

*Electric Vehicle  
Troubleshooting  
& Repair*

*Automotive  
Mechanic  
Training*

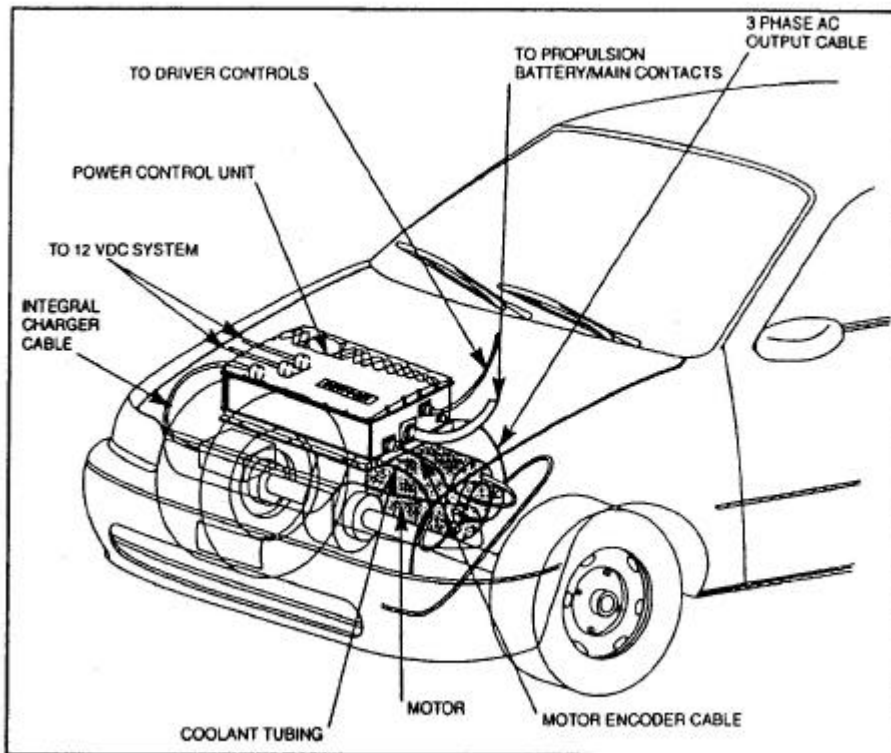
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## Drive System Components

### Diagram

The diagram below shows an overview of the system components.



**System Components**

## Drive System Components

### PCU Purpose

The purpose of the power control unit (PCU) is to:

- Converts direct current into vector controlled alternating current signal which controls the vehicles speed and direction
- Provides accessory power
- Charges accessory battery
- Charges battery pack (via integral charger)

### PCU Components

The PCU contains the following components:

- Power inverter (50-kilowatt, three-phase AC output)
- DC/DC Converter (Accessory power supply)
- Integral charger

The *power inverter* converts high voltage DC into three-phase AC power for the motor.

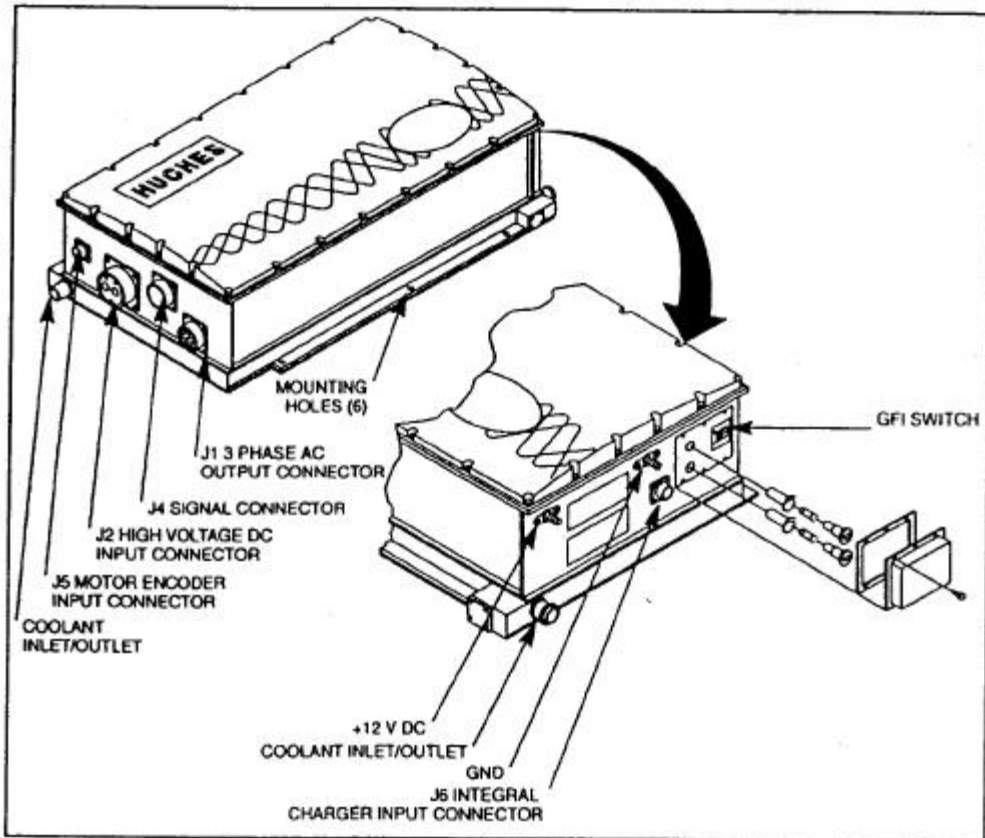
The DC/DC *converter* provides a charge for the 12 volt auxiliary battery and also provides accessory power when the vehicle Vs motoring or charging.

*The integral charger* charges the vehicle's battery pack and is compatible with 1101220 VC single-phase 20 amp service.

## Drive System Components

### PCU Diagram

The diagram below shows the detail of the PCU connections.



**Power Control Unit**

## Drive System Components

### Motor

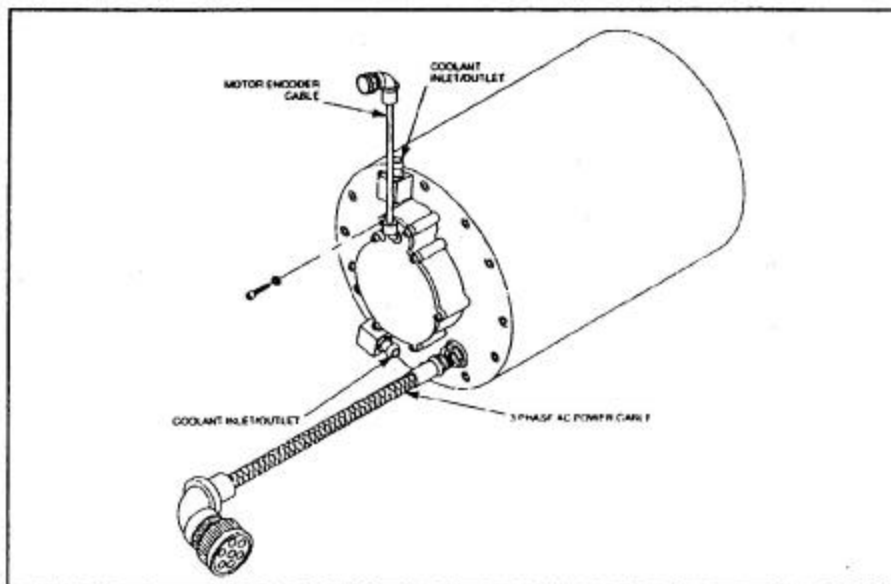
The motor is a three-phase AC induction traction motor. The traction motor can be coupled to a standard transmission that is fixed in second gear. The motor is electronically tuned to the output of the power inverter of the PCU, increasing the power transfer to the road.

Attached to the motor for control are the:

- Motor encoder
- Motor encoder cable

The *motor encoder*, located in the motor housing, monitors the rotation of the motor spindle. The encoder translates the rotation of the motor spindle into electrical impulses and is relayed through the motor encoder cable to the PCU. Then the PCU calculates the motor speed from electrical impulses.

The 5 volt *motor encoder cable* carries motor speed information and motor temperature information to the PCU. The temperature signal voltage is between 0 and 5 volts and is in direct relationship to the temperature of the motor.



Motor

## **Interface Junction Box**

### **Overview**

The interface junction box is the communications medium between the vehicle and the PCU. The wires from the terminal blocks inside the interface junction box connect to the PCU through the J4 connector.

It is also used for the computer connection when computer diagnostics are used. (it uses a nine pin RS32 computer interface.)

### **Diagram**

Refer to the fold-out wiring diagram included in this section for a layout of the components of the interface junction box.





## Interface Junction Box

### Explanation

The junction box contains:

- 12 volt grounding block ( grounds electronics in the box)
- 12 volt terminal block (provides 12 volts to the relays and any other necessary feeds)
- Four relays (water pump, fan, reverse lights, and ignition)
- State of charge and temperature interface (provides information to the dash)
- PRND2L interface (tells what gear the vehicle is in)
- 24 terminal blocks (send and receive information - see list below for explanation.

### *Terminal Block Explanations*

- 1 . *Key on* - senses if the key is on
- 2--5. PRND2L - indicates what gear the vehicle is in
6. CP (option) Receives information from the Charge port assembly - indicating connection present (CP)
7. *Batt Soc* - receives battery charge information from the SOC (State of Charge) Interface
8. *Temp* - receives temperature information from the engine coolant temperature (ECT) interface
9. *Ready* - sends ready signal to the dash indicating the vehicle is ready to drive

## Interface Junction Box

### Explanation

### *Terminal Block Explanations (continued)*

10. *Charge complete* - sends charging signal to the dash when charging is complete (blinking while charging and solid when done)
11. *Fault* - sends fault signal to the dash
12. *Brake Ped (Wiper)* - variable resistance output from the brake pedal
13. *Regen - (limit)* - not used at this time (regen limit is now pre-set in the PCU)
14. *Cooling* - turns on the water pump when charging or driving
15. *Fan* - turns on the fan when the PCU senses over temperature of the PCU or motor
16. *Agnd* - used as a grounding point
17. *Dsp Ser Out* - digital signal processor serial output output connector from the interface junction box and the laptop computer
18. *Dsp Ser In* - digital signal processor serial input input connector the laptop computer to the interface junction box
19. *P 12v Bat* - internal 12 volt supply for the PCU
20. *Pot +5 Pwr* - 5 volt power supply for the accelerator pots
21. *Pot Rtn* - return circuit from the accelerator pot
22. *Accel 0* - variable resistance output from one of two accelerator pots
23. *Acel I* - variable resistance output from the other accelerator\_pot

## 61 Pin Interface

### Overview

The chart below shows the connection between the 61 PCU connections and the 23 interface junction connections.

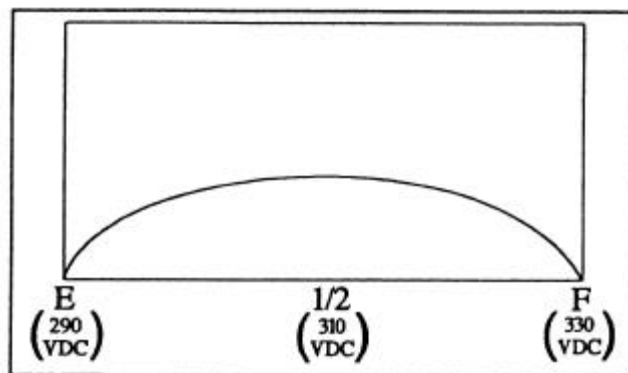
61 Pin Letter	Terminal	Wire Color	Circuit
A	1	Orange	Key on 12 Volt
B	2	Blue/Red	PRNDL A
C	3	Green/White	PRNDL B
D	4	White	PRNDL C
E	5	Green	PRNDL P
K *K	6 16	Orange/Red	Charge Port *No Charge Port
P	16	Wh/Grn/Brn	Mstr-Disc
R	7	Red/Black	Soc
S	8	Red/Green	Temperature
V	9	Wh/Red/Blk	Ready
W	10	Wh/Red/Org	Charge Complete
Y	11	Wh/Brn/Blue	Fault
BB	12	Org/Blk/Wht	Regen Pot
CC	13	Red/Blk/Grn	Brake Limit Switch
EE	Loop to FF	Blue/Org/Wht	Aux Lockout
FF	Loop to EE	Org/Blk/Grn	Aux Lockout
d	14	Blue	Water Pump
e	15	Blue/White	Fan
i	16	Black	Ground
j	16	Blk/Red/Wht	Ground
k	16	Blk/Red/Grn	Ground
m	16	Blk/Org/Wht	Ground
n	17	White/Black	Dsp-Ser-Out
q	18	White/Red	Dsp-Ser-In
v	19	Red	Batt 12 V
w	20	Red/White	Pot 5V
x	21	Black/White	Pot 5V RTN
y	22	Orange/Black	Accel 0
z	23	Orange/Green	Accel 1

## State of Charge Gauge

**Overview** The state of charge gauge indicate the voltage of the main battery pack. The state of charge is powered by the PCU.

**Explanation** Positive voltage is sent from Pin R of the 61 Pin PCU connector to Pin 7 of the interface junction box. This voltage ranges from 0.7 volts DC (empty) to 3.5 volts DC (full). This voltage is controlled by a counter in the PCU which ranges from 0 to 29,490. (The counter can be checked in DOLCOM.)

The voltage is then amplified to match the original equipment of the manufacturer.



**State of Charge Gauge**

## **Battery Pack**

**Overview**                      The battery pack is used power the vehicle. It is the vehicle's fuel supply.

**Explanation**                      The battery pack contains fifty-two 12 volt batteries which are wired in two parallel strings each containing 26 batteries in series. The total nominal voltage is 312. The total usable energy capacity is approximately 18 Kwh.

The most positive point of each string of batteries is at the main contractor and the most negative point (common negative) of the battery back is at the 300 amp fuse.

**Diagrams**                      Refer to the following pages for a diagram of the top and bottom layers of batteries. There is also a side view diagram.

# Battery Pack

## Components

The main battery pack contains the following components:

### *Main Switch*

The main switch separates each series string between battery 1 0 and 1 1 of each string of 26 batteries. (Separates the top stack from the bottom stack.)

### *Fuses*

The main battery pack contains the following fuses:

- 300 amp fuse connected to the common battery negative
- Four 200 amp fuses - one in the upper and lower levels of each series string.
- 10 amp pre-charge fuse
- 15 amp heater fuse

### *Relays*

The main battery pack contains the following relays-

- Two main contactors (relays) connected to the most battery positive of each string
- Auxiliary relay which energizes the two main contactors via a signal from the PCU
- Heater relay attached to the 15 amp heater fuse

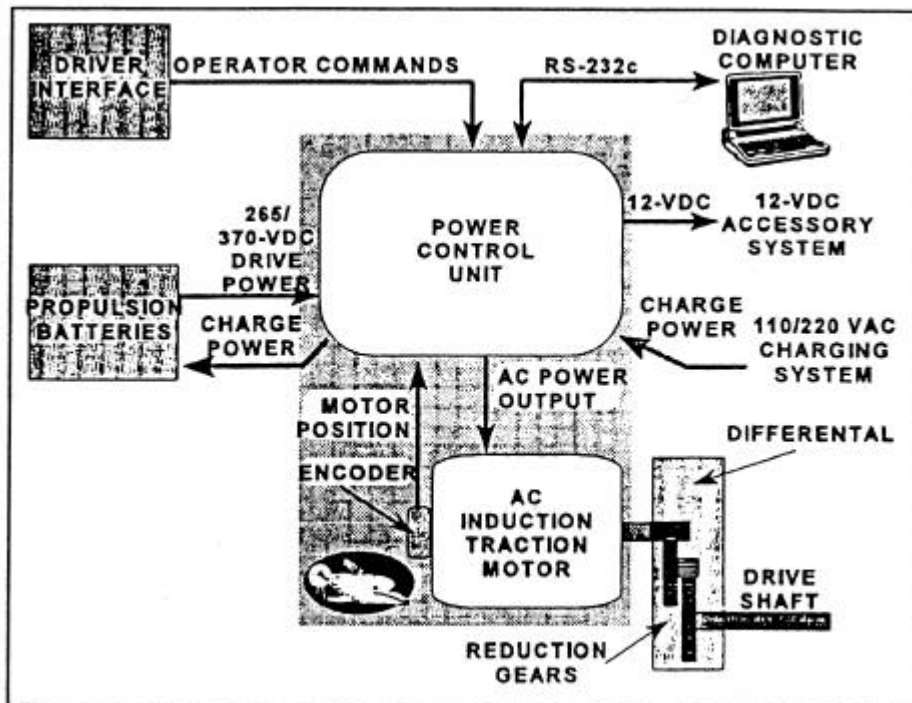
## System Tie-in

### Overview

The diagram below shows how the components tie-in. In addition to the Power Control Unit and Motor, the system also contains the main battery pack and is controlled by driver input. An explanation of each component is on the following page.

### Diagram

The diagram below shows the functional tie-in of all the system components.



System Tie-In

## System Tie-In

### Components

#### *Motor*

The motor connects directly to the transmission differential. It interfaces with the:

- spline differential
- cooling system
- encoder cable assembly to the PCU

#### *Power Control Unit (PCU)*

The PCU is mounted above the motor in the engine compartment. It interfaces with the:

- 12-vdc accessory system
- driver controls (accelerator pedal and instrumentation)
- inductive charge port
- 110/220 volt AC charging system
- battery pack main contacts
- cooling system



## System Tie-in

### Components (continued)

#### *Battery Pack*

The battery pack provides drive power to the PCU. (265 to 370 volts DC, maximum 220 amperes.)

#### *DCI DC Converter*

The DC/DC converter provides +12 volts DC accessory power for the instrumentation, headlights, tail lights, and standard accessories and charges the 12 volt auxiliary battery..

#### *Integral (Conductive) Charging System*

The integral charger within the PCU charges the main battery pack.

#### *Inductive Charging System*

The inductive charging system contains three on-board components:

- charge port - inlet for the off-board charger paddle (converts high frequency AC power from the paddle to DC power for the main battery pack)
- charge controller - computer device that monitors and controls inductive charging
- filter/current sense - senses and filters DC current before it goes to the main battery pack

#### *Driver Controls*

The driver controls the operation of the system through:

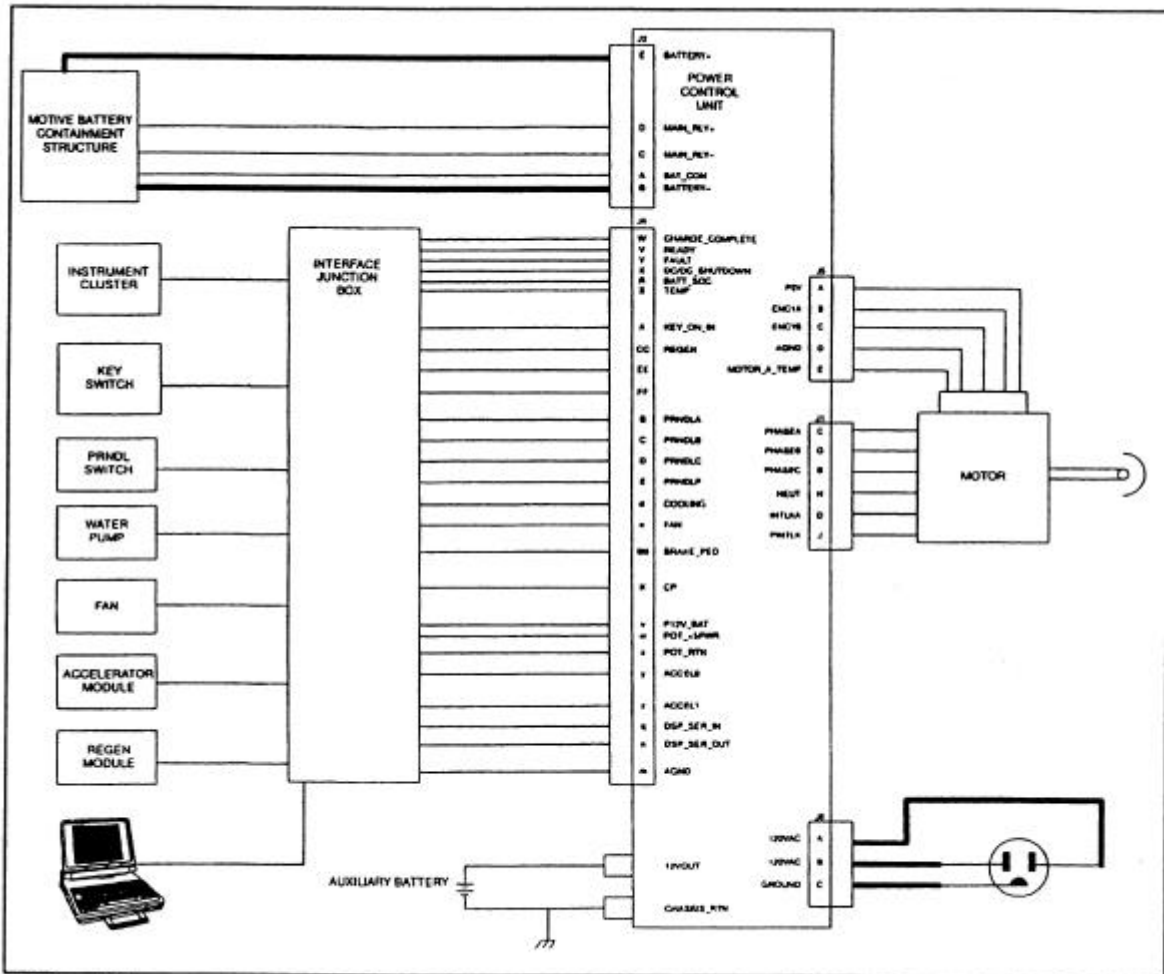
- key position
- accelerator and brake position
- mode selection (forward and reverse drive and charge)

# Drive System Wiring Diagram

**Overview** To understand how the drive system operates, you will need to be able to interpret the wiring diagram.

**Diagram** The diagram below shows the wiring detail of the drive system.

Note: The PCU is sealed and you will **not** be working inside it, but you should have an understanding of how it is wired.



Wiring Diagram

# Cooling System

## Overview

The cooling system cools the motor and the electronic components inside the inverter. When the coolant temperature reaches 115°F the radiator fan will turn on. The system will shut down if the temperature increases to a temperature above 150°F.

The system contains the following components:

- Radiator and Fan
- Pump (12 volt)
- Motor
- Inverter

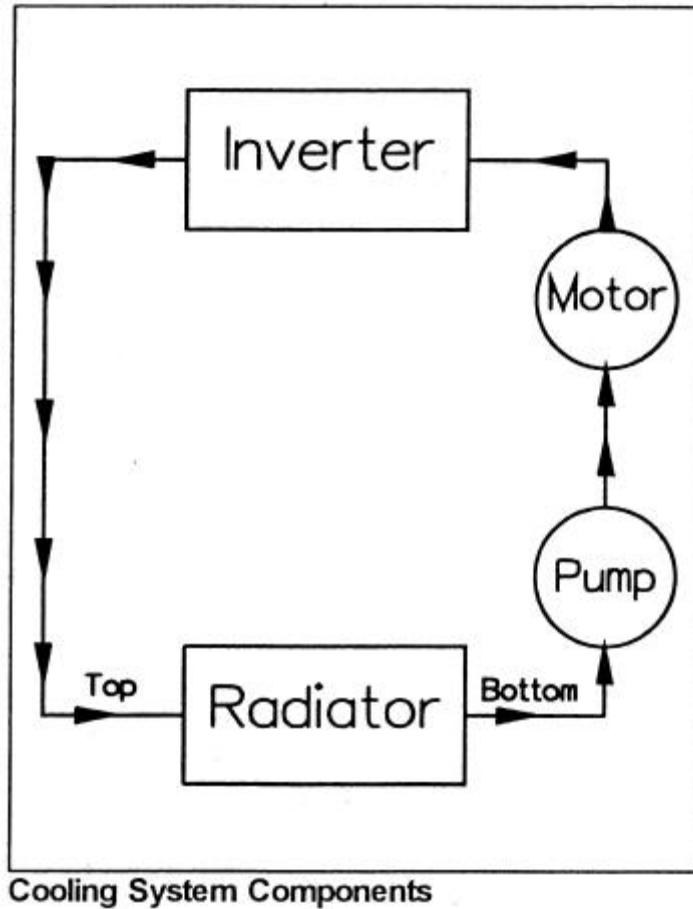
## Explanation

The pump moves the coolant (50/50 solution of water and ethylene glycol based anti-freeze) at a flow rate of 2 gpm. It pumps the coolant from the bottom of the radiator, through the motor and the cold plate on the bottom of the inverter and back to the top of the radiator. The pump will operate during charging and driving, but not during trickle charge mode or before the accelerator pedal is depressed in drive mode.

## Cooling System (continued)

### Diagram

The diagram below shows the relationship of the cooling system components.



# Safety

## Overview

When performing maintenance on electric vehicles it is extremely important to follow all safety precautions. Since the vehicles are powered with two parallel strings of twenty-six 12 volt batteries, the vehicles have nominal voltage of 312 volts. Severe injury or death could result in an electrical shock.

When working on electric vehicles, remove all rings, metal watches, metal bracelets or loose necklaces to avoid shock.

All clothing worn must be 100% natural fiber (cotton, wool, etc.).

## Precautions

Follow the safety precautions as listed below when working on electric vehicles.

1. Turn the key switch and the main battery pack switch to the OFF position.
2. Disconnect the negative auxiliary battery cable when:
  - Removing or installing any electrical unit
  - Tools or equipment could easily come in contact with "live" exposed electrical terminals

### *General Safety Practices*

- Always cover up other batteries when removing a battery. Use rubber mats (without magnets), plexiglass, cardboard or wood
- Do not leave metal tools around the battery packs - they can easily conduct electricity
- Loose terminals can damage the battery (the loose terminals act as a resistor and the heat will cause damage)

## **Safety** (continued)

- Remove the copper bus bars when isolating a battery to
- reduce the voltage
  
- Label all bad batteries when they are removed
  
- When reinstalling the battery connectors, replace all lock washers and install the fuse part of the connector first
  
- Do not steam clean or wash under the hood. The heat and water will damage the electrical components
  
- When working with the main battery pack or the auxiliary battery wear chemical goggles and face shields
  
- Turn off the main battery switch before you disconnect any cables, connectors or components on the vehicle. The main switch should also be turned off whenever removing the main battery pack cover
  
- When removing cables within the battery pack, tape exposed and loose ends with electrical tape
  
- When taking meter readings, be sure not to touch the exposed metal parts of the test leads.

## Starting the Vehicle

**Overview** Starting an electric vehicle is similar to starting a gasoline powered vehicle. Notice in the procedure below the slight differences.

**Procedure** Follow the procedure below to start the vehicle.

<b>ACTION</b>	<b>RESULT</b>
Insert the key into the switch	
Turn key to the on position	<p>The fault indicator will light for five seconds while the diagnostics are being run.</p> <p>Initially, you will hear the power steering pump relay close and then a few seconds later, and if no faults occur, you will hear the main solenoid contacts for the battery click and the ready indicator will light.</p>
Place the vehicle in gear	<p>The temperature gauge will fluctuate from minimum to maximum depending on the load and ambient temperature to which the system is subjected.</p> <p>The temperature indicator will normally stay in the lower half of the gauge.</p> <p>The PCU will shut down when the temperature of the coldplate is greater than 150° F.</p>

## Charging the Vehicle

**Procedure** Follow the procedure below to charge the vehicle.

<b>Action</b>	<b>Result</b>
Ensure the main battery is switched to the on position	<b>Note:</b> Main battery switch should normally be on at all time, except when repairing.
Ensure that the key is in the off position.	<b>Note:</b> The vehicle will not charge if the key is in the ON position.
<b>For Inductive Charging</b>  Insert charge paddle into charge port (Charging will take 3-4 hours)  <b>For Conductive Charging</b>  Plug vehicle into 110/220 volt outlet (use cord supplied with vehicle) (Charging will take 12-16 hours)	Charge indicator blinks during the charge cycle. Charge indicator will be continuously lit when the charging is complete.
<b>For Inductive Charging</b>  Disconnect the charge paddle from the vehicle  <b>For Conductive Charging.</b>  Disconnect 110/220 volt AC single-phase line from charger receptacle.	



## Maintenance Procedures

### Overview

The drive system requires no scheduled maintenance, however, to maintain peak operating efficiency both the coolant and interface cables should be checked regularly.

### Maintenance

Because these items interface with the drive system and affect the system's efficiency, they should be checked as indicated on the schedule below.

<b>Item</b>	<b>Interval</b>	<b>Maintenance</b>
Coolant	Every 2 weeks	Check coolant level and top off with 50/50 water and ethylene glycol based anti-freeze.  Coolant should be replaced every 12 months (Refer to Coolant Replacement Procedure)
Cables	Every 2 months	Perform a visual inspection and replace if needed.

## Parts Numbers

**Overview** When ordering parts, refer to the chart below for the appropriate part number.

**Parts and Numbers** Notice that there are two motor assemblies, one for the prizim and one for the S-1 0 trucks.

<b>Part</b>	<b>Number</b>
PCU	A04601AA0
<b>Motor Assembly (Prizm)</b>	A04731AA0
Motor Encoder with Cable (W14)	A4706AA0
Optical Encoder Module (basic motor only)	HEDT-9100 F00
11 MM Opt Rad Code Wheel (basic motor only)	HEDS-5120F13
Grommet	MS35489-8
Motor Encoder Lid Gasket	A04705FX0
<b>Motor Assembly (S-10 Trucks)</b>	A04731AA0-1
Motor Encoder (W14)	A4706AA0-1
Optical Encoder Module (-1 motor only)	QEDS-5922
Grommet	MS35489-8
Motor Encoder Lid Gasket	A04705FX0