

# CHARGING SYSTEM

## CONTENTS

	page		page
<b>GENERAL INFORMATION</b>		<b>CHARGING SYSTEM</b> . . . . . 2	
OVERVIEW . . . . .	1	CURRENT OUTPUT TEST . . . . .	4
<b>DESCRIPTION AND OPERATION</b>		ON-BOARD DIAGNOSTIC TEST FOR	
BATTERY TEMPERATURE SENSOR . . . . .	2	CHARGING SYSTEM . . . . .	6
CHARGING SYSTEM OPERATION . . . . .	1	<b>REMOVAL AND INSTALLATION</b>	
ELECTRONIC VOLTAGE REGULATOR . . . . .	2	BATTERY TEMPERATURE SENSOR . . . . .	7
GENERATOR . . . . .	2	GENERATOR . . . . .	6
<b>DIAGNOSIS AND TESTING</b>		<b>SPECIFICATIONS</b>	
BATTERY TEMPERATURE SENSOR . . . . .	5	GENERATOR RATINGS . . . . .	8
CHARGING SYSTEM RESISTANCE TESTS . . . . .	3	TORQUE CHART . . . . .	8

## GENERAL INFORMATION

### OVERVIEW

The battery, starting, and charging systems operate with one another, and must be tested as a complete system. To allow the vehicle to start and charge properly, all of the components involved in these three systems must perform within specifications.

Group 8A in this service manual covers the battery, Group 8B covers the starting system, and Group 8C covers the charging system. Refer to Group 8W, Wiring Diagrams for complete circuit descriptions and diagrams. When attempting to diagnose any of these systems, it is important to keep their interdependency in mind.

Certain charging system circuits are monitored by On-Board Diagnostics (OBD) built into the Powertrain Control Module (PCM). Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for certain failures it detects. Refer to On-Board Diagnostics in Group 25, Emission Control System for a complete list of DTC's and for information necessary to access a DTC. For charging system diagnostic information, refer to the appropriate Powertrain Diagnostic Procedures service manual.

## DESCRIPTION AND OPERATION

### CHARGING SYSTEM OPERATION

The charging system consists of:

- Generator
- Electronic Voltage Regulator (EVR) circuitry within the Powertrain Control Module (PCM)

- Ignition switch (refer to Group 8D, Ignition System for information)
- Battery (refer to Group 8A, Battery for information)
- Battery temperature sensor
- Generator Lamp (if equipped)
- Check Gauges Lamp (if equipped)
- Voltmeter (refer to Group 8E, Instrument Panel and Gauges for information)
- Wiring harness and connections (refer to Group 8W, Wiring for information)

The charging system is turned on and off with the ignition switch. When the ignition switch is turned to the ON position, battery voltage from the powertrain control module (PCM) is supplied to the generator rotor to produce a magnetic field. This is done through one of the two field terminals at the rear of generator.

The amount of DC current produced by the generator is controlled by the EVR (field control) circuitry contained within the PCM. 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 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. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in elec-

## DESCRIPTION AND OPERATION (Continued)

tronic memory for certain failures it detects. Refer to On-Board Diagnostics in Group 25, Emission Control System for more DTC information.

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 Group 8E, Instrument Panel and Gauges for additional information.

## GENERATOR

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.

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 Y type stator winding connections deliver the induced AC current to 3 positive and 3 negative diodes for rectification. From the diodes, rectified DC current is delivered to the vehicle electrical system through the generator battery and ground terminals.

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.

## BATTERY TEMPERATURE SENSOR

The battery temperature sensor 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 to vary the battery charging rate. System voltage will be higher at colder temperatures and is gradually reduced at warmer temperatures.

## ELECTRONIC VOLTAGE REGULATOR

The Electronic Voltage Regulator (EVR) is not a separate component. It is actually a voltage regulating circuit located within the Powertrain Control

Module (PCM). The EVR is not serviced separately. If replacement is necessary, the PCM must be replaced.

**Operation:** The amount of DC 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 and battery temperature (refer to Battery Temperature Sensor for more information). It then compensates and regulates generator current output accordingly. Also refer to Charging System Operation for additional information.

## DIAGNOSIS AND TESTING

## CHARGING SYSTEM

The following procedures may be used to diagnose the charging system if:

- the generator 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
- a faulty or improperly adjusted switch that allows a lamp to stay on. See Ignition-Off Draw Test in Group 8A, Battery for more information.

## INSPECTION

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 Group 8A, 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.

## DIAGNOSIS AND TESTING (Continued)

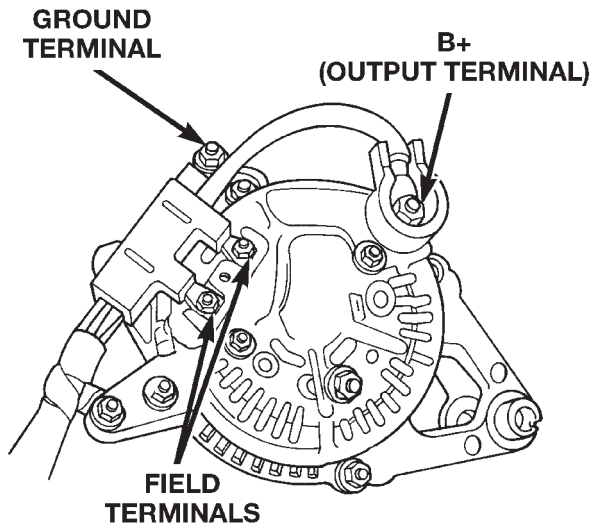
(5) Inspect generator drive belt condition and tension. Tighten or replace belt as required. Refer to Belt Tension Specifications in Group 7, Cooling System.

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

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

## CHARGING SYSTEM RESISTANCE TESTS

These tests will show the amount of voltage drop across the generator output wire, from the generator output (B+) terminal to the battery positive post. They will also show the amount of voltage drop from the ground (-) terminal on the generator to the battery negative post. Typical generator wiring harnesses are shown in (Fig. 1) or (Fig. 2). Wiring harness routing as shown may be slightly different depending on vehicle model and/or engine. Refer to Group 8W, Wiring Diagrams for additional information.



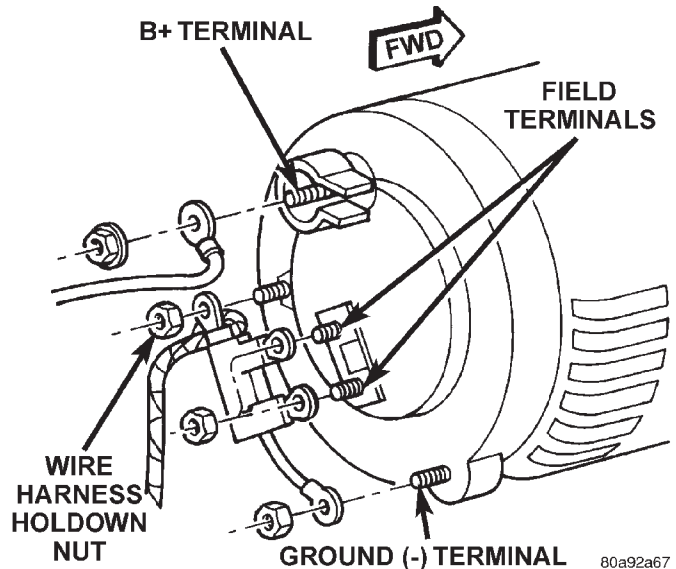
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**Fig. 1 Generator Terminals (Typical Wiring Harness Shown)**

A voltmeter with a 0–18 volt DC scale should be used for these tests. By repositioning the voltmeter test leads, the point of high resistance (voltage drop) can easily be found.

## PREPARATION

(1) Before starting test, make sure battery is in good condition and is fully-charged. See Group 8A, Battery for more information.



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**Fig. 2 Generator Terminals (Typical Wiring Harness Shown)**

(2) Check condition of battery cables at battery. Clean if necessary.

(3) Start the engine and allow it to reach normal operating temperature.

(4) Shut engine off.

(5) Connect an engine tachometer.

(6) Fully engage the parking brake.

## TEST

(1) Start engine.

(2) Place heater blower in high position.

(3) Turn on headlamps and place in high-beam position.

(4) Turn vehicle interior lamps on.

(5) Bring engine speed up to 2400 rpm and hold.

(6) Testing (+) circuitry:

(a) Touch the negative lead of voltmeter directly to battery positive post.

(b) Touch the positive lead of voltmeter to the B+ output terminal stud on the generator (not the terminal mounting nut). Voltage should be no higher than 0.6 volts. If voltage is higher than 0.6 volts, touch test lead to terminal mounting stud nut and then to the wiring connector. If voltage is now below 0.6 volts, look for dirty, loose or poor connection at this point. Also check condition of the generator output wire-to-battery bullet connector (if equipped). Refer to Group 8, Wiring for connector location. A voltage drop test may be performed at each (+) connection in this circuit to locate the excessive resistance.

(7) Testing (-) circuitry:

(a) Touch the negative lead of voltmeter directly to battery negative post.

## DIAGNOSIS AND TESTING (Continued)

(b) Touch the positive lead of voltmeter to the ground terminal stud on the generator case (not the terminal mounting nut). Voltage should be no higher than 0.3 volts. If voltage is higher than 0.3 volts, touch test lead to terminal mounting stud nut and then to the wiring connector. If voltage is now below 0.3 volts, look for dirty, loose or poor connection at this point. A voltage drop test may be performed at each (-) connection in this circuit to locate the excessive resistance. This test can also be performed between the generator case and the engine. If test voltage is higher than 0.3 volts, check for corrosion at generator mounting points or loose generator mounting.

## CURRENT OUTPUT TEST

The current output test will determine if the charging system can deliver its minimum test current (amperage) output. Refer to the Specifications section at the end of this group for minimum test current (amperage) requirements.

The first part of this test (Test 1) will determine the combined amperage output of both the generator and the Electronic Voltage Regulator (EVR) circuitry. The second part of this test (Test 2) will determine only generator amperage and **will not** include analysis of EVR circuitry. EVR circuitry is located within the Powertrain Control Module (PCM). To test voltage regulator circuitry, refer to the appropriate Powertrain Diagnostic Procedures service manual.

## PREPARATION

(1) Determine if any Diagnostic Trouble Codes (DTC's) exist. To determine a DTC, refer to On-Board Diagnostics in this group. For repair, refer to the appropriate Powertrain Diagnostic Procedures manual.

(2) Before starting test, make sure battery is in good condition and is fully-charged. See Group 8A, Battery for more information.

(3) Check condition of battery cables at battery. Clean if necessary.

(4) Perform the previous Charging System Resistance Tests (voltage drop tests). This will ensure clean and tight generator/battery electrical connections.

(5) Be sure the generator drive belt is properly tensioned. Refer to Group 7, Cooling System for information.

(6) A volt/amp tester equipped with both a battery load control (carbon pile rheostat) and an inductive-type pickup clamp (ammeter probe) will be used for this test. Refer to operating instructions supplied with tester. When using a tester equipped with an inductive-type clamp, removal of wiring at the generator will not be necessary.

(7) Start the engine and allow it to reach operating temperature.

(8) Shut engine off.

(9) Turn off all electrical accessories and all vehicle lighting.

(10) Connect the volt/amp tester leads to the battery. Be sure the carbon pile rheostat control is in the OPEN or OFF position before connecting leads. See Load Test in Group 8A, Battery for more information. Also refer to the operating instructions supplied with test equipment.

(11) Connect the inductive clamp (ammeter probe). Refer to the operating instructions supplied with test equipment.

(12) If volt/amp tester is not equipped with an engine tachometer, connect a separate tachometer to the engine.

## TEST 1

(1) Perform the previous test Preparation.

(2) Fully engage the parking brake.

(3) Start engine.

(4) Bring engine speed to 2500 rpm.

(5) With engine speed held at 2500 rpm, slowly adjust the rheostat control (load) on the tester to obtain the highest amperage reading. Do not allow voltage to drop below 12 volts. Record the reading. **This load test must be performed within 15 seconds to prevent damage to test equipment.** On certain brands of test equipment, this load will be applied automatically. Refer to the operating manual supplied with test equipment.

(6) The ammeter reading must meet the Minimum Test Amps specifications as displayed in the Generator Ratings chart. This can be found in the Specifications section at the end of this group. A label stating a part reference number is attached to the generator case. On some engines this label may be located on the bottom of the case. Compare this reference number to the Generator Ratings chart.

(7) Rotate the load control to the OFF position.

(8) Continue holding engine speed at 2500. If EVR circuitry is OK, amperage should drop below 15–20 amps. With all electrical accessories and vehicle lighting off, this could take several minutes of engine operation. If amperage did not drop, refer to the appropriate Powertrain Diagnostic Procedures manual for testing.

(9) Remove volt/amp tester.

If minimum amperage could not be met, proceed to Test 2. This test will determine if the generator is faulty, or if EVR circuitry is defective.

## TEST 2

(1) Perform the previous test preparation.

(2) Fully engage the parking brake.



## DIAGNOSIS AND TESTING (Continued)

(3) Connect one end of a jumper wire to a good ground. Connect the other end of jumper wire to the generator field driver (-) terminal. The 2 field terminals (+ and -) are located on the back of the generator (Fig. 1) or (Fig. 2). To locate and identify the (-) terminal and circuit, refer to Group 8W, Wiring Diagrams. Another way to identify the (-) terminal is to start the engine and measure voltage at both field terminals. The (+) terminal will show battery voltage (12.5–14.5 volts). The (-) terminal will show 3–5 volts less than battery voltage.

**CAUTION:** Do not connect the jumper ground wire to the generator field source (+) field terminal. Damage to electrical system components may result.

Connecting the jumper wire will remove the voltage regulator circuitry from the test. It will also generate a Diagnostic Trouble Code (DTC).

(4) Start engine. **Immediately** after starting, reduce engine speed to idle. This will prevent any electrical accessory damage from high voltage.

(5) Adjust carbon pile rheostat (load) and engine speed in slow increments until a speed of 1250 rpm, and a voltmeter reading of 15 volts is obtained. Immediately record ammeter reading. Do not apply load to system longer than 15 seconds as damage to test equipment may result.

**CAUTION:** When adjusting rheostat load, do not allow voltage to rise above 16 volts. Damage to the battery and electrical system components may result.

(6) The ammeter reading must meet the Minimum Test Amps specifications as displayed in the Generator Ratings chart. This can be found in the Specifications section at the end of this group. A label stating a part reference number is attached to the generator case. On some engines this label may be located on the bottom of the case. Compare this reference number to the Generator Rating chart.

(7) Remove volt/amp tester.

(8) Remove jumper wire.

(9) Use the DRB scan tool to erase the DTC. Refer to the DRB screen for procedures.

## RESULTS

- If amp reading meets specifications in Test 2, generator is OK.

- If amp reading is less than specified in Test 2, and wire resistance (voltage drop) tests were OK, the generator should be replaced. Refer to Removal and Installation in this group for procedures.

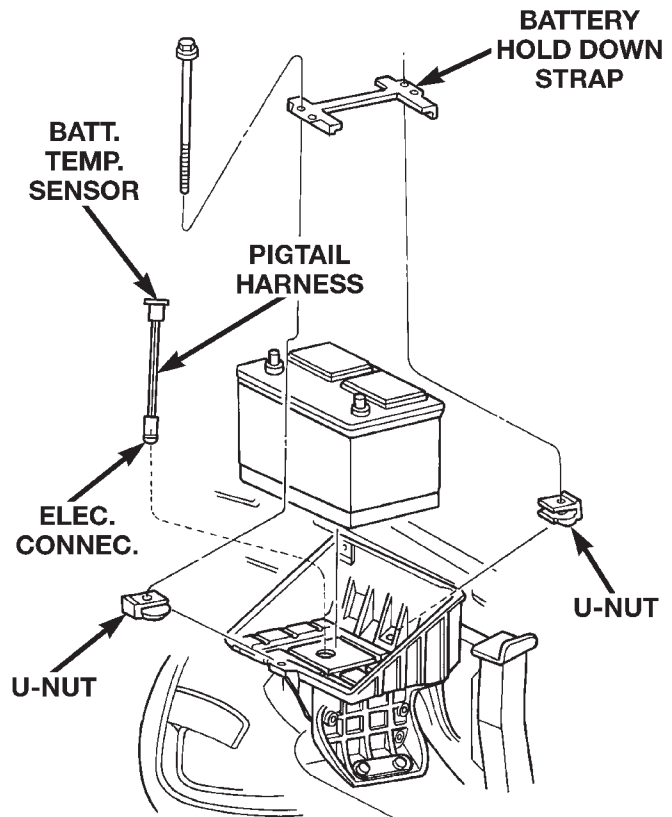
- If Test 2 results were OK, but Test 1 results were not, the problem is in EVR circuitry. Refer to

appropriate Powertrain Diagnostic Procedures manual for diagnosis.

## BATTERY TEMPERATURE SENSOR

To perform a complete test of this sensor and its circuitry, refer to the appropriate Powertrain Diagnostic Procedures manual. To test the sensor only, refer to the following:

(1) The sensor is located under the battery and is attached (snapped into) the battery tray (Fig. 3). On models equipped with a diesel engine (dual batteries), only one sensor is used. Location is under battery on drivers side of vehicle. A two-wire pigtail harness is attached directly to the sensor. The opposite end of this harness connects the sensor to the engine wiring harness.



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**Fig. 3 Battery Temperature Sensor Location**

(2) Disconnect the two-wire pigtail harness from the engine harness.

(3) Attach ohmmeter leads to the wire terminals of the pigtail harness.

(4) At room temperature of 25° C (75–80° F), an ohmmeter reading of 9,000 (9K) to 11,000 (11K) ohms should be observed.

(5) If reading is above or below the specification, replace the sensor.

(6) Refer to the Removal and Installation section for procedures.

## DIAGNOSIS AND TESTING (Continued)

## ON-BOARD DIAGNOSTIC TEST FOR CHARGING SYSTEM

The Powertrain Control Module (PCM) 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 circuits are checked continuously and some are checked only under certain conditions.

For DTC information, refer to Diagnostic Trouble Codes in Group 25, Emission Control System. This will include a complete list of DTC's including DTC's for the charging system.

## REMOVAL AND INSTALLATION

## GENERATOR

## REMOVAL

**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. Diesel Engines: Disconnect both negative battery cables at both batteries.

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

(3) Remove generator pivot and mounting bolts/nut (Fig. 4) or (Fig. 5). The diesel engine uses a bolt at top mounting and a bolt/nut at lower mounting. Position generator for access to wire connectors.

(4) Remove nuts from harness holddown, battery terminal, ground terminal and 2 field terminals. Remove wire connectors. A typical generator wiring harness is shown in (Fig. 6). Wiring harness routing as shown may be slightly different depending on vehicle model and/or engine. Refer to Group 8W, Wiring Diagrams for additional information.

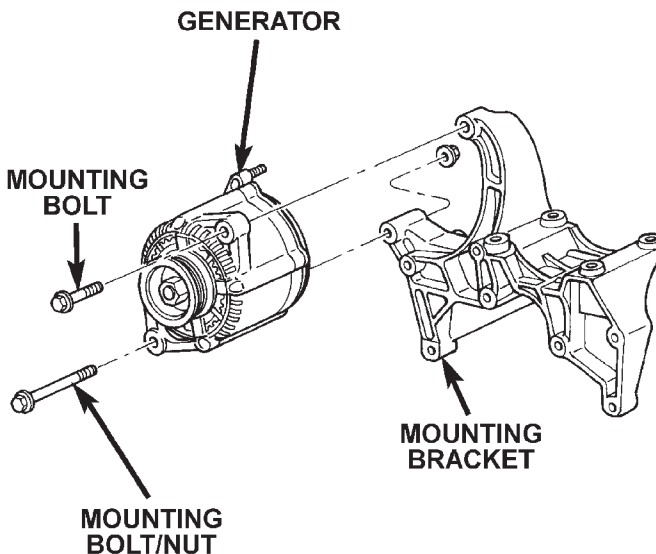
(5) Remove generator from vehicle.

## INSTALLATION

(1) Position generator to engine and install wiring to rear of generator. Tighten all wiring fasteners as follows:

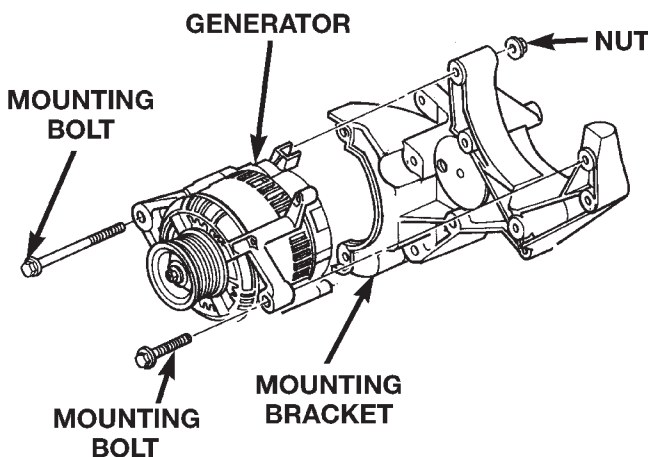
- Battery terminal nut—8.5 N·m (75 in. lbs.)
- Ground terminal nut—8.5 N·m (75 in. lbs.)
- Harness holddown nut—8.5 N·m (75 in. lbs.)
- Field terminal nuts—2.8 N·m (25 in. lbs.)

(2) Install generator mounting fasteners and tighten as follows:



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**Fig. 4 Remove/Install Generator—3.9L/5.2L/5.9L Engines**



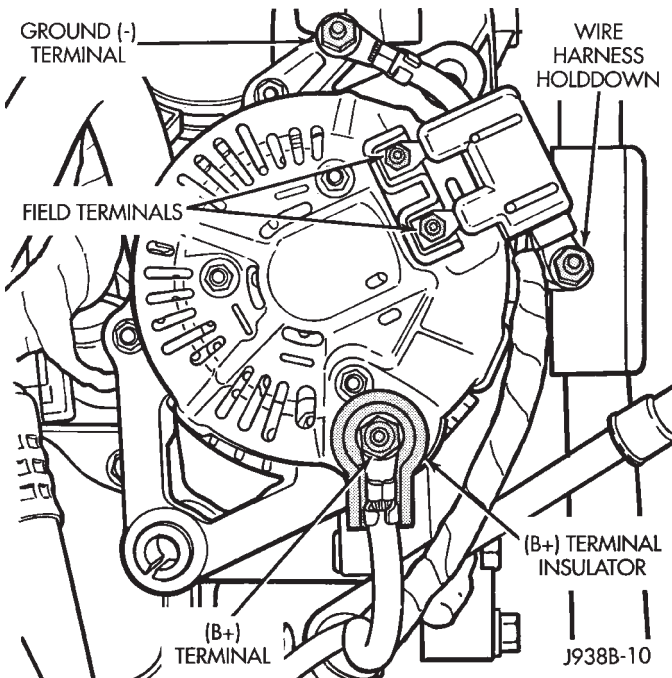
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**Fig. 5 Remove/Install Generator—8.0L Engine**

- Generator mounting bolt—All gas powered engines—41 N·m (30 ft. lbs.)
- Generator pivot bolt/nut—All gas powered engines—41 N·m (30 ft. lbs.)
- Generator mounting bolt—Diesel powered engines—54 N·m (40 ft. lbs.)
- Generator pivot bolt/nut—Diesel powered engines—54 N·m (40 ft. lbs.)

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

## REMOVAL AND INSTALLATION (Continued)



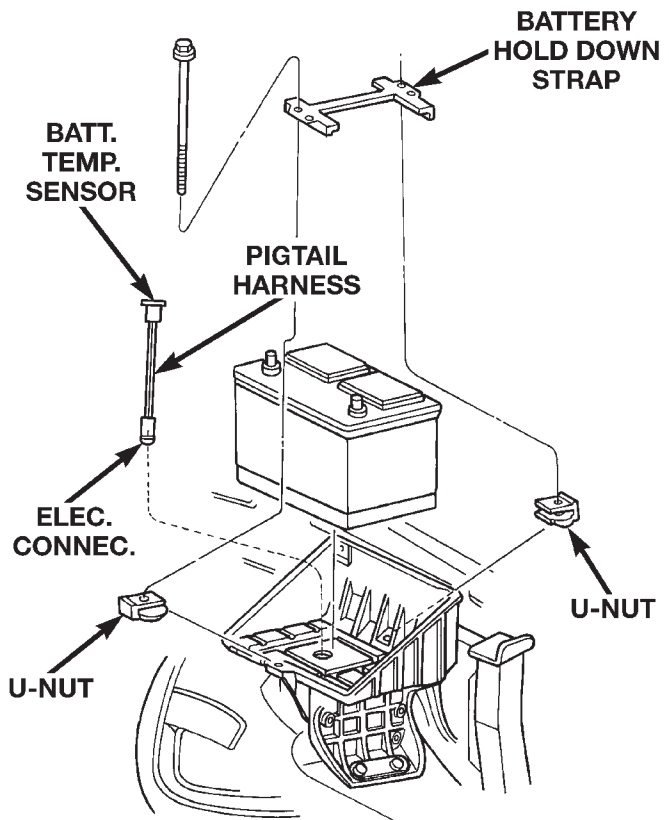
**Fig. 6 Remove/Install Generator Connectors—Typical**

**CAUTION:** When installing a serpentine accessory drive belt, the belt **MUST** be routed correctly. The water pump will 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 Group 7, Cooling System.

- (3) Install generator drive belt. Refer to Group 7, Cooling System for procedure.
- (4) Install negative battery cable(s) to battery(s).

### BATTERY TEMPERATURE SENSOR

The battery temperature sensor is located under the vehicle battery (Fig. 7) and is attached (snapped into) a mounting hole on battery tray. On models equipped with a diesel engine (dual batteries), only one sensor is used. The sensor is located under the battery on drivers side of vehicle.



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**Fig. 7 Battery Temperature Sensor Location**

#### REMOVAL

- (1) Remove battery. Refer to Group 8A, Battery for procedures.
- (2) Disconnect sensor pigtail harness from engine wire harness.
- (3) Pry sensor straight up from battery tray mounting hole.

#### INSTALLATION

- (1) Feed pigtail harness through mounting hole in top of battery tray and press sensor into top of tray (snaps in).
- (2) Connect pigtail harness.
- (3) Install battery. Refer to Group 8A, Battery for procedures.

## SPECIFICATIONS

## GENERATOR RATINGS

TYPE	PART NUMBER	RATED SAE AMPS	ENGINES	MINIMUM TEST AMPS
DENSO	52067912	117	3.9L/5.2L/5.9L GAS	90
DENSO	52067913	136	3.9L/5.2L/5.9L GAS	100
DENSO	56027221	136	5.9L DIESEL	120

## TORQUE CHART

DESCRIPTION	TORQUE
Generator Mounting Bolt—All Gas	
Powered Engines . . . . .	.41 N·m (30 ft. lbs.)
Generator Pivot Bolt/Nut—All Gas	
Powered Engines . . . . .	.41 N·m (30 ft. lbs.)
Generator Mounting Bolt—Diesel	
Engine . . . . .	.54 N·m (40 ft. lbs.)
Generator Pivot Bolt/Nut—Diesel	
Engine . . . . .	.54 N·m (40 ft. lbs.)
Battery Terminal Nut . . . . .	.8.5 N·m (75 in. lbs.)
Ground Terminal Nut . . . . .	.8.5 N·m (75 in. lbs.)
Harness Hold-down Nut . . . . .	.8.5 N·m (75 in. lbs.)
Field Terminal Nuts . . . . .	.2.8 N·m (25 in. lbs.)