

CHARGING SYSTEM DESCRIPTION A...**CHARGING SYSTEM DESCRIPTION AND OPERATION (GENERATOR/BATTERY CONTROL MODULE) (ENGINE ELECTRICAL)**Document ID#
1467477**Charging System Description and Operation (Generator/Battery Control Module)****Electrical Power Management (EPM) Overview**

The Electrical Power Management (EPM) System is designed to monitor and control the [charging system](#) and send diagnostic messages to alert the driver of possible problems with the battery and generator. This EPM System primarily utilizes existing on-board computer capability to maximize the effectiveness of the generator, to manage the load, improve battery state-of-charge (SOC) and life, and minimize the systems impact on fuel economy. The EPM System performs 3 functions:

- It monitors the battery voltage and estimates the battery condition.
- It takes corrective actions by adjusting the regulated voltage.
- It performs diagnostics and driver notification.

The battery condition is estimated during key-off and during key-on. During key-off the SOC of the battery is determined by measuring the open-circuit voltage. The SOC is a function of the acid concentration and the internal resistance of the battery, and is estimated by reading the battery open-circuit-voltage when the battery has been at rest for several hours.

The SOC can be used as a diagnostic tool to tell the customer or the dealer the condition of the battery. Throughout key-on the algorithm continuously estimates SOC based on adjusted net amp hours, battery capacity, initial SOC, and temperature.

While running, the battery degree of discharge is primarily determined by a battery current sensor, which is integrated to obtain net amp hours.

In addition, the EPM function is designed to perform regulated voltage control (RVC) to improve battery SOC, battery life, and fuel economy. This is accomplished by using knowledge of the batteries SOC and temperature to set the charging voltage to an optimum battery voltage level for recharging without detriment to battery life.

The [Charging System](#) Description and Operation is divided into 3 sections. The first section describes the [charging system](#) components and their integration into the EPM. The second section describes [charging system](#) operation. The third section describes the instrument panel cluster operation of the charge indicator, driver information center messages and voltmeter operation.

Charging System Components**Generator**

The generator is a serviceable component. If there is a diagnosed failure of the generator it must be replaced as an assembly. The engine drive belt drives the generator. When the rotor is spun it induces an alternating current (AC) into the stator windings. The AC voltage is then sent through a series of diodes for rectification. The rectified voltage has been converted into a direct current (DC) for use by the vehicles electrical system to maintain electrical loads and the battery charge. The voltage regulator integral to the generator controls the output of the generator. It is not serviceable. The voltage regulator controls the amount of current provided to the rotor. If the generator has field control circuit failure, the generator defaults to an output voltage of 13.8 volts.

Generator Battery Control Module

The generator battery control module is a class 2 device. It communicates with the powertrain control module (PCM), instrument panel cluster and the body control module for electrical power management (EPM) operation. It is a serviceable component that is connected to the negative battery cable at the battery. It directly controls the generator field control circuit, charge indicator control, input to the generator. It continuously monitors the generator field duty cycle signal circuit and the battery voltage. If the generator battery control module loses communication with the PCM, the default voltage will be set to 13.8 volts and the module will set U1016. If the generator battery control module loses communication with the body control module (BCM), the module will set U1064.

Powertrain Control Module (PCM)

The PCM provides information over the class 2 serial data circuit to the generator battery control module. The generator battery control module monitors the following data parameters provided by the PCM:

- Intake air temperature

- Fuel grams per second
- Throttle position
- Engine cooling fan speed
- Engine coolant temperature
- Exterior Environment – Outside Air Temperature

The generator battery control module uses these data parameters for different **charging system** modes depending on the required voltage needed.

Instrument Panel Cluster (IPC)

The instrument panel cluster (IPC) provides a means of customer notification in case of a failure. There are two means of notification, a battery charge indicator and a driver information center message of SERVICE **CHARGING SYSTEM** FAILURE and **CHARGING SYSTEM** FAULT.

Charging System Operation

The purpose of the **charging system** is to maintain the battery charge and vehicle loads. There are 9 modes of operation and they include:

- Charge Mode
- Fuel Economy Mode
- Voltage Reduction Mode
- Start Up Mode
- Headlamp Mode
- Battery Sulfation Protection Mode
- Windshield Wiper Voltage Boost Mode
- Fuel Pump Voltage Boost Mode
- De-Ice Voltage Boost Mode

The generator battery control module monitors the generator performance through the generator field duty cycle signal circuit, the generator field control circuit, and the battery positive voltage circuit. The generator battery control module controls the generator through the generator field control, charge indicator control, circuit. The signal is a 5-volt pulse width modulation (PWM) signal of 128 Hz +/- 5 percent with a duty cycle of 0–100 percent. The duty cycle sent by the generator battery control module is limited between 36–90 percent. When the engine is turned OFF, the module will send 0 percent duty cycle, low voltage. When there is loss of class 2 communication with the powertrain control module (PCM), the module will send 100 percent duty cycle, 13.8 volts. The following table shows the commanded duty cycle and output voltage of the generator:

Commanded Duty Cycle	Generator Output Voltage
10%	11.0 V
20%	11.56 V
30%	12.12 V
40%	12.68 V
50%	13.25 V
60%	13.81 V
70%	14.37 V
80%	14.94 V

90%

15.5 V

The generator provides a feedback signal of the generator voltage output through the generator field duty cycle signal circuit to the generator battery control module. The signal is a 5-volt PWM signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–99 percent. Between 0–5 percent and 100 percent are for diagnostic purposes.

Charge Mode

The generator battery control module will enter Charge Mode when at least one of the following conditions is met:

- The electric cooling fans are on high speed.
- The rear defogger is ON.
- The battery state of charge is less than 80 percent.
- The battery current is not between -8 and 15 amps.
- The estimated ambient air temperature is less than 0°C.
- DTC B1516 is set.

Once one of these conditions are met the generator battery control module will set the targeted generator output voltage to the nominal optimum battery voltage which is from 13.9–15.5 volts, the voltage set point is based on the batteries state of charge and estimated battery temperature. The battery voltage ramps up to the targeted set point at a rate of 20 mV per second.

Fuel Economy Mode

The generator battery control module will enter Fuel Economy Mode when all of the following conditions are true:

- Estimated ambient air temperature is equal to or greater than 0°C (32°F).
- The calculated battery current is less than 15 amperes and greater than - 8 amperes.
- The battery state of charge is greater than or equal to 80 percent.
- The rear defoggers are turned OFF.
- The electric cooling fans are on low speed or OFF.

The targeted generator output voltage is 13 volts. The generator battery control module will exit this mode once the criteria are met for Charge Mode or it will boost voltage to a pre-determined set point for the fuel pump, headlamps, or windshield wipers.

Voltage Reduction Mode

The generator battery control module will enter Voltage Reduction Mode when the calculated ambient air temperature is above 0°C (32°F); the calculated battery current is less than 2 amperes and greater than -7 amperes, the generator field duty cycle is less than 99 percent. the rear defoggers are turned OFF, and the electric cooling fans are on low speed or OFF. Its targeted generator output voltage is 87 percent of the Charge Mode set point but limited to 12.9 volts. The generator battery control module will exit this mode once the criteria are met for Charge Mode or it will boost voltage to a pre-determined set point for the fuel pump, headlamps, or windshield wipers.

Start Up Mode

After the engine has started the generator battery control module sets a targeted generator output voltage of 14.5 volts for 30 seconds.

Headlamp Mode

The generator battery control module will enter the Headlamp Mode when the headlamps, low or high beams, are turned ON. The voltage will ramp up or down to 14.5 volts at a rate of 10 mV/second. The module will exit this mode once the headlamps are turned OFF and enter Charge Mode, Fuel Economy Mode, or Voltage Reduction Mode.

Battery Sulfation Mode

The generator battery control module will enter this mode when the interpreted generator output voltage is less than 13.2 volts for 45 minutes. Once in this mode the generator battery control module will set the targeted output voltage to the nominal optimum battery voltage, see Charge Mode, for 3 minutes. The generator battery control module will then determine which mode to enter depending on vehicle conditions.

Windshield Wiper Voltage Boost Mode

When the generator battery control module is in Fuel Economy Mode or Voltage Reduction Mode, the module will boost battery voltage to 14.5 volts when the windshield wipers are ON, intermittent, low, or high speed, after 8 seconds. The voltage will ramp to 14.5 volts at a rate of 50 mV/second. The module will exit this mode once the Windshield Wipers are OFF for 5 seconds and the module will enter Charge Mode, Fuel Economy Mode, or Voltage Reduction Mode.

Fuel Pump Voltage Boost Mode

When the generator battery control module is in Fuel Economy Mode or Voltage Reduction Mode, the module will immediately boost battery voltage to 13.4 volts when the instantaneous fuel flow is greater than 21k grams/second and the throttle position sensor pedal position is greater than 90 percent. The module will exit this mode once the instantaneous fuel flow is less than 5k grams/second and enter Charge Mode, Fuel Economy Mode, or Voltage Reduction Mode.

De-Ice Voltage Boost Mode

The generator battery control module will enter De-Ice Voltage Boost Mode when the estimated ambient air temperature is less than or equal to -1°C and the engine coolant temperature is less than or equal to 75°C. The module will be in Charge Mode if the above conditions are true. Once the engine coolant temperature becomes greater than 75°C, the module will remain in Charge Mode or enter Fuel Economy Mode or Voltage Reduction Mode based on the vehicle conditions.

Instrument Panel Cluster (IPC) Operation

Charge Indicator Operation

The instrument panel cluster (IPC) illuminates the charge indicator in the message center when the one or more of the following occurs:

NOTE: The generator battery control module is not set up to set a DTC if the battery voltage is too high or too low. Check with the powertrain control module (PCM) to see if they set a DTC when the battery voltage is too high or too low.

- The IPC determines that the system voltage is less than 11 volts or greater than 16 volts. The IPC receives a class 2 message from the body control module (BCM) indicating there is a system voltage range concern.
- The IPC performs the displays test at the start of each ignition cycle. The indicator illuminates for approximately 3 seconds.
- The ignition is ON, with the engine OFF.
- The generator battery control module determines there is a fault and sends a class 2 message to the IPC to illuminate the charge indicator.

Charging System Failure

The generator battery control module will send a class 2 message to the IPC for the **CHARGING SYSTEM FAILURE** message to be displayed. It is commanded ON when DTC B1487 sets. The message is turned off when the conditions for clearing the DTC have been met and after an ignition cycle.

Service Charging System

The generator battery control module will send a class 2 message to the IPC for the **SERVICE CHARGING SYSTEM** message to be displayed. It is commanded ON when DTC B1390, B1488, B1492, or B1516 sets. The message is turned off when the conditions for clearing the DTC have been met and after an ignition cycle.

Battery Voltage Gauge Operation

The IPC displays the system voltage as received from the BCM over the GMLAN serial data circuit. If there is no communication with the BCM then the gauge will indicate minimum.

Utilities and light duty full size pickups are equipped with a new regulated voltage control (RVC) system. This system turns off the alternator when it is not required in order to improve fuel economy. The generator will turn back on when additional voltage is required. This will cause the voltmeter to fluctuate between 12 and 14 volts as opposed to non-regulated systems which usually maintain a more consistent reading of 14 volts. This fluctuation with the RVC system is normal system operation and NO repairs should be attempted.

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