



Electrical Troubleshooting Manual Battery & Drive System

Every MILES Makes A Difference

Table of Contents

Introduction	3	Schematics and Troubleshooting:	
Functional Description of Drive Components	4	110 VAC to 72 VDC Charger	29
Schematics and Testing	17	Charge Controller Board (CCB) and A/C Motor Sensors	31
Testing Procedures & Safety	18	Throttle position Sensor (TPS)	33
Preparations for Testing	20	DC/DC Converter	35
Reading Controller Trouble Codes (DTC's)	21	Key Switch, RKS Relay	37
Pinpoint Test example	23	Interlock Relays & Switches, Vacuum Booster Pump	39
Controller Pinpoint Tests	25	Heater	42
		Appendix-DTs	44

Introduction

This Electrical Troubleshooting Manual is intended to provide the Technician servicing the Miles ZX40ST with all the information needed to diagnose faults in the Electric Drive System.

The Manual contains a functional description of the Miles ZX40ST system followed by notes on schematics, test procedures and most importantly, safety procedures.

These are followed by complete information about the 35 pin Connector at the Curtis Controller and sub-system schematics with troubleshooting charts that will guide you through diagnosis.

PLEASE take time to read the functional description, test procedures and Safety Advisories before getting into specific test procedures on the vehicle. Reading the functional description will provide an over-all understanding of the drive system which will make your diagnostic tests make sense and shorten the time needed for testing.

Never attempt to perform tests if you do not understand what you are doing and which circuit you are testing. If you have any questions about this manual or any of its procedures, be sure to contact Technical Support at Miles Electric Vehicles!

Above all, Practice Safety at all times! Never work on wet floors or a wet vehicle. Road Salt, mixed with water, is an electrolyte that will amplify the effect of any contact with any of the electrical systems aboard the ZX40ST. Only perform diagnosis or repair in a clean, dry well lit shop. Only work on a clean, dry vehicle.

We are confident that once you have studied this manual and carried out some tests, you will understand the system and will master the diagnostic skills needed to quickly and efficiently service this vehicle.

Good Luck!

Miles Electric Vehicles

Drive Components Functional Description

- The Miles ZX40 ST Pickup is a NEV (Neighborhood Electric Vehicle) featuring a 72 volt drive system operating a three phase induction AV motor/generator which drives the vehicle through a conventional transmission.
- Since the ZX40 ST is based on a conventional gasoline powered vehicle, the three/phase induction motor/generator is mounted in place of the gasoline engine and is coupled to the transmission using a direct shaft coupling. A clutch is not necessary. The transmission is locked into second gear and the shift selector has been removed during manufacture. Reverse is achieved by simply reversing the direction of the motor/generator.
- Since the electric motor is capable of producing its full rated torque from 0 RPM to its maximum operating speed, no clutch or variable gear ratios are needed to operate this NEV within its rated operating range.
- Regenerative braking, which extends the range of the ZX40ST by converting the vehicle's kinetic energy to electrical energy during braking, is achieved by electronically switching the three phase motor into a three phase generator when the brake pedal is applied. The vehicle also utilizes a vacuum boosted hydraulic/friction brake system to stop the vehicle during braking.

What the servicing Tech needs to remember:

- The most important point to keep in mind when performing diagnostics and repair on the ZX40ST is that it utilizes four separate electrical systems. These four primary systems are:
- The 120 VAC system. This is similar to the fuel hose on a gasoline vehicle. The 120 VAC system extends from where the charging cord is connected at the wall outlet, through the charge receptacle on the vehicle, and on to the Charging Unit located directly under the drivers seat.

The Delta-Q charger, which converts 120 VAC to 72 VDC for the main battery pack



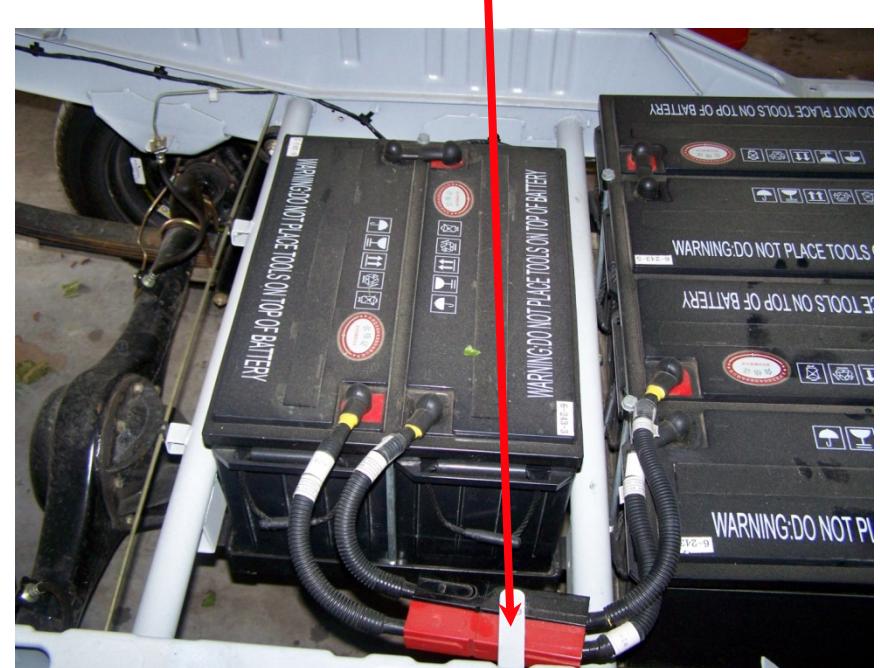
The 72 Volt System

- This is the primary system on the vehicle and provides the energy needed to operate the traction motor. It also accumulates the Generator output when the system is in Regenerative Mode and provides the energy for the Vehicle's Heater Coil. The 72 Volt system consists of 6 large AGM 12V Batteries connected in series and located beneath the payload bed of the vehicle.

The main battery pack, viewed from the Right Side of the vehicle with the payload bed removed.

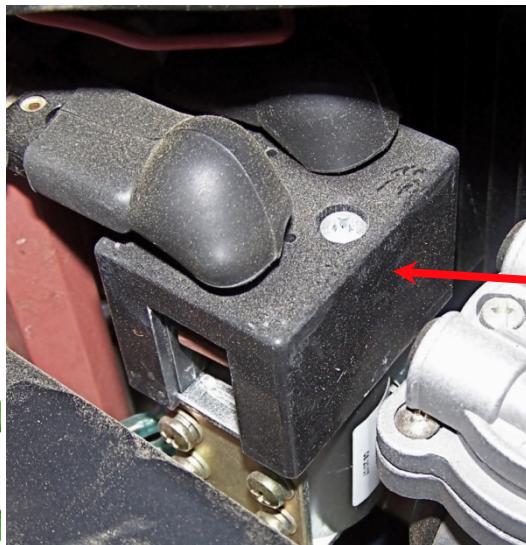
Caution! Note the service disconnects in the foreground. These should be disconnected whenever working on any of the vehicle electrical components. To disconnect, simply pull them apart while wearing HV Gloves & safety glasses

72V Service Disconnects (+ & -)



The 12 Volt Auxiliary System

- The Miles ZX40ST has a conventional 12 VDC electrical system which operates all of the conventional components of the vehicle such as lights, wipers, heater blower, horn, etc. The Auxiliary Battery is located under the driver's seat. Since the ZX40ST does not have a 12V alternator, the Auxiliary Battery's charge is maintained by a DC/DC Converter which steps the 72V from the main batteries down to 13.5 VDC, which will maintain a full charge on the Auxiliary Battery. Besides operating the secondary vehicle systems such as the lights, wipers, etc. the Auxiliary System's most important responsibility is to control the 72V Contactor Relay through operation of the key switch. The Contactor Relay controls the connection between the 72 VDC Battery Pack and the Motor Controller. It is activated by turning the ignition key to the "ON" position. If the Contactor Relay is "OFF", no power is supplied to the Motor Controller and the vehicle will not move.



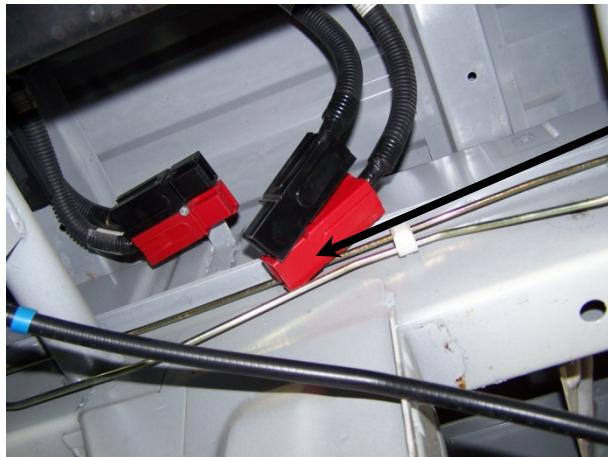
The 12 VDC Auxiliary Battery

The Contactor Relay



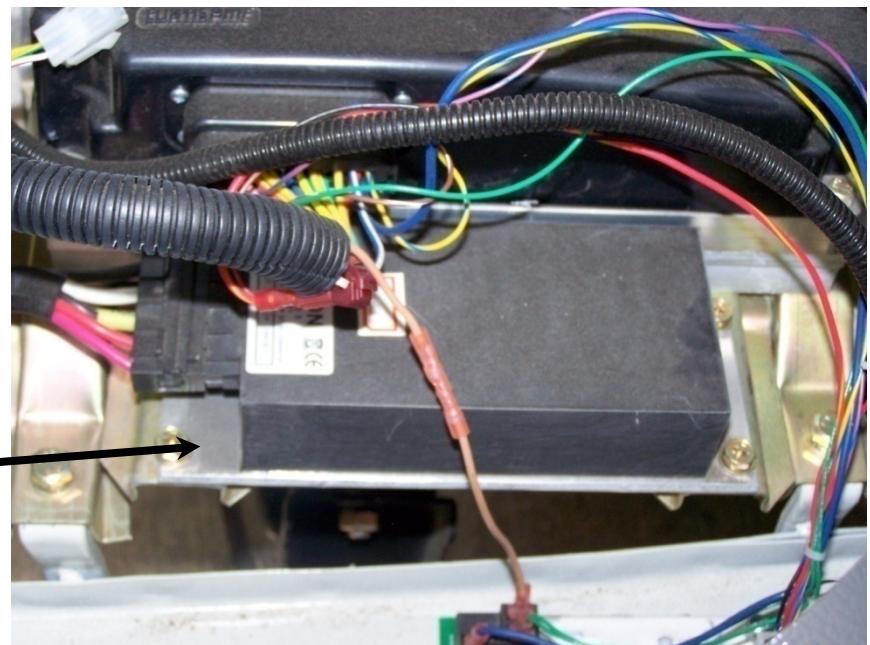
The 12 Volt Auxiliary System

- **IMPORTANT!! The DC/DC Converter is always active as long as the main Battery connectors are connected, the DC/DC converter will supply 13.5 Volts to the vehicle electrical system. For this reason it is important that the 72 VDC main disconnects be disconnected whenever any repair operation which would call for the 12V Aux. Battery to be disconnected is to be performed.**



The Main
Disconnect,
viewed from
below the
vehicle

The DC/DC Converter, under
the Passenger Seat. This
unit is always LIVE unless
the 72V Main Disconnect is
separated!



The 12 VDC Motor Controller System

- This is the heart of the drive system. When accelerating, the Controller converts the DC current from the 72 Volt Main Batteries to three alternating current phases which are then sent to the motor windings. Since the motor speed is not constant, the frequency of the phases must be continuously adjusted by the controller to avoid “Slip” between the electro-magnetic fields in the motor windings and those in the Motor Armature. Phasing is accomplished by the input of dual optical speed/position sensors mounted in the motor itself. During braking, the Controller converts the motor to a generator and rectifies the incoming A/C current back to 72 VDC for charging of batteries. Brake power is determined by the hydraulic pressure in the brake system. Brake hydraulic pressure is converted to an electrical input to the controller by a Brake Pressure Transducer (DC). The Curtis A/C Motor Controller produces its own filtered 12 Volt DC Voltage which is utilized as the reference/power source for all sensors that input into the Motor Controller. This includes the Throttle Potentiometer, Motor Speed Sensors, etc.

The 12 VDC Motor Controller System



The Curtis Motor Controller is located underneath the Passenger Seat. Nearly all testing of the vehicle drive system can be performed here.

The 12 VDC Motor Controller System

It is important for the servicing Technician to remember that the ZX40ST really has two different vehicle grounds:

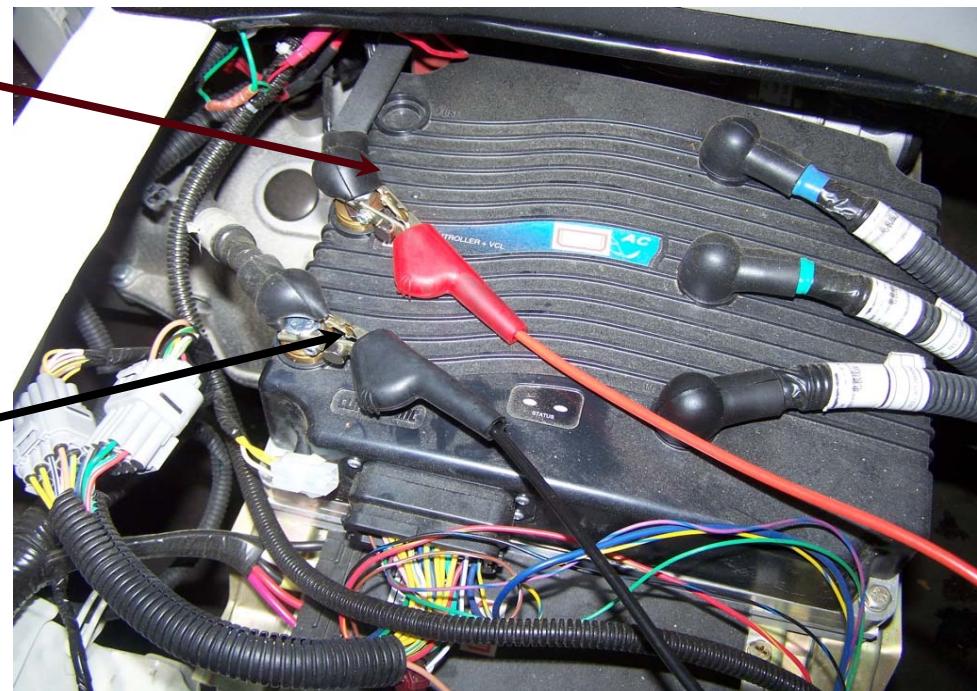
- 1- The Aux. Battery-the Negative terminal of the Auxiliary Battery can be used as a test point for all conventional 13.5V vehicle systems (lighting, horns, etc.)
- 2- For testing any of the drive system sensors or components, the only ground that can be utilized is the B- terminal (72 V) on the Motor Controller, or the reference ground bus, which can be accessed at Pin 7 of the Curtis Motor Controller.

B+ 72V Terminal

Be sure that no voltage is present across the B+ and B- Terminals

of the Controller before performing any repairs to the Drive Components. The B- terminal should be used as a meter ground for all Controller Electrical Tests!

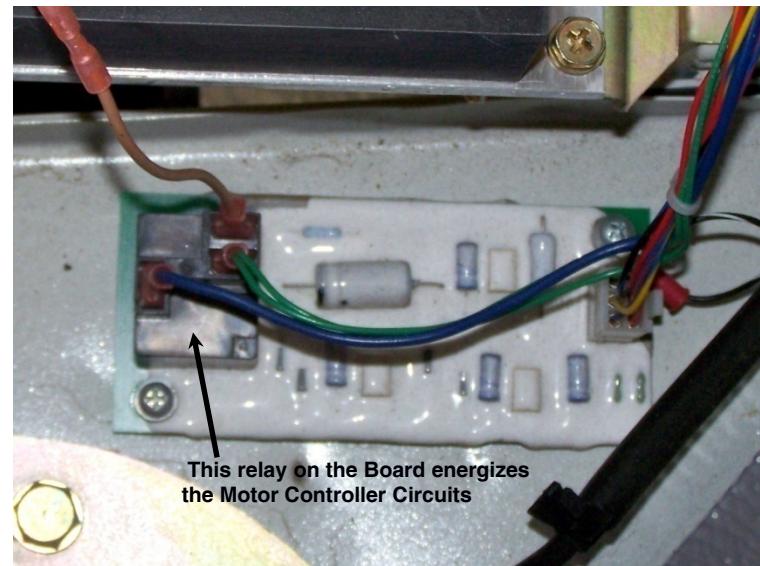
B- (Negative) 72V Terminal



Additional Drive System Components: Battery Charge Controller Board

- The Battery Charge Controller Board receives an input from the Delta-Q Battery Charger whenever the ZX40ST is connected to 120 VAC. When the Controller Board receives this input, it “turns on” the Motor Controller by applying 72 V to the controller. (Note that the Contactor Relay is not energized by this action.) The Motor Controller must be able to monitor the SOC (State of Charge) of the Main Battery Pack during the charging process so it must receive power and have a low current connection to the Battery Pack. The Charge Controller Board serves this purpose.

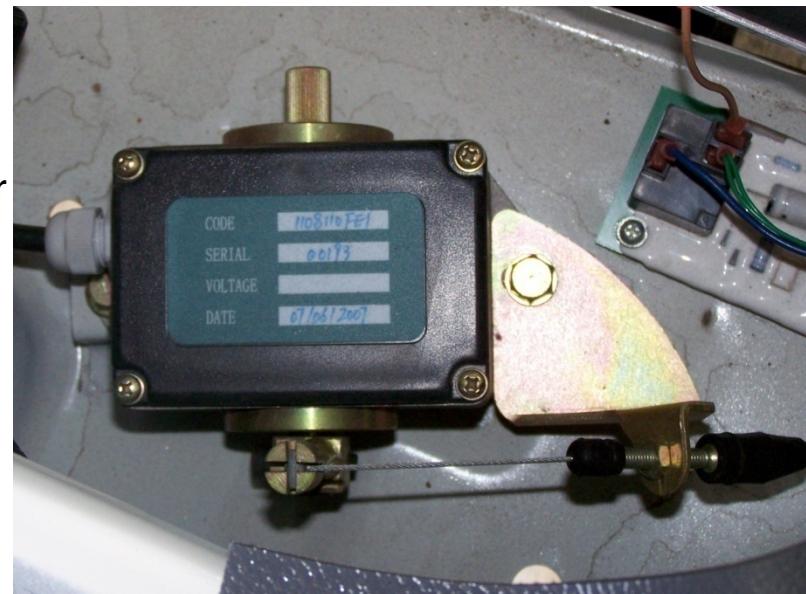
The Battery Charge
Controller Board, just to the
right of the DC/DC Converter



Additional Drive System Components: Throttle Potentiometer

- The Throttle Potentiometer converts the physical position of the accelerator pedal (conveyed by cable) into a variable voltage signal which is sent to the Motor Controller. A simple analog rheostat is used to create the Throttle Signal. The unit also contains a CTP or Closed Throttle Position switch which inputs to the controller whether or not the accelerator pedal is being depressed.

The Throttle Potentiometer, under the Passenger Seat. Cable is connected to the accelerator pedal.



Additional Drive System Components: The Contactor Relay

- The Contactor Relay and Main Fuse. The Contactor isolates the 72 VDC Main Battery Pack from the Motor Controller whenever the Ignition Key is not in the “ON” position. The 500 amp Fuse will blow if excessive current flows through the Contactor Circuit.

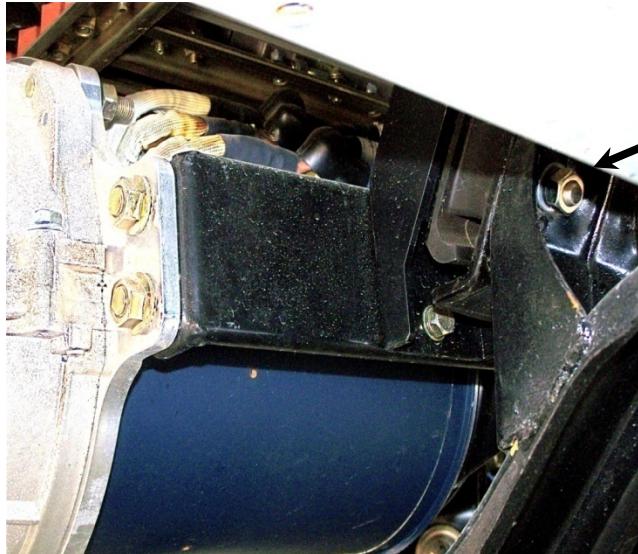
The 500 Amp fuse protects the 72V circuit. The insulated support stud shown here has been removed as part of the TSB.

The Contactor sits directly underneath the E-Brake assembly



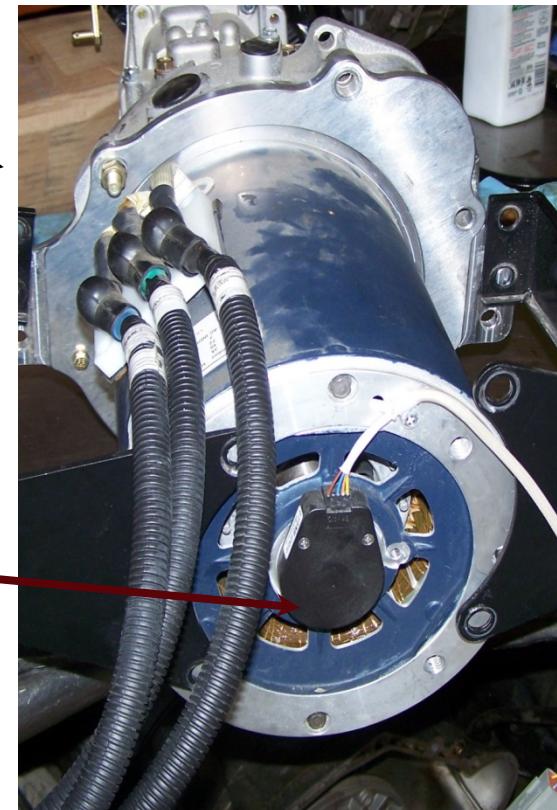
Additional Drive System Components: The A/C Induction Traction Motor/Generator

- The Traction Motor/Generator. This is mounted directly under the Cab and is coupled directly to the vehicle transmission. View A is looking forward from Right Side. (Note RH Motor Mount) View B is a view of the motor removed. In addition to a three phase motor/generator, the unit contains a dual circuit optical speed sensor to accomplish phasing and a temperature sensor to reduce load or even shut the system down if the motor should over-heat.



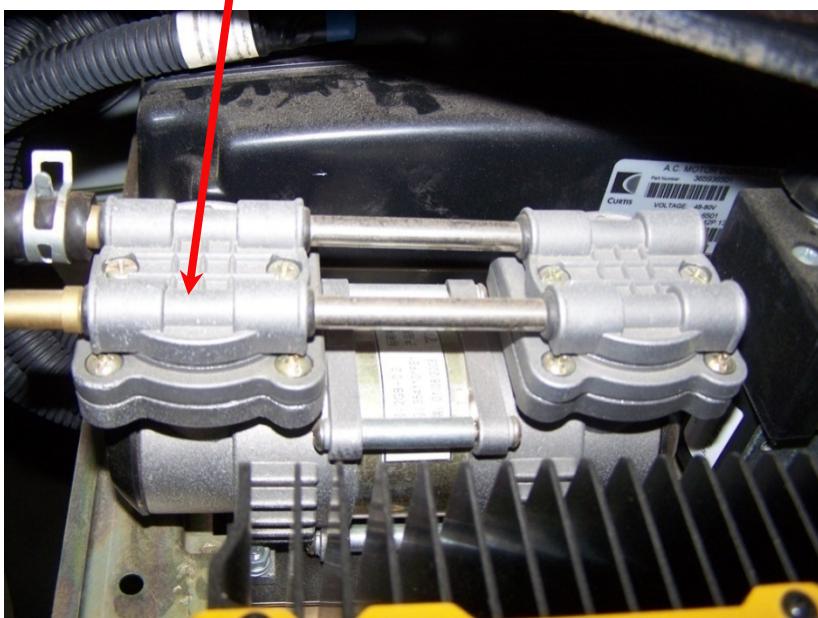
View A View B

Motor Sensor
Electronics, Speed and
Temperature Sensors



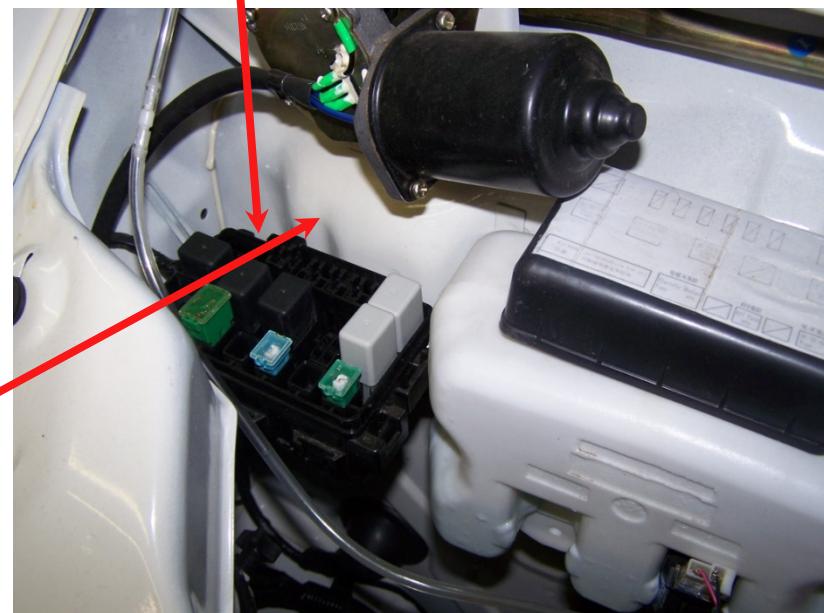
Additional Drive System Components: Brake Vacuum Pump & 72V Fuse Box

- The Vacuum Pump provides vacuum needed to operate the vacuum brake booster. It is located just forward of the Contactor Relay and is controlled by vacuum switch mounted on the booster vacuum line under the hood. It will run momentarily when the key is switched on and when the brakes are being applied.



Caution! This fuse box contains high current 72 V circuits. Observe all High Voltage Safety Procedures when servicing these fuses!

Three important fuses can be found under the hood below the wiper motor. These are (left to right) the 72V fuses for the Electric Heater Element, the fuse for the KSI Circuit (72V) and the Fuse for the DC/DC Converter.



Schematics and Testing

Diagnostic troubleshooting within the ZX40ST drive system can be accomplished either by use of the Curtis Controller Scan Tool or pinpoint testing of the various electrical circuits using a DVOM. This Troubleshooting Manual is designed to guide you through the pinpoint test process using the DVOM. Even if you have the Scan Tool available, you may find these pinpoint test procedures valuable to verify Scan Tool Data and to better understand the workings of the ZX40ST drive system.

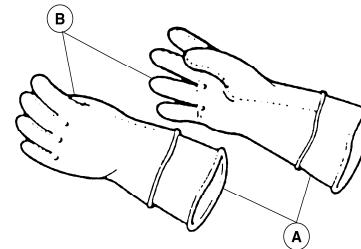
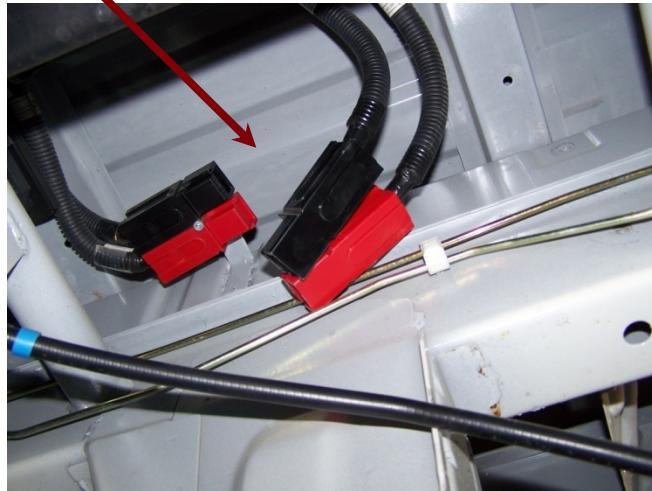
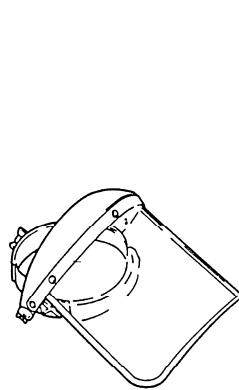


The Curtis Scan Tool (left) A good quality DVOM with (Bed of Nails) test leads (right) which safely penetrates wire insulation



Testing Procedures & Safety

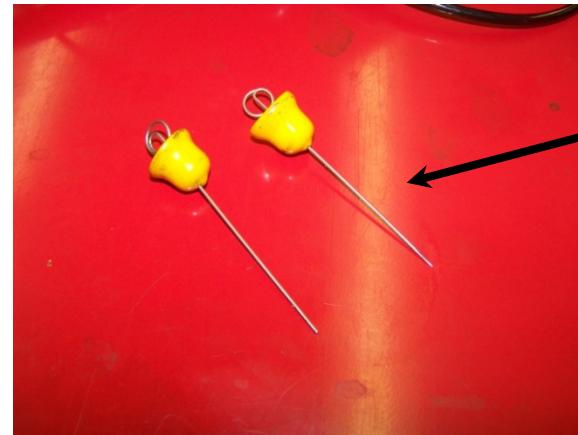
- Wear high Voltage insulated Gloves and Eye protection. (Face Shield or Safety Glasses)
- Don't wear watches or rings while servicing Electric or Hybrid Vehicles
- Always test for the presence of high voltage before touching a high voltage circuit or component
- Never leave the key in the ignition unless you want the ignition switch to be ON!
- Disable the 72 Volt Battery Pack before servicing any driveline components



ER075-A

Testing Procedures & Safety

Use Bed of Nails or self piercing test leads to probe individual wires or clamp to terminals.
(recommended)



Probes can be used to insert into the back of wiring connectors.

An electrical probe can also be used to probe wires or connectors



Preparing to Test the System



The Curtis Motor Controller is located underneath the Passenger Seat. Nearly all testing of the vehicle drive system can be performed here.

Controller Trouble Codes

During normal operation, the yellow LED on the controller will flash. (Key ON) If the Controller detects a fault in the drive system, the LED's will flash in sequence and provide a two digit code number. With this number, refer to the Controller Code List to determine the fault. Or you can connect the Curtis scan tool and read the DTC directly.

To obtain codes from the Controller, turn the Key to the On position. Wait for the Red LED to blink once. This single blink indicates that the flash sequence from the Yellow LED will be the 1st digit of the DTC. The Red LED will then flash twice. The next flashes from the Yellow LED will be the 2nd digit of the DTC.

Example: With the Key OFF, disconnect the Throttle Position Sensor. Turn the key ON. You will see the following sequence at the Controller LEDS;

Red- 1 flash, 1st digit coming

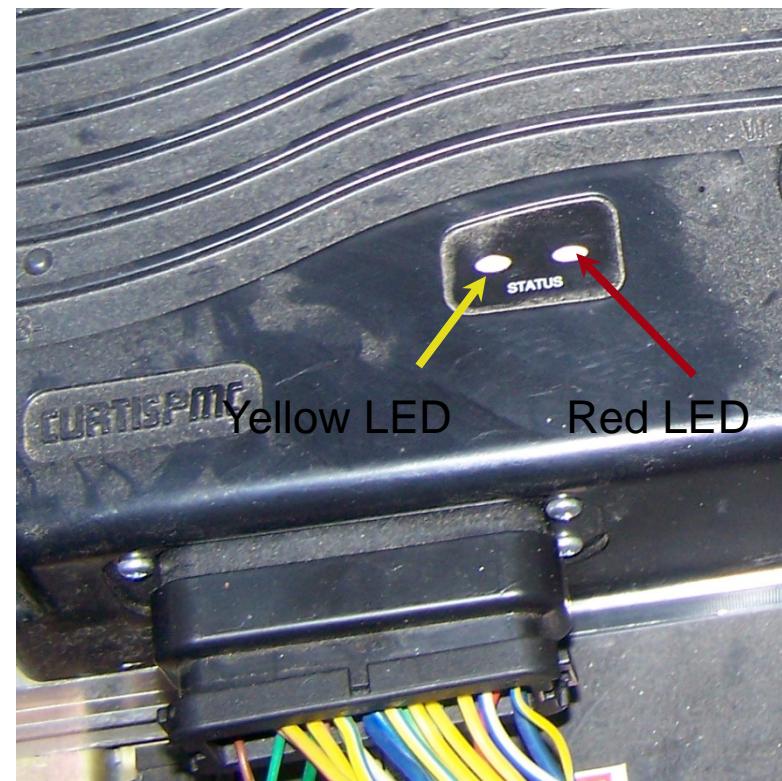
Yellow- 4 flashes, the 1st digit

Red- 2 flashes, 2nd digit coming

Yellow- 1 flash, the second digit

This indicates a Code 41 (Throttle Wiper High)

Turn the key off and reconnect the TPS. The Code will clear itself when the Controller determines the fault has been corrected.



Controller Trouble Codes

During normal operation, the yellow LED on the controller will flash. (Key ON) If the Controller detects a fault in the drive system, the LED's will flash in sequence and provide a two digit code number. With this number, refer to the Controller Code List to determine the fault. Or you can connect the scan tool and read the DTC directly.

With the Curtis Scan Tool, as before, unplug the TPS with the key OFF. Turn the key ON, Connect the Scanner at the 4 pin plug in the wiring harness near the 35 Pin connector. Turn the key ON. The scanner will initialize. At the Main Menu select "Faults". Right click to "System Faults". Right click again, specific fault readout will be: "Brake Wiper High"



Pinpoint Test Example

How it works:

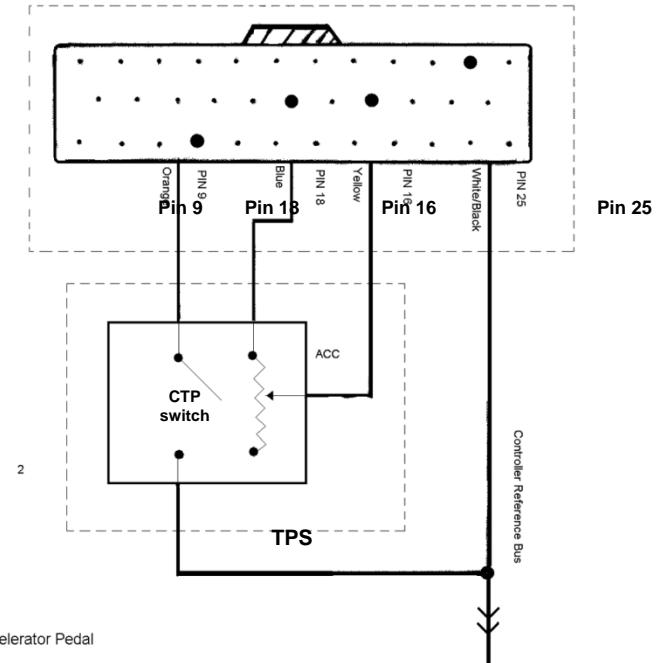
The Controller sends a 12V reference voltage to the TPS on Pin 16. The TPS drops this voltage low depending on the position of the sensor shaft. The voltage is low (about 200mv) at closed throttle and moves higher as the throttle is opened. Even at WOT the voltage will not approach the 12V reference signal sent out by the Controller.

Therefore, if the Controller reads 12V on Pin 16, it knows that the circuit through the TPS has very high resistance to ground. It then sets the DTC, Throttle Wiper High.

What could be wrong:

- A break in the Yellow wire or bad connection in one of the connectors.
- A break in the Blue ground (Pin 18) wire or bad connection in one of the connectors.
- An internal open in the TPS itself.
- An open ground circuit at Pin 18 of the Controller.

To continue with this example, the next step would be to test the TPS circuit and verify the fault using pinpoint tests.



Pinpoint Test Example

This example should illustrate why pinpoint testing is so important even when an advanced scan tool is available. As we have seen, a DTC 41 could be caused by a broken wire, a defective connector (There are 3 connectors between the Controller and the TPS), a defective TPS or even a defective Controller!

The following pages contain test procedures, the pin layout, wire colors and test values for the 35 pin connector at the Controller.

Be sure to follow all safety practices when testing the ZX40ST electrical systems!

Controller Pinpoint Tests

This is the 35 pin connector on the outboard side of the Controller. The pins are arranged in 3 rows. The top and bottom rows have 12 pins in each row. The middle row has 11 pins. The connector is installed “upside down”, so pin 1 is in the bottom row, farthest to the right. The bottom row contains pins 1 through 12. The middle row contains pins 13 through 23. The top row contains pins 24 through 35. Pin 35 is the top row, farthest to the left. Note the locking eye at the bottom center of the connector housing which receives the locking tab on the harness (female) connector.

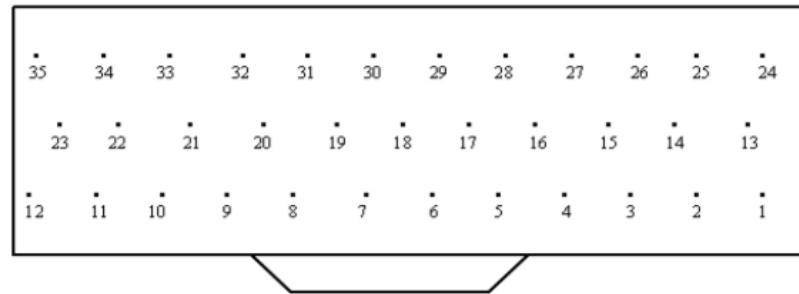
During all testing, we will refer to these pin numbers. All tests are performed with the 35 Pin Connector “connected”

To remove the connector, with the Key removed from the ignition and no voltage present between the Controller B+ and B- connectors, slide a small screwdriver tip into the Locking Tab- it has a slot that will receive the screwdriver tip- (a small mirror will be useful the first time this is attempted) and gently pry the latch downward while pulling the connector away from the controller.



35 Pin Connector

This is the Controller View (Male Side)



Pin #		Pin #		Pin #	
1	72V from CCB, key on	13	Contactor On Confirm	24	CCB control signal
2	Open	14	Open	25	12V Positive Ref. Bus
3	Open	15	Open	26	5V reference to motor sensors
4	Reverse light relay control (-)	16	TPS Load Input (Wiper)	27	Open
5	Open	17	Variable Brake Input	28	Serial Data to Scanner
6	Contactor Relay Signal (-72V)	18	TPS Reference Ground	29	Serial Data to Scanner
7	12V Ground Ref. Bus	19	Open	30	SOC signal to Battery Discharge Indicator (BDI)
8	Temp Signal from Traction Motor	20	State of Charge data to CCB	31	Drive motor Phase A speed input
9	TPS Input	21	Open	32	Drive motor Phase B speed input
10	72V from CCB when Charging	22	Forward Input from Selector switch	33	Reverse Input from Selector switch
11	Open	23	Open	34	Open
12	12V Positive Ref. Bus			35	Open

Test Information

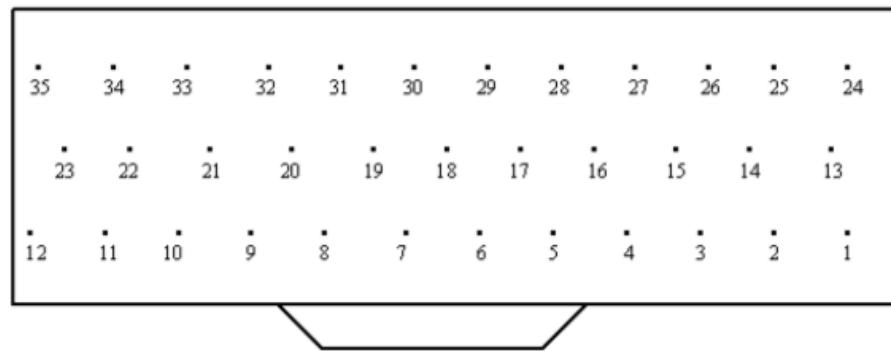
Test Values, using pinpoint tests at 35 Pin Controller Connector. Test conditions: Connector plugged into Controller; key on, vehicle stationary, E-Brake applied unless noted.

Pin #		Pin #		Pin #	
1	+ 72 VDC	13	+ 72VDC	24	0 V
2	Open	14	Open	25	+ 12V
3	Open	15	Open	26	+ 5V
4	+ 12V, but Grd. when in Reverse and E-Brake released	16	Depends on throttle position, from >200 mV to >3.8V	27	Open
5	Open	17	Approx. 1V to >4V when brake pedal applied	28	Serial Data no value
6	- 72V (Grd)	18	- 12V (Grd)	29	Serial Data no value
7	- 12V (Grd)	19	Open	30	Dc Voltage signal., around 6V Depends on SOC
8	1.2 V at 80°F	20	Serial Data no value	31	When traction motor running, 600 to over 3000 Hz, DC
9	+ 12V when throttle open	21	Open	32	When traction motor running, 600 to over 3000 Hz, DC
10	0V, 72V when Charging	22	+ 12V, Grd. when in Forward and E-Brake released	33	+ 12V, Grd. when in Forward and E-Brake released
11	Open	23	Open	34	Open
12	+ 12V			35	Open

Caution! Follow all safety Procedures for Electrical Testing of High Voltage Systems!

Wiring Information: Wire Colors at 35 Pin Controller Connector

Do not rely on wire colors completely.
Always verify Pin # you are testing!

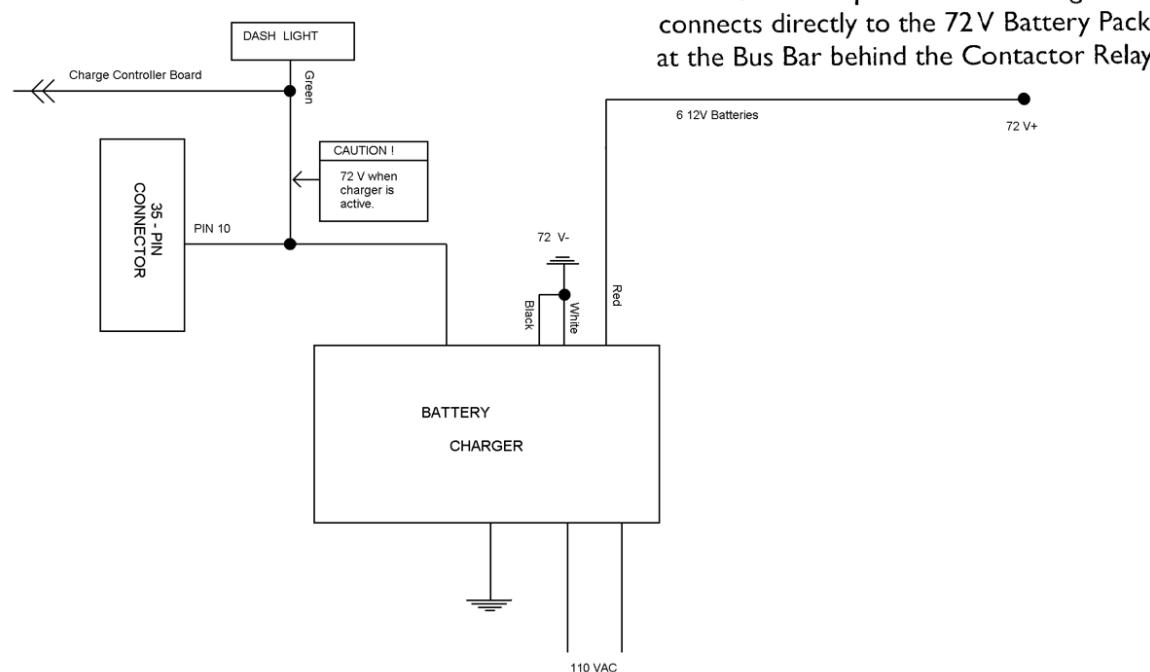


35 Pin Connector
This is the
Controller View
(Male Side)

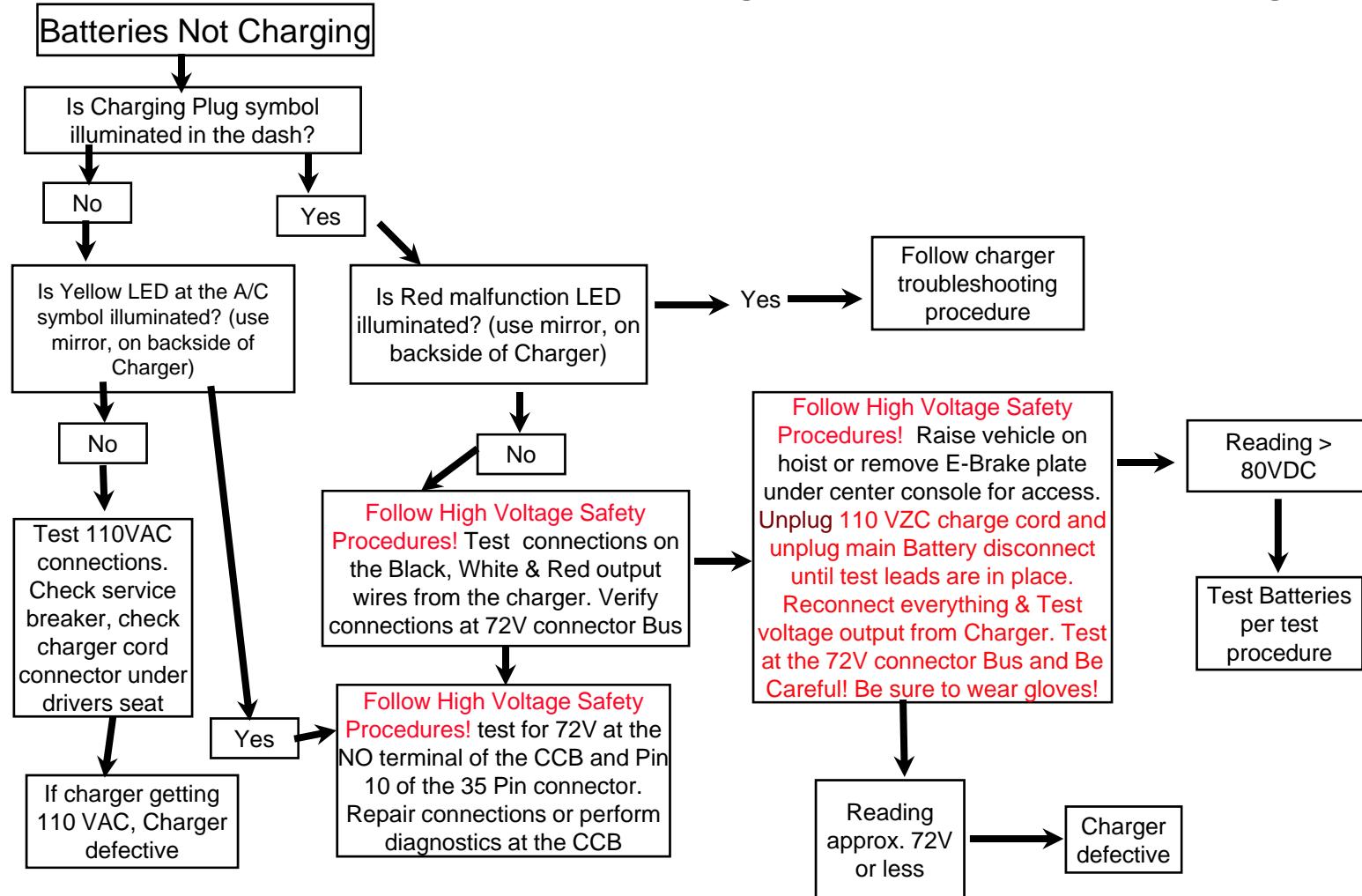
Pin #		Pin #		Pin #	
1	Blue	13	Red	24	Yellow/Blue
2	Open	14	Open	25	White/Blue
3	Open	15	Open	26	Yellow
4	Green	16	Yellow	27	Open
5	Open	17	Green	28	Yellow
6	Gray/Blue	18	Blue	29	Yellow/Blue
7	Black	19	Open	30	Blue/Silver
8	White/Black	20	Pink/Blue	31	Yellow/Blue
9	Green	21	Open	32	Yellow
10	Green	22	Pink/Blue	33	Yellow/Red
11	Open	23	Open	34	Open
12	Brown/White			35	Open

110 VAC to 72 VDC Charger

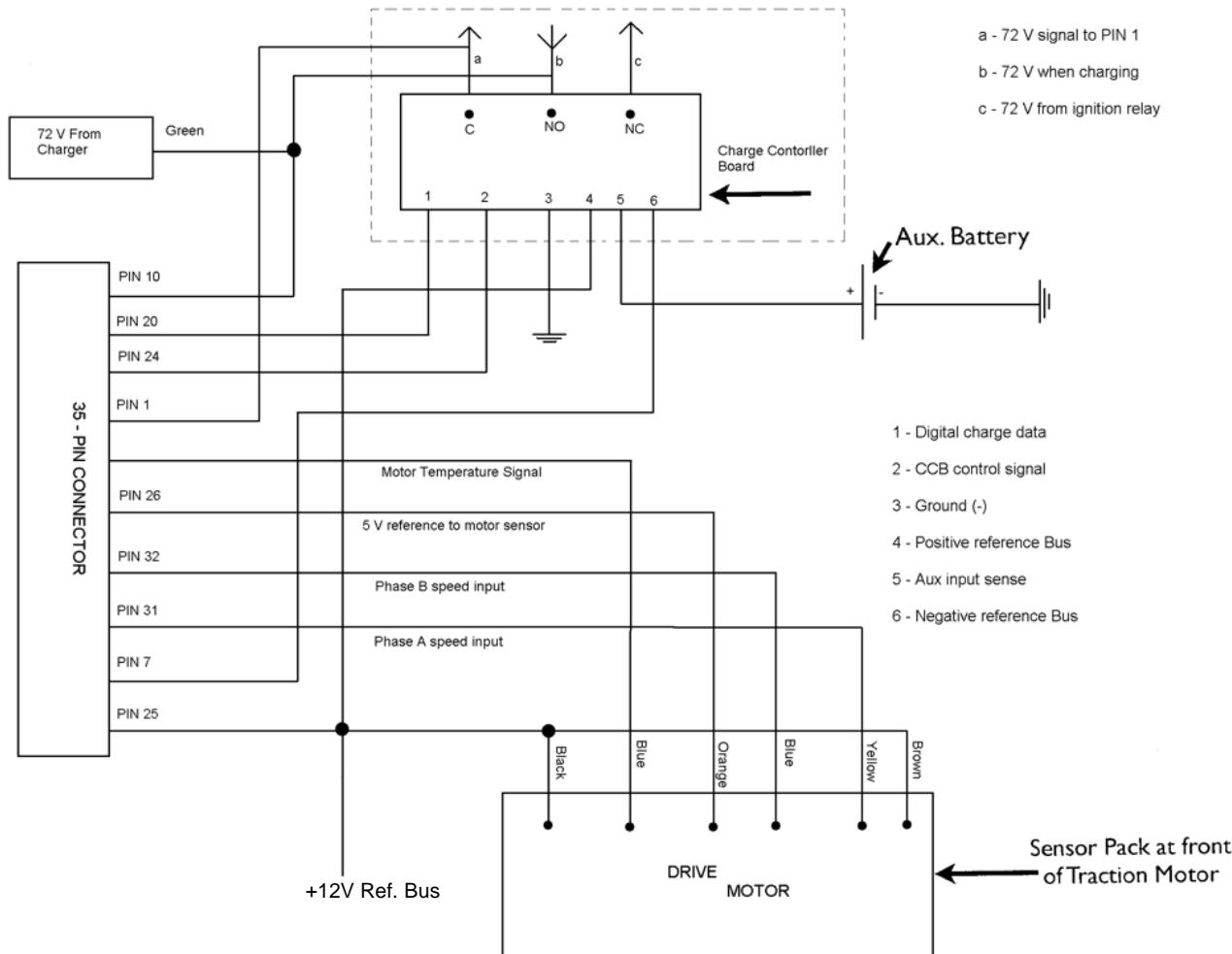
Note! When charging, Pin 10 of the 35 Pin connector carries a 72V Signal! Whenever the key is “ON”, Pin 1 of the 35 Pin connector carries 72 V!



110 VAC to 72 VDC Charger Troubleshooting



Charge Controller Board & A/C Motor Sensors



Charge Controller Board & A/C Motor Sensors Troubleshooting

Faults in either the CCB or the Traction Motor Sensors will likely be diagnosed by the Controller and the specific faults can be read out. (see procedures).

CCB Failure. The most likely failure of this component will be failure to "wake up" the Controller when the vehicle is being recharged.

When vehicle plugged in, "Charge Indicator" on dash illuminated, but yellow LED on Controller not flashing.

Verify 72V available at CCB Relay Pin C

No Voltage: Find open wire or connector & repair

72V present. Check for 72V at Controller Pin 10. If no voltage, replace CCB.

Caution! Observe all High Voltage Safety procedures when testing this circuit!

If Pin 10 has 72V, perform Controller Tests

Motor temp fault (Code 15 or 16)

Verify that Traction Motor did not overheat!

Test voltage at Controller Pin 8

Approx. 1V

Voltage too high or too low; Verify 5V reference at Controller Pin 26 and 12V reference available to Motor

Clear Code & retest. May be Controller Fault

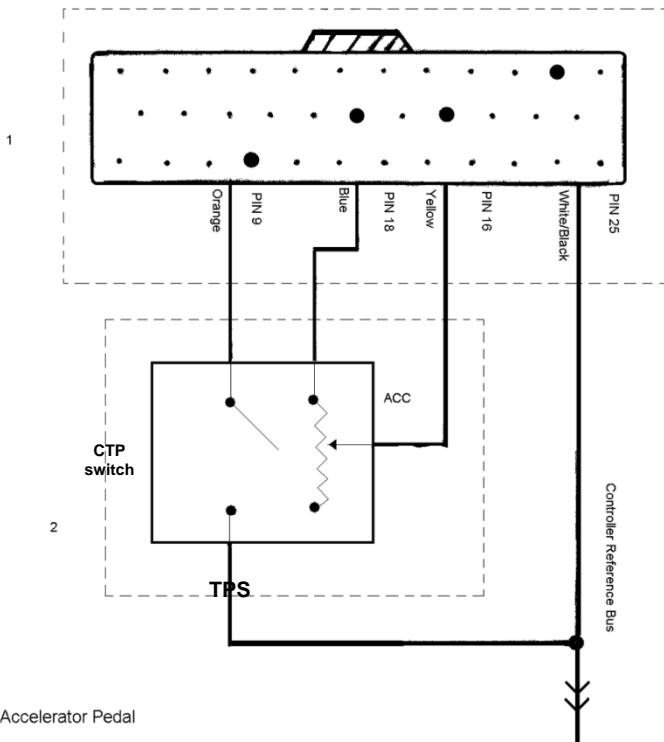
If wiring or supply voltage not at fault, Temp. sensor in Traction Motor defective

If 5V reference not available, check circuit for shorts. If no short found, Controller defective

Traction Motor Speed inputs Phase A & B

To test: Place rear axle on jack stands or raise vehicle so rear wheels are off the ground. Connect DVOM or Scope to Controller Pins 7 (Grd) and pin 31. Turn key on, release handbrake and put into Drive. Set DVOM or Scope to read Frequency (Hz). See Test Information for specs. Move + lead from Pin 31 to Pin 32, (Phase A to Phase B, repeat test. Incorrect readings on either Phase would indicate a defective sensor assembly.

Throttle Position Sensor (TPS)



ACC - Accelerator Pedal

1 - 35 Pin Connector

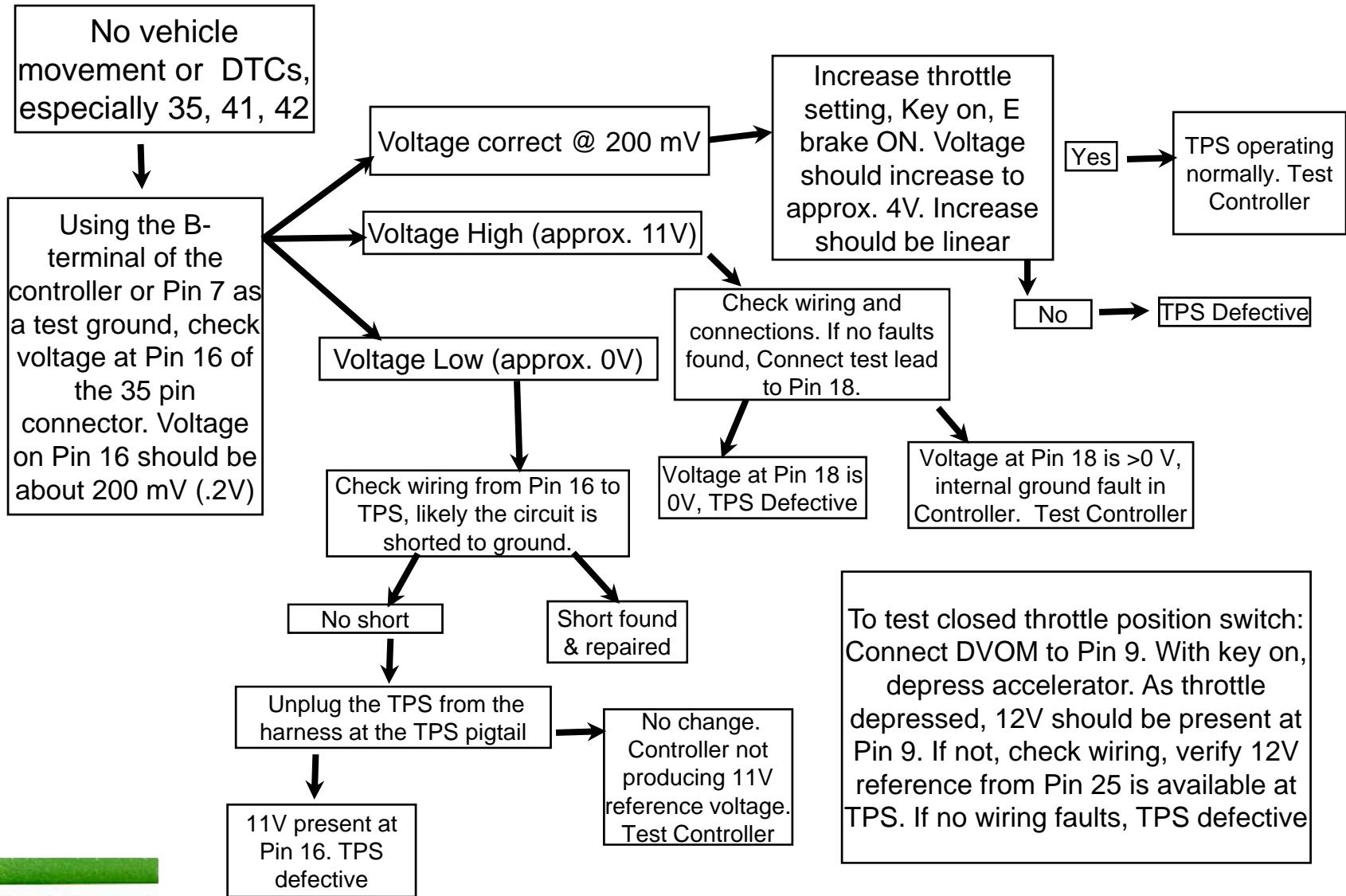
2 - Throttle Potentiometer

How it works:

The Controller sends a 12V reference voltage to the TPS on Pin 16. The TPS drops this voltage low through a variable resistance to ground depending on the position of the sensor shaft. The voltage is low (about 200 mV) at closed throttle and moves higher as the throttle is opened. Even at WOT the voltage will not approach the 12V reference signal sent out by the Controller.

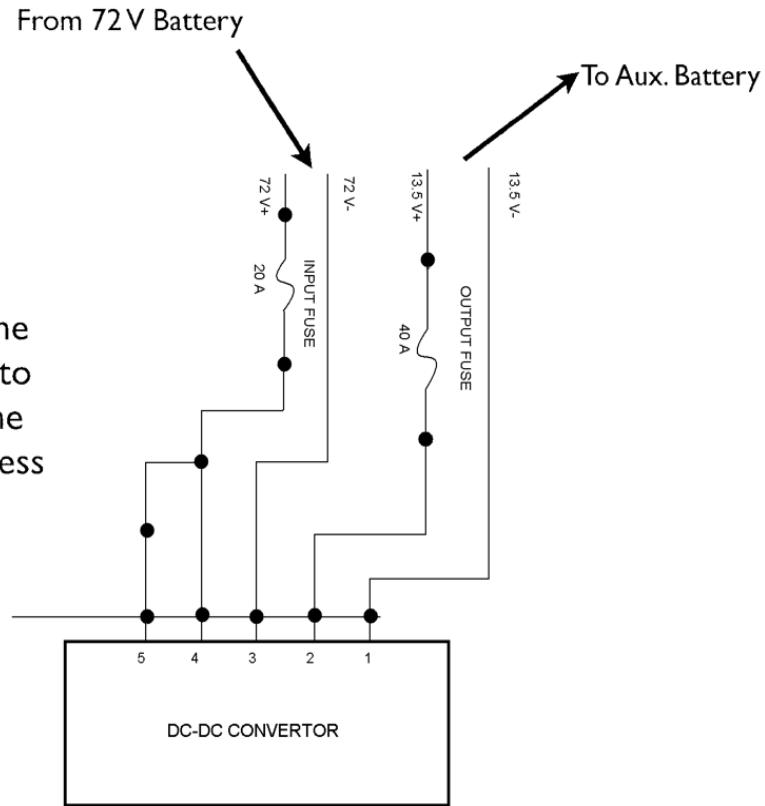
A Closed Throttle Position Switch is normally open. When the accelerator is depressed, this switch closes and applies 12V to Pin 9.

TPS Troubleshooting

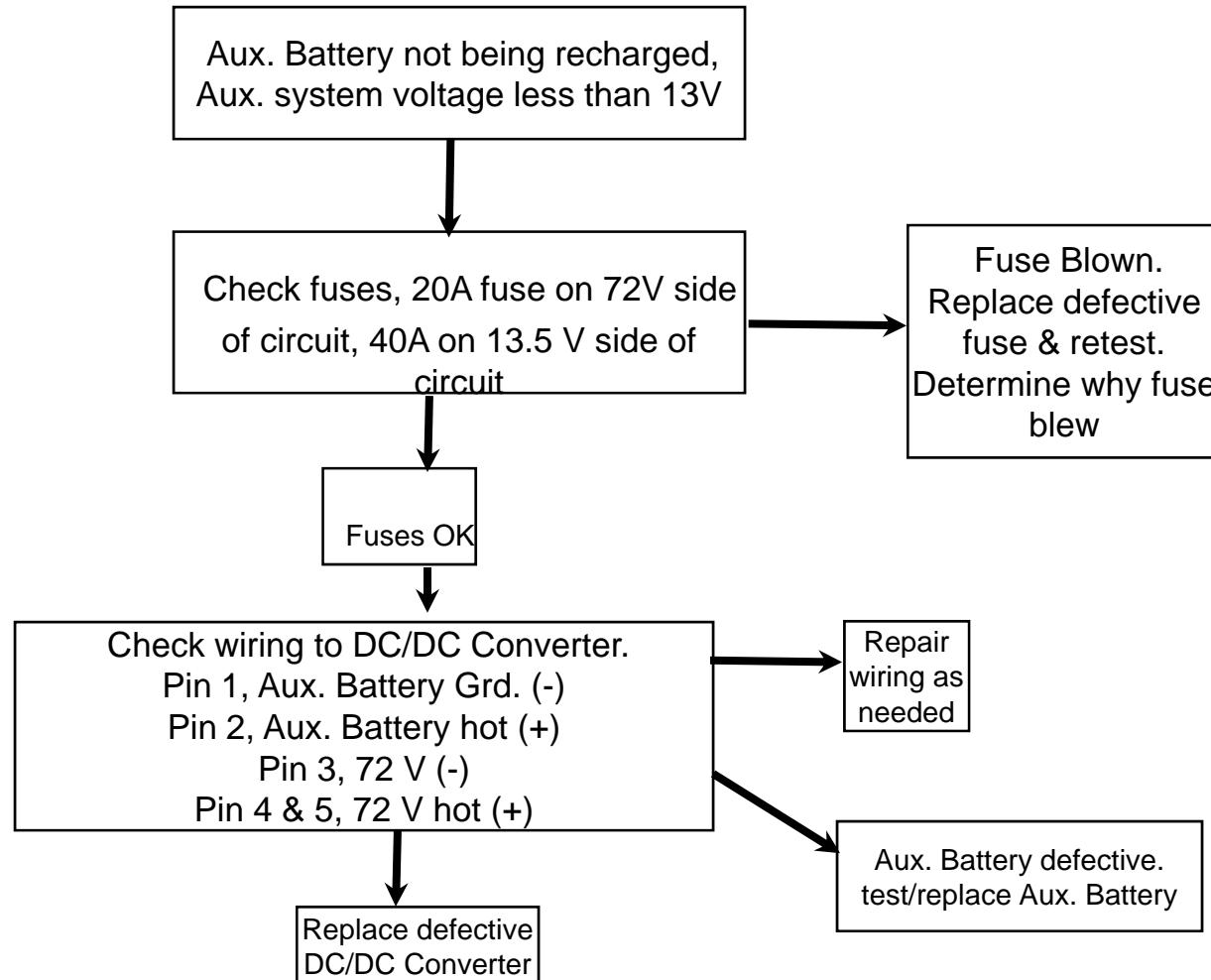


DC-DC Converter

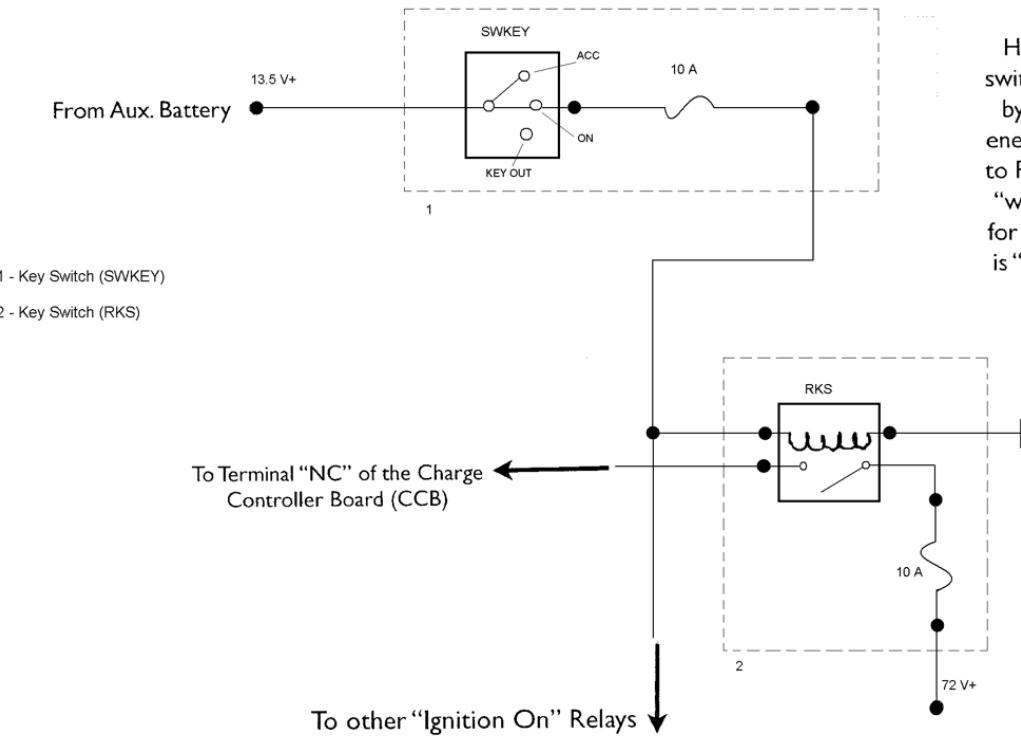
Pin 5 is the control input for the Converter. By being jumpered to Pin 4, it is always “hot”, thus the Converter is always “ON” (Unless the main disconnect is disconnected)



DC-DC Converter Troubleshooting

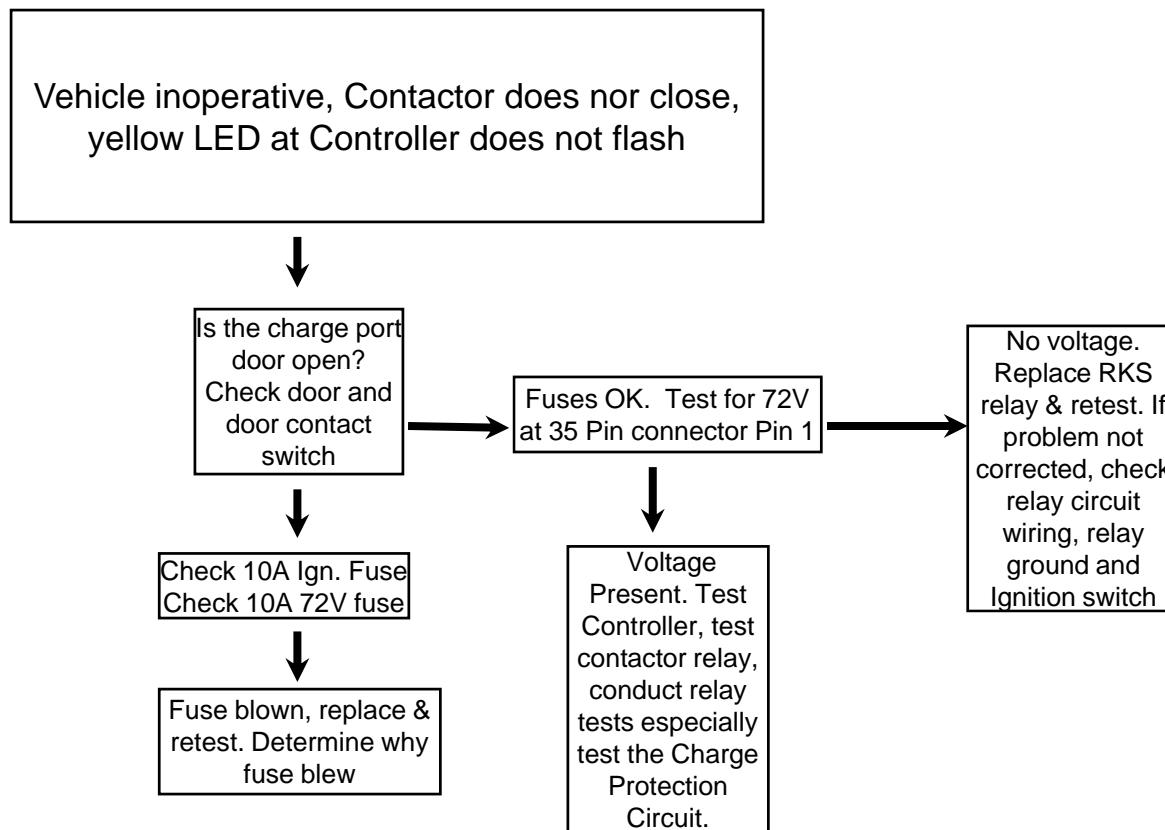


Key Switch, RKS Relay

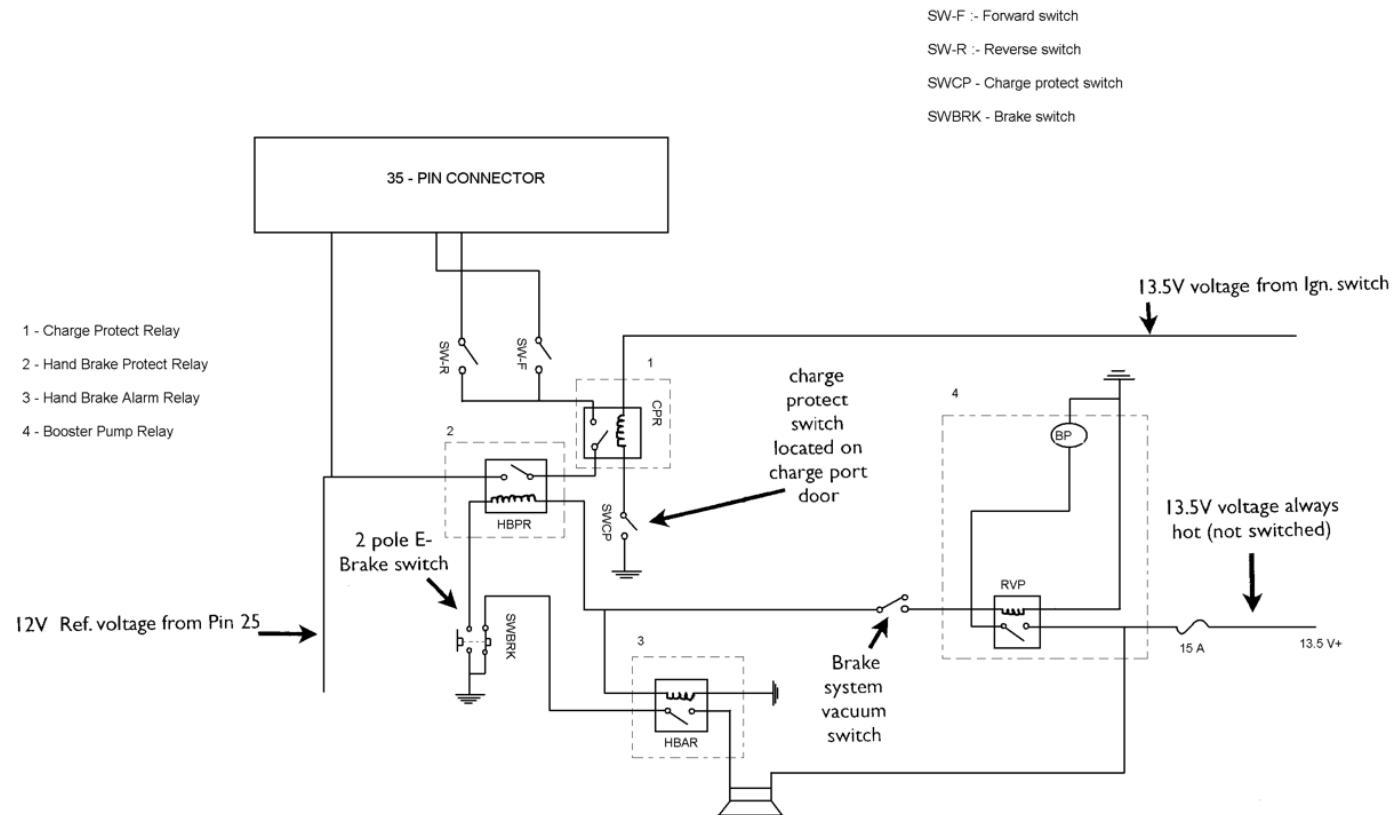


How it works: When the Ignition Key is switched "ON", the RKS Relay is energized by voltage from the Aux. Battery. When energized, the RKS Relay sends 72V power to Pin 1 of the 35 Pin connector. This signal "wakes up" the Controller, in preparation for vehicle operation. Once the Controller is "awake" it provides 12V & 5V reference voltages to various sensors.

Key Switch, RKS Relay Troubleshooting



Interlock relays, Switches & Brake Booster Vacuum Pump



Interlock Relays & Switches & Brake Booster Vacuum Pump Troubleshooting

How it all works: In order for the vehicle to move, a 12V signal must be present at either controller Pin 22 (forward) or 33 (reverse). This signal comes from the drive selector switch located on the center console. The switch is supplied with a 12V reference voltage from the Controller. However, in order to reach the selector switch it must pass in series through two relays. These relays are designed to prevent the vehicle from moving either with the E-Brake ON or the Charge Port Door open (and the vehicle likely plugged into a wall socket)

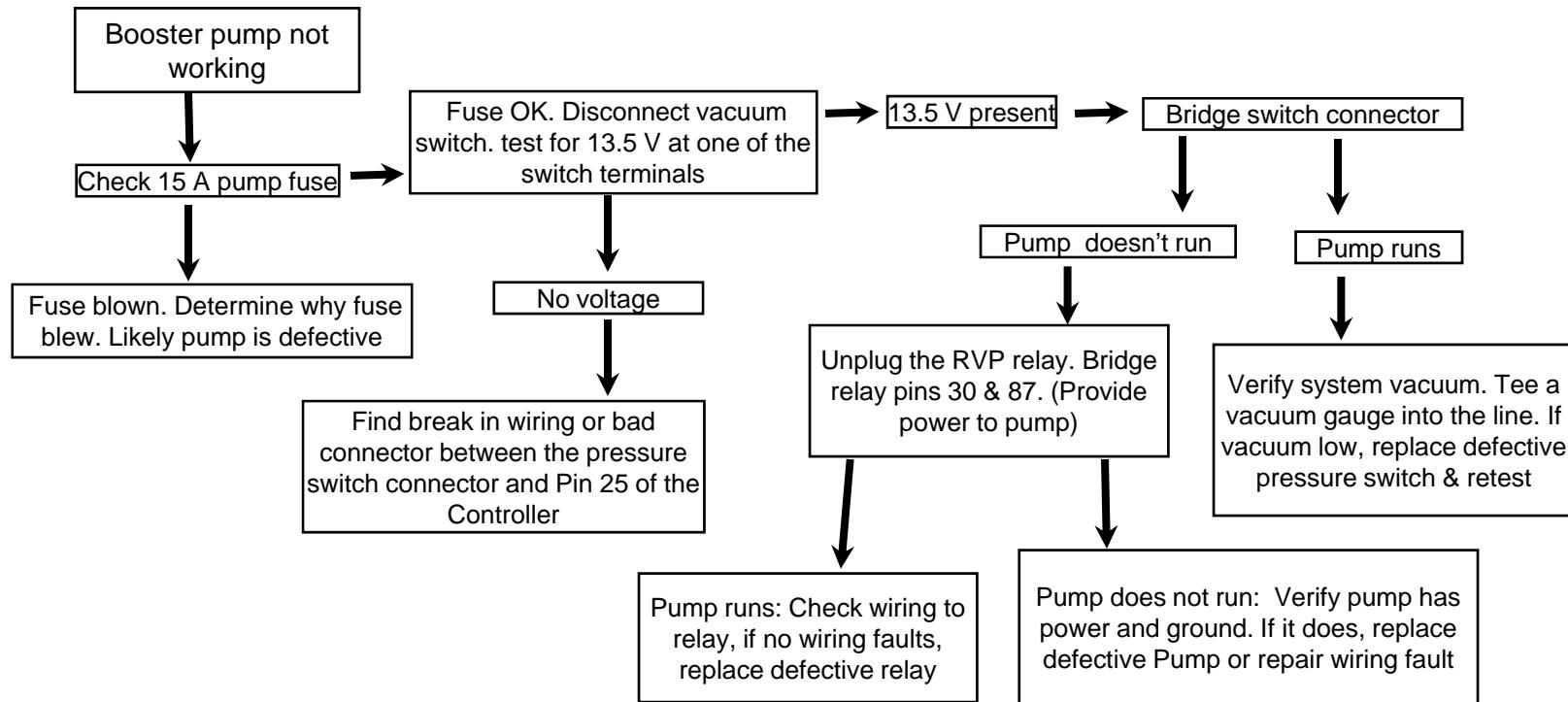
On the schematic, Relay 1 is the CPR or charge protect relay. The relay coil has power whenever the Key Switch is on. The relay can only be energized when the relay coil receives a ground which cannot happen unless the switch on the charge port door is closed. This is the Charger Protect Circuit.

Relay 2 is the Hand Brake Relay. Like the CP relay, the relay coil gets power from the ignition switch. The relay coil cannot get a ground unless the handbrake lever is “down”, which completes the ground circuit for this relay. If there is no voltage present at the drive selector switch, the fault will lie in one of these two relays or their control switches. The switches would be the most likely to fail. With the key on, operate the handbrake. The HBP relay should be heard to click. Likewise, opening the Charger Port door and operating the charge protect switch be hand, key on, should produce an audible click in the CP relay.

Remember that the CP switch is exposed to moisture, road dirt, etc. so it may be prone to failure. The HBP switch has just been upgraded. See applicable TSB.

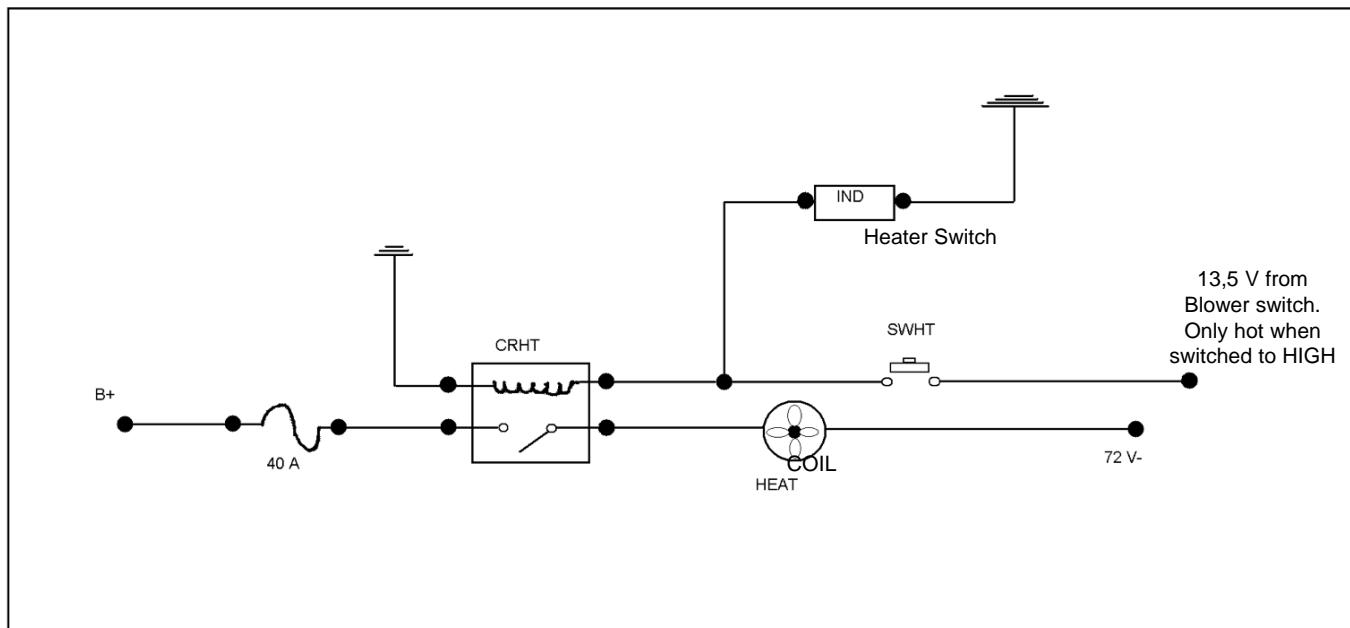
Since the Miles ZX40ST does not have a “Park” gear, the hand brake alarm relay will provide a ground to an alarm horn that is always supplied with power. The ground is interrupted when the hand brake is set. This assures that the operator will not leave the vehicle without setting the E-Brake.

Brake Booster Vacuum Pump Troubleshooting



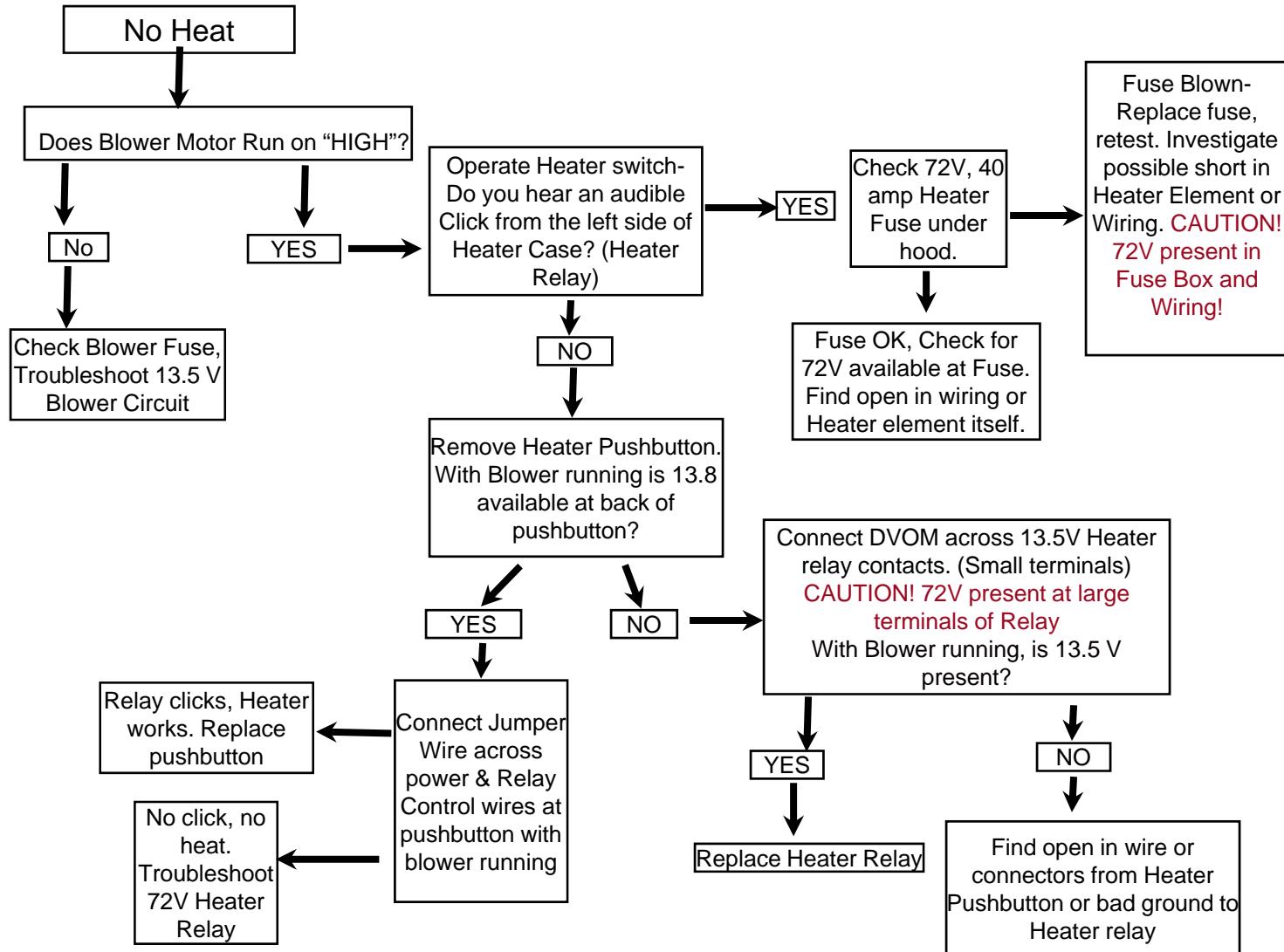
Heater

The Heater Coil is powered by the 72 Volt circuit. In order to prevent the coil from overheating, it is wired so that the heater coil relay can only be energized when the Blower is set to the HIGH setting. The two lower blower speeds have been disabled.



Heater Troubleshooting

42



Appendix: Curtis Diagnostic Trouble Codes & Descriptions

Code	Cause	Correction
12	Controller Over-current 1.External Short of Phase U, V or W Motor Connections 2.Motor Parameters are Mistuned 3.Controller Defective Set; Phase Current Exceeded the current measurement limit	Set/Clear Condition
13	Current Sensor Fault 1.Leakage to vehicle frame from phase U, V or W (short in motor stator) 2.Controller defective Set; Phase current exceeded the current measurement limit	Clear; Cycle Key
14	Pre-charge Failed 1.External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging 2.See 1311 menu Monitor >> Battery; Capacitor Voltage Set; Pre-charge failed to charge the capacitor bank to the KSI voltage	Clear; Cycle Key
15	Controller Severe Undertemp 1.Controller is operating in an extreme environment 2. See 1311 menu Monitor >> Controller: Temperature Set; Heatsink temperature below -40°C	Clear; Cycle Interlock Input or use VCL function Precharge()
16	Controller Severe Overtemp 1.Controller is operating in an extreme environment 2.Excessive load on vehicle 3.Improper mounting of controller 4.See 1311 menu Monitor >> Controller: Temperature Set; Heatsink temperature above +95°C	Clear; Bring Heatsink temperature above -40°C and cycle interlock or KSI
17	1.Battery Menu parameters are misadjusted 2. Non-controller system drain on battery 3. Battery resistance 4.Battery disconnected while driving 5.See 1311 menu Monitor >> Battery: Capacitor Voltage 6.Blown B+ fuse or main contactor did not close Set; Capacitor bank voltage dropped below the Severe Undervoltage limit with FET bridge enabled	Severe Undervoltage
18	Severe Overvoltage 1.Battery menu parameters are misadjusted 2.Battery resistance too high for given regen current 3.Battery disconnected while regen braking 4.See 1311 menu Monitor >> Battery: Capacitor Voltage Set; Capacitor bank voltage exceeded the Severe Overvoltage limit, and then cycle key	Clear – Bring Capacitor voltage above Severe Undervoltage Limit

Code	Cause	Correction
21	Controller Undertemp Cutback 1.Controller is performance-limited at this temperature 2.Controller is operating in an extreme environment 3. See 1311 menu Monitor >> Controller: Temperature Set; Heatsink temperature dropped below -25°C	Clear; Bring capacitor voltage below Severe Overvoltage limit, and then cycle key
22	Controller Overtemp Cutback 1.Controller is performance-limited at this temperature 2.Controller is operating in an extreme environment 3.Excessive load on vehicle 4.Improper mounting of controller 5.See 1311 menu Monitor >> Controller: Temperature Set; Heatsink temperature exceeded 85°C	Clear; Bring Heatsink temperature above -25°C
23	Undervoltage Cutback 1.Normal operation. Fault shows that the batteries need recharging. Controller is performance Limited at this voltage. 2.Battery parameters are misadjusted. 3.Non-controller system drain on battery. 4.Battery resistance too high. 5.Battery disconnected while driving. 6.See 1311 menu Monitor >> Battery: Capacitor Voltage. 7.Blown B+ fuse or main contactor did not close. Set; Bring capacitor voltage below the Overvoltage limit	Clear; Bring Heatsink temperature below 85°C.
24	1.Normal Operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2.Battery parameters are misadjusted. 3.Battery resistance too high for given regen current. 4.Batery disconnected while regen braking. 5.See 1311 menu Monitor >> Battery: Capacitor Voltage Set; Capacitor bank voltage exceeded the Overvoltage limit with the FET bridge enabled.	Overvoltage cutback
25	+5V Supply Failure 1.External load impedance on the +5V supply (pin 26) is too low Set; +5V supply (pin 26) outside the +5V ± 10% range	Clear; Bring capacitor voltage below the Overvoltage limit
26	Digital Out 6 Overcurrent 1.External load impedance on Digital Output 6 Driver (pin 19) is too low Set; Digital Output 6 (pin 19) current exceeded 15 mA	Clear; Bring voltage within range

Code	Cause	Correction
27	Digital Out 7 Overcurrent 1.External load impedance on Digital Output 7 Driver (pin 20) is too low Set; Digital Output 7 (pin 20) current exceeded 15 mA	Clear; Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again
28	Motor Temp Hot Cutback 1.Motor temperature is at or above the programmed Temperature Hot setting, and requested current is being cut back 2.Motor Temperature Control Menu parameters are mis-tuned 3.See 1311 menus Monitor>> Motor: Temperature and Monitor >> Inputs: Analog2 4.If application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off. Set; Motor temperature is at or above the Temperature Hot parameter setting	Clear; Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again
29	Motor Temp Sensor Fault 1.Motor thermistor is not connected properly 2.If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off 3.See 1311 menus Monitor >> Motor: Temperature and Monitor >> Inputs: Analog2 Set; Motor thermistor input (pin 8) is at the voltage rail (0 or 10V)	Clear; Bring the motor temperature within range
31	Coil Driver Open/Short 1.Open or short on driver load 2.Dirty connector pins 3.Bad crimps or faculty wiring Set; Driver 1 (pin 6) is either open or shorted	Clear; Bring the motor thermistor input voltage within range
31	Main Open/Short 1.Open or short on driver load 2.Dirty connector pins 3.Bad crimps or faulty wiring Set; Main contactor driver (pin 6) is either open or shorted	Clear; correct open or short, and cycle driver
32	Coil 2 Driver Open/Short 1.Open or short on driver load 2.Dirty connector pins 3.Bad crimps or faulty wiring Set; Driver 2 (pin 5) is either open or shorted	Clear; Correct open or short, and cycle driver
32	EM Brake Open/Short 1.Pen Brake Open/Short 2.Dirty Connector Pins 3.Bad crimps or faulty wiring Set; Electromagnetic brake driver (pin 5) is either open or shorted.	Clear; Correct open or short, and cycle driver

Code	Cause	Correction
34	1.Open or short driver load 2.Dirty connector pins 3.Bad crimps or faulty wiring Set; Driver 4 (pin 3) is either open or shorted	Coiled Driver Open/Short
35	PD Open/Short 1.Open or short on driver load 2.Dirty connector pins 3. Bad crimps or faulty wiring Set; Motor encoder phase failure detected	Clear; Correct open or short, and cycle driver
36	Encoder Fault 1.Motor encoder failure 2.Bad crimps or faulty wiring 3.See1311 menu Monitor >> Motor: Motor RPM Set; Motor encoder phase failure detected	Clear; Cycle Key
37	Motor Open 1.Motor phase is open 2.Bad crimps or faulty wiring 3.Bad crimps or faulty wiring Set; Motor phase U, V or W detected open	Clear; Cycle Key
38	Main Contactor Welded 1.Main contactor tips are welded closed 2.Motor phase U is disconnected or open 3.An alternate voltage path (such as an external Precharge resistor) is providing a current to the capacitor bank (B+ connection terminal) Set; Just prior to the main contactor closing, the capacitor bank voltage (B+ connection terminal) was loaded for a short time and the voltage did not discharge	Clear; Cycle Key
39	Main Contactor Did Not Close 1.Main contactor did not close 2.Main contactor tips are oxidized, burned, or not making good contact 3.External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging Set; With the main contactor command closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+	Clear; Cycle Key
41	Throttle Wiper High 1.Throttle pot wiper voltage too high 2.See 1311 menu Monitor >> Inputs: Throttle Pot Set; Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_Pot_Faults())	Clear; Bring the throttle pot wiper voltage below the fault threshold.

Code	Cause	Correction
42	Throttle Wiper Low 1.Throttle pot wiper voltage too low 2.See 1311 menu Monitor >> Inputs: Throttle Pot Set; Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function Setup_Pot_Faults())	Clear; Bring throttle pot wiper voltage above the fault threshold
43	Brake Wiper High 1.Brake pot wiper voltage too high 2.See 1311 menu Monitor >> Inputs: brake Pot Set; Brake pot wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_Pot_Faults())	Clear; Bring brake pot wiper voltage below the fault threshold
44	Brake Wiper Low 1.Brake pot wiper voltage too low 2.See 1311 menu Monitor >> Inputs: Brake Pot Set; Brake Pot Wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function Setup_Pot)Faults()	Clear; Bring brake pot wiper voltage above the fault threshold
45	Pot Low Overcurrent 1.Combined pot resistance connected to pot low is too low 2.See 1311 menu Monitor >> Outputs: Pot Low Set; Pot low (pin 18) current exceeds 10mA	Clear; Clear pot low overcurrent condition and cycle key
46	EEPROM Failure 1.Failyre to write to EEPROM memory. This can be caused by EEPROM memory writes initiated by VCL, by the CAN bud, by adjusting parameters with the 1311, or by loading new software into the controller Set; Controller operating system tried to write to EEPROM memory and failed	Clear; Download the correct software (OS) and matching parameter default settings into the controller and cycle key
47	Emer Rev HPD 1.Emergency Reverse Operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral. Set; At the conclusion of Emergency Reverse, the fault was set because various inputs were not returned to neutral	Clear; If EMER_Interlock = On, clear the interlock, throttle, and direction inputs. If EMER_Interlock = Off, clear the throttle and direction inputs.
49	Parameter Change Fault 1.This is a safety fault cause by a change in certain 1311 parameter setting so that the vehicle will not operate until key is cycled. For example, if a user changes the Throttle Type this fault will appear and require cycling the key before the vehicle can operate. Set; Adjustment of a parameter setting that requires cycling of the key.	Clear; Cycle key
51-67	OEM Faults 1.These faults can be defined by the OEM and are implemented in the application-specific VCL code. See OEM documentation Set; See OEM documentation	Clear; See OEM documentation

Code	Cause	Correction
68	<p>VCL Runtime Error</p> <p>1.VCL code encountered a runtime VCL error</p> <p>2.See 1311 menu Monitor >> Controller: VCL Error Module and VCL Error. This error can then be compared to the runtime VCL module ID and error code definitions found in the specific OD system information file.</p> <p>Set; Runtime VCL code error condition</p>	<p>Clear; Edit VCL application software to fix this error condition; flash the new compiled software and matching parameters defaults; cycle key</p>
69	<p>External Supply Out of Range</p> <p>1.External load on the 5V and 12V supplies draws either too much or too little current</p> <p>2.Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned</p> <p>3. See 1311 menu Monitor >> Outputs: Ext Supply Current</p> <p>Set; The external supply current (combined current used by the 5V supply [pin 26] and 12V supply [pin 25]) is either greater than the upper current threshold or lower than the lower current threshold. The two thresholds are defined by the Ext Supply Max and Ext Supply Min parameter settings.</p>	<p>Clear; Bring the external supply current within range</p>
71	<p>OS General</p> <p>1.Internal controller fault</p> <p>Set; Internal controller fault detected</p>	<p>Clear; Cycle Key</p>
72	<p>PDO Timeout</p> <p>1.Time between CAN PDO messages received exceeded the PDO Timeout Period</p> <p>Set; Time between CAN PDO messages exceeded the PDO Timeout Period</p>	<p>Clear; Cycle Key</p>
73	<p>Stall Detect</p> <p>1.Stalled motor</p> <p>2.Motor encoder failure</p> <p>3.Bad crimps or faulty wiring</p> <p>4.Problems with power supply for the motor encoder</p> <p>5.See 1311 menu Monitor >> Motor: Motor RPM</p> <p>Set; No motor encoder movement detected</p>	<p>Clear; Either cycle key, or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0</p>
87	<p>Motor Characterization Fault</p> <p>1.Motor characterization failed because of an Overvoltage or Undervoltage fault, Motor Temperature Sensor fault, or Motor_Temperature >150°C during the characterization process</p> <p>Set; Motor characterization failed during the motor characterization process</p>	<p>Clear; Cycle Key</p>
88	<p>Encoder Characterization Fault</p> <p>1.Encoder characterization failed during the motor characterization process</p> <p>2.Motor encoder pulse rate is not a standard value (32, 48, 64, 80 ppr)</p> <p>Set; During the motor characterization process, encoder pulses were detected by the Encoder_Steps were not detected as 32, 48, 64 or 80 ppr</p>	<p>Clear; Manually set Encoder_Steps to the correct value for the motor encoder and cycle key</p>
89	<p>Motor Type Fault</p> <p>1.The Motor_Type parameter value is out of range</p> <p>Set; Motor_Type parameter is set to an illegal value</p>	<p>Clear; Set Motor_Type to correct value and cycle key</p>

Code	Cause	Correction
92	<p>EM Brake Failed to Set</p> <p>1.Vehicle movement sensed after the EM Brake has been commanded to set 2.EM Brake will not hold the motor from rotating</p> <p>Set; After the EM Brake was commanded to set and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed</p>	Clear; Activate the throttle
93	<p>Limited Operating Strategy (LOS)</p> <p>1.Limited Operating Strategy (LOS) control mode has been activated, as a result of either an Encoder Fault (Code 36) or a Stall Detect Fault (Code 73)</p> <p>2.Motor encoder failure</p> <p>3.Bad crimps or faulty wiring</p> <p>4.Vehicle is stalled</p> <p>Set; Encoder fault (Code 36) or Stall Detect Fault (Code 73) was activated, and Brake or Interlock has been applied to activate LOS control mode, allowing limited motor control.</p>	Clear; Cycle Key, or if the LOS mode was activated by the Stall Fault, clear LOS by ensuring encoder senses proper operation, Motor RPM = 0, and Throttle Command = 0
94	<p>Emer Rev Timeout</p> <p>1.Emergency Reverse was activated and concluded because the EMR Timeout timer has expired</p> <p>2.The emergency reverse input is stuck On.</p> <p>Set; Emergency Reverse was activated and ran until the EMR Timeout timer has expired</p>	Clear; Turn the emergency reverse input Off.

END