RICO Quick Troubleshooting Guide

Curtis 1204 / 1205 Controller

Table of Contents

6 GLOSSARY: FEATURES and FUNCTIONS

Acceleration rate

A built-in acceleration rate circuit maintains a maximum rate of power increase to the motor. If the throttle is applied full on at start-up, the acceleration rate setting determines how quickly the controller output increases. The standard setting is such that with the throttle full on, the controller requires approximately one second to reach full output. This feature contributes to smooth, gentle starts.

On some 1204/1205 models, the acceleration rate is adjustable via an externally accessible trimpot. See Section 4 for adjustment instructions. The deceleration rate is fixed, and cannot be adjusted.

Accelerator pot fault protection (runaway protection)

To prevent uncontrolled operation, these controllers shut off the motor in the event of an open circuit fault in the accelerator potentiometer or its wiring. The standard configuration is a two-wire pot ranging from 0 ohms for full off to 5000 ohms for full on; if the controller detects an abnormally high accelerator input (more than about 1.5 times the normal input resistance), it shuts off its output to the motor, thus preventing a runaway. The controller returns to normal operation when the fault (e.g., broken potbox wiring, broken connectors) has been repaired.

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.

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 and service life are improved. Similarly, there is less wear and tear on the vehicle drivetrain, as well as on the ground on which the vehicle rides (an important consideration with golf courses and tennis courts, for example).

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. The battery needs to supply only a fraction of the current that would be required by a conventional controller (in which the battery current and motor current are always equal). The current multiplication feature gives vehicles using Curtis PMC controllers dramatically greater driving range per battery charge.

Environmental protection

Curtis PMC 1204 and 1205 controllers are housed in rugged anodized aluminum extrusions that provide environmental protection. Controllers must be kept clean and dry, however, to ensure long life.

High pedal disable (HPD) *[OPTIONAL FEATURE]*

By preventing the vehicle from being turned on with the throttle applied, HPD ensures the vehicle starts smoothly and safely. If the operator attempts to start the vehicle when the throttle is already applied, the controller (and the vehicle) will remain off. 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 pedal linkage (e.g., bent parts, broken return spring) give a throttle input signal to the controller even with the pedal released.

The 1204 and 1205 controllers are available either with or without the HPD feature.

KSI

KSI (Key Switch Input) provides power to the controller's logic board via both the keyswitch and the footpedal microswitch. For vehicles that have no keyswitch, KSI is routed through the footpedal microswitch. For non-vehicle applications (such as conveyor belts), KSI may simply be tied to B+.

MOSFET

A MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is a type of transistor characterized by its fast switching speeds and very low losses.

Overtemperature

See *Thermal protection*.

Plug braking

The vehicle can be braked electrically by selecting the opposite direction with the forward/reverse switch without releasing the throttle. When the motor is reversed, the armature acts as a generator; the controller regulates the current in the motor field winding to give an appropriate level of plug braking torque. The vehicle brakes smoothly to a stop, then accelerates in the other direction. (NOTE: The controller may be unable to provide plug braking if the vehicle is moving too slowly for the motor to generate the necessary plug braking current.)

The plug current limit is factory set to meet customer requirements. On some 1204/1205 models, the plug current limit is adjustable via an externally accessible trimpot. See Section 4 for adjustment instructions.

If plug braking is not desired, the vehicle can be wired so that moving the forward/reverse switch through neutral causes the vehicle to freewheel as long as the accelerator is applied. If the throttle is released and reapplied, plug braking will then occur. To inhibit plug braking in this way, your controller must have the optional HPD feature. Wiring details are provided in Section 3.

A 1 kHz tone may be heard during plug braking.

PWM

PWM (Pulse Width Modulation), 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. PWM is described in more detail in Appendix B.

Smooth, stepless operation

Like all Curtis PMC 1200 Series controllers, the 1204 and 1205 models allow superior operator control of the vehicle’s drive motor speed. The amount of current delivered to the motor is set by varying the “on” time (duty cycle) of the controller’s power MOSFET transistors. This technique — pulse width modulation — permits silent, stepless operation. Pulse width modulation is described in Appendix B.

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 75°C (167°F), the current limit decreases to approximately half its rated value.

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. Although this action is not damaging to the controller, it does suggest a mismatch. 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 half of the set current. When the controller warms up, full current limit and performance return automatically.

Undertemperature

See *Thermal protection*.

Undervoltage protection

The control circuitry requires a minimum battery voltage to function properly. The controller is therefore designed so its output is gradually reduced if the battery voltage falls below a certain level. Cutback voltages for the various models are listed in the specifications (Appendix C). Reducing the output to the motor allows the battery voltage to recover, and an equilibrium is established in which the battery supplies as much current as it can without falling below the cutback voltage.

5 TROUBLESHOOTING AND BENCH TESTING

Some behaviors that may seem to suggest controller malfunction do not, in fact, indicate a problem but rather are typical of normal operation. Before undertaking the diagnostic tests, check to see whether your problem is addressed in the first section, "Operational Notes." The diagnostic tests are designed to enable you to determine whether the trouble is in the controller or in some other part of the motor control circuitry. ***The controllers themselves are sealed and not field serviceable; contact your local Curtis PMC service center if the problem is in the controller.*** *The diagnostic section provides enough detail to enable you to track circuitry problems to their source and repair them. Finally, the bench tests will allow you to confirm controller operation in a simple, low-power test configuration. Bench testing is primarily intended for checking out a number of controllers on a regular basis.*

OPERATIONAL NOTES

Noise

Controller operation is normally silent. An exception is that a 1 kHz tone may be heard during plug braking. This noise is normal and indicates that plugging is taking place. The noise will stop when plug braking stops.

Inability of Vehicle to Plug Brake to a Stop on a Steep Ramp

If the vehicle is rolling backwards down a steep ramp in reverse and the throttle is applied demanding forward drive, the controller will attempt to plug the vehicle to a stop. If the ramp is so steep that the plugging current setpoint is insufficient to stop the vehicle, it will continue to be braked but will nevertheless roll down the ramp. If the mechanical brakes are applied, and the vehicle is stopped, the full drive current will be available when the throttle is applied and the vehicle will proceed up the ramp.

Sluggish Vehicle Behavior

Loss of power will be noticeable when the batteries become overly discharged. This is a normal response to low battery voltage. Curtis PMC 1204/1205 controllers are designed to protect against damage caused by low batteries. On 24–36 volt controllers, for example, power to the motor is cut back when the voltage goes below 16 volts. Refer to the specifications (Appendix C) for other models.

Hot Controller

If the controller gets hot, it does not necessarily indicate a serious problem. Curtis PMC 1204/1205 controllers protect themselves by reducing power to the motor if their internal temperature exceeds 75°C (167°F). Power output will be reduced for as long as the overheat condition remains, and full power will return when the unit cools.

In typical applications, overheating will rarely be a problem. However, operation with oversized motors and vehicle overloading may cause overheating, particularly if the controller is mounted so that heat cannot be conducted away from its case or if other heat-generating devices are nearby. If thermal cutback occurs often during normal operation, the controller is probably undersized and should be replaced with a higher current model.

Unintended Activation of HPD

Sudden applications of full throttle may activate the HPD feature, in applications where the pedal microswitch is wired in line with KSI. This happens if the pot is rotated well into its active stroke before the microswitch can cause the controller to power up. Normal nonabusive application of the throttle should not cause this action.

IN-VEHICLE DIAGNOSTIC TESTS

These tests require a general purpose volt ohmmeter; you can use either a conventional "V-O-M" or an inexpensive digital voltmeter.

The troubleshooting chart *(opposite)* serves as a guide to the procedures that follow. Before starting these tests, refer to the appropriate wiring diagrams and make sure your controller is hooked up properly.

CAUTION

Working on electric vehicles is potentially dangerous. You should protect yourself while performing the diagnostic tests by jacking up the vehicle to get the drive wheels off the ground, opening the battery circuit before working on the motor control circuit, wearing safety glasses, and using properly insulated tools *(see page 2)*.

Fig. 19 *Guide to troubleshooting procedures.* [To use this guide, refer to the specified **PROCEDURES**.]

TEST 1 Check for power to the controller

Check voltage at CONTROLLER B- and BATTERY B+ terminals. **1-A, B, C**
It should read full voltage for system.

- *if NO* → Bad, discharged, or miswired batteries, or corroded connections. **1-C**
- *if YES* ↓

Check voltage at CONTROLLER B- and CONTROLLER B+ terminals. **1-D**
It should read 1 to 5 volts less than full battery voltage.

- *if NO* → TOO HIGH: contactor is welded. TOO LOW: 250 Ω resistor or controller is defective. **1-D**

TEST 2 Check for main contactor operation and KSI

Check voltage at contactor and at KSI terminal. **2-A, B, C**
Contactor should read full rated voltage, and KSI must be above 8V.

- *if NO* → Trace flow to locate problem. **2-D**
- *if YES* ↓

Check voltage across contactor power terminals. **2-D**
There should be no measurable voltage drop.

- *if YES* → If voltage drop occurs, contactor is defective. **2-E**

TEST 3 Check potbox circuitry (0–5kΩ throttles)

Check resistance at potbox wires while depressing pedal. **3-A**
Resistance should be between 0–50 ohms with pedal UP, and 4500–5500 ohms with pedal DOWN.

- *if NO* → Defective potbox, broken wires to potbox, or improper mechanical operation. **3-B**
- *if YES* ↓

Check for shorts between potbox wires and vehicle frame. **3-C**
Resistance should be at least 1 megohm.

- *if NO* → If lower than 1 MΩ, wiring or potbox is defective. **3-C**
- *if YES* ↓

Check voltage at upper throttle input terminal on controller. **3-E**
Voltage should be 3.6 to 4.2 volts with pedal UP, and 9.1 to 10.3 volts with pedal DOWN.

- *if NO* → Terminal area is probably contaminated with acid or dirt. **3-E, F**

TEST 4 Check for controller output

Check voltage output while depressing pedal (B+ to M-). **4-A, B, C**
Voltage should be zero with pedal UP, and full battery voltage with pedal DOWN.

- *if NO* → Controller is defective. **4-C**
- *if YES* ↓

Check current in controller's M- (motor field) lead while depressing pedal. **4-D, E**
Current should be high, and motor should turn.

- *if NO* → If no current, look for open circuit. If current is high but motor won't turn, check motor, wiring & plug diode. **4-F, G, H, I**

TEST 1 **Check for power to the controller**

1-A Leave the keyswitch off for these tests.

1-B Verify that battery (-) connects to the B- terminal of the controller. Connect voltmeter (-) lead to this point.

1-C Connect voltmeter (+) to the battery side of the main contactor. Check for full battery voltage. If it is not there, the trouble is in the battery pack, the cables to it, or the power fuse.

1-D Connect the voltmeter (+) lead to the controller B+ terminal. You should read a voltage 1 to 5 volts less than the full battery voltage. If this voltage is zero or close to zero, the trouble is either a bad controller, a bad 250 Ω resistor across the contactor, or an incorrectly connected cable between the contactor and the controller. Trace the cable to make sure it is hooked up right. Remove and test the 250 Ω resistor with an ohmmeter. If these check out, the controller is malfunctioning. If you see full battery voltage at this point, then the contactor has welded and must be replaced.

TEST 2 **Check for main contactor operation and KSI**

2-A Turn the key on, place the forward/reverse switch in forward or reverse, and depress the footpedal until its microswitch operates. (In these procedures, we assume the footpedal is equipped with the recommended microswitch.)

2-B This should cause the main contactor to operate with an audible click. Connect the voltmeter across the contactor coil terminals. You should see full battery voltage (minus the polarity diode drop).

2-C The controller KSI terminal should also be getting full battery voltage. Verify this by connecting the voltmeter (-) to the controller's B- terminal, and the voltmeter (+) to the controller's KSI terminal.

2-D If the contactor and KSI terminal are not getting voltage, that's the problem. Use the voltmeter to find out where it is not getting through. Connect the voltmeter (-) to the controller's B- terminal and check the following points with the voltmeter (+) lead to trace

the flow:
1. First, check both sides of the control wiring fuse.
2. Check both sides of the polarity protection diode to make sure its polarity is correct.
3. Check both sides of the keyswitch.
3. Check both sides of the pedal microswitch.
4. Finally, check the contactor coil and controller KSI.

2-E If the contactor coil and KSI are getting voltage, make sure the contactor is really working by connecting the voltmeter across its contacts (the big terminals). There should be no measurable voltage drop. If you see a drop, the contactor is defective. (We assume the recommended precharge resistor is in place.)

TEST 3 Check the potbox circuitry

The following procedure applies to the standard throttle input configuration for these controllers, which is a nominal 5kΩ pot connected as a two-wire rheostat (0 = full off, 5 kΩ = full on), and also to 5kΩ–0 configurations. Some 1204/1205 controllers are sold with other input characteristics. If your installation uses a controller with a throttle input other than 0–5kΩ or 5kΩ–0, find out what its range is and use a procedure comparable to the one below to make sure your pedal/potbox is working correctly.

3-A With the keyswitch off, pull off the connectors going to the throttle input of the controller. Connect an ohmmeter to the two wires going to the potbox and measure the resistance as you move the pedal up and down. The resistance at the limits should be within these ranges:

	RESISTANCE (in ohms)	
	STANDARD 0–5kΩ POT	5kΩ–0 POT
Pedal up:	0 – 50	4500 – 5500
Pedal down:	4500 – 5500	0 – 50

3-B If these resistances are wrong, it is because the pot itself is faulty, the wires to the pot are broken, or the pedal and its linkage are not moving the potbox lever through its proper travel. Actuate the pedal and verify that the potbox lever moves from contacting the pedal-up stop to nearly contacting the pedal-down stop. If the mechanical operation looks okay, replace the potbox.

3-C While you have the potbox wires off the controller, use an ohmmeter to check for shorts between these wires and the vehicle frame. You should see a resistance of at least 1 megohm. If it is lower than that, inspect the wiring for damaged insulation or contact with acid. If necessary, replace the potbox.

3-D Push the wires back on the controller terminals. It doesn't matter which wire goes on which terminal.

3-E Inspect the terminal area of the controller closely. Occasionally a buildup of dirt or acid residue of a conductive nature causes electrical leakage between the throttle input terminals and the B- or M- terminals, leading to faulty controller operation. To check for this problem, measure the voltage at the appropriate throttle input terminal (upper for 0–5kΩ pots, lower for 5kΩ–0 pots), by connecting the voltmeter (-) lead to the controller's B- terminal. The keyswitch must be on and a direction selected for this test.

	ACCELERATOR INPUT VOLTAGE (in volts)	
	STANDARD 0–5kΩ POT *UPPER TERMINAL*	5kΩ–0 POT *LOWER TERMINAL*
Pedal up:	3.8	4.3
Pedal down:	9.5	10.2

Compare your readings with these; if they are different by more than a few tenths of a volt, contamination is probably the cause.

3-F Carefully clean off the terminal area of the controller with a cotton swab or clean rag moistened with water, and dry thoroughly.

CAUTION **Be sure to turn everything off before cleaning.**

Now test the controller to see if proper operation is restored. If so, take steps to prevent this from happening again: dirt and water **must** be kept from reaching the terminal area of the controller. If the voltages are still out of range, the controller is at fault and should be replaced.

TEST 4 Check for controller output

4-A The first step is to measure the output drive voltage to the motor at the controller's M- terminal.

4-B Connect the voltmeter (+) lead to the controller's B+ terminal. Connect the voltmeter (-) lead to the controller's M- terminal.

4-C Turn on the keyswitch with the forward/reverse switch in neutral, and then select a direction and watch the voltmeter as you depress the pedal. The voltmeter should read zero (or close to zero) before you apply the pedal, and should read full battery voltage with the pedal fully depressed. If it does not, the controller is defective and must be replaced.

4-D The next step is to measure the current in the controller's M- lead. If you have a means of measuring this high dc current, such as a shunt/meter setup or a clamp-on dc ammeter, use it. If not, we recommend that you buy an inexpensive ammeter of the type that is simply held against the wire being tested. These are readily available at auto parts stores, and their accuracy is adequate for this test.

4-E Turn on the keyswitch with the forward/reverse switch in neutral, and then select a direction and watch the ammeter while depressing the pedal.

4-F If you see no current flowing in the M- lead, the problem is an open circuit in the motor or the wiring between the motor and the controller. Check the forward/reverse switch. If your vehicle uses contactors for reversing, check to see that they are operating and that their contacts are closing. If these are okay, check the motor armature and field for opens.

4-G If you do see a high current flowing in the M- lead, but the motor does not turn, the problem is a short in the motor circuit, a miswired motor, or a short in the controller's internal plug diode. Test the plug diode as follows:

1. Remove power by opening the battery circuit. Take the cable off the controller's A2 terminal.

2. Use an ohmmeter to check the resistance between the controller's A2 and B+ terminals. You are testing for the presence of a diode inside the controller, so swap the two leads of the ohmmeter and look for a low resistance one way and a much higher one the other way. If your meter has a diode test function, use it.
3. If you find the diode to be shorted, the controller is defective.

4-H Put the A2 cable back on the controller and reconnect the battery.

4-I If the plug diode is okay, there is a short in the motor circuit. The short could be in the forward/reverse switch, so look there first. Because the resistance of the motor is so low, the motor must be tested separately if it is suspected of having a shorted winding.

BENCH TESTING

First, before starting any bench testing, pick up the controller and shake it. If anything rattles around inside, the unit should be returned.

CAUTION

Protect yourself during bench testing. Wear safety glasses and use insulated tools.

Equipment Needed

The simple setup shown in Figure 20 is required for testing these controllers on the bench. You will need:

1. a POWER SUPPLY with a voltage equal to the rating of the controller you want to test. You can use either a string of batteries or a regulated line-operated power supply. Because only low power tests will be described, a 10 amp fuse should be wired in series with the batteries to protect both operator and controller against accidental shorts. A battery charger alone should not be used as a power supply, because without a battery load its output voltage may exceed the rating of the controller.
2. an ACCELERATOR POTBOX. For controllers with the standard input configuration (a 5 kΩ pot wired as a two-terminal rheostat), a Curtis PMC potbox or any 5 kΩ pot will work fine.

For controllers with other input options, use whatever kind of potbox is used on the vehicle.

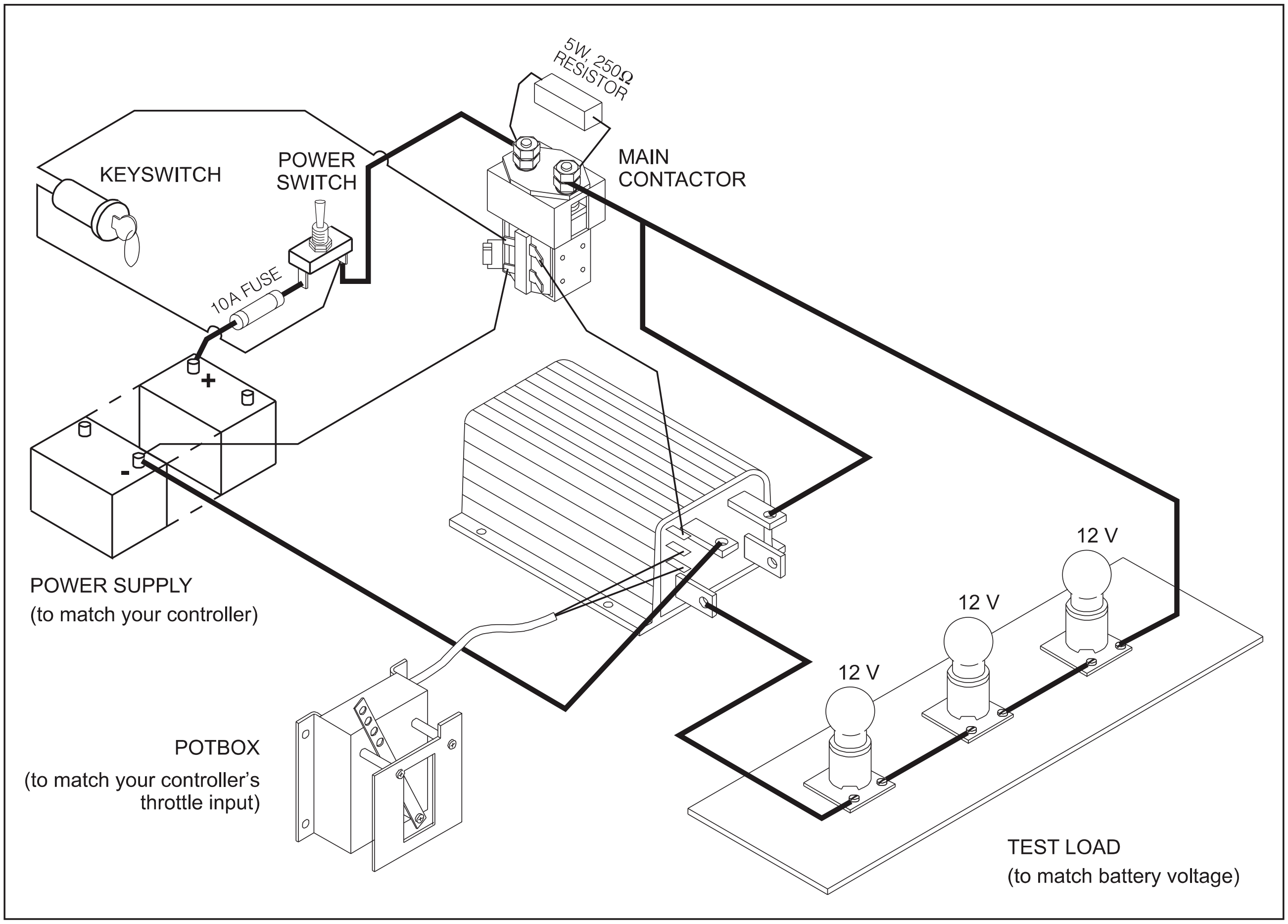
3. a POWER SWITCH to disconnect all power from the test setup.

4. a MAIN CONTACTOR with a 250 ohm, 5 watt resistor across its high-power contacts and a KEYSWITCH to turn it on and off.

5. a TEST LOAD consisting of incandescent light bulbs wired in series to get the same voltage as your power supply. (For example, with a 36 volt battery, use three 12 volt bulbs.)

6. a general purpose VOLT OHMMETER or DIGITAL VOLTMETER.

Fig. 20 *Setup for bench testing.*



Bench Test Procedure

A. Hook up the controller as shown. Connect the voltmeter leads to the controller's B+ and B- terminals.

B. Turn on the power switch (not the keyswitch) and watch the voltmeter. Its reading should build up slowly over several seconds to within a couple of volts of full battery voltage. If this voltage does not come up, the controller is bad.

C. Now turn on the keyswitch. The main contactor should turn on and the voltage at the controller's B+ and B- terminals should now equal the full battery voltage. Move the potbox lever through its range. The lamps should go smoothly from full off to full on with the pot.

D. If the controller has HPD, test this feature as follows:

   1. Turn off the keyswitch.

   2. Move the potbox lever about halfway.

   3. Turn the keyswitch switch on. Verify that the lamps do not come on until the potbox lever is moved most of the way toward OFF and then moved back up.

E. Test the controller's potbox fault protection feature by pulling off one of the potbox's two connections to the controller's throttle input terminals while the lamps are on (potbox lever in the ON position). The lamps should turn off. With the potbox lever still in the ON position, reconnect the wire. The lamps should smoothly increase in brightness to their previous level.

F. Finally, remove the controller from the test setup and check its internal plug diode, as described in Troubleshooting Procedure **4-G**.