Section 5

HV Battery Control Systems

Overview

The principal role of the hybrid battery system is to monitor the condition of the HV battery assembly through the use of the battery ECU. That information is then transmitted to the HV Control ECU. The battery ECU calculates the SOC (State of Charge) of the HV battery based on voltage, current and temperature. It then sends the results to the HV Control ECU. As a result, the proper charge and discharge control is performed.

This system also controls the battery blower motor controller in order to maintain a proper temperature at the HV battery assembly. To do this while the vehicle is being driven, the battery ECU determines and controls the operating mode of the battery blower assembly in accordance with the temperature of the HV battery assembly.

SAFETY TIP

ALWAYS wear high-voltage insulated gloves when diagnosing the Hybrid System. Check your gloves before wearing! Even a tiny pinhole can be dangerous, as electricity will find its' way in. To check your gloves, blow air into each glove, hold the glove tight like a balloon and make sure no air escapes.

High-voltage insulated gloves can be ordered from the Toyota SPX/OTC SST catalog under part numbers:

Small gloves - 00002-03100-S

Medium gloves - 00002-03200-M

Large gloves - 00002-03300-L

NOTE

Careless handling of this hybrid system may result in electrocution or electrical leakage. When servicing the hybrid system strictly follow the instructions found in the Repair Manual.

HV - Nickel Metal Hydride Battery

In the HV battery pack, six nickel metal hydride type 1.2V cells are connected in series to form one module.

In the '01-03 Prius, 38 modules are divided into two holders and connected in series. Thus, the HV battery contains a total of 228 cells and has a rated voltage of 273.6V.

In the '04 and later Prius, 28 modules are connected for a rated voltage of 201.6V. The cells are now connected in two places, reducing the internal resistance of the battery.

The electrode plates in the HV battery are made of porous nickel and metal hydride alloy.

NOTE For battery recycling information, please refer to the Warranty Policy and Procedure manual.

HV Battery Pack Information

HV Battery Pack	'04 Prius and Later	'01 -'03 Prius
Battery pack voltage	201.6V	273.6V
Number of NiMH battery modules in the pack	28	38
Number of cells	168	228
NiMH battery module voltage	7.2V	←

System Main Relay (SMR)

The System Main Relay (SMR) connects and disconnects the power source of the high-voltage circuit on command from the HV ECU. A total of three relays, one for the negative side and two for the positive side, are provided to ensure proper operation.

When energized, SMR1 and SMR3 are turned ON. Next, SMR2 is turned ON and SMR1 is turned OFF. By allowing a controlled current via the resistor to pass through initially in this manner, the circuit is protected against inrush current.

When de-energized, SMR2 and SMR3 are turned OFF in that order, and the HV ECU verifies that the respective relays have been properly turned OFF.

System Main Relay (SMR)

The SMR connects and disconnects the power source of the high-voltage circuit. A total of three relays, one for the negative side and two for the positive side, are provided to ensure proper operation.

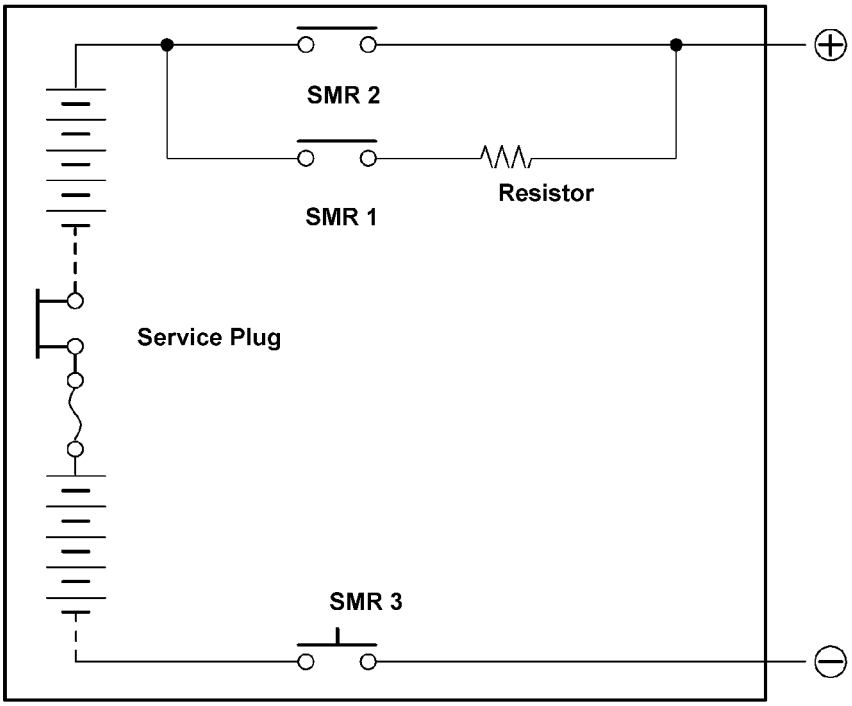


Figure 5.1 T072f501c

State of Charge (SOC)

The battery ECU constantly monitors HV battery temperature, voltage and amperage. It also checks for leaks in the HV battery.

While the vehicle is in motion, the HV battery undergoes repetitive charge/discharge cycles as it becomes discharged by MG2 during acceleration, and charged by the regenerative brake during deceleration. The battery ECU outputs charge/discharge requests to the HV ECU so that the SOC can be constantly maintained at a median level by estimating the charge/discharge amperage.

The target SOC is 60%. When the SOC drops below the target range, the battery ECU informs the HV ECU. The HV ECU then signals the engine ECM to increase power to charge the HV battery. If the SOC is below 20%, the engine is not producing power.

Delta SOC

The Delta SOC should not exceed 20%. Normal low to high deviation is 20% in order to calculate the SOC from one module to the next across the battery group. When the Delta SOC exceeds 20%, this means that the HV Battery ECU cannot correct or maintain the SOC difference within the acceptable range.

DTC P3006 Battery SOC Uneven ('01-'03 Prius)

The charging rate of each battery is monitored through the battery voltage detection line. Since the stall test suggested in the Repair Manual is not a reliable test, drive the vehicle under load while viewing the Min/Max voltage on the Diagnostic Tester. For example, drive up a steep hill very slowly. This kind of load stresses the battery and will allow detection of weak modules.

CAUTION

This is a two-person test. One person should drive the vehicle while the other monitors the Diagnostic Tester.

If P3006 is the only DTC, refer to the Repair Manual to do a stall test. Monitor the swing and the difference in voltage between the data MAX V and MIN V.

HV Battery Cooling System

The battery ECU detects the rise in the battery temperature via three temperature sensors in the HV battery and one intake air temperature sensor. Then the battery ECU actuates the cooling fan under duty cycle control in order to maintain the temperature of the HV battery within the specified range.

The battery ECU keeps the fan OFF or running at LO if:

- The A/C is being used to cool the vehicle.
- Some margin is left in the temperature of the battery.

This gives priority to cooling down the cabin, which is important because on the '04 & later Prius the cooling system draws intake air from the cabin.

DTC P3076 Abnormal Battery Cooling Fan Air Flow ('01-'03 Prius)

If foreign matter clogs the duct, the HV battery might not be able to cool sufficiently. Insufficient cooling will cause the output control warning light to illuminate and may cause DTC P3076.

NOTE

In the '01-03 Prius, the fresh air duct permits the flow of cooling air when the vehicle is stopped after driving. When washing the car, do not allow large quantities of water to enter the duct.

HV Battery Malfunction Monitoring

The HV Battery Malfunction Monitoring function in the battery ECU monitors the temperature and voltage of the HV battery. If a malfunction is detected, the battery ECU restricts or stops the charging and discharging of the HV battery. In addition, this function illuminates the warning light, outputs DTCs and stores them in memory.

HV Battery Diagnosis

When a HV battery malfunction occurs, the system sets a Master Warning light and illuminates the battery symbol on the Malfunction Indicator. Use the Diagnostic Tester to view the HV Battery Data List. The Data List provides battery system information down to a module pair level.

NOTE

Check for external contamination when a battery malfunction occurs. Find out where the customer works, where they park, etc. There may be excessive foreign matter entering into the vent.

High-Voltage Component Service Safety

During high-voltage component service:

- ALWAYS disconnect the auxiliary battery before removing the high-voltage service plug.
- ALWAYS use high-voltage insulated gloves when disconnecting the service plug.
- ALWAYS use a DVOM to confirm that high-voltage circuits have 0V before performing any service operation.
- ALWAYS confirm that you have the service plug in your pocket before performing any service operations.
- ALWAYS use the Repair Manual diagnostic procedures.

NOTE

ALWAYS assume that high-voltage circuits are energized.

Remember that removal of the service plug does not disable the individual high-voltage batteries.

High-Voltage Battery Service

During high-voltage battery service:

- ALWAYS use high-voltage insulated gloves and safety glasses when disassembling the high-voltage battery.
- Remove ALL metal objects that may touch the workbench.
- Understand the voltage potential that is within your reach.

High-Voltage Battery Charger

When a HV battery needs to be recharged, a special high-voltage battery charger must be used. These battery chargers come from Japan and are not sold to dealers. Your regional FTS or FPE will bring the charger to your dealership and perform the charging operation. **ONLY FTSs and FPEs are authorized to use the charger!**

When using the charger, the immediate area must be secured with warning tape and the vehicle must be outside. This tool will charge the battery from below 15% SOC to 40-50% SOC in approximately three hours. Target SOC is 60%.

NOTE

The power connector on the high voltage charger can be physically plugged into a standard 110V AC - 60 Hz socket, but the charger is **NOT** an 110V device. Therefore, you must **ALWAYS** use the transformer box!

High-Voltage Battery Charger

The small orange cable is the 300-volt DC output. The small black cable powers the 12V system for battery cooling fans and computer.

IMPORTANT: The power connector on the high voltage charger can be physically plugged into a standard 110V AC-60 Hz socket, but the charger is **NOT** a 110V device. **You must ALWAYS** use the transformer box shown on the left side of the photo when powering up the charger.

Figure 5.2 T072f502p

Connection Wires

In the vehicle, the mating connector for the orange wire is inside the left end of the battery pack, under the cover. Use care when pulling out the plug in the battery pack. The wires are not heavily insulated and the sheet metal case is sharp.

Figure 5.3 T072f503p

Control Panel

The unit will charge the battery pack from below 15% SOC to a "startable" 40-50% SOC in about 3 hours.

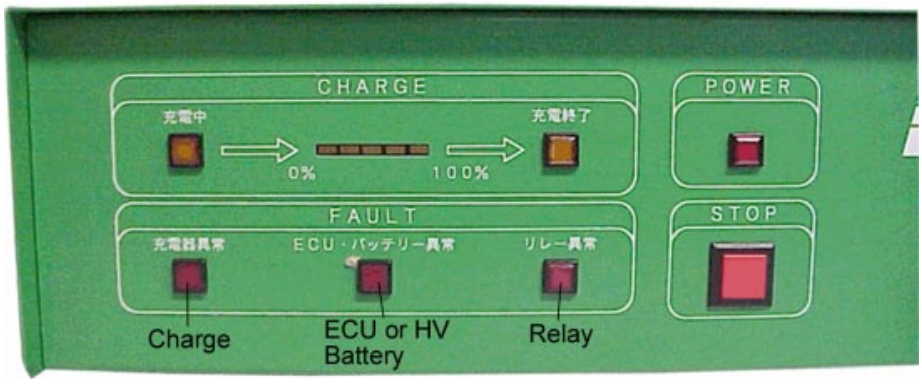


Figure 5.4 T072f504p

Charging HV Battery

The photo below shows the high-voltage battery charger connected to a '01-'03 Prius.

CAUTION Before connecting the charger, wear insulated gloves and remove the service plug. Keep the ignition key in your pocket for safety.

HV Battery Charger

('01 - '03 Prius)

HV Battery Charger connected to the vehicle.

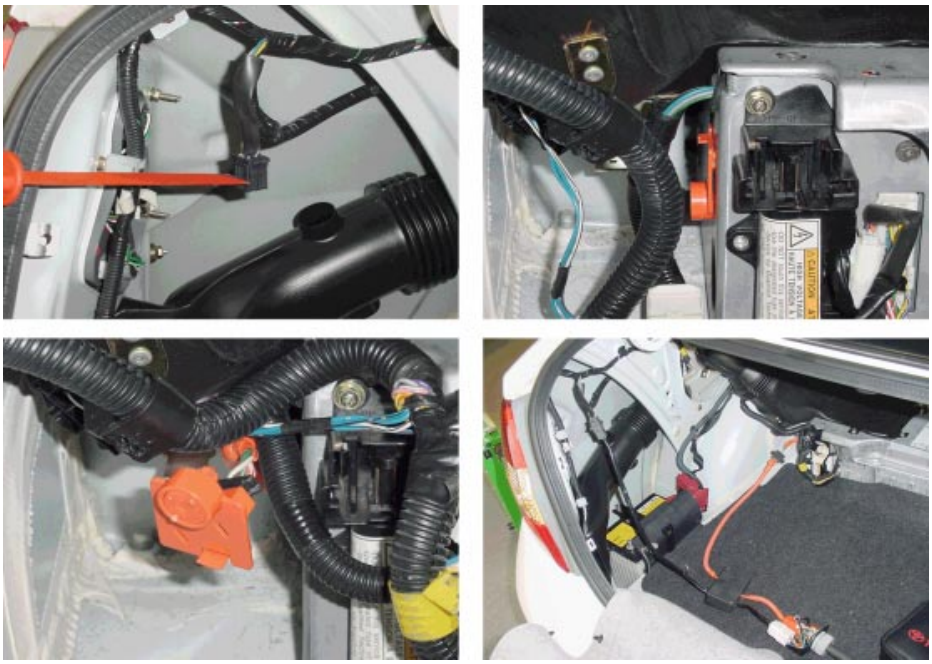


Figure 5.5 T072f505p

Charging HV Battery ('04 & later Prius)

The '04 & later Prius uses the same battery charger as earlier models, but uses a wiring harness specifically designed for the newer model. The charger connection points have changed.

Before connecting the charger, wear insulated gloves and remove the service plug. Keep the ignition key and service plug in your pocket.

The software logic on the '04 Prius has changed to help prevent customers from running the HV battery low enough to where the charger is needed. The vehicle simply will not crank after the customer has tried several times after running out of gas for example. If the charger is needed, call your regional FTS or FPE for assistance. Refer to the graphic below for the HV battery charger connection points.

HV Battery Charging

('04 & later Prius)

ALWAYS use the transformer box when connecting the HV battery charger.

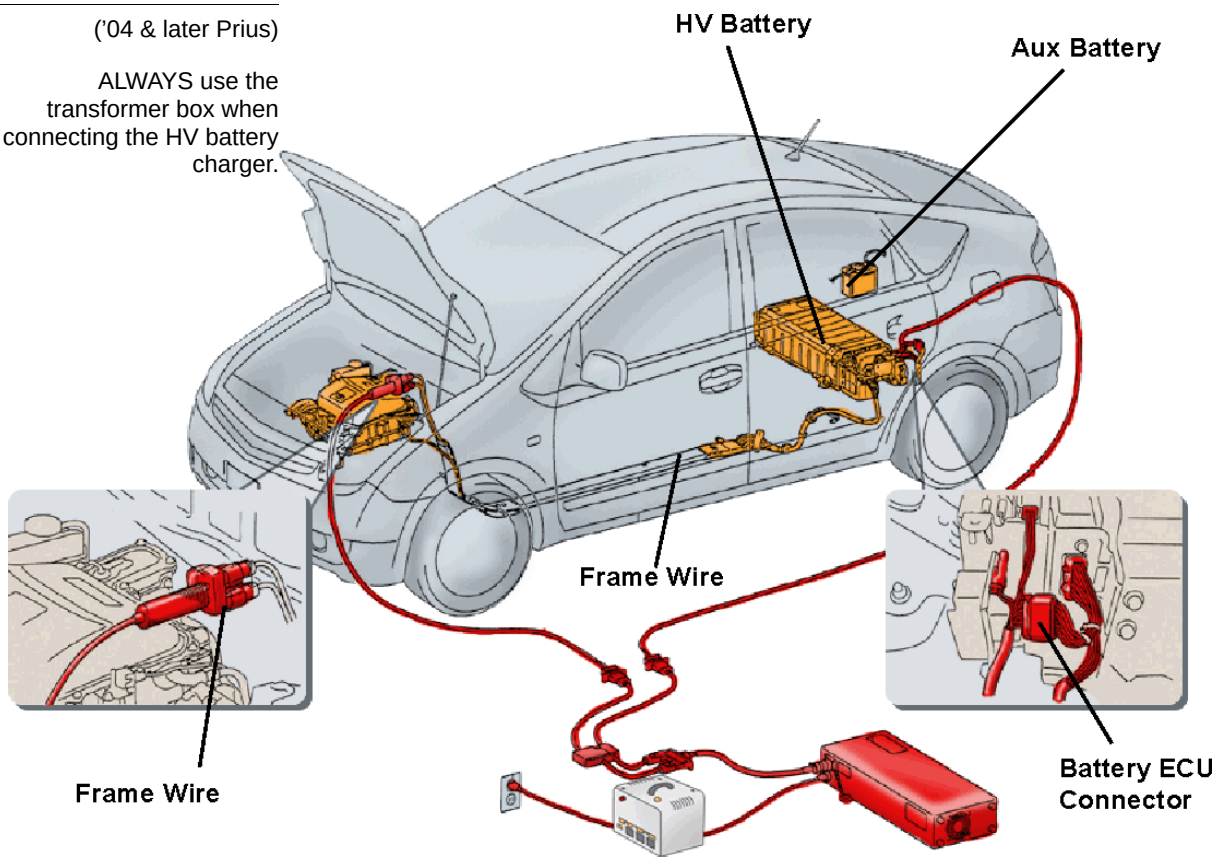
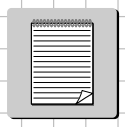


Figure 5.6

T072f506c



Notes

WORKSHEET 5-1
HV Battery Diagnosis (Customer Concern)

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will diagnose two HV Battery concerns. You will use the provided HV battery DTCs, Freeze Frame Data and Information Codes.

Section 1 - DTC Diagnosis

Repair Order

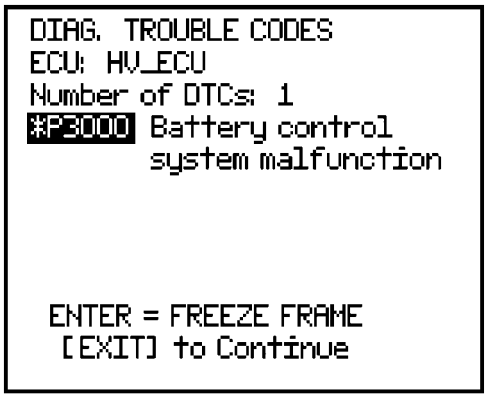
VIN JT2BK18U930071601	Year/Make/Model 03/Toyota/Prius	Production Date 8/10/02	RO Number 319902
Air Cond. Y	PS Y	Trans A	Mileage 3,075
Time Received 10:58am	Date/Time Promised 5/01/03 6:00pm	Priority 4	
Comments: The customer complains that there was a loss of power, and warning lights turned ON.			

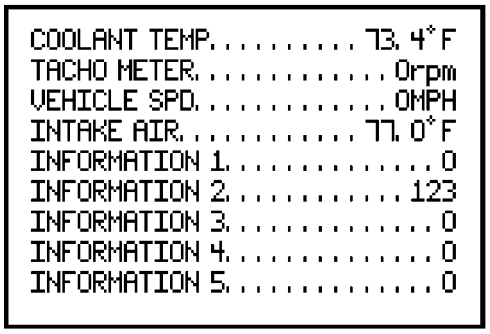
1. View the Repair Order above along with the DTCs, Information Codes and Freeze Frame data provided by the instructor to diagnose the customer's complaint.

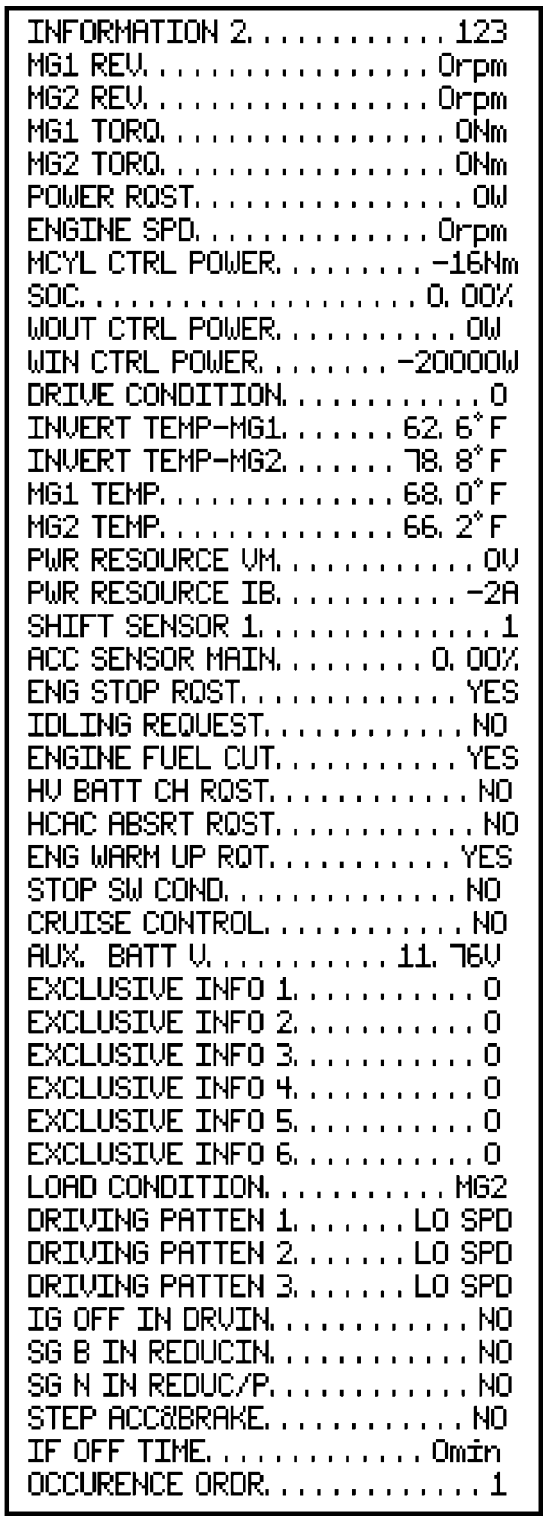
2. List all the DTCs and Information Codes along with their descriptions. Then put the codes in the proper heirarchy to help diagnose the problem.

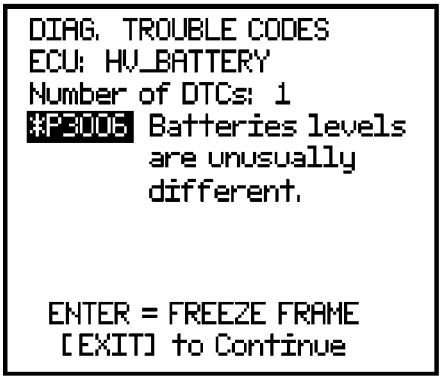
3. What information should you look for in the Freeze Frame data for P3006?

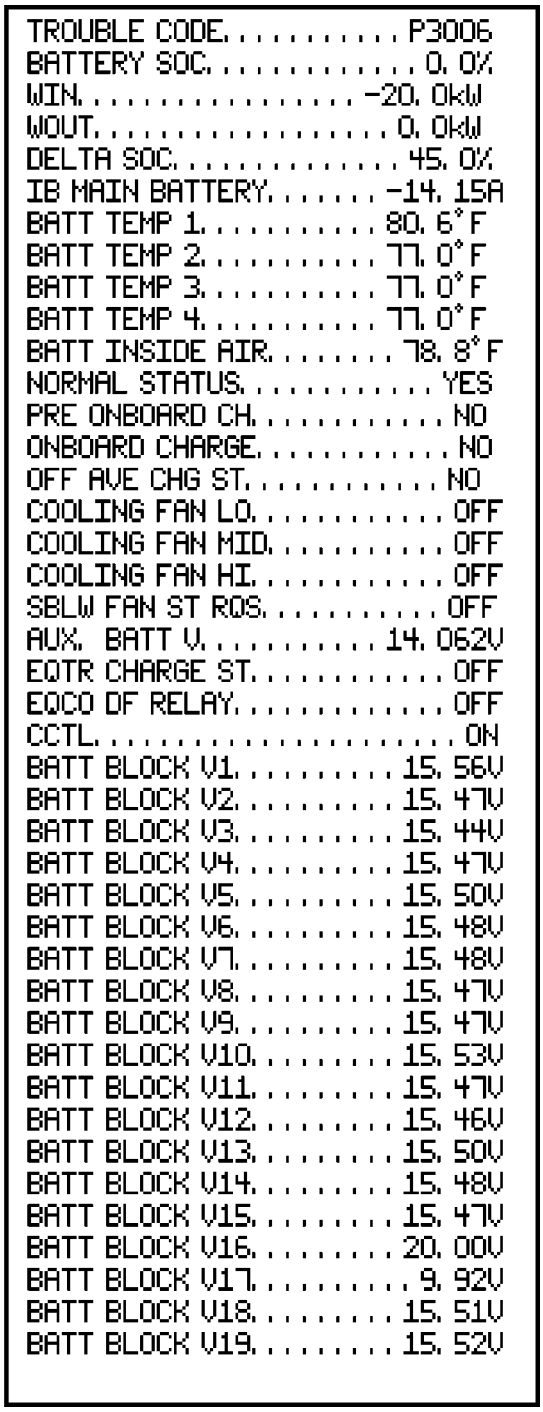
4. Can you predict what the diagnosis might be?


DIAG. TROUBLE CODES
ECU: HV_ECU
Number of DTCs: 1
*P3000 Battery control
system malfunction
ENTER = FREEZE FRAME
[EXIT] to Continue


COOLANT TEMP. . . . . 73. 4°F
TACHO METER. 0rpm
VEHICLE SPD. 0MPH
INTAKE AIR. . . . . 77. 0°F
INFORMATION 1. 0
INFORMATION 2. 123
INFORMATION 3. 0
INFORMATION 4. 0
INFORMATION 5. 0


INFORMATION 2. 123
MG1 REV. 0rpm
MG2 REV. 0rpm
MG1 TORQ. 0Nm
MG2 TORQ. 0Nm
POWER RQST. 0W
ENGINE SPD. 0rpm
MCYL CTRL POWER. . . . . -16Nm
SOC. 0. 00%
WOUT CTRL POWER. 0W
WIN CTRL POWER. . . . . -20000W
DRIVE CONDITION. 0
INVERT TEMP-MG1. . . . . 62. 6°F
INVERT TEMP-MG2. . . . . 78. 8°F
MG1 TEMP. . . . . 68. 0°F
MG2 TEMP. . . . . 66. 2°F
PWR RESOURCE VM. 0V
PWR RESOURCE IB. . . . . -2A
SHIFT SENSOR 1. 1
ACC SENSOR MAIN. 0. 00%
ENG STOP RQST. . . . . YES
IDLING REQUEST. . . . . NO
ENGINE FUEL CUT. . . . . YES
HV BATT CH RQST. . . . . NO
HCAC ABSRT RQST. . . . . NO
ENG WARM UP RQT. . . . . YES
STOP SW COND. . . . . NO
CRUISE CONTROL. . . . . NO
AUX. BATT V. 11. 76V
EXCLUSIVE INFO 1. 0
EXCLUSIVE INFO 2. 0
EXCLUSIVE INFO 3. 0
EXCLUSIVE INFO 4. 0
EXCLUSIVE INFO 5. 0
EXCLUSIVE INFO 6. 0
LOAD CONDITION. MG2
DRIVING PATTEN 1. . . . . LO SPD
DRIVING PATTEN 2. . . . . LO SPD
DRIVING PATTEN 3. . . . . LO SPD
IG OFF IN DRVIN. . . . . NO
SG B IN REDUCIN. . . . . NO
SG N IN REDUC/P. . . . . NO
STEP ACC&BRAKE. . . . . NO
IF OFF TIME. 0min
OCCURENCE ORDR. 1


DIAG. TROUBLE CODES
ECU: HV_BATTERY
Number of DTCs: 1
#P3006 Batteries levels are unusually different.
ENTER = FREEZE FRAME
[EXIT] to Continue


TROUBLE CODE..... P3006
BATTERY SOC..... 0.0%
WIN..... -20.0kW
WOUT..... 0.0kW
DELTA SOC..... 45.0%
IB MAIN BATTERY..... -14.15A
BATT TEMP 1..... 80.6°F
BATT TEMP 2..... 77.0°F
BATT TEMP 3..... 77.0°F
BATT TEMP 4..... 77.0°F
BATT INSIDE AIR..... 78.8°F
NORMAL STATUS..... YES
PRE ONBOARD CH..... NO
ONBOARD CHARGE..... NO
OFF AVE CHG ST..... NO
COOLING FAN LO..... OFF
COOLING FAN MID..... OFF
COOLING FAN HI..... OFF
SBLW FAN ST ROS..... OFF
AUX. BATT V..... 14.062V
EQTR CHARGE ST..... OFF
EQCO DF RELAY..... OFF
CCTL..... ON
BATT BLOCK V1..... 15.56V
BATT BLOCK V2..... 15.47V
BATT BLOCK V3..... 15.44V
BATT BLOCK V4..... 15.47V
BATT BLOCK V5..... 15.50V
BATT BLOCK V6..... 15.48V
BATT BLOCK V7..... 15.48V
BATT BLOCK V8..... 15.47V
BATT BLOCK V9..... 15.47V
BATT BLOCK V10..... 15.53V
BATT BLOCK V11..... 15.47V
BATT BLOCK V12..... 15.46V
BATT BLOCK V13..... 15.50V
BATT BLOCK V14..... 15.48V
BATT BLOCK V15..... 15.47V
BATT BLOCK V16..... 20.00V
BATT BLOCK V17..... 9.92V
BATT BLOCK V18..... 15.51V
BATT BLOCK V19..... 15.52V