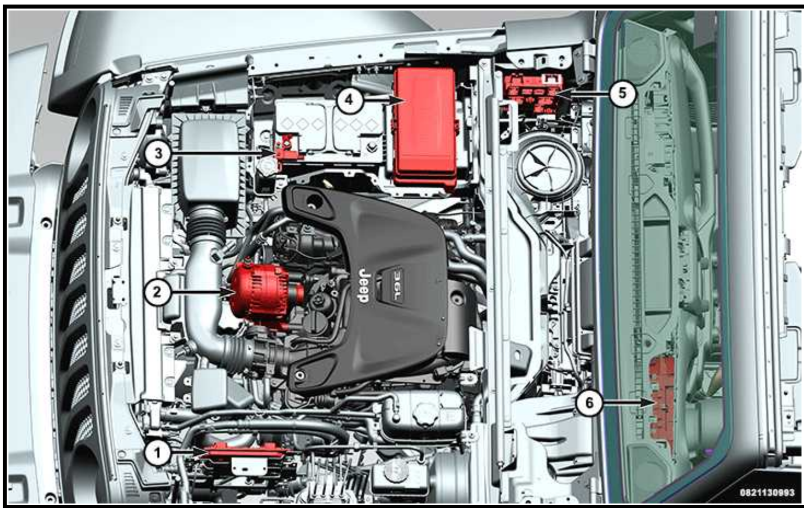
DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

DESCRIPTION

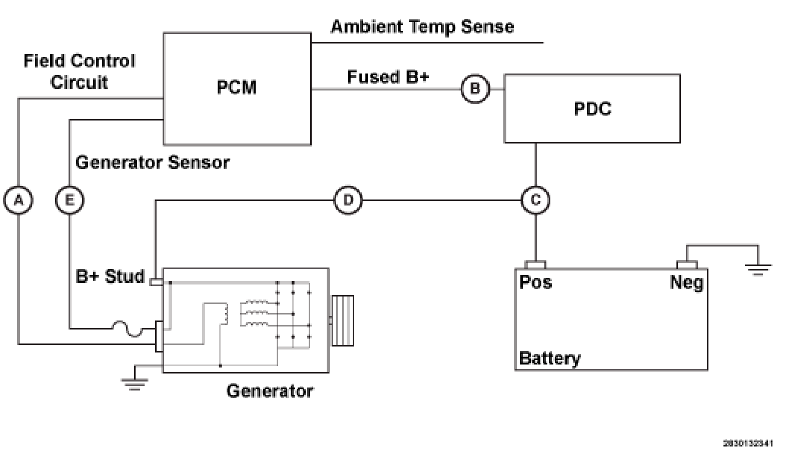


The charging system consists of the following components:

COMPONENT INDEX

1.	Refer to POWERTRAIN CONTROL MODULE (PCM) with an integrated Electronic Voltage Regulator (EVR).
2.	Refer to GENERATOR.
3.	Refer to INTELLIGENT BATTERY SENSOR (IBS).
4.	Refer to POWER DISTRIBUTION CENTER (PDC).
5.	Refer to BODY CONTROL MODULE (BCM).
6.	Refer to INSTRUMENT PANEL CLUSTER (IPC).

STANDARD GENERATOR SYSTEM OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) generator field control circuit (A) on and off. When the generator field is turned on, the system voltage increases. When the generator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature, and the engine speed. A constant system voltage (B, C, D) can be maintained only when the generator field is switched on and off at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine speed.

During normal operation, the voltage reading at the generator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system voltage and is sensed by the PCM through the fused B+ circuit (B). With the generator connector plugged in, the voltage reading on the generator sense circuit will be approximately 3.5 volts less than the voltage at the generator output stud due the resistor inside the generator. This is the generator sense (E) input to the PCM. These two voltage sense inputs are used and compared during the different diagnostics performed on the EVR System by the PCM.

In diagnostic mode, when the PCM detects that the output voltage is too high or too low, the PCM runs a series of diagnostics to determine the cause. When the diagnostic is initiated, the PCM will change the field control circuit and look for a change in the output voltage. If no reaction is detected, the PCM rationalizes that it has lost control of the generator field control (A) due to an open or shorted condition. If the generator field control is active, and the engine speed is above a calibrated threshold, the PCM will run a series of tests that turn the generator field control off and on for a brief period of time and monitors the system voltage (B) for a calibrated amount of change in the voltage, to determine a failure of the generator. This diagnostic test requires repeated failures to insure that an erroneous fault is not set.

BODY CONTROL MODULE (BCM)

Refer to **COMPONENT INDEX**.

NOTE: The following information applies to vehicles equipped with a smart generator.

The BCM has two functions:

- it is the gateway for the battery status signals coming from the Intelligent Battery Sensor (IBS) to the Controller Area Network-Chassis (CAN-C) network
- it receives information from some vehicle loads and manages voltage limits by increasing or decreasing the generator voltage output. The battery voltage limits are monitored while these requested voltage changes are occurring. The BCM calculates the limits of the maximum charging voltage by utilizing a LIN bus message from the IBS indicating the battery temperature.

Depending on the state of some electrical loads and the maximum charging limit already calculated by the BCM, the BCM will set the minimum and maximum voltage limits for the generators target voltage. These limits are then broadcast on the CAN-C network.

The following signals are transmitted by BCM to the PCM using the CAN-C network:

- The battery current
- The battery temperature (B°C)
- The battery voltage (V)
- The battery state of charge (%)
- The maximum voltage allowed by BCM (V)
- The minimum voltage allowed by BCM (V)
- The IBS status signals
- The SAM failure status

The value of the voltage high strategy calculated by the BCM is performed by reading the following signals:

- High beams activated
- Front fog lamps activated
- Rear fog lamps activated
- The front wiper motor low or high state

- Rear wiper motor activated
- Low beams activated
- Positive Temperature Coefficient (PTC) heaters are present
- Programmable auxiliary switches are on. An equipped Power Take-Off (PTO) unit is an example of when you would find an auxiliary switch bank.
- Battery maximum charging voltage. This condition is always active.

The value of the voltage low strategy calculated by the BCM is performed by reading the following signals:

- High beams activated
- Front fog lamps activated
- Rear fog lamps activated
- The front wiper motor low or high state
- Rear wiper motor activated
- Low beams activated
- PTC heaters are present
- Programmable auxiliary switches are on. An equipped PTO unit is an example of when you would find an auxiliary switch bank.
- Requests from the Heating Ventilation and Air Conditioning (HVAC) system.

GENERATOR

Refer to **COMPONENT INDEX**.

Standard Generator

As the energized rotor begins to rotate within the generator, the spinning magnetic field induces a current into the windings of the stator coil.

The Y type stator winding connections deliver the induced Alternating Current (AC) to positive and negative diodes for rectification. From the diodes, rectified Direct Current (DC) is delivered to the vehicles electrical system through the generator, battery, and ground terminals.

Noise emitting from the generator may be caused by:

- Worn, loose or defective bearings
- Loose or defective drive pulley
- Incorrect, worn, damaged or misadjusted drive belt
- Loose mounting bolts
- Misaligned drive pulley
- Defective stator or diode
- Damaged internal fins

INSTRUMENT PANEL CLUSTER (IPC)

Refer to **COMPONENT INDEX**.

The IPC will switch on the charge system indicator (battery indicator, battery telltale) and the charging system audible chime when the IPC receives indication of a charging system failure from the PCM over the CAN-C network.

INTELLIGENT BATTERY SENSOR (IBS)

Refer to **COMPONENT INDEX**.

The IBS serves two primary purposes. The first is to provide the PCM with both immediate and historical calculated battery information, so the PCM can precisely control the charging system. The second purpose is to provide calculated data to the BCM for operation of the load-shedding feature. A fused power circuit and the bus are connected to the IBS though a two-terminal connector.

The IBS contains a low value resistor, or shunt. The shunt creates voltage drop, which is read by an internal controller to determine the current flow in and out of the battery. In addition to the shunt, the IBS contains a sensor to monitor the battery's temperature. Data gathered by the IBS, including temperature, voltage, and current measurements, are transmitted over a communication bus to the BCM, which is the LIN master node of the IBS. In addition to real-time measurements, the IBS transmits some calculated battery data over the bus, including SOC, State of Health (SOH), and State of Function (SOF). These values are calculated by storing measurements over time.

- SOC = Battery SOC is expressed as a percentage. The IBS calculates the SOC based on measured voltage, and charge and discharge rates. Therefore, SOC is not a direct percentage of battery voltage.
- SOF = Battery SOF is a calculated prediction of the lowest voltage the battery will drop to during engine cranking.

The battery sensor is readable and diagnosable by using the diagnostic scan tool which can display all of the available parameters needed for vehicle servicing or trouble shooting.

When the IBS is powered up for the first time or is powered after a battery disconnect, it enters a "recalibration" phase, where the IBS must recognize the type of battery and its characteristics and state. This information is sent to the IBS by the BCM. In this phase the tolerances on the state functions (SOC, SOF) are greater than in normal working condition. When the IBS is disconnected from the battery, the device loses its stored memory. When power is restored, the IBS starts a relearn process. Until the relearn process is complete, accurate battery state information is unavailable to other vehicle systems. The IBS relearn process requires one start and at least four hours of quiescent time (vehicle off, electrical system asleep). The relearn process is restarted every time power is reconnected to the IBS. This has a major effect on the Engine Start Stop (ESS) feature.

POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

The IBS and BCM communicate with the PCM to provide the proper charging strategy for the vehicle based on ambient temperature, vehicle electrical load and voltage.

POWER DISTRIBUTION CENTER (PDC)

Refer to **COMPONENT INDEX**.

The PDC for this vehicle is designed to provide safe, reliable, centralized and convenient access to distribution of the electrical current required to operate all of the many standard and optional factory-installed electrical and electronic powertrain, chassis, safety, comfort and convenience systems. At the same time, these systems were designed to provide centralized locations for conducting diagnosis of faulty circuits and for sourcing the additional current requirements of many aftermarket vehicle accessory and convenience items. The PDC connects directly to the B+ cable.

This power distribution system also incorporate various types of circuit control and protection features, including:

- Automatic resetting circuit breakers
- Cartridge fuses
- Blade fuses
- Printed Circuit Board (PCB) and non-PCB Relays

SYSTEM OPERATION - SMART CHARGING SYSTEM

Most current vehicles utilize the Smart Charging control strategy. This strategy helps to improve vehicle performance, reduce CO2 emissions and increase fuel efficiency. The control strategy takes into account battery state of charge and electrical loads on the battery, as well as engine load. Vehicles that utilize the Smart Charging control strategy are equipped with an Intelligent Battery Sensor (IBS). The IBS is an important component of the Smart Charging control strategy.

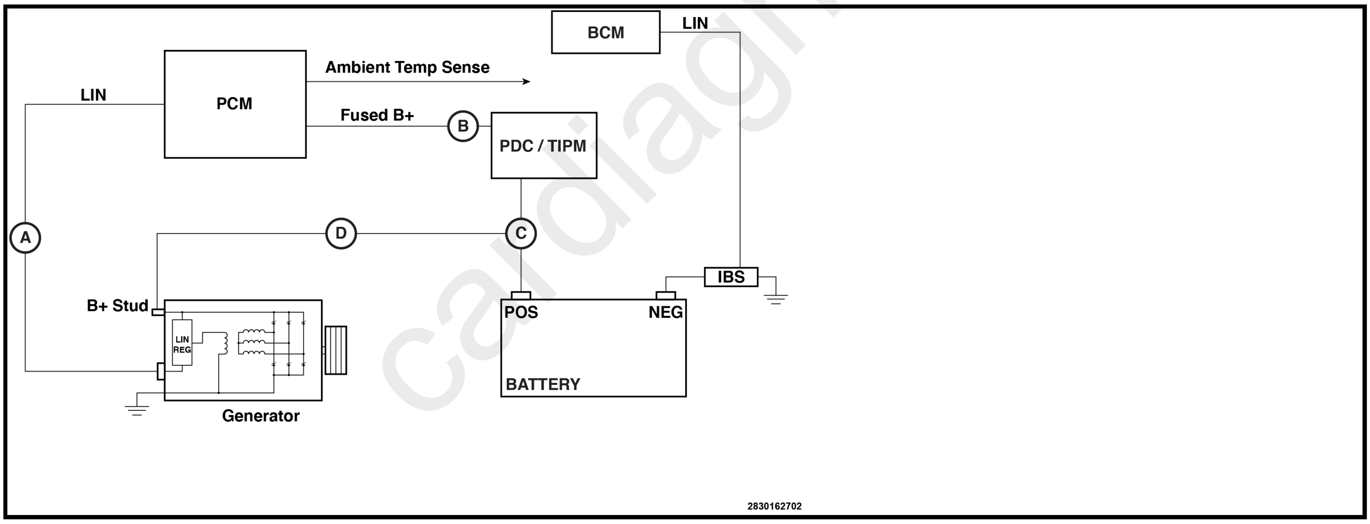
- **Idle and acceleration:** Charging is typically suspended during idle and acceleration conditions. Due to this strategy it can be common for the alternator output to be equal to, or close to typical battery voltage at idle and during engine acceleration.
- **Steady state speeds:** During steady state speeds the charge rate is typically low, just enough to maintain battery voltage.
- **Deceleration (regenerative braking):** The charge rate is typically very high during deceleration.

The Smart Charging strategy can be used with any combination of the following vehicle configurations:

- Single Battery System
- Dual Battery System
- Electronic Voltage Regulation (EVR) Charging systems which use a standard alternator directly controlled by the PCM
- Charging systems using a smart alternator communicating with the PCM via LIN Bus

On vehicles equipped with a smart alternator, the PCM sends voltage set point and ramp time commands to the alternator via a LIN bus communication circuit. The alternator controls the charging rate based on these commands.

FUNCTIONAL DESCRIPTION - SMART ALTERNATOR



The Smart Alternator communicates with the Powertrain Control Module (PCM) over a Pulse Width Modulated (PWM) LIN BUS communication circuit. The Smart Alternator contains an internal Intelligent Voltage Regulator that controls the Alternator overall operation. The Smart Alternator requires Battery supply on the Fused B+ circuit and a good case ground to power up the internal regulator and operate correctly. **The PCM sends the Smart Alternator the following messages/commands over the LIN BUS circuit:**

- Wake-up signal
- Voltage set point
- Ramp time
- Maximum current output based on operating and environmental conditions

The Smart Alternator controls the charging rate based on the PCM input commands. The Smart Alternator also performs diagnostics for electrical and mechanical faults with the Alternator. **The Smart Alternator sends the**

following information/faults regarding diagnostics and Alternator load conditions back to the PCM over the LIN BUS circuit:

- Regulator duty cycle
- Internal Battery voltage
- Measured energizing current
- Integrated circuit temperature
- Pulley rotational speed
- Error messages for internal mechanical error, electrical error, or over temperature error

FUNCTIONAL DESCRIPTION - INTELLIGENT BATTERY SENSOR (IBS)

The Intelligent Battery Sensor (IBS) is an electrical shunt with a microprocessor that is mounted in-line with the negative Battery Cable. The IBS monitors the Battery voltage as well as current flow into and out of the battery. The IBS also has a built-in thermistor that calculates the battery temperature. The microprocessor uses this data to calculate Battery State of Charge (SOC), battery internal resistance, charge received, electrical demand, and time in service. This information is reported through the LIN Bus circuit to the Body Control Module (BCM). The BCM broadcasts the information to the Powertrain Control Module (PCM) over the CAN Bus.

The IBS SOC data is also used by the BCM and other modules to determine when to begin disabling certain vehicle features that draw excessive electrical loads due to a low battery SOC. The SOC threshold for starting to disable features can vary based on vehicle and engine but is typically in the 50% to 60% range. The following items can contribute to, and should be considered when diagnosing a low SOC condition before replacing an IBS or battery:

- If the vehicle is jump started at the battery posts bypassing the IBS.
- If the battery is blind charged at the battery posts bypassing the IBS.
- Repeated short trip driving events not allowing enough charge time.
- The IBS accuracy is off and needs to relearn the battery SOC.

Depending on the vehicle, there could be a non-MIL DTC (P057F) set, or an EVIC message indicating a low battery state of charge limiting some features, such as ESS. In some cases, properly charging the batteries through the IBS can raise the IBS SOC enough to regain functionality and repair the issue. However, it can sometimes take two or three, 4-hour BUS off sleep cycles for an IBS to learn and update the Battery SOC. The IBS can be initiated into a learning curve by completely disconnecting the IBS from the battery, and disconnecting harness connector for 20 seconds. The IBS battery feed, LIN Bus and ground circuits should be checked before reconnecting the IBS. The IBS should default to approximately 80% SOC when reconnected. However, the IBS accuracy is determined to be low until the IBS can relearn battery SOC. This occurs after an engine run cycle and a subsequent ignition off sleep cycle of between one to four hours. Some features will be disabled until the IBS SOC is updated.

FUNCTIONAL DESCRIPTION - POWER DISTRIBUTION CENTER (PDC)

The PDC is designed to provide safe, reliable, centralized and convenient access to distribution of the electrical current required to operate all of the many standard and optional factory-installed electrical and electronic powertrain, chassis, safety, comfort and convenience systems. At the same time, these systems were designed to provide centralized locations for conducting diagnosis of faulty circuits and for sourcing the additional current requirements of many aftermarket vehicle accessory and convenience items. The PDC connects directly to the Battery Positive (B+) cable.

The power distribution systems also incorporate various types of circuit control and protection features, including:

- Automatic resetting circuit breakers
- Cartridge fuses

- Blade fuses
- Removable Relays
- Non serviceable Printed Circuit Board (PCB) Relays

The charging system is protected by a larger amperage fuse that is typically in the fuse array attached to the PDC.

FUNCTIONAL DESCRIPTION - INSTRUMENT PANEL CLUSTER (IPC)

The IPC will turn on the charge system indicator (battery indicator, battery telltale) and the charging system audible chime when the IPC receives indication of a charging system failure from the PCM over the Controller Area Network-Chassis (CAN-C) network.

FUNCTIONAL DESCRIPTION - BODY CONTROL MODULE (BCM)

The BCM is the gateway for all bus communications needing to be gated from one bus network to a different bus network. This grants the modules on different busses the ability to interact with each other. If the Local Interface Network (LIN) or CAN bus communications go down, the BCM will set the appropriate DTCs and display Signal Not Available (SNA) values.

The Intelligent Battery Sensor (IBS) communicates with the BCM through a LIN bus circuit. The BCM collects information relating to battery state of charge, temperature and electrical loads on the battery from the IBS. This information is broadcast over the bus networks to other modules, including the Powertrain Control Module (PCM) which uses this information to control and monitor the charging system.

FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM communicates and commands the charging rate to the Smart Alternator via the LIN bus circuit. The PCM does not directly perform diagnostics of the Smart Alternator. However, the PCM does store and report the faults communicated from the Smart Alternator via the LIN bus circuit.

The PCM diagnostic monitor compares the reported battery voltage from the Intelligent Battery Sensor (IBS) to the currently requested set voltage from the Smart Alternator. A fault will be detected if the absolute difference (VOLTAGE_DELTA) between commanded Smart Alternator and actual IBS voltage values vary from one another above a calibrated threshold for an accumulated period of time. When the PCM determines there is a charging system failure the PCM will send a message to the Instrument Cluster to illuminate the check gauges lamp (if equipped) with the engine running.

DIAGNOSIS AND TESTING

CHARGING SYSTEM - SMART ALTERNATOR

The PCM does not directly perform diagnostics for the Smart Alternator. However, the PCM does store and report the faults communicated from the Smart Alternator via the LIN bus circuit. The PCM diagnostic monitor compares the reported battery voltage from the Intelligent Battery Sensor (IBS) to the currently requested set voltage from the Smart Alternator. A fault will be detected if the absolute difference (VOLTAGE_DELTA) between commanded Smart Alternator and actual IBS voltage values vary from one another above a calibrated threshold over an accumulated period.

CHARGING SYSTEM TESTING

PRELIMINARY INSPECTION

Perform the following inspections before diagnosing the Smart Alternator system:

1. Verify proper battery condition and charge level.
2. Inspect condition and connections at the battery cable terminals, battery posts, ground locations and Smart Alternator. They should be clean and tight. Repair as required.

3. Inspect all fuses in both the BCM and Power Distribution Center (PDC) for tightness in receptacles. They should be properly installed and tight. Repair or replace as required.
4. Inspect Alternator drive belt and tensioner condition. Verify proper belt tension.

DIAGNOSTIC OVERVIEW - SMART ALTERNATOR

PCM DIAGNOSTICS: When an electrical, mechanical or over-temp fault is detected and reported by the Smart Alternator to the PCM, the PCM sets a fault (P-code) and sends a default voltage set point of 14.0 volts to the Smart Alternator. Most vehicles will combine the failure modes into one fault code (P065A). However, some vehicles will separate each failure mode and set individual DTCs. **It is important to note that on vehicles that use the combined P065A fault** that this DTC can also set if the **difference** between the commanded set point and IBS voltage feedback are greater than a calibrated threshold. This means that the charging output should be checked before condemning an Alternator as faulty when a DTC is present.

When communication is lost between the PCM and Smart Alternator, the Smart Alternator will default to a voltage set point between 13.5 and 14.0 volts. The PCM will set a loss of communication fault (U-code) against the Smart Alternator. Besides an open or shorted LIN Bus circuit, the PCM can also lose communication with the Smart Alternator if the battery supply (open in the cable) or case ground to the Smart Alternator is lost. An open charging system fuse can cause a loss of battery supply to the Smart Alternator.

DIAGNOSTIC STRATEGY: Since the Smart Charging system does not always charge at idle, it is not unusual to see typical battery voltage present at the Smart Alternator stud during idling. Monitoring the voltage at the Smart Alternator stud at idle is not an effective way of checking the Smart Alternator output capability. This could lead to misdiagnosis and unnecessary replacement of the Smart Alternator. If it is suspected that the Smart Alternator is not charging to the level commanded by the PCM, a more effective way to determine this is to disconnect the LIN Bus circuit at the Smart Alternator and monitoring the voltage alternator stud. Disconnecting the communication line should cause the Smart Alternator to default to charging between approximately 13.5 and 14 volts. If the voltage does not increase to 13.5 to 14.0 volts at idle with the LIN Bus circuit open, the Smart Alternator is most likely faulty.

NOTE: **This method only applies to the Smart Alternators, not to the Electronic Voltage Regulation (EVR) charging systems with a standard Alternator. Standard Alternators are controlled directly by the PCM using a PWM voltage supply to energize the field.**

TECHNICAL SPECIFICATIONS

GENERATOR

3.6L W/ESS	180/220/240 AMP
3.0L Diesel	180/220/240 AMP

TORQUE SPECIFICATIONS

CHARGING SYSTEM - 3.0L

DESCRIPTION	SPECIFICATION	COMMENT
Generator Bolts	**63 N.m (48 Ft. Lbs.)**	-
Generator B+ Cable Nut	**20 N.m (15 Ft. Lbs.)**	-
Generator Nut	**63 N.m (48 Ft. Lbs.)**	-
Generator Stud	**10 N.m (89 In. Lbs.)**	-

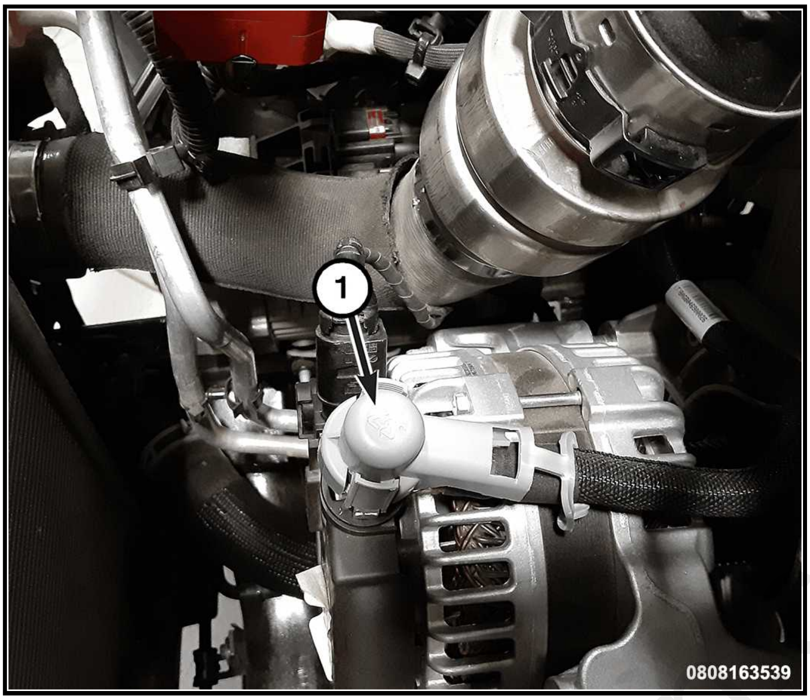
GENERATOR

REMOVAL AND INSTALLATION

GENERATOR - 3.0L DIESEL

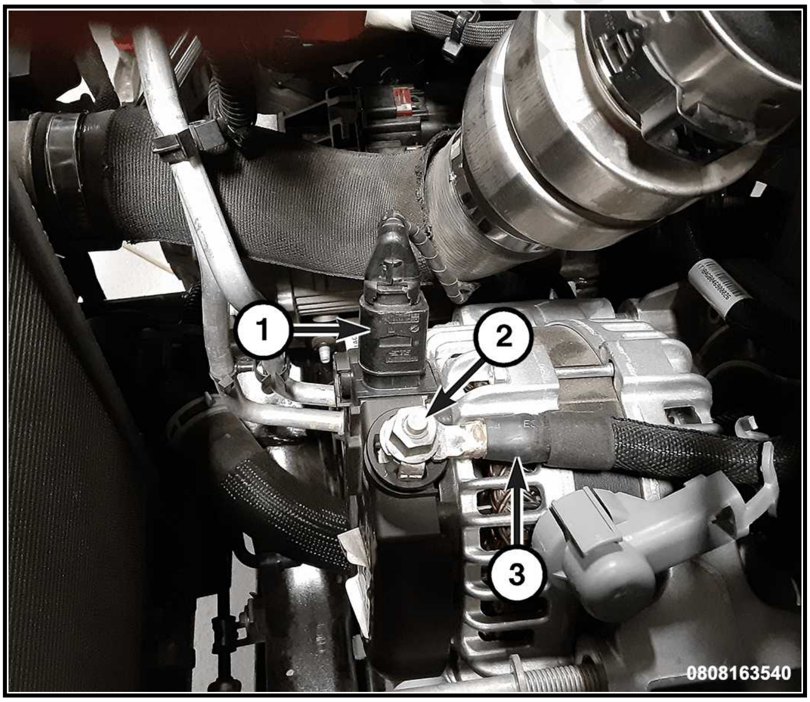
REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the serpentine belt. Refer to **BELT, SERPENTINE, REMOVAL AND INSTALLATION** .
3. Remove the cooling fan. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION** .



1 - B+ Cable Protective Cover	

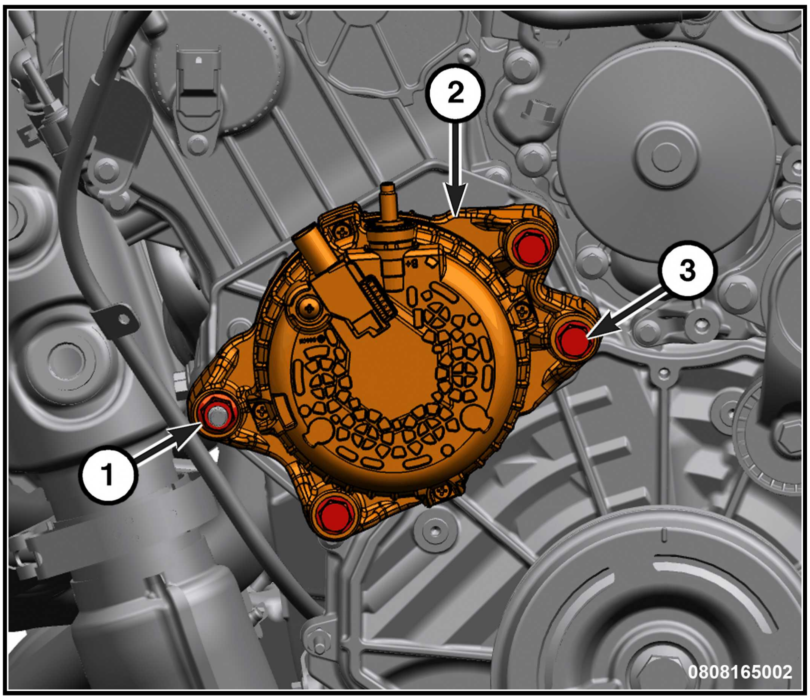
4. Remove the protective cover from the B+ cable.



1 - Wire Harness Connector
2 - B+ Nut
3 - Cable

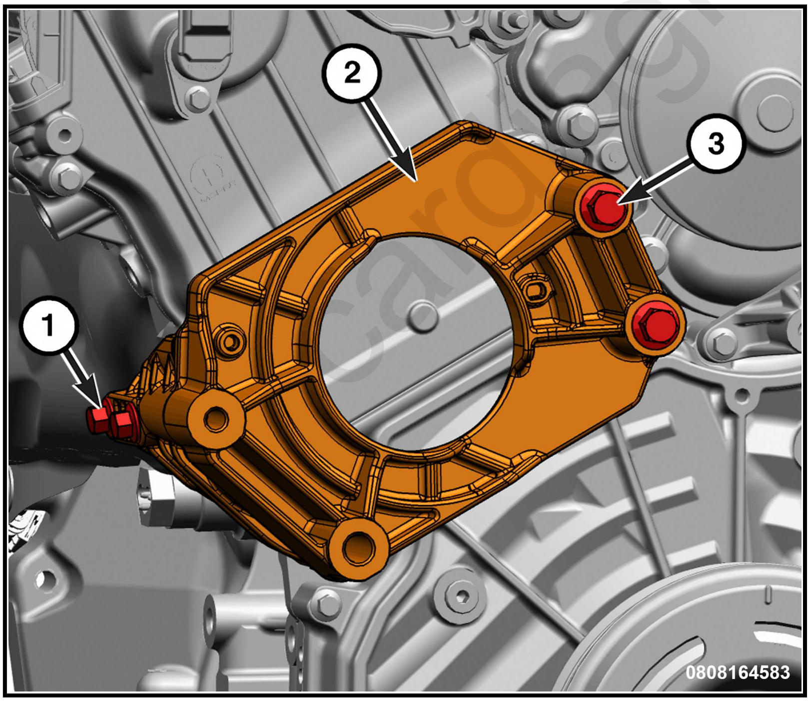
5. Disconnect the field generator wire harness connector.

6. Remove the B+ nut and cable from the generator.



1 - Generator Nut	
2 - Generator	
3 - Generator Bolts	

7. Remove the fasteners and the generator.



1 - Generator Bolts	
2 - Generator Mounting Bracket	
3 - Generator Bolts	

8. If necessary, remove the bolts and the generator mounting bracket.

INSTALLATION

During installation, torque the fasteners to the specifications in the torque table(s) below.

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Position the generator and route the serpentine belt on the generator before installing the generator bolts.

TORQUE SPECIFICATIONS

CHARGING SYSTEM - 3.0L

DESCRIPTION	SPECIFICATION	COMMENT
Generator Bolts	**63 N.m (48 Ft. Lbs.)**	-
Generator B+ Cable Nut	**20 N.m (15 Ft. Lbs.)**	-
Generator Nut	**63 N.m (48 Ft. Lbs.)**	-
Generator Stud	**10 N.m (89 In. Lbs.)**	-