current limits for both high speed and low speed are adjustable.

Disable Recovery *(see Fault Recovery)*

Fault Detection

An internal micro controller automatically maintains surveillance over the functioning of the controller. When a fault is detected, the appropriate fault code is signaled via the LED, which is externally visible on the front face of the controller. The diagnostic codes flashed by the LED are listed in Section 5, Troubleshooting.

If the fault is critical, the controller is disabled. More typically, the fault is a remediable condition and temporary–for example, an under voltage fault is cleared when the condition is removed.

The automatic fault detection system includes:

emergency reverse circuit check
F/R contactor coil open / shorted driver
F/R contactor driver over current / contactor coil short
F/R contactor welded
overvoltage cutoff
power supply out of range (internal)
M- fault ‘
memory checks upon start-up
throttle fault
under voltage cutback
watchdog (external)
watchdog (internal)

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 (including recovery from disable)

Almost all faults require a cycling of the KSI or brake/seat switch input to reset the controller and

enable operation.

The only exceptions are these:

FAULT	RECOVERY
anti-TIE DOWN	release and reapply HSS
contactor over current	when condition clears
emergency reverse	re-apply BB or cycle brake
HPD	lower throttle to below HPD threshold
overvoltage	when battery voltage drops below overvoltage
SRO	when proper sequence is followed
thermal cutback	when temperature changes
throttle fault	clears when condition is gone
under voltage	when battery voltage rises above under voltage
(all other faults)	(cycle KSI or brake/seat switch)

High-pedal-disable (HPD)

The HPD feature prevents the vehicle from being started while the throttle is applied. The controller can be programmed to have HPD based on either brake/seat switch input or KSI.

Brake-type HPD

To start the vehicle, the controller must receive a brake/seat switch input before receiving a throttle input. Controller operation will be disabled immediately if pedal demand (throttle input) is greater than 25% duty factor at the time the brake/seat switch is closed. Normal controller operation is regained by reducing the throttle demand to less than 25%.

Sequencing delay, which can be set with the hand held programmer, provides a variable delay before disabling the controller. If the brake/seat switch is opened while the throttle is above the HPD threshold (25%), HPD is not activated if the brake/seat switch is then closed before the delay time elapses.

KSI-type HPD

The HPD feature can be activated by KSI input instead of brake/seat switch input, if preferred. To start the vehicle, the controller must receive a KSI input before receiving a throttle input.

High speed

The high speed switch (HSS) feature allows the vehicle to be operated in two distinct speed ranges. The maximum speed for each range can be adjusted (from 40% to 100% PWM duty cycle), via the hand held programmer. The throttle input to the controller is automatically re-scaled to use the whole range of throttle movement in order to obtain 0% to full allowed speed (or creep speed to full allowed speed) in each speed range.

High speed operation is selected by means of the high speed switch (HSS). If high speed is not selected, the controller operates by default in low speed. When the controller returns to low speed from high speed, it automatically changes the main current limit, the emergency reverse current limit, the plug current limit, and the ramp start current limit to their low speed values.

If the anti-TIE DOWN feature is active, HSS must be re-selected after the brake/seat switch is closed.

KSI

KSI (Key Switch Input) provides power to the controller's logic board, and initializes and starts diagnostics. In combination with the brake input, KSI enables all logic functions.

Some vehicles may have no key switch (KSI simply tied to B+) or may have the key permanently turned on.

LED

An LED on the controller's front face flashes a code if a fault is detected by the controller. The fault codes are listed in Table 1. The fault code will continue to ash until the fault condition has been cleared during active fault detection. This will typically happen after cycling KSI for power-up fault conditions, and cycling the brake/seat switch for faults detected during operation.

Low Speed *(see High speed)*

MOSFET

A MOSFET (**m**etal **o**xide **s**emiconductor **f**ield **e**ffect **t**ransistor) is a type of transistor characterized by its fast switching speeds and very low losses.

Over temperature

At Over temperature (from 85°C to 95°C), the drive current limit is linearly decreased from full set current down to zero. (Plug current, however, is not reduced–in order to provide full vehicle braking under all thermal conditions.) The operating PWM frequency is shifted to 1.5 kHz when the controller is operating in the Over temperature range.

Overvoltage Cutoff

Overvoltage resets the microprocessor, inhibits the PWM, and opens the contactors, thereby shutting down the controller. Overvoltage can result during battery charging or from an improperly wired controller. Controller operation resumes when the voltage is brought within the acceptable range. The cutoff voltage and re-enable voltage are percentages of the battery voltage, and are set at the factory.

Plug Braking

Plug braking takes place when a series motor is driven electrically in a direction opposite from the direction it is turning. The 11980169 & 1190170 controls the led current to obtain smooth and controlled plug braking torque. During plug braking, the maximum current limit is automatically changed to the plug current limit, and the PWM frequency is changed to 1.5 kHz. NOTE: Plug current limit controls the field current; the armature current in plug mode will be higher than the field current.

There are two types of plug braking control -- fixed and variable. The fixed plug current limit is set to a fixed level. The variable plug current limit varies the current limit to correspond to the throttle position.

The high speed and low speed plug current limits are both adjustable.

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.

Quick-Start

Upon receiving a quick throttle demand from neutral, the controller will exceed normal acceleration momentarily in order to overcome inertia. The " quick-start" algorithm is applied each time the vehicle passes through neutral and is not in plug mode. If the vehicle is in plug, the quick-start function is disabled, allowing normal plug braking to occur.

Ramp start (anti-rollback)

The ramp start feature allows the vehicle to be started with a higher plug current limit to prevent rolling downhill. Ramp start increases the plug current limit for the selected direction only . When the opposite direction is selected, ramp start will be canceled and a 3-step sequence must be followed to re-activate it:

STEP 1. select a direction for more than 1 sec.,
STEP 2. return to neutral, and
STEP 3. re-select the same direction.

Once the vehicle is operating in ramp start mode, it will continue to do so until the opposite direction is selected for more than one second.

When the brake is first released, the ramp start current limit level will be obtained when either direction is selected in plug braking mode. In ramp start mode, either direction selected will allow the ramp start current limit level. This condition remains until the other direction is selected for more than one second. The new direction then becomes the decision direction, and the 3-step ramp start sequence is required to regain the ramp start current limit level in plug.

The ramp start current limit is adjustable, via the hand held programmer.

Reset

Almost all faults require a cycling of the KSI or brake/seat switch input to reset the controller and enable operation; *see "Fault recovery" for exceptions*.

Temperature compensation for current limits

Full temperature compensation provides constant current limits throughout the normal operating range (Heat sink temperatures of -25°C to +85°C). The temperature sensor is also used to calculate and display the Heat sink temperature on the hand held programmer.

Temperature extreme current-limit cutback *(see Over temperature, Under temperature)*

Temperature extreme data storage

The maximum and minimum temperatures read at the Heat sink at any time during powering of the controller are stored in the controller' s memory. These values (which can be accessed via the programmer' s Test Menu) are cleared each time the controller' s diagnostic history led is cleared.

Throttle response

The dynamic throttle response (duty factor as a function of time) is shaped by the acceleration rate setting. Dynamic throttle response is linear. 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.

Under temperature

When the controller is operating at less than -25°C, the current limit is cut back to approximately one-half of the set current. The operating PWM frequency is shifted to 1.5 kHz when the controller is operating at Under temperature.

Under voltage cutback

Under voltage protection automatically disables the controller output if battery voltage is detected below the under voltage point at start-up, or when the battery voltage is pulled below the under voltage point by an external load. The under voltage cutback point is set in ROM, and is not adjustable. During normal operation, the controller duty factor will be reduced when the batteries discharge down to less than the under voltage level. If the motor current is such that the batteries are being pulled below the minimum point, the duty factor will be reduced until the battery voltage recovers to the minimum level. In this way the controller " servos" the duty factor around the point which maintains the minimum allowed battery voltage.

If the voltage continues to drop below the under voltage level to a severe under voltage condition (due to battery drain or external load), the controller continues to behave in a predictable fashion, with its output disabled.

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 150 msec and turns off the controller. The external watchdog also directly disengages all contactors and 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 start.

Section L: BDI

The **DISCHARGE pot** on all Curtis 933/I units leaves the factory set at **DISCHARGE** "**N**" , which means the discharge profile is set for a final end point of 1.73 VPC, where lockout will occur. This profile has proven to be the most common.

Turning the pot clockwise from " **N**" to "**P**" decreases the depth of discharge and, in turn, the operating time of the equipment. Turning it counterclockwise from " **N**" to "**K**" increases the depth of the discharge and, in turn, the operating time of the equipment.

Example: On occasion, equipment is required for work beyond its normally assigned work cycle and time does' not permit changing of battery. In these cases, lift lockout can be delayed by increasing the depth of discharge from the standard 1.73 VPC (" **N**" setting) to as low as 1.56 VPC (" beyond **K**" setting).

Example: Equipment and battery are sized for the type of work they are used for. On occasion, equipment designated for heavy work might be used for light tasks. Lighter work means low-current drains which, in turn, means the recommended 80% depth of discharge lockout points will be at a higher voltage level. In these cases, to properly align the low-current work profile and the required higher lift lockout point, the DISCHARGE pot can be adjusted to the " **O**" (1.78 VPC) or the "**P**" (1.82 VPC) settings.

It is **IMPORTANT** to **NOTE** that adjustments of the DISCHARGE pot can be made at any time during a work cycle prior to lift lockout. However, DISCHARGE pot adjustments made late in a work cycle have little or no effect in delaying lift lockout in that particular work cycle. In most cases, DISCHARGE pot adjustments are made prior to or at the beginning of a work cycle to effectively change the discharge profile of that work cycle. Once lift lockout does occur, the gage must be reset before DISCHARGE pot adjustments can have an effect.

TABLE OF POT SETTINGS AND ASSOCIATED VOLTAGE PER CELL

DISCHARGE		**RESET**	
P	1.82 VPC*	**E**	2.18 VPC
O	1.78	**D**	2.15
N (Factory Set)	1.73	**C**	2.12
M	1.68	**B** (Factory Set)	2.09
L	1.63	**A**	2.06
K	1.57	beyond **A**	2.00
beyond **K**	1.56		

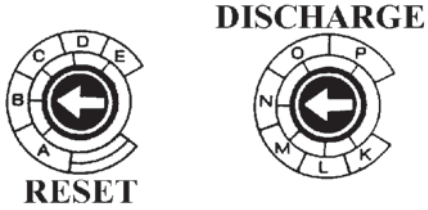
* The DISCHARGE voltage of the 933/I is not an instantaneous voltage, nor a measure of the open circuit voltage at the time of lift lockout.

WHAT SHOULD THE DRIVER DO?

1. Gage fails to reset — This means the battery is not properly charged and should not be used. Have maintenance people check battery and charger. If possible, get a different battery.

2. Warning light blinks — Normally returns to charger station for a freshly charged battery. However, 5% energy reserve before lockout permits completion of urgent tasks.

ADJUSTMENTS



Two pots are available for adjustment. These should only be used by authorized personnel under the circumstances described later.

The **RESET** pot determines the level to which the battery must be charged before the gage will swing to full. It is factory set at **B**. Batteries with open circuit voltages greater than 2.09 volts per cell will cause the gage needle to go to full (green ball position). 2.09 volts per cell correspond approximately to 1245 specific gravities.

RESET only takes place when the battery is disconnected for at least 15 seconds and then reconnected to a battery whose open circuit voltage is greater than 2.09 volts per cell.

Turning the **RESET** pot from **B** towards **E** increases the voltage at which the battery is accepted. (Battery charged to higher specific gravity than 1245).

Turning the **RESET** pot from **B** towards **A** decreases the voltage, at which the battery is accepted. (Battery charged to lower specific gravity than 1245).

If the battery is not properly charged, the gage will remain at its original position before changing batteries. For instance, if the truck was brought in with the gage at lockout (needle next to red ball, red light blinking), and a new, improperly charged battery is then connected, the needle will remain next to the red ball and the red light will continue to blink.

All units are shipped from the factory set to full. No matter what the state-of-charge of the first battery the unit is connected to, the gage will read full. Thereafter, the gage will continue to read the state-of-charge of the last battery used on the truck, if the new battery is improperly charged.

The **DISCHARGE** pot determines the level at which lift lockout takes place. It is factory set at **N** which corresponds to 1.73 volts per cell.

Going from **N** toward **K** will cause the battery to be more deeply discharged at lockout.

ADJUSTMENT PROCEDURES

Adjustments may be required for the following reasons and should only be done by authorized personnel.

SYMPTOM: The gage will not reset

Where batteries cannot be fully charged, the gage will not reset at the **B** setting and should be turned down to **A** so that operations can continue until the problem is corrected or more batteries and chargers are purchased.

The **A** setting corresponds to 1210 specific gravities and should only be used as a stop gap measure.

SYMPTOM: The truck comes in too soon for a battery change

If the battery is being appropriately charged (Reset at **B**) and the truck is being worked hard, the gage will lock out at what appears to be early. More time on the floor can be obtained by turning the **DISCHARGE** pot toward **K** from **N**.

Before making the adjustment, the specific gravity at the point where the meter light goes on should be checked. Under no circumstances should the adjustment be made if the specific gravity corresponds to more than 80% discharge at the 6-hour rate. Since the specific gravity (typically 1140) can vary from 1100 to 1180 from cell type to cell type, the battery dealer should be consulted in interpreting the reading obtained.

SYMPTOM: The specific gravity at lockout is very low

This can occur with a lightly worked truck where there are very little lifting and a lot of travel. Most commonly, it happens with walkie pallet trucks.

Typically, the battery will be used for several shifts before being recharged. The discharge rate of the battery will be approximating 10 to 20 hours.

THIS CONDITION MUST BE CORRECTED.

Make a coarse adjustment by turning the discharge pot from **N** to **P** and measure the specific gravity after each of several cycles of operation.

Fine tune, if necessary by turning back toward **O** if the specific gravity is too high.