ELECTRONIC CONTROL MODULES

TABLE OF CONTENTS

COMMUNICATION

DESCRIPTION

The DaimlerChrysler Programmable Communication Interface (PCI) data bus system is a single wire multiplex system used for vehicle communications on many DaimlerChrysler Corporation vehicles. Multiplexing is a system that enables the transmission of several messages over a single channel or circuit. All DaimlerChrysler vehicles use this principle for communication between various microprocessor-based electronic control modules. The PCI data bus exceeds the Society of Automotive Engineers (SAE) J1850 Standard for Class B Multiplexing.

COMMUNICATION (Continued)

Many of the electronic control modules in a vehicle require information from the same sensing device. In the past, if information from one sensing device was required by several controllers, a wire from each controller needed to be connected in parallel to that sensor. In addition, each controller utilizing analog sensors required an Analog/Digital (A/D) converter in order to ″read″ these sensor inputs. Multiplexing reduces wire harness complexity, sensor current loads and controller hardware because each sensing device is connected to only one controller, which reads and distributes the sensor information to the other controllers over the data bus. Also, because each controller on the data bus can access the controller sensor inputs to every other controller on the data bus, more function and feature capabilities are possible.

In addition to reducing wire harness complexity, component sensor current loads and controller hardware, multiplexing offers a diagnostic advantage. A multiplex system allows the information flowing between controllers to be monitored using a diagnostic scan tool. The DaimlerChrysler system allows an electronic control module to broadcast message data out onto the bus where all other electronic control modules can ″hear″ the messages that are being sent. When a module hears a message on the data bus that it requires, it relays that message to its microprocessor. Each module ignores the messages on the data bus that are being sent to other electronic control modules.

OPERATION

Data exchange between modules is achieved by serial transmission of encoded data over a single wire broadcast network. The wire colors used for the PCI data bus circuits are yellow with a violet tracer, or violet with a yellow tracer, depending upon the application. The PCI data bus messages are carried over the bus in the form of Variable Pulse Width Modulated (VPWM) signals. The PCI data bus speed is an average 10.4 Kilo-bits per second (Kbps). By comparison, the prior two-wire Chrysler Collision Detection (CCD) data bus system is designed to run at 7.8125 Kbps.

The voltage network used to transmit messages requires biasing and termination. Each module on the PCI data bus system provides its own biasing and termination. Each module (also referred to as a node) terminates the bus through a terminating resistor and a terminating capacitor. There are two types of nodes on the bus. The dominant node terminates the bus through a 1 KW resistor and a 3300 pF capacitor. The Powertrain Control Module (PCM) is the only dominant node for the PCI data bus system. A standard node terminates the bus through an 11 KW resistor and a 330 pF capacitor.

The modules bias the bus when transmitting a message. The PCI bus uses low and high voltage levels to generate signals. Low voltage is around zero volts and the high voltage is about seven and one-half volts. The low and high voltage levels are generated by means of variable-pulse width modulation to form signals of varying length. The Variable Pulse Width Modulation (VPWM) used in PCI bus messaging is a method in which both the state of the bus and the width of the pulse are used to encode bit information. A ″zero″ bit is defined as a short low pulse or a long high pulse. A ″one″ bit is defined as a long low pulse or a short high pulse. A low (passive) state on the bus does not necessarily mean a zero bit. It also depends upon pulse width. If the width is short, it stands for a zero bit. If the width is long, it stands for a one bit. Similarly, a high (active) state does not necessarily mean a one bit. This too depends upon pulse width. If the width is short, it stands for a one bit. If the width is long, it stands for a zero bit.

In the case where there are successive zero or one data bits, both the state of the bus and the width of the pulse are changed alternately. This encoding scheme is used for two reasons. First, this ensures that only one symbol per transition and one transition per symbol exists. On each transition, every transmitting module must decode the symbol on the bus and begin timing of the next symbol. Since timing of the next symbol begins with the last transition detected on the bus, all of the modules are re-synchronized with each symbol. This ensures that there are no accumulated timing errors during PCI data bus communication.

The second reason for this encoding scheme is to guarantee that the zero bit is the dominant bit on the bus. When two modules are transmitting simultaneously on the bus, there must be some form of arbitration to determine which module will gain control. A data collision occurs when two modules are transmitting different messages at the same time. When a module is transmitting on the bus, it is reading the bus at the same time to ensure message integrity. When a collision is detected, the module that transmitted the one bit stops sending messages over the bus until the bus becomes idle.

Each module is capable of transmitting and receiving data simultaneously. The typical PCI bus message has the following four components:

- **Message Header** - One to three bytes in length. The header contains information identifying the message type and length, message priority, target module(s) and sending module.
- **Data Byte(s)** - This is the actual message that is being sent.

COMMUNICATION (Continued)

- **Cyclic Redundancy Check (CRC) Byte** - This byte is used to detect errors during a message transmission.
- **In-Frame Response (IFR) byte(s)** - If a response is required from the target module(s), it can be sent during this frame. This function is described in greater detail in the following paragraph.

The IFR consists of one or more bytes, which are transmitted during a message. If the sending module requires information to be received immediately, the target module(s) can send data over the bus during the original message. This allows the sending module to receive time-critical information without having to wait for the target module to access the bus. After the IFR is received, the sending module broadcasts an End of Frame (EOF) message and releases control of the bus.

The PCI data bus can be monitored using the DRBIII® scan tool. It is possible, however, for the bus to pass all DRBIII® tests and still be faulty if the voltage parameters are all within the specified range and false messages are being sent.

CONTROLLER ANTILOCK BRAKE

DESCRIPTION

The Controler Antilock Brake (CAB) is mounted to the Hydraulic Control Unit (HCU) and operates the ABS system (Fig. 1).

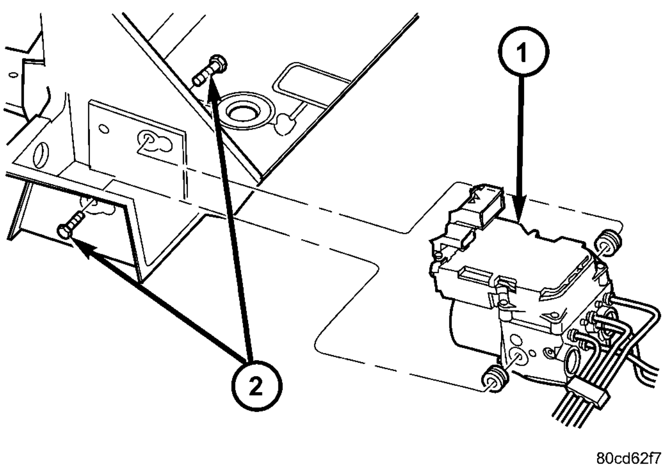

Fig. 1 HYDRAULIC CONTROL UNIT

1 - HYDRAULIC CONTROL UNIT
2 - MOUNTING BOLTS

OPERATION

The CAB voltage source is through the ignition switch in the RUN position. The CAB contains a self check program that illuminates the ABS warning light when a system fault is detected. Faults are stored in a diagnostic program memory and are accessible with the DRB III scan tool. ABS faults remain in memory until cleared, or until after the vehicle is started approximately 50 times. Stored faults are **not** erased if the battery is disconnected.

NOTE: If the CAB is being replaced with a new CAB is must be reprogrammed with the use of a DRB III.

REMOVAL

(1) Remove the negative battery cable from the battery.

(2) Pull up on the CAB harness connector release and remove connector.

(3) Remove the CAB mounting bolts.

(4) Remove the pump connector from the CAB.

(5) Remove the CAB from the HCU.

INSTALLATION

NOTE: If the CAB is being replaced with a new CAB is must be reprogrammed with the use of a DRB III.

(1) Install CAB to the HCU.

(2) Install the pump connector to the CAB.

(3) Install mounting bolts. Tighten to 2 N·m (16 in. lbs.).

(4) Install the wiring harness connector to the CAB and push down on the release to secure the connector.

(5) Install negative battery cable to the battery.

DATA LINK CONNECTOR

DESCRIPTION - DATA LINK CONNECTOR

The Data Link Connector (DLC) is located at the lower edge of the instrument panel near the steering column.

OPERATION - DATA LINK CONNECTOR

The 16–way data link connector (diagnostic scan tool connector) links the Diagnostic Readout Box (DRB) scan tool or the Mopar Diagnostic System (MDS) with the Powertrain Control Module (PCM).

ENGINE CONTROL MODULE

DESCRIPTION - ECM

The Engine Control Module (ECM) is bolted to the left side of the engine below the intake manifold (Fig. 2).

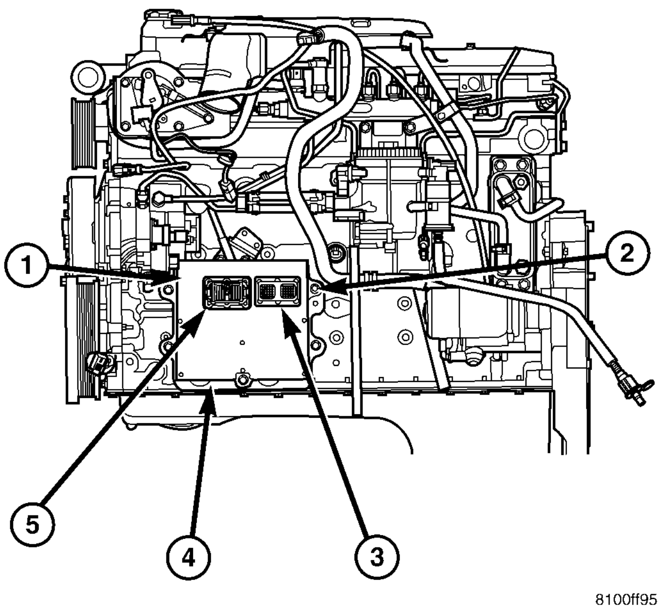

Fig. 2 DIESEL ECM

1 - ENGINE CONTROL MODULE (ECM)
2 - ECM MOUNTING BOLT
3 - 50-WAY CONNECTOR
4 - SUPPORT PLATE
5 - 60-WAY CONNECTOR

OPERATION - ECM

The main function of the Engine Control Module (ECM) is to electrically control the fuel system. The Powertrain Control Module (PCM) **does not control** the fuel system.

The ECM can adapt its programming to meet changing operating conditions. **If the ECM has been replaced, flashed or re-calibrated, the ECM must learn the Accelerator Pedal Position Sensor (APPS) idle voltage. Failure to learn this voltage may result in unnecessary diagnostic trouble codes. Refer to ECM Removal/Installation for learning procedures.**

The ECM receives input signals from various switches and sensors. Based on these inputs, the ECM regulates various engine and vehicle operations through different system components. These components are referred to as **ECM Outputs.** The sensors and switches that provide inputs to the ECM are considered **ECM Inputs.**

NOTE: ECM Inputs:

- Accelerator Pedal Position Sensor (APPS) Volts
- APPS1 Signal — For off engine APPS
- APPS2 Signal — For off engine APPS
- APPS Idle Validation Switches #1 and #2
- Battery voltage
- Camshaft Position Sensor (CMP)
- CCD bus (+) circuits
- CCD bus (-) circuits
- Crankshaft Position Sensor (CKP)
- Data link connection for DRB scan tool
- Engine Coolant Temperature (ECT) sensor
- Ground circuits
- Fuel Pressure Sensor
- Battery Temperature
- Fan speed
- Inlet Air Temperature Sensor/Pressure Sensor
- Intake Air Temperature Sensor/MAP Sensor
- Oil Pressure SWITCH
- Power ground
- Sensor return
- Signal ground
- Water-In-Fuel (WIF) sensor

NOTE: ECM Outputs:

After inputs are received by the ECM, certain sensors, switches and components are controlled or regulated by the ECM. These are considered **ECM Outputs.** These outputs are for:

- CCD bus (+) circuits
- CCD bus (-) circuits
- CKP and APPS outputs to the PCM
- Data link connection for DRB scan tool
- Five volt sensor supply
- Fuel transfer (lift) pump
- Intake manifold air heater relays #1 and #2 control circuits
- Malfunction indicator lamp (Check engine lamp) (databus)
- Oil Pressure Swith/warning lamp (databus)
- Fuel Control Actuator
- Wait-to-start warning lamp (databus)
- Fan Clutch PWM
- Water-In-Fuel (WIF) warning lamp (databus)

REMOVAL

The Engine Control Module (ECM) is bolted to a support bracket near the fuel filter. The support bracket mounts to the block with four capscrews and vibration isolators. A ground wire is fastened to the bracket. The other end of the wire is fastened to the engine block.

(1) Record any Diagnostic Trouble Codes (DTC's) found in the ECM.

ENGINE CONTROL MODULE (Continued)

To avoid possible voltage spike damage to either the Engine Control Module ECM, ignition key must be off, and negative battery cables must be disconnected before unplugging ECM connectors.

(2) Disconnect both negative battery cables at both batteries.

(3) Remove the 50–way and 60–way connector bolts at the ECM. Note: Tthe connector bolt is a female allen head. As bolt is being removed, very carfully remove connectors from the ECM.

(4) Remove five ECM mounting bolts and remove ECM form the vehicle (Fig. 3).

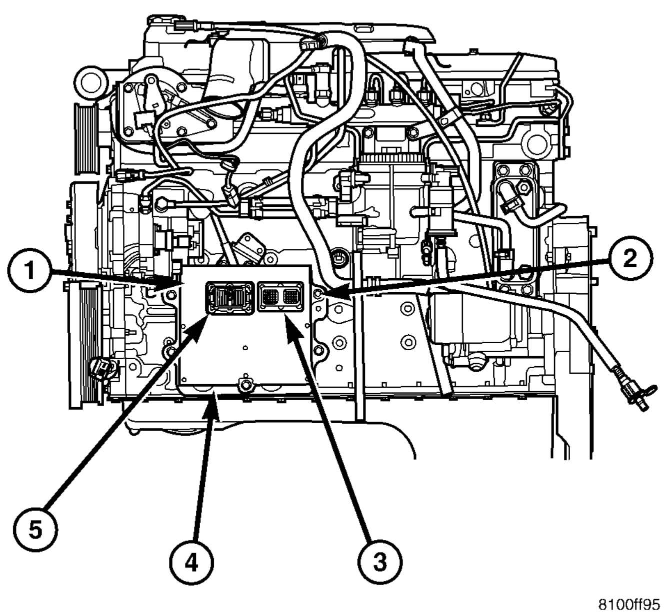

Fig. 3 DIESEL ECM

1 - ENGINE CONTROL MODULE (ECM)
2 - ECM MOUNTING BOLT
3 - 50-WAY CONNECTOR
4 - SUPPORT PLATE
5 - 60-WAY CONNECTOR

INSTALLATION

Do not apply paint to ECM. Poor ground will result.

(1) Position ECM to ECM support bracket and install five mounting bolts. Tighten bolts to 24 N·m (18 ft. lbs.).

(2) Check pin connectors in ECM and the 50–way and 60–way connectors for corrosion or damage. Repair as necessary.

(3) Clean pins in the 50–way and 60–way electrical connectors with a quick-dry electrical contact cleaner.

(4) Very carefully install the 50–way and 60–way connectors to ECM. Tighten connector allen bolts.

(5) Install both negative battery cables.

(6) **Turn key to ON position. Without starting engine, slowly press throttle pedal to floor and then slowly release. This step must be done (one time) to ensure accelerator pedal position sensor calibration has been learned by ECM. If not done, possible DTC's may be set.**

(7) Use DRB scan tool to erase any stored companion DTC's from ECM.

FRONT CONTROL MODULE

DESCRIPTION

The Front Control Module (FCM) is a micro controller based module located in the left front corner of the engine compartment. On this model the integrated power module must be positioned aside in order to access the front control module. The front control module mates to the power distribution center to form the Integrated Power Module (IPM). The integrated power module connects directly to the battery and provides the primary means of circuit protection and power distribution for all vehicle electrical systems. The front control module controls power to some of these vehicle systems electrical and electromechanical loads based on inputs received from hard wired switch inputs and data received on the PCI bus circuit (J1850).

For information on the **Integrated Power Module Refer to the Power Distribution Section** of the service manual.

OPERATION

As messages are sent over the PCI bus circuit, the front control module reads these messages and controls power to some of the vehicles electrical systems by completing the circuit to ground (low side driver) or completing the circuit to 12 volt power (high side driver). The following functions are **Controlled** by the Front Control Module:

- Headlamp Power with Voltage Regulation
- Windshield Wiper "ON/OFF" Relay Actuation
- Windshield Wiper "HI/LO" Relay Actuation
- Windshield Washer Pump Motor
- Fog Lamp Relay Actuation
- Park Lamp Relay Actuation
- Horn Relay Actuation

The following inputs are **Received/Monitored** by the Front Control Module:

- B+ Connection Detection
- Power Ground
- Ambient Temperature Sensing
- Ignition Switch Run
- Washer Fluid Level Switch
- Windshield Wiper Park Switch
- PCI Bus Circuit

FRONT CONTROL MODULE (Continued)

DIAGNOSIS AND TESTING - FRONT CONTROL MODULE

The front control module is a printed circuit board based module with a on-board micro-processor. The front control module interfaces with other electronic modules in the vehicle via the Programmable Communications Interface (PCI) data bus (J1850). In order to obtain conclusive testing the Programmable Communications Interface (PCI) data bus network and all of the electronic modules that provide inputs to, or receive outputs from the front control module must be checked. All PCI (J1850) communication faults must be resolved prior to further diagnosing any front control module related issues.

The front control module was designed to be diagnosed with an appropriate diagnostic scan tool, such as the DRB III®. The most reliable, efficient, and accurate means to diagnose the front control module requires the use of a DRB III® scan tool and the proper Body Diagnostic Procedures manual.

Before any testing of the front control module is attempted, the battery should be fully charged and all wire harness and ground connections inspected around the affected areas on the vehicle.

REMOVAL

(1) Disconnect the positive and negative battery cables from the battery.

(2) Partially remove the integrated power module from the engine compartment (Refer to 8 - ELECTRICAL/POWER DISTRIBUTION/INTEGRATED POWER MODULE - REMOVAL).

(3) Remove the front control module retaining screws.

(4) Using both hands, pull the front control module **straight** from the integrated power module assembly to disconnect the 49-way electrical connector and remove the front control module from the vehicle.

INSTALLATION

(1) Install the front control module on the integrated power module assembly by pushing the 49-way electrical connector straight in.

(2) Install the front control module retaining screws. Torque the screws to 7 in. lbs.

(3) Install the integrated power module (Refer to 8 - ELECTRICAL/POWER DISTRIBUTION/INTEGRATED POWER MODULE - INSTALLATION).

(4) Connect the positive and negative battery cables.

HEATED SEAT MODULE

DESCRIPTION

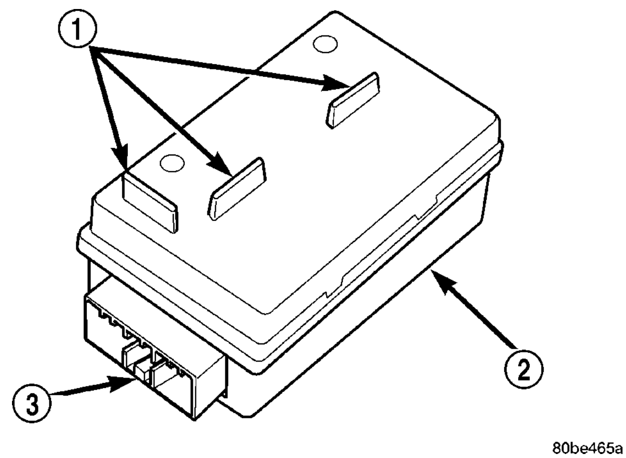

Fig. 4 Heated Seat Module

1 - MOUNTING TABS (NOT USED ON DR)
2 - HEATED SEAT MODULE
3 - ELECTRICAL CONNECTOR RECEPTACLE

The heated seat module is also known as the Seat Heat Interface Module. The heated seat module (Fig. 4) is located under the drivers front seat cushion, where it is secured to a mounting bracket. The heated seat module has a single connector receptacle that allows the module to be connected to all of the required inputs and outputs through the seat wire harness.

The heated seat module is an electronic microprocessor controlled device designed and programmed to use inputs from the battery, the two heated seat switches and the two heated seat sensors to operate and control the heated seat elements in both front seats and the two heated seat indicator lamp Light-Emitting Diodes (LEDs) in each heated seat switch. The heated seat module is also programmed to perform self-diagnosis of certain heated seat system functions and provide feedback of that diagnosis through the heated seat switch indicator lamps.

The heated seat module cannot be repaired. If the heated seat module is damaged or faulty, the entire module must be replaced.

OPERATION

The heated seat module operates on fused battery current received from the integrated power module. Inputs to the module include a resistor multiplexed heated seat switch request circuit for each of the two heated seat switches and the heated seat sensor inputs from the seat cushions of each front seat. In response to those inputs the heated seat module controls battery current feeds to the heated seat ele-

HEATED SEAT MODULE (Continued)

ments and sensors, and controls the ground for the heated seat switch indicator lamps.

When a heated seat switch (Driver or Passenger) is depressed a signal is received by the heated seat module, the module energizes the proper indicator LED (Low or High) in the switch by grounding the indicator lamp circuit to indicate that the heated seat system is operating. At the same time, the heated seat module energizes the selected heated seat sensor circuit and the sensor provides the module with an input indicating the surface temperature of the selected seat cushion.

The Low heat set point is about 36° C (96.8° F), and the High heat set point is about 42° C (107.6° F). If the seat cushion surface temperature input is below the temperature set point for the selected temperature setting, the heated seat module energizes an N-channel Field Effect Transistor (N-FET) within the module which energizes the heated seat elements in the selected seat cushion and back. When the sensor input to the module indicates the correct temperature set point has been achieved, the module de-energizes the N-FET which de-energizes the heated seat elements. The heated seat module will continue to cycle the N-FET as needed to maintain the selected temperature set point.

If the heated seat module detects a heated seat sensor value input that is out of range or a shorted or open heated seat element circuit, it will notify the vehicle operator or the repair technician of this condition by flashing the High and/or Low indicator lamps in the affected heated seat switch. Refer to **Diagnosis and Testing Heated Seat System** in Heated Systems for flashing LED diagnosis and testing procedures. Refer to **Diagnosis and Testing Heated Seat Module** in this section for heated seat module diagnosis and testing procedures.

DIAGNOSIS AND TESTING - HEATED SEAT MODULE

If a heated seat fails to heat and one or both of the indicator lamps on a heated seat switch flash, refer to **Diagnosis and Testing Heated Seat System** in Heated Seats for the location of flashing LED heated seat system diagnosis and testing procedures. If a heated seat heats but one or both indicator lamps on the heated seat switch fail to operate, test the heated seat switch. Refer to **Diagnosis and Testing Heated Seat Switch** in Heated Seats for heated seat switch diagnosis and testing procedures. If the heated seat switch checks OK, proceed as follows.

(1) Check the heated seat element (Refer to 8 - ELECTRICAL/HEATED SEATS/HEATED SEAT ELEMENT - DIAGNOSIS AND TESTING).

(2) Check the heated seat sensor (Refer to 8 - ELECTRICAL/HEATED SEATS/HEATED SEAT SENSOR - DIAGNOSIS AND TESTING).

(3) Check the heated seat switch (Refer to 8 - ELECTRICAL/HEATED SEATS/DRIVER HEATED SEAT SWITCH - DIAGNOSIS AND TESTING).

NOTE: Refer to Wiring for the location of complete heated seat system wiring diagrams and connector pin-out information.

(4) Using a voltmeter, backprobe the appropriate heated seat module connector, do not disconnect. Check for voltage at the appropriate pin cavities. 12v should be present. If OK go to Step 5, if Not, Repair the open or shorted voltage supply circuit as required.

(5) Using a ohmmeter, backprobe the appropriate heated seat module connector, do not disconnect. Check for proper continuity to ground on the ground pin cavities. Continuity should be present. If OK replace the heated seat module with a known good unit and retest system, if Not OK, Repair the open or shorted ground circuit as required.

REMOVAL

(1) Position the driver seat to the full rearward and inclined position.

(2) Working under the driver front seat, remove the two heated seat module retaining screws. Due to the fact that the retaining screws are installed with the seat cushion pan removed, a small right angle screwdriver will be required to access and remove the screws.

(3) Disconnect the seat wire harness connector from the connector receptacle on the back of the heated seat module. Depress the connector retaining tab and pull straight apart.

(4) Remove the heated seat module from under the front seat.

INSTALLATION

(1) Position the heated seat module under the front seat.

(2) Connect the seat wire harness connector on the connector receptacle on the back of the heated seat module.

(3) Working under the driver front seat, install the heated seat module retaining screws.

(4) Re-position the driver seat.

POWERTRAIN CONTROL MODULE

DESCRIPTION

DESCRIPTION - PCM

The Powertrain Control Module (PCM) is located in the right-rear section of the engine compartment under the cowl (Fig. 5).

Two different PCM's are used (JTEC and NGC). These can be easily identified. JTEC's use three 32–way connectors, NGC's use four 38–way connectors

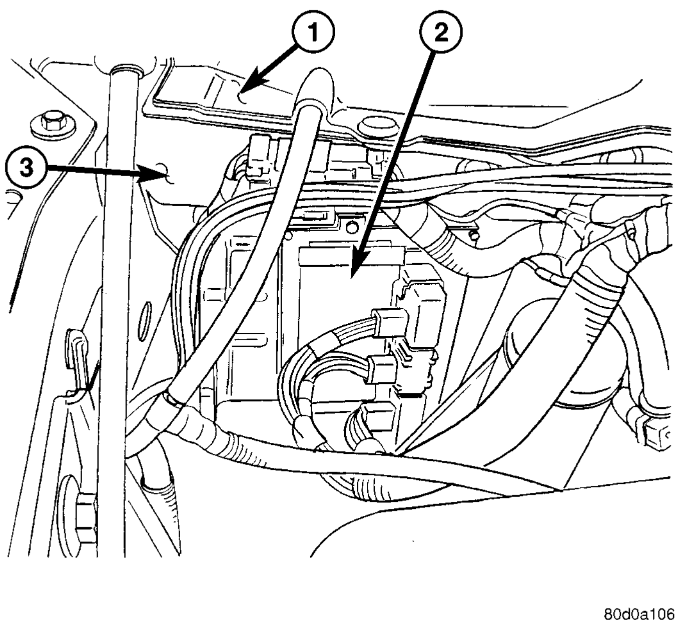

Fig. 5 POWERTRAIN CONTROL MODULE (PCM) LOCATION

1 - COWL GRILL
2 - PCM
3 - COWL (RIGHT-REAR)

DESCRIPTION - MODES OF OPERATION

As input signals to the Powertrain Control Module (PCM) change, the PCM adjusts its response to the output devices. For example, the PCM must calculate different injector pulse width and ignition timing for idle than it does for wide open throttle (WOT).

The PCM will operate in two different modes: **Open Loop and Closed Loop**.

During Open Loop modes, the PCM receives input signals and responds only according to preset PCM programming. Input from the oxygen (O2S) sensors is not monitored during Open Loop modes.

During Closed Loop modes, the PCM will monitor the oxygen (O2S) sensors input. This input indicates to the PCM whether or not the calculated injector pulse width results in the ideal air-fuel ratio. This ratio is 14.7 parts air-to-1 part fuel. By monitoring the exhaust oxygen content through the O2S sensor, the PCM can fine tune the injector pulse width. This is done to achieve optimum fuel economy combined with low emission engine performance.

The fuel injection system has the following modes of operation:

- Ignition switch ON
- Engine start-up (crank)
- Engine warm-up
- Idle
- Cruise
- Acceleration
- Deceleration
- Wide open throttle (WOT)
- Ignition switch OFF

The ignition switch On, engine start-up (crank), engine warm-up, acceleration, deceleration and wide open throttle modes are Open Loop modes. The idle and cruise modes, (with the engine at operating temperature) are Closed Loop modes.

IGNITION SWITCH (KEY-ON) MODE

This is an Open Loop mode. When the fuel system is activated by the ignition switch, the following actions occur:

- The PCM pre-positions the idle air control (IAC) motor.
- The PCM determines atmospheric air pressure from the MAP sensor input to determine basic fuel strategy.
- The PCM monitors the engine coolant temperature sensor input. The PCM modifies fuel strategy based on this input.
- Intake manifold air temperature sensor input is monitored.
- Throttle position sensor (TPS) is monitored.
- The auto shutdown (ASD) relay is energized by the PCM for approximately three seconds.
- The fuel pump is energized through the fuel pump relay by the PCM. The fuel pump will operate for approximately three seconds unless the engine is operating or the starter motor is engaged.
- The O2S sensor heater element is energized via the ASD or O2S heater relay. The O2S sensor input is not used by the PCM to calibrate air-fuel ratio during this mode of operation.

ENGINE START-UP MODE

This is an Open Loop mode. The following actions occur when the starter motor is engaged.

The PCM receives inputs from:

POWERTRAIN CONTROL MODULE (Continued)

- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal

The PCM monitors the crankshaft position sensor. If the PCM does not receive a crankshaft position sensor signal within 3 seconds of cranking the engine, it will shut down the fuel injection system.

The fuel pump is activated by the PCM through the fuel pump relay.

Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.

The PCM determines the proper ignition timing according to input received from the crankshaft position sensor.

ENGINE WARM-UP MODE

This is an Open Loop mode. During engine warm-up, the PCM receives inputs from:

- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)

Based on these inputs the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM adjusts engine idle speed through the idle air control (IAC) motor and adjusts ignition timing.
- The PCM operates the A/C compressor clutch through the A/C compressor clutch relay. This is done if A/C has been selected by the vehicle operator and specified pressures are met at the high and low–pressure A/C switches. Refer to Heating and Air Conditioning for additional information.
- When engine has reached operating temperature, the PCM will begin monitoring O2S sensor input. The system will then leave the warm-up mode and go into closed loop operation.

IDLE MODE

When the engine is at operating temperature, this is a Closed Loop mode. At idle speed, the PCM receives inputs from:

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Battery voltage
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Oxygen sensors

Based on these inputs, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM monitors the O2S sensor input and adjusts air-fuel ratio by varying injector pulse width. It also adjusts engine idle speed through the idle air control (IAC) motor.
- The PCM adjusts ignition timing by increasing and decreasing spark advance.
- The PCM operates the A/C compressor clutch through the A/C compressor clutch relay. This is done if A/C has been selected by the vehicle operator and specified pressures are met at the high and low–pressure A/C switches. Refer to Heating and Air Conditioning for additional information.

CRUISE MODE

When the engine is at operating temperature, this is a Closed Loop mode. At cruising speed, the PCM receives inputs from:

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Oxygen (O2S) sensors

Based on these inputs, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then adjust the injector pulse width by turning the ground circuit to each individual injector on and off.

- The PCM monitors the O2S sensor input and adjusts air-fuel ratio. It also adjusts engine idle speed through the idle air control (IAC) motor.
- The PCM adjusts ignition timing by turning the ground path to the coil(s) on and off.
- The PCM operates the A/C compressor clutch through the clutch relay. This happens if A/C has been selected by the vehicle operator and requested by the A/C thermostat.

ACCELERATION MODE

This is an Open Loop mode. The PCM recognizes an abrupt increase in throttle position or MAP pressure as a demand for increased engine output and vehicle acceleration. The PCM increases injector pulse width in response to increased throttle opening.

DECELERATION MODE

When the engine is at operating temperature, this is an Open Loop mode. During hard deceleration, the PCM receives the following inputs.

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Vehicle speed

If the vehicle is under hard deceleration with the proper rpm and closed throttle conditions, the PCM will ignore the oxygen sensor input signal. The PCM will enter a fuel cut-off strategy in which it will not supply a ground to the injectors. If a hard deceleration does not exist, the PCM will determine the proper injector pulse width and continue injection.

Based on the above inputs, the PCM will adjust engine idle speed through the idle air control (IAC) motor.

The PCM adjusts ignition timing by turning the ground path to the coil on and off.

WIDE OPEN THROTTLE MODE

This is an Open Loop mode. During wide open throttle operation, the PCM receives the following inputs.

- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal

During wide open throttle conditions, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off. The PCM ignores the oxygen sensor input signal and provides a predetermined amount of additional fuel. This is done by adjusting injector pulse width.
- The PCM adjusts ignition timing by turning the ground path to the coil(s) on and off.

IGNITION SWITCH OFF MODE

When ignition switch is turned to OFF position, the PCM stops operating the injectors, ignition coil, ASD relay and fuel pump relay.

DESCRIPTION - 5 VOLT SUPPLIES

Two different Powertrain Control Module (PCM) five volt supply circuits are used; primary and secondary.

DESCRIPTION - IGNITION CIRCUIT SENSE

This circuit ties the ignition switch to the Powertrain Control Module (PCM).

DESCRIPTION - POWER GROUNDS

The Powertrain Control Module (PCM) has 2 main grounds. Both of these grounds are referred to as power grounds. All of the high-current, noisy, electrical devices are connected to these grounds as well as all of the sensor returns. The sensor return comes into the sensor return circuit, passes through noise suppression, and is then connected to the power ground.

The power ground is used to control ground circuits for the following PCM loads:

- Generator field winding
- Fuel injectors
- Ignition coil(s)
- Certain relays/solenoids
- Certain sensors

DESCRIPTION - SENSOR RETURN

The Sensor Return circuits are internal to the Powertrain Control Module (PCM).

Sensor Return provides a low–noise ground reference for all engine control system sensors. Refer to Power Grounds for more information.

POWERTRAIN CONTROL MODULE (Continued)

OPERATION

OPERATION - PCM

The PCM operates the fuel system. The PCM is a pre-programmed, triple microprocessor digital computer. It regulates ignition timing, air-fuel ratio, emission control devices, charging system, certain transmission features, speed control, air conditioning compressor clutch engagement and idle speed. The PCM can adapt its programming to meet changing operating conditions.

The PCM receives input signals from various switches and sensors. Based on these inputs, the PCM regulates various engine and vehicle operations through different system components. These components are referred to as Powertrain Control Module (PCM) Outputs. The sensors and switches that provide inputs to the PCM are considered Powertrain Control Module (PCM) Inputs.

The PCM adjusts ignition timing based upon inputs it receives from sensors that react to: engine rpm, manifold absolute pressure, engine coolant temperature, throttle position, transmission gear selection (automatic transmission), vehicle speed, power steering pump pressure, and the brake switch.

The PCM adjusts idle speed based on inputs it receives from sensors that react to: throttle position, vehicle speed, transmission gear selection, engine coolant temperature and from inputs it receives from the air conditioning clutch switch and brake switch.

Based on inputs that it receives, the PCM adjusts ignition coil dwell. The PCM also adjusts the generator charge rate through control of the generator field and provides speed control operation.

NOTE: PCM Inputs:

- ABS module (if equipped)
- A/C request (if equipped with factory A/C)
- A/C select (if equipped with factory A/C)
- A/C pressure transducer
- Auto shutdown (ASD) sense
- Battery temperature sensor
- Battery voltage
- Brake switch
- J1850 bus (+) circuits
- J1850 bus (-) circuits
- Camshaft position sensor signal
- Crankshaft position sensor
- Data link connection for DRB scan tool
- EATX module (if equipped)
- Engine coolant temperature sensor
- Fuel level (through J1850 circuitry)
- Generator (battery voltage) output
- Ignition circuit sense (ignition switch in on/off/crank/run position)
- Intake manifold air temperature sensor
- Knock sensors (2 on 3.7L engine)
- Leak detection pump (switch) sense (if equipped)
- Manifold absolute pressure (MAP) sensor
- Oil pressure
- Oxygen sensors
- Park/neutral switch (auto. trans. only)
- Power ground
- Power steering pressure switch (if equipped)
- Sensor return
- Signal ground
- Speed control multiplexed single wire input
- Throttle position sensor
- Transfer case switch (4WD range position)
- Vehicle speed signal

NOTE: PCM Outputs:

- A/C clutch relay
- Auto shutdown (ASD) relay
- J1850 bus (+/-) circuits for: speedometer, voltmeter, fuel gauge, oil pressure gauge/lamp, engine temp. gauge and speed control warn. lamp
- Data link connection for DRB scan tool
- EGR valve control solenoid (if equipped)
- EVAP canister purge solenoid
- Five volt sensor supply (primary)
- Five volt sensor supply (secondary)
- Fuel injectors
- Fuel pump relay
- Generator field driver (-)
- Generator field driver (+)
- Idle air control (IAC) motor
- Ignition coil(s)
- Leak detection pump (if equipped)
- Malfunction indicator lamp (Check engine lamp). Driven through J1850 circuits.
- Oxygen sensor heater relays
- Oxygen sensors (pulse width modulated)
- Radiator cooling fan relay (pulse width modulated)
- Speed control vacuum solenoid
- Speed control vent solenoid
- Tachometer (if equipped). Driven through J1850 circuits.
- Transmission convertor clutch circuit. Driven through J1850 circuits.

OPERATION - 5 VOLT SUPPLIES

Primary 5–volt supply:

- supplies the required 5 volt power source to the Crankshaft Position (CKP) sensor.
- supplies the required 5 volt power source to the Camshaft Position (CMP) sensor.
- supplies a reference voltage for the Manifold Absolute Pressure (MAP) sensor.

POWERTRAIN CONTROL MODULE (Continued)

• supplies a reference voltage for the Throttle Position Sensor (TPS) sensor.

Secondary 5–volt supply:

• supplies the required 5 volt power source to the oil pressure sensor.

• supplies the required 5 volt power source for the Vehicle Speed Sensor (VSS) (if equipped).

• supplies the 5 volt power source to the transmission pressure sensor (certain automatic transmissions).

OPERATION - IGNITION CIRCUIT SENSE

The ignition circuit sense input tells the PCM the ignition switch has energized the ignition circuit.

Battery voltage is also supplied to the PCM through the ignition switch when the ignition is in the RUN or START position. This is referred to as the ″ignition sense″ circuit and is used to ″wake up″ the PCM. Voltage on the ignition input can be as low as 6 volts and the PCM will still function. Voltage is supplied to this circuit to power the PCM's 8-volt regulator and to allow the PCM to perform fuel, ignition and emissions control functions.

REMOVAL

USE THE DRB SCAN TOOL TO REPROGRAM THE NEW POWERTRAIN CONTROL MODULE (PCM) WITH THE VEHICLES ORIGINAL IDENTIFICATION NUMBER (VIN) AND THE VEHICLES ORIGINAL MILEAGE. IF THIS STEP IS NOT DONE, A DIAGNOSTIC TROUBLE CODE (DTC) MAY BE SET.

The PCM is located in the engine compartment attached to the dash panel (Fig. 6).

To avoid possible voltage spike damage to the PCM, ignition key must be off, and negative battery cable must be disconnected before unplugging PCM connectors.

(1) Disconnect negative battery cable at battery.

(2) Remove cover over electrical connectors. Cover snaps onto PCM.

(3) Carefully unplug the three 32–way connectors (four 38–way connectors if equipped with NGC) from PCM (Fig. 7).

(4) Remove three PCM mounting bolts (Fig. 7) and remove PCM from vehicle.

INSTALLATION

USE THE DRB SCAN TOOL TO REPROGRAM THE NEW POWERTRAIN CONTROL MODULE (PCM) WITH THE VEHICLES ORIGINAL IDENTIFICATION NUMBER (VIN) AND THE VEHICLES ORIGINAL MILEAGE. IF THIS STEP IS NOT DONE, A DIAGNOSTIC TROUBLE CODE (DTC) MAY BE SET.

(1) Install PCM and 3 mounting bolts to vehicle.

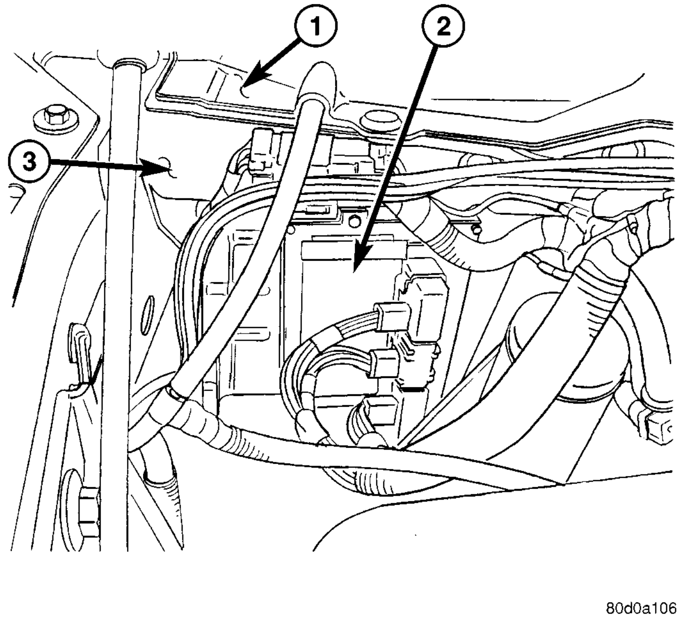

Fig. 6 PCM LOCATION

1 - COWL GRILL
2 - PCM
3 - COWL (RIGHT-REAR)

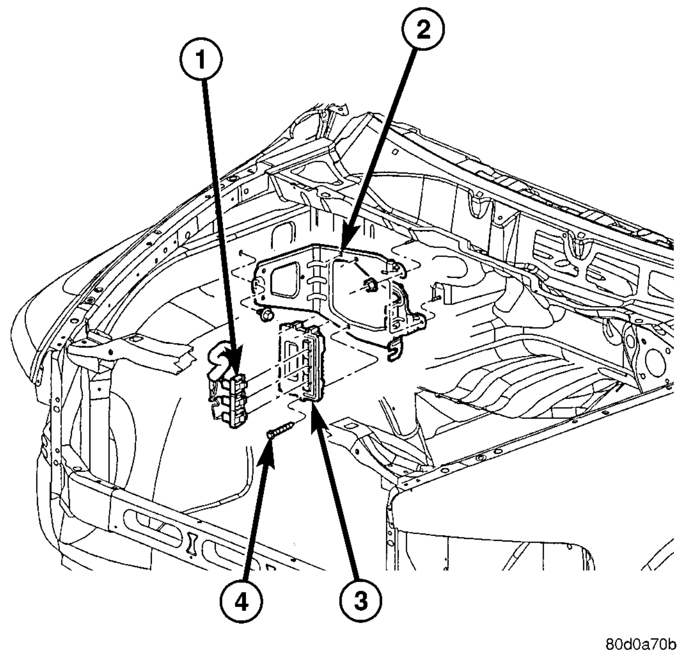

Fig. 7 PCM REMOVAL / INSTALLATION

1 - THREE 32-WAY CONNECTORS WITH JTEC (FOUR 38-WAY CONNECTORS WITH NGC)
2 - PCM MOUNTING BRACKET
3 - PCM
4 - PCM MOUNTING SCREWS (3)

POWERTRAIN CONTROL MODULE (Continued)

(2) Tighten bolts. Refer to torque specifications.

(3) Check pin connectors in the PCM and the three 32–way connectors (four 38–way connectors if equipped with NGC) for corrosion or damage. Also, the pin heights in connectors should all be same. Repair as necessary before installing connectors.

(4) Install three 32–way connectors (four 38–way connectors if equipped with NGC).

(5) Install cover over electrical connectors. Cover snaps onto PCM.

(6) Install negative battery cable.

(7) Use the DRB scan tool to reprogram new PCM with vehicles original Vehicle Identification Number (VIN) and original vehicle mileage.

SENTRY KEY IMMOBILIZER MODULE

DESCRIPTION

The Sentry Key Immobilizer Module (SKIM) contains a Radio Frequency (RF) transceiver and a central processing unit, which includes the Sentry Key Immobilizer System (SKIS) program logic. The SKIS programming enables the SKIM to program and retain in memory the codes of at least two, but no more than eight electronically coded Sentry Key transponders. The SKIS programming also enables the SKIM to communicate over the Programmable Communication Interface (PCI) bus network with the Powertrain Control Module (PCM), and/or the DRBIII® scan tool.

OPERATION

The SKIM transmits and receives RF signals through a tuned antenna enclosed within a molded plastic ring that is integral to the SKIM housing. When the SKIM is properly installed on the steering column, the antenna ring is oriented around the ignition lock cylinder housing. This antenna ring must be located within eight millimeters (0.31 inches) of the Sentry Key in order to ensure proper RF communication between the SKIM and the Sentry Key transponder.

For added system security, each SKIM is programmed with a unique “Secret Key” code and a security code. The SKIM keeps the “Secret Key” code in memory. The SKIM also sends the “Secret Key” code to each of the programmed Sentry Key transponders. The security code is used by the assembly plant to access the SKIS for initialization, or by the dealer technician to access the system for service. The SKIM also stores in its memory the Vehicle Identification Number (VIN), which it learns through a PCI bus message from the PCM during initialization.

The SKIM and the PCM both use software that includes a rolling code algorithm strategy, which helps to reduce the possibility of unauthorized SKIS disarming. The rolling code algorithm ensures security by preventing an override of the SKIS through the unauthorized substitution of the SKIM or the PCM. However, the use of this strategy also means that replacement of either the SKIM or the PCM units will require a system initialization procedure to restore system operation.

When the ignition switch is turned to the ON or START positions, the SKIM transmits an RF signal to excite the Sentry Key transponder. The SKIM then listens for a return RF signal from the transponder of the Sentry Key that is inserted in the ignition lock cylinder. If the SKIM receives an RF signal with valid “Secret Key” and transponder identification codes, the SKIM sends a “valid key” message to the PCM over the PCI bus. If the SKIM receives an invalid RF signal or no response, it sends “invalid key” messages to the PCM. The PCM will enable or disable engine operation based upon the status of the SKIM messages.

The SKIM also sends messages to the Instrument Cluster which controls the VTSS indicator LED. The SKIM sends messages to the Instrument Cluster to turn the LED on for about three seconds when the ignition switch is turned to the ON position as a bulb test. After completion of the bulb test, the SKIM sends bus messages to keep the LED off for a duration of about one second. Then the SKIM sends messages to turn the LED on or off based upon the results of the SKIS self-tests. If the VTSS indicator LED comes on and stays on after the bulb test, it indicates that the SKIM has detected a system malfunction and/or that the SKIS has become inoperative.

If the SKIM detects an invalid key when the ignition switch is turned to the ON position, it sends messages to flash the VTSS indicator LED. The SKIM can also send messages to flash the LED as an indication to the customer that the SKIS has been placed in it’s “Customer Learn” programming mode. See Sentry Key Immobilizer System Transponder Programming in this section for more information on the “Customer Learn” programming mode.

For diagnosis or initialization of the SKIM and the PCM, a DRBIII® scan tool and the proper Powertrain Diagnostic Procedures manual are required. The SKIM cannot be repaired and, if faulty or damaged, the unit must be replaced.

STANDARD PROCEDURE - PCM/SKIM PROGRAMMING

NOTE: There are two procedures for transfering the secret key to the SKIM:

- **When ONLY the SKIM module is replaced, the secret key is transfered from the PCM to the SKIM. The ORGINAL KEYS may then be programmed to the SKIM.**
- **When ONLY the PCM is replaced, then the secret key is transfered from the SKIM to the PCM. The ORGINAL KEYS may be used.**
- **When BOTH the SKIM and the PCM are replaced the secret key is transferred from the SKIM to the PCM, and NEW KEYS must be programmed.**

NOTE: Before replacing the Powertrain Control Module (PCM) for a failed driver, control circuit, or ground circuit, be sure to check the related component/circuit integrity for failures not detected due to a double fault in the circuit. Most PCM driver/control circuit failures are caused by internal component failures (i.e. relay and solenoids) and shorted circuits (i.e. pull-ups, drivers and switched circuits). These failures are difficult to detect when a double fault has occurred and only one Diagnostic Trouble Code (DTC) has set.

When a PCM (SBEC) and the Sentry Key Immobilizer Module (SKIM) are replaced at the same time perform the following steps in order:

(1) Program the new PCM (SBEC).

(2) Program the new SKIM.

(3) Replace all ignition keys and program them to the new SKIM.

PROGRAMMING THE PCM (SBEC)

The Sentry Key Immobilizer System (SKIS) Secret Key is an ID code that is unique to each SKIM. This code is programmed and stored in the SKIM, PCM and transponder chip (ignition keys). When replacing the PCM it is necessary to program the secret key into the new PCM using the DRBIII® scan tool. Perform the following steps to program the secret key into the PCM.

(1) Turn the ignition switch on (transmission in park/neutral).

(2) Use the DRBIII® scan tool and select THEFT ALARM, SKIM then MISCELLANEOUS.

(3) Select PCM REPLACED (GAS ENGINE).

(4) Enter secured access mode by entering the vehicle four-digit PIN.

(5) Select ENTER to update PCM VIN.

NOTE: If three attempts are made to enter secure access mode using an incorrect PIN, secured access mode will be locked out for one hour. To exit this lockout mode, turn the ignition to the RUN position for one hour then enter the correct PIN. (Ensure all accessories are turned OFF. Also monitor the battery state and connect a battery charger if necessary).

(6) Press ENTER to transfer the secret key (the SKIM will send the secret key to the PCM).

(7) Press Page Back to get to the Select System menu and select ENGINE, MISCELLANEOUS, and SRI MEMORY CHECK.

(8) The DRBIII® scan tool will ask, Is odometer reading between XX and XX? Select the YES or NO button on the DRB III® scan tool. If NO is selected, the DRBIII® scan tool will read, Enter odometer Reading<From I.P. odometer>. Enter the odometer reading from the instrument cluster and press ENTER.

PROGRAMMING THE SKIM

(1) Turn the ignition switch on (transmission in park/neutral).

(2) Use the DRBIII® scan tool and select THEFT ALARM, SKIM then MISCELLANEOUS.

(3) Select SKIM REPLACED (GAS ENGINE).

(4) Program the vehicle four-digit PIN into SKIM.

(5) Select COUNTRY CODE and enter the correct country.

NOTE: Be sure to enter the correct country code. If the incorrect country code is programmed into the SKIM, the SKIM must be replaced.

(6) Select YES to update the VIN (the SKIM will learn the VIN from the PCM).

(7) Press ENTER to transfer the secret key (the PCM will send the secret key information to the SKIM).

(8) Program ignition keys to the SKIM.

NOTE: If the PCM and the SKIM are replaced at the same time, all vehicle keys will need to be replaced and programmed to the new SKIM.

PROGRAMMING IGNITION KEYS TO THE SKIM

(1) Turn the ignition switch on (transmission in park/neutral).

(2) Use the DRBIII® scan tool and select THEFT ALARM, SKIM then MISCELLANEOUS.

(3) Select PROGRAM IGNITION KEY'S.

(4) Enter secured access mode by entering the vehicle four-digit PIN.

SENTRY KEY IMMOBILIZER MODULE (Continued)

NOTE: A maximum of eight keys can be learned to each SKIM. Once a key is learned to a SKIM, it (the key) cannot be transferred to another vehicle.

(5) If ignition key programming is unsuccessful, the DRBIII® scan tool will display one of the following messages:

(a) Programming Not Attempted - The DRBIII® scan tool attempts to read the programmed key status and there are no keys programmed into SKIM memory.

(b) Programming Key Failed (Possible Used Key From Wrong Vehicle) - SKIM is unable to program key due to one of the following:

- Faulty ignition key transponder.
- Ignition key is programmed to another vehicle.

(c) 8 Keys Already Learned, Programming Not Done - SKIM transponder ID memory is full.

(6) Obtain ignition keys to be programmed from customer (8 keys maximum).

(7) Using the DRBIII® scan tool, erase all ignition keys by selecting MISCELLANEOUS and ERASE ALL CURRENT IGN. KEYS.

(8) Program all ignition keys.

Learned Key In Ignition - Ignition key transponder ID is currently programmed in SKIM memory.

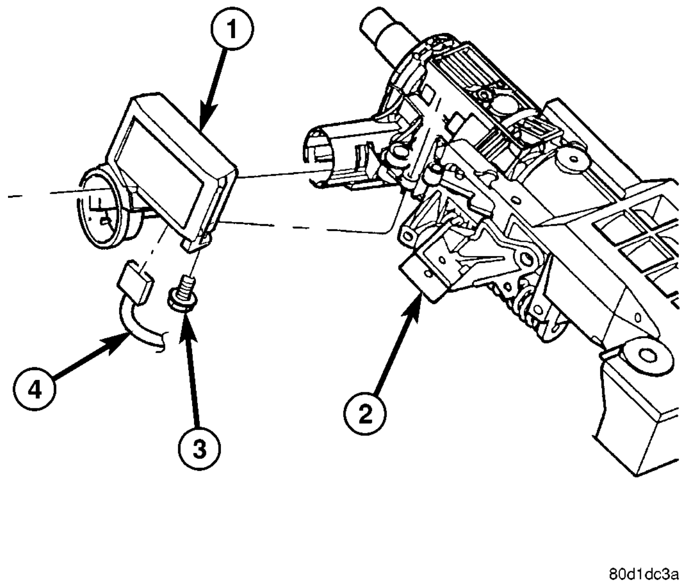

Fig. 8 SENTRY KEY IMMOBILIZER MODULE (SKIM)

1 - SENTRY KEY IMMOBILIZER MODULE (SKIM)
2 - STEERING COLUMN
3 - SCREW
4 - WIRING HARNES

REMOVAL

(1) Disconnect and isolate the battery negative cable.

(2) Remove the steering column upper and lower shrouds. Refer to Steering, Column, Shroud, Removal.

(3) Disconnect the steering column wire harness connector from the Sentry Key Immobilizer Module (SKIM)

(4) Remove the screw securing the SKIM module to the steering column (Fig. 8).

(5) Release the SKIM antenna ring retaining clips from around the ignition switch lock cylinder housing and remove the SKIM.

INSTALLATION

NOTE: If the SKIM is replaced with a new unit, a DRBIII® scan tool MUST be used to initialize the new SKIM and to program at least two Sentry Key transponders. (Refer to 8 - ELECTRICAL/VEHICLE THEFT SECURITY - STANDARD PROCEDURE).

(1) Slide the SKIM antenna ring around the ignition switch lock cylinder housing and clip in place (Fig. 8).

(2) Install the retaining screw.

(3) Connect the steering column wire harness connector to the Sentry Key Immobilizer Module (SKIM).

(4) Install the steering column upper and lower shrouds. Refer to Steering, Column, Shroud, Installation.

(5) Connect the battery negative cable.

TRANSFER CASE CONTROL MODULE

DESCRIPTION

The Transfer Case Control Module (TCCM) (Fig. 9) is a microprocessor-based assembly, controlling the 4X4 transfer case shift functions via the actuation of a shift motor and utilizing the feedback of a mode sensor assembly. Communication is via the PCI serial bus. Inputs include user selectable 4X4 modes that include 2WD, 4HI, 4LO, and Neutral. The logic and driver circuitry is contained in a molded plastic housing with an embedded heat-sink and is located behind the left side of the lower instrument panel.

OPERATION

The Transfer Case Control Module (TCCM) utilizes the input from the transfer case mounted mode sensor, the instrument panel mounted selector switch, and the following information from the vehicle's PCI serial bus to determine if a shift is allowed.

- Engine RPM and Vehicle Speed

TRANSFER CASE CONTROL MODULE (Continued)

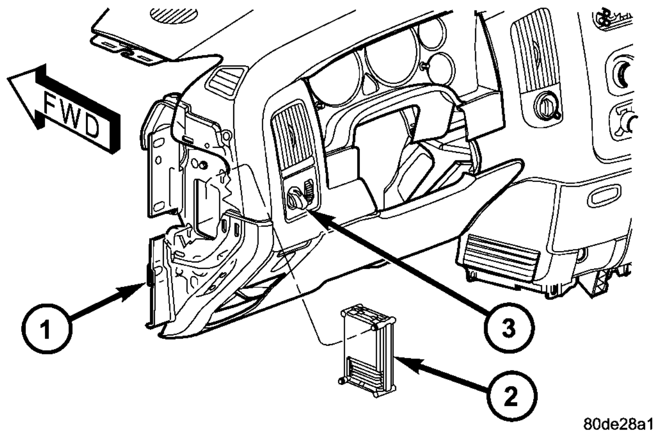

Fig. 9 Transfer Case Control Module (TCCM) Location

1 - INSTRUMENT PANEL
2 - TRANSFER CASE CONTROL MODULE (TCCM)
3 - TRANSFER CASE SELECTOR SWITCH

- Diagnostic Requests
- Manual Transmission and Brake Applied
- PRNDL
- Ignition Status
- ABS Messages

Once the TCCM determines that a requested shift is allowed, it actuates the bi-directional shift motor as necessary to achieve the desired transfer case operating mode. The TCCM also monitors the mode sensor while controlling the shift motor to determine the status of the shift attempt.

Several items can cause the requested shift not to be completed. If the TCCM has recognized a fault (DTC) of some variety, it will begin operation in one of four Functionality Levels. These levels are:

- **Level Zero** - Normal Operation.
- **Level One** - Only Mode Shifts Are Allowed.
- **Level Two** - Only Mode Shifts and Shifts Into LOW Are Allowed (No Neutral Shifts Are Allowed).
- **Level Three** - No Shifts Are Allowed

The TCCM can also be operating in one of three possible power modes. These power modes are:

- **Full Power Mode** is the normal operational mode of the module. This mode is achieved by normal PCI bus traffic being present and the ignition being in the RUN position.
- **Reduced Power Mode** will be entered when the ignition has been powered off. In this state, the module will shut down power supplied to external devices, and to electronic interface inputs and outputs. From this state the module can enter either Sleep Mode or Full Power Mode. To enter this mode, the module must receive an ignition message denoting that the ignition is off, or not receive any messages for 5 ±0.5 seconds. To exit this mode, the module must receive one ignition message that denotes that the ignition is in the RUN position.
- **Sleep Mode** will be entered, from the Reduced Power Mode, when no PCI traffic has been sensed for 20 ±1 seconds. If during Sleep Mode the module detects PCI bus traffic, it will revert to the Reduced Power mode while monitoring for ignition messages. It will remain in this state as long as there is traffic other than run or start messages, and will return to Sleep mode if the bus goes without traffic for 20 ±1 seconds.

SHIFT REQUIREMENTS

If the TCCM is in full power mode and at functionality level zero, it uses the following criteria to determine if a shift is allowed.

If any of the driver controllable conditions are not met once the shift request is recognized, the TCCM will solidly illuminate the source position's LED and flash the desired position's LED for all shifts except NEUTRAL. The NEUTRAL shift LED strategy will be discussed later.

Mode shifts will be allowed regardless of transmission gear or vehicle speed, whenever the following conditions are met:

- Front and rear wheel speed are within 21 km/hr (13 mph).
- A change in the Selector switch state indicates that a mode shift has been requested.
- A valid mode sensor signal is being sensed by the TCCM.
- Proper transmit/receive messages are occurring on the PCI bus.
- Ignition key switch is in the RUN position.

Range shifts will be allowed only if all of the following conditions are met:

- Front and rear wheel speed are within 21 km/hr (13 mph).
- A change in the Selector Switch state indicating a range shift has been requested.
- Transmission in NEUTRAL signal must be recognized for at least 1.5 seconds ±100 msec. (Automatic transmissions only)
- Proper transmit/receive messages are occurring on the PCI bus.
- Clutch signal is recognized for 500 msec ± 50 msec (Manual transmissions only).
- Vehicle speed is less than or equal to 4.8 km/hr (3 miles per hour).
- Ignition key switch is in the RUN position.
- A valid mode sensor signal is being sensed by the TCCM.

A **shift into transfer case Neutral** will be allowed only if all of the following conditions are met:

- Front and rear wheel speed are within 21 km/hr (13 mph).

TRANSFER CASE CONTROL MODULE (Continued)

- The recessed Neutral Selection switch has been depressed continuously for 4.0 seconds ±100 msec while all shift conditions have been continuously met.
- Transmission in NEUTRAL signal recognized from the bus. (Automatic transmissions only)
- Clutch signal is recognized from the bus (Manual transmissions only).
- Proper message transmissions/receptions are occurring on the PCI bus.
- Vehicle speed is less than or equal to 4.8 km/hr (3 miles per hour).
- Ignition key switch is in the RUN position, engine off.
- Foot Brake is applied.
- A valid mode sensor signal is being sensed by the TCCM.

A **shift out of transfer case Neutral** will be allowed only if all of the following conditions are met:

- Front and rear wheel speed are within 21 km/hr (13 mph).
- The recessed Neutral Selection switch has been depressed continuously for 1.0 seconds ±100 msec while all shift conditions have been continuously met.
- Transmission in NEUTRAL signal recognized from the bus.(Automatic transmissions only)
- Clutch signal is recognized from the bus (Manual transmissions only).
- Proper message transmissions/receptions are occurring on the PCI bus.
- Vehicle speed is less than or equal to 4.8 km/hr (3 miles per hour).
- Ignition key switch is in the RUN position.
- Foot Brake is applied.
- A valid mode sensor signal is being sensed by the TCCM.

SHIFT SEQUENCES

Once all the driver controllable conditions for the requested shift have been met, the TCCM begins a shift timer with a maximum duration of 1 second per 'D' channel transition. If the shift timer expires before the TCCM recognizes to correct mode sensor code, the shift is considered to have been blocked. The blocked shift will increment the blocked shift counter by one. The TCCM strategy for handling blocked shifts will be described later. The process the TCCM performs for the various shifts will be described first.

RANGE AND MODE SHIFTS

The process for performing all the range and mode shifts are the same. The following steps describe the process.

- Allow time for Selector Switch debounce; 250 msec ±50 msec.
- Extinguish the source gear's LED while flashing desired transfer case position's LED.
- Engage the shift motor for a maximum of 1 second ±100 msec per 'D' channel transition in the destination gear's direction while monitoring the mode sensor channel transitions.
- Disengage the shift motor when the correct mode sensor code is recognized.
- Solidly illuminate the selected gear's LED.
- Transmit a bus message that the transfer case shift is complete.
- If the desired mode sensor code is not received after the shift timer expires (ie. a blocked or other condition exists), stop driving the motor and wait for 200 msec ±50 msec. The shift motor is then reversed in the direction back toward the source gear for up to 1.0 seconds ±100 msec. per 'D' channel. The TCCM waits for 2.0 seconds ±50 msec. and repeats the attempt to shift to the desired position.

The exception to the preceding sequence is when a shift from 4L to 2WD/AWD is requested. If 2WD/AWD is requested from the 4L position, the transfer case is first driven to the 4H position. If the 4H position is reached, the transfer case is then driven back to the 2WD/AWD position and the shift is considered complete. If the transfer case does not reach any the 4H position, but is in the 2WD/AWD 'D' channel, or the 2WD/AWD between gear position on the 4H side of 2WD/AWD, the shift is also considered complete.

SHIFT OUT OF NEUTRAL

- Extinguish the Neutral LED.
- Engage the shift motor for a maximum of 1 second ±100 msec toward the transfer case 4H mode position while monitoring the mode sensor channel transitions.
- Disengage the shift motor when the correct mode sensor code is recognized.
- Extinguish the Neutral LED.
- Transmit a bus message that the transfer case shift is complete.
- If the desired mode sensor code is not received after the shift timer expires (ie. a blocked or other condition exists), stop driving the motor and wait for 200 msec ±50 msec. The shift motor is then reversed in the direction back toward the source gear for up to 1.0 seconds 100 msec. The TCCM waits for 2.0 seconds ±50 msec. and repeats the attempt to shift to the desired position.
- When the Neutral button is released, if the 4H position is the desired position, the shift is complete. Illuminate the 4H LED.
- Otherwise when the Neutral button is released, if all of the shift requirements are being met then engage the shift motor towards the desired position for 1 second ±100 msec per 'D' channel. (if require-

TRANSFER CASE CONTROL MODULE (Continued)

ments for shifting are not met, illuminate the 4H LED and flash the destination LED as an indication to the driver that all of the driver controllable shift conditions are not being met). If this requires another range or mode shift, begin the range/mode shift process.

- If the desired mode sensor code is not received after the shift timer expires (i.e. a blocked or other condition exists), refer to the section on Blocked Shift Strategy.

BLOCKED SHIFT STRATEGY

When a shift is commanded, the shift motor will be driven towards its destination position, except in the case of shifting out of Neutral if 4L was selected (the transfer case will shift to the 4H position first, before proceeding to 4L). If the shift is blocked on the way to the destination, the TCCM may attempt to drive the motor back to the original position. This process will be allowed to occur 5 times. If the transfer case has reached a non-NEUTRAL 'D' channel during the shift re-attempts, the LED for the achieved gear position is illuminated and the shift attempts are stopped. To re-attempt the desired shift, the selector switch will need to be rotated to the current position until the switch debounce timer expires then a shift will need to be requested again.

At the end of the 5th blocked attempt, the shift motor is driven towards the last known 'D' channel position. If this motor drive allows the transfer case to reach the 2WD/AWD 'D' channel, or the 2WD/AWD between gear position on the 4H side of 2WD/AWD, the shift is considered complete and the shift attempts are ended.

If the mode sensor is in the NEUTRAL region at the expiration of the shift timer, the TCCM will continue to make the shift attempts according to the blocked shift strategy independent of whether or not the driver controlled conditions are met.

For shifts from NEUTRAL, if all 5 attempts fail to reach the desired position (which by default is 4H), the motor will be driven to stall in the direction of 4H or 4L, depending on the achieved position. If the transfer case has reached the 2WD/AWD or 4L between gear position nearest the NEUTRAL positions and the shift conditions are no longer being met, the transfer case will be driven toward the corresponding 'D' channel. Otherwise, the transfer case will be driven in the direction opposite the last attempt with the desired target being 4H or 4L.

If the transfer case reaches the 2WD/AWD 'D' channel when being driven in the 4H direction, then one final 1.0 second drive toward 4H is attempted. If the transfer case then reaches any of the 4H positions, the shift is considered complete and the 4H LED is illuminated. If the transfer case is still the 2WD/AWD position, the shift is considered complete and the 2WD/AWD LED is illuminated.

NOTE: If after the 5th blocked shift and reversal attempt, if the transfer case position is in the NEUTRAL region, shift attempts will continue until a non-NEUTRAL 'D' channel is reached.

SHIFT REVERSAL TARGETS

If the shift timer expires (1 second per 'D' channel) and the transfer case has not reached the desired position, all shifts will attempt to return to their original position with the exceptions of:

- If the intended shift is going to the High rail from Low and can't make it, but it can make the 2WD/AWD position, the motor stops at that position. The TCCM will not attempt to cross back over NEUTRAL if it does not have to. This means that there was a block on the first attempt to go to 4H and the transfer case has made it through NEUTRAL to a known good position, then the motor will go back only to the 2WD/4WD position and execute the remainder of the attempts from there.
- For shifts out of NEUTRAL, any time a shift is commanded out of NEUTRAL, the system needs to get out. The TCCM should never go to NEUTRAL unless the driver is commanding it and all required conditions are being met

ENCODER DRIFT CORRECTION

Whenever a shift is completed, the TCCM stores the position in memory as the transfer case's intended position. The TCCM continuously monitors the mode sensor and if the mode sensor drifts toward into a NEUTRAL region sensor position for 2.0 seconds, the TCCM will perform a motor drive to correct the drift. The transfer case will be driven toward the intended position for 1.0 seconds 100 msec. The TCCM will wait for 2.0 seconds ±50 msec. and repeat the attempt to shift to the desired position. This will continue until the intended position is reached.

SHIFT MOTOR BRAKING

Two modes of shift motor braking are employed to improve shift performance, static and dynamic. Static shift motor braking is utilized under the following conditions:

- Whenever the transfer case is in the 2WD/AWD or 4L 'D' channel position.
- Whenever an invalid mode sensor code is present.

Static motor braking is achieved by applying +12V on both shift motor wires.

NOTE: Static Shift Motor Braking is independent of ignition key position.

TRANSFER CASE CONTROL MODULE (Continued)

SHIFT ATTEMPT LIMIT

To protect the transfer case system, the TCCM will impose a limit on the number of shifts that can occur over a calibrated time period. The system will monitor the number of ’D’ channel segment transitions that occur in any 30 second time period. If the number of segment transitions is 30 or greater, the system will go into a default mode. The default mode of operation for shifting is that the number of allowed ’D’ channel transitions permitted to occur will be 3 over each 15 second ±100 msec calibrated window of time. After 5 minutes ±100 msec, the motor can be assumed to have cooled down and the system will revert to normal operation. The following rules also apply to the shift limit:

- The attempt limit will not prevent shifts coming out of NEUTRAL, they will be allowed regardless of the counter/timer.
- Any shift that is in progress when the counter reaches a maximum count in time will be allowed to complete before the default mode is entered. D-channel transitions during this period will not be counted towards the default mode limit.
- A block, regardless of the direction, whether towards destination or back towards reversal target (shift timer expiring), will count as a value of 2 transitions towards the 30 segment transitions to go into default mode as defined above. Current attempt limit values are 30 transitions in 30 seconds and default mode values are 3 transitions every 15 seconds for 5 minutes.

TRANSMISSION CONTROL MODULE

DESCRIPTION

The Transmission Control Module (TCM) (Fig. 10) may be sub-module within the Powertrain Control Module (PCM) or a standalone module, depending on the vehicle engine. The PCM, and TCM when equipped, is located at the right rear of the engine compartment, near the right inner fender.

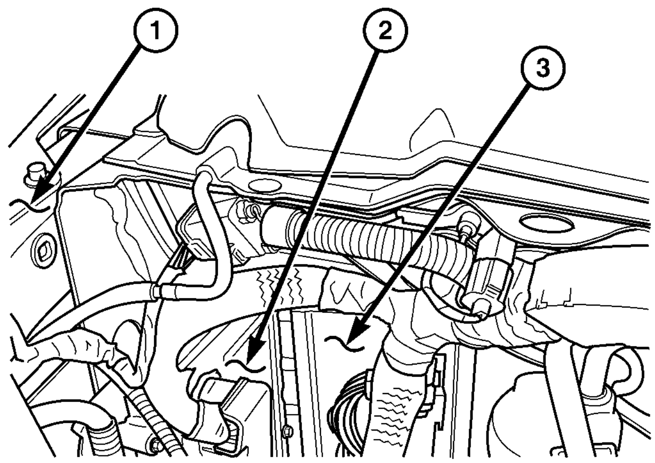

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Fig. 10 PCM/TCM Location

1 - RIGHT FENDER
2 - TRANSMISSION CONTROL MODULE
3 - POWERTRAIN CONTROL MODULE

OPERATION

The Transmission Control Module (TCM) controls all electronic operations of the transmission. The TCM receives information regarding vehicle operation from both direct and indirect inputs, and selects the operational mode of the transmission. Direct inputs are hardwired to, and used specifically by the TCM. Indirect inputs are shared with the TCM via the vehicle communication bus.

Some examples of **direct inputs** to the TCM are:

- Battery (B+) voltage
- Ignition “ON” voltage
- Transmission Control Relay (Switched B+)
- Throttle Position Sensor
- Crankshaft Position Sensor
- Transmission Range Sensor
- Pressure Switches
- Transmission Temperature Sensor
- Input Shaft Speed Sensor
- Output Shaft Speed Sensor
- Line Pressure Sensor

Some examples of **indirect inputs** to the TCM are:

- Engine/Body Identification
- Manifold Pressure
- Target Idle
- Torque Reduction Confirmation
- Engine Coolant Temperature
- Ambient/Battery Temperature
- DRBIII® Scan Tool Communication

Based on the information received from these various inputs, the TCM determines the appropriate shift schedule and shift points, depending on the present operating conditions and driver demand. This is possible through the control of various direct and indirect outputs.

Some examples of TCM **direct outputs** are:

- Transmission Control Relay
- Solenoids
- Torque Reduction Request

Some examples of TCM **indirect outputs** are:

- Transmission Temperature (to PCM)
- PRNDL Position (to BCM)

In addition to monitoring inputs and controlling outputs, the TCM has other important responsibilities and functions:

- Storing and maintaining Clutch Volume Indexes (CVI)
- Storing and selecting appropriate Shift Schedules
- System self-diagnostics
- Diagnostic capabilities (with DRBIII® scan tool)

TRANSMISSION CONTROL MODULE (Continued)

NOTE: If the TCM has been replaced, the "Quick Learn Procedure" must be performed. (Refer to 8 - ELECTRICAL/ELECTRONIC CONTROL MODULES/TRANSMISSION CONTROL MODULE - STANDARD PROCEDURE)

BATTERY FEED

A fused, direct battery feed to the TCM is used for continuous power. This battery voltage is necessary to retain memory in the TCM. When the battery (B+) is disconnected, this memory is lost. When the battery (B+) is restored, this memory loss is detected by the TCM and a Diagnostic Trouble Code (DTC) is set.

CLUTCH VOLUME INDEXES (CVI)

An important function of the TCM is to monitor Clutch Volume Indexes (CVI). CVIs represent the volume of fluid needed to compress a clutch pack.

The TCM monitors gear ratio changes by monitoring the Input and Output Speed Sensors. The Input, or Turbine Speed Sensor sends an electrical signal to the TCM that represents input shaft rpm. The Output Speed Sensor provides the TCM with output shaft speed information.

By comparing the two inputs, the TCM can determine transmission gear position. This is important to the CVI calculation because the TCM determines CVIs by monitoring how long it takes for a gear change to occur (Fig. 11).

Gear ratios can be determined by using the DRBIII® Scan Tool and reading the Input/Output Speed Sensor values in the "Monitors" display. Gear ratio can be obtained by dividing the Input Speed Sensor value by the Output Speed Sensor value.

For example, if the input shaft is rotating at 1000 rpm and the output shaft is rotating at 500 rpm, then the TCM can determine that the gear ratio is 2:1. In direct drive (3rd gear), the gear ratio changes to 1:1. The gear ratio changes as clutches are applied and released. By monitoring the length of time it takes for the gear ratio to change following a shift request, the TCM can determine the volume of fluid used to apply or release a friction element.

The volume of transmission fluid needed to apply the friction elements are continuously updated for adaptive controls. As friction material wears, the volume of fluid need to apply the element increases.

Certain mechanical problems within the input clutch assembly can cause inadequate or out-of-range element volumes. Also, defective Input/Output Speed Sensors and wiring can cause these conditions. The following chart identifies the appropriate clutch volumes and when they are monitored/updated:

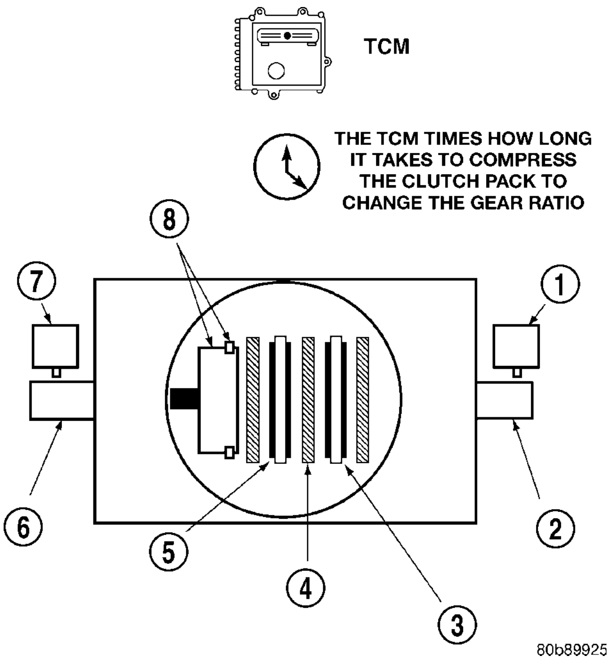


Fig. 11 Example of CVI Calculation

1 - OUTPUT SPEED SENSOR
2 - OUTPUT SHAFT
3 - CLUTCH PACK
4 - SEPARATOR PLATE
5 - FRICTION DISCS
6 - INPUT SHAFT
7 - INPUT SPEED SENSOR
8 - PISTON AND SEAL

CLUTCH VOLUMES		
Clutch	When Updated	Proper Clutch Volume
L/R	2-1 or 3-1 downshift	45 to 134
2C	3-2 kickdown shift	25 to 85
OD	2-3 upshift	30 to 100
4C	3-4 upshift	30 to 85
UD	4-3 kickdown shift	30 to 100

SHIFT SCHEDULES

As mentioned earlier, the TCM has programming that allows it to select a variety of shift schedules. Shift schedule selection is dependent on the following:

- Shift lever position
- Throttle position
- Engine load
- Fluid temperature
- Software level

As driving conditions change, the TCM appropriately adjusts the shift schedule. Refer to the following chart to determine the appropriate operation expected, depending on driving conditions.

TRANSMISSION CONTROL MODULE (Continued)

Schedule	Condition	Expected Operation
Extreme Cold	Oil temperature below -16° F	-Park, Reverse, Neutral and 1st and 3rd gear only in D position, 2nd gear only in Manual 2 or L -No EMCC
Super Cold	Oil temperature between -12° F and 10° F	- Delayed 2-3 upshift - Delayed 3-4 upshift - Early 4-3 coastdown shift - High speed 4-2, 3-2, 2-1 kickdown shifts are prevented -Shifts at high throttle openings willl be early. - No EMCC
Cold	Oil temperature between 10° F and 36° F	-Shift schedule is the same as Super Cold except that the 2-3 upshifts are not delayed.
Warm	Oil temperature between 40° F and 80° F	- Normal operation (upshift, kickdowns, and coastdowns) - No EMCC
Hot	Oil temperature between 80° F and 240° F	- Normal operation (upshift, kickdowns, and coastdowns) - Normal EMCC operation
Overheat	Oil temperature above 240° F or engine coolant temperature above 244° F	- Delayed 2-3 upshift - Delayed 3-4 upshift - 3rd gear FEMCC from 30-48 mph - 3rd gear PEMCC above 35 mph - Above 25 mph the torque converter will not unlock unless the throttle is closed or if a wide open throttle 2nd PEMCC to 1 kickdown is made

STANDARD PROCEDURE

STANDARD PROCEDURE - TCM QUICK LEARN

The quick learn procedure requires the use of the DRB® scan tool.

This program allows the electronic transmission system to recalibrate itself. This will provide the proper transmission operation. The quick learn procedure should be performed if any of the following procedures are performed:

- Transmission Assembly Replacement
- Transmission Control Module Replacement
- Solenoid Pack Replacement
- Clutch Plate and/or Seal Replacement
- Valve Body Replacement or Recondition

To perform the Quick Learn Procedure, the following conditions must be met:

- The brakes must be applied
- The engine speed must be above 500 rpm
- The throttle angle (TPS) must be less than 3 degrees
- The shift lever position must stay in PARK until prompted to shift to overdrive
- The shift lever position must stay in overdrive after the Shift to Overdrive prompt until the DRB® indicates the procedure is complete
- The calculated oil temperature must be above 60° and below 200°

STANDARD PROCEDURE - DRIVE LEARN

When a transmission is repaired and a Quick Learn procedure has been performed on the Transmission Control Module (TCM), the following Drive Learn procedure can be performed to fine tune any shifts which are particularly objectionable.

NOTE: It is not necessary to perform the complete Drive Learn procedure every time the TCM is Quick Learned. Perform only the portions which target the objectionable shift.

TRANSMISSION CONTROL MODULE (Continued)

LEARN A SMOOTH 1ST NEUTRAL TO DRIVE SHIFT

Perform this procedure only if the complaint is for a delayed or harsh shift the first time the transmission is put into gear after the vehicle is allowed to set with the engine not running for at least 10 minutes. Use the following steps to have the TCM learn the 1st N-D UD CVI.

NOTE: The transmission oil temperature must be between 80 - 110°F (27 - 43°C).

(1) Start the engine only when the engine and ignition have been off for at least ten (10) minutes.

(2) With the vehicle at a stop and the service brake applied, record the 1st N-D UD CVI while performing a Neutral to Drive shift. The 1st N-D UD CVI accounts for air entrapment in the UD clutch that may occur after the engine has been off for a period of time.

(3) Repeat Step 1 and Step 2 until the recorded 1st N-D UD CVI value stabilizes.

NOTE: It is important that this procedure be performed when the transmission temperature is between 80 - 110°F (27 - 43°C). If this procedure takes too long to complete fully for the allowed transmission oil temperature, the vehicle may be returned to the customer with an explanation that the shift will improve daily during normal vehicle usage. The TCM also learns at higher oil temperatures, but these values (line pressure correction values) are not available for viewing on the DRB® III.

LEARN A SMOOTH NEUTRAL TO DRIVE GARAGE SHIFT

Perform this procedure if the complaint is for a delayed or harsh shift when the transmission is put into gear after the vehicle has had its first shift. Use the following steps to have the TCM learn the Norm N-D UD CVI.

NOTE: The transmission oil temperature must be between 80 - 110°F (27 - 43°C) to learn the UD CVI. Additional learning occurs at temperatures as low as 0°F and as high as 200°F. This procedure may be performed at any temperature that experiences poor shift quality. Although the UD CVI may not change, shift quality should improve.

(1) Start the vehicle engine and shift to drive.

(2) Move the vehicle forward to a speed of at least 16 km/h (10 MPH) and come to a stop. This ensures no air is present in the UD hydraulic circuit.

(3) Perform repeated N-D shifts at a stop while pausing in Neutral for at least 2-3 seconds and monitor Norm N-D UD CVI volume until the value stabilizes. The value will change during the N-D shift. This is normal since the UD value is different for the N-D shift then the normal value shown which is used for 4-3 coastdown and kickdowns. Perform repeated shifts in this temperature range until the Norm N-D UD CVI value stabilizes and the N-D shifts become smooth.

LEARN THE 1ST 2-3 SHIFT AFTER A RESTART OR SHIFT TO REVERSE

Use the following steps to have the TCM learn the 1st 2-3 shift OD CVI.

NOTE: The transmission oil temperature must be above 80°F (27°C).

(1) With the vehicle engine running, select reverse gear for over 2 seconds.

(2) Shift the transmission to Drive and accelerate the vehicle from a stop at a steady 15 degree throttle opening and perform a 2-3 shift while noting the 1st 2-3 OD CVI.

(3) Repeat Step 1 and Step 2 until the 1st 2-3 upshift becomes smooth and the 1st 2-3 OD CVI stabilizes.

LEARN A SMOOTH 2-3 AND 3-4 UPSHIFT

NOTE: The transmission oil temperature must be above 110°F (43°C).

Use the following steps to have the TCM learn the OD and 4C CVI's.

(1) Accelerate the vehicle from a stop at a steady 15 degree throttle opening and perform multiple 1-2, 2-3, and 3-4 upshifts. The 2nd 2-3 shift following a restart or shift to reverse will be shown during the shift as a value between the 1st 2-3 OD CVI and the normal OD CVI. Updates to the normal OD CVI will occur after the 2nd shift into 3rd gear, following a restart or shift to reverse.

(2) Repeat Step 1 until the 2-3 and 3-4 shifts become smooth and the OD and 4C CVI become stable.

LEARN A SMOOTH 4-3 COASTDOWN AND PART THROTTLE 4-3 KICKDOWN

NOTE: The transmission oil temperature must be above 110°F (43°C).

Use the following steps to have the TCM learn the UD shift volume.

(1) At a vehicle speed between 64-97 km/h (40-60 MPH), perform repeated 4-3 kickdown shifts.

TRANSMISSION CONTROL MODULE (Continued)

(2) Repeat Step 1 until the UD volume becomes somewhat stable and the shift becomes smooth.

LEARN A SMOOTH 1-2 UPSHIFT AND 3-2 KICKDOWN

Use the following steps to have the TCM learn the 2C shift volume.

NOTE: The transmission oil temperature must be above 110°F (43°C).

(1) With a vehicle speed below 48 km/h (30 MPH) and the transmission in 3rd gear, perform multiple 3-2 kickdowns.

(2) Repeat Step 1 until the 3-2 kickdowns become smooth and the 2C CVI becomes stable.

LEARN A SMOOTH MANUAL 2-1 PULLDOWN SHIFT AS WELL AS A NEUTRAL TO REVERSE SHIFT

NOTE: The transmission oil temperature must be above 110°F (43°C).

Use the following steps to have the TCM learn the LR volume.

(1) With the vehicle speed around 40-48 km/h (25-30 MPH) in Manual 2nd, perform manual pull-downs to Low or 1st gear at closed throttle.

(2) Repeat Step 1 until the LR CVI becomes stable and the manual 2-1 becomes smooth.

LEARN A SMOOTH NEUTRAL TO REVERSE SHIFT

NOTE: The transmission oil temperature must be above 110°F (43°C).

(1) With the vehicle at a stop, perform Neutral to Reverse shifts until the shift is smooth. An unlearned Neutral to Reverse shift may be harsh or exhibit a double bump.

(2) If any of the shifts are still not smooth after the clutch volume stabilizes, an internal transmission problem may be present.

LEARN A SMOOTH 4-5 UPSHIFT

NOTE: The transmission oil temperature must be above 110°F (43°C).

Use the following steps to have the TCM learn the Alt 2C CVI.

(1) Accelerate the vehicle through 88 km/h (55mph) at a steady 10-15 degree throttle opening and perform multiple 4-5 upshifts.

(2) Repeat Step 1 until the 4-5 shift become smooth and theAlt 2C CVI become stable. There is a separate 2C volume used and learned for 4-5 shifts, 2CA. It is independent of the 2C CVI learned on 3-2 kickdowns.

ENGINE SYSTEMS

TABLE OF CONTENTS

BATTERY SYSTEM

TABLE OF CONTENTS

BATTERY SYSTEM

DESCRIPTION

A single 12-volt battery is standard factory-installed equipment on gasoline engine equipped models. Diesel engine equipped vehicles utilize two 12-volt batteries connected in parallel. All of the components of the battery system are located within the engine compartment of the vehicle. The battery system for this vehicle, covers the following related components, which are covered in further detail later in this section of the service manual:

- **Battery** - The storage battery provides a reliable means of storing a renewable source of electrical energy within the vehicle.
- **Battery Cables** - The battery cables connect the battery terminal posts to the vehicle electrical system.
- **Battery Holddown** - The battery holddown hardware secures the battery in the battery tray in the engine compartment.
- **Battery Tray** - The battery tray provides a secure mounting location in the vehicle for the battery and an anchor point for the battery holddown hardware.

BATTERY SYSTEM (Continued)

For battery system maintenance schedules and jump starting procedures, see the owner's manual in the vehicle glove box. Optionally, refer to the Lubrication and Maintenance section of this manual for the proper battery jump starting procedure. While battery charging can be considered a maintenance procedure, the battery charging procedure and related information are located later in this section of the service manual. This was done because the battery must be fully-charged before any battery system diagnosis or testing procedures can be performed.

OPERATION

The battery system is designed to provide a safe, efficient, reliable and mobile means of delivering and storing electrical energy. This electrical energy is required to operate the engine starting system, as well as to operate many of the other vehicle accessory systems for limited durations while the engine and/or the charging system are not operating. The battery system is also designed to provide a reserve of electrical energy to supplement the charging system for short durations while the engine is running and the electrical current demands of the vehicle exceed the output of the charging system. In addition to delivering, and storing electrical energy for the vehicle, the battery system serves as a capacitor and voltage stabilizer for the vehicle electrical system. It absorbs most abnormal or transient voltages caused by the switching of any of the electrical components or circuits in the vehicle.

DIAGNOSIS AND TESTING - BATTERY SYSTEM

The battery, starting, and charging systems in the vehicle operate with one another and must be tested as a complete system. In order for the engine to start and the battery to maintain its charge properly, all of the components that are used in these systems must perform within specifications. It is important that the battery, starting, and charging systems be thoroughly tested and inspected any time a battery needs to be charged or replaced. The cause of abnormal battery discharge, overcharging or early battery failure must be diagnosed and corrected before a battery is replaced and before a vehicle is returned to service. The service information for these systems has been separated within this service manual to make it easier to locate the specific information you are seeking. However, when attempting to diagnose any of these systems, it is important that you keep their interdependency in mind.

The diagnostic procedures used for the battery, starting, and charging systems include the most basic conventional diagnostic methods, to the more sophisticated On-Board Diagnostics (OBD) built into the Powertrain Control Module (PCM). Use of an induction-type milliampere ammeter, a volt/ohmmeter, a battery charger, a carbon pile rheostat (load tester), a 12-volt test lamp and/or special service tools may be required. All OBD-sensed systems are monitored by the PCM. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for any failure it detects. Always check the PCM for stored trouble codes before returning the vehicle to service. Refer to Charging System for the proper charging system test procedures. Refer to Starting System for the proper starting system test procedures.

MICRO 420 BATTERY TESTER

The Micro 420 automotive battery tester is designed to help the dealership technician diagnose a defective battery. Follow the instruction manual supplied with the tester to properly diagnose a battery. If the instruction manual is not available, refer to the standard procedure in this section, which includes the directions for using the Micro 420 battery tester.

BATTERY SYSTEM (Continued)

BATTERY SYSTEM DIAGNOSIS		
CONDITION	POSSIBLE CAUSES	CORRECTION
THE BATTERY SEEMS WEAK OR DEAD WHEN ATTEMPTING TO START THE ENGINE.	1. The electrical system ignition-off draw is excessive.	1. Refer to the IGNITION-OFF DRAW TEST Standard Procedure for the proper test procedures. Repair the excessive ignition-off draw, as required.
	2. The charging system is faulty.	2. Determine if the charging system is performing to specifications. Refer to Charging System for additional charging system diagnosis and testing procedures. Repair the faulty charging system, as required.
	3. The battery is discharged.	3. Determine the battery state-of-charge using the Micro 420 battery tester. Refer to the Standard Procedures in this section for additional test procedures. Charge the faulty battery, as required.
	4. The battery terminal connections are loose or corroded.	4. Refer to Battery Cables for the proper battery cable diagnosis and testing procedures. Clean and tighten the battery terminal connections, as required.
	5. The battery has an incorrect size or rating for this vehicle.	5. Refer to Battery System Specifications for the proper size and rating. Replace an incorrect battery, as required.
	6. The battery is faulty.	6. Determine the battery cranking capacity using the Micro 420 battery tester. Refer to the Standard Procedures in this section for additional test procedures. Replace the faulty battery, as required.
	7. The starting system is faulty.	7. Determine if the starting system is performing to specifications. Refer to Starting System for the proper starting system diagnosis and testing procedures. Repair the faulty starting system, as required.
	8. The battery is physically damaged.	8. Inspect the battery for loose terminal posts or a cracked and leaking case. Replace the damaged battery, as required.

BATTERY SYSTEM (Continued)

BATTERY SYSTEM DIAGNOSIS		
CONDITION	POSSIBLE CAUSES	CORRECTION
THE BATTERY STATE OF CHARGE CANNOT BE MAINTAINED.	1. The battery has an incorrect size or rating for this vehicle.	1. Refer to Battery System Specifications for the proper specifications. Replace an incorrect battery, as required.
	2. The battery terminal connections are loose or corroded.	2. Refer to Battery Cable for the proper cable diagnosis and testing procedures. Clean and tighten the battery terminal connections, as required.
	3. The electrical system ignition-off draw is excessive.	3. Refer to the IGNITION-OFF DRAW TEST Standard Procedure for the proper test procedures. Repair the faulty electrical system, as required.
	4. The battery is faulty.	4. Test the battery using the Micro 420 battery tester. Refer to Standard Procedures for additional test procedures. Replace the faulty battery, as required.
	5. The starting system is faulty.	5. Determine if the starting system is performing to specifications. Refer to Starting System for the proper starting system diagnosis and testing procedures. Repair the faulty starting system, as required.
	6. The charging system is faulty.	6. Determine if the charging system is performing to specifications. Refer to Charging System for additional charging system diagnosis and testing procedures. Repair the faulty charging system, as required.
	7. Electrical loads exceed the output of the charging system.	7. Inspect the vehicle for aftermarket electrical equipment which might cause excessive electrical loads.
	8. Slow driving or prolonged idling with high-amperage draw systems in use.	8. Advise the vehicle operator, as required.
THE BATTERY WILL NOT ACCEPT A CHARGE.	1. The battery is faulty.	1. Test the battery using the Micro 420 battery tester. Charge or replace the faulty battery, as required.

ABNORMAL BATTERY DISCHARGING

Any of the following conditions can result in abnormal battery discharging:

1. A faulty or incorrect charging system component. Refer to Charging System for additional charging system diagnosis and testing procedures.
2. A faulty or incorrect battery. Use Micro 420 battery tester and refer to Battery System for additional battery diagnosis and testing procedures.
3. A faulty circuit or component causing excessive ignition-off draw.
4. Electrical loads that exceed the output of the charging system. This can be due to equipment installed after manufacture, or repeated short trip use.
5. A faulty or incorrect starting system component. Refer to Starting System for the proper starting system diagnosis and testing procedures.
6. Corroded or loose battery posts and/or terminal clamps.
7. Slow driving speeds (heavy traffic conditions) or prolonged idling, with high-amperage draw systems in use.

CLEANING

The following information details the recommended cleaning procedures for the battery and related com-

BATTERY SYSTEM (Continued)

ponents. In addition to the maintenance schedules found in this service manual and the owner's manual, it is recommended that these procedures be performed any time the battery or related components must be removed for vehicle service.

(1) Clean the battery cable terminal clamps of all corrosion. Remove any corrosion using a wire brush or a post and terminal cleaning tool, and a sodium bicarbonate (baking soda) and warm water cleaning solution (Fig. 1).

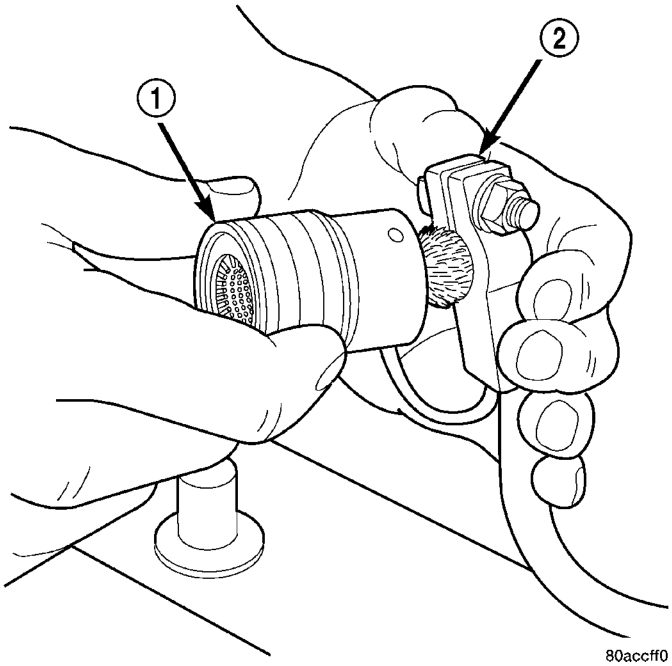


Fig. 1 Clean Battery Cable Terminal Clamp - Typical

1 - TERMINAL BRUSH
2 - BATTERY CABLE

(2) Clean the battery tray and battery holddown hardware of all corrosion. Remove any corrosion using a wire brush and a sodium bicarbonate (baking soda) and warm water cleaning solution. Paint any exposed bare metal.

(3) If the removed battery is to be reinstalled, clean the outside of the battery case and the top cover with a sodium bicarbonate (baking soda) and warm water cleaning solution using a stiff bristle parts cleaning brush to remove any acid film (Fig. 2). Rinse the battery with clean water. Ensure that the cleaning solution does not enter the battery cells through the vent holes. If the battery is being replaced, refer to Battery System Specifications for the factory-installed battery specifications. Confirm that the replacement battery is the correct size and has the correct ratings for the vehicle.

(4) Clean the battery thermal guard with a sodium bicarbonate (baking soda) and warm water cleaning solution using a stiff bristle parts cleaning brush to remove any acid film.

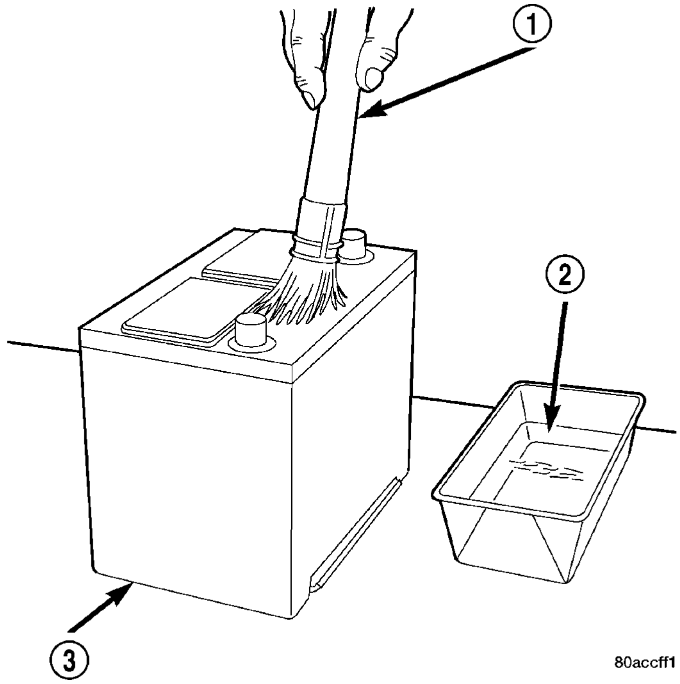


Fig. 2 Clean Battery - Typical

1 - CLEANING BRUSH
2 - WARM WATER AND BAKING SODA SOLUTION
3 - BATTERY

(5) Clean any corrosion from the battery terminal posts with a wire brush or a post and terminal cleaner, and a sodium bicarbonate (baking soda) and warm water cleaning solution (Fig. 3).

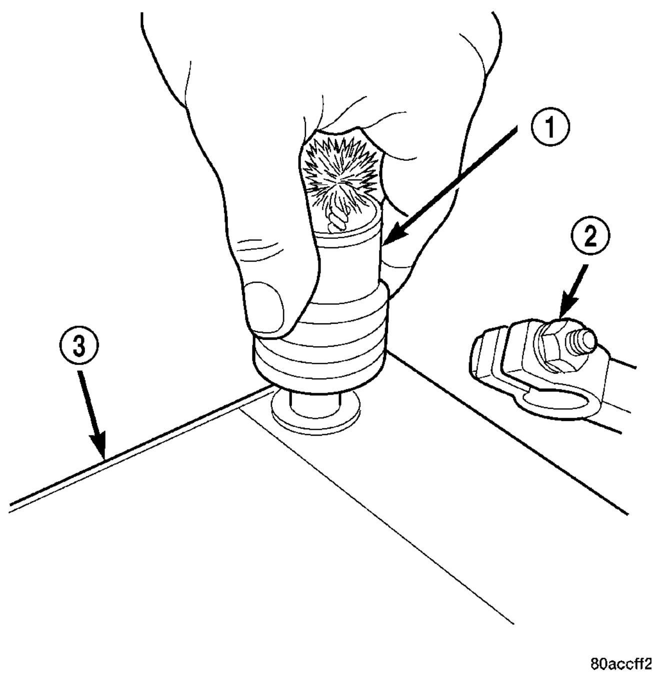


Fig. 3 Clean Battery Terminal Post - Typical

1 - TERMINAL BRUSH
2 - BATTERY CABLE
3 - BATTERY

BATTERY SYSTEM (Continued)

INSPECTION

The following information details the recommended inspection procedures for the battery and related components. In addition to the maintenance schedules found in this service manual and the owner's manual, it is recommended that these procedures be performed any time the battery or related components must be removed for vehicle service.

(1) Inspect the battery cable terminal clamps for damage. Replace any battery cable that has a damaged or deformed terminal clamp.

(2) Inspect the battery tray and battery holddown hardware for damage. Replace any damaged parts.

(3) Slide the thermal guard off of the battery case (if equipped). Inspect the battery case for cracks or other damage that could result in electrolyte leaks. Also, check the battery terminal posts for looseness. Batteries with damaged cases or loose terminal posts must be replaced.

(4) Inspect the battery thermal guard (if equipped) for tears, cracks, deformation or other damage. Replace any battery thermal guard that has been damaged.

(5) Inspect the battery built-in test indicator sight glass (if equipped) for an indication of the battery condition. If the battery is discharged, charge as required. Refer to Standard Procedures for the proper battery built-in indicator test procedures. Also refer to Standard Procedures for the proper battery charging procedures.

SPECIFICATIONS

The battery Group Size number, the Cold Cranking Amperage (CCA) rating, and the Reserve Capacity (RC) rating or Ampere-Hours (AH) rating can be found on the original equipment battery label. Be certain that a replacement battery has the correct Group Size number, as well as CCA, and RC or AH ratings that equal or exceed the original equipment specification for the vehicle being serviced. Battery sizes and ratings are discussed in more detail below.

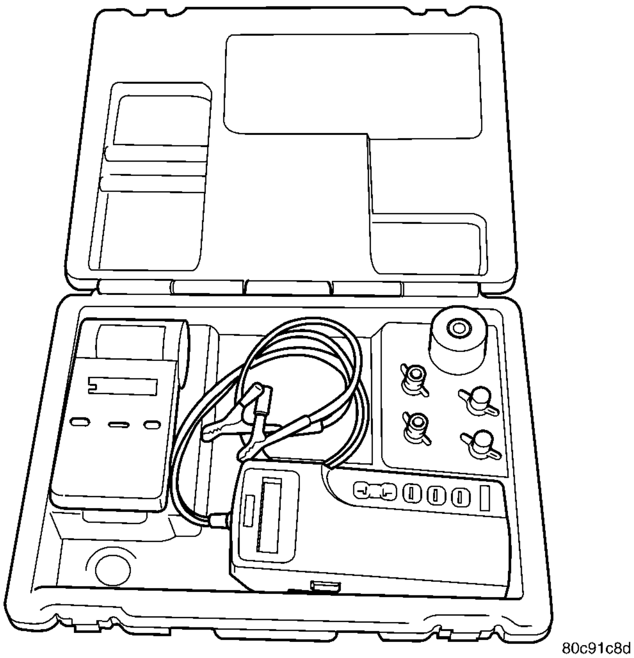
- **Group Size -** The outside dimensions and terminal placement of the battery conform to standards established by the Battery Council International (BCI). Each battery is assigned a BCI Group Size number to help identify a correctly-sized replacement.
- **Cold Cranking Amperage -** The Cold Cranking Amperage (CCA) rating specifies how much current (in amperes) the battery can deliver for thirty seconds at -18° C (0° F). Terminal voltage must not fall below 7.2 volts during or after the thirty second discharge period. The CCA required is generally higher as engine displacement increases, depending also upon the starter current draw requirements.
- **Reserve Capacity -** The Reserve Capacity (RC) rating specifies the time (in minutes) it takes for battery terminal voltage to fall below 10.5 volts, at a discharge rate of 25 amperes. RC is determined with the battery fully-charged at 26.7° C (80° F). This rating estimates how long the battery might last after a charging system failure, under minimum electrical load.
- **Ampere-Hours -** The Ampere-Hours (AH) rating specifies the current (in amperes) that a battery can deliver steadily for twenty hours, with the voltage in the battery not falling below 10.5 volts. This rating is also sometimes identified as the twenty-hour discharge rating.

BATTERY CLASSIFICATIONS & RATINGS					
Part Number	BCI Group Size Classification	Cold Cranking Amperage	Reserve Capacity	Ampere - Hours	Load Test Amperage
56029449AB	65	600	120 Minutes	66	300
56029451AB	65	750	150 Minutes	75	375
56028450AA	65	600	120 Minutes	66	300
56028452AA	65	750	150 Minutes	75	375
56028452AB	65	700	130 Minutes	70	350
56029396AA	65	700	130 Minutes	70	350
56029382AA	65	700	130 Minutes	70	350

BATTERY SYSTEM (Continued)

SPECIAL TOOLS

BATTERY SYSTEM SPECIAL TOOLS



Micro 420 Battery Tester

BATTERY

DESCRIPTION

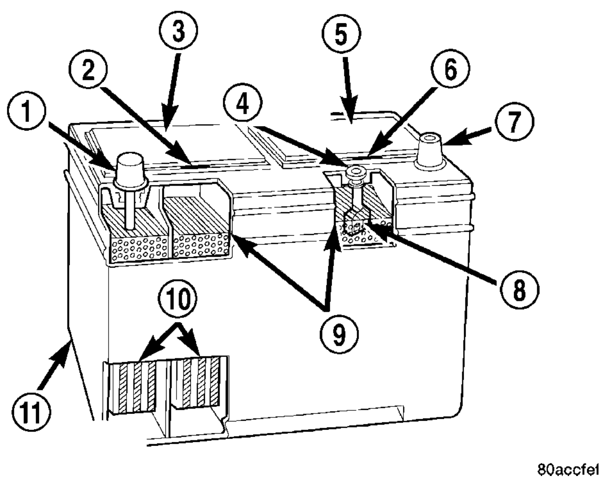


Fig. 4 Low-Maintenance Battery - Typical

1 - POSITIVE POST
2 - VENT
3 - CELL CAP
4 - TEST INDICATOR (IF EQUIPPED)
5 - CELL CAP
6 - VENT
7 - NEGATIVE POST
8 - GREEN BALL
9 - ELECTROLYTE LEVEL
10 - PLATE GROUPS
11 - LOW-MAINTENANCE BATTERY

A large capacity, low-maintenance storage battery (Fig. 4) is standard factory-installed equipment on this model. Models equipped with a diesel engine must utilize two 12-volt batteries connected in parallel. Male post type terminals made of a soft lead material protrude from the top of the molded plastic battery case to provide the means for connecting the battery to the vehicle electrical system. The battery positive terminal post is physically larger in diameter than the negative terminal post to ensure proper battery connection. The letters **POS** and **NEG** are also molded into the top of the battery case adjacent to their respective positive and negative terminal posts for identification confirmation. Refer to Battery Cables for more information on the battery cables that connect the battery to the vehicle electrical system.

The battery is made up of six individual cells that are connected in series. Each cell contains positively charged plate groups that are connected with lead straps to the positive terminal post, and negatively charged plate groups that are connected with lead straps to the negative terminal post. Each plate consists of a stiff mesh framework or grid coated with lead dioxide (positive plate) or sponge lead (negative plate). Insulators or plate separators made of a non-conductive material are inserted between the positive and negative plates to prevent them from contacting or shorting against one another. These dissimilar metal plates are submerged in a sulfuric acid and water solution called an electrolyte.

The factory-installed battery has a built-in test indicator (hydrometer). The color visible in the sight glass of the indicator will reveal the battery condition. Refer to Standard Procedures for the proper built-in indicator test procedures. **The factory-installed low-maintenance battery has non-removable battery cell caps.** Water cannot be added to this battery. The battery is not sealed and has vent holes in the cell caps. The chemical composition of the metal coated plates within the low-maintenance battery reduces battery gassing and water loss, at normal charge and discharge rates. Therefore, the battery should not require additional water in normal service. Rapid loss of electrolyte can be caused by an overcharging condition.

DIAGNOSIS AND TESTING - BATTERY

The battery must be completely charged and the terminals should be properly cleaned and inspected before diagnostic procedures are performed. Refer to Battery System Cleaning for the proper cleaning procedures, and Battery System Inspection for the proper battery inspection procedures. Refer to Standard Procedures for the proper battery charging procedures.

BATTERY (Continued)

MICRO 420 BATTERY TESTER

The Micro 420 automotive battery tester is designed to help the dealership technician diagnose the cause of a defective battery. Follow the instruction manual supplied with the tester to properly diagnose a battery. If the instruction manual is not available, refer to the standard procedure in this section, which includes the directions for using the Micro 420 battery tester.

WARNING: IF THE BATTERY SHOWS SIGNS OF FREEZING, LEAKING OR LOOSE POSTS, DO NOT TEST, ASSIST-BOOST, OR CHARGE. THE BATTERY MAY ARC INTERNALLY AND EXPLODE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.

WARNING: EXPLOSIVE HYDROGEN GAS FORMS IN AND AROUND THE BATTERY. DO NOT SMOKE, USE FLAME, OR CREATE SPARKS NEAR THE BATTERY. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.

WARNING: THE BATTERY CONTAINS SULFURIC ACID, WHICH IS POISONOUS AND CAUSTIC. AVOID CONTACT WITH THE SKIN, EYES, OR CLOTHING. IN THE EVENT OF CONTACT, FLUSH WITH WATER AND CALL A PHYSICIAN IMMEDIATELY. KEEP OUT OF THE REACH OF CHILDREN.

A battery that will not accept a charge is faulty, and must be replaced. Further testing is not required. A fully-charged battery must be load tested to determine its cranking capacity. A battery that is fully-charged, but does not pass the load test, is faulty and must be replaced. Always test battery using the Micro 420 battery tester before attempting to replace a battery under the manufactures warranty provisions.

NOTE: Completely discharged batteries may take several hours to accept a charge. Refer to Standard Procedures for the proper battery charging procedures.

STANDARD PROCEDURE

STANDARD PROCEDURE - BATTERY CHARGING

Battery charging can be performed fast or slow, in terms of time. **Slow** battery charging is the best means of restoring a battery to full potential. Fast battery charging should only be performed when absolutely necessary due to time restraints. A battery is fully-charged when:

- All of the battery cells are gassing freely during battery charging.
- A green color is visible in the sight glass of the battery built-in test indicator.
- Three hydrometer tests, taken at one-hour intervals, indicate no increase in the temperature-corrected specific gravity of the battery electrolyte.
- Open-circuit voltage of the battery is 12.65 volts or above.

WARNING: NEVER EXCEED TWENTY AMPERES WHEN CHARGING A COLD (-1° C [30° F] OR LOWER) BATTERY. THE BATTERY MAY ARC INTERNALLY AND EXPLODE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.

CAUTION: Always disconnect and isolate the battery negative cable before charging a battery. Do not exceed sixteen volts while charging a battery. Damage to the vehicle electrical system components may result.

CAUTION: Battery electrolyte will bubble inside the battery case during normal battery charging. Electrolyte boiling or being discharged from the battery vents indicates a battery overcharging condition. Immediately reduce the charging rate or turn off the charger to evaluate the battery condition. Damage to the battery may result from overcharging.

CAUTION: The battery should not be hot to the touch. If the battery feels hot to the touch, turn off the charger and let the battery cool before continuing the charging operation. Damage to the battery may result.

NOTE: Models equipped with the diesel engine are equipped with two 12-volt batteries, connected in parallel (positive-to-positive and negative-to-negative). In order to ensure proper charging of each battery, these batteries MUST be disconnected from each other, as well as from the vehicle electrical system while being charged.

Some battery chargers are equipped with polarity-sensing circuitry. This circuitry protects the battery charger and the battery from being damaged if they are improperly connected. If the battery state-of-charge is too low for the polarity-sensing circuitry to detect, the battery charger will not operate. This makes it appear that the battery will not accept charging current. See the instructions provided by

BATTERY (Continued)

the manufacturer of the battery charger for details on how to bypass the polarity-sensing circuitry.

After the battery has been charged to 12.4 volts or greater, perform a load test to determine the battery cranking capacity. Refer to Standard Procedures for the proper battery load test procedures. If the battery will endure a load test, return the battery to service. If the battery will not endure a load test, it is faulty and must be replaced.

Clean and inspect the battery hold downs, tray, terminals, posts, and top before completing battery service. Refer to Battery System Cleaning for the proper battery system cleaning procedures, and Battery System Inspection for the proper battery system inspection procedures.

CHARGING A COMPLETELY DISCHARGED BATTERY

The following procedure should be used to recharge a completely discharged battery. Unless this procedure is properly followed, a good battery may be needlessly replaced.

(1) Measure the voltage at the battery posts with a voltmeter, accurate to 1/10 (0.10) volt (Fig. 5). If the reading is below ten volts, the battery charging current will be low. It could take some time before the battery accepts a current greater than a few milliamperes. Such low current may not be detectable on the ammeters built into many battery chargers.

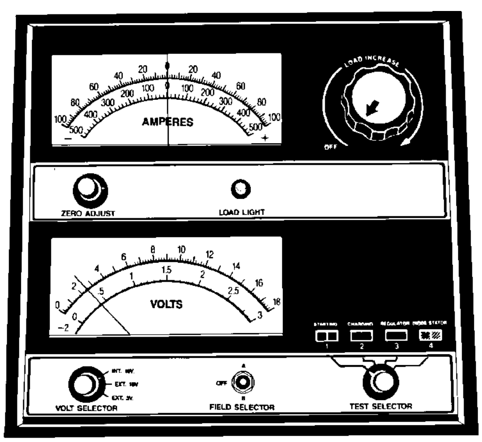


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Fig. 5 Voltmeter - Typical

(2) Disconnect and isolate the battery negative cable. Connect the battery charger leads. Some battery chargers are equipped with polarity-sensing circuitry. This circuitry protects the battery charger and the battery from being damaged if they are improperly connected. If the battery state-of-charge is too low for the polarity-sensing circuitry to detect, the battery charger will not operate. This makes it appear that the battery will not accept charging current. See the instructions provided by the manufacturer of the battery charger for details on how to bypass the polarity-sensing circuitry.

(3) Battery chargers vary in the amount of voltage and current they provide. The amount of time required for a battery to accept measurable charging current at various voltages is shown in the Charge Rate Table. If the charging current is still not measurable at the end of the charging time, the battery is faulty and must be replaced. If the charging current is measurable during the charging time, the battery may be good and the charging should be completed in the normal manner.

CHARGE RATE TABLE	
Voltage	Hours
16.0 volts maximum	up to 4 hours
14.0 to 15.9 volts	up to 8 hours
13.9 volts or less	up to 16 hours

CHARGING TIME REQUIRED

The time required to charge a battery will vary, depending upon the following factors:

- **Battery Capacity** - A completely discharged heavy-duty battery requires twice the charging time of a small capacity battery.
- **Temperature** - A longer time will be needed to charge a battery at -18° C (0° F) than at 27° C (80° F). When a fast battery charger is connected to a cold battery, the current accepted by the battery will be very low at first. As the battery warms, it will accept a higher charging current rate (amperage).
- **Charger Capacity** - A battery charger that supplies only five amperes will require a longer charging time. A battery charger that supplies twenty amperes or more will require a shorter charging time.
- **State-Of-Charge** - A completely discharged battery requires more charging time than a partially discharged battery. Electrolyte is nearly pure water in a completely discharged battery. At first, the charging current (amperage) will be low. As the battery charges, the specific gravity of the electrolyte will gradually rise.

The Battery Charging Time Table gives an indication of the time required to charge a typical battery at room temperature based upon the battery state-of-charge and the charger capacity.

BATTERY (Continued)

BATTERY CHARGING TIME TABLE			
Charging Amperage	5 Amps	10 Amps	20 Amps
Open Circuit Voltage	Hours Charging @ 21° C (70° F)		
12.25 to 12.49	6 hours	3 hours	1.5 hours
12.00 to 12.24	10 hours	5 hours	2.5 hours
10.00 to 11.99	14 hours	7 hours	3.5 hours
Below 10.00	18 hours	9 hours	4.5 hours

STANDARD PROCEDURE - BUILT-IN INDICATOR TEST

If equipped, an indicator (hydrometer) built into the top of the battery case provides visual information for battery testing (Fig. 6). Like a hydrometer, the built-in indicator measures the specific gravity of the battery electrolyte. The specific gravity of the electrolyte reveals the battery state-of-charge; however, it will not reveal the cranking capacity of the battery. A load test must be performed to determine the battery cranking capacity. Refer to Standard Procedures for the proper battery load test procedures.

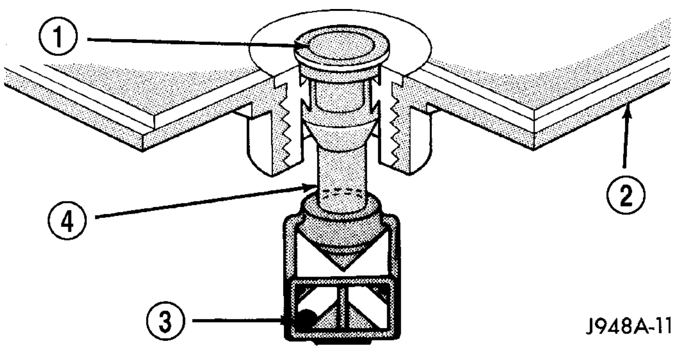

Fig. 6 Built-In Indicator

1 - SIGHT GLASS
2 - BATTERY TOP
3 - GREEN BALL
4 - PLASTIC ROD

Before testing, visually inspect the battery for any damage (a cracked case or cover, loose posts, etc.) that would cause the battery to be faulty. In order to obtain correct indications from the built-in indicator, it is important that the battery be level and have a clean sight glass. Additional light may be required to view the indicator. **Do not use open flame as a source of additional light.**

To read the built-in indicator, look into the sight glass and note the color of the indication (Fig. 7). The battery condition that each color indicates is described in the following list:

- **Green** - Indicates 75% to 100% battery state-of-charge. The battery is adequately charged for further testing or return to service. If the starter will not crank for a minimum of fifteen seconds with a fully-charged battery, the battery must be load tested. Refer to Standard Procedures for the proper battery load test procedures.
- **Black or Dark** - Indicates 0% to 75% battery state-of-charge. The battery is inadequately charged and must be charged until a green indication is visible in the sight glass (12.4 volts or more), before the battery is tested further or returned to service. Refer to Standard Procedures for the proper battery charging procedures. Also refer to Diagnosis and Testing for more information on the possible causes of the discharged battery condition.
- **Clear or Bright** - Indicates a low battery electrolyte level. The electrolyte level in the battery is below the built-in indicator. A maintenance-free battery with non-removable cell caps must be replaced if the electrolyte level is low. Water must be added to a low-maintenance battery with removable cell caps before it is charged. Refer to Standard Procedures for the proper battery filling procedures. A low electrolyte level may be caused by an overcharging condition. Refer to Charging System for the proper charging system diagnosis and testing procedures.

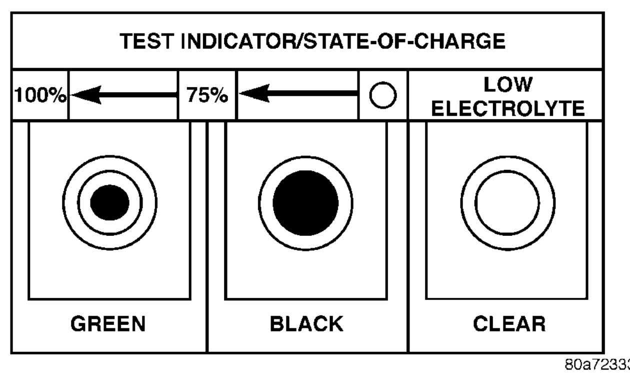

Fig. 7 Built-In Indicator Sight Glass Chart

STANDARD PROCEDURE - OPEN-CIRCUIT VOLTAGE TEST

A battery open-circuit voltage (no load) test will show the approximate state-of-charge of a battery. This test can be used in place of the hydrometer test when a hydrometer is not available, or for maintenance-free batteries with non-removable cell caps.

Before proceeding with this test, completely charge the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE).

(1) Before measuring the open-circuit voltage, the surface charge must be removed from the battery.

BATTERY (Continued)

Turn on the headlamps for fifteen seconds, then allow up to five minutes for the battery voltage to stabilize.

(2) Disconnect and isolate both battery cables, negative cable first.

(3) Using a voltmeter connected to the battery posts (see the instructions provided by the manufacturer of the voltmeter), measure the open-circuit voltage (Fig. 8).

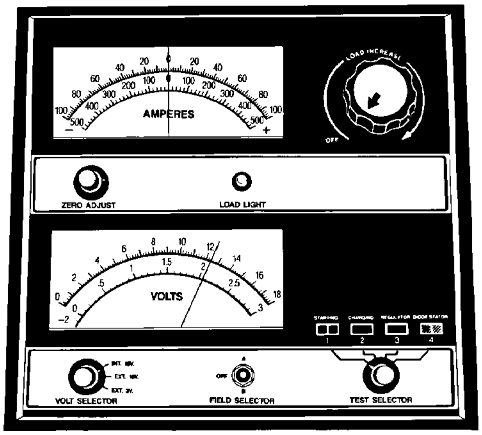

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Fig. 8 Testing Open-Circuit Voltage - Typical

See the Open-Circuit Voltage Table. This voltage reading will indicate the battery state-of-charge, but will not reveal its cranking capacity. If a battery has an open-circuit voltage reading of 12.4 volts or greater, it may be load tested to reveal its cranking capacity (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE).

OPEN CIRCUIT VOLTAGE TABLE	
Open Circuit Voltage	Charge Percentage
11.7 volts or less	0%
12.0 volts	25%
12.2 volts	50%
12.4 volts	75%
12.6 volts or more	100%

STANDARD PROCEDURE - IGNITION-OFF DRAW TEST

The term Ignition-Off Draw (IOD) identifies a normal condition where power is being drained from the battery with the ignition switch in the Off position. A normal vehicle electrical system will draw from five to thirty-five milliamperes (0.005 to 0.035 ampere) with the ignition switch in the Off position, and all non-ignition controlled circuits in proper working order. Up to thirty-five milliamperes are needed to enable the memory functions for the Powertrain Control Module (PCM), digital clock, electronically tuned radio, and other modules which may vary with the vehicle equipment.

A vehicle that has not been operated for approximately twenty days, may discharge the battery to an inadequate level. When a vehicle will not be used for twenty days or more (stored), remove the IOD fuse from the Integrated Power Module (IPM). This will reduce battery discharging.

Excessive IOD can be caused by:

- Electrical items left on.
- Faulty or improperly adjusted switches.
- Faulty or shorted electronic modules and components.
- An internally shorted generator.
- Intermittent shorts in the wiring.

If the IOD is over thirty-five milliamperes, the problem must be found and corrected before replacing a battery. In most cases, the battery can be charged and returned to service after the excessive IOD condition has been corrected.

(1) Verify that all electrical accessories are off. Turn off all lamps, remove the ignition key, and close all doors. If the vehicle is equipped with an illuminated entry system or an electronically tuned radio, allow the electronic timer function of these systems to automatically shut off (time out). This may take up to three minutes. See the Electronic Module Ignition-Off Draw Table for more information.

ELECTRONIC MODULE IGNITION-OFF DRAW (IOD) TABLE			
Module	Time Out? (If Yes, Interval And Wake-Up Input)	IOD	IOD After Time Out
Radio	No	1 to 3 milliamperes	N/A
Audio Power Amplifier	No	up to 1 milliampere	N/A
Powertrain Control Module (PCM)	No	0.95 milliampere	N/A

BATTERY (Continued)

ELECTRONIC MODULE IGNITION-OFF DRAW (IOD) TABLE			
Module	Time Out? (If Yes, Interval And Wake-Up Input)	IOD	IOD After Time Out
ElectroMechanical Instrument Cluster (EMIC)	No	0.44 milliampere	N/A
Combination Flasher	No	0.08 milliampere	N/A

(2) Determine that the underhood lamp is operating properly, then disconnect the lamp wire harness connector or remove the lamp bulb.

(3) Disconnect the battery negative cable.

(4) Set an electronic digital multi-meter to its highest amperage scale. Connect the multi-meter between the disconnected battery negative cable terminal clamp and the battery negative terminal post. Make sure that the doors remain closed so that the illuminated entry system is not activated. The multi-meter amperage reading may remain high for up to three minutes, or may not give any reading at all while set in the highest amperage scale, depending upon the electrical equipment in the vehicle. The multi-meter leads must be securely clamped to the battery negative cable terminal clamp and the battery negative terminal post. If continuity between the battery negative terminal post and the negative cable terminal clamp is lost during any part of the IOD test, the electronic timer function will be activated and all of the tests will have to be repeated.

(5) After about three minutes, the high-amperage IOD reading on the multi-meter should become very low or nonexistent, depending upon the electrical equipment in the vehicle. If the amperage reading remains high, remove and replace each fuse or circuit breaker in the Integrated Power Module (IPM), one at a time until the amperage reading becomes very low, or nonexistent. Refer to the appropriate wiring information in this service manual for complete Integrated Power Module fuse, circuit breaker, and circuit identification. This will isolate each circuit and identify the circuit that is the source of the high-amperage IOD. If the amperage reading remains high after removing and replacing each fuse and circuit breaker, disconnect the wire harness from the generator. If the amperage reading now becomes very low or nonexistent, refer to Charging System for the proper charging system diagnosis and testing procedures. After the high-amperage IOD has been corrected, switch the multi-meter to progressively lower amperage scales and, if necessary, repeat the fuse and circuit breaker remove-and-replace process to identify and correct all sources of excessive IOD. It is now safe to select the lowest milliampere scale of the multi-meter to check the low-amperage IOD.

CAUTION: Do not open any doors, or turn on any electrical accessories with the lowest milliampere scale selected, or the multi-meter may be damaged.

(6) Observe the multi-meter reading. The low-amperage IOD should not exceed thirty-five milliamperes (0.035 ampere). If the current draw exceeds thirty-five milliamperes, isolate each circuit using the fuse and circuit breaker remove-and-replace process in Step 5. The multi-meter reading will drop to within the acceptable limit when the source of the excessive current draw is disconnected. Repair this circuit as required; whether a wiring short, incorrect switch adjustment, or a component failure is at fault.

STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER

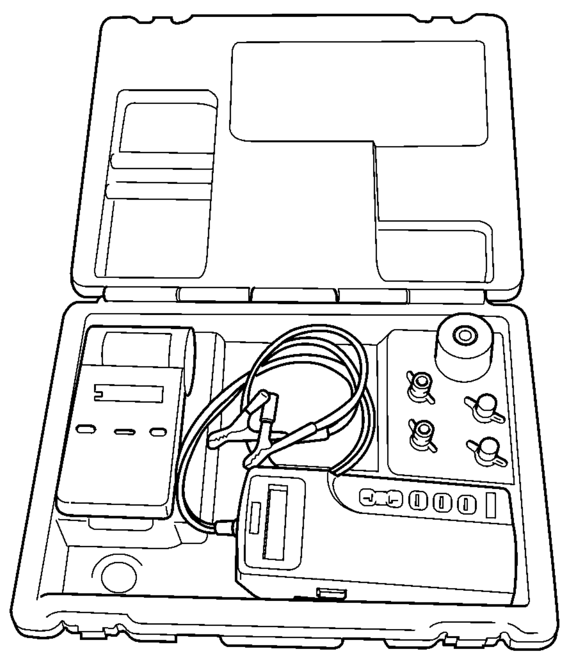

Fig. 9 MICRO 420 BATTERY TESTER

Always use the Micro 420 Instruction Manual that was supplied with the tester as a reference. If the Instruction Manual is not available the following procedure can be used:

BATTERY (Continued)

WARNING: ALWAYS WEAR APPROPRIATE EYE PROTECTION AND USE EXTREME CAUTION WHEN WORKING WITH BATTERIES.

BATTERY TESTING

(1) If testing the battery OUT-OF-VEHICLE, clean the battery terminals with a wire brush before testing. If the battery is equipped with side post terminals, install and tighten the supplied lead terminal stud adapters. Do not use steel bolts. Failure to properly install the stud adapters, or using stud adapters that are dirty or worn-out may result in false test readings.

(2) If testing the battery IN-THE-VEHICLE, make certain all of the vehicle accessory loads are OFF, including the ignition. **The preferred test position is at the battery terminal**. If the battery is not accessible, you may test using both the positive and negative jumper posts. Select TESTING AT JUMPER POST when connecting to that location.

(3) Connect the tester (Fig. 9) to the battery or jumper posts, the red clamp to positive (+) and the black clamp to negative (–).

NOTE: Multiple batteries connected in parallel must have the ground cable disconnected to perform a battery test. Failure to disconnect may result in false battery test readings.

(4) Using the ARROW key select **in** or **out** of vehicle testing and press ENTER to make a selection.

(5) If not selected, choose the Cold Cranking Amp (CCA) battery rating. Or select the appropriate battery rating for your area (see menu). The tester will then run its self programmed test of the battery and display the results. Refer to the test result table noted below.

CAUTION: If REPLACE BATTERY is the result of the test, this may mean a poor connection between the vehicle's cables and battery exists. After disconnecting the vehicle's battery cables from the battery, retest the battery using the OUT-OF-VEHICLE test before replacing.

(6) While viewing the battery test result, press the CODE button and the tester will prompt you for the last 4 digits of the VIN. Use the UP/DOWN arrow buttons to scroll to the correct character; then press ENTER to select and move to the next digit. Then press the ENTER button to view the SERVICE CODE. Pressing the CODE button a second time will return you to the test results.

BATTERY TEST RESULTS	
GOOD BATTERY	Return to service
GOOD - RECHARGE	Fully charge battery and return to service
CHARGE & RETEST	Fully charge battery and retest battery
REPLACE BATTERY	Replace the battery and retest complete system
BAD-CELL REPLACE	Replace the battery and retest complete system

NOTE: The SERVICE CODE is required on every warranty claim submitted for battery replacement.

REMOVAL

(1) Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.

(2) Loosen the battery negative cable terminal clamp pinch-bolt hex nut.

(3) Disconnect the battery negative cable terminal clamp from the battery negative terminal post. If necessary, use a battery terminal puller to remove the terminal clamp from the battery post (Fig. 10).

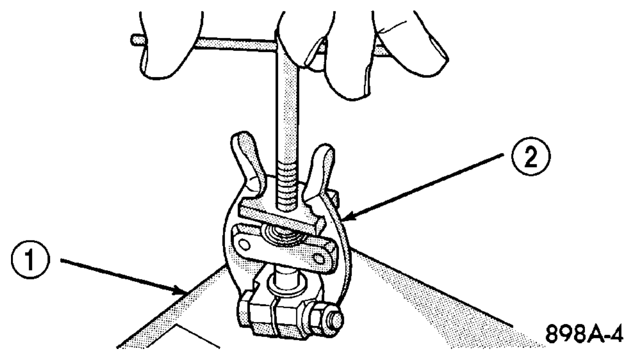

Fig. 10 Removing Battery Cable Terminal Clamp

1 - BATTERY
2 - BATTERY TERMINAL PULLER

(4) Loosen the battery positive cable terminal clamp pinch-bolt hex nut.

(5) Disconnect the battery positive cable terminal clamp from the battery positive terminal post. If necessary, use a battery terminal puller to remove the terminal clamp from the battery post (Fig. 10).

(6) Remove the battery hold down retaining bolt.

WARNING: WEAR A SUITABLE PAIR OF RUBBER GLOVES (NOT THE HOUSEHOLD TYPE) WHEN REMOVING A BATTERY BY HAND. SAFETY GLASSES SHOULD ALSO BE WORN. IF THE BATTERY IS CRACKED OR LEAKING, THE ELECTROLYTE CAN BURN THE SKIN AND EYES.

BATTERY (Continued)

(7) Remove the battery from the battery tray.

INSTALLATION

(1) Clean and inspect the battery.

(2) Position the battery onto the battery tray. Ensure that the battery positive and negative terminal posts are correctly positioned. The battery cable terminal clamps must reach the correct battery terminal post without stretching the cables.

(3) Position the battery hold down and install the retaining bolt.

CAUTION: Be certain that the battery cable terminal clamps are connected to the correct battery terminal posts. Reversed battery polarity may damage electrical components of the vehicle.

(4) Clean the battery cable terminal clamps and the battery terminal posts.

(5) Reconnect the battery positive cable terminal clamp to the battery positive terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).

(6) Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).

(7) Apply a thin coating of petroleum jelly or chassis grease to the exposed surfaces of the battery cable terminal clamps and the battery terminal posts.

(8) Obtain a DRB III® scan tool and check the PCM for any stored battery disconnect trouble code, if required.

BATTERY HOLDDOWN

DESCRIPTION

The battery hold down hardware includes a bolt and a molded plastic hold down bracket which meshes with the battery tray when properly installed. The battery tray and hold down hardware combine to form a very stable and secure battery hold down assembly.

OPERATION

The battery holddown secures the battery in the battery tray. This holddown is designed to prevent battery movement during the most extreme vehicle operation conditions. Periodic removal and lubrication of the battery holddown hardware is recommended to prevent hardware seizure at a later date.

CAUTION: Never operate a vehicle without a battery holddown device properly installed. Damage to the vehicle, components and battery could result.

REMOVAL

(1) Loosen and remove the battery hold down retaining bolt.

(2) Remove the battery hold down bracket from the battery case.

INSTALLATION

(1) Clean and inspect the battery hold down hardware (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).

(2) Position the battery hold down bracket in the battery tray. Be certain that the hold down bracket is properly positioned in the battery tray before tightening the hold down hardware.

(3) Install and tighten the battery hold down retaining bolt.

BATTERY CABLES

DESCRIPTION

The battery cables are large gauge, stranded copper wires sheathed within a heavy plastic or synthetic rubber insulating jacket. The wire used in the battery cables combines excellent flexibility and reliability with high electrical current carrying capacity. Refer to Wiring for the location of the proper battery cable wire gauge information.

The battery cables cannot be repaired and, if damaged or faulty they must be replaced. Both the battery positive and negative cables are available for service replacement only as a unit with the battery positive cable wire harness or the battery negative cable wire harness, which may include portions of the wiring circuits for the generator and other components on some models.

Most models feature a stamped brass clamping type female battery terminal crimped onto one end of the battery cable wire and then solder-dipped. A pinch-bolt and hex nut are installed at the open end of the female battery terminal clamp. The battery positive cable also includes a red molded rubber protective cover for the female battery terminal clamp. Large eyelet type terminals are crimped onto the opposite end of the battery cable wire and then solder-dipped. The battery positive cable wires have a red insulating jacket to provide visual identification and feature a larger female battery terminal clamp to allow connection to the larger battery positive terminal post. The battery negative cable wires have a black insulating jacket and a smaller female battery terminal clamp.

OPERATION

The battery cables connect the battery terminal posts to the vehicle electrical system. These cables

BATTERY CABLES (Continued)

also provide a return path for electrical current generated by the charging system for restoring the voltage potential of the battery. The female battery terminal clamps on the ends of the battery cable wires provide a strong and reliable connection of the battery cable to the battery terminal posts. The terminal pinch bolts allow the female terminal clamps to be tightened around the male terminal posts on the top of the battery. The eyelet terminals secured to the ends of the battery cable wires opposite the female battery terminal clamps provide secure and reliable connection of the battery to the vehicle electrical system.

DIAGNOSIS AND TESTING - BATTERY CABLES

A voltage drop test will determine if there is excessive resistance in the battery cable terminal connections or the battery cables. If excessive resistance is found in the battery cable connections, the connection point should be disassembled, cleaned of all corrosion or foreign material, then reassembled. Following reassembly, check the voltage drop for the battery cable connection and the battery cable again to confirm repair.

When performing the voltage drop test, it is important to remember that the voltage drop is giving an indication of the resistance between the two points at which the voltmeter probes are attached. **EXAMPLE:** When testing the resistance of the battery positive cable, touch the voltmeter leads to the battery positive cable terminal clamp and to the battery positive cable eyelet terminal at the starter solenoid B(+) terminal stud. If you probe the battery positive terminal post and the battery positive cable eyelet terminal at the starter solenoid B(+) terminal stud, you are reading the combined voltage drop in the battery positive cable terminal clamp-to-terminal post connection and the battery positive cable.

VOLTAGE DROP TEST

WARNING: MODELS EQUIPPED WITH A DIESEL ENGINE HAVE AN AUTOMATIC SHUTDOWN (ASD) RELAY LOCATED IN THE POWER DISTRIBUTION CENTER (PDC). REMOVAL OF THE ASD RELAY MAY NOT PREVENT THE DIESEL ENGINE FROM STARTING. BE CERTAIN TO DISCONNECT THE FUEL SHUTDOWN SOLENOID WIRE HARNESS CONNECTOR TO PREVENT THE ENGINE FROM STARTING. FAILURE TO DO SO MAY RESULT IN PERSONAL INJURY.

The following operation will require a voltmeter accurate to 1/10 (0.10) volt. Before performing this test, be certain that the following procedures are accomplished:

- The battery is fully-charged and tested (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE).
- Fully engage the parking brake.
- If the vehicle is equipped with an automatic transmission, place the gearshift selector lever in the Park position. If the vehicle is equipped with a manual transmission, place the gearshift selector lever in the Neutral position and block the clutch pedal in the fully depressed position.
- Verify that all lamps and accessories are turned off.
- To prevent a gasoline engine from starting, remove the Automatic ShutDown (ASD) relay. The ASD relay is located in the Integrated Power Module (IPM), in the engine compartment. See the fuse and relay layout label on the underside of the IPM cover for ASD relay identification and location.

(1) Connect the positive lead of the voltmeter to the battery negative terminal post. Connect the negative lead of the voltmeter to the battery negative cable terminal clamp (Fig. 11). Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If voltage is detected, correct the poor connection between the battery negative cable terminal clamp and the battery negative terminal post.

NOTE: If the vehicle is equipped with two 12v batteries, step #1 must be performed twice, once for each battery.

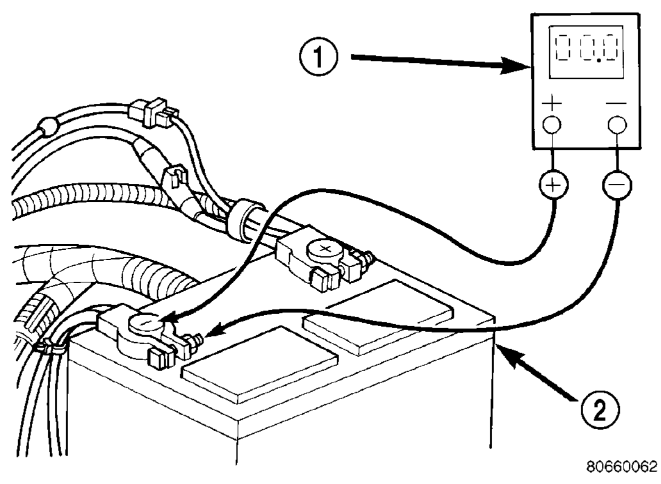

Fig. 11 Test Battery Negative Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

(2) Connect the positive lead of the voltmeter to the battery positive terminal post. Connect the negative lead of the voltmeter to the battery positive cable terminal clamp (Fig. 12). Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If voltage is detected, correct the poor connection

BATTERY CABLES (Continued)

between the battery positive cable terminal clamp and the battery positive terminal post.

NOTE: If the vehicle is equipped with two 12v batteries, step #2 must be performed twice, once for each battery.

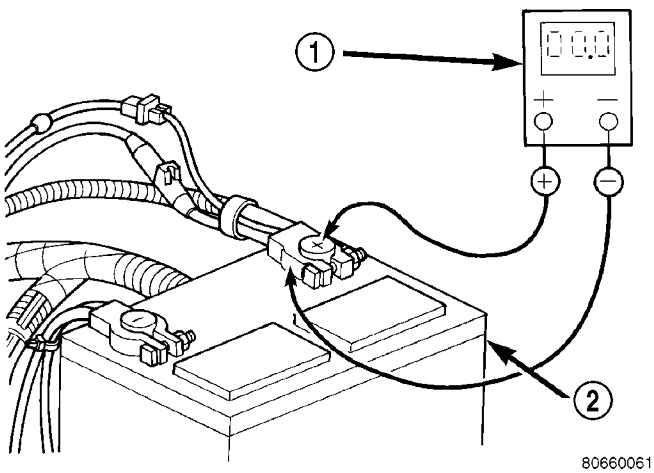

Fig. 12 Test Battery Positive Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

(3) Connect the voltmeter to measure between the battery positive cable terminal clamp and the starter solenoid B(+) terminal stud (Fig. 13). Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If the reading is above 0.2 volt, clean and tighten the battery positive cable eyelet terminal connection at the starter solenoid B(+) terminal stud. Repeat the test. If the reading is still above 0.2 volt, replace the faulty battery positive cable.

NOTE: If the vehicle is equipped with two 12v batteries, step #3 must be performed twice, once for each battery.

(4) Connect the voltmeter to measure between the battery negative cable terminal clamp and a good clean ground on the engine block (Fig. 14). Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If the reading is above 0.2 volt, clean and tighten the battery negative cable eyelet terminal connection to the engine block. Repeat the test. If the reading is still above 0.2 volt, replace the faulty battery negative cable.

NOTE: If the vehicle is equipped with two 12v batteries, step #4 must be performed twice, once for each battery.

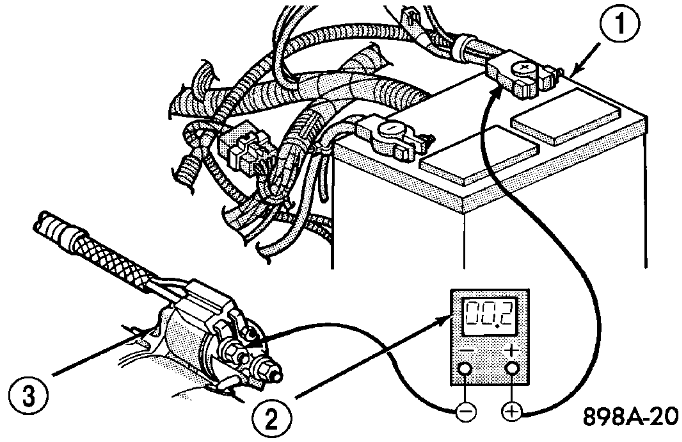

Fig. 13 Test Battery Positive Cable Resistance - Typical

1 - BATTERY
2 - VOLTMETER
3 - STARTER MOTOR

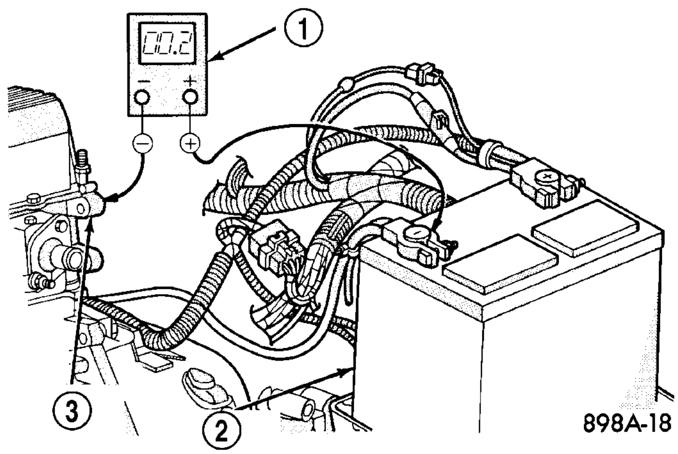

Fig. 14 Test Ground Circuit

1 - VOLTMETER
2 - BATTERY
3 - ENGINE GROUND

REMOVAL

(1) Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.

(2) Disconnect and isolate the remote battery negative cable terminal.

(3) Remove the battery from the vehicle. Refer to the procedure in this group.

(4) One at a time, trace the battery cable retaining pushpins, fasteners and routing clips until the cable is free from the vehicle.

(5) Remove the battery cable from the engine compartment.

BATTERY CABLES (Continued)

INSTALLATION

(1) Position the battery cable in the engine compartment.

(2) One at a time, install the battery cable retaining pushpins, fasteners and routing clips until the cable is installed exactly where it was in the vehicle. Refer to Wiring for illustrations.

(3) Install the battery in the vehicle. Refer to the procedure in this group.

(4) Connect the battery negative cable terminal.

BATTERY TRAY

DESCRIPTION

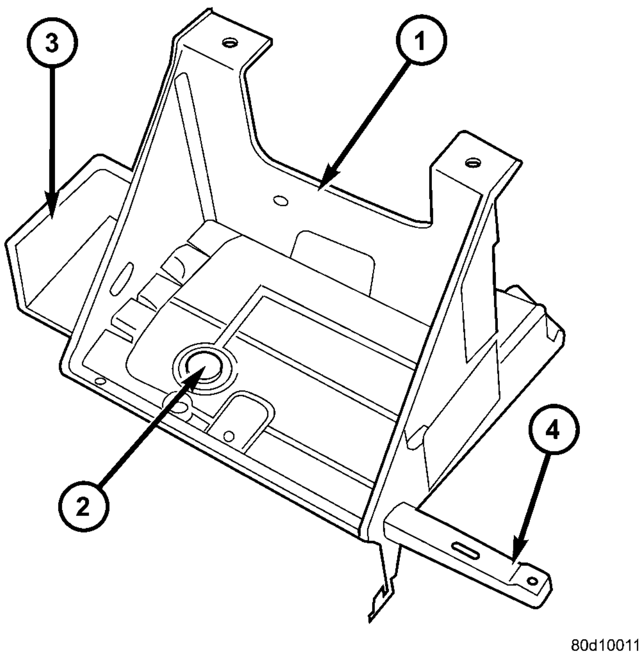

Fig. 15 DR Battery Tray

1 - BATTERY TRAY ASSEMBLY
2 - BATTERY TEMPERATURE SENSOR
3 - ANTI-LOCK BRAKE CONTROLLER MOUNTING LOCATION
4 - INTEGRATED POWER MODULE MOUNTING SANCTION

The molded plastic tray battery tray is located in the left front corner of the engine compartment. On this model, the battery tray also provides an anchor point for the anti-lock brake controller, cruise control servo (if equipped) and the integrated power module (Fig. 15). The battery hold down hardware is contained within the battery tray. A hole in the bottom of the battery tray is fitted with a battery temperature sensor. Refer to Charging System for more information on the battery temperature sensor.

OPERATION

The battery tray and the battery hold down hardware combine to secure and stabilize the battery in the engine compartment, which prevents battery movement during even the most extreme vehicle operation. Unrestrained battery movement during vehicle operation could result in damage to the vehicle, the battery, or both.

REMOVAL

LEFT SIDE

(1) Remove the battery from the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - REMOVAL).

(2) Remove the integrated power module (Refer to 8 - ELECTRICAL/POWER DISTRIBUTION/INTELLIGENT POWER MODULE - REMOVAL).

(3) Disconnect the wire harness retainers from the battery tray assembly.

(4) Remove the anti-lock brake controller (if equipped) retaining bolts and support the brake controller with mechanics wire. It is not necessary to completely remove the anti-lock brake control unit.

(5) Remove the left front wheelhouse splash shield(Refer to 23 - BODY/EXTERIOR/LF WHEELHOUSE SPLASH SHIELD - REMOVAL).

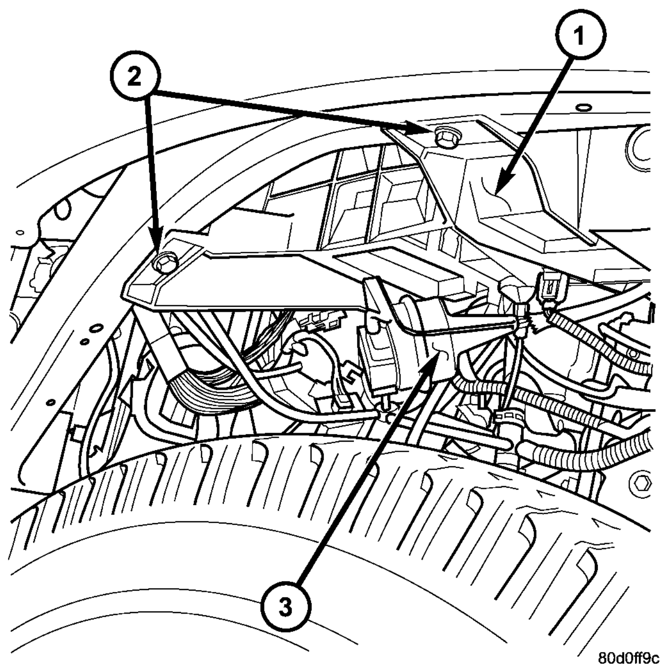

Fig. 16 Lower Battery Tray Retaining Bolts

1 - BATTERY TRAY ASSEMBLY
2 - BATTERY TRAY RETAINING BOLTS
3 - CRUISE CONTROL SERVO

BATTERY TRAY (Continued)

(6) Mark the location of the cruise servo (if equipped) and remove the retaining screws. Position the servo out of the way.

(7) Remove the battery temperature sensor from the battery tray (Refer to 8 - ELECTRICAL/CHARGING/BATTERY TEMPERATURE SENSOR - REMOVAL).

(8) Disconnect the purge solenoid from its mounting bracket.

(9) Disconnect the left front fender ground wire.

(10) Remove the remaining battery tray retaining bolts (Fig. 16).

(11) Remove the battery tray from the vehicle.

RIGHT SIDE

(1) Remove the battery from the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - REMOVAL).

(2) Remove the right front wheelhouse splash shield.

(3) Disconnect the right front fender ground wire.

(4) Remove fasteners from grid heater relay bracket.

(5) Remove air box.

(6) Remove the remaining battery tray retaining bolts (Fig. 17).

(7) Remove the battery tray from the vehicle.

INSTALLATION

LEFT SIDE

(1) Position the battery tray assembly and install the retaining bolts.

(2) Connect the left front fender ground wire.

(3) Install the purge solenoid on its mounting bracket.

(4) Install the battery temperature sensor in the battery tray (Refer to 8 - ELECTRICAL/CHARGING/BATTERY TEMPERATURE SENSOR - INSTALLATION).

(5) Install the cruise servo (if equipped) and retaining screws.

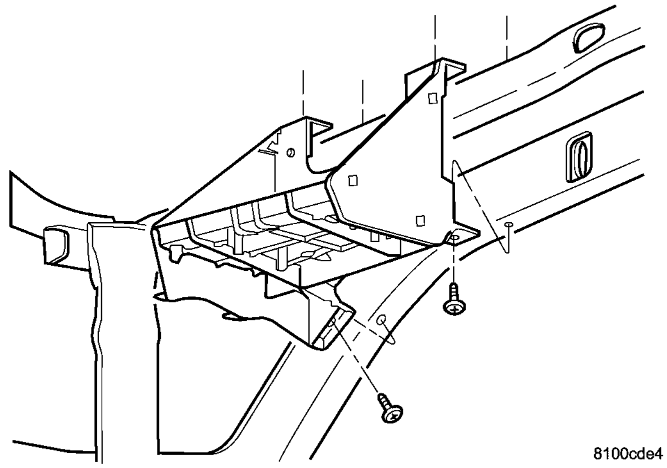

Fig. 17 RIGHT SIDE BATTERY TRAY

(6) Install the left front wheelhouse splash shield (Refer to 23 - BODY/EXTERIOR/LF WHEELHOUSE SPLASH SHIELD - INSTALLATION).

(7) Install the anti-lock brake controller (if equipped).

(8) Connect the wire harness retainers on the battery tray assembly.

(9) Install the integrated power module (Refer to 8 - ELECTRICAL/POWER DISTRIBUTION/INTELLIGENT POWER MODULE - INSTALLATION).

(10) Install the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - INSTALLATION).

RIGHT SIDE

(1) Position the battery tray assembly and install the retaining bolts.

(2) Connect the right front fender ground wire.

(3) Install the air box.

(4) Install the grid heater relay bracket.

(5) Install the right front wheelhouse splash shield.

(6) Install the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - INSTALLATION).

CHARGING

TABLE OF CONTENTS

CHARGING

DESCRIPTION

The charging system consists of:
- Generator
- Electronic Voltage Regulator (EVR) circuitry within the Powertrain Control Module (PCM). Electronic Control Module (ECM) for diesel engines.
- Ignition switch
- Battery (refer to 8, Battery for information)
- Battery temperature sensor
- Check Gauges Lamp (if equipped)
- Voltmeter (refer to 8, Instrument Panel and Gauges for information)
- Wiring harness and connections (refer to 8, Wiring Diagrams for information)

OPERATION

The charging system is turned on and off with the ignition switch. The system is on when the engine is running and the ASD relay is energized. When the ASD relay is on, voltage is supplied to the ASD relay sense circuit at the PCM (ECM Diesel). This voltage is connected through the PCM (ECM Diesel) and supplied to one of the generator field terminals (Gen. Source +) at the back of the generator.

The amount of direct current produced by the generator is controlled by the EVR (field control) circuitry contained within the PCM (ECM Diesel). This circuitry is connected in series with the second rotor field terminal and ground.

A battery temperature sensor, located in the battery tray housing, is used to sense battery temperature. This temperature data, along with data from monitored line voltage, is used by the PCM (ECM Diesel) to vary the battery charging rate. This is done by cycling the ground path to control the strength of the rotor magnetic field. The PCM then compensates and regulates generator current output accordingly.

All vehicles are equipped with On-Board Diagnostics (OBD). All OBD-sensed systems, including EVR (field control) circuitry, are monitored by the PCM (ECM Diesel). Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for certain failures it detects.

The Check Gauges Lamp (if equipped) monitors: **charging system voltage,** engine coolant temperature and engine oil pressure. If an extreme condition is indicated, the lamp will be illuminated. This is done as reminder to check the three gauges. The signal to activate the lamp is sent via the CCD bus circuits. The lamp is located on the instrument panel. Refer to 8, Instrument Panel and Gauges for additional information.

DIAGNOSIS AND TESTING - CHARGING SYSTEM

The following procedures may be used to diagnose the charging system if:
- the check gauges lamp (if equipped) is illuminated with the engine running
- the voltmeter (if equipped) does not register properly
- an undercharged or overcharged battery condition occurs.

Remember that an undercharged battery is often caused by:
- accessories being left on with the engine not running

CHARGING (Continued)

• a faulty or improperly adjusted switch that allows a lamp to stay on. Refer to Ignition-Off Draw Test in 8, Battery for more information.

INSPECTION

The PCM (Powertrain Control Module), or ECM (Diesel) monitors critical input and output circuits of the charging system, making sure they are operational. A Diagnostic Trouble Code (DTC) is assigned to each input and output circuit monitored by the On-Board Diagnostic (OBD) system. Some charging system circuits are checked continuously, and some are checked only under certain conditions.

Refer to Diagnostic Trouble Codes in; Powertrain Control Module; Electronic Control Modules for more DTC information. This will include a complete list of DTC's including DTC's for the charging system.

To perform a complete test of the charging system, refer to the appropriate Powertrain Diagnostic Procedures service manual and the DRB® scan tool. Perform the following inspections before attaching the scan tool.

(1) Inspect the battery condition. Refer to 8, Battery for procedures.

(2) Inspect condition of battery cable terminals, battery posts, connections at engine block, starter solenoid and relay. They should be clean and tight. Repair as required.

(3) Inspect all fuses in both the fuseblock and Power Distribution Center (PDC) for tightness in receptacles. They should be properly installed and tight. Repair or replace as required.

(4) Inspect generator mounting bolts for tightness. Replace or tighten bolts if required. Refer to the Generator Removal/Installation section of this group for torque specifications.

(5) Inspect generator drive belt condition and tension. Tighten or replace belt as required. Refer to Belt Tension Specifications in 7, Cooling System.

(6) Inspect automatic belt tensioner (if equipped). Refer to 7, Cooling System for information.

(7) Inspect generator electrical connections at generator field, battery output, and ground terminal (if equipped). Also check generator ground wire connection at engine (if equipped). They should all be clean and tight. Repair as required.

SPECIFICATIONS

GENERATOR RATINGS

TYPE	PART NUMBER	RATED SAE AMPS	ENGINES
DENSO	56029700AA	136	3.7L / 4.7L
DENSO	56029701AA	136	5.9L Gas
BOSCH	56041120AC	136	3.7L / 4.7L
BOSCH	56028238AB	136	5.9L Gas
DENSO	56028560AA	136	8.0L
DENSO	56028696AA	136	5.7L Gas/5.9L Diesel
BOSCH	56028699AA	136	5.7L Gas/5.9L Diesel

SPECIFICATIONS - TORQUE - GENERATOR / CHARGING SYSTEM

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Generator Mounting Bolts - 5.7L	41	30	-
Generator Support Bracket Bolt/Nuts - 5.7L	41	30	-
Generator Mounting Bolts - 8.0L	41	30	-
Generator Upper Mounting Bolt - 5.9L Diesel Engine	41	30	-
Generator Upper Mounting Bolt - 5.9L Gas Engine	41	30	-

CHARGING (Continued)

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Generator Lower Pivot Bolt / Nut - 5.9L Gas Engine	41	30	-
Generator Vertical Mounting Bolt - 3.7L / 4.7L Engines	55	40	-
Generator (long) Horizontal Mounting Bolt - 3.7L / 4.7L Engines	55	40	-
Generator (short) Horizontal Mounting Bolt - 3.7L / 4.7L Engines	74	55	-
Generator B+ Output Cable Terminal Nut	12	-	108

BATTERY TEMPERATURE SENSOR

DESCRIPTION

The Battery Temperature Sensor (BTS) is attached to the battery tray located under the battery.

OPERATION

The BTS is used to determine the battery temperature and control battery charging rate. This temperature data, along with data from monitored line voltage, is used by the PCM (ECM Diesel) to vary the battery charging rate. System voltage will be higher at colder temperatures and is gradually reduced at warmer temperatures.

The PCM sends 5 volts to the sensor and is grounded through the sensor return line. As temperature increases, resistance in the sensor decreases and the detection voltage at the PCM increases.

The BTS is also used for OBD II diagnostics. Certain faults and OBD II monitors are either enabled or disabled, depending upon BTS input (for example, disable purge and enable Leak Detection Pump (LDP) and O2 sensor heater tests). Most OBD II monitors are disabled below 20°F.

REMOVAL

The battery temperature sensor is located under the vehicle battery and is attached (snapped into) a mounting hole on battery tray (Fig. 1).

(1) Remove battery. Refer to 8, Battery for procedures.

(2) Pry sensor straight up from battery tray mounting hole to gain access to electrical connector (Fig. 1).

(3) Disconnect sensor from engine wire harness electrical connector.

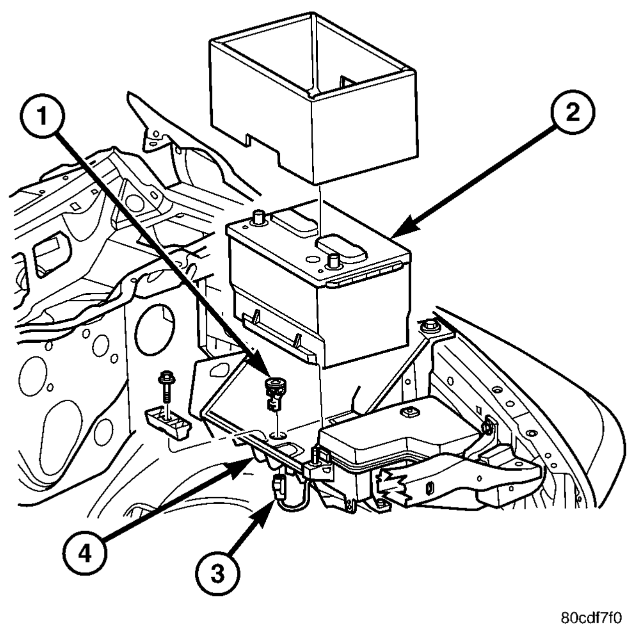

Fig. 1 BATTERY TEMPERATURE SENSOR LOCATION

1 - BATTERY TEMP. SENSOR
2 - BATTERY
3 - SENSOR ELEC. CONNECT.
4 - BATTERY TRAY

INSTALLATION

The battery temperature sensor is located under the vehicle battery and is attached (snapped into) a mounting hole on battery tray.

(1) Pull electrical connector up through mounting hole in top of battery tray.

(2) Connect sensor.

(3) Snap sensor into battery tray.

(4) Install battery. Refer to 8, Battery for procedures.

GENERATOR

DESCRIPTION

The generator is belt-driven by the engine using a serpentine type drive belt. It is serviced only as a complete assembly. If the generator fails for any reason, the entire assembly must be replaced.

OPERATION

As the energized rotor begins to rotate within the generator, the spinning magnetic field induces a current into the windings of the stator coil. Once the generator begins producing sufficient current, it also provides the current needed to energize the rotor.

The stator winding connections deliver the induced alternating current to 3 positive and 3 negative diodes for rectification. From the diodes, rectified direct current is delivered to the vehicle electrical system through the generator battery terminal.

Although the generators appear the same externally, different generators with different output ratings are used on this vehicle. Be certain that the replacement generator has the same output rating and part number as the original unit. Refer to Generator Ratings in the Specifications section at the back of this group for amperage ratings and part numbers.

Noise emitting from the generator may be caused by: worn, loose or defective bearings; a loose or defective drive pulley; incorrect, worn, damaged or misadjusted fan drive belt; loose mounting bolts; a misaligned drive pulley or a defective stator or diode.

REMOVAL

3.7L / 4.7L

WARNING: DISCONNECT NEGATIVE CABLE FROM BATTERY BEFORE REMOVING BATTERY OUTPUT WIRE (B+ WIRE) FROM GENERATOR. FAILURE TO DO SO CAN RESULT IN INJURY OR DAMAGE TO ELECTRICAL SYSTEM.

(1) Disconnect negative battery cable at battery.

(2) Remove generator drive belt. Refer to 7, Cooling System for procedure.

(3) Unsnap plastic insulator cap from B+ output terminal (Fig. 2).

(4) Remove B+ terminal mounting nut at rear of generator (Fig. 2). Disconnect terminal from generator.

(5) Disconnect field wire connector at rear of generator (Fig. 2) by pushing on connector tab.

(6) Remove 1 rear vertical generator mounting bolt (Fig. 3).

(7) Remove 2 front horizontal generator mounting bolts (Fig. 3).

(8) Remove generator from vehicle.

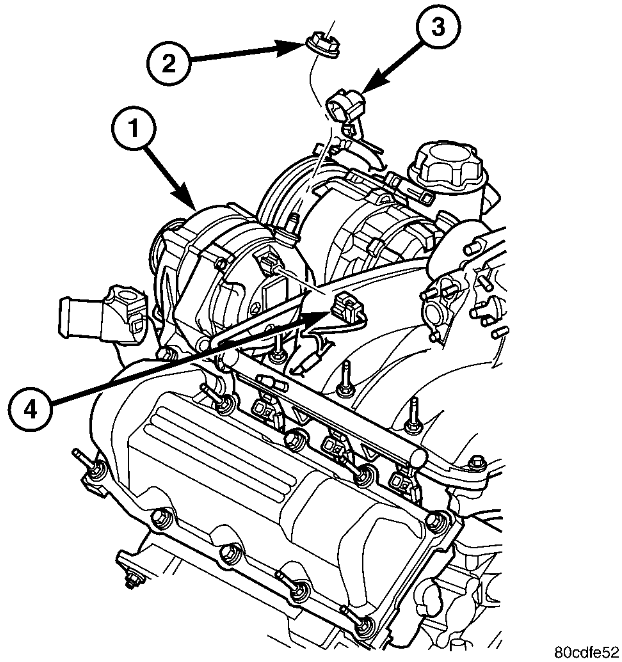

Fig. 2 GENERATOR CONNECTORS - 3.7L / 4.7L

1 - GENERATOR
2 - B+ NUT
3 - PLASTIC INSULATOR CAP
4 - FIELD WIRE CONNECTOR

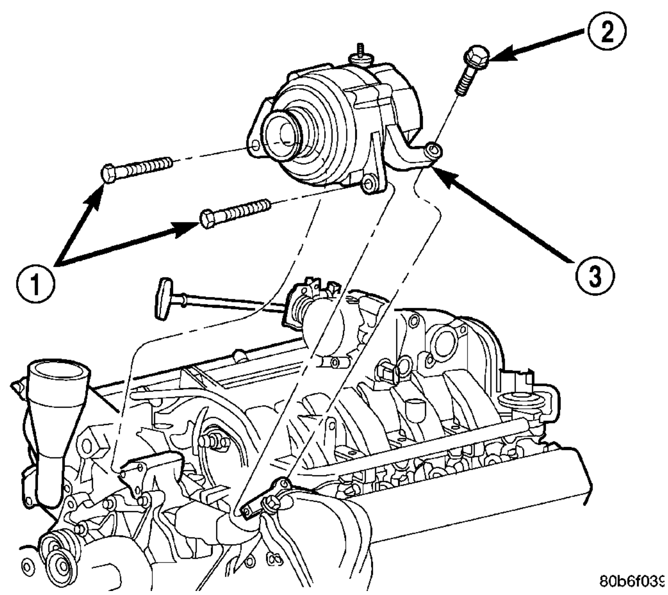

Fig. 3 REMOVE / INSTALL GENERATOR - 3.7L / 4.7L

1 - LOWER BOLTS
2 - REAR BOLT
3 - GENERATOR

GENERATOR (Continued)

5.7L

WARNING: DISCONNECT NEGATIVE CABLE FROM BATTERY BEFORE REMOVING BATTERY OUTPUT WIRE (B+ WIRE) FROM GENERATOR. FAILURE TO DO SO CAN RESULT IN INJURY OR DAMAGE TO ELECTRICAL SYSTEM.

(1) Disconnect negative battery cable at battery.
(2) Remove generator drive belt. Refer to 7, Cooling System for procedure.
(3) Unsnap plastic insulator cap from B+ output terminal.
(4) Remove B+ terminal mounting nut at rear of generator. Disconnect terminal from generator.
(5) Disconnect field wire connector at rear of generator by pushing on connector tab.
(6) Remove generator support bracket nuts and bolt (Fig. 4) and remove support bracket.
(7) Remove 2 generator mounting bolts (Fig. 5).
(8) Remove generator from vehicle.

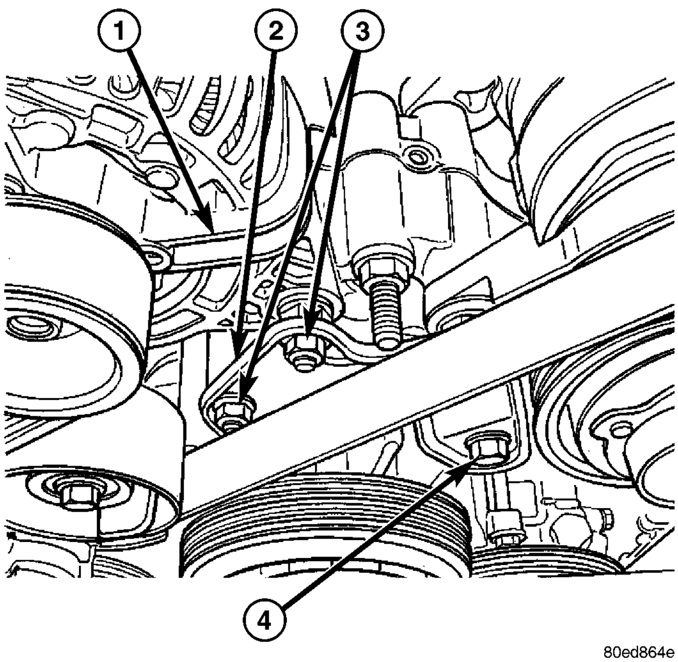

Fig. 4 GENERATOR SUPPORT BRACKET- 5.7L

1 - GENERATOR
2 - SUPPORT BRACKET
3 - BRACKET NUTS
4 - BRACKET BOLT

5.9L Diesel

WARNING: DISCONNECT BOTH NEGATIVE CABLES FROM BOTH BATTERIES BEFORE REMOVING BATTERY OUTPUT WIRE (B+ WIRE) FROM GENERATOR. FAILURE TO DO SO CAN RESULT IN INJURY OR DAMAGE TO ELECTRICAL SYSTEM.

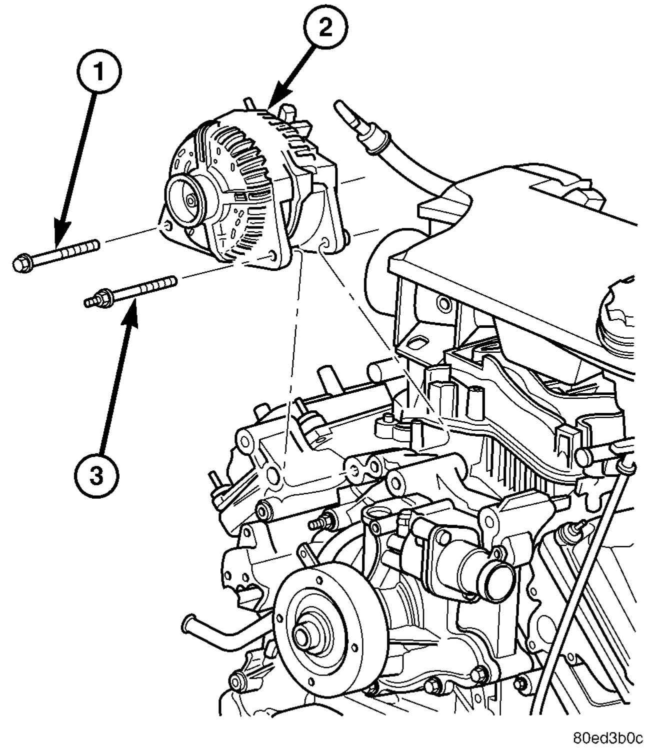

Fig. 5 REMOVE / INSTALL GENERATOR - 5.7L

1 - MOUNTING BOLT
2 - GENERATOR
3 - MOUNTING STUD / BOLT

(1) Disconnect both negative battery cables at both batteries.
(2) Remove generator drive belt. Refer to 7, Cooling System for procedure.
(3) Unsnap plastic insulator cap from B+ output terminal.
(4) Remove B+ terminal mounting nut at rear of generator (Fig. 7). Disconnect terminal from generator.
(5) Disconnect field wire connector at rear of generator by pushing on connector tab.
(6) Remove upper mounting bracket bolt (Fig. 6).
(7) Remove lower mounting bracket bolt and nut (Fig. 6).
(8) Remove generator from vehicle.

5.9L Gas

WARNING: DISCONNECT NEGATIVE CABLE FROM BATTERY BEFORE REMOVING BATTERY OUTPUT WIRE (B+ WIRE) FROM GENERATOR. FAILURE TO DO SO CAN RESULT IN INJURY OR DAMAGE TO ELECTRICAL SYSTEM.

(1) Disconnect negative battery cable at battery.
(2) Remove generator drive belt. Refer to 7, Cooling System for procedure.

GENERATOR (Continued)

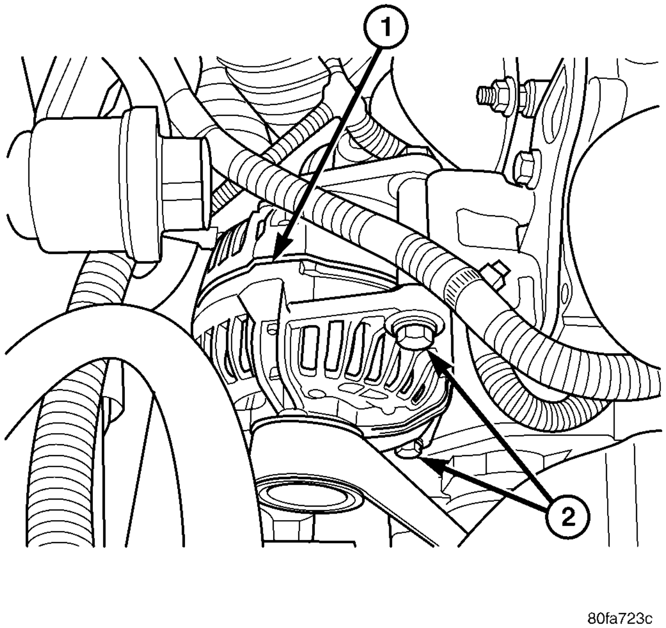

Fig. 6 5.9L DIESEL GENERATOR

1 - GENERATOR
2 - MOUNTING BOLTS

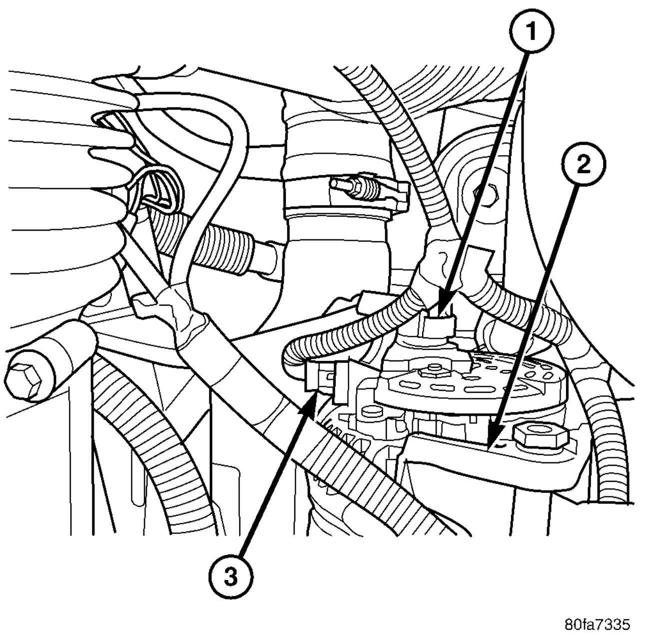

Fig. 7 5.9L DIESEL GENER. CONNECTORS

1 - B+ CONNECTOR
2 - GENERATOR
3 - FIELD WIRE CONNECTOR

(3) Unsnap plastic insulator cap from B+ output terminal (Fig. 8).

(4) Remove B+ terminal mounting nut at rear of generator (Fig. 8). Disconnect terminal from generator.

(5) Disconnect field wire connector at rear of generator (Fig. 8) by pushing on connector tab.

(6) Remove 1 upper generator mounting bolt (Fig. 9).

(7) Remove 1 lower generator mounting bolt / nut (Fig. 9).

(8) Remove generator from vehicle.

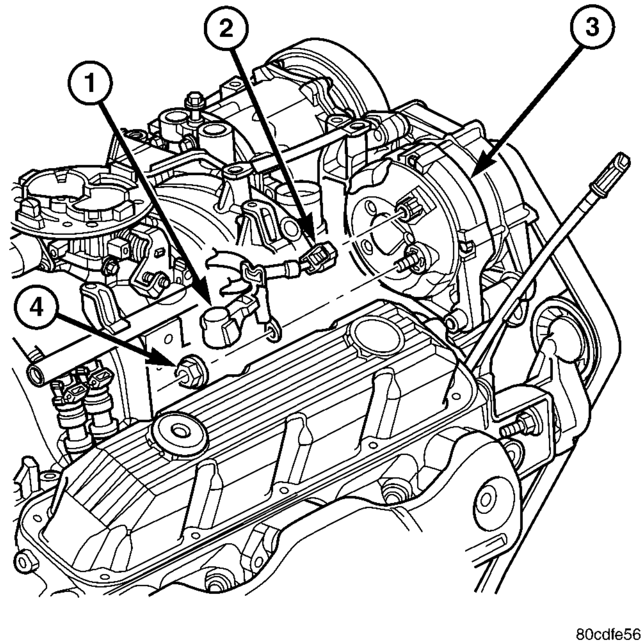

Fig. 8 GENERATOR CONNECTORS - 5.9L GAS

1 - PLASTIC INSULATOR CAP
2 - FIELD WIRE CONNECTOR
3 - GENERATOR
4 - B+ NUT

8.0L

WARNING: DISCONNECT NEGATIVE CABLE FROM BATTERY BEFORE REMOVING BATTERY OUTPUT WIRE (B+ WIRE) FROM GENERATOR. FAILURE TO DO SO CAN RESULT IN INJURY OR DAMAGE TO ELECTRICAL SYSTEM.

(1) Disconnect negative battery cable at battery.

(2) Remove generator drive belt. Refer to 7, Cooling System for procedure.

(3) Unsnap plastic insulator cap from B+ output terminal.

(4) Remove B+ terminal mounting nut at rear of generator. Disconnect terminal from generator.

(5) Disconnect field wire connector at rear of generator by pushing on connector tab.

(6) Remove upper mounting bolt and nut (Fig. 10).

(7) Remove lower mounting bolt (Fig. 10).

GENERATOR (Continued)

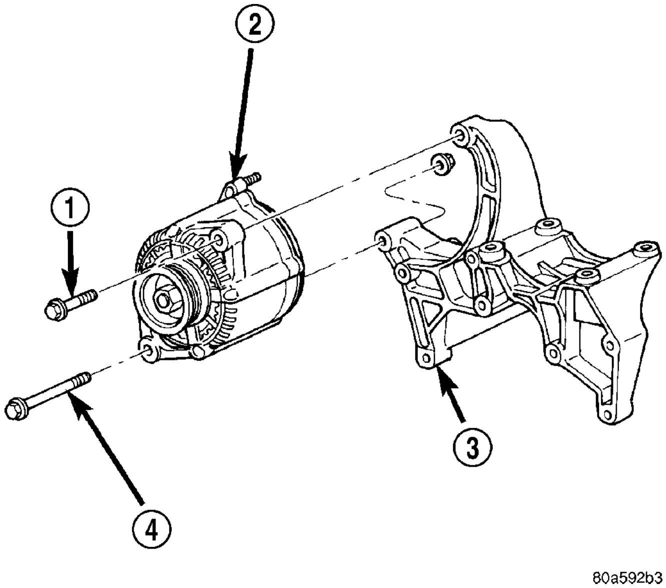

Fig. 9 REMOVE / INSTALL GENERATOR - 5.9L GAS

1 - MOUNTING BOLT
2 - GENERATOR
3 - MOUNTING BRACKET
4 - MOUNTING BOLT/NUT

(8) Remove generator from vehicle.

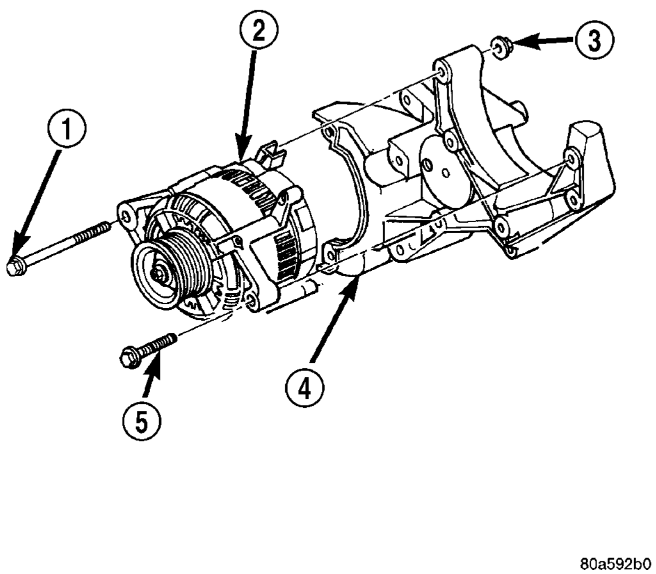

Fig. 10 REMOVE / INSTALL GENERATOR – 8.0L ENGINE

1 - MOUNTING BOLT
2 - GENERATOR
3 - NUT
4 - MOUNTING BRACKET
5 - MOUNTING BOLT

INSTALLATION

3.7L / 4.7L

(1) Position generator to engine and install 2 horizontal bolts and 1 vertical bolt.

(2) Tighten all 3 bolts. Refer to Torque Specifications.

(3) Snap field wire connector into rear of generator.

(4) Install B+ terminal eyelet to generator output stud. Tighten mounting nut. Refer to Torque Specifications.

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

(5) Install generator drive belt. Refer to 7, Cooling System for procedure.

(6) Install negative battery cable to battery.

5.7L

(1) Position generator to engine and install 2 mounting bolts.

(2) Tighten bolts. Refer to Torque Specifications.

(3) Position support bracket to front of generator and install bolt and nuts. Tighten bolt / nuts. Refer to Torque Specifications.

(4) Snap field wire connector into rear of generator.

(5) Install B+ terminal eyelet to generator output stud. Tighten mounting nut. Refer to Torque Specifications.

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

(6) Install generator drive belt. Refer to 7, Cooling System for procedure.

GENERATOR (Continued)

(7) Install negative battery cable to battery.

5.9L Diesel

(1) Position generator to upper and lower mounting brackets and install upper bolt and lower bolt / nut.

(2) Tighten all bolts / nut. Refer to Torque Specifications.

(3) Snap field wire connector into rear of generator.

(4) Install B+ terminal eyelet to generator output stud. Tighten mounting nut. Refer to Torque Specifications.

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

(5) Install generator drive belt. Refer to 7, Cooling System for procedure.

(6) Install both negative battery cables to both batteries.

8.0L

(1) Position generator to engine and install lower bolt and upper bolt / nut.

(2) Tighten all bolts / nut. Refer to Torque Specifications.

(3) Snap field wire connector into rear of generator.

(4) Install B+ terminal eyelet to generator output stud. Tighten mounting nut. Refer to Torque Specifications.

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

(5) Install generator drive belt. Refer to 7, Cooling System for procedure.

(6) Install negative battery cable to battery.

5.9L Gas

(1) Position generator to engine and install upper bolt and lower bolt / nut.

(2) Tighten all bolts / nut. Refer to Torque Specifications.

(3) Snap field wire connector into rear of generator.

(4) Install B+ terminal eyelet to generator output stud. Tighten mounting nut. Refer to Torque Specifications.

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

(5) Install generator drive belt. Refer to 7, Cooling System for procedure.

(6) Install negative battery cable to battery.

VOLTAGE REGULATOR

DESCRIPTION

The Electronic Voltage Regulator (EVR) is not a separate component. It is actually a voltage regulating circuit located within the PCM (Powertrain Control Module) (within the ECM for diesel engines). The EVR is not serviced separately. If replacement is necessary, the PCM must be replaced.

OPERATION

The amount of direct current produced by the generator is controlled by EVR circuitry contained within the PCM. This circuitry is connected in series with the generators second rotor field terminal and its ground.

Voltage is regulated by cycling the ground path to control the strength of the rotor magnetic field. The EVR circuitry monitors system line voltage (B+) and battery temperature (refer to Battery Temperature Sensor for more information). It then determines a target charging voltage. If sensed battery voltage is 0.5 volts or lower than the target voltage, the PCM grounds the field winding until sensed battery voltage is 0.5 volts above target voltage. A circuit in the PCM cycles the ground side of the generator field up to 100 times per second (100Hz), but has the capability to ground the field control wire 100% of the time (full field) to achieve the target voltage. If the charging rate cannot be monitored (limp-in), a duty cycle of 25% is used by the PCM in order to have some generator output. Also refer to Charging System Operation for additional information.

STARTING

TABLE OF CONTENTS

STARTING

DESCRIPTION

The starting system consists of:

- Starter relay
- Starter motor (including an integral starter solenoid)

Other components to be considered as part of starting system are:

- Battery
- Battery cables
- Ignition switch and key lock cylinder
- Clutch pedal position switch (manual transmission)
- Park/neutral position switch (automatic transmission)
- Wire harnesses and connections.

The Battery, Starting, and Charging systems operate in conjunction with one another, and must be tested as a complete system. For correct operation of starting/charging systems, all components used in these 3 systems must perform within specifications. When attempting to diagnose any of these systems, it is important that you keep their interdependency in mind.

The diagnostic procedures used in each of these groups include the most basic conventional diagnostic methods, to the more sophisticated On-Board Diagnostics (OBD) built into the Powertrain Control Module (PCM). Use of an induction-type milliampere ammeter, volt/ohmmeter, battery charger, carbon pile rheostat (load tester), and 12-volt test lamp may be required.

Certain starting system components are monitored by the PCM and may produce a Diagnostic Trouble Code (DTC). Refer to Diagnostic Trouble Codes in Emission Control for a list of codes.

OPERATION

The starting system components form two separate circuits. A high-amperage feed circuit that feeds the starter motor between 150 and 350 amperes (700 amperes - diesel engine), and a low-amperage control circuit that operates on less than 20 amperes. The high-amperage feed circuit components include the battery, the battery cables, the contact disc portion of the starter solenoid, and the starter motor. The low-amperage control circuit components include the ignition switch, the clutch pedal position switch (manual transmission), the park/neutral position switch (automatic transmission), the starter relay, the electromagnetic windings of the starter solenoid, and the connecting wire harness components.

If the vehicle is equipped with a manual transmission, it has a clutch pedal position switch installed in series between the ignition switch and the coil battery terminal of the starter relay. This normally open switch prevents the starter relay from being energized when the ignition switch is turned to the Start position, unless the clutch pedal is depressed. This feature prevents starter motor operation while the clutch disc and the flywheel are engaged. The starter relay coil ground terminal is always grounded on vehicles with a manual transmission.

If the vehicle is equipped with an automatic transmission, battery voltage is supplied through the low-amperage control circuit to the coil battery terminal of the starter relay when the ignition switch is turned to the Start position. The park/neutral position switch is installed in series between the starter relay coil ground terminal and ground. This normally

STARTING (Continued)

open switch prevents the starter relay from being energized and the starter motor from operating unless the automatic transmission gear selector is in the Neutral or Park positions.

When the starter relay coil is energized, the normally open relay contacts close. The relay contacts connect the relay common feed terminal to the relay normally open terminal. The closed relay contacts energize the starter solenoid coil windings.

The energized solenoid pull-in coil pulls in the solenoid plunger. The solenoid plunger pulls the shift lever in the starter motor. This engages the starter overrunning clutch and pinion gear with the starter ring gear.

As the solenoid plunger reaches the end of its travel, the solenoid contact disc completes the high-amperage starter feed circuit and energizes the solenoid plunger hold-in coil. Current now flows between the solenoid battery terminal and the starter motor, energizing the starter.

Once the engine starts, the overrunning clutch protects the starter motor from damage by allowing the starter pinion gear to spin faster than the pinion shaft. When the ignition switch is released to the On position, the starter relay coil is de-energized. This causes the relay contacts to open. When the relay contacts open, the starter solenoid plunger hold-in coil is de-energized.

When the solenoid plunger hold-in coil is de-energized, the solenoid plunger return spring returns the plunger to its relaxed position. This causes the contact disc to open the starter feed circuit, and the shift lever to disengage the overrunning clutch and pinion gear from the starter ring gear.

DIAGNOSIS AND TESTING - STARTING SYSTEM

The battery, starting, and charging systems operate in conjunction with one another, and must be tested as a complete system. For correct starting/charging system operation, all of the components involved in these 3 systems must perform within specifications.

Starting System Diagnosis

CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER FAILS TO OPERATE.	1. Battery discharged or faulty.	1. Refer to Battery. Charge or replace battery, if required.
	2. Starting circuit wiring faulty.	2. Refer to 8, Wiring Diagrams. Test and repair starter feed and/or control circuits, if required.
	3. Starter relay faulty.	3. Refer to Starter Relay in Diagnosis and Testing. Replace starter relay if required.
	4. Ignition switch faulty.	4. Refer to Ignition Switch and Key Lock Cylinder. Replace ignition switch if required.
	5. Clutch pedal position switch faulty.	5. Refer to Clutch Pedal Position Switch.
	6. Park/Neutral position switch faulty or misadjusted.	6. Refer to Park/Neutral Position Switch. Replace park/neutral position switch if required.
	7. Starter solenoid faulty.	7. Refer to Starter Motor. Replace starter motor assembly if required.
	8. Starter motor faulty.	8. If all other starting system components and circuits test OK, replace starter motor.
STARTER ENGAGES, FAILS TO TURN ENGINE.	1. Battery discharged or faulty.	1. Refer to Battery. Charge or replace battery if required.
	2. Starting circuit wiring faulty.	2. Refer to 8, Wiring Diagrams. Test and repair starter feed and/or control circuits if required.
	3. Starter motor faulty.	3. If all other starting system components and circuits test OK, replace starter motor assembly.
	4. Engine seized.	4. Refer to Engine Diagnosis in the Diagnosis and Testing section of 9, Engine.

STARTING (Continued)

Starting System Diagnosis		
CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER ENGAGES, SPINS OUT BEFORE ENGINE STARTS.	1. Starter ring gear faulty.	1. Refer to Starter Motor Removal and Installation. Remove starter motor to inspect starter ring gear. Replace starter ring gear if required.
	2. Starter motor faulty.	2. If all other starting system components and circuits test OK, replace starter motor assembly.
STARTER DOES NOT DISENGAGE.	1. Starter motor improperly installed.	1. Refer to Starter Motor Removal and Installation. Tighten starter mounting hardware to correct torque specifications.
	2. Starter relay faulty.	2. Refer to Starter Relay Diagnosis and Testing. Replace starter relay if required.
	3. Ignition switch faulty.	3. Refer to Ignition Switch and Key Lock Cylinder. Replace ignition switch if required.
	4. Starter motor faulty.	4. If all other starting system components and circuits test OK, replace starter motor.

INSPECTION

For complete starter wiring circuit diagrams, refer to 8, Wiring Diagrams. Before removing any unit from starting system for repair or diagnosis, perform the following inspections:

WARNING: ON VEHICLES EQUIPPED WITH AIRBAGS, REFER TO 8, PASSIVE RESTRAINT SYSTEMS, BEFORE ATTEMPTING ANY STEERING WHEEL, STEERING COLUMN, OR INSTRUMENT PANEL COMPONENT DIAGNOSIS OR SERVICE. FAILURE TO TAKE THE PROPER PRECAUTIONS COULD RESULT IN ACCIDENTAL AIRBAG DEPLOYMENT AND POSSIBLE PERSONAL INJURY.

- **Battery** - Visually inspect battery for indications of physical damage and loose or corroded cable connections. Determine state-of-charge and cranking capacity of battery. Charge or replace battery if required. Refer to **Battery** in 8, Battery. **Note: If equipped with diesel engine, a dual battery system may be used, and both batteries must be inspected.**
- **Ignition Switch** - Visually inspect ignition switch for indications of physical damage and loose or corroded wire harness connections. Refer to **Ignition Switch and Key Lock Cylinder.**
- **Clutch Pedal Position Switch** - If equipped with manual transmission, visually inspect clutch pedal position switch for indications of physical damage and loose or corroded wire harness connections. Refer to **Clutch Pedal Position Switch** in 6, Clutch.
- **Park/Neutral Position Switch** - If equipped with automatic transmission, visually inspect park/neutral position switch for indications of physical damage and loose or corroded wire harness connections. Refer to **Park/Neutral Position Switch** in 21, Transmission.
- **Starter Relay** - Visually inspect starter relay for indications of physical damage and loose or corroded wire harness connections.
- **Starter Motor** - Visually inspect starter motor for indications of physical damage and loose or corroded wire harness connections.
- **Starter Solenoid** - Visually inspect starter solenoid for indications of physical damage and loose or corroded wire harness connections.
- **Wiring** - Visually inspect wire harnesses for damage. Repair or replace any faulty wiring, as required. Refer to 8, Wiring Diagrams.

TESTING

COLD CRANKING TEST

For complete starter wiring circuit diagrams, refer to 8, Wiring Diagrams. The battery must be fully-charged and load-tested before proceeding. Refer to **Battery** in 8, Battery.

(1) Connect volt-ampere tester to battery terminals (Fig. 1). See instructions provided by manufacturer of volt-ampere tester being used. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, tester should be connected to battery on left side of vehicle only. Also, tester current reading must be taken from positive battery cable lead that connects to starter motor.**

(2) Fully engage parking brake.

(3) If equipped with manual transmission, place gearshift selector lever in Neutral position and block clutch pedal in fully depressed position. If equipped

STARTING (Continued)

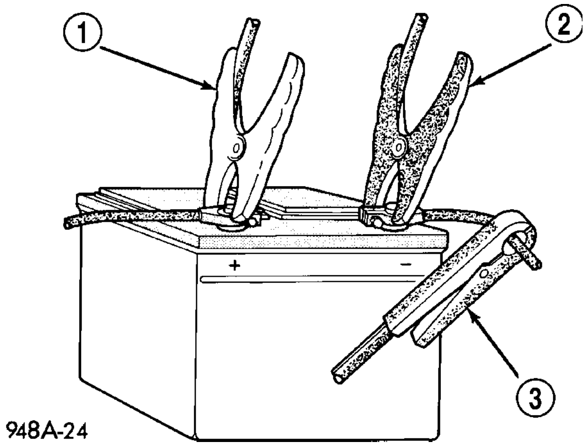

Fig. 1 VOLTS-AMPS TESTER CONNECTIONS - TYPICAL

1 - POSITIVE CLAMP
2 - NEGATIVE CLAMP
3 - INDUCTION AMMETER CLAMP

with automatic transmission, place gearshift selector lever in Park position.

(4) Verify that all lamps and accessories are turned off.

(5) To prevent a gasoline engine from starting, remove Automatic ShutDown (ASD) relay. To prevent a diesel engine from starting, remove Fuel Pump Relay. These relays are located in Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

WARNING: IF EQUIPPED WITH DIESEL ENGINE, ATTEMPT TO START ENGINE A FEW TIMES BEFORE PROCEEDING WITH FOLLOWING STEP.

(6) Rotate and hold ignition switch in Start position. Note cranking voltage and current (amperage) draw readings shown on volt-ampere tester.

(a) If voltage reads below 9.6 volts, refer to **Starter Motor** in Diagnosis and Testing. If starter motor is OK, refer to **Engine Diagnosis** in 9, Engine for further testing of engine. If starter motor is not OK, replace faulty starter motor.

(b) If voltage reads above 9.6 volts and current (amperage) draw reads below specifications, refer to **Feed Circuit Test** in this section.

(c) If voltage reads 12.5 volts or greater and starter motor does not turn, refer to **Control Circuit Testing** in this section.

(d) If voltage reads 12.5 volts or greater and starter motor turns very slowly, refer to **Feed Circuit Test** in this section.

NOTE: A cold engine will increase starter current (amperage) draw reading, and reduce battery voltage reading.

FEED CIRCUIT TEST

The starter feed circuit test (voltage drop method) will determine if there is excessive resistance in high-amperage feed circuit. For complete starter wiring circuit diagrams, refer 8, Wiring Diagrams.

When performing these tests, it is important to remember that voltage drop is giving an indication of resistance between two points at which voltmeter probes are attached.

Example: When testing resistance of positive battery cable, touch voltmeter leads to positive battery cable clamp and cable connector at starter solenoid. If you probe positive battery terminal post and cable connector at starter solenoid, you are reading combined voltage drop in positive battery cable clamp-to-terminal post connection and positive battery cable.

The following operation will require a voltmeter accurate to 1/10 (0.10) volt. Before performing tests, be certain that following procedures are accomplished:

- Battery is fully-charged and load-tested. Refer to **Battery** in 8, Battery.
- Fully engage parking brake.
- If equipped with manual transmission, place gearshift selector lever in Neutral position and block clutch pedal in fully depressed position. If equipped with automatic transmission, place gearshift selector lever in Park position.
- Verify that all lamps and accessories are turned off.
- To prevent a gasoline engine from starting, remove Automatic ShutDown (ASD) relay. To prevent a diesel engine from starting, remove Fuel Pump Relay. These relays are located in Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

(1) Connect positive lead of voltmeter to negative battery cable terminal post. Connect negative lead of voltmeter to negative battery cable clamp (Fig. 2). Rotate and hold ignition switch in Start position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and terminal post. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, procedure must be performed twice, once for each battery.**

(2) Connect positive lead of voltmeter to positive battery terminal post. Connect negative lead of voltmeter to battery positive cable clamp (Fig. 3). Rotate and hold ignition switch in Start position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and terminal post. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed twice, once for each battery.**

STARTING (Continued)

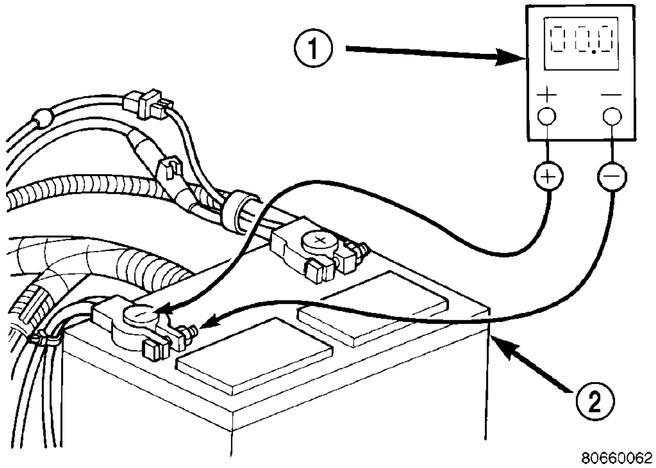

Fig. 2 TEST BATTERY NEGATIVE CONNECTION RESISTANCE - TYPICAL

1 - VOLTMETER
2 - BATTERY

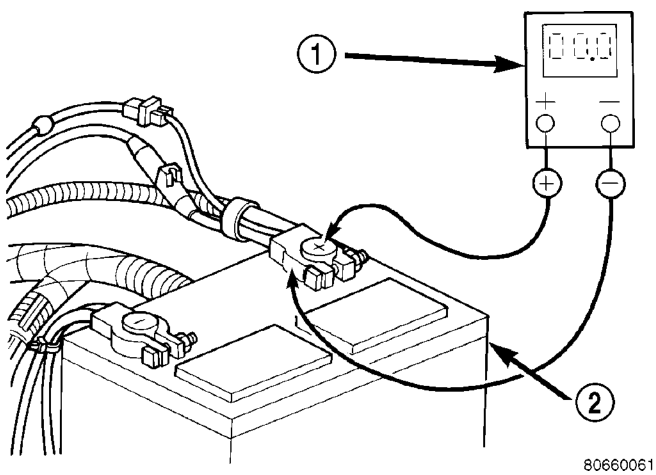

Fig. 3 TEST BATTERY POSITIVE CONNECTION RESISTANCE - TYPICAL

1 - VOLTMETER
2 - BATTERY

(3) Connect voltmeter to measure between battery positive terminal post and starter solenoid battery terminal stud (Fig. 4). Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten battery cable connection at solenoid. Repeat test. If reading is still above 0.2 volt, replace faulty positive battery cable. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed on driver side battery only.**

(4) Connect voltmeter to measure between negative battery terminal post and a good clean ground on engine block (Fig. 5). Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten negative battery cable attachment on engine block. Repeat test. If reading is still above 0.2 volt, replace faulty negative battery cable. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed twice, once for each battery.**

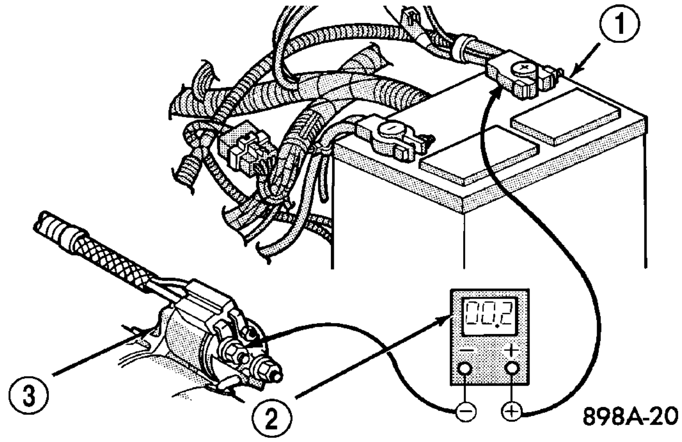

Fig. 4 TEST BATTERY POSITIVE CABLE RESISTANCE - TYPICAL

1 - BATTERY
2 - VOLTMETER
3 - STARTER MOTOR

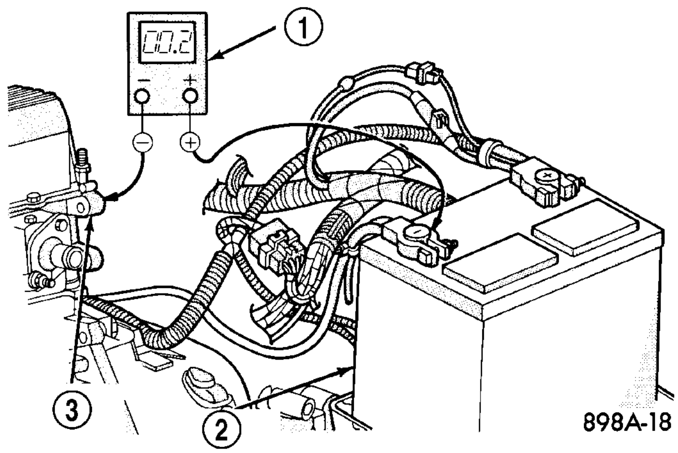

Fig. 5 TEST GROUND CIRCUIT RESISTANCE - TYPICAL

1 - VOLTMETER
2 - BATTERY
3 - ENGINE GROUND

(5) Connect positive lead of voltmeter to starter housing. Connect negative lead of voltmeter to negative battery terminal post (Fig. 6). Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, correct poor starter to engine block ground contact. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed on driver side battery only.**

STARTING (Continued)

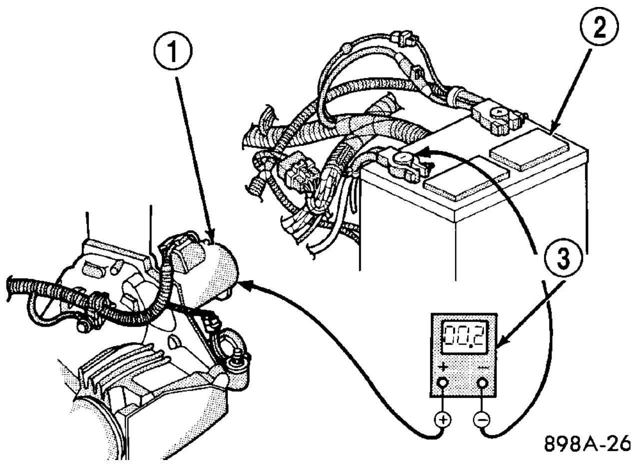

Fig. 6 TEST STARTER GROUND - TYPICAL

1 - STARTER MOTOR
2 - BATTERY
3 - VOLTMETER

(6) If equipped with dual battery system (certain diesel equipped models), connect positive lead of voltmeter to positive battery cable clamp on battery located on left side of vehicle. Connect negative lead of voltmeter to positive battery terminal post on battery located on right side of vehicle. Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten battery cables at both batteries. Repeat test. If reading is still above 0.2 volt, replace faulty positive battery cable.

If resistance tests detect no feed circuit problems, refer to **Starter Motor** in the Diagnosis and Testing.

CONTROL CIRCUIT TESTING

The starter control circuit components should be tested in the order in which they are listed, as follows:

- **Starter Relay** - Refer to **Starter Relay** Diagnosis and Testing.
- **Starter Solenoid** - Refer to **Starter Motor** Diagnosis and Testing.
- **Ignition Switch** - Refer to **Ignition Switch and Key Lock Cylinder**
- **Clutch Pedal Position Switch** - If equipped with manual transmission, refer to **Clutch Pedal Position Switch** in 6, Clutch.
- **Park/Neutral Position Switch** - If equipped with automatic transmission, refer to **Park/Neutral Position Switch** in 21, Transmission.
- **Wire harnesses and connections** - Refer to 8, Wiring Diagrams.

SPECIFICATIONS

STARTING SYSTEM

Starter Motor and Solenoid			
Manufacturer	Denso	Denso	Denso
Part Number	56028715AD	56027703AD	4741012
Engine Application	3.7L / 4.7L / 5.7L / 5.9L	8.0L	5.9L Diesel
Power Rating	1.4 Kilowatt / 1.9 Horsepower	1.4 Kilowatt / 1.9 Horsepower	2.7 Kilowatt / 3.6 Horsepower
Voltage	12 Volts	12 Volts	12 Volts
Number of Brushes	4	4	4
Drive Type	Gear Reduction	Gear Reduction	Conventional
Free Running Test Voltage	11 Volts	11 Volts	11 Volts
Free Running Test Amperage Draw	73 Amperes	73 Amperes	200 Amperes
Free Running Test Minimum Speed	3601 rpm	3601 rpm	3000
Solenoid Closing Maximum Voltage Required	7.5 Volts	7.5 Volts	8.0 Volts
* Cranking Amperage Draw Test	125 - 250 Amperes	125 - 250 Amperes	450 - 700 Amperes
* Test at operating temperature. Cold engine, tight (new) engine, or heavy oil will increase starter amperage draw.			

STARTING (Continued)

SPECIFICATIONS - TORQUE - STARTING SYSTEM

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Battery Cable Eyelet Nut at Solenoid (large nut - gas engines)	25	19	221
Battery Cable Eyelet Nut at Solenoid (large nut - diesel engine)	14	-	120
Starter Solenoid Nut (small nut - diesel engine)	6	-	55
Starter Mounting Bolts - Gas Engines	68	50	-
Starter Mounting Nut - Gas Engines	68	50	-
Starter Mounting Bolts - Diesel	43	32	-

STARTER MOTOR

DIAGNOSIS AND TESTING - STARTER MOTOR

Correct starter motor operation can be confirmed by performing the following free running bench test. This test can only be performed with starter motor removed from vehicle. Refer to Specifications for starter motor specifications.

(1) Remove starter motor from vehicle. Refer to Starter Motor Removal and Installation.

(2) Mount starter motor securely in a soft-jawed bench vise. The vise jaws should be clamped on the mounting flange of starter motor. Never clamp on starter motor by field frame.

(3) Connect a suitable volt-ampere tester and a 12-volt battery to starter motor in series, and set ammeter to 100 ampere scale. See instructions provided by manufacturer of volt-ampere tester being used.

(4) Install jumper wire from solenoid terminal to solenoid battery terminal. The starter motor should operate. If starter motor fails to operate, replace faulty starter motor assembly.

(5) Adjust carbon pile load of tester to obtain free running test voltage. Refer to Specifications for starter motor free running test voltage specifications.

(6) Note reading on ammeter and compare reading to free running test maximum amperage draw. Refer to Specifications for starter motor free running test maximum amperage draw specifications.

(7) If ammeter reading exceeds maximum amperage draw specification, replace faulty starter motor assembly.

STARTER SOLENOID

This test can only be performed with starter motor removed from vehicle.

(1) Remove starter motor from vehicle. Refer to Starter Motor Removal and Installation.

(2) Disconnect wire from solenoid field coil terminal.

(3) Check for continuity between solenoid terminal and solenoid field coil terminal with a continuity tester (Fig. 7). There should be continuity. If OK, go to Step 4. If not OK, replace faulty starter motor assembly.

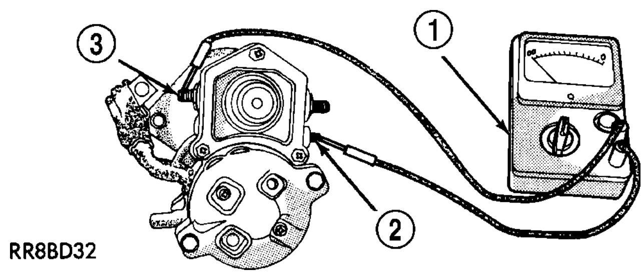

Fig. 7 CONTINUITY BETWEEN SOLENOID AND FIELD COIL TERMINALS - TYPICAL

1 - OHMMETER
2 - SOLENOID TERMINAL
3 - FIELD COIL TERMINAL

(4) Check for continuity between solenoid terminal and solenoid case (Fig. 8). There should be continuity. If not OK, replace faulty starter motor assembly.

REMOVAL

3.7L / 4.7L

(1) Disconnect and isolate negative battery cable.

(2) Raise and support vehicle.

(3) Note: If equipped with 4WD and certain transmissions, a support bracket is used between front axle and side of transmission. Remove 2 support bracket bolts at transmission. Pry support bracket slightly to gain access to lower starter mounting bolt.

STARTER MOTOR (Continued)

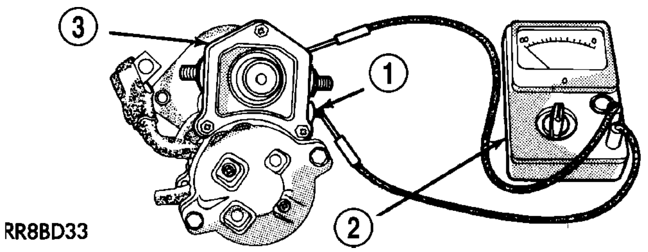

Fig. 8 CONTINUITY BETWEEN SOLENOID TERMINAL AND CASE - TYPICAL

1 - SOLENOID TERMINAL
2 - OHMMETER
3 - SOLENOID

(4) Remove 1 bolt and 1 nut if equipped with a manual transmission (Fig. 9).

(5) Remove 2 bolts if equipped with an automatic transmission (Fig. 10).

(6) Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process, do not let starter motor hang from wire harness.

(7) Tilt nose downwards and lower starter motor far enough to access and remove nut that secures battery positive cable wire harness connector eyelet to solenoid battery terminal stud. Do not let starter motor hang from wire harness.

(8) Remove battery positive cable wire harness connector eyelet from solenoid battery terminal stud.

(9) Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.

(10) Remove starter motor.

5.7L Gas

(1) Disconnect and isolate negative battery cable.

(2) Raise and support vehicle.

(3) Note: If equipped with 4WD and certain transmissions, a support bracket is used between front axle and side of transmission. Remove 2 support bracket bolts at transmission. Pry support bracket slightly to gain access to lower starter mounting bolt.

(4) Remove 2 mounting bolts (Fig. 11).

(5) Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process, do not let starter motor hang from wire harness.

(6) Tilt nose downwards and lower starter motor far enough to access and remove nut that secures battery positive cable wire harness connector eyelet to solenoid battery terminal stud. Do not let starter motor hang from wire harness.

(7) Remove battery positive cable wire harness connector eyelet from solenoid battery terminal stud.

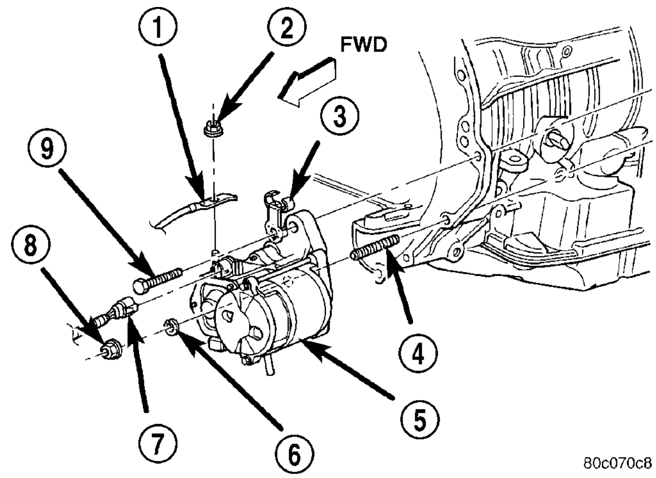

Fig. 9 STARTER R/I - 3.7L/4.7L - MAN. TRANS.

1 - EYELET TERMINAL
2 - NUT
3 - BRACKET
4 - STUD
5 - STARTER MOTOR
6 - LOCK WASHER
7 - WIRE HARNESS CONNECTOR
8 - NUT
9 - SCREW AND WASHER (2)

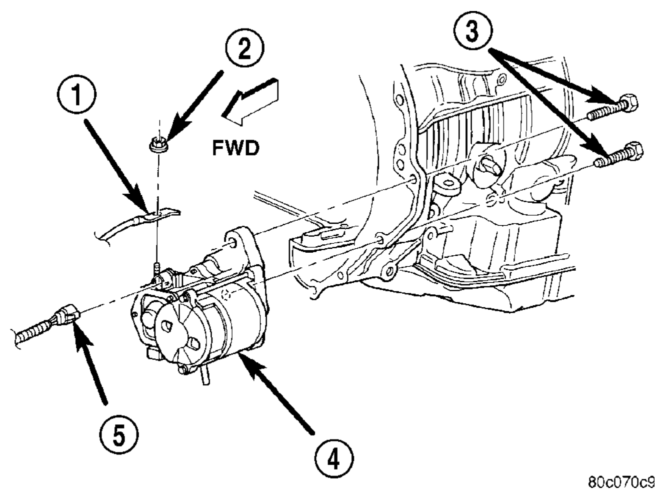

Fig. 10 STARTER R/I - 3.7L/4.7L - AUTO. TRANS.

1 - EYELET TERMINAL
2 - NUT
3 - SCREW AND WASHER (2)
4 - STARTER MOTOR
5 - WIRE HARNESS CONNECTOR

(8) Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.

(9) Remove starter motor.

5.9L Diesel

(1) Disconnect and isolate both negative battery cables at both batteries.

(2) Raise and support vehicle.

(3) Remove 3 starter mounting bolts (Fig. 12).

STARTER MOTOR (Continued)

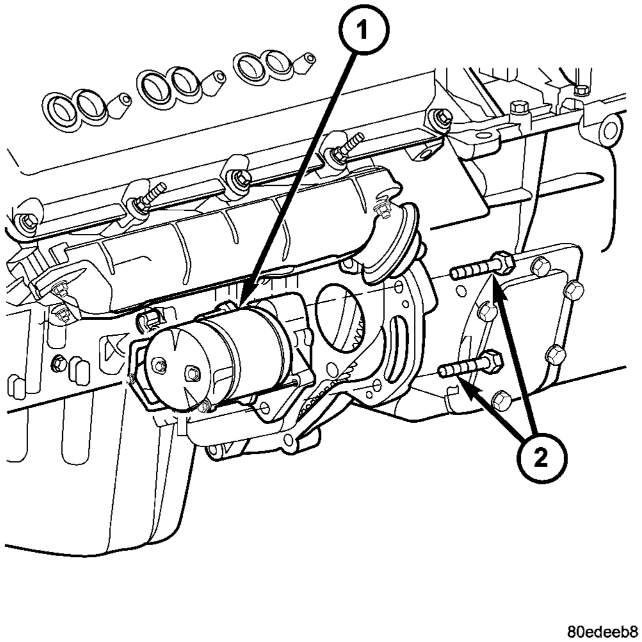

Fig. 11 STARTER R/I - 5.7L

1 - STARTER MOTOR
2 - MOUNTING BOLTS

(4) Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process. Do not let starter motor hang from wire harness.

(5) Tilt nose downwards and lower starter motor far enough to access and remove nuts securing starter wiring harness to starter (Fig. 13). Do not let starter motor hang from wire harness.

(6) Remove starter motor from engine. Note: Certain diesel engines use an aluminum spacer (Fig. 12). Note position and orientation of spacer before removal.

5.9L Gas

(1) Disconnect and isolate negative battery cable.

(2) Raise and support vehicle.

(3) Note: If equipped with 4WD and certain transmissions, a support bracket is used between front axle and side of transmission. Remove 2 support bracket bolts at transmission. Pry support bracket slightly to gain access to lower starter mounting bolt.

(4) Remove nut and lock washer securing starter motor to mounting stud (Fig. 14).

(5) While supporting starter motor, remove upper mounting bolt from starter motor.

(6) If equipped with automatic transmission, slide cooler tube bracket forward on tubes far enough for starter motor mounting flange to be removed from lower mounting stud.

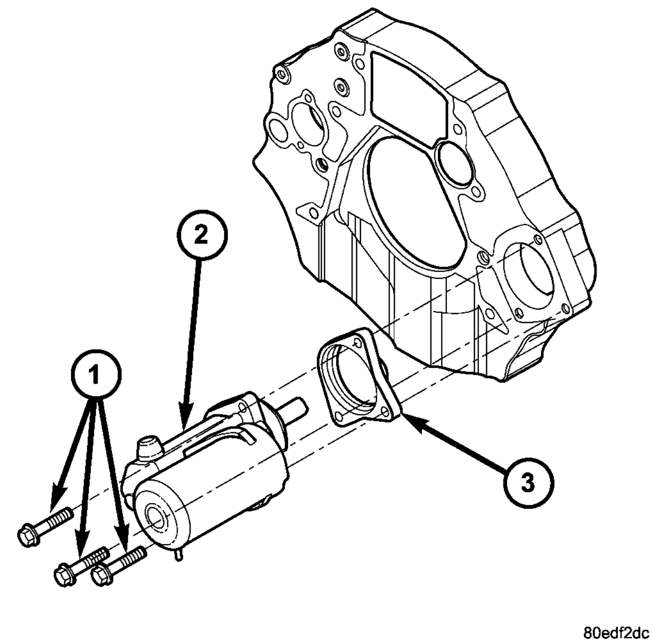

Fig. 12 STARTER R/I - 5.9L DIESEL

1 - MOUNTING BOLTS (3)
2 - STARTER MOTOR
3 - SPACER (CERTAIN TRANSMISSIONS)

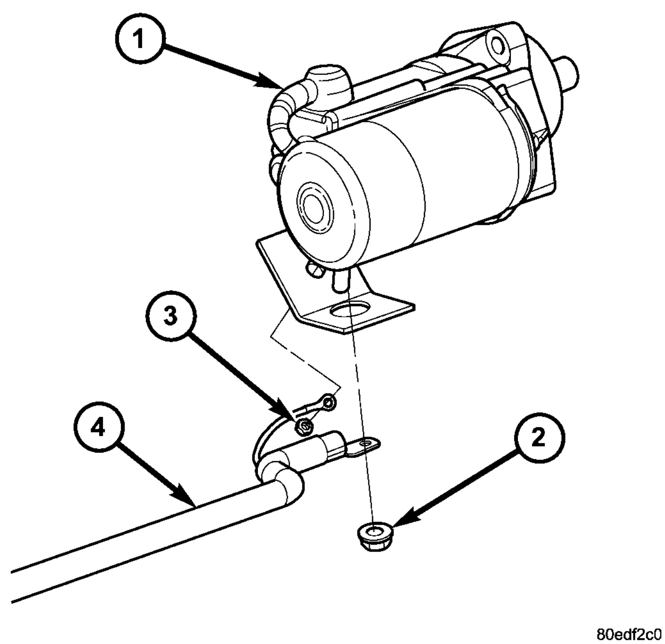

Fig. 13 STARTER ELECTRICAL CONNECTORS - 5.9L DIESEL

1 - STARTER MOTOR
2 - BATTERY CABLE NUT
3 - SOLENOID NUT
4 - HARNESS ASSEMBLY

(7) Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear

STARTER MOTOR (Continued)

housing. Always support starter motor during this process, do not let starter motor hang from wire harness.

(8) Tilt nose downwards and lower starter motor far enough to access and remove nut that secures battery positive cable wire harness connector eyelet to solenoid battery terminal stud. Do not let starter motor hang from wire harness.

(9) Remove battery positive cable wire harness connector eyelet from solenoid battery terminal stud.

(10) Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.

(11) Remove starter motor.

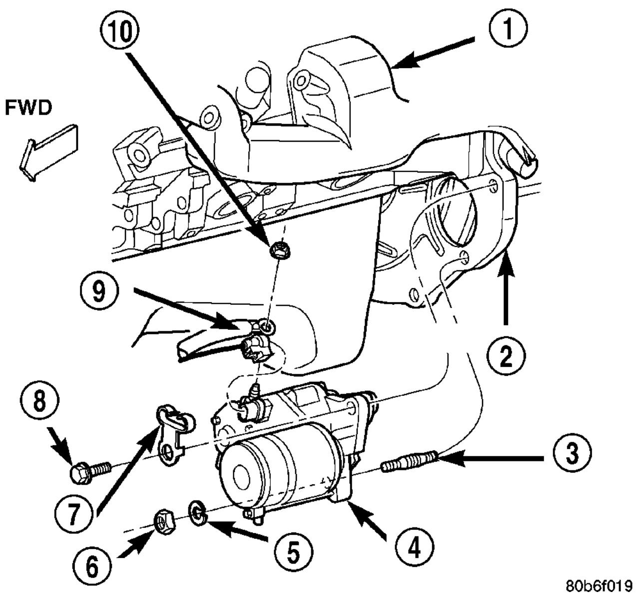

Fig. 14 STARTER R/I - 5.9L GAS

1 - ENGINE
2 - STARTER MOUNTING FLANGE
3 - STUD
4 - STARTER MOTOR
5 - LOCK WASHER
6 - NUT
7 - BRACKET
8 - BOLT
9 - POSITIVE BATTERY CABLE WIRE HARNESS
10 - POSITIVE BATTERY CABLE WIRE HARNESS NUT

INSTALLATION

3.7L / 4.7L

(1) Connect solenoid wire to starter motor (snaps on).

(2) Position battery cable to solenoid stud. Install and tighten battery cable eyelet nut. Refer to Torque Specifications. Do not allow starter motor to hang from wire harness.

(3) Position starter motor to transmission.

(4) If equipped with automatic transmission, slide cooler tube bracket into position.

(5) Install and tighten both bolts (auto. trans.), or 1 nut and 1 bolt (man. trans.). Refer to Torque Specifications.

(6) Lower vehicle.

(7) Connect negative battery cable.

5.7L

(1) Connect solenoid wire to starter motor (snaps on).

(2) Position battery cable to solenoid stud. Install and tighten battery cable eyelet nut. Refer to Torque Specifications. Do not allow starter motor to hang from wire harness.

(3) Position starter motor to engine.

(4) If equipped with automatic transmission, slide cooler tube bracket into position.

(5) Install and tighten both mounting bolts. Refer to Torque Specifications.

(6) Lower vehicle.

(7) Connect negative battery cable.

5.9L Diesel

(1) **If Equipped:** Position and hold aluminum spacer to rear of starter while positioning starter to engine.

(2) Connect solenoid wire to starter motor. Tighten nut.

(3) Position battery cable to starter stud. Install and tighten battery cable nut. Refer to Torque Specifications. Do not allow starter motor to hang from wire harness.

(4) Position starter motor to transmission.

(5) If equipped with automatic transmission, slide cooler tube bracket into position.

(6) Install and tighten 3 starter mounting bolts. Refer to Torque Specifications.

(7) Lower vehicle.

(8) Connect both negative battery cables to both batteries.

5.9L Gas

(1) Connect solenoid wire to starter motor (snaps on).

(2) Position battery cable to solenoid stud. Install and tighten battery cable eyelet nut. Refer to Torque Specifications. Do not allow starter motor to hang from wire harness.

(3) Position starter motor to transmission.

(4) If equipped with automatic transmission, slide cooler tube bracket into position.

(5) Install and tighten both bolts (auto. trans.), or 1 nut and 1 bolt (man. trans.). Refer to Torque Specifications.

(6) Lower vehicle.

(7) Connect negative battery cable.

STARTER MOTOR RELAY

DESCRIPTION

The starter relay is an electromechanical device that switches battery current to the pull-in coil of the starter solenoid when ignition switch is turned to Start position. The starter relay is located in the Power Distribution Center (PDC) in the engine compartment. See PDC cover for relay identification and location.

The starter relay is a International Standards Organization (ISO) relay. Relays conforming to ISO specifications have common physical dimensions, current capacities, terminal patterns, and terminal functions.

The starter relay cannot be repaired or adjusted. If faulty or damaged, it must be replaced.

OPERATION

The ISO relay consists of an electromagnetic coil, a resistor or diode, and three (two fixed and one movable) electrical contacts. The movable (common feed) relay contact is held against one of the fixed contacts (normally closed) by spring pressure. When electromagnetic coil is energized, it draws the movable contact away from normally closed fixed contact, and holds it against the other (normally open) fixed contact.

When electromagnetic coil is de-energized, spring pressure returns movable contact to normally closed position. The resistor or diode is connected in parallel with electromagnetic coil within relay, and helps to dissipate voltage spikes produced when coil is de-energized.

DIAGNOSIS AND TESTING - STARTER RELAY

The starter relay (Fig. 15) is located in Power Distribution Center (PDC). Refer to PDC cover for relay identification and location. For complete starter relay wiring circuit diagrams, refer to 8, Wiring Diagrams.

(1) Remove starter relay from PDC.

(2) A relay in de-energized position should have continuity between terminals 87A and 30, and no continuity between terminals 87 and 30. If OK, go to Step 3. If not OK, replace faulty relay.

(3) Resistance between terminals 85 and 86 (electromagnet) should be 75 ± 5 ohms. If OK, go to Step 4. If not OK, replace faulty relay.

(4) Connect 12V battery to terminals 85 and 86. There should now be continuity between terminals 30 and 87, and no continuity between terminals 87A and 30. If OK, perform Relay Circuit Test that follows. If not OK, replace faulty relay.

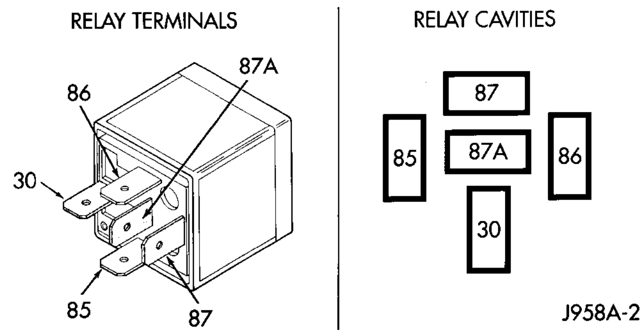

Fig. 15 TYPE 1 RELAY

TERMINAL LEGEND

NUMBER	IDENTIFICATION
30	COMMON FEED
85	COIL GROUND
86	COIL BATTERY
87	NORMALLY OPEN
87A	NORMALLY CLOSED

RELAY CIRCUIT TEST

(1) The relay common feed terminal cavity (30) is connected to battery voltage and should be hot at all times. If OK, go to Step 2. If not OK, repair open circuit to fuse in PDC as required.

(2) The relay normally closed terminal (87A) is connected to terminal 30 in the de-energized position, but is not used for this application. Go to Step 3.

(3) The relay normally open terminal (87) is connected to common feed terminal (30) in the energized position. This terminal supplies battery voltage to starter solenoid field coils. There should be continuity between cavity for relay terminal 87 and starter solenoid terminal at all times. If OK, go to Step 4. If not OK, repair open circuit to starter solenoid as required.

(4) The coil battery terminal (86) is connected to electromagnet in relay. It is energized when ignition switch is held in Start position. On vehicles with manual transmission, clutch pedal must be fully depressed for this test. Check for battery voltage at cavity for relay terminal 86 with ignition switch in Start position, and no voltage when ignition switch is released to On position. If OK, go to Step 5. If not OK with automatic transmission, check for open or short circuit to ignition switch and repair, if required. If circuit to ignition switch is OK, refer to **Ignition Switch and Key Lock Cylinder**. If not OK with a manual transmission, check circuit between relay and clutch pedal position switch for open or a short. If circuit is OK, refer to **Clutch Pedal Position Switch** in 6 , Clutch.

STARTER MOTOR RELAY (Continued)

(5) The coil ground terminal (85) is connected to the electromagnet in the relay. On vehicles with manual transmission, it is grounded at all times. On vehicles with automatic transmission, it is grounded through park/neutral position switch only when gear-shift selector lever is in Park or Neutral positions. Check for continuity to ground at cavity for relay terminal 85. If not OK with manual transmission, repair circuit to ground as required. If not OK with automatic transmission, check for pen or short circuit to park/neutral position switch and repair, if required. If circuit to park/neutral position switch is OK, refer to **Park/Neutral Position Switch** in 21, Transmission.

REMOVAL

The starter relay is located in the Power Distribution Center (PDC) (Fig. 16). Refer to label on PDC cover for relay location.

(1) Disconnect and isolate negative battery cable.

(2) Remove cover from Power Distribution Center (PDC) for relay identification and location.

(3) Remove starter relay from PDC.

(4) Check condition of relay terminals and PDC connector terminals for damage or corrosion. Repair if necessary before installing relay.

(5) Check for pin height (pin height should be the same for all terminals within the PDC connector). Repair if necessary before installing relay.

INSTALLATION

(1) Push down firmly on starter relay until terminals are fully seated into PDC receptacle.

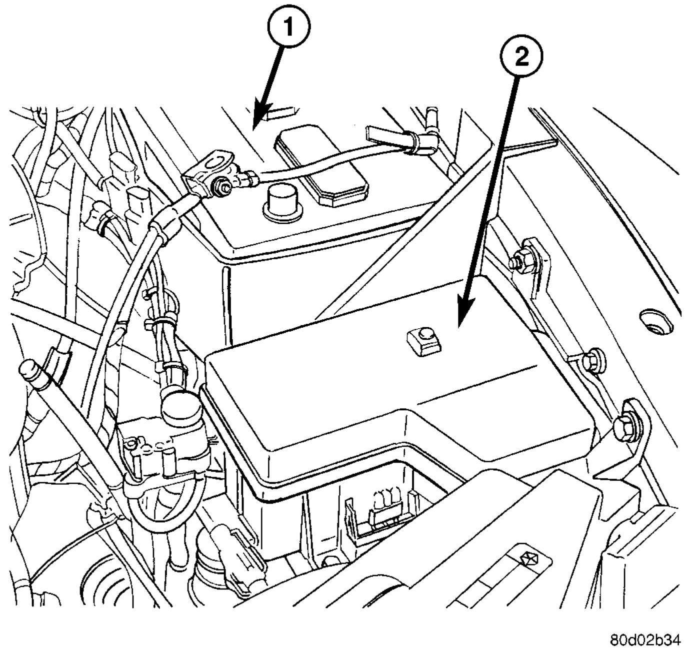

Fig. 16 PDC LOCATION

1 - BATTERY
2 - PDC (POWER DISTRIBUTION CENTER)

(2) Install PDC cover.

(3) Connect battery cable.