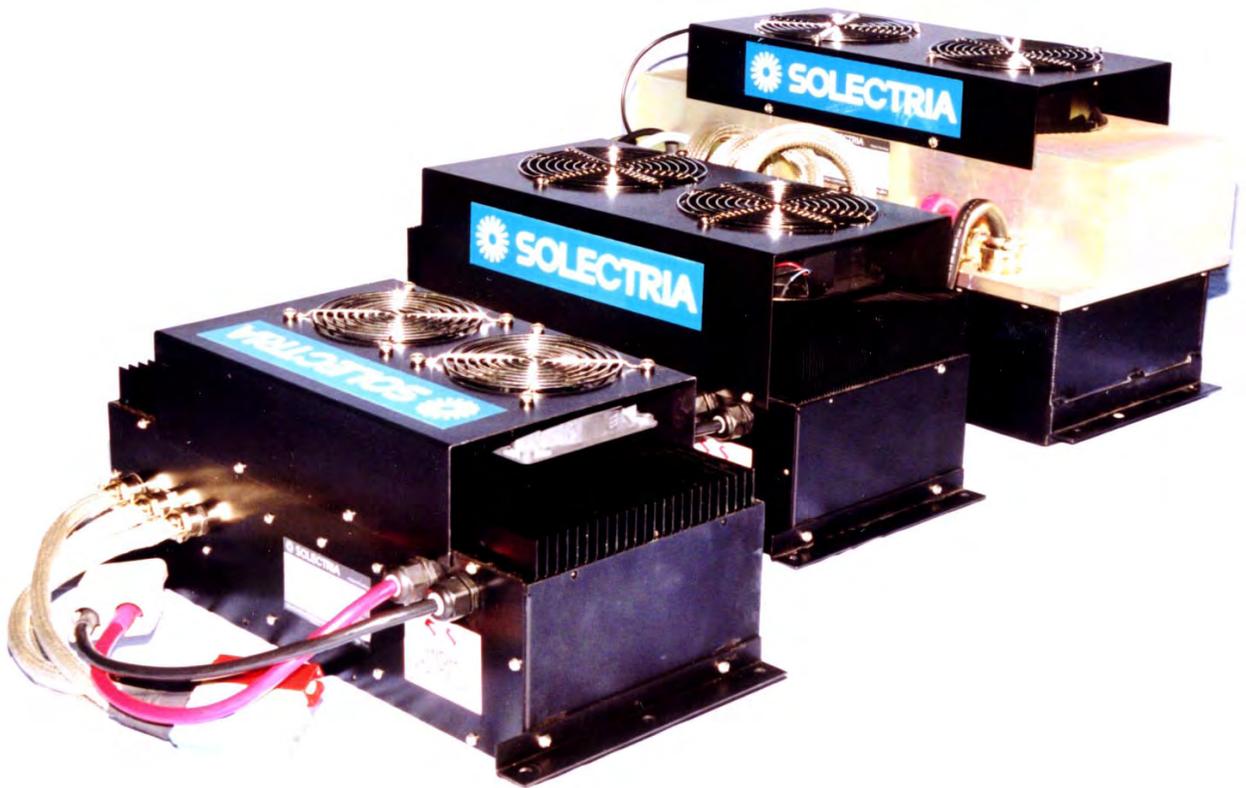




Service Manual for Universal Motor Controllers (UMOCs)



Second Edition

Addendum to Umoc Service Manual

As an addendum to the service manual for the Solectria Universal Motor Controller (UMOC), the following procedure should be followed in regards to the use of connector grease on all Anderson and 9 and 25 pin D-sub connectors.

Before making any Anderson or D-sub connection, always apply Nyogel Grease (Part # 760G), GM Connector Grease (Part # 12345579) or other dielectric grease for protection against corrosion or electrical tracking at connector pins and cable shells.

- **For 9 and 25 pin D-sub connectors:** Apply grease **sparingly** to the connector pins and to the connectors' cable collar of both the male and female ends.

◆ **Note:** Excessive grease will attract dirt particles that can interfere with pin contacts when you disconnect and reconnect your cables.

- **For Anderson connectors:** Apply grease to the pin contacts and back-fill the pin casings with grease.

Do not apply grease to your Deutsch or Packard connectors

If you have any questions regarding the proper use of connector grease on your D-sub or Anderson connectors, please call the Solectria Customer Service Department for details.

Foreword

Caution

The information provided in this manual is intended for use by persons with appropriate technical skills. Any effort to perform repairs to, or service your unit without the proper tools or knowledge required for the work can result in personal injury and product damage.

To Report Errors in the Manual

If, while reading through this manual, you discover an error in the technical information provided, Solectria asks that you notify its Customer Service Department at the phone number provided in your warranty. Please be prepared to provide the following information:

- Your name
- Name and edition of your manual
- Page number(s) where the error(s) appear
- Serial number of your unit

Please feel free to call with any suggestions that you may have regarding the content of your manual.

© 1999 Solectria Corporation

All Rights Reserved

No part of this manual may be reproduced, stored in any retrieval system, or transmitted in any form or by any means (including but not limited to electronic, mechanical, photocopying, and recording) without the prior written permission of Solectria Corporation. This applies to all text, illustrations, tables, and charts.

Introduction

Congratulations on your purchase of a Solectria Universal Motor Controller (UMOC). By choosing the Solectria UMOC, you join others that have made a commitment to the high efficiency and exceptional design that has set the standard in the electric vehicle industry.

A UMOC is a self-contained, microprocessor controlled, three-phase AC vector control power converter for AC induction or DC brush-less traction drive and auxiliary drive motors.

Responding to all input sensors and commands, your UMOC provides all the power outputs necessary to operate an over the road vehicle. In addition to controlling the main traction motor, your UMOC sends the signals that control the dashboard displays and exterior signal lighting of the vehicle.

The UMOC is available in many sizes and configurations. Size ranges from ultra-light models, designed for solar power racing cars, to large commercial units capable of powering a city transit bus. Other configurations supply 60-cycle three-phase AC power for driving a standard industrial motor.

All units (except auxiliary drives) can use an AC motor as an alternator to generate or recover DC power; switching smoothly under power from motor to alternator and back again whenever needed.

Since Solectria is confident in the craftsmanship of its products and because our components are engineered to work together for maximum efficiency and reliability, we highly recommend that you use our motors and components when designing your vehicle's systems. With Solectria's guidance, you can easily customize your UMOC's parameters to respond to your systems changing requirements.

Your UMOC was built upon a foundation of experience that has come from over a decade of quality research and development. In the unlikely event that you should encounter a problem with your unit, or if you simply have a question, Solectria provides you with an excellent customer service support staff and a comprehensive component warranty.

Table of Contents

FORWARD	III
CAUTION	III
TO REPORT ERRORS IN THE MANUAL	III
INTRODUCTION	V
SPECIFICATIONS	1
<i>Naming Convention for the Solectria Universal Motor</i>	
<i>Controller</i>	4
FEATURES	6
HOW TO USE THIS MANUAL	9
<i>Short Cuts</i>	10
<i>Safety</i>	11
INSTALLATION	13
9-PIN ENCODER (SPEED SENSOR) CONNECTION	29
SYSTEMS CHECK	59
TEST DRIVE	71
FAULT DIAGNOSIS	81
CONCLUSION	117
WARRANTY	119
MAINTENANCE	123
APPENDICES	127
UMOC INTERFACE PACKAGES OF DUAL & SINGLE DRIVE	
SYSTEMS	128

INDEX _____ **149**

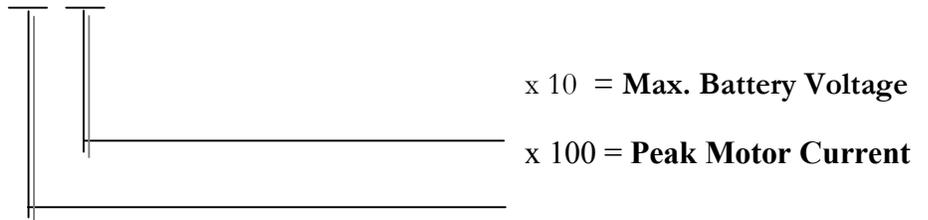
INDEX _____ **150**

Specifications

Naming Convention for the Solectria Universal Motor Controller

The following defines the alphanumeric nomenclature that appears in the model title of your UMOC.

UMOC440 (T), (F) (A) or (S)



T= High Efficiency

F= Heavy Duty Cooling (Standard)

S= Sensorless UMOC

A= Auxiliary

For Example: A UMOC640 has a 600A peak motor current and a 400V peak battery voltage.

Table 1.

Model	Special Notes	Battery Min. (Nominal)	Battery Max. (Nominal)	Min Operational Voltages	Max Operational Voltages	Peak RMS Motor Current	Peak Electrical kW	Vehicle type	Weight (lbs)*	Max on Charge Voltage	Max Battery current	Input Wire size AWG	Cooling Fan current (max. amps)@ 12V
UMOC225	Discontinued		144V			140A	20	car	27				
UMOC320T	Discontinued		144V			240A	34	car	27				
UMOC340	Discontinued		312V			210A	65	car	26	400V	180A	4	1.9A
UMOC440, UMOC440F	Discontinued		312V										
AC325						240A	40	car	26				
UMOC425T		120V	192V	90V	240V	240A	45	car	28	250V			
UMOC440T		216V	312V	160V	370V	250A	78	car	28	400V			
UMOC440TF		216V	312V	160V	370V	250A	78	van	35	400V	250A	2	4.4A
UMOC640		156V	312V	120V	370V	400A	100	bus	55	400V	425A	2	4.4A
UMOC645**		156V	336V	120V	370V	420A	110	bus	55	450V			
UMOC340A-> UMOC440T-A	Special		312V			180A	56	inverter	26	400V			
UMOC425T-S	Special		192V			180A	34	inverter	26	250V			
UMOC340S-> UMOC440T-S	Special		312V			180A	56	inverter	26	400V	250A	2	4.4A

*weight does not include cooling fans

** Available first quarter 2000

Motor Model	AC10	ACgtx20	AC21	AC25	AC42	AC50	AC55	AC60	AC90*
Peak Torque (Nm)	50	70	90	140	160	145	240	290	630
Max current (A rms)	200A	240A	280A	225A	240A	240A	250A	400A	400A
Continuous Torque (Nm)	10	20	21	25	42	50	55	60	90
Continuous Power (kW)	5kW	12kW	13kW	16kW	21kW	30kW	34kW	36kW	57kW
Peak Efficiency	88%	90%	92%	91%	93%	93%	93%	93%	93%
Motor controller	UMOC425T	AC325	UMOC425T	UMOC425T	UMOC440T	UMOC440TF	UMOC440TF	UMOC640	UMOC645
Peak Electrical Power	17kW	34kW	37kW	30kW	75kW	78kW	78kW	100kW	110kW
at voltage of	144V	144V	144V	144V	312V	312V	312V	312V	336V
Nominal Speed (krpm)	2	4	3	1.2	4	4	2.5	3	2
Max. Speed (krpm)	12	12	12	12	10	10	10	10	6
Weight (lbs)	40	70	86	104	133	198	234	248	440
Diameter (in)	7.6	8.5	9.75	9.75	9.75	13.5	13.5	13.5	15.5
Length (in)	10	11.5	12.13	13	14.5	16-17*	17-18*	18.5	22

*Depending on end bells and options

Table 2.

The charts on the previous page show the size and capacities of currently available Solectria UMOCs. In addition, the chart also gives examples of the more common applications for individual units.

Features

Your UMOC unit has been specially designed for maximum performance and reliability. Other features of your unit include

Self-contained operation

A high-speed microprocessor

Multilevel safety systems for user protection

Unit swap-out time of five minutes

Programmable with ordinary laptop by user

Self diagnostics monitor operation continuously

Output short-circuit protection (except model 225)

Air-cooling, which reduces the cost and complexity of your system

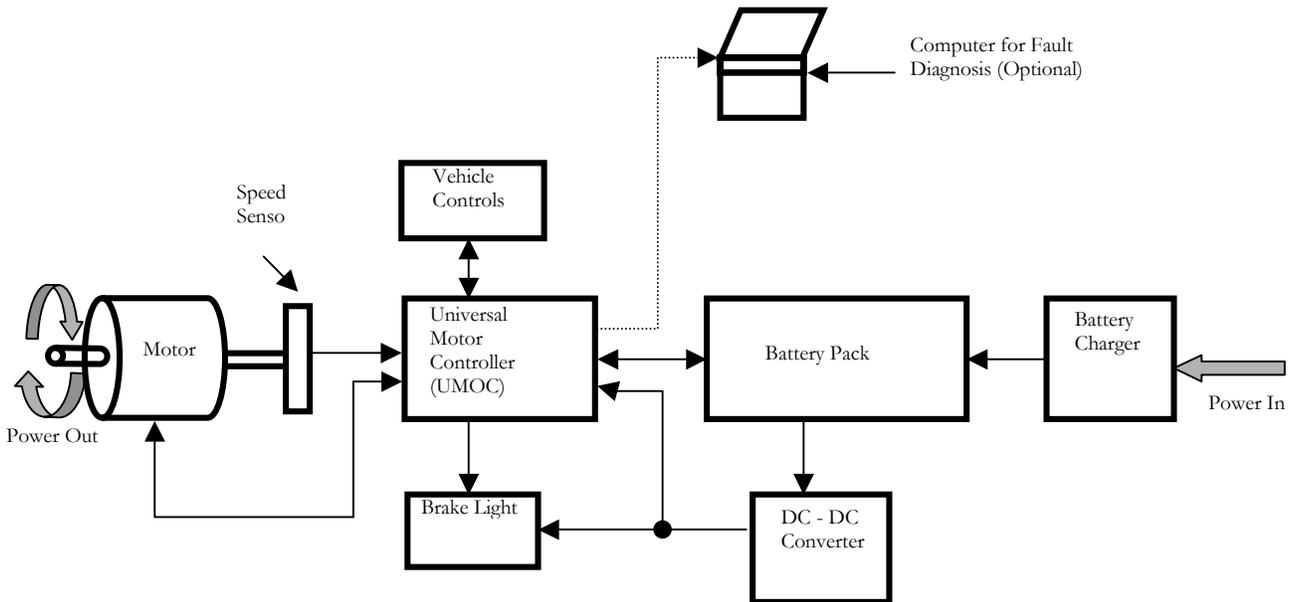
Lightweight all-aluminum construction

Built-in battery protection feature extends battery life

A ratio-metric speedometer pulse output signal that drives your electronic speedometer and includes an instant calibration feature. (Optional)

Also included with your UMOC is an interface kit. Please check with your Solectria Sales or Customer Service representative if you have any questions regarding the features or assembly parts of your unit.

Figure 1: Components Block Diagram



How to Use This Manual

The following section will aid you in your ability to quickly get the information that you need from this manual and help you perform tasks safely.

Short Cuts

You do not need to hunt through the entire manual to locate the information you need to perform certain tasks. The following steps describe what you can do in order to quickly find information that best fits your needs.

If all of the connections needed for installing your UMOC are already in place and you are only swapping your current UMOC with a replacement unit, you can proceed to the “*Swapping Units*” section of the chapter titled “*Installation*”.

If your UMOC is already installed and you would simply like to run a systems check of your unit, you can skip to the chapter titled “*Systems Check*”.

If you own a dual-drive system and are working with more than one UMOC at a time, there are issues specific to installing your units. To help you find information in text that relates to dual-drive systems, look for the $\Delta\Delta$ symbols at the left-hand side of the page. To test your dual-drive system, you can skip to the section titled “*Testing Your Dual-Drive System*”.

Safety

Your UMOC, when attached to a power source, contains voltages sufficient to cause severe personal injury. *Always use caution when operating near sources of high voltage.*

Warning Labels

Labels will be located on the right-hand side of the page to indicate areas in a procedure where you should be taking appropriate precautions. Labels include:

Safety Symbols

CAUTION	DANGER	WARNING
(Indicates the risk of injury or causing damage to your unit)	(Indicates the risk of being killed)	(Indicates the risk of being killed or seriously injured)

Always use caution when working on or around any electrical equipment. **Wear eye protection at all times.** The following symbols will be located in the right-hand margin of your manual to indicate sections in a procedure where extra caution and/or safety equipment is required.

Hearing Protection Required



Eye Protection Required



Risk of Electrical Shock



Risk of Burns from Battery Acids



Always follow any safety instructions that are given at the beginning of a procedure. If you are uncertain as to the safe and proper handling of your equipment, contact your Solectria Customer Service representative at the phone numbers provided in your warranty before proceeding.

Installation

System Requirements

You must have the following three items in order to ensure that your UMOC will operate properly with the drive system that you have developed.

a battery pack of sufficient voltage and capacity

an accessory kit with interface box and accelerator pedal unit connections

a motor with an incremental rotary encoder that has been configured to match the programming of the UMOC♦

♦**Note:** Motors that use a sensorless UMOC with no sensor do not require a shaft encoder

Use table 1. in section 1 to help determine that the UMOC you have purchased is compatible with your motor and drive system.

Interface Kit

Your UMOC comes with a kit that contains parts for connecting the unit to your drive system. These include:

an interface box

forward / reverse switch assembly

accelerator pedal box

cable and connector kit.

Some configurations include a driver console in place of, or in addition to, the interface box.

It is important to remember that there are two distinct types of interface kits: one is for single-motor systems and the other is for dual-motor systems. Check the items listed in Appendix A- “Interface Kit Contents” to make sure that you have the appropriate kit for your UMOC.

◆ **Note:** Any damage resulting from bypassing the interface box with a direct connection of customer equipment is not covered under warranty.

Shipping Carton

Keep your shipping carton!

Your carton is specially designed to prevent shipping damage to the metal case and cable connectors of your UMOC. If the carton is lost, Solectria will supply a replacement carton for a fee. If the unit must be shipped immediately, you must triple-wrap it with large cell bubble-pack and place it securely in a double-walled, corrugated carton for shipment back to Solectria. Any repair costs for the unit that are associated with case damage due to improper shipment will be borne by the carrier or the customer and will affect your warranty.

CAUTION

Do not connect equipment directly to the UMOC without the interface box or console

Tools

Whether installing a new unit or swapping out an old one, you will need certain tools in order to install and test your UMOC. These include:



- A laptop computer or computer with screen

Microsoft HyperTerminal communications software

A 7/16" socket wrench with extension

A small flat-head screwdriver

Electric drill with a 1/4" metal drill bit

Use all safety precautions when using metal tools near a source of electricity or making electrical connections and as always, wear eye protection.

Before You Mount Your UMOC

Listed is a set comprehensive installation requirements for your UMOC. When planning a new installation, please consider all the points below. Your design will be a success if these installation and operation guidelines are followed.

Do not loosen any screws or hardware on the outside of the UMOC case. Each fastener and grommet is carefully tightened with sealant during construction. If fasteners are loosened or removed, the factory seal will be lost. Units received for repairs that have been opened by the customer will be ineligible for warranty coverage.

Do not drill holes into the case of your UMOC. Use only the mounting holes provided.

Never remove the mounting brackets from the unit for any reason. If the mounting brackets have been removed, reinstall them with 8-32 stainless-steel screws only. Before installing, holes must be covered with sealant. Use only GE silicone type II sealant. Do not use type I sealant. Type I sealant emits corrosive vapors which are harmful to electronic components.

If ductwork must be attached to the air intake grills on top of the unit, adhesive strips of Velcro may be applied to the fan housing. The ductwork must be easily removable in order for the UMOC to be serviced.

Do not attach other vehicle accessories to the top of the vibration mounts. The vibration mounts supplied with the UMOC are matched to the weight of the unit. Besides transmission of unwanted vibrations, attaching objects to the UMOC mounting bolts will make removal and installation difficult.

When carrying, installing, or removing your UMOC, never lift the unit by the wires.

See the “Maintenance” section regarding waterproofing UMOC connectors.

Mounting Your UMOC

Once you have decided on the best location for your UMOC based on specifications, you can now mount it into position.

Environmental Considerations

Choosing a good location will result in improved performance and longevity of the unit. Your UMOC should be mounted face-up and located in a position that provides easy access for servicing and replacement. Your UMOC should be kept dry at all times. It is understood, however, some water splash to the underside of your vehicle is unavoidable. Your UMOC is factory sealed to withstand small amounts of moisture. We ask that you use the following guidelines regarding placement of your UMOC:

Avoid locations where your unit will be routinely exposed to water.

Do not wash your unit with a pressure sprayer. Large amounts of water will cause a malfunction.

If you have reason to believe water has entered the unit, do not open the case. Disconnect your unit and return it for service as soon as possible.

Keep the protective plastic cap over the unit’s serial data port when not in use.

Units with extensive water damage may not be repairable. Customer units returned to Solectria with the factory seal broken will be ineligible for warranty service.

◆ *Special Notes Re: Hybrid Vehicle Owners*

There are certain considerations regarding the placement of your UMOC if your unit is being installed into a Hybrid Electric vehicle platform.

Your unit must be located away from sources of intense heat, such as combustion engines or exhaust manifolds. Besides reducing power output, high temperatures will shorten the overall life of the unit.

Do not to locate your UMOC in an engine compartment. The unit can become covered with an oily film from small oil leaks or crankcase vapors. This will complicate matters if the unit is returned for repairs or upgrades.

Vibration Mounts

All electronic systems must be isolated from vehicle vibration. This is done through the use of vibration mounts.

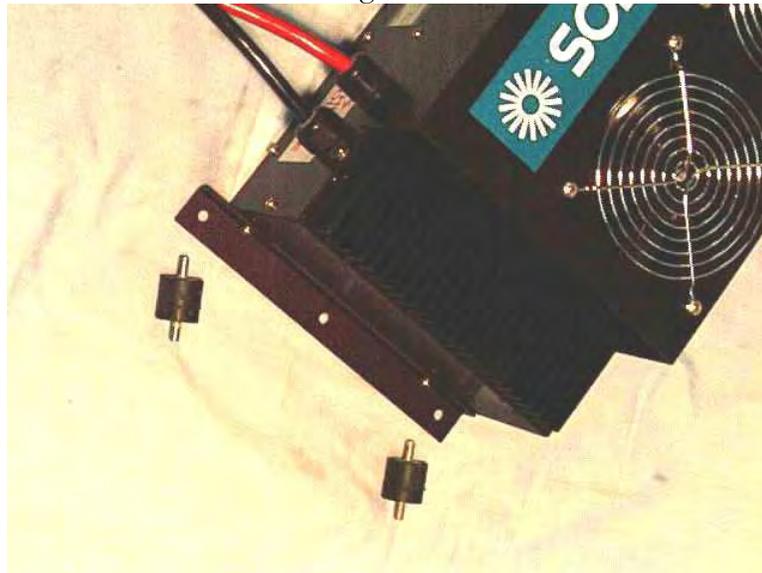


Figure 2: UMOC Vibration Mounts

All UMOCs are shipped from the factory with vibration mounts in the accessory kit. If the UMOC is bolted directly to the vehicle frame without the vibration mounts in place, it will be difficult to obtain a unit lifetime of greater than two years.

The factory supplied vibration mounts must be operated in compression, with the weight of the UMOC on them. For improved vibration protection, or when the UMOC is not mounted face-up, heavy-duty Barry mounts must be used. Barry mounts are available through Solectria or from Barry Controls.

Cooling Air Requirements

Ample quantities of outside air must be available to cool your unit. Your UMOC is air cooled because this gives greater overall electrical efficiency along with reduced system cost. Your UMOC cooling system is maintenance free. However, performance and lifetime will both be reduced if cooling air is not available. Consider this when choosing a location for the unit. Some points to keep in mind:

Cooling fans are not designed to draw air through ductwork more than two feet long, with bends, or of a smaller cross-section than the fan air intake opening.

If ductwork is required, additional blowers must be added to restore the airflow rate to the same level as a unit operating in free air. (See appendix H)

To check for proper airflow, operate the unit under the most demanding conditions (for example, at high ambient temperatures or hill climbing) for 15 minutes. Exhaust air temperature measured at the cooling fins should not exceed 50 degrees Centigrade during this period. The unit should not be routinely exposed to ambient temperatures above 50 degrees C° unless equipped with high-power cooling fans designed for warmer climates. See the chart in appendix B for temperature de-rating curves.

Regarding the use of Ductwork

The use of ductwork is not recommended. At the same time, heated exhaust air exiting the unit must not be allowed to reenter the air intake grilles. If this happens, temperatures will quickly rise. Power will be automatically reduced to prevent further heating. This constitutes misuse, and if returned for service, discoloration of internal plastic parts from prolonged elevated temperatures will be evident. This will affect your new-product warranty coverage.

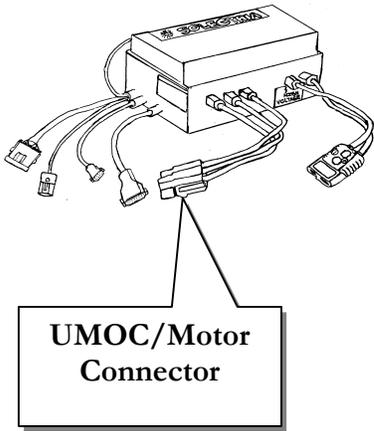
Any ductwork used to supply cooling air to your unit's fan air intake grilles, must have a cross-sectional size at least as large as the fan intake grille itself.

For example, a single 5-inch fan should be supplied through a ductwork having a cross-section of no smaller than five inches. Two 5 inch fans would require a duct of at least seven inch diameter cross-section, and so forth. Because of the changes in air static pressure resulting from ductwork, airflow is reduced. Length of the ductwork should be kept to a minimum.

Do not restrict airflow by adding louvered grilles unless the louvers are fixed in the full-open position.

External Fans and Blowers

Your UMOC controls the power to the cooling fans mounted on the top of the unit. When cooling is needed for the unit's heat-sink fins, the fans are switched on by the unit's internal microprocessor. If external fans or blowers are needed, these fans must not be connected to the UMOC fan power cable. The external fan or blower motors should be connected to the vehicle's 12-volt system directly. If you wish to control external fans or dampers with the UMOC fan power signal, Solectria can supply a fan relay kit for an additional charge. Damage to the unit from the connection of external fans or blowers to fan power outputs are not covered under warranty.



Connecting Your Motor to Your UMOC

Now that you have made sure that your UMOC is located in a safe and dry place, receives sufficient airflow and has been securely mounted, you must now make the connections between the unit and the motor. First, use the guidelines given regarding the cooling requirements of your motor. You will also be given information on the grounding and phasing of your motor as well as instructions on how to properly splice your motor wires, should it be necessary to extend their length. Making the actual connection between your motor and your UMOC is as simple as pushing together the three-phase plugs from each unit.

Motor Cooling Requirements

Depending on class of duty, it may be necessary to cool the motor(s) with forced air (except for motors that are water-cooled). Suitable blowers or fans can be purchased from Solectria. For water-cooled motors, refer to the documentation supplied with your motor.

Airflow

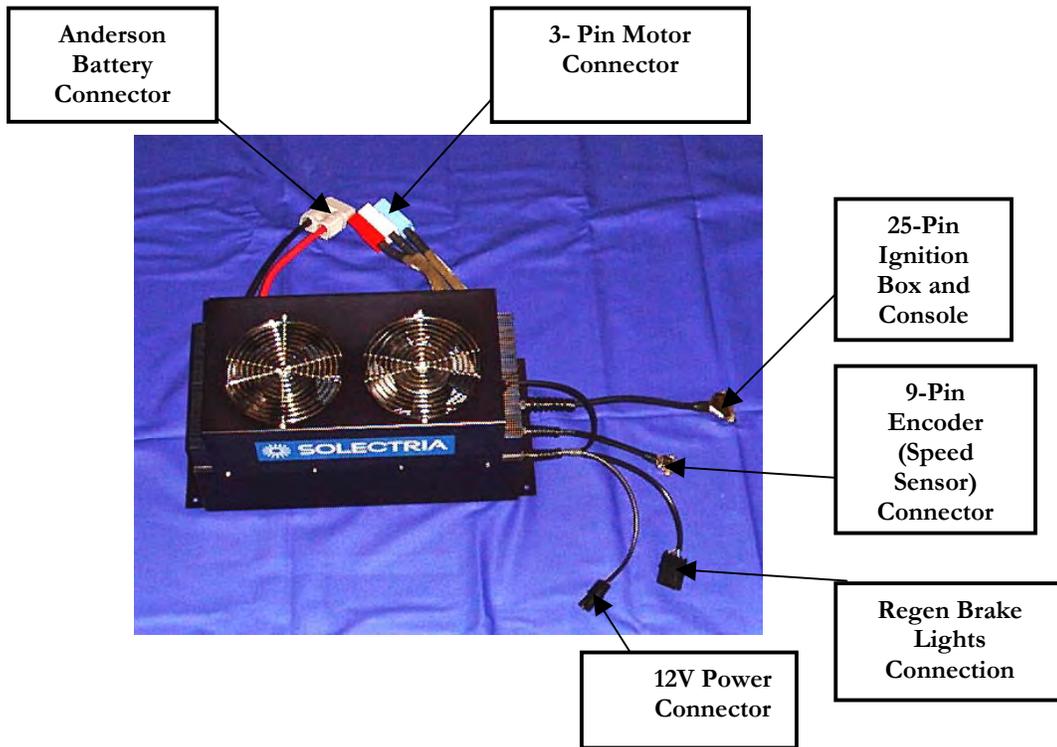
Air velocity of 40 ft/sec over the motor cooling fins is required. At lower rates, the available duty cycle is reduced. This may be acceptable in air-over situations where adequate cooling is provided by vehicle ram air. A good example is a traction motor mounted in an exposed underbody position combined with a light to medium duty cycle (such as the Solectria Citivan delivery van).

Table 3. Motor Cooling Recommendations

Type of Service	Recommended motor cooling
Light duty Example: 2500lb car with AC21 motor	200-250 cfm 6 inch diameter brushless fan with 120 °F thermal switch fastened to motor case. Switch type = close on rise
Medium duty Example: Truck or bus with AC42 or AC50	400-500 cfm blower providing actual airflow of 300 cfm. Fan should run continuously. In cold climates, a thermal switch must be added as above.
Heavy duty Example: Large vehicle with AC60 motor	700-1000 cfm blower with actual airflow of 600-800 cfm. Blower should run continuously whenever vehicle is in use.

Problems with Overcooling

Very high airflow rates can allow the motor to operate at full power for a prolonged period. This can result in overheating of the rotor. In this situation, you should consider choosing a larger motor or a supply of cooling air for the internal rotor. The internal rotor is not protected electrically from overheating like the stator windings. If the stator windings should overheat during prolonged high-speed driving or hill-climbing, temperature sensors embedded within the stator windings will signal the microprocessor to reduce the motor power. In many driving situations this will not be noticeable, but the installation should be planned to minimize the occurrence. Some traffic operations requiring bursts of brisk acceleration may be adversely affected by reduced power.



Motor Power Wires

The three color-coded wires (red, white, and blue or other similar colors) connect to the motor. For correct operation, the colors must be matched: red to red, and so forth. If, during motor wiring or installation, two of the three wires are reversed, the motor will not operate. This is known as Phasing.

Motor Phasing

All UMOC's and Solectria motors have been phased properly and motor wire connectors are color-coded before leaving the factory. Use the color-coded plastic connector housings to identify wires. For wires without connectors, wires are identified by color bands or by tags reading "Blue," "Red" or "White", for example.

Unlike standard industrial 3-phase motors, the direction of rotation is controlled by the microprocessor and cannot be reversed simply by exchanging wires (except for UMOC's without sensors).

Important: to facilitate testing and repair, the colors and ordering of the controller wires must not be changed. Units received for repair with the colors and/or wires out of order will be reset to the original configuration so that they can be tested. Make any required changes to the motor wires, not to the controller wires.

◆Special Note Regarding Motor Shaft Direction

The direction of rotation of motor shaft is set at the factory as a software parameter based on the customer order. All units are set to clockwise or counter clockwise based on customer request.

When vehicle construction is completed, it is quite often discovered that the opposite direction of rotation would be appropriate. Shaft direction is easily changed with the user data screen. (Check your warranty before charging)

Use a computer with the HyperTerminal communications software and the information provided in appendix E." Solectria recommends that you return the unit to the factory to have the shaft direction reversed. Be sure to pack the unit properly to avoid shipping damage.

Grounding Your Motor and UMOC

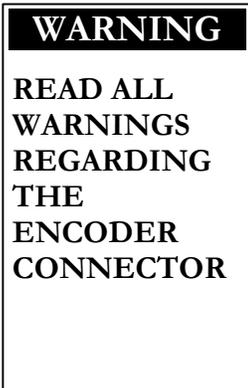
To minimize the introduction of noise resulting from poor grounds, ground the motor and the UMOC to the vehicle frame. (See appendix I for grounding your UMOC).

CAUTION

The small screws on the mounting brackets must not be removed or loosened.



The motor housing may be connected to the vehicle frame using a bonding jumper connected to a good grounding point on the motor frame. You can ground your UMOC by placing a ring terminal under one of the four mounting screws. Vibration mounts on the UMOC insulate the UMOC case from possible grounding. To ground the case, install a bonding wire from one of the UMOC mounting bolts to the vehicle frame. Be sure to use a toothed washer to penetrate the anodized coating on the mounting bracket. For vehicles with nonmetallic bodies, the motor and controller cases may be bonded to one another with a jumper wire. A signal ground is provided through the encoder cable.



Warnings Regarding the Encoder Connector and Grounding

Since high voltages can develop on the encoder cable, follow these warnings:

Do not handle the encoder connector while the motor is running.

Never unplug the connector without first switching off the power.

While unplugging or fastening the connector, use both hands.

Grasp the connector shells by the plastic cable strain relief at the base and not by the metal housing.

Prevent the possibility of electric shock by switching off the motor controller completely, before connecting or disconnecting the encoder connector.

Splicing Wires

If it becomes necessary to lengthen the motor wires in order to carry out or modify an installation, be sure to mark the wires with respect to color (Red, White, and Blue), before proceeding. Spare connector pins are available at competitive prices from Solectria. To prevent splicing, specify the length of motor wires desired when ordering your motor.

Follow these guidelines when splicing extensions onto the connector wires of your motor or UMOC.

The same wire size (gauge) as the original wires must be used

Wires must be covered with braid or conduit for EMI reduction

All connections must be secure and well insulated

Braid must be insulated from wire at all points

Braid must have good overall continuity

Wire conductors must not touch together during operation

Crimping Connector Tips

Use the information given in appendix L to help you properly crimp the Anderson connector tips. Remember, connector tips (top and bottom) must be free of solder and other residues in order to make a reliable connection.

Keep these other things in mind regarding crimping connector tips.

Check the pins after crimping the connector tips to be sure that they have not become bent during the crimping process.

It is best to use a crimping tool that is designed specifically for the pins.

Pins must be straight to ensure a good connection. Insert the pins into the plastic housings until you hear a ‘click’.

Try connecting the motor plug to the UMOC. If the pins are in good condition, the plug will be somewhat difficult to insert. If the plugs slide together easily, the connector pins are not exerting sufficient pressure to provide a good connection. Disassemble the connector and check for bent pins. Do not force the connector if it cannot be mated. Disassemble the connector and check for bent pins. See appendix L for detailed instructions regarding crimping and soldering connections.

Soldering Connector Pins

As mentioned previously, pins that are not professionally crimped may be soldered to insure a good connection. While soldering, position the pins so that solder does not drip down onto the contact area. If it does, wipe clean with a wet sponge before the solder solidifies.

After soldering, clean any remaining flux residue from the pins using a cloth moistened with alcohol. Avoid scraping or brushing the pins with a metallic object because this will remove the silver plating.

Connecting Your UMOC to Your Motor

After following all of the guidelines for setting up your motor and your UMOC, you can now connect the two units together. To make the connection, simply push the three-phase, red, white and blue connector pins from the UMOC to the matching red, white and blue connectors of the motor. From this point you can connect your ignition box or driver console systems.

9-Pin Encoder (Speed Sensor) Connection

The 9-Pin encoder, or ‘speed sensor’ connection allows your UMOC to monitor the speed, direction and temperature of your motor.

Warnings Regarding the 9-Pin Encoder (Speed Sensor) Cable and Grounding

Since high voltages can develop on the encoder cable, follow these warnings:

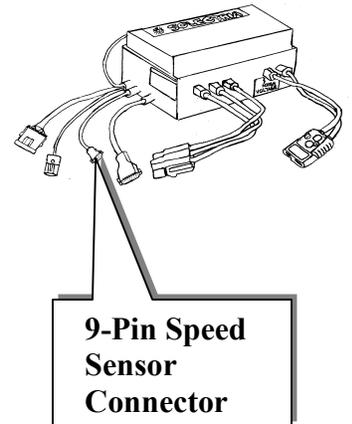
- Prevent the possibility of electric shock by switching off the motor controller completely, before connecting or disconnecting the encoder connector.
- Do not handle the encoder (speed sensor) connector while the motor is running.
- While unplugging or fastening the connector, use both hands. Grasp the connector shells by the plastic cable strain relief at its base and not by the metal housing.

Speed sensor cable extensions must be completely shielded

Cable shields must have good overall continuity

Sensor cable plugs must not touch motor wire braid at any point

-



Once the 9-pin encoder connection has been made between your motor and your UMOC, you can then move onto connecting the 25-pin cable of your unit to your ignition box or driver's console.

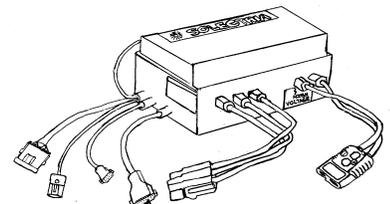
25-Pin Ignition Box and Driver Console Connections

Now that you have mounted your UMOC and connected the unit to your motor, you can next make the connection between your UMOC and your ignition box (single-drive vehicles) or driver console (used in dual-drive vehicles), using the 25-pin cable link.

The UMOC was designed to operate with a Solectria ignition box or driver console only. Do not attempt to remove any of the safety feature interfaces.

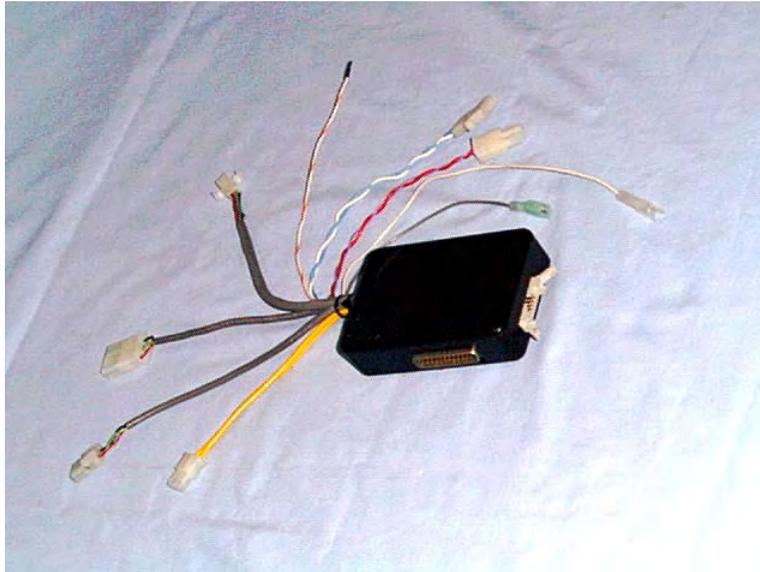
Follow all instructions and guidelines regarding the installation of your ignition box or driver console.

For those with dual-drive systems, read all of the information regarding issues specific to your requirements.



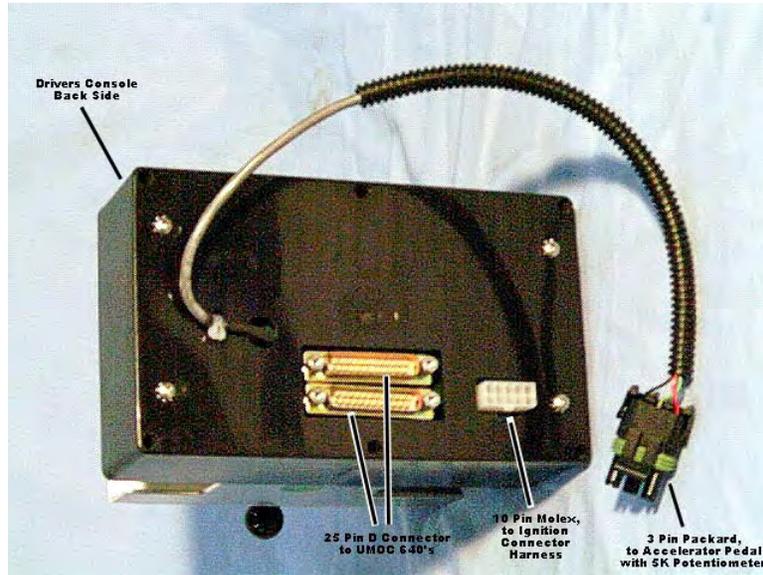
**25-Pin
Ignition Box
and Console**

Single-Drive / Ignition Box Systems

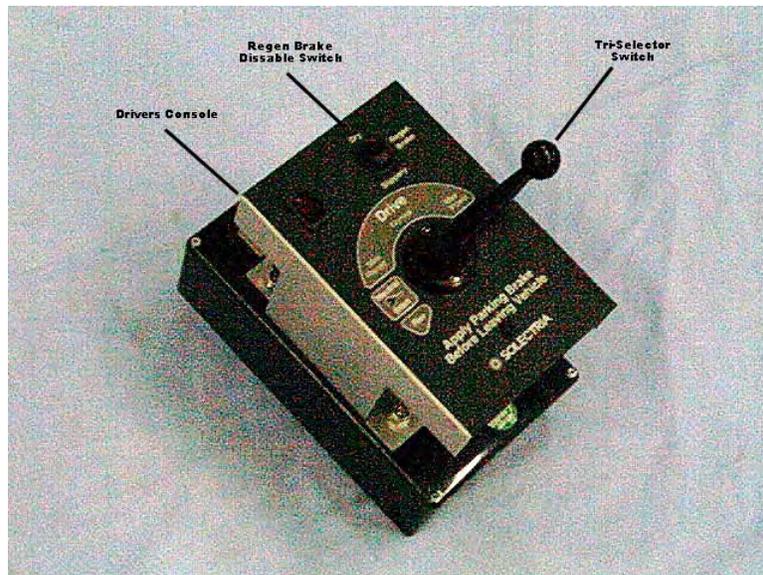


Ignition box

Your ignition or “interface” box should be located in a protected area such as underneath the dash of your vehicle. It should also be kept dry at all times. When all wires are attached and checked, connect the 25-pin cable from the ignition box to the UMOC. See appendix C for details.



ΔΔ Dual Drive Systems with Console



Connect and check all console wiring, then choose a good mounting location close to the operator's position such that the console controls may be reached comfortably by the operator. Avoid locations where any liquids spilled from a nearby drink-holder may enter the console. Also avoid areas near a window which might be left open to admit rain. After installation, connect the 25-pin cables, one to each UMOC motor controller.

◆ *Special Notes for Dual Drive Systems with Consoles*

▲▲Re: Cable Interaction

If you are operating a dual drive system and wish to test an individual UMOC / motor system separately, you must disconnect the 25-pin cable from the system not in use. Otherwise, if the disabled system is powered down or malfunctioning, this will affect the working system through interaction between the two units via the 25-pin cables. Operating the console with one system only will also affect pedal position response. For any pedal adjustments or repairs, be sure both 25-pin cables are connected. Connecting the 25-pin cables incorrectly can result in a "Pedal Error" message appearing on your computer screen. Vehicle operation can become unpredictable or stop altogether.

▲▲Re: 12-Volt Power for Console

Dual-drive systems will not function if 12-Volt power to the console is lost. If both drive systems operate with a test box, but neither drive operates with the console, check the 12-volt power input to the console and also the inline fuse(s).

Systems without proper UMOC or motor grounding will blow the fuse in the console in the following manner: If a 12-volt accessory is grounded to either the motor shell or UMOC case, and either the motor or the UMOC is not grounded to the vehicle frame, the only ground path for the 12 volt accessory will be through the ground of the 25-pin cable. To return to vehicle grounding, the ground current then flows through the console’s 12-volt return inline fuse. This fuse is not sized to carry large currents.

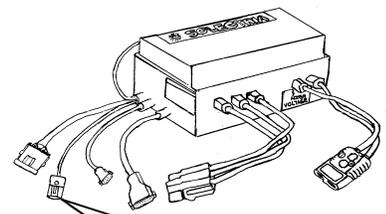
The condition described above is known as a ‘ground loop’. Ground loops must be avoided for reliable vehicle operation. The console circuit board will be damaged if the inline fuse is removed or replaced with a larger fuse. Instead, it is best to ground the drive system properly to prevent short circuits or poorly grounded accessories. Once you have made all of the connections necessary for operating your ignition box or driver console, you can now connect your system to the 12-volt power supply.

Connecting 12-Volt Power to Your UMOC

The signal that tells your UMOC to begin and cease operations is referred to as the **keyed 12 volts**. This 12-Volt signal, supplied when the ignition key of your vehicle is turned to the ‘on’ position, also serves as a 12-volt power source to your UMOC.

Cooling Fan 12-Volt Power

Power for the UMOC cooling fan motors is derived from the keyed 12-volt input. The keyed 12-volt circuit should be capable of supplying the maximum fan current anticipated. (See the fan current table in the “Specifications” section)



12-Volt Power Connector

CAUTION

Do not allow keyed 12-volt power to rise above 16 volts. Doing so may damage the cooling fans.

Voltage Range for 12-volt Power

The range for the keyed 12-volt power is 11-16 volts. At any voltage below 12.0, cooling fan power is reduced. For an additional charge, Solectria can supply UMOC's for vehicles with 24-volt electrical systems as a special order (except certain models - please contact the factory). This refers to the vehicle's lighting and auxiliary power circuit and *not* the main battery voltage of an electric vehicle.

CAUTION

Never connect any part of the main battery circuit to the vehicle frame or ground the main battery in any way. Doing so will damage the internal filters of the UMOC, and will blow an internal fuse.

◆ Important Note Regarding Keyed 12-Volt Power

The negative wire of many 12-volt vehicle accessories is often connected to the metallic vehicle frame. Conversely, many 12-volt accessories have the negative input wire connected to its own metal case. For this reason, never use a section of the main vehicle battery of an electric vehicle to supply 12 volts accessory power. This will unbalance the main battery, causing it to fail. In addition, it creates a hazardous condition. Be sure not to use the motor shell or UMOC case for a grounding point for other electrical accessories.

For example, your motor's cooling blower, motor negative return must be connected by a separate wire to your vehicle's frame or to a proper ground point. It also must not be connected to the motor case for a ground. If this should happen, blower motor current or short-circuit current can flow through the encoder cable ground conductor. This can damage the cable ground circuit or introduce noise into the encoder signal. The result will be a malfunction of the drive system. In all cases, 12-volt accessories must be grounded separately to a good vehicle ground, and not grounded to the drive system.

Brownouts

The circuit used to supply keyed 12-volts to the UMOC should be a clean, stable source of power. Large variations of voltage on the keyed 12-volts signal line will result in erratic operation of the UMOC as follows: If the keyed 12-volts signal drops below six volts, even for a very short period, the UMOC, sensing the instability, will shut down completely. After such an interruption, it will take approximately one second or more for the drive to come back online. This type of response is required in order to provide the fail-safe function.

Fail Safe Function

The keyed 12-volt signal provides the capability for rapid shutdown. In an emergency situation, driving signals to the motor may be completely interrupted by removing the keyed 12-volt signal. When the keyed 12-volt signal is present, all of the internal power supplies of your UMOC are operating. Power supplies shut down when the 12-volt signal is not present.

In this way, it is possible to safely remove all power and possibility of unwanted operation by removing the keyed 12-volt power from the 2-pin 12-volt power connector of your UMOC. To do this, either turn off the key, add an emergency-stop switch and/or other safety device to the keyed 12-volt power input line.

Optional, Internal DC-DC Converter

If vehicle-supplied 12-volt power is not available, the UMOC may be equipped with an internal 12-volt DC-DC converter as an option. The internal DC-DC converter is capable of supplying modest electrical loads to typical automotive accessories such as head lamps and radios.

It also supplies power to the UMOC cooling fans. Internal DC-DC converters are only available on UMOC models series 340 and 440.

The output current rating for the internal DC-DC converter is 28A at 12V or 14A at 24V. Internal DC-DC converters cannot be paralleled with external converters.

◆ **Note:** When using a UMOC with internal DC-DC converter, there is a small, standby battery current drain. The drain of a standard UMOC consists only of leakage currents that are essentially zero.

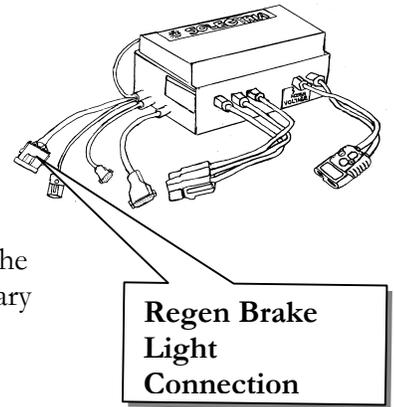
Connecting ‘Regen’ Brake Lights

It is very important the vehicle brake lights come on whenever the UMOC enters regenerative braking mode. The stop lamp signal is supplied via the UMOC’s 12-volt auxiliary connector. Regenerative or ‘regen’ braking, is capable of slowing the vehicle rapidly while returning energy to the battery. Unwanted kinetic energy is converted to electrical energy.

If desired, the UMOC features an additional 12-volt output circuit that may be programmed by special request. UMOC 12-volt auxiliary outputs are isolated “dry contact” type solid-state relays with a 4-amp continuous rating. Outputs are reverse-polarity protected. If connected in reverse, outputs remain “on” continuously as a diagnostic. Outputs must be fused with external 4-amp fuses.

Your UMOC accessory kit contains a forward/reverse selector switch that also features a dry contact output to supply power to the vehicle reverse lights. Current capacity is higher than the UMOC’s programmable light output. The forward/reverse selector switch contacts are rated at 10 amps.

To make contact between the 4-pin Packard connector from your dash and the other from your UMOC, simply push the two sides of the connector together until you hear the ‘click’ of the two halves locking into place.



Brake Light Direct Connection

For small lightweight vehicles using LED brake lights without large ballast resistors, or vehicles with small incandescent lamps, the brake light circuit may be connected directly to the brake light output of your UMOC. An external four-amp fuse must be included in the circuit. A smaller size fuse may be used. Do not use a fuse size larger than 4 amp, or connect loads larger than 4-amp.

Brake Light Relay Connection

For larger vehicles using several incandescent brake lights with a total current drain exceeding four amps, the brake lights are connected to external brake light relay, supplied by Solectria. The brake light relay then connects to the regen brake output of your UMOC. In all cases, the brake lights are connected such that the pressing the brake pedal activates the brake lights as well. (See Appendix D for the relay connection diagram)

Brake Light Fuses

Auxiliary circuit fuses are not located within the sealed UMOC case. This makes fuse replacement easier.. External, easily accessible fuses may be installed in a convenient location by the customer. To prevent damage to internal solid-state relays in the event of a short-circuit, fuse sizes for UMOC 12-volt output circuits must not exceed four-amps. For custom installations, Solectria can supply properly rated fuses, fuse holders, and fuse holder mounting boxes at competitive prices.

Testing Regen Brake Lights

It is very important to test the regen brake lights after installation. With someone following behind you, drive your vehicle up to 30 mph and then release the accelerator pedal. The brake lights should come on and remain on until the wheels come to a stop.

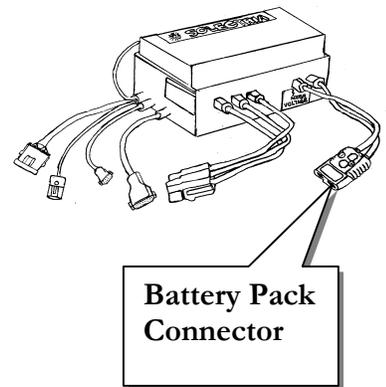
If the brake lights stay on all the time, even when the UMOC is off, reverse the two wires going to the regen brake light output circuit.

Connecting Your Battery Pack to Your UMOC

Once the motor connections have been made, you can now proceed to connect your battery pack to your UMOC unit. Follow all of the instructions regarding safety. Read all section text before attempting any of the procedures described.

Voltage Ratings

Units leaving the factory are programmed for a designated battery voltage. All units have both minimum and maximum voltage settings that can, within certain limits, be changed by the customer. Before changing any settings, consult the factory to review possible effects of changes.



To assure good operation during all states of charge and for good battery protection, battery voltage settings must match the actual battery pack in use. When the battery becomes depleted during operation, motor torque is limited by the UMOC's operating software to prevent battery damage. During charging, battery voltage may increase beyond the operating limits. This is permissible, as long as charging voltage does not exceed ratings.

Please refer to the table in the Specifications section.

Safety Precautions

There are important guidelines that must be followed when operating on or near batteries or any source of electricity. Read all of the following safety precautions before beginning work on your battery pack.

Use insulated tools and always give electricity the respect it deserves. High voltage battery packs *can kill*.

Use an approved face shield when making connections

When replacing a connector housing, *remove and re-insert only one pin at a time*. That way, the pins will not come in contact with each other.

Never connect any terminals of a battery to the vehicle frame, as is commonly done with 12-volt vehicle power.

All exposed metal surfaces carrying battery current such as fuses, terminals, shunts, switches and the like should be placed beneath a protective cover or inside an insulated box.

All battery wiring components mentioned directly above must be properly sized and rated to safely carry the maximum current that will flow through them.

Bare metal surfaces carrying opposite polarity DC battery current (positive and negative) inside fuse and connection boxes must be separated as much as possible to avoid mutual contact by metal tools or

other parts. We recommend a minimum of six inches.

Never use a bare metal plate for a battery box cover. The vehicle could roll in an accident and the battery terminals fall against the cover. An insulating sheet of 94V-0, G-10 fiberglass of 0.060 thickness is ideal for this purpose.

Battery connectors must be located where they will not come in contact with water or fine spray mists of road salt, and where the connectors are free to drain and dry quickly if they do get wet. Important: Battery connectors must not sit on a horizontal surface where they could remain wet.

Battery cables must be of an appropriate voltage rating, should not run near sharp edges, and should be attached every 6 to 8 inches to an insulated surface.

Battery wires must be *individually* covered with protective wire loom and must remain separated from each other by 4 to 6 inches wherever possible to prevent conditions that might sustain an electric arc. Arcs can be initiated by water and salt entering the battery plugs, or by physical damage from a road accident.

Check voltmeter for proper range and lead connection before touching test probes to battery pack or connectors. (If the voltmeter is set to a current range, or the test leads are plugged into the current inputs, this will blow a fuse or damage the voltmeter. This may cause personal injury.)

Work with one hand behind the back when making connections. This greatly reduces the chance of heart failure caused by an electric current flowing through the chest area.

Workers should be trained in CPR and correct response procedures regarding electrical shock.

Never open your UMOC. Residual stored energy may exist for several hours after disconnection from the battery.

◆Note: New product warranty coverage does not apply to units that have been opened.

Do not touch the metal terminals of the UMOC battery plug.

Do not allow children to handle the DC battery connector plugs of electric vehicles. As long as battery plugs remain connected, there is little or no danger. Unplugging the connectors exposes the holes containing the live contacts down inside the plugs.

Keep fingers away from internal contacts when working on battery plugs.

When working on high-voltage systems, never work alone.

Battery Capacity

For good system performance, battery capacity must be at least one-fourth the maximum battery current. This is a good rule-of-thumb and is derived from limits to battery voltage swing due to discharge and regeneration current demands from the drive system. Information is based on commonly available sealed lead acid battery types.

For example; using the information in table 1, a UMOG 840 requiring a maximum of 500 Amps battery current, should be used with a battery rated for no less than 125 Ampere-hours. For **hybrid vehicles** using both a battery and another source of power, subtract the continuous current rating of the other device. Again, using table 1, if the other source can supply 100 Amps continuous, this reduces the maximum battery current needed to 400 Amps. Only a 100 Ampere-hour battery is then required.

Battery Voltages

The **maximum** battery voltage parameter sets the level to which battery voltage will rise during regeneration. The **minimum** battery voltage parameter sets the level to which a battery may become depleted during operation, until operation is not possible. The trade-off is range and battery life. If the settings are too close together, vehicle range is reduced and battery life is extended. This refers to battery life measured in months, years, or hundreds of cycles. If the settings are too far apart, range will be good, but the batteries may be destroyed in a short time.

Battery voltage parameters must be set to conform with battery manufacturer requirements.

Types of Batteries:

Battery voltage settings differ depending on how many cells are in the battery, and which type of battery chemistry is

CAUTION

For belt drive systems, motor current is limited to prevent damage to belts. Exceeding the recommended maximum motor current will result in rapid belt wear or failure.

CAUTION

For motors with integral gear box, increasing motor current above the factory setting or recommended limit voids the gear box warranty and may damage the gear box.

being used. Battery type and size also determine the maximum battery currents allowable.

Both maximum battery current and maximum regeneration current may be adjusted using the parameter screen. (See appendix E) For some battery types including lead-acid, reducing the maximum battery current will increase the vehicle range at the expense of acceleration. This is the function of the Tri-Power selector or power saver (when equipped).

◆ **Note:** Regeneration *battery* current effects the strength of regeneration mostly at higher rpm.

Motor currents:

◆ **Note:** Regeneration *motor* current effects the strength of regeneration mostly at low rpm.

Both available torque and motor heating can be controlled by adjusting the maximum motor current. It's a good idea not to increase the maximum motor current above the setting supplied by the factory. This will result in rapid heating of the motor and possible loss of vehicle performance at high motor temperatures.

Please note all cautions and remember that motor damage caused by overheating is not covered under warranty. In some cases, it is possible to reduce motor heating considerably, without affecting vehicle performance, by reducing the maximum motor current.

Checking UMOC/Battery Polarity

Your UMOC is protected against reverse polarity. Use a voltmeter and check **all** battery and connector polarities before connecting your UMOC, or any other device, to your battery. Be sure to follow all safety procedures. Damage caused by reverse polarity is not covered under the new product warranty.

Measuring Battery Voltages

Before connecting the battery for the first time, measure each battery to determine its individual voltage and keep note of individual readings. Measure the total voltage.

Add the individual voltages using a calculator. If the readings don't add up, check for one or more batteries connected in reverse.

Any battery modules left connected in reverse will be destroyed once the vehicle is driven for a short time. Do not skip this step.

When finished connecting batteries, re-check all connections for tightness. Loose connections will overheat quickly and may damage batteries or interconnects.

Battery Fusing

Battery packs **must** be fused with fast-acting fuses rated for the DC battery voltage and current from the table. These protect the system from inadvertent short circuits of a fully charged battery. Because a depleted battery may not produce sufficient short-circuit current to open the fuse, do not use a current rating higher than in the table. AC-rated fuses cannot break a DC arc under some conditions. Battery fuses for use with UMOC motor controllers are available from Solectria at competitive prices.

Battery Interconnects

Battery interconnects must be rated to carry the current listed in the table 1. Use the following guidelines when working with battery interconnects.

Note: Always clean battery terminals before installing.

For lead battery terminals, use a wire brush and No-Ox[®] grease and brush them until they shine. No-Ox grease will prevent oxidation after the terminals are brushed, and will not interfere with electrical conductivity.

CAUTION

Avoid fuses with only an AC and not a DC rating

WARNING

The bolts of all cables carrying battery current must be torque tightened to the battery manufacturers specifications. Failure to do so can result in the catastrophic failure of your system. Also, be sure to use lock-washers at all such connections.

Nye ® Grease may also be used. For terminal types other than lead, follow the directions of the manufacturer. If battery terminals are not cleaned prior to installation, the oxide and any dirt on the surface will prevent a good connection. Heating will result, followed by more oxidation. The terminal will then overheat and damage the battery.

Battery interconnect lugs must lie flat against the terminal.

Do not **file or wire-brush battery interconnect lugs.**

Do not **use washers in between the interconnect lugs and the terminal.**

Use stainless steel bolts only. Brass or copper bolts are too soft.

Follow safety procedures and reserve one interconnect* until after all wiring is completed and all polarities are checked.

- When wiring new or replacement battery packs from individual modules, omit one interconnect from the centermost battery in the string. This way, the maximum available voltage present during any assembly accidents will be halved.

Placement of Current Shunts

If you are using a current shunt, place it in the negative battery connection. This assures correct function of Solectria plug-and-play accessories. Solectria components, such as amp-hour counters, can be damaged if you install the current shunt in the battery positive connection.

Handling Battery Connector Tips

The battery (and motor) connectors are silver-plated for excellent conductivity, long life and to reduce the effects of oxidation. ***Never file or wire-brush the connector tips.*** This will remove the silver plating and give an inferior connection, prone to oxidation and heating.

Soldering Battery Connections

If battery connections cannot be crimped properly, then they should be soldered.

Avoid getting any flux or solder on the pin-mating surface or the reverse side of the pin tip where it locks into the housing. If this should happen, heat the pin until the solder melts, then wipe it clean with a wet sponge. Do not allow solder residues of any kind to remain on the mating surfaces.

◆Note Re: Battery Voltages and Plugs

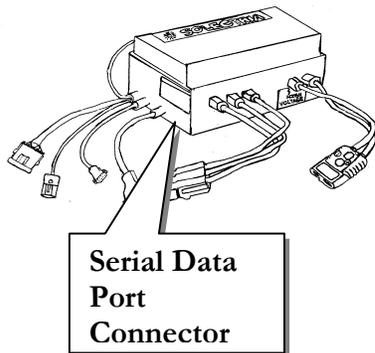
If external capacitors are being used, the system must allow for allow five minutes to pass between the capacitor opening and closing again.

Units supplied with gray plastic battery connectors can be safely exposed to battery voltages as high as 400 volts. Units supplied with orange battery connectors must not be exposed to input voltages higher than 200 volts. Always check the nameplate to determine the voltage rating of a particular unit. On the top of the UMOC is a Solectria logo sticker. The absolute maximum voltage rating can be determined by the color of the sticker.

Table 4. UMOG Voltage

Sticker Color (background)	Logo Color (foreground)	maximum voltage
teal	white	400
black	white	300
white	red	250
red	white	200

Serial Data Port



The serial data port is used for communication between the UMOG and a personal computer that uses Windows, Macintosh or DOS operating systems.

A 9-pin shielded straight-through cable can be connected and run to the passenger compartment of the vehicle. The cable can be left connected for the monitoring or logging of data. It is also possible to fine-tune the settings of your UMOG while driving, using a laptop computer connected to the serial data port

Serial Data Port Protector Cap

The serial data port connector is protected from dirt and moisture by a red plastic cap. Always replace the cap when the serial port is not in use to prevent electrostatic discharge (ESD), dirt, or dust from entering the serial port. Additional caps are available from Solectria, (part # DB 9-F dust cap), or from Radio Shack.

Cable Types

When connecting to the serial port, you must use a straight-through cable. **Do not use a null-modem cable.** *Null-modem* cables have internal connections that may be harmful to the unit and no data will be received. If in doubt, test the cable with an ohmmeter before using. Each pin, on one end of the cable, should connect (have continuity) to the same-numbered pin on the opposite end of the cable. Only certain early model UMOC's that have a white-colored data connector require a null-modem adapter or null-modem cable.

Shielding Serial Port Cable

While not absolutely necessary, the serial port cable should be shielded with an internal metal foil or braid. All good-quality computer serial cables are shielded. Do not use homemade cables. Operating the unit with an unshielded cable will introduce noise into the serial port connection, may cause data errors, poor performance and unpredictable response.

Warning Regarding Grounding the Serial Port Cable

When installing and testing a new system for the first time, it is best to use a portable computer running off battery power. **Do not** ground the cable at the UMOC.

The metal jackscrews on your UMOC's case are grounded to the case. It is a good idea to **use a cable with a plastic plug, or remove the jackscrews from the plug if operating a computer from AC mains power.**

Your UMOC's serial port is optically isolated from the unit. Grounding the serial cable to the UMOC jackscrews will defeat this isolation.

Any fault current (from a malfunctioning battery charger or other device) flowing to the vehicle frame will then flow through the serial cable and through the computer, to ground. **This may damage the computer's ground system.**

CAUTION

Do not use a null-modem cable for your Solectria data port connection.

RS-232 Communications Interface

RS-232 is a standard communication protocol and is compatible with a variety of computer-based devices. Only one computer can be connected to the RS-232 at a time.

ΔΔ For dual-drive systems, the same computer may communicate with both drives. This requires two separate cables from the computer and two serial ports.

ΔΔ As an easier solution for connecting to dual-drive systems is to swap the serial cable from one drive to another, as needed.

Communications Software

For Windows-based computers, the built-in communications software “HyperTerminal” may be used. For instructions on how to use HyperTerminal, consult your Windows documentation, or see Appendix E.

RS-485 Interface Connection

The RS-485 interface is no longer supported due to very low customer demand. Please contact the factory for information on customizing your data interface for high-volume sales applications, if RS-485 or other data interface is needed.

CAUTION

Do not use any motor type which differs from the one listed on the nameplate unless you have received prior authorization from Solectria.

Swapping your UMOC for a Replacement Unit

If a UMOC malfunctions, the factory will ship a pre-programmed matching unit for direct replacement. Installation is as simple as bolting the unit down and connecting the power and sensor plugs.

Use the following procedures to check the parameters of your existing UMOC, so that they can be compared to those of your replacement unit before installing. After installation, you can either download the saved parameters from your older unit, or go ahead and operate your system if the parameters of the newer unit already match. If this is a first time installation, go to the section titled “Mounting Your UMOC” in the “Installation” section of this manual.

Checking Software Parameters

1. Connect a computer to the serial data port of the unit you are replacing.
2. Be sure you are swapping out a like unit model or one that is compatible with your drive system. The UMOC’s model number and recommended motor type for operation are found on the unit’s nameplate. In some cases it will not be possible to use a UMOC with a different type motor unless the unit is first returned to the factory for modification.
3. Use the directions given in appendix E to hook-up your computer to your unit and find the necessary information.
4. Write down the “build date” listed on the computer screen’s banner line. (The build date refers to the release date of the software, not to the date on which the unit was physically built).

ΔΔ The replacement unit should have the same build date if it is a dual-drive system.

ΔΔ Dual-drive systems should not be operated with different software versions (different banner build dates). Premature wear of drive system components may result.

CAUTION

Once the unit is removed from the vehicle and disconnected from the battery, it will be impossible to read the software settings.

ΔΔ For dual-drive systems, model, software version (build dates), and parameter settings (or configuration number) must match, otherwise the units will not share well. Two like units with matching build dates and configuration numbers will give ideal performance.

For all other systems, a matching date is preferred but not required.

Note: Units built after March 31, 1999 clearly state the software version number in the banner line.

Copying Parameters

For two UMOC's with the same version software, saved settings from one of the older units can be transferred to the replacement unit. Follow the instructions in Appendix B and save a copy of the older unit's parameter screen settings to your computer *before* installing the replacement unit.

Print a copy of the saved settings. This way, if the computer file is lost, it can still be possible to configure the unit properly using the printed information.

Comparing Parameter Files

Compare the file you have just created to your paper printout of the older unit's settings. Check each parameter to make sure there's an exact match. Make sure the parameters are numbered the same for each file. Once you are certain the two files are the same, the auto programming files (see appendix E) can be used to program one or more UMOCs.

Saving and Rebooting

If everything goes as planned, and auto programming is successful, be sure to save the new parameter values by writing to the memory. The procedure for writing values to long-term memory is covered in appendix E.

Checking Drive System Performance

It is a good idea to test drive the vehicle after downloading new parameters. Once you are satisfied with your vehicle's operation, save the new parameters to long-term memory. Save the current settings to disk and write down the configuration number of your unit.

Systems Check

Cable Adapters

UMOCs with model serial numbers in the low 100's require a null-modem adapter when installing the serial port cable, depending on the *color* of the data port connector. Use an insulated adapter, if possible, and proceed as follows:

Before connecting the serial port cable, note the color of the plastic connector body on your UMOC's case. If the color is black, connect the cable directly. If the plug color is white, a null-modem adapter or null-modem cable must be used; otherwise no data will be received.

Black plugs are currently being used in production. Therefore, no null-modem adapter is needed.

On-Charge Voltage

CAUTION

Never attempt to operate the motor drive while the battery is being charged

When a vehicle is on charge, the battery voltage naturally goes up. This is true for most batteries. Motor controllers are set at the factory to operate over the range of voltages normally expected, including voltages experienced immediately after charging. However, battery voltage while in the process of charging may exceed the maximum voltage allowed during operation. This aspect should be a consideration during system design, not fault diagnosis.

Never attempt to operate the motor drive while the battery is being charged. The charger disable circuit is provided for this reason. It protects the motor control from being exposed to voltages which are dangerously high. Some implementations may present excess battery voltage immediately after charging.

The microprocessor, reading data from the internal precision voltmeter, will respond by reducing motor current under the circumstances until the voltage falls within the operating range, protecting the controller from damage.

Measuring Battery Voltage

After connecting the UMOC main battery plug, carefully measure the battery voltage using a voltmeter. To do this, it is often possible to insert the voltmeter test probes into the back of the battery connector.

If uncertain of proper procedure, skip this step. Once you have established communication with your UMOC, you can read battery voltage by looking at the user data screen on your computer.

Turning on Your “Keyed” 12-Volts Systems

The term “Keyed” 12-volts refers to the current that powers your 12-volt accessories, and is started by turning your vehicle’s ignition to the “ON” position.

Make sure that your ignition switch is in the ‘OFF’ position. Before turning on the keyed 12-volts, have either your test box and laptop (or other computer) connected and in an observable position, or have the battery level indicator and / or status lights (if equipped) within view if a computer is not available.

WARNING

Hazardous voltages are present inside the main battery plug.

Observing Your Vehicles' Diagnostics

Diagnostic tests require about 2 seconds, and may be observed by the operator via your vehicles LED read out lights, dash systems or your test box. When your keyed 12-volts system is first switched on, the UMOC will power-up and begin diagnostic tests. When all tests are completed, motor drive operation can begin.

Familiarizing yourself with these outward signs and signals will make diagnosis easy should a problem develop later.

◆ **Note:** For units shipped before June 30, 1998, observable diagnostics may differ slightly.



Figure 3: Photo of test box

Connecting a Test Box

Test Box Status light and Battery Indicators

◆ **Note:** Some customer units do not have battery indicators, or, have only a red “battery low” light, and not a green “battery full” light.

WARNING

If a test box is to be used, drive wheels must be jacked up off the floor. Observe all safety precautions.

WARNING

Never use a test box to operate a vehicle. Using the test box defeats important safety features which are for your protection.

WARNING

Do not connect a test box if the drive wheels are touching the ground. The drive may start suddenly and unexpectedly, depending on test box switch settings.

WARNING

Do not free-spin any motor and drive train system faster than the top speed of the vehicle.

The **status** light on the test box, normally colored yellow, comes on at the following times:

During the self-test

After a malfunction

Before the error detection circuitry is reset by the operating system.

The battery indicator lights, low and high (or “full”), come on during the self-test and remain on during the first part of the pre-charge delay. If a power bus malfunction has occurred, such as a capacitor or IGBT failure that prevents completion of pre-charge, “high” and “low” lights will both remain on. Nearing the end of pre-charge when internal voltages are within the range of normal operation, and at all other times, only one (or neither) will light.

The purpose of the test box is to troubleshoot a malfunction or verify operation of a new drive. Please follow all directions for the use of your test box closely and read all warnings before connecting and operating.

Test Box Switch Settings

Before connecting your test box

- Place all switches in the off position

Be sure the drive wheels are free to rotate

Connect your test box to the 25-pin cable

◆ **Note:** Do not use a test box to spin a brush-less DC motor unless the vehicle drive train is connected. The drive train components provide an inertial braking action that will prevent the motor from over-speeding. If a brush-less DC motor is operated without a load, test box settings may cause a sudden increase in rpm at top speed, which can destroy the motor. Damage of this type is not covered under warranty.

Sequence of Power-Up

Connect the battery plug on the UMOC to the battery pack plug.

Include an appropriately-sized fuse in the battery circuit.

Power on Self-Test:

When ready, turn the key on. Self-test will begin. You may observe the following:

- ***Fan Power Cycle***

Cooling fans will spin very briefly.

◆ **Note:** with some brands of fans, the fans will not spin during self-test every time.

- ***Brake Lights Cycle***

The regen brake lights will come on briefly and then go out.

- ***Tests complete***

After about 1 second, the status light, fans, and brake lights will turn off. The “banner” (line of text giving model number, software version and drive configuration) will appear on the laptop screen (if connected).

- ***Capacitors Pre-Charge is Complete***

After the capacitors pre-charge delay, or if the unit has been connected to the battery long enough, the battery high and low indicators (when equipped) will go out. If the battery has been recently fully charged, the “battery full” indicator light (when equipped) may remain lighted.

CAUTION

Drive wheels must be safely off the ground unless you are seated in the operator's position and have made all preparations for vehicle motion to take place. Before driving a newly designed vehicle for the first time, it is best to test the drive system with the drive wheels jacked up.

Closing the UMOC's Contactor

When pre-charge is complete, the main contactor can be closed to begin operation. The contact will close when the voltage reading on the user data screen (Battery Voltage or Batt V) increases to within 3 to 5 volts of the actual battery voltage. In your vehicle, shift to "Neutral" or "Off" to enable the contact.

If you are using a test box, turning the power switch to "On" will close the contact.

◆ **Note:** Units built after December 31, 1998 require the direction selector switch to be in "Neutral" or "Off" before the contact will close.

If Contact Does Not Close

Please check the following before assuming that there has been an internal malfunction of your UMOC.

Pre-charge: **the capacitors have not been given time to charge**

Neutral interlock: : **the direction handle is in "forward" or "reverse"**

Charger is on: **(the contactor won't operate if the charger is connected to AC power)**

25-pin "driver" cable: **cable has become loose or disconnected**

Keyed 12 volts: **the keyed 12 volts is not on, or fuse is bad**

Keyed 12 volts: **no 12 volts at ignition box or console**

Power switch:: **the test box switch is not on (when using a test box).**

Voltage bus error **(The battery voltage is too high or too low to allow operation).**

Motor Spin Test

After the contact closes, try spinning the motor. Lift the drive wheels off the ground and make sure that your vehicle is safely supported. Using the selector switch, choose “forward” or “reverse.” Depress the accelerator pedal slowly, more and more until the motor starts to spin. ***You will need to press it more than halfway.***

Shaft Direction

Occasionally, due to transmission and differential gearing, drive wheels will turn backward when the selector lever is in “forward.” This is no cause for alarm. Shaft direction is easily reversed (Through software. See your warranty or call Solectria for details regarding the changing of your parameters) in the user parameter screen and can be changed at any time (see Appendix E). Never attempt to change shaft direction by connecting motor wires (phases) in a different order. The result will be no operation.

ΔΔ Direction Labels for Opposed-Motor Dual Drives

For opposed dual-drive systems, pairs of units are shipped from the factory configured as one clockwise and one counterclockwise. Units are labeled accordingly with stickers. The stickers are an aid to installation only. In any case, the stickers should be removed at the time of installation. If the units have been exchanged by mistake, they can be moved.

Encoder test

When testing new installations, if the motor does not spin, or spins very slowly, place the unit in neutral and turn off the switches on the test box (if used). Following safety precautions, spin the motor shaft or drive wheel by hand. If turning a drive wheel by hand, make sure *only one* wheel turns (block the other wheel if needed). You should see the rpm reading change and be displayed on the user data screen (left column). If the rpm remains always at zero, check the encoder connections.

CAUTION

Do not spin your motor more than 2,000 RPM without the motor being under load. Damage to the rotor may result.

CAUTION

Loose hair or clothing can become entangled in rotating parts. Also, be sure to keep control cables away from rotating parts or driveshafts. Drive shaft parts can snag on loose cables, causing severe damage.

Phasing

If the motor shaft will not spin, but “wiggles” or turns very slowly, exchange any two of the motor wires (not the controller wires). This method applies to induction motors only. The need to do this is extremely rare, except for motors that have been customer-replaced or worked on. Complete drive systems are always shipped from the factory with correct phasing, because they are tested for operation before shipment.

Monitoring the User Data Screen While Driving

If a problem occurs while driving, enlist the services of a helper who can watch the screen while you drive. If a helper is not available, and the drive system shuts down, use the following procedure:

If the drive system shuts down while holding the accelerator down, continue to press the accelerator to the floor without releasing it. If operation doesn't resume, keep your foot to the floor and shift into neutral or off. Carefully pull over to the side of the road, braking with the left foot.

Apply the hazard warning lamps and parking brake. After determining that you are in a safe location, study the user data screen. As long as you hold the accelerator down, fault codes will be saved. This is an easy way to diagnose a problem quickly.

Be sure to choose a lightly traveled road where it is safe to pull over. If this procedure is inconvenient, see the “data logging” section below.

ΔΔ Testing Dual Drive Systems

For dual drive systems, it is very important to test the operation of each drive separately before testing them together. If both drive systems operate perfectly alone, but not together, it is possible to monitor both user data screens at the same time. This occurrence is rare, and a problem with the control console should be suspected.

ΔΔDual cables

The minimum requirement for monitoring two drives at once is to have two serial cables. Plug in the cable of the drive you wish to monitor into the laptop.

Important: Reboot (restart) the UMOC microprocessor by pressing Shift-B before disconnecting the cable. This way, noise pulses generated when this connecting the cable will not send an arbitrary command to the UMOC.

ΔΔDual Serial Ports

It's much better to have two serial ports on the laptop. Connect one drive cable to each port.

ΔΔDual Windows

It's possible to open two windows of your communications software and configure one window for each serial port. You can then see and log data from both drives at the same time.

Data Logging

If you have trouble giving the user data screen your full attention, you may also log serial data to a capture file. Configure your communications software to capture the text coming from the serial port. Because of restrictions related to file size, you may want to limit capture time to 15 or 20 minutes due to the high data rate.

File sizes will grow to several megabytes. If you need to save your capture files to a floppy disk, compression software is very effective. Capture files can be compressed by a factor of 10 or more.

Emailed files that are sent to Solectria must be no more than two megabytes in size and compressed into a zip file.

Test Drive

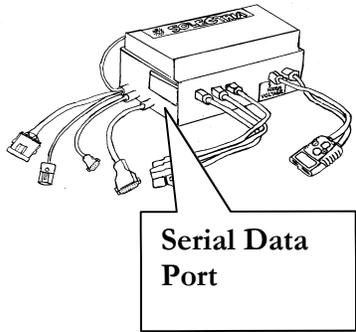
It's best to do the initial driving tests with a laptop computer connected to the serial data port, especially on a first-of-a-kind platform.

Connecting Your Computer to Your UMOC

Checking Cable/Loop-Back Test

If you know your communications software is working properly, you can test your serial port and cable using the following method

1. Unplug the serial cable from the UMOC, leaving the serial cable connected to the computer.
2. Look at the free end of the cable you just disconnected. You should see very small numbers inside the plug, identifying the pin numbers.
3. Connect a small jumper wire between pin numbers two and three of the serial cable connected to the computer.
4. Try typing a few letters on the keyboard. Each letter you type should appear on your computer screen. If not, your cable is bad, or there is a problem with the serial port at your computer.
5. Make sure the software is configured to use the correct serial port. Many computers have more than one serial port. Keep experimenting using this method, or try a different computer until you get things working.



◆ **Note:** This method will work for either a straight-through or null-modem cable.

Software Settings

It won't be possible to see the banner line, or communicate with the UMOG unless the communication settings are correct. See Appendix E.

Adjust the communications software to the following settings: 38400, N, 8,1 or 38400, 8, N, 1.

The User Data Screen

After the banner line appears on your computer screen, press the "Enter" key on your laptop. The user data screen will appear. Some units require a password to see the user data screen. Press "Enter" to clear the password buffer, then enter the password. Make sure "CAPS LOCK" is off. Your password must be entered exactly. If there is no response, try again.

The Parameter Screen

If the unit operates, but feels weak or performs poorly in some other respect, check the parameter screen to make sure the settings are correct. Solectria keeps records of parameter settings for each unit that leaves the factory. Also, there are many standard configurations. (See appendix E) Remember, changing your parameters can void your warranty; call Solectria's Customer Service Department for details.

The parameter screen lists the settings that can be changed by the user. To change a parameter, type the number of the parameter you wish to change, and press the enter key. You will be prompted at the bottom of the screen to enter a new value.

There are limits to the numbers you can enter. If the number you enter is outside of the limits, you will be prompted again. After entering the number, the parameter list will reappear with the new value listed. Parameters may be changed while driving. This is a good way to fine-tune a drive system. All Solectria UMOC's are set to a standard configuration. What remains is to confirm that the configuration number of your unit matches the application. Changing any parameters will change your configuration number to 0, and will void your warranty.

If you do not know your configuration number, or if you want to change your parameters, you may call the Solectria Customer Service Department. Pre-approved parameter configurations are available for auto downloading. Have your serial number in hand before calling.

◆Special Note Regarding “Configuration Number Equals Zero”

A unit where the configuration number equals zero is a custom configuration.

One-of-a-kind units are often shipped with a unique parameter set not corresponding to any current standard configuration. The drive parameters are carefully set manually and recorded to a log file for as-built records.

◆**Note:** If the customer changes any of the UMOC's parameters, the configuration number is automatically set to zero at that time. Once changes are saved to long-term memory, it will not be possible to re-establish the configuration number, even if the parameters are changed back to their original values. This is done to prevent the occurrence of standard configurations with any incorrect parameters and can affect your warranty.

The only way to re-establish the configuration number is to auto-download a standard parameter file. See Appendix E.

Changing Your Parameters

Small, gradual changes are better than large changes. Some parameters may interact slightly. It is a good idea to write down “before” and “after” values when changing or fine-tuning parameters. Many parameters are set at the factory to their ideal values, and any departure will result in reduced performance.

◆ **Note** that the changes you make will disappear once the power is turned off. To make the changes permanent, it is necessary to write long-term memory. (See Appendix E) Remember the following when changing your UMOC’s parameters:

Once you write long-term memory, previous settings are lost.

Setting incorrect parameters results in poor performance or erratic operation.

Incorrect parameter settings may damage batteries, motors, or the unit itself. This will affect your warranty.

Incorrect setting of brake light current may result in a vehicle accident.

ΔΔ Pedal settings affect load sharing on dual-drive systems and therefore must be the same on both UMOCs.

Choosing Parameters:

The Solectria Customer Service Department is willing to provide assistance with setting drive parameters to their proper values. Additionally, all drive systems are configured and tested at the factory. It is not necessary to change any parameter settings in order to bring up a new installation. All Solectria complete drive systems are delivered for plug and play operation.

CAUTION

If command processing proceeds in a way other than expected and the “caps lock” indicator is illuminated, switch off or reboot the UMOC at once. Do not write the long-term memory. Doing so may reconfigure the unit. Switch off the power for 30 seconds, then power up the unit and check the configuration and settings before driving the vehicle. Be sure “caps lock” is not activated on the computer.

Passwords

Units that were shipped from the factory with a password use the following password: **stdUMoC**. You must enter the capitalization correctly, and CAPS LOCK must be off. Note: it is very important never to use the caps lock feature when communicating with a UMOC motor controller. Units shipped with version 1.6 software and later do not require a password, however the user may add a custom password if desired.

◆ *Special Note Regarding “Caps Lock”*

Correct operation will no longer be possible if the default parameters have accidentally been written to long-term memory. This will happen if “Caps Lock” is on and “P” is pressed to bring up the parameter screen, then “W” is pressed *at any time* subsequently, until the unit is shut off or “B” is pressed.

Customer units with “user data screen” function shipped after June 30, 1998 are not subject to this restriction.

Viewing the User Data Screen

Use the following procedures to view the user data screen on your computer.

1. Prepare the laptop with the communication software.
2. Connect the serial cable to the serial data port on the side of the UMOC. The UMOC must be connected to battery voltage using the large battery connector on the side of the UMOC.
3. Bring up the communication software on the computer.
4. Turn on the ignition key of the vehicle or supply 12-volts to the 2-pin, 12-volt connector of your UMOC.

5. When you see the **banner line**, press the **enter** key once or twice to clear the password buffer (see note directly below).
 6. Enter the password. The user data screen will appear. If it doesn't, check your communication settings. The password may have been changed by another user. If the password is lost or forgotten, it can be re-programmed by returning the unit for service, or contacting Customer Service for password-changing software.
- ◆ More recent units only require pressing the "Enter" key on the computer to display the user data screen, and do not require a password.

◆ *Special Note Regarding Passwords*

If the user password is changed for any reason and is then lost or forgotten, it may be necessary to return the unit to Solectria for reprogramming. Contact the Customer Service Department for details.

Diagnosing Faults by Looking at the User-Data Screen

As mentioned, the user data screen provides a wealth of information for troubleshooting purposes. If a drive system malfunctions, a laptop should be connected and the user data screen consulted to find the source of the malfunction. Because a computer screen is only capable of displaying 80 columns by 25 rows of text, the information has been abbreviated. Please refer to the user data screen examples in Appendix E for explanation of all abbreviations. The first step to fault diagnosis is to connect the computer, and begin communicating with the unit. (See the section titled "Connecting Your Computer to Your UMOC").

Power

Acceleration should be brisk for a properly sized system. Try the different settings of the Tri-Power Selector (if equipped).

Smoothness

Vehicle operation should be free of shuddering, bucking, and other instabilities. Instabilities can result from a number of problems, including incorrect parameter settings. See the section entitled “miscellaneous problems” under “Fault diagnosis”.

Regeneration Disable

◆ **Note:** All vehicles must be equipped with a regeneration disable switch. During periods of ice, snow, or heavy rain, regeneration (or “regen”) should be shut off.

Test the operation of regen to familiarize yourself with its effect. For units built prior to January 1, 1999, regen may be less noticeable at high speeds.

WARNING

Regen braking, like regular braking, can cause wheels to skid if applied too strongly. This can lead to loss of vehicle control.

Speedometer Calibration

For vehicles equipped with the electronic speedometer option, test the speedometer and calibrate it using the parameter screen and a vehicle dynamometer or “measured mile.” You can call Solectrias’ Customer Service Department for more details.

Motor Over-Heating

While test driving, be alert to high motor and UMOG temperatures as displayed under “Limits to Torque” on the user data screen. An overheated motor will result in loss of power, especially after going down hills or slowing down with regen on expressway off-ramps. Be aware that any time the screen shows a limit due to motor temperature, available acceleration may be quite low. If this happens, try to improve motor cooling or reduce the motor current setting slightly until the problem diminishes.

No Communications

Each time the unit is turned on, it sends information to the serial port. These include **model number**, **build date**, and **configuration number**. This is called the **banner line**. If you do not see the banner when switching on the unit, either the unit is not communicating, or there's a problem with your communications software, serial data port, or cable. See appendix E.

Data Logging

If you have trouble giving the user data screen your full attention, you may also log serial data to a capture file. Call Solectria for more information regarding how to create a capture file.

Checking Cooling Fan Operation

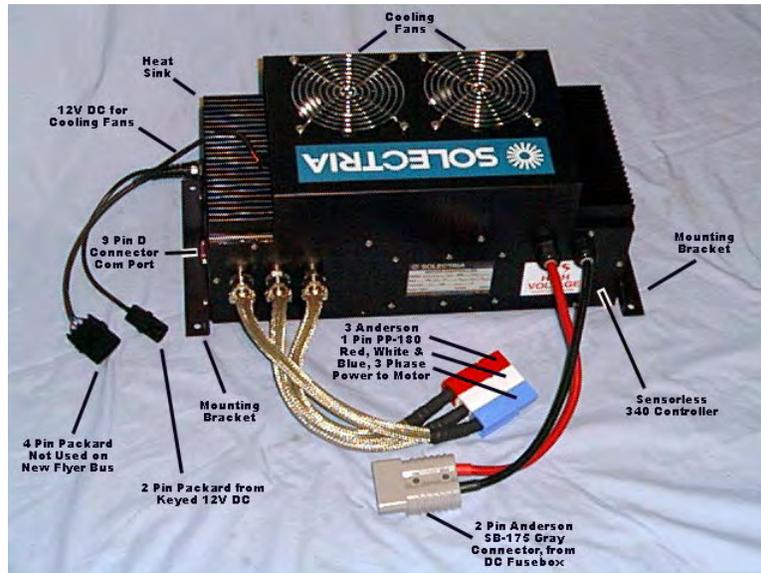


Figure 4: UMOC Cooling Fans

Drive the vehicle for a few minutes or operate the unit until the user data screen shows a heat-sink temperature of 31 degrees Celsius or more. The cooling fans should be on.. Replace defective fans promptly. Operating the unit with one or more dead fans will stress the unit and should be avoided. Replacement fans are available from Solectria.

When checking the cooling fans, or if high heat-sink temperatures (+50° to +60° Celsius) have been noted, check ductwork and installation to make certain the UMOC cooling fans are not drawing in hot exhaust air from the UMOC heat-sink air outlets.

Fan motors operated at these temperatures have demonstrated a life expectancy of only about one year. UMOCs use ball-bearing industrial grade fans. Fans operated at normal ambient temperatures of +30° Celsius and below should last the life of the vehicle.

Fault Diagnosis

Fans Not Running

To conserve energy and fan life, the fans stop running whenever heat-sink temperature is below 30° C. If the unit appears to be dead and the fans are not running, make the following three checks:

Battery Voltage

Verify that battery voltage is present at the battery connector.

12-Volt Power

Verify that 12-volt power is present at the 2-pin, 12-Volt connector using the procedures directly below.

Disconnect the two-pin connector for the keyed 12 volts at the UMOC, and

Connect a test light to the *vehicle side* of the cable.

Turn on the ignition key. The test light will come on if 12-Volts is present at the connector. (A voltmeter is not a good choice for this job. It does not present a load to the keyed 12-Volt circuit. A small leakage current will cause the voltmeter to indicate 12 volts when in reality, there may not be enough current available to operate the motor controller.)

Use the same technique to also test the 12-Volt power supplied to the ignition box or console.

Using the fan assembly to test the keyed 12 volt power:

If a 12-Volt load or test light is not available, the keyed 12 Volts cable can be plugged into the fans to do a test. Carefully disconnect the fan power connector on the side of the fan housing (most models) and plug the keyed 12-Volt supply directly into the socket on the fan housing. Turn on the ignition key. If the fans run, 12 volts is present. *Be sure to put the plugs back in the correct order before proceeding.*

◆ **Note:** On UMOC 200 series, 600 series, and 800 series units, the fan connector plug is not accessible from the outside of the fan housing. Use a test light instead.

Symptoms

It is best to locate and repair any problems with the keyed 12-Volt circuit whenever it is even remotely suspected of being the cause of a problem.

As mentioned, power interruptions as short as a few milliseconds may cause the UMOC to shut down and restart. This can result in serious vehicle performance problems.

Using an Auxiliary Battery to Test the UMOC 12-Volt Power Circuit

If you suspect problems with your 12-Volt system, the UMOC can be tested by connecting it to a 12-Volt battery. The minimum recommended size is 12V, 7Ah.

The battery must be able to supply the cooling fan current for the duration of the test. Cooling fan current can be as high as 7-amps. Be sure to have an inline fuse, size 10 amp, in series with the test battery. If a short circuit is present, UMOC internal wiring will be damaged if a fuse is not used with the test battery.

CAUTION

Be sure to put the plugs back in the correct order before proceeding

CAUTION

If a short circuit is present, UMOC internal wiring will be damaged if a fuse is not used with the test battery

Test Box

If all voltages are present and the unit still appears to be dead, try operating the unit with a test box. Never connect the test box unless the wheels are jacked up. Switch on the keyed 12-Volt power with the test box connected.

If the test box lights come on briefly, the microprocessor is running. If the unit runs properly with the test box, but does not work when connected to the ignition box, the problem is in the ignition box cable, the ignition box, the direction selector switch, or the pedal box.

Test the 25-pin cable from the UMOC to the ignition box or console. Unplug the 25-pin connector at the ignition box or console and connect the test box at that point. Remember, be sure the wheels are free to rotate safely. If the drive operates properly with the test box connected this way, the 25-pin cable is most likely good.

A more thorough test of the 25-pin cable is to perform a continuity check on each pin of the cable using a continuity tester, cable tester, or ohmmeter.

◆**Note:** Systems with consoles do not have all 25 pins of the connector installed. There will be no continuity on those pins that are omitted.

Fans run Constantly

For ambient temperatures above 30 degrees Centigrade, the fans will run constantly. This is a normal condition, which provides maximum cooling at all times. However, if you know the unit is cold, and the fans run constantly, investigate further.

Plugs Exchanged

Some units designed for hot climates have the fans connected so that they will run continuously. If this is not the case, check to see whether the 12-Volt plugs have been reversed. If the keyed 12-Volts is plugged into the fans, the fans will run continuously but the unit will be dead. If the fans are connected properly on a cold unit but continue to run constantly, the processor has malfunctioned.

Processor Fault:

If cooling fans, brake lights, battery indicator lights, or other accessories remain on continuously and the unit does not drive the motor, the microprocessor has failed. Do not attempt to repair or operate the unit in this condition.

If you suspect trouble with the processor, try to recycle the unit by disconnecting the keyed 12-Volts from the UMOC 2-pin 12 volt connector for 30 seconds. If normal operation cannot be restored after following the tests listed above, return the unit for service. Do not reconnect the unit to the main battery.

No Communications

Each time the unit is turned on, it sends information to the serial port. These include model number, build date, and configuration number. This is called the banner line.

WARNING

Connecting a unit with a microprocessor problem to the main battery may damage the unit.

CAUTION

If command-processing proceeds other than expected, and the “caps lock” indicator is illuminated, switch off or reboot the UMOC at once. Do not write the long-term memory. Doing so will reconfigure the unit. Switch off the power for 30 seconds, then power up the unit and check the configuration and settings before driving the vehicle. Be sure “caps lock” is not activated on the computer.

If you do not see the banner when switching on the unit, either the unit is not communicating, or there’s a problem with your communications software, serial data port, or cable. See appendix E.

Banner is Garbled

If you turn on the power and see a line of unreadable characters on the screen, you probably need to adjust your communication settings. Follow the above procedure and when finished, turn the power to the UMOC off and then back on again. If you now see the banner line clearly, you are ready to communicate with the unit.

Unit Communicates but no Motor Operation

Once communication is established, it will now be possible to “see inside” the unit for very easy fault diagnosis. Clues to the causes of most faults will appear somewhere in the various columns of the user data screen.

Many units require a password to be entered from the computer keyboard before user screen data is presented. This is done to prevent accidental or unwanted parameter changes. If desired, the user can disable the password.

DANGER

It is dangerous to operate a vehicle with a problem in the pedal circuit. Vehicle acceleration could become unpredictable. No matter how many safety systems are implemented, there will always be a *slight* chance of unintended acceleration. This is true for **any** drive-by-wire vehicle. No level of complexity can eliminate this possibility *completely*. In the UMOC, a four-level safety system has been implemented to make this occurrence as remote as practically possible.

Faults Related to Driver & Dashboard 25-pin Cable

The UMOC motor controller communicates to vehicle controls and displays via the 25-pin cable connected to the side of the unit. This is the same cable that is used to connect the test box. If a malfunction occurs in the 25-pin cable, ignition box, vehicle control or display systems, clues to the malfunction may be found on the user data screen. Refer to the sample user data screen.

The first line, labeled “AD”, shows the numerical value of analog to digital converter values supplied to the microprocessor. Directly below, labeled “D”, are the motor current values in binary and the motor current sensor readings in amps (A). In the center of the user data screen are three columns.

The first column, labeled INFO, displays commanded torque and current values, rpm, unit temperature and battery voltage. The second column, entitled Limits to Torque, provides any information regarding power reductions being caused by user controls, equipment temperature, battery voltage, and rpm. The right most column, labeled Status, shows the operating state of internal systems. These are the main contactor system or “Relay”, the high current Power Stage which drives the motor, regenerative braking function, Error detection circuitry, forward-reverse selector position, and pedal circuit supervisory status.

Pedal Error:

The UMOC’s accelerator pedal circuit is fully supervised by the microprocessor. This means if a malfunction or bad connection develops anywhere in the pedal circuit, the microprocessor acts to prevent any further operation of the drive system.

If the drive system fails to operate, and you see the words “**PEDAL ERROR**” or “**PEDAL FAULT**” displayed in the status column, this means a wire has broken or short-circuited somewhere in the pedal circuit. Do not operate the vehicle until the cause is discovered.

Use the following guidelines to prevent an accident from occurring and to avoid compromising safety systems.

Investigate and repair all pedal error faults at once.

Do not connect unapproved third-party pedals to the system.

Always shift to neutral before leaving the operators position.

Service or parking brakes must be applied in order for the vehicle to remain motionless.

Under no circumstances shall the hill-hold function (when equipped) be used for vehicle braking or “hill-holding” unless the driver is seated in the operator’s position.

If erratic or undesired acceleration is detected, discontinue operation at once and determine the cause.

Electrical

If a pedal error is discovered, look at the left most value on the line labeled AD. This represents the pedal voltage as seen by the microprocessor (expressed in arbitrary units).

If the value is at five or below, suspect a short-circuit in the pedal connections or broken wire on pin 24 of the 25-pin connector circuit or a broken wire in the accelerator pedal cable or connector.

If the A/D value is over 1000, suspect a broken wire on pin 13 of the 25-pin connector or a broken wire in the accelerator pedal cable or connector. Please note that the safety interlock system will not allow operation to begin until the A/D value falls to level below 100. Thus, when turning on the system for the first time, the pedal must first be released in order for the unit to function at all. See below.

Mechanical

The accelerator pedal linkage must be adjusted properly, and the pedal potentiometer must be in good condition and working properly in order for the UMOC to start up, and operate properly.

If the pedal linkage is adjusted such that the A/D value never falls below 100, operation will be impossible. Additionally, pressing the accelerator pedal to the floor with the direction selector in “off” or “neutral” should increase the A/D value seen on the user data screen to around 700. If not, full power acceleration will not be achieved.

This example should serve as a good introduction to the importance of the user data screen for maintenance and troubleshooting of the drive system.

As is becoming true for the entire automotive industry, there are classes of problems that are impossible to solve unless the microprocessor system can be communicated with. This is because the microprocessor is capable of “talking” about problems that may not be outwardly apparent.

Relay Off

It is also possible for a malfunction in the 25-pin cable or attached equipment to prevent closure of the main operating contractor relay inside the UMOC motor controller. If the main contractor will not close, no operation of the drive system is possible.

The main contractor closes with an audible “clunk” which is easily recognized by the experienced observer. When using the test box, the main contractor may be opened and closed with the on-off switch (if all other conditions are met). This signal is on pin 14 of the 25-pin cable. Please recall from the “Operation” section under “closing the contractor,” that other factors may also prevent the relay from closing, besides those related to the 25 pin cable noted here.

Direction Switch

The ignition box or console contains interlock circuits that will also prevent the main contractor from closing. When the ignition key is first turned on, 12-Volts is applied to the UMOC 2-pin 12-Volt connector and to the ignition box 12-Volt input wire. The signal to close the contractor will not be sent until the direction handle is moved to the neutral or off position.

◆ **Note:** that this is yet another safety interlock system intended to prevent unwanted or unintended operation of the drive system.

ΔΔ Dual-Drive Systems with Direction Switch Error

For vehicles containing two separate drive systems and a control console, user intervention is required before the vehicle can be driven on one controller only.

If power is shut off to one drive system only, or if an internal malfunction in one drive system causes of total loss of power to that drive, the vehicle will drive in reverse, but not in forward. This prevents possible drive system damage

resulting from torque imbalance that is caused by driving the vehicle with one system only.

Use the following procedures if it is necessary to drive the vehicle on one system only; for example, to return the vehicle to a repair depot where it may be serviced.

1. First, check and reset all circuit breakers supplying power to the drive systems, as an effort to restore normal operation. If full power cannot be restored, it will be necessary to determine which drive system has malfunctioned.
2. If the console is equipped with drive status lights, turn off the ignition key to the vehicle and wait 30 seconds. Turn the key to the “on” position and observe the status lights. They should come on briefly during the power-on self-test interval.

If one of the two status lights does not come on, or stays on, that is the malfunctioning drive.

1. Remove the 25-pin cable from the malfunctioning drive. If in doubt, or if the console does not have status lights, try one and then the other.
2. Once the 25-pin cable has been disconnected from the malfunctioning drive, it will be possible to operate the vehicle using the remaining working drive only. Avoid hard acceleration if possible, to reduce stress on the drive system while the vehicle is being driven back for service.
3. After the malfunction has been corrected, be sure to reconnect the 25-pin cable.

Charger Disable

When the vehicle is being charged, a signal is sent to the ignition box or console to prevent operation of the drive system. Besides protecting the motor controller from exposure to high charging voltages, this prevents the vehicle from being driven away with the charging cord still connected.

Many vehicle owners, unable to get the drive system to operate, have later discovered the charging cord connected to the vehicle. For this reason, it is better to install the charging socket on the same side of the vehicle as the driver's door. If this isn't possible, then locate the charger status lights in a position observable by the operator.

Drive-Disable Function

All vehicles equipped with Δ -Y (delta-wye) switching include a drive disable function. Transit buses with electrically operated doors may also include this function. This signal is on pin 11 of the 25-pin cable. These systems may not be tested with a test box unless the test box has first been modified to include the drive disable function. While the drive disable function prevents motor operation, it does not prevent the main contactor from closing. Refer to the ignition box and console wiring diagrams in appendix C.

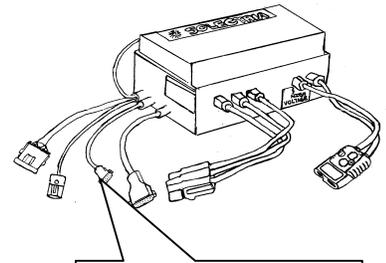
Faults Related to Speed Sensor Cable

The nine-pin speed sensor cable connects the motor to the UMOC motor controller. Motor speed, direction, and temperature values are reported to the microprocessor. If the speed sensor plug is disconnected entirely, or, if one of the wires inside the cable becomes broken, the motor will continue to operate at very low rpm. If the motor spins very slowly, or if vehicle speed will not exceed one mile per hour, check the motor speed sensor cable and observable diagnostics as follows:

RPM Indication:

Use the following procedures to determine if the motor speed sensor has stopped functioning.

1. Jack up the drive wheels, and place the selector switch in the off or neutral position.
2. Look at the “INFO” column of the user data screen. At the bottom, you will see “rotor 0 rpm”.
3. Turn the drive wheels or the motor shaft slowly by hand. If both drive wheels are off the floor, make sure only one drive wheel turns. As the motor shaft begins to rotate, the rpm display will change from 0 to nonzero rpm. If the motor shaft is rotating and the rpm indication remains at zero, the speed sensor has malfunctioned.
4. Check the sensor cable for loose connections or damage.



**9-Pin Encoder
(Speed Sensor)
Cable**

CAUTION

Loose hair or clothing can become entangled in rotating parts. Also, be sure to keep control cables away from rotating parts or driveshafts. Drive shaft parts can snag on loose cables, causing severe damage

Improper speed sensor adjustment will cause one or more of the following:

- **poor operation**
- **drive instability**
- **differences in operation between forward and reverse**
- **operation limited to a certain rpm**
- **over-current faults**

Some types of speed sensors require special tools to adjust. It's best not to attempt adjustment of the speed sensor unless correct procedures can be followed. Contact the Solectria Customer Service Department for assistance with speed sensor adjustments.

Motor Temperature Sensor

If a problem develops in the motor temperature sensor circuit of the cable, this will be displayed on the user data screen in the "Limits to Torque" column as "Motor Temp 0.1" or "Motor Temp 0.01." A motor with an open circuit or short circuit in the temperature sensor wires will have very little or no power. See the section titled "Faults Related to Temperature" for more information.

Grounding

It is important for the motor speed sensor cable to have a good ground. The metal connector shells become grounded to each other when the connectors are attached. If the ground connection is lost due to breakage inside the cable, motor operation will be erratic.

If the motor operates roughly or jerks at low rpm, shut off the drive system and measure ground continuity of the cable. It's also a good idea to ground the motor case to the vehicle

WARNING

Do *not* wrap the connector with tape. This will trap moisture inside the connector if it becomes wet

frame if metallic, or to the motor controller case if the frame is not metallic.

◆ **Special note Regarding Accessory and Motor Sensor Grounding**

Never ground any accessories to the motor or UMOC case. Ground current flowing through the sensor cable will disrupt normal operation of the drive. Improper grounding can also present a shock hazard.

Important: After checking the ground circuit continuity, insulate the nine-pin connector shells with plastic automotive split wire loom so that the connector shells will not come in contact with any metal objects. You can also tie the cable out of the way using cable ties. Do **not** wrap the connector with tape. This will trap moisture inside the connector if it becomes wet.

If the nine-pin cable connector **does** intermittently touch against a metallic object while the vehicle is being driven, a ground current will flow that will disrupt the normal operation of the drive. This may cause the drive to shut down repeatedly. After performing any service work on the vehicle, always check the nine pin connector shells to be sure they are insulated from touching nearby metal objects. This will enable smooth operation.

Faults Related to Temperature

Controller

If the microprocessor has determined an over-temperature condition exists, power will be reduced proportionally to the severity of over temperature. On the user data screen, heat-sink temperature is indicated. This is a very accurate measurement.

When unit temperatures reach over 50° Centigrade, the motor controller will begin to limit power in order to forestall further overheating. The “temp” indicator light (when equipped) will be illuminated.

Motor

In the “Limits to Torque” column of the user data screen (see “Note Re: limits to torque” just below), motor temperature values are used as a guideline to protect the motor.

Temperature sensors are embedded in the actual copper windings inside the motor stator. At very high temperatures, the copper wire insulation will begin to break down. The temperature sensors prevent this by supplying data to the microprocessor. Motor torque is reduced (see below) and the “temp” indicator is illuminated (when equipped).

At all motor temperatures below the limit, full motor power is available. For this reason, is important to cool the motor properly. Otherwise, torque may suddenly be lost, and vehicle performance will suffer.

◆*Note About Limits to Torque*

All values in the “Limits to Torque” column represent a multiplier that is used to calculate resultant torque from the desired torque commanded by the operator via the accelerator pedal. The lower the multiplier, the lower the resulting torque value. Values range from 1.0 for full torque, to 0.01, or even 0.0 for little or *no* motor torque. Multipliers are compared by the microprocessor, and the minimum of the values is used as a multiplier for output motor torque.

Faults Related to Battery Voltage:

If the battery voltage is too high or too low, the drive system will not operate. Because the UMOC motor controller was designed for maximum possible electrical efficiency, it’s best to operate it within the voltage limits for which it was designed.

Over-Voltage:

Your UMOC will limit torque whenever a battery over voltage condition exists. This is most common during regeneration, when power directed into the battery tends to raise its voltage. This protects the battery from damage. Maximum battery voltage is carefully set at the factory, and may be adjusted by the user in the parameter screen. (See your warranty regarding changing parameters) Use care when adjusting the maximum battery voltage. Refer to battery manufacturers' data to determine what voltage level the battery may safely handle.

In addition, your unit will stop operating if the input voltage is too high. This may be seen in the limits to torque column. If the battery voltage increases still further, an over voltage fault will occur. This will be noted in the status column. If you see over voltage faults, battery voltage has become dangerously high.

Total destruction of the power electronics section of your unit is possible. If you are experiencing over-voltage faults, look into the cause immediately and have it corrected. This caution applies especially to hybrid vehicles that contain other systems capable of charging or raising the battery voltage.

Initial Driving

For high-power systems, typically those found on transit buses, the batteries are charged to a very high voltage. This improves overall electrical efficiency.

When the ignition key is first turned on, and the accelerator pedal is depressed, the drive system will start at reduced torque. This causes battery current to flow, which quickly reduces the battery voltage. Then, full torque is applied. The whole process takes about five seconds. This action occurs only immediately after charging, and does not happen during normal driving.

Under-voltage

During driving, the battery becomes depleted, and battery voltage continues to drop. This is true for all batteries. A point is reached at which further discharge is likely to damage the battery, or interfere with safe vehicle operation.

In accordance with battery manufacturers specifications, battery current is reduced when voltage approaches the limiting value. Finally, a battery voltage is reached at which torque, and battery current, equals zero. On the user data screen, this can be noted in the limits to torque column. Additionally, battery voltage is displayed in the info column. This is a very accurate measurement.

The UMOC motor controller incorporates a precision volt meter which is carefully calibrated at the factory, and cannot be re-calibrated in the field.

◆ **Note:** A battery voltage calibration check cannot be performed unless the contactor is closed. If you can hear the contactor close, and an external volt meter is known to be in good calibration disagrees with the voltage reading on the user data screen by more than 3%, return the unit for service. The internal voltmeter is factory calibrated to within 0.1 volt at operating voltage. For systems with a nominal battery voltage of 200 volts or higher, if the reading on the user data screen is within 3 to 5 volts of the actual battery voltage as measured at the UMOC's battery connector, with the contactor closed and motor a current of zero, it should be considered calibrated.

Low Battery Indication

If the low battery indicator light (when equipped) illuminates, the UMOC has begun to limit torque based on battery voltage measurement. The result will be reduced performance. Return to a charging station and charge the battery as soon as possible. Discharging a battery beyond the point where the "low battery" light illuminates may shorten battery life.

Try to limit driving in such a way that the low battery light does not illuminate. Reducing the setting of the power saver control (when equipped) or the Tri-Power Selector will assist in preventing the low battery light from coming on.

Parameters

For certain battery types, including nickel-metal hydride, high battery current will cause battery voltage to drop quite a bit. The result will be reduced performance, even when the battery is not depleted. This will be indicated by the illumination of the low battery light, and will be indicated on the user data screen as a limit to torque based on battery voltage. This condition may be improved by lowering the minimum battery voltage setting in the parameter screen. Be sure not to exceed the manufacturers recommended limits. Battery damage may result.

If a further improvement is needed, the “**battery limiting**” parameter can be reduced slightly. Use care when reducing the setting of the battery limiting parameter. As battery limiting is reduced, overall drive instability will increase. Low values of battery limiting, while increasing performance for some types of batteries, will introduce shakes or shudders into vehicle operation, especially during regeneration. Systems that have a nominal battery voltage of 276 or greater, use 20 volts or more of battery limiting. Systems with nominal battery voltages from 144 to 250 are normally set to 15 volts battery limiting.

Limits to Torque and Battery Indicators

In all cases of battery over voltage or under voltage, the resulting action will be evident in the “limits to torque” column of the user data screen.

For your convenience, it is not necessary to connect a computer to your unit to observe battery voltage limiting. Instead, a “battery low” limiting indicator may be connected to pin numbers 1 and 8 at the 25-pin connector of the ignition box.

Use a standard LED lamp that can be driven by a current of 0.01 amperes. A current limiting resistors is not necessary. See Appendix C. Many Solectria vehicles have low battery indicators installed as standard equipment. Please contact Customer Service about warranty requirements before connecting any LED lamps to your ignition box or console.

◆ **Note Regarding Battery Indicators:** Some special-purpose vehicles use the “**battery full**” LED indicator for another function. “Battery full” indication is not available for customer use in this situation.

Relay Fault

If the unit will not operate, and “**relay fault**” is displayed in the status column of the user data screen, return the unit for service. For safety reasons, the contactor relay system is supervised by the microprocessor and includes a fail-safe function.

If the relay fails to close, the microprocessor will wait for 10 seconds and then try closing the relay again. If the relay fails to open, the microprocessor will remove power from the motor as a safety precaution. “**Relay fault**” will be displayed and the yellow “**status**” light will be illuminated (when equipped).

WARNING

Do not operate or connect to a battery, a unit that has been dropped, been in a vehicle accident, and/or makes a noise of loose parts rattling or rolling around inside the case

Damage

Relay faults, although rare, are normally caused by damage to the contactor relay. The damage is typically mechanical, not electrical.

Moisture

If poor installation results in moisture entering the unit, the relay contacts may become oxidized. This will result in poor electrical connection. The microprocessor will detect this and generate a relay fault. It will be necessary for the relay to be repaired or replaced. Relays are not field serviceable.

G-Force Limit

The relay is designed with breakaway plastic clips that will fail if the relay experiences shock in excess of 200 G's. If the entire unit is accidentally dropped, it's a good idea to return it for service. "**Relay fault**" will be indicated on the user data screen if the relay has become damaged.

Excessive Cycling of Relay

In cases of battery charger malfunction or other circumstances which can cause the relay to cycle on and off rapidly, the relay system will shut down and a relay fault will be displayed. To reset the unit, shut off the power to the UMOC for five minutes. When normal operating conditions are restored, the UMOC will function normally. Look into the cause of the excessive relay cycling and correct the problem.

Self-Cleaning Feature

If the microprocessor detects the presence of dirt or oxidation on the relay contacts, it will disable the unit and attempt to clean the relay contacts by cycling them once every 10 seconds. "**Relay fault**" will be displayed. If the relay is unable to clean itself after 10 or 20 cycles, or if a relay fault occurs while driving the vehicle, return the unit for service.

Power Stage Fault

The final category of operation is the power stage fault. This is the most serious category. In general, a display of power stage fault indicates that serious damage has occurred or is about to occur.

The "Power Stage" consists of specialized silicon transistors that operate at extremely high currents. Included in the power stage are other electrical components and safety systems that are all designed to ensure that the operating conditions required by the rather unforgiving silicon transistors are not exceeded.

Different types of errors that result in a display of power stage fault are discussed below in the section entitled “**Error PAL**.” Power stage faults can be divided into two categories: those in the controller, and those in the motor.

Internal Damage

If one or more of the power stage components have become damaged, this will result in an **over-current**, **DESAT**, or **IPM** fault, and no operation. The yellow “**status**” light will be illuminated (when equipped). For an explanation of **DESAT** and **IPM** faults, see the section entitled “**Error PAL**”.

Motor Short - Circuited

The three types of faults mentioned above could also be the result of motor damage.

Testing the Motor

The most likely location of a motor short-circuit is in the wiring and junction box connected to the motor. Proceed as follows:

1. Disconnect the battery and motor and inspect the wiring thoroughly.
2. Open the junction box and look for metal wires touching the case of the motor or junction box, or touching each other. This problem is more common in Wye-connected motors.
3. Look for evidence of sparking, melting, or overheating of plastic insulation and note any unusual or burning smells.

4. Motor winding resistance may be checked if a milli-ohm meter is available. Motor winding inductance can be compared to the expected value using an inductance meter. Compare each winding in the motor to the others: A to B, B to C, and C to A. When you are satisfied the motor wiring is in good condition, install the junction box cover.

5. Next, perform a ground test.

Grounded Stator

Sometimes, a damaged motor will develop electrical continuity between the stator windings and the frame or shell. Unplug the motor and, using an ohm meter, check for any continuity between the motor case and any one of the three main motor wires. There should be none. Resistance readings should be infinite.

Identification of Thermal Damage

Temperature sensors serve to limit motor temperature, but should not be relied upon exclusively to protect the motor. Even after a motor cooling system has failed, it is still possible for a motor to operate at maximum temperature regardless of power level. If this continues for several months, the motor will slowly destroy itself.

Color

Motors subject to extended periods of overheating will darken noticeably. This is true of exterior as well as interior features. The nameplate, protective dip, bearing grease, sensor head, winding varnish, slot insulators, and even metallic parts will assume a very dark color.

Smell

All motors, especially new ones, produce a sweet smell when heated. The smell can be quite strong. This is not a sign of over temperature. A motor that has overheated to the point of experiencing winding damage will have a burnt smell.

CAUTION
<p>If there is any DC continuity between the motor shell and the motor wires when tested with an ohm meter, discontinue using the motor. The motor should be repaired before operating it any further. In addition, operation with a shorted motor may damage the grounding and filtering circuits of the motor controller or vehicle, and may cause internal fuse failure.</p>

Some people may find it very difficult to distinguish one smell from another. This ability comes from experience. When evaluating motor damage, it is necessary to rely on smell, visual clues, and experience. The effects of heat damage are quite evident.

◆ **Note Regarding Monitoring Motor Temperature:**

A good way to monitor motor temperature and function of motor cooling is to attach a small thermal disc snap switch to one of the motor cooling fins. A good temperature value would be 190° to 210° F (95° to 100° C). The snap switch can then be wired to a dashboard indicator light. Snap switches are available from Solectria or from Selco.

Error PAL

Introduction

To help distinguish between the various conditions that can lead to a power stage fault, the UMOC contains an error detection system. A short history of detected faults is displayed by the microprocessor after interrogating part of the system known as the **Error PAL**.

The **Error PAL** system is *external* to the microprocessor. This way, errors that stem from the microprocessor itself can also be detected. On the user data screen the contents of the **Error PAL** and the type of the last error are displayed in the “**Status**” column.

Types of Errors

The types of errors that can be displayed by the **Error PAL** vary according to model and software version of the UMOC. Not all errors are displayed by all models.

LED Power Error:

The LED Power error indicates a problem in the power supply section of the motor controller. It is a serious error, but, depending on model, LED power error, when not combined with other errors, can be considered normal. This is because some UMOC models, such as the 440, switch off certain power supplies while performing the self-test. This causes the error to appear (see next paragraph).

Do not return a unit for service if the only error indicated is LED Power error. If you cannot find any other indications of a problem to aid in troubleshooting, contact the Solectria Customer Service Department for assistance.

Power-On Self-Test

Every time the keyed 12-volts signal is applied to the motor controller, the processor begins a series of routine diagnostic tests. If all tests proceed normally and no problems are found, operation may begin. One of the tests measures critical power supplies to determine if output voltages are correct. As mentioned above, a power supply named LED power is shut off during the diagnostic test sequence on some models.

During power on testing, the processor may elect to perform re-calibrations. This may add slightly to start-up time. In general, testing will not last for more than five seconds. Start-up usually takes about one second.

◆ **Note:** Units built before January 1, 1999 do not self-calibrate.

CAUTION

Do not intentionally connect a replacement UMOC to a motor that is known to have a short-circuit

DESAT / IPM Error:

This is a serious error which is caused either by a damaged “power stage” or by a motor with a short-circuited winding. To avoid damage to a replacement unit, be sure to test the motor thoroughly before swapping out the unit with another motor controller. If the error continues, return the unit for service. This error is not related to changes in parameter settings.

DANGER

Units subjected to severe over-voltage from hybrid generating equipment will rupture the UMOC’s outer case and expel hot gases

◆ *Special Note Regarding Motor Short - Circuits:*

The UMOC 225 is a unique design offering higher electrical efficiency, lighter weight and the lowest cost of any UMOC. It does not, however, incorporate output short-circuit protection. If a model 225 is connected to a short-circuited motor, damage may result. In this case, the unit must be returned for service. All other UMOC models built after June 30, 1998 have output short-circuit protection and can withstand connection to a short-circuited motor without damage.

Over-current error:

Engineering improvements and better software control have eliminated the over-current errors that were somewhat commonplace in very early UMOC designs. It is still possible for a bad motor speed sensor to cause an over-current error. Conflicting speed data results in a difference between rotor and stator rpm. The resulting high slip value causes excess current to flow.

Connecting a UMOC configured for one type of motor, to a different type of motor may cause an over-current fault. If in doubt, look at the UMOC nameplate to determine motor type, or call Customer Service for assistance.

The over-current faults produced by the two problems above cause the drive to shut down. Investigate the cause and solve the problem before continuing.

Over-voltage error:

An over-voltage error is a very rare error, caused by connecting the unit to the wrong type of battery system. It may also be caused by malfunction in hybrid generating equipment. A third possibility would be loose battery connections.

Whenever regeneration is being used (most UMOCs use the regeneration feature), it is very important to maintain good connections to the vehicle battery. If not, this or the other two conditions mentioned here will cause the input voltage to rise to a dangerously high level. The cause of this error must be determined and corrected. Units subjected to over-voltage may be seriously damaged.

Stay well clear of the UMOC area if you are working on a hybrid vehicle, (that is, a vehicle with on-board generating equipment) and you are investigating an over-voltage situation. Disconnect the motor controllers until the problem is corrected. As with all high-power systems, always wear the proper protective gear when working near energized equipment, for example a clear plastic face shield or safety goggles.



“Error PAL: OK” or <<none>>

If this message appears on your user data screen, there are no errors detected by the **Error PAL**.

Motor Turns Very Slowly

With the drive system selector in “Neutral” or “Off,” spin the motor shaft to determine if the motor is free to rotate (raise the drive wheels off the ground). If the motor cannot be rotated, check for a mechanical problem with the drive. Also be sure to release the parking pawl or parking brake (if equipped).

◆ **Note:** some systems incorporate a parking brake which is automatically applied when the direction selector is switched to “Neutral,” and possibly in other conditions as well. Perform the following tests if the motor is free to rotate, but spins very slowly when powered by the drive system.

DANGER

Keep loose hair and clothing away from rotating parts.

No rpm Indication

With the drive selector in “Neutral,” spin the motor shaft by hand while watching the rpm display in the info column. A constant rpm of 0 indicates a bad motor speed sensor or sensor cable. If the rpm display is working, proceed to the next test.

Limits to Torque

If available motor torque is very low, check the limits to torque, on the user data screen. Check the pedal torque value in the info column. In the parameter screen, check the parameter values against ones known to be correct. It's best not to change parameters unless the correct parameters are known beyond a doubt.

Motor Operates but then Shuts Down

The most common cause of this problem would be a power stage fault. Connect a laptop and monitor the user data screen during the shutdown. The status column is a good place to look. By carefully examining the screen, it is usually possible to determine the cause of the shutdown.

Miscellaneous Problems

Brake lights stay on all the time (new installations)

Disconnect the four-pin connector containing the brake light circuit at the motor controller. If the brake lights remain on, the problem is in the brake light relay circuit or vehicle wiring.

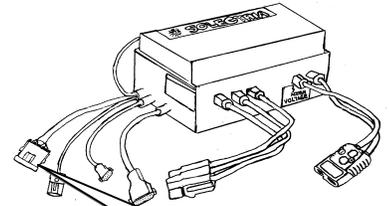
If the brake lights go out, disassemble the four-pin connector on the vehicle side of the wiring harness (not the motor controller side) and reverse pins C and D. Then, reconnect the four-pin connector. If the brake lights do not come on, operate the vehicle to verify correct function of the regen brake lights. If function is not correct, or if the brake lights remain on all the time, put back the wires in positions C and D to their original locations and return the motor controller for service.

ΔΔ For dual-drive systems, if the regen brake lights do not operate, unplug the 4-pin connector from the brake light relay to the UMOC, and instead, plug the connector from the relay into the 4-pin connector of the *other* UMOC.

If regen brake light function is restored, continue to drive the vehicle this way. Tag the first unit as defective with a repair tag, and swap out the defective unit at a later time.

Operation is not Smooth

This can be divided into two categories. The first would be poor response to changes in pedal position. The second would be drive instabilities related to certain operating conditions, such as vehicle speed.



**4-Pin Packard
Connector for
Regen Brake
Lights**

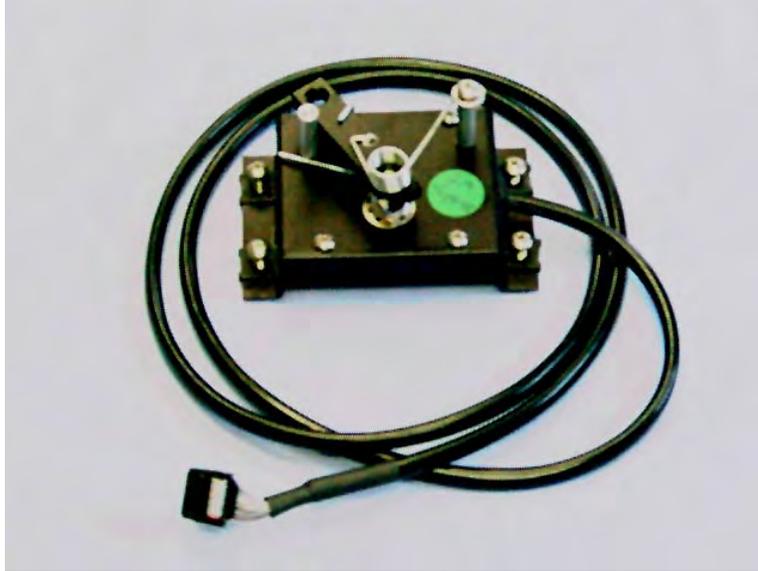


Figure 5: Pedal pot box

Checking the Pedal Pot

Pedal potentiometers (Pedal Pots) sometimes exhibit problems. While a good potentiometer may last a lifetime, poor quality units often fail at around 20,000 miles. Use an analog ohm-meter such as a Simpson 260, or a Solectria pedal potentiometer tester (specialized equipment for sale or lease. Contact Customer Service for details. Unplug the pedal connector from the ignition box, and measure the resistance as you vary pedal position. See Appendix F for instructions on how to connect an ohmmeter to the pedal connector. The resistance should change smoothly. Be sure to measure both sides of the potentiometer. Change in pedal resistance, either up or down, must be consistent with the direction that you are moving the pedal, throughout the entire range. If not, or if the resistance change is not smooth, replace the potentiometer.

Be sure to use the same type of potentiometer as was originally installed. Standard potentiometers available at electronics supply stores **will not work**. The internal construction differs greatly. Replacement potentiometers are available from Solectria for all Solectria products.

After replacing the potentiometer, it will be necessary to calibrate it (some models). Before reconnecting the pedal pot cable to the ignition box, connect an ohmmeter to the pedal cable following the directions in appendix F.

Loosen the set screw on the lever arm and, using a screwdriver inserted into the end of the potentiometer shaft, adjust the potentiometer shaft until one-half of the potentiometer reads near zero ohms at one of the mechanical stops.

The other half of the potentiometer must measure close to zero ohms at the other mechanical stop. Fine-tune the adjustment until it is centered. Tighten the set screw securely.

◆ **Note:** Some potentiometers are factory calibrated and cannot be adjusted.

Vibrations

Various system interactions on any given electric vehicle platform may result in drive system instability. These instabilities or vibrations can usually be “tuned out” by careful parameter selection, proper tire pressure, good speed sensor function, and an understanding of the trade-offs involved.

Battery Full

When using regeneration on a battery that is not depleted, voltage will quickly rise to limiting value. In some cases, an oscillation may develop.

Be sure battery limiting is not set too low. Typically, it should not be set to less than 15V. In this case, the problem would tend to disappear after driving for a few miles. If the oscillation occurs in one direction only, say in reverse but not in forward, suspect a speed sensor problem.

Other Causes

During acceleration or regeneration, the drive train of the vehicle will wind up to a certain extent. Twisting of drive shafts, flexing of motor mounts and tire side-walls all contribute to the effect. Suspension also contributes through reaction to drive shaft torque.

Due to this winding up effect, a sudden change in torque can result in a sudden change of instantaneous rpm. Symptoms of this effect are noted when regenerating to a stop, and when accelerating at full power and moderate rpm.

When regeneration stops, however, the loss of regen torque allows the drive train to quickly unwind. If enough play exists in the drive train, motor rpm without regen (which was *slowing* the motor) will suddenly exceed brake minimum speed. Thus regen will turn on once again. The result is a slight shuddering which lasts about one second. If objectionable, brake minimum speed can be adjusted up or down slightly until the shuddering stops. Before doing so, check your tire pressure.

Regeneration at Low rpm

When regenerating to a standstill, rpm decreases until a point is reached at which the same amount of energy is being used as is produced. Thus it is not desirable to regenerate down to zero rpm.

Besides wasting power, this would cause the vehicle to stop abruptly. A much smoother solution is afforded by setting the brake minimum speed parameter to a comfortable value. Typical values range from 200 to 400 rpm.

Control Loop

Under hard acceleration and full power, some drive trains exhibit the tendency to wind up to such a degree that the internal damping software is overwhelmed, and an oscillation may develop.

Normally, increasing the damping level will smooth out the oscillation. It is also possible to increase the damping to a level that makes the problem worse. If your Solectria drive system has trouble with oscillations, please contact the factory for assistance.

Tire Pressure

An important factor when dealing with oscillations is tire pressure. The lower the tire pressure, the more the tire side-wall will be allowed to flex, and the worse instabilities will become.

Always inflate tires to the maximum pressure listed on the side wall to give maximum vehicle range and avoid problems with oscillations. Changing to a different brand of tire may also help. "Fuel saver" tire types are recommended.

While it's true that heavier side-walls may be more resistant to flexing, the only way to find out is through trial and experiment. Contact Solectria for recommendations about choosing tires likely to yield a satisfactory result.

Pedal and Linkage Design

In prototype electric vehicles the quick acceleration of the electric motor will cause the vehicle to accelerate away from the driver (the mass of the driver causes them to stay still as the cushioned seat back accelerates toward them.).

As the vehicle accelerates away from the driver, the right foot comes off the accelerator pedal and the motor starts to go into regen mode. As the vehicle slows the now moving driver continues to move and their foot reapplies pressure to the accelerator pedal, starting a cycle of oscillation.

This pedal feedback is associated with light vehicles and vehicles with a poor accelerator pedal mechanical design. This problem is best described as the same “drive bucking” feeling that one would experience in a manual-transmission, internal combustion engine vehicle, that occurs when the clutch pedal is released too rapidly.

Please use the following guidelines when installing and operating your vehicle’s pedal potentiometer.

Be careful of excessive pedal linkage leverage. This causes small foot movements to have a great effect on acceleration.

Avoid pedal locations that require the driver’s leg and/or foot to be fully extended. The more the driver’s knee is over their heel, the better.

Pedal linkage kinematics start at the drivers hip and not at the pedal.

The lighter the vehicle or stronger the drive system, the more pedal travel is required to prevent this feedback. Six inches of travel at the driver’s toe is a good number to start a design with.

Avoid having the driver's heel off the floor of the vehicle. Having the heel on the floor is a must to reduce this type of feedback.

The driver's seat must be well connected to the vehicle, a loose seat or springy seat will greatly aggravate the problem.

Please contact the Solectria Customer Service Department for instructions if you have a newly designed system and are still experiencing instabilities (such as shuddering, jerking, or oscillations) even after having gone through all of the above points.

There are several remedies that may be applied to various customer situations. It is possible that some small matter has been overlooked and an easy change or adjustment will solve the problem.

Rpm

Maximum motor rpm is set at the factory and should not be changed.

Induction motors and brush-less DC motors can both be damaged by over-speeding.

WARNING

Do not allow your vehicle to coast downhill at speeds higher than its maximum rated speed. Motors damaged by over-speeding will be considered a *total loss*, and will not be covered under warranty

Pedal Settings:

Pedal settings may be changed slightly to suit the users requirement.

◆ **Note:** pedal position controls motor *torque*, not motor speed. See appendix G

ΔΔ Note Regarding Pedal Settings for Dual-Drive Systems:

Pedal settings of motor controllers used on dual-drive systems must be identical. The units will not torque-share properly if the pedal settings differ. The resulting torque imbalance may damage drive system hubs or components. This concludes the text describing the function, installation and fault diagnosis of your Solectria Universal Motor Controller (UMOC).

Conclusion

Your UMOC was constructed with the highest standards for quality and design possible. We hope that this service manual will enable you to more fully understand the workings of your unit and to use it safely.

If you have had any questions regarding the contents of this manual or would like to know more about the features of your UMOC, please feel free to contact the Solectria Customer Service Department at the phone numbers provided in your warranty.

Warranty

Solectria Components Warranty Policy

In an effort to keep our customers completely satisfied with the quality and performance of items purchased from Solectria, the following warranty policy applies.

Solectria Corporation shall pay for the repair or replacement (at our option) of any component found to be defective due to flaws in materials and/or workmanship within the first 12 months following the date of sale with no (US\$0.00) deductible, with the exceptions noted below. The customer shall pay for the shipping cost (UPS ground) to return the unit(s) to Solectria. For warranty repairs and replacements, Solectria will pay the shipping costs (UPS ground) of returning the unit to the customer. Solectria will not pay for the cost of rush delivery.

For the purpose of this warranty, components include but are not limited to motors, motor controllers, DC-DC converters, battery chargers, amp-hour counters, etc.

This warranty **does not cover:**

1. Products that have been opened, tampered with, or modified in any way.
2. Items defined as routine maintenance.
3. Damage caused by misuse, accident, alteration, lack of maintenance, inadequate packaging or use of incorrect lubricants.
4. Damage or corrosion caused by exposure to after-market products, the environment, or chemical treatments, and;
5. Wear items including but not limited to extension cords, plugs, connectors, cables, and enclosures.
6. Damage caused by improper parameter settings

In the event that it becomes necessary to return a product to us for service, call ahead for a Return of Merchandise Authorization Number to help expedite the repair. Any item being returned should be wrapped securely in the original or similar packaging to prevent damage in transit. Use the following guidelines for packing your unit for return shipment.

Keep your shipping carton!

Your carton is specially designed to prevent shipping damage to the metal case and cable connectors of your unit. If the carton is lost, Solectria will supply a replacement carton for a fee.

If the unit must be shipped immediately, you must triple-wrap it with large cell bubble-pack and place it securely in a double-walled, corrugated carton for shipment back to Solectria. Any repair costs for the unit that are associated with case damage due to improper shipment will be borne by the carrier or the customer and will affect your warranty.

Returned items should be sent to:

Solectria Corporation
Component Repair Department
33 Industrial Way
Wilmington MA 01887 USA

All items returned for repair must include a letter indicating, return address and contact, model number, serial number, date of purchase (or receipt of purchase), and reason for return. If this information is not provided the repair will be delayed.

Customer will be charged an evaluation fee for Non-Warranty items returned to Solectria. Warranty items returned to Solectria that are found operable will also incur an evaluation fee. Call Solectria's Customer Service Department for details.

Maintenance

CAUTION

Do not use a pressure-sprayer to clean drive system components, including the UMOC. Spray will be forced inside the UMOC case, encoder housing, and connectors. This will cause a malfunction and may result in a shock hazard.

Cleaning

Requirements and provisions for cleaning were described in the installation section. Provided the needed access is available, simply remove any insects and debris from the cooling fins. Also remove any visible road salt residue by wiping with a damp cloth. If allowed to remain on the unit, corrosion and connector damage may result from the presence of salt residues.

Maintenance of cables and plugs

Battery and motor plugs

Check motor and battery plugs for signs of overheating and melting. Plugs should be removable, but not too easily. Always be sure plugs are inserted *completely*.

DANGER

For systems with battery voltages of 250 and higher, battery plugs must be in a dry location, and must not be wrapped. If the connector is in a poorly chosen location and becomes encrusted with road salt residues, upon exposure to water the connector may burst into flame.

Subminiature 9-pin connectors:

Check for signs of water damage and corrosion. The 9-pin connector should have insulating loom around it and should not touch metal objects.

Waterproofing for your connectors

If your UMOC does not have waterproof connectors and will be exposed to a moist or corrosive environment, Solectria suggests you apply Nyogel (part # 760G), or GM Connector Grease (part # 12345579) or other dielectric grease for protection against corrosion or electrical tracking at connector pins and cable shells.

Waterproof connectors include

Deutsch

Packard

Non-Waterproof Connectors include

9 & 25 pin D-Sub

Anderson

Molex and Amp White Plastic

Appendices

Appendix A

UMOC Interface Packages of Dual & Single Drive Systems

Single Drive Systems

Item	Quantity
ABC-1, REV 2	1
F/R Switch Assembly	1
Power Saver Pot	1
Regen-disable Switch (Mini)	1
IB95-97	1
25pin Cable Assembly	1
200A 500v Semi	1
Amp1F Plug	1
Molex 4M Plug	1
Molex 2F Mini Plug	1
Packard Seal 18-22awg	6
Packard 2F Tower	1
Packard 4F Tower	1
SB175 Grey	1
SB175/PP180 2awg pin	2
Slide Term Insul F 22-18	1
Amp-F Pin	1
Molex M Pin	2
Molex Mini F Pin	2
Packard F Pin	6
1" Rubber Isolator	4
EMI Sock	1

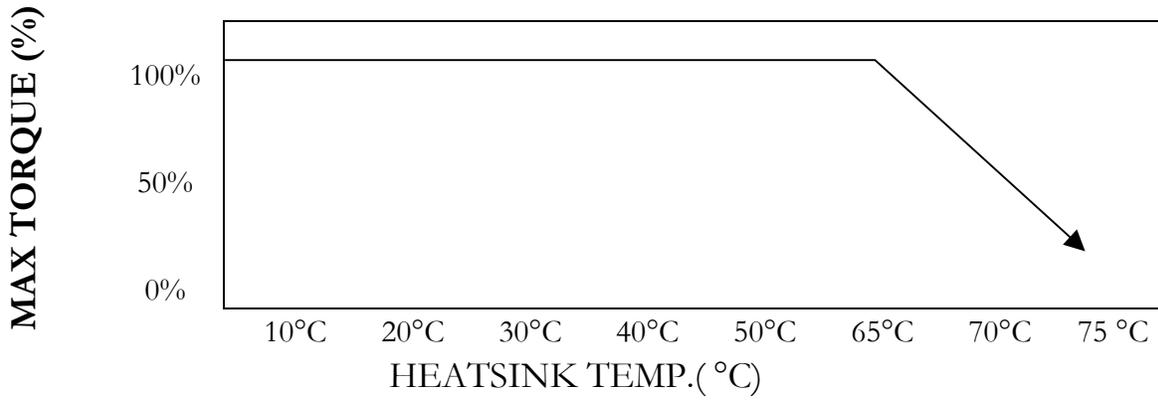
Zip-tie Large Black	4
¼ gr8 SAE f/w	8
¼-20 Nyloc Nut	8

Dual Drive Interface

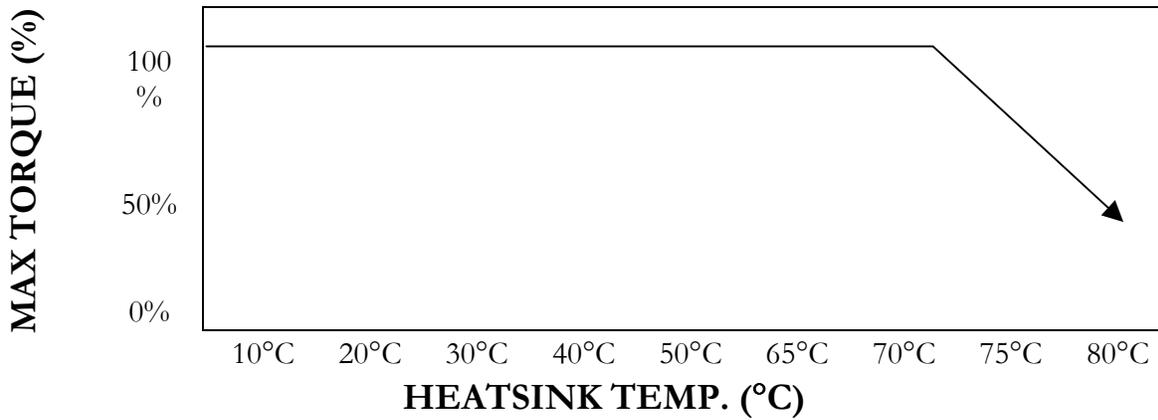
<i>Item</i>	<i>Quantity</i>
Regen Brake Harness	1
UMOC 12V Power Supply	2
25 Pin Extension Cord	2
Charger Drive Disable Cable	1
Ignition Connector	1
Throttle Extension Cord	1
SB175 Grey	2
SB175/PP180 2awg Pin	4
DeutschF#18contact	2
DT06-2S	1
W2S	1
1" Rubber Isolator	8
EMI Sock	2
Zip-tie (Med. Black)	8
¼ SS L/w	16
¼-20 SS Hex Nut	16

Appendix B

Torque Decrease VS. Heatsink Temp. For UMOC440



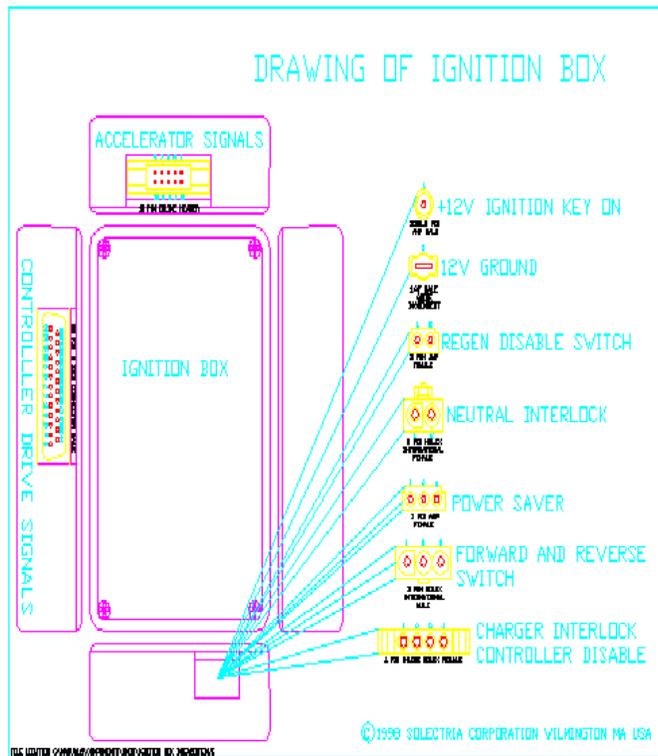
Torque Decrease VS. Heatsink Temp. For UMOC640



Appendix C

Appendix C1

Appendix C-1
Ignition Box Drawing



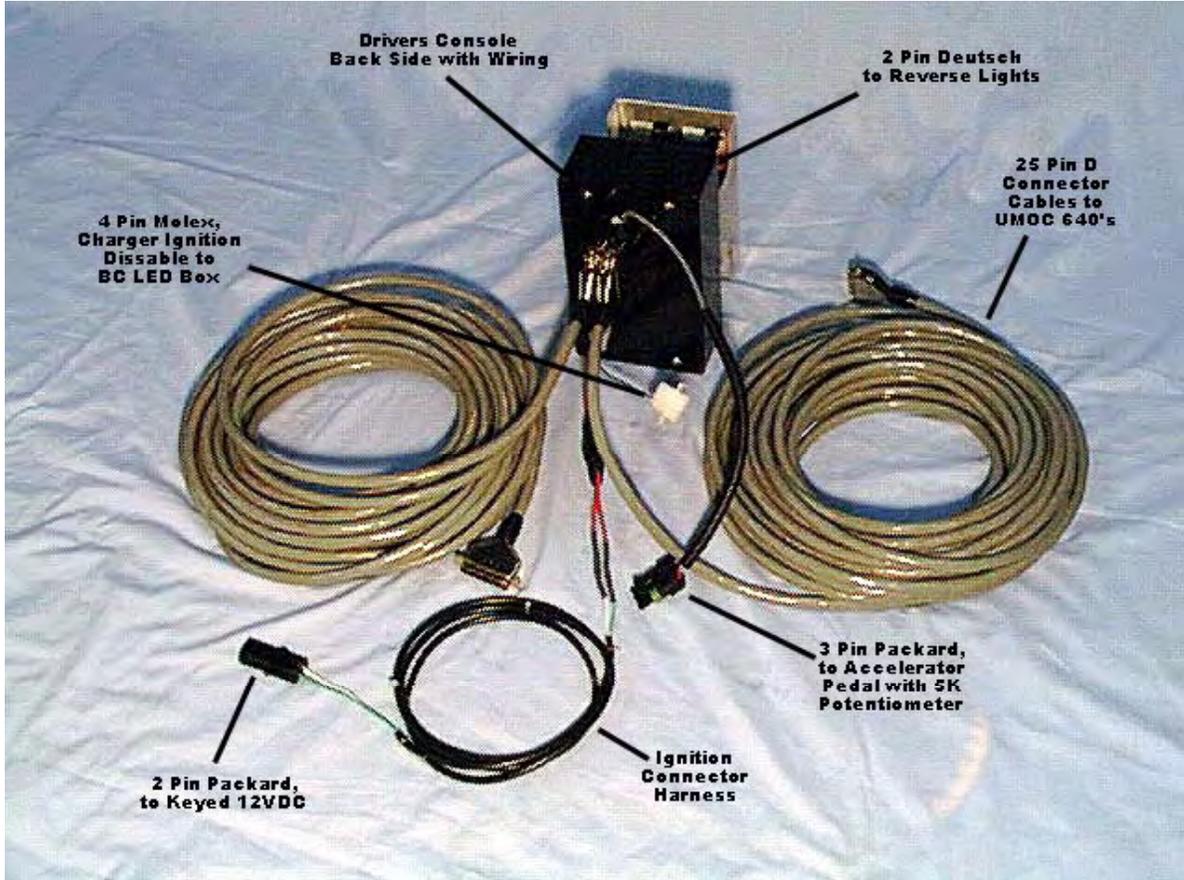
Appendix C2A – Driver’s Console

The drivers console is made up of the Tri-selector switch, the regen brake disable switch, an accessory switch and the ignition box, which is located on the bottom of the console. The Tri-selector switch provides 3 forward power levels, neutral and reverse positions. The regen brake disable switch allows the driver to turn off the regen braking; this is advantageous during slippery road conditions. The accessory switch is rated for 12 A at 12VDC, and is used in other Solectria vehicles as the heater switch, but it can be used for other 12V applications. The ignition box has inputs from the Tri-selector switch, the regen disable switch, the throttle pedal, charger ignition disable and keyed 12V-DC. It sends signals to the reverse light and to the UMOC drive motor controllers. The Tri-selector switch and the regen brake disable switch are hard wired to the ignition box; contact Solectria if you need to separate either of these from the ignition box.

The throttle pedal (5 K Ohm) is wired to the ignition box using a 10 or 3-Pin Packard connector, depending on the accelerator potentiometer used. The charger ignition disable is wired to the ignition box using a 4-pin Molex connector. Keyed 12V-DC is connected to the ignition box using a 2-Pin Packard connector. The drive motor UMOC controllers are wired to the ignition box using 25-Pin D connectors. The reverse lights are wired to the ignition box using a 2-Pin Deutsch connector. The 12VDC accessory switch is wired with standard automotive blade connectors. The Drivers console is not user serviceable, and any attempt to open or service will void all applicable warranties. Mounting of the driver’s console is left up to the installer. Solectria recommends that any mounting holes be drilled in the aluminum parts.

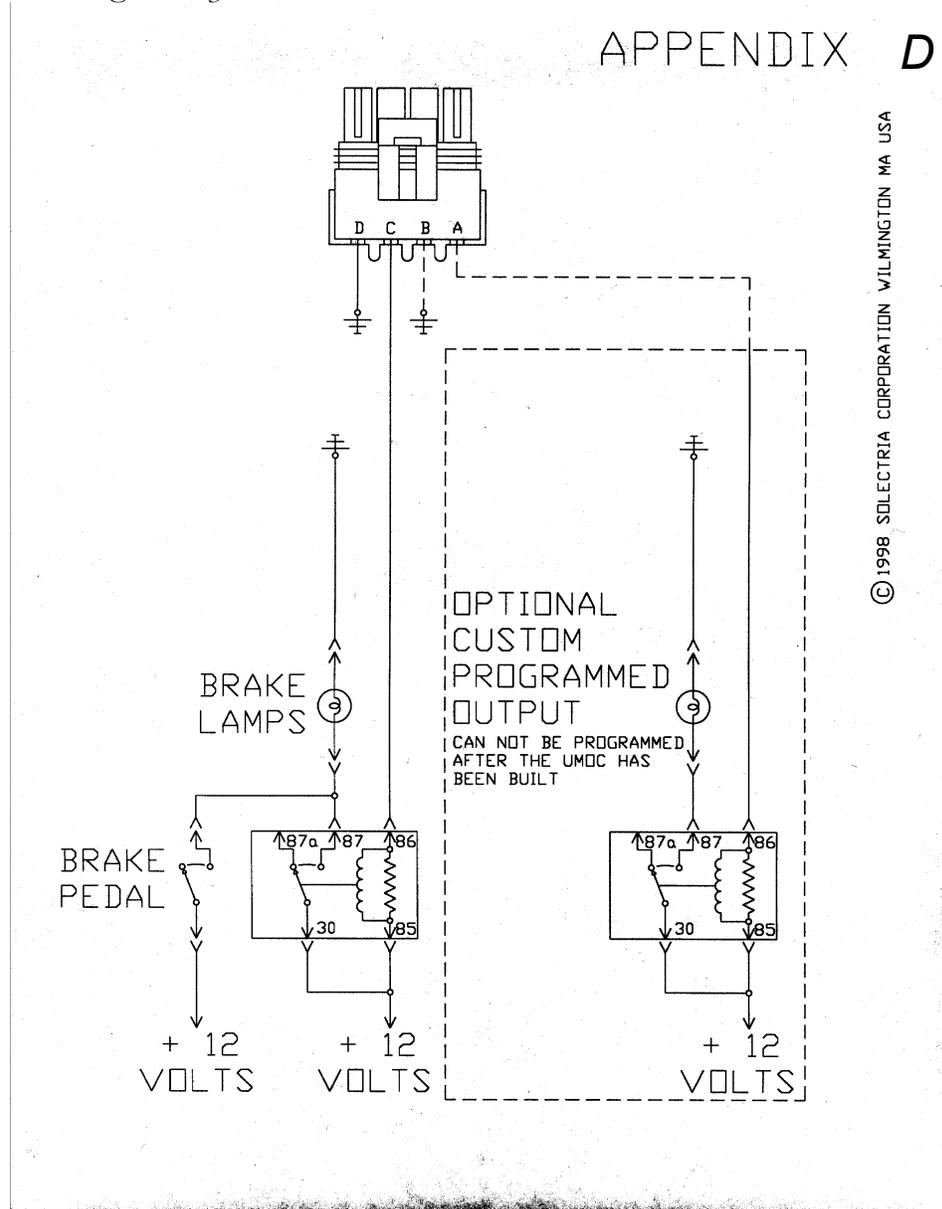
CAUTION: Be sure to use drill stops to protect wires, plugs and switches from aluminum chips, drill bits and punches.

Appendix C2B – Driver’s Console (Dual drive shown)



Appendix D

Break light Relay Connections



Appendix E

Appendix E is the HyperTerminal Manual and is supplied separately

Appendix F

- Field Testing Procedure for Potentiometer Box

The potentiometer box (pot box) internal connections are as follows:

10 pin ribbon cable:

- | | |
|----|------------------------|
| 1 | NC |
| 2 | NC |
| 3 | Max Pedal |
| 4 | Moving Contact (wiper) |
| 5 | Moving Contact (wiper) |
| 6 | Min Pedal |
| 7 | Reserved |
| 8 | Reserved |
| 9 | NC |
| 10 | NC |

Note: Pins 4 and 5 are connected together electrically.

To test the pot box in the field, proceed as follows:

1. Make sure pot-box arm is at full rest position.
2. Disconnect the pot box cable from the box where it terminates. (early models - at controller ; later models - at ignition box)
3. Connect analog ohmmeter between pins 3 and 4. Reading should be 5000 ohms +/- 20 %.
4. Connect ohmmeter between pins 5 and 6. Reading should be between 0 and 100 ohms.
5. Slowly press down the accelerator pedal. The ohmmeter reading should smoothly increase to a high value.

Conditions:

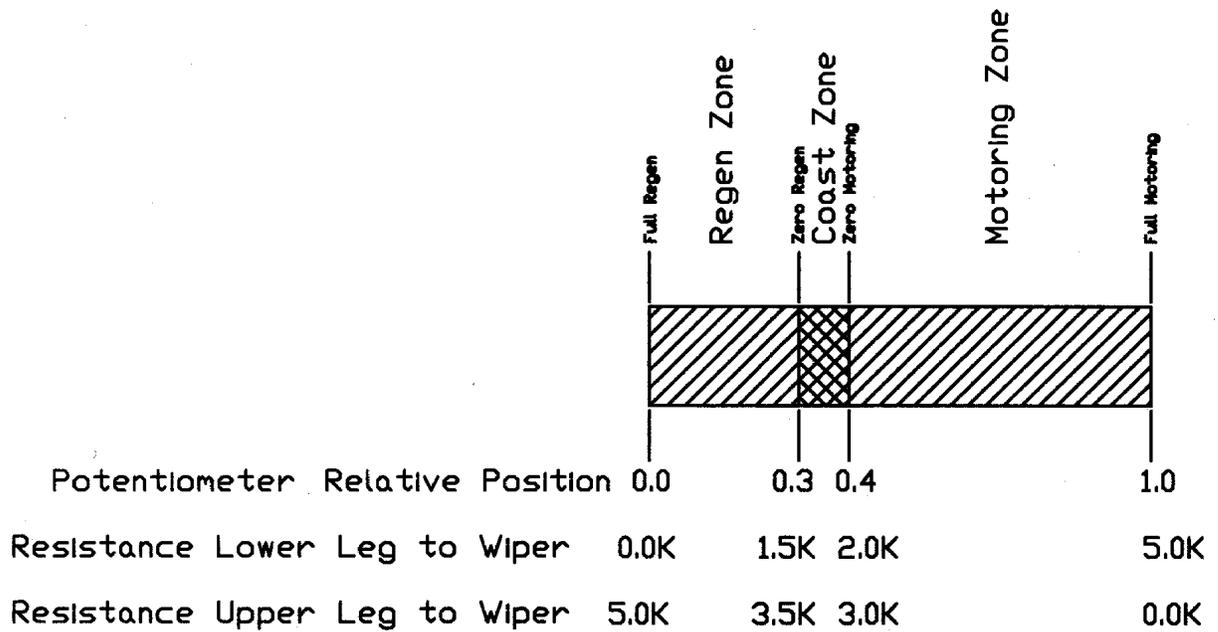
- a. There must be no continuity between chassis ground and pins 3,4,5.
- b. The lowest reading in step 4 should not exceed 100 ohms +/- 20%
- c. Resistance change must be smooth, with steady increase / decrease.

***Note:** The potentiometer used is of special manufacture. If the potentiometer is replaced with a stock item of the same resistance and form factor, it will not be possible to obtain the above readings. Please contact Solectria if test results are outside of these specs.*

Appendix G

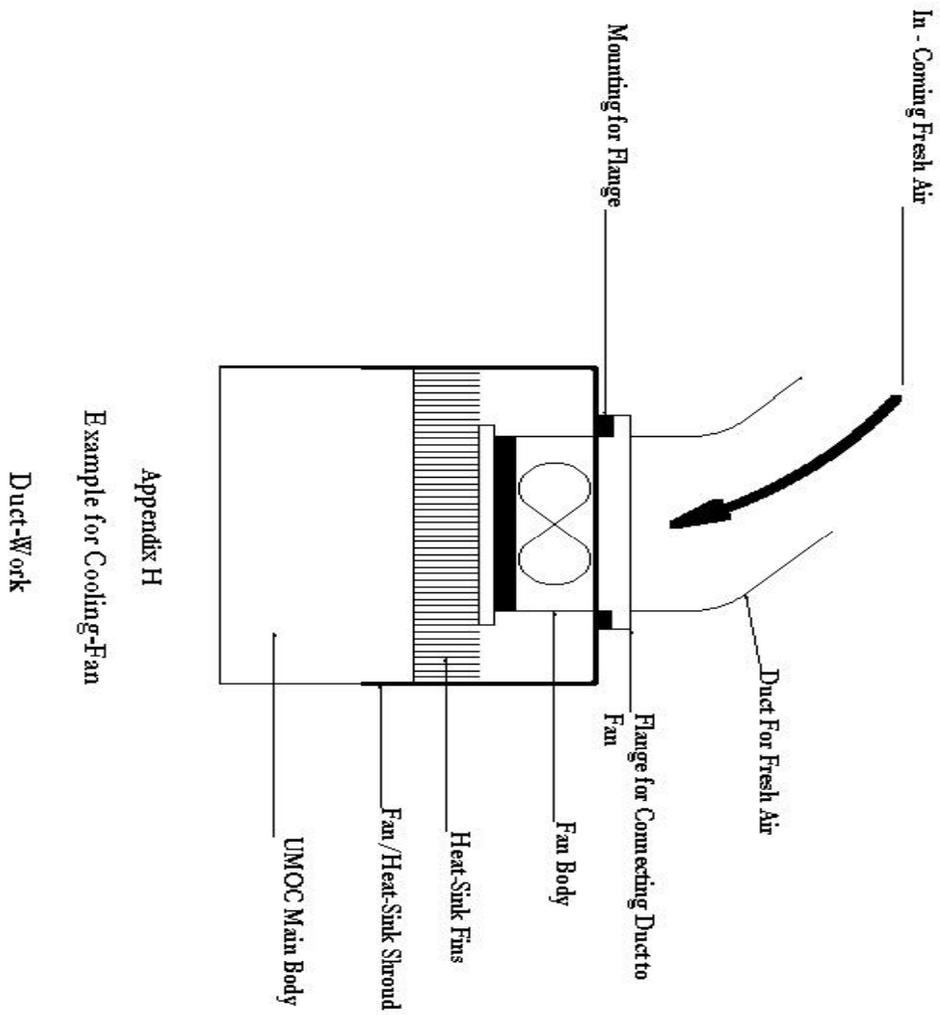
Pedal Potensiometer Settings

Pedal Potentiometer Accel/Regen Zones



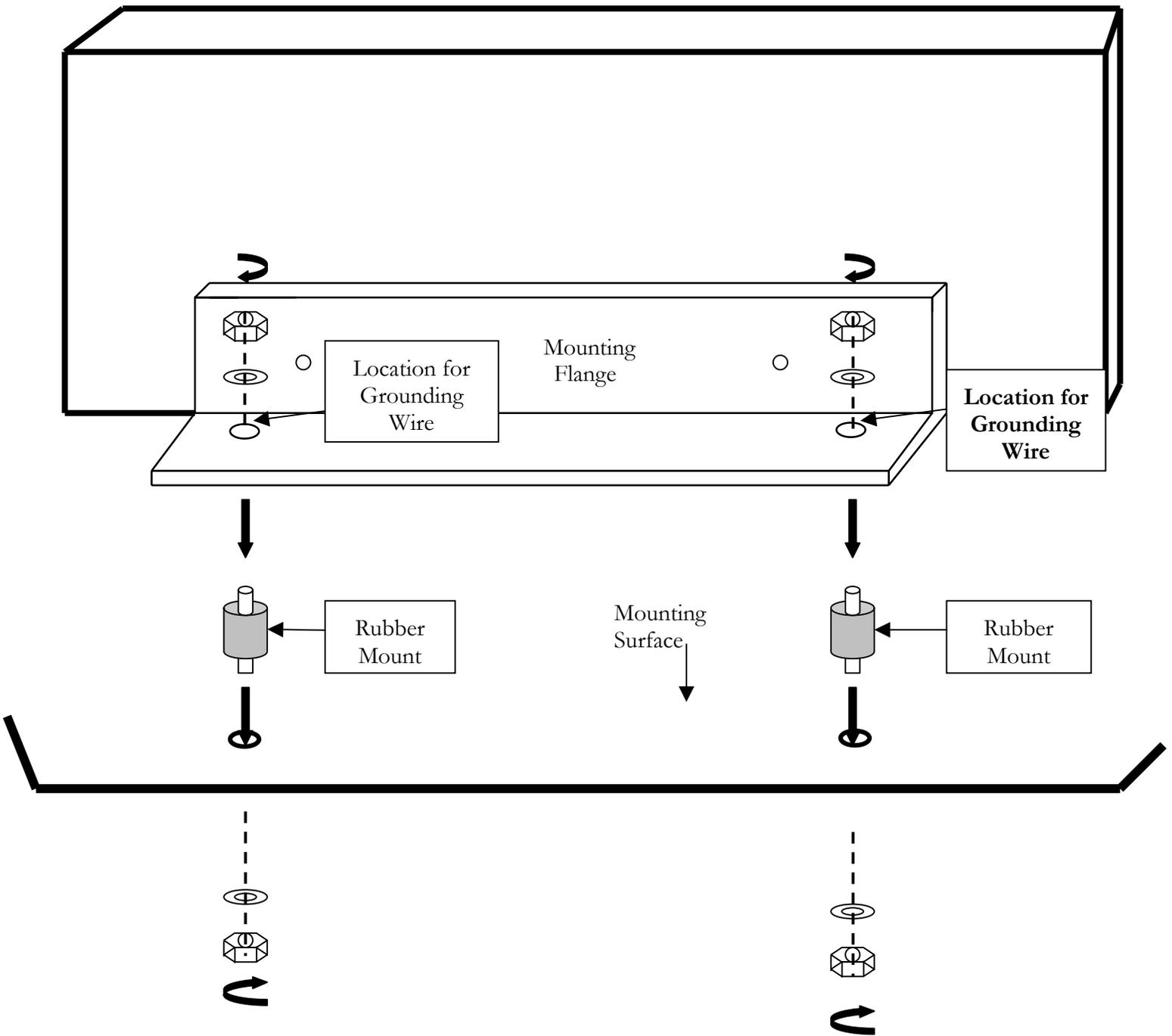
Appendix H

Example Ductwork



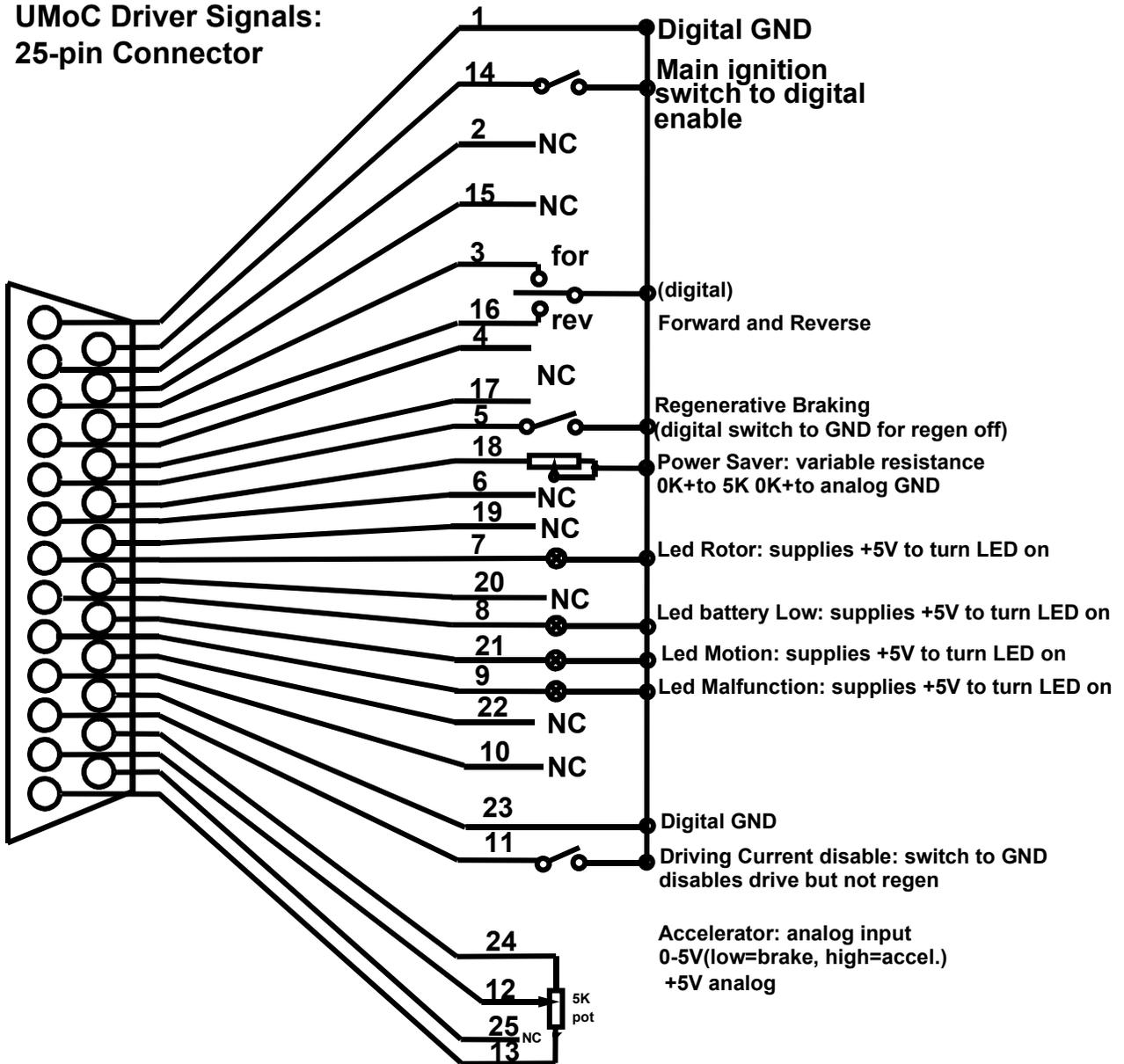
Appendix H
Example for Cooling-Fan
Duct-Work

Appendix I



Appendix J

UMoC Driver Signals:
25-pin Connector



Not all options are available on all models

Appendix K

The list below gives you the translation of abbreviations used for the parameters that appear on your user data screen.

As Seen on Your Screen	Translation	Notes
0 Max Bat. Volts:	Maximum Battery (Volt)	upper regen limit
1 Max Fwd Speed :	Maximum Forward Speed	RPM x 1000
2 Min Bat. Volts:	Minimum Battery (Volts)	lower drive limit
3 Max Rev Speed:	Maximum Reverse Speed	RPM x 1000
4 Max Pwr Mtr I :	Maximum Motor Current	to the motor (Amps peak)
5 Brake Min Spd	Brake Minimum Speed	speed at which regen shuts off
6 Max Reg Mtr I :	Maximum Regen Current	from motor
7 Brake Lt Curr.: comes on	Brake Lamp Current	Current level at which lamp
8 Power Svr. Pot: potentiometer	Power Saver Potentiometer	value of power saver
9 Pedal MaxBrake: Maximum Brake	Maximum Brake	% of pedal movement for
10 Power Svr. Min	Power Saver Minimum	Drive motor Current
11 Pedal Brake : Brake	Brake	% of pedal movement for
12 Power Svr. Max:	Power Saver Maximum	Drive motor Current
13 Pedal Accel : Acceleration	Acceleration	% of pedal movement for
14 Regen Bat Max	Regen Maximum	Drive motor Current
15 Pedal MaxAccel: Max. Acceleration	Maximum Acceleration	% of pedal movement for
16 Shaft Dir.: clockwise	Shaft Direction	1 = clockwise -1 = anti
17 Speed Limiting:	Speed Limiting	
18 Bat. Limiting :	Battery Limiting Margin	
19 Brake Limiting:	Brake Limiting	

20 Vel. Damp tau :	Acceleration Damp
21 Low Cur. Slip :	Low Current Motor Slip
22 Acc. Damp tau :	Drive Viscosity Constant
23 Slip @ 300 pA:	High Current Motor Slip
24 Damp viscosity:	Drive Damping Viscosity
25 Max Sync. Ind.:	Maximum Synchronization Inductance
26 Id Slew Limit :	Slew Limit
27 Max Leak. Ind.:	Maximum Leakage Inductance
28 Iq Slew Limit :	Slew Limit
29 50% Ind. Cur. :	Induction Current
30 Dq Slew Limit	Slew Limit
31 Configuration#:	Configuration Number
32 Eff IGBT Res :	Efficient IGBT Resistance

Appendix L

Crimping

Preventive Maintenance

Damaged connectors, contacts and cables may present hazards, resulting in inefficient battery and charger operation. To avoid these problems, conduct the following maintenance checks at least once annually. When you see a problem, *take corrective action immediately*.

1. Dirty Connectors

When engaged and disengaged, the crown contact surfaces of Anderson SB Connectors "over wipe," thus providing a self-cleaning action. To ensure the continued benefit of this feature, clean the contact surfaces and lubricate the connector. Use a "white" lithium grease, which may be obtained from hardware stores and automotive parts suppliers.

2. Melting Connectors

Connector housings overheat and melt for many reasons. To prevent this:

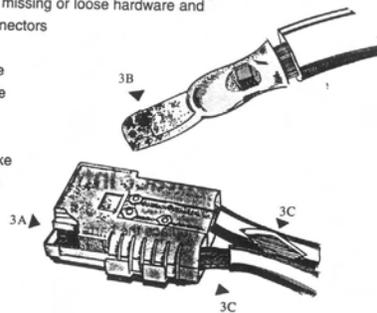
- A. Examine the crimp between cable and contact. Improper crimping, corrosion, and broken wires result in unnecessary resistance causing the contact to heat up like a toaster.
- B. Check contact crown surfaces for signs of "pitting" caused by dirt or disengaging connectors under load. One badly pitted contact, particularly in a connector attached to a battery charger, can lead to pitting on crown surfaces of other contacts. If not corrected, this can result in an epidemic of bad connectors throughout a fleet of electric vehicles and in chargers and batteries.
- C. Check to see if batteries are being disconnected while the charger is still on. This causes the contacts to arc at the tips, with progressive pitting and silver removal from tip to crown. If this practice is occurring, discontinue it now to avoid major repairs in the future.

3. Other Conditions

If any of the following conditions exist, the connector housing, contact and/or cable should be replaced immediately.

- A. **Housing:** Cracks, missing pieces, evidence of excessive heat, discoloration.
- B. **Contacts:** Pitting, burns, corrosion, excessive wear, cracked crimp barrels, discoloration
- C. **Cable:** Exposed copper near housing, cracked cable, peeling or frayed insulation
- D. **Handles:** Loose attachment and such signs of damage as missing or loose hardware and cracked or broken plastic (Handles should be used for connectors that are hard to reach or move.)
- E. **Cable Clamps:** Loose attachments, signs of abraded cable jacket, missing or loose hardware. (Cable clamps should be used to relieve strain on unmounted cable.)

NOTE: See the enclosed connector maintenance checklist. Make copies to have a supply whenever maintenance procedures are conducted.



Crimping

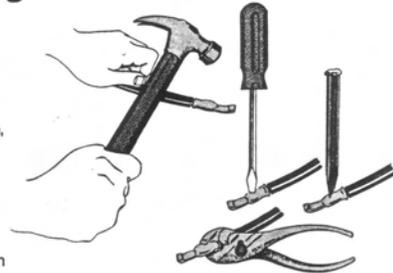
Connector Crimping & Soldering

3. Crimping

The best preparation will be defeated if inadequate tools or improper crimping procedures are employed. Never use a hammer and chisel or the "squeeze-in-a-vise" method. They won't do the job, and will lead directly to substantial reduction in connector life.

Use a crimping tool. It effectively compresses the contact barrel tightly around the cable strands so that all of them are pressed tightly against each other and the inside wall of the contact barrel. Doing this requires that the stripped cable be inserted all the way into the barrel of the contact, and that the contact point is centered in the crimping tool.

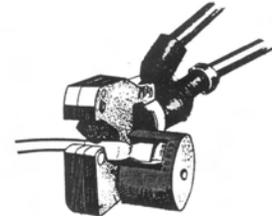
When the crimp has been completed, check the appearance of the contact. A properly crimped contact barrel is compacted tightly with the outer strands. The outer strands on an improperly crimped barrel will be loose and will not have adequate clamping force. Test for low pull-out force by giving the cable a tug. If the cable can be loosened, recrimp until it is tight.



Properly Crimped



Improperly Crimped
(Contains air pockets)



Pneumatic Crimp

4. Soldering

The alternative to crimping is to solder all cable strands within the contact barrel. The right proportion of solder is essential if this procedure is employed. Use a quality 60/40 solder (60 percent tin, 40 percent lead) in wire form with a rosin flux core. Cable strands should be separately fluxed with rosin paste, and the contact should be held in a vise with the barrel entrance facing up. Apply heat to the outside of the barrel while the solder flows in beside the wire strands.

Here are some things to avoid when soldering.

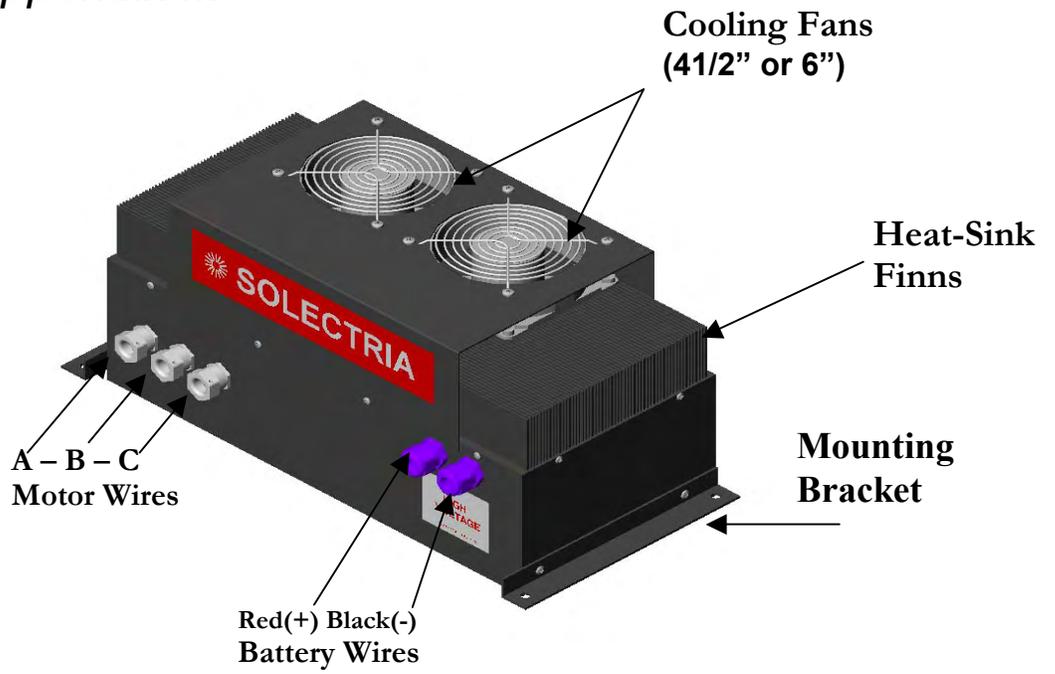
- A. Don't use too much solder- to the point that it flows out of the contact barrel.
- B. Don't allow flux or solder on the outside of the contact. This will interfere with contact mounting within the installation or with the contact connection to a mating connector.
- C. Don't overheat and cause excessive solder to "wick" up into the cable and stiffen it. This could interfere with contact flexibility when connectors are mated.
- D. Don't solder when contact is in the connector housing. Solder away from the housing and then insert the contact into the housing.

NOTE: Underwriters Laboratories (UL) requires the use of a cable clamp for soldered connections to unsupported leads.

5. Inserting Contact into Housing

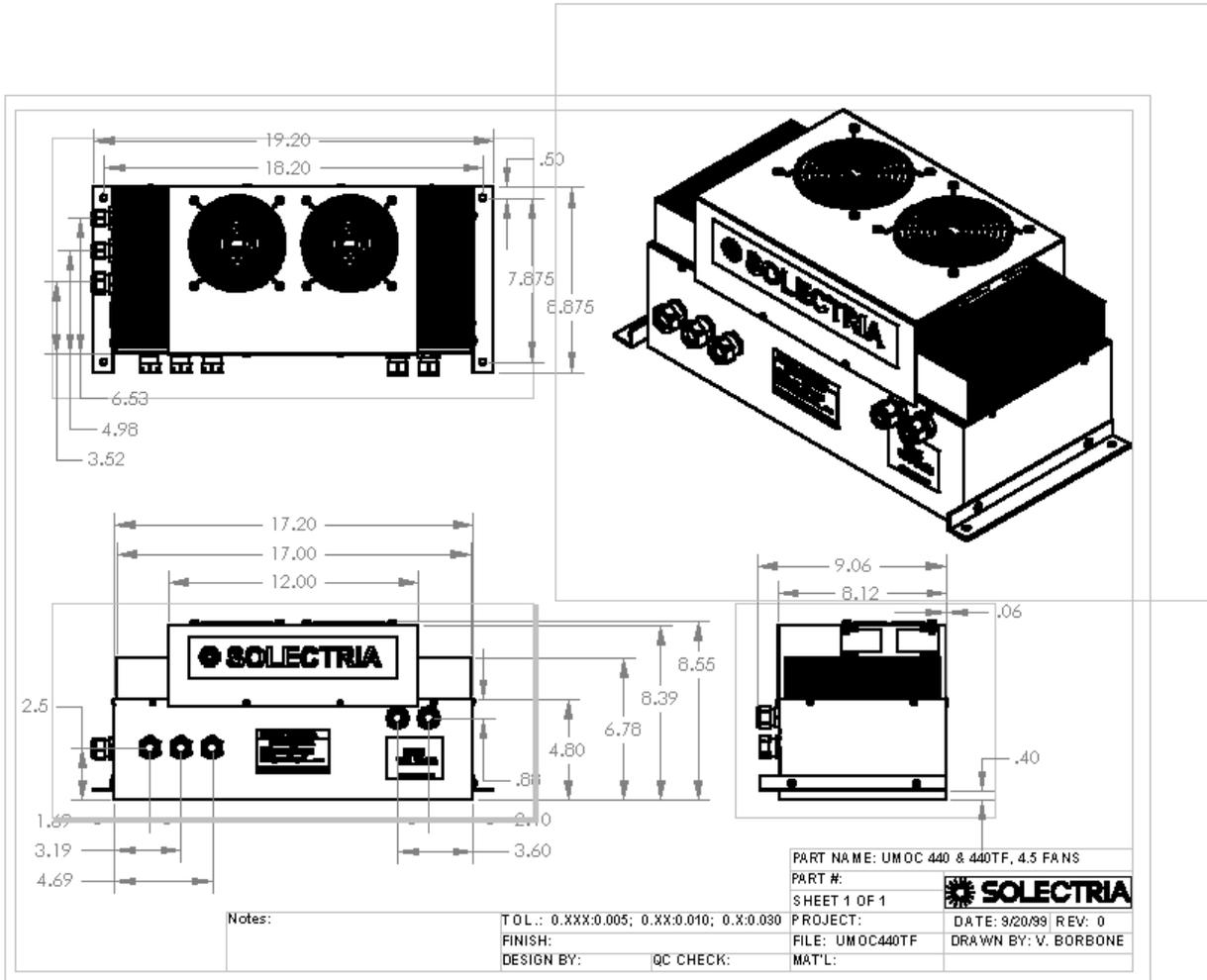
Contacts should never be forced into housing. If the contact does not fit easily, check the contact barrel for distortion. Replace the barrel if it is distorted or shows signs of wear or damage.

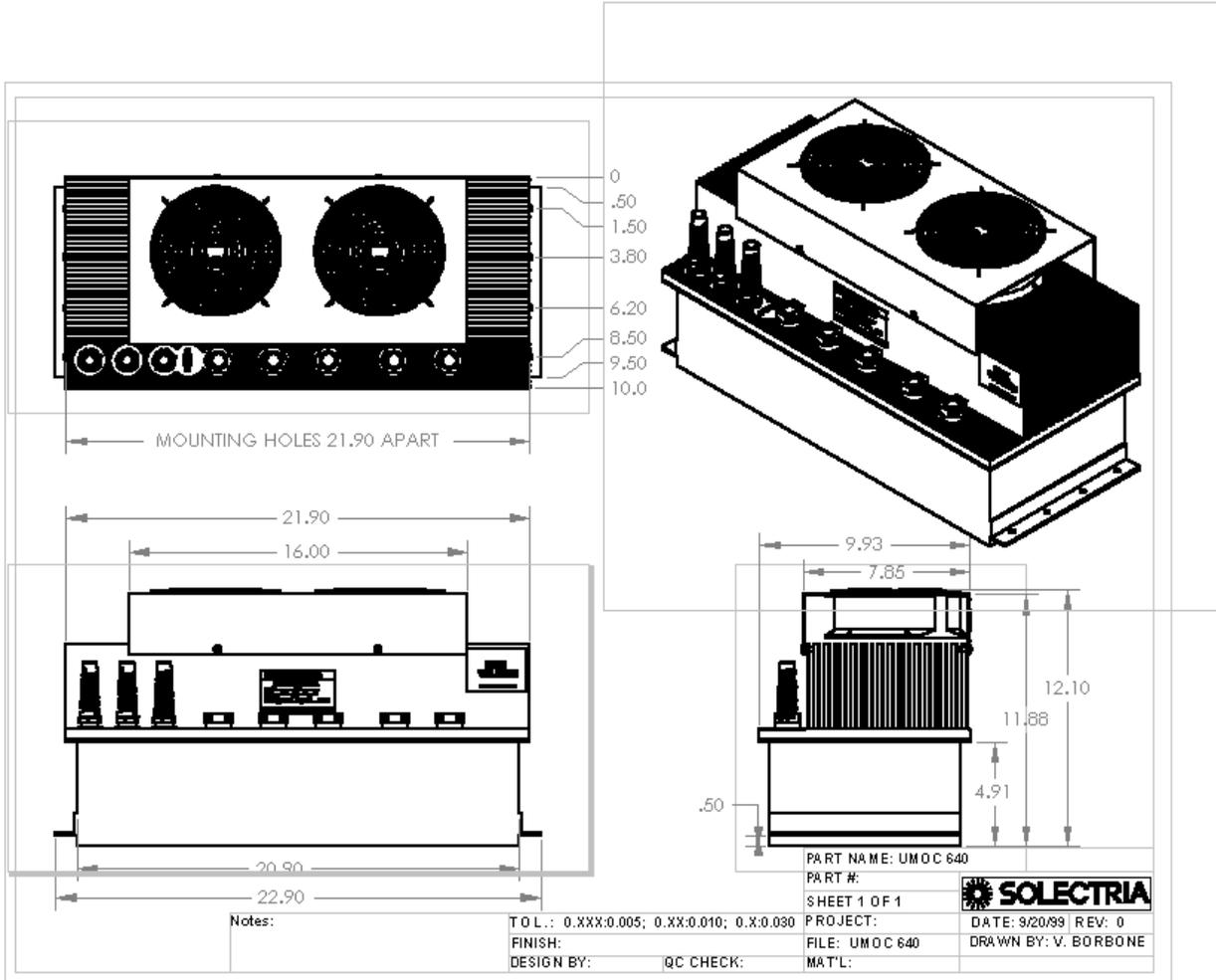
Appendix M



UMOC 440TF

Appendix N





Index

Index

- “low battery” light, 98*
- “PEDAL ERROR”, 87*
- “PEDAL FAULT”, 87*
- 12-Volt power, 34, 82, 84*
- 12-Volt Power, 34, 35, 36, 82, 83*
- 24-volt electrical systems, 36*
- 25-pin cable, 31, 32, 34, 35, 64, 84, 86, 90, 91, 92*
- 25-Pin Ignition Box and Driver Console Connections, 31*
- 9-pin, 52, 124*
- A/D value, 89*
- acceleration, 23, 48, 78, 88, 89, 91, 112, 113, 114*
- accelerator pedal, 14, 15, 41, 67, 87, 88, 89, 96, 97, 114*
- accessory kit, 14, 20, 39*
- Airflow, 22*
- Appendices,**
127
- auto programming, 56*
- Back-up Lights, 39*
- Banner is garbled, 86**
- banner line, 55, 56, 73, 77, 79, 85, 86*
- battery box, 45*
- Battery cables, 45*
- Battery Capacity, 47*
- Battery full, 100, 112*
- Battery Indicators, 63*
- battery plug, 46, 61, 65*
- battery terminals, 45, 49, 50*
- battery voltage, 36, 41, 42, 47, 49, 60, 61, 66, 76, 82, 87, 96, 97, 98, 99*
- Battery Voltage, 61, 66, 82*
- Battery voltages, 47*
- Battery Voltages, 49, 51*
- brake lights, 39, 40, 41, 65, 85, 109*
- Brake Lights, 41*
- Brake lights cycle, 65*
- Brake lights stay on all the time, 109*
- Brownouts, 37*
- build date, 55, 79, 85*
- Cable adapters, 60**
- Cable Types, 53*
- Cable/Loop-Back Test, 72*
- capacitors, 65, 66*
- Capacitors Pre-Charge is Complete, 65*
- Caps Lock, 76*
- CAPS LOCK. See . See*
- Charger disable, 92*
- Checking condition of cables and plugs, 124*
- Checking the pedal pot, 110*
- Choosing Parameters, 75*
- cleaning, 101, 124*
- Cleaning, 124*
- Closing the UMOC’s Contact, 66*
- Color, 52, 103*
- Communications Software, 54*
- Comparing Parameter files, 56*

- configuration number, 56, 57, 74, 79, 85*
- Configuration Number Equals Zero, 74*
- Connecting a Test Box.** *See*
- Connecting Your Battery Pack to Your UMOC, 41*
- Connecting your computer, 72*
- Connecting Your Motor to Your UMOC, 22*
- Connecting Your UMOC to Your Motor, 28*
- connections, 10, 14, 16, 22, 27, 35, 41, 44, 46, 49, 51, 53, 67, 88, 93, 107*
- Connector Tips, 27, 51*
- console, 15, 28, 31, 34, 35, 66, 69, 82, 84, 90, 91, 92, 100*
- Contact Does Not Close, 66*
- contactor will not close, 90*
- Control loop, 113*
- Controller, v, 95*
- Cooling air, 20*
- Cooling fan, 83*
- Cooling Fan Operation, 80*
- Copying Parameters, 56*
- crimping connector tips, 27*
- Current capacity, 39*
- Current Shunts, 51*
- Damage, 21, 48, 64, 100*
- Data Logging, 70, 79*
- delta-wye, 92*
- DESAT, 102, 106*
- Diagnosing Faults, 77*
- Direct Connection, 40*
- Direction Labels, 67*
- direction selector, 66, 84, 89, 107*
- Direction switch, 90*
- Discharging a battery, 98*
- Drive System Performance, 57*
- Drive-disable function, 92**
- Dual cables, 69**
- Dual Drive Systems with Console, 33*
- Dual Serial Ports, 69*
- Dual Windows, 69*
- Dual-drive systems with direction switch error, 90*
- Ductwork, 21*
- Electrical, 12, 88*
- Encoder, 26, 67**
- encoder cable, 26, 36*
- encoder connections, 67*
- Environmental, 18*
- Error PAL, 102, 104, 105, 107*
- Error PAL: OK, 107*
- Excessive cycling of relay, 101*
- External Fans and Blowers, 21*
- Fail Safe function, 37*
- fail-safe function, 37, 100*
- Fan power cycle, 65*
- Fans Not Running, 82*
- Fans run constantly, 85*
- fault diagnosis, 25, 60, 77, 86*

Fault Diagnosis,

81

*Faults related to speed
sensor cable, 93*

*Faults Related to
Temperature, 95*

Fuses, 40

Fusing, 49

G-force limit, 101

ground test, 103

Grounded stator, 103

*grounding, 22, 26, 35, 36,
95*

*Grounding, 25, 26, 53, 94
heat-sink temperature, 80,
82, 95*

Hybrid Vehicle Owners, 19

HyperTerminal, 16, 25, 54

*Identification of thermal
damage, 103*

*ignition box, 28, 31, 32, 35,
66, 82, 84, 86, 90, 92, 99,
100, 110, 111*

incandescent lamps, 40

Index, 150

Induction motor, 115

Initial driving, 97

*installation, 17, 23, 24, 27,
31, 34, 41, 50, 55, 67, 75,
80, 100, 124*

Installation, 10, 13, 54

Interconnects, 49

interface box, 14, 15

Interface Kit, 15

Internal damage, 102

*Internal DC-DC Converter,
38*

IPM fault, 102

junction box, 102, 103

Keyed, 61

keyed 12-volts, 37, 61, 62

leakage current, 82

LED, 40, 62, 100, 105

Limits to torque, 99, 108

*Limits to Torque, 78, 87, 94,
96*

*Limits to torque and battery
indicators, 99*

*long-term memory, 56, 57,
74, 75, 76*

Low battery indication, 98

Maintenance, 123

Mechanical, 89

*Miscellaneous problems,
109*

*model number, 55, 65, 79,
85*

Moisture, 100

*Monitoring the User Data
Screen, 68*

*motor, v, 14, 15, 22, 23, 24,
25, 26, 27, 28, 29, 31, 34,
35, 36, 37, 42, 48, 49, 51,
55, 60, 62, 64, 67, 68, 76,
78, 82, 85, 86, 87, 90, 92,
93, 94, 95, 96, 98, 100,
102, 103, 104, 105, 106,
107, 108, 109, 112, 114,
115, 116, 124*

*Motor, v, 22, 23, 24, 25, 48,
60, 67, 78, 93, 94, 96, 102,
103*

Motor Cooling

Requirements, 22

Motor currents, 48

motor heating, 48

- Motor operates but then shuts down, 108*
- Motor Over-Heating, 78*
- Motor Power Wires, 24*
- motor shaft, 67, 93*
- Motor short-circuited, 102*
- Motor Spin Test, 67*
- Motor temperature sensor, 94*
- Motor turns very slowly, 107*
- mounting, 17, 26, 34, 40*
- Mounting, 18*
- nameplate, 51, 55, 103, 106*
- neutral interlock, 66*
- No communications, 85*
- No Communications, 79*
- No rpm indication, 108*
- null-modem, 53, 60, 73*
- Observing Your Vehicles**
- Diagnostics, 62**
- On-charge voltage, 60*
- operation, 6, 17, 24, 27, 34, 35, 37, 42, 55, 57, 60, 62, 64, 66, 67, 68, 69, 75, 76, 78, 80, 85, 86, 87, 88, 89, 90, 91, 92, 94, 95, 98, 99, 101, 102, 105*
- Operation is not smooth, 109*
- Other causes, 112*
- Overcooling, 23*
- Over-current error, 106*
- Over-voltage, 97, 107*
- Parameter Screen, 73*
- Parameters, 74, 75, 99*
- Passwords, 76, 77*
- Pedal and linkage design, 114*
- pedal error, 88*
- Pedal error, 87*
- Pedal settings, 75, 116*
- pedal settings for dual-drive systems, 116*
- Phasing, 24, 25, 68*
- Plugs exchanged, 85*
- polarity, 39, 44, 48*
- Polarity, 48*
- potentiometer, 89, 110, 111, 114*
- Power, 21, 24, 35, 37, 48, 65, 77, 87, 99, 101, 102, 105*
- Power on self-test, 65*
- Power stage fault, 101*
- power switch, 66*
- Power-on self-test, 105*
- pre-charge delay, 64, 65*
- Processor fault, 85*
- Protector Cap, 52*
- reduced power, 23*
- regen brake lights, 109*
- Regeneration at low rpm, 113*
- Regeneration Disable, 78*
- Relay Connection, 40*
- Relay fault, 100, 101*
- Relay off, 90*
- replacement unit, 10, 55, 56, 106*
- Replacement Unit, 54*
- Rpm, 115*
- RPM indication, 93*
- RS-232, 54*
- RS-485, 54*
- safety, 6, 11, 12, 16, 37, 41, 44, 48, 50, 67, 88, 89, 90, 100, 101, 107*
- Safety Precautions, 44*
- Saving and rebooting, 56*
- Sequence of Power-Up, 65*

- serial data port*, 52, 72, 76, 79, 86
- Serial Data Port*, 52
- Serial Port Cable*, 53
- Shaft direction***, 25, 67
- Shaft Direction*, 25
- Shielding*, 53
- Shipping Carton*, 15
- silver plating*, 28, 51
- Single-Drive / Ignition Box Systems*, 32
- Smell*, 103
- Smoothness*, 78
- Software Parameters*, 55
- Software settings*, 73
- Soldering*, 28, 51
- solid-state relays*, 39, 40
- speed sensor cable*, 93, 94
- speedometer*, 6, 78
- Speedometer Calibration*, 78
- Splicing Wires*, 27
- Status light***, 63
- Subminiature D connectors*, 124
- Symptoms*, 83, 112
- System Requirements*, 14
- Systems Check*, 10, 59
- test box*, 34, 61, 62, 63, 64, 66, 67, 84, 86, 90, 92
- Test box*, 84
- Test Box Switch***
 - Settings*, 64
- Test Drive***, 71
- test light*, 82, 83
- Testing Dual drive systems*, 69
- Tests complete*, 65
- the user data screen*, 25, 61, 66, 67, 68, 70, 73, 76, 77, 78, 79, 80, 86, 87, 89, 93, 94, 95, 96, 98, 99, 100, 101, 104, 108
- Tire pressure*, 113
- Tools*, 16
- Tri-Power selector*, 48
- Types of batteries*, 47
- Types of Errors*, 105
- Under-voltage*, 98
- user data screen*, 73, 76, 77, 86, 107
- User Data screen*, 73
- vibration mounts*, 17, 19, 20
- Vibration mounts*, 26
- Vibration Mounts*, 19
- Vibrations*, 111
- Voltage bus error*, 66
- Voltage range for 12-volt power*, 36
- Voltage ratings*, 41
- voltmeter*, 45, 48, 61, 82, 98
- warranty*, v, 15, 17, 18, 21, 46, 48, 64, 100
- Warranty***, 119, 120
- water*, 18, 22, 45, 124
- water-cooled motors*, 22