Valeo

TECHNICAL
BULLETIN

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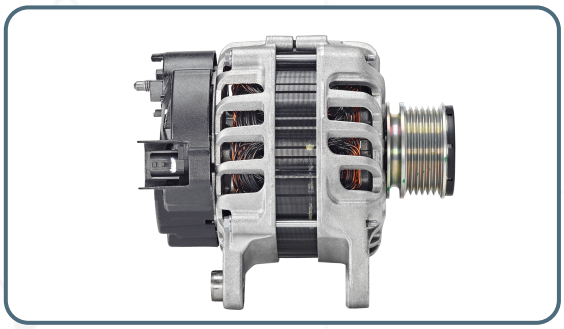


SMART ALTERNATORS AND SMART CHARGING SYSTEMS

Applicable to:
All smart alternators

TECHNICAL SERVICE BULLETIN

This document must be thoroughly reviewed prior to the replacement of the alternator. Compliance with the procedures and recommendations herein is essential to ensure optimal performance and longevity of the spare part.
Installation must be performed exclusively by a trained and qualified professional.

SMART CHARGING SYSTEMS

In modern vehicles, the push for greater fuel efficiency and reduced emissions has led to the development of more intelligent electrical systems. The key component of this evolution is the **smart alternator**.

A **smart alternator**, sometimes called a variable voltage alternator, is an alternator whose electrical output is not fixed but is actively controlled by an external computer, typically the vehicle's Powertrain Control Module (PCM).

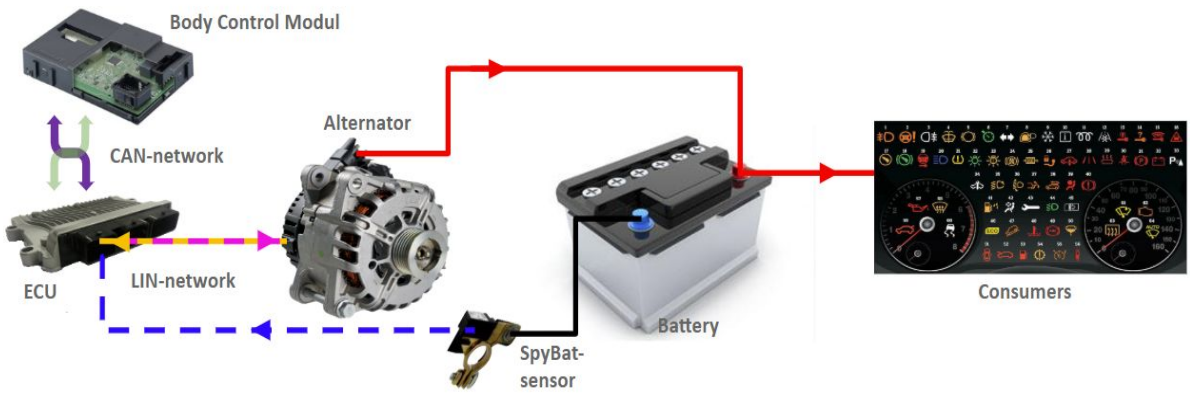
How does it differ from a traditional alternator ?

- **Traditional alternator:** contains an internal voltage regulator that aims to maintain a relatively constant charging voltage (usually between **13.8 V and 14.4 V**) whenever the engine is running. Its primary job is to keep the battery charged and power the vehicle's consumers
- **Smart alternator**: does not have a simple, fixed output. The PCM can command it to increase, decrease, or even temporarily stop its output based on the vehicle's real-time needs. The voltage can fluctuate significantly, sometimes dropping as low as 12.3 V and peaking around 15 V.

A **smart charging system** is the entire network of components and logic that controls the smart alternator. It's the "brain" that makes the alternator "smart." This system integrates the alternator into the vehicle's overall energy management strategy.

KEY COMPONENTS AND FUNCTIONS OF A SMART CHARGING SYSTEM

- **The smart alternator:** the "muscle" of the system, generating the electrical power as commanded.
- **The PCM:** the "brain" that makes all the decisions. It constantly analyzes information from various sensors.
- **Battery sensor:** a crucial component, often located on the negative battery terminal. It monitors the battery's state of charge, temperature, and overall health.
- **Vehicle sensors:** the PCM also takes into account other data like engine speed, vehicle speed, accelerator pedal position, and electrical load (e.g., if you turn on the headlights, A/C, or heated seats).



HOW IT ALL WORK TOGETHER ?

The PCM uses all this sensor data to make intelligent decisions about when and how much to charge the battery. The goal is to reduce the mechanical load that the alternator puts on the engine, which in turn saves fuel, sothe emissions and consequently less workload for the alternator.

- **During acceleration,** the system might reduce the alternator's output to dedicate more engine power to the wheels, improving performance and fuel economy.
- **During deceleration or braking,** the system will command the alternator to increase its output to maximum.
- **When the battery is full,** if the battery sensor indicates a high state of charge (e.g., 80-85%), the system may lower the alternator's output to the bare minimum needed to run the car's consumers, preventing overcharging and reducing engine drag.

KEY BENEFITS OF A SMART CHARGING SYSTEM

- **Improved fuel efficiency:** by reducing unnecessary load on the engine, the vehicle consumes less fuel.
- **Lower emissions:** less fuel burned means fewer CO2 and other harmful emissions are produced.
- **Enhanced battery life:** the system is designed to maintain the battery at an optimal state of charge (often around 80%) and avoid the damaging effects of constant overcharging.
- **Better vehicle performance:** minimizing engine load during acceleration can provide a slight boost in performance.
- **Increase alternator lifetime**

COMMUNICATION PROTOCOLS

Several communication protocols are used in the smart alternators:

- **C Terminal / RLO:** the PCM sends a simple, one-way command signal down a single wire to the alternator's C-Terminal, telling it when to reduce its charging output in order to improve fuel economy.
- **BSS Bit Synchronous Signal:** it works as a two-way digital conversation on a single wire, where the PCM sends commands to the alternator and the alternator replies with detailed status and diagnostic data. It is a direct predecessor to the more universal LIN Bus system.
- **PWM Pulse Width Modulation:** it works by having the PCM send a digital signal of ON/OFF pulses, where the percentage of "on" time (duty cycle) directly commands the alternator's charging output level.
- **GENMON GENerator MONitor / GENCOM GENerator COMmand:** it uses two dedicated wires for a two-way conversation: one wire (GENCOM) for the PCM to send charging commands to the alternator, and a second wire (GENMON) for the alternator to report its operational status back.
- **LIN Local Interconnect Network:** enables a two-way digital conversation on a single wire, allowing the PCM to precisely command the alternator's charging voltage and receive back detailed operational data like temperature and load.

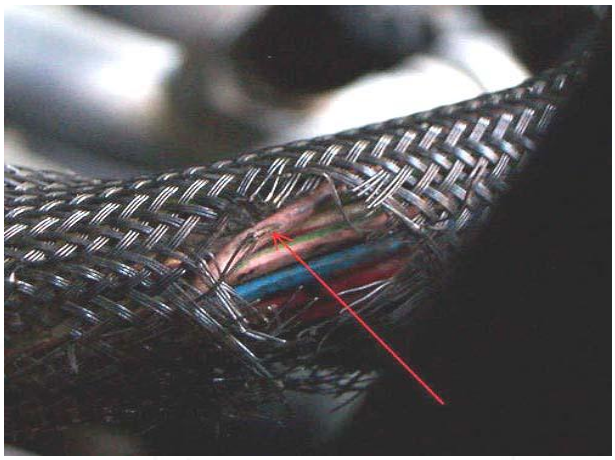
GENERIC DIAGNOSTIC PROCESS FOR SMART ALTERNATORS

1. Verify the Battery Type and Health

You should always start by confirming the battery is the **correct type for the vehicle**, fully charged and in good state (no corrosion, overheat...). A thorough inspection of all power and ground cables, as well as the smaller control wires, is always a critical first step.

2. Visual Inspection

- Meticulously inspect the wiring for any signs of chafing, melting, or corrosion, especially near hot engine components.



- Check for secure connections at the alternator's connector and the main B+ terminal. Ensure the engine and chassis grounds are clean and tight.
- Inspect the alternator for any evidence of **fluid contamination (oil, coolant, etc.)** and for signs of **physical damage**, such as corrosion, cracks in the housing or a damaged pulley.

3. Check for Diagnostic Trouble Codes (DTC)

Using a Diagnostic tool, check for any DTC related to the alternator.

- Check for **DTCs** first. Look for codes, e.g. "Lost Communication with Alternator" or specific alternator faults (e.g. P0620).
- Look at **live data**. The scan tool should show what the PCM is requesting ("Alternator Requested Voltage") versus what the alternator is delivering ("Alternator Actual Voltage"). If the PCM is requesting 14.5 V but the alternator is only putting out 12.5 V, then there is a problem.

4. Isolate the Alternator / Default mode

The concept of forcing the alternator into a "default" or standalone charging mode is a common diagnostic strategy. However, how to do this and what to expect to see will vary depending on the car manufacturer and the model.

5. Analysing the Smart Charging Signals

For a more in-depth analysis, an oscilloscope is required to observe the communication between the PCM and the alternator. Refer to a wiring diagram specific to the vehicle that is being serviced in order to identify the correct pinout.

- Reference voltage/time: this wire provides a reference voltage based on time to the alternator.
- Communication line: this wire provides the communication between the PCM and the alternator.

6. Load Testing the System

A practical way to assess the smart charging system's response is to perform a load test.

- With all connections restored and the engine running, monitor the battery voltage.
- Turn on all major electrical consumers (high beams, fog lights, interior blower on high speed, rear defroster, etc.).
- The battery voltage should initially dip slightly and then recover to a stable charging voltage, and will vary depending on the battery's state of charge and temperature.
- If the voltage drops significantly and does not recover, it points to a problem with the alternator's ability to meet the electrical demand, which could be, for example, an internal fault or an issue with the command signal from the PCM.

SPECIFICITY FOR FORD SMART ALTERNATORS

The 'smart charging system' found in numerous Fords means the alternator is no longer a simple, self-regulating component. It is directly controlled by the vehicle's PCM, which uses sensor data to charge the battery with maximum efficiency. A common pitfall in diagnosing this system occurs when the battery light comes on; e.g. it is not necessarily a faulty alternator. Before condemning the alternator, it's crucial to verify few points:

1. Verify the Battery Type and Health

Ford's smart charging system is designed to work specifically with a **Silver Calcium battery**.

The charging strategy and voltages can be incompatible with conventional lead-acid batteries, leading to charging anomalies.

- Confirm the installed battery is a Silver Calcium type.
- Regardless of the type, perform a full battery health check. A faulty or deeply discharged battery can mimic alternator problems. The battery should be fully charged before proceeding with further tests.

2. Visual Inspection

A common point of failure in the Ford smart charging system is the wiring harness between the alternator and the PCM.

- Meticulously inspect the wiring loom for any signs of chafing, melting, or corrosion, especially near hot engine components. It is a common reason for Battery light switching ON on the dashboard. In that case, a wiring loom replacement will solve the issue.

- Check for secure connections at the alternator's 3-pin connector and the main B+ terminal. Ensure the engine and chassis grounds are clean and tight.
- Inspect the alternator for any evidence of fluid contamination (oil, coolant, etc.) and for signs of physical damage, such as cracks in the housing or a damaged pulley.

3. Check for Diagnostic Trouble Codes (DTC)

Using a Diagnostic tool, check for any DTC related to the alternator or the charging system.

4. Isolate the Alternator / Default mode

This crucial test helps determine if the alternator is capable of charging without commands from the PCM.

1. Disconnect the 3-Pin Connector: With the ignition off, carefully disconnect the 3-pin electrical connector from the alternator.

2. Start the Engine: start the vehicle and briefly raise the engine RPM to around 2,000. Attention: **the engine must not be ON for more than 30 seconds without the connector !**
3. Measure the Charging Voltage: with a multimeter, measure the voltage directly at the battery terminals. A healthy alternator in "default mode" will charge at a steady voltage, typically between 13.5V and 13.8V.
    a. If the voltage is within this range, the alternator itself is likely functional. The problem is more likely to be with the wiring, the PCM, or the battery.
    b. If the voltage remains at battery level (around 12.6V or less), and the preliminary checks are clear, the alternator is likely faulty.

5. Analysing the smart charging signals / output pins

For a more in-depth analysis, an oscilloscope is required to observe the communication between the PCM and the alternator. This involves back-probing the wires at the 3-pin connector while it is connected and the engine is running.
The three pins on the Valeo smart alternator connector have specific functions:

- Pin 1 (GENMON - Generator Monitor): this is the alternator's feedback signal to the PCM, indicating its current load. It should be a constant square wave.
- Pin 2 (GENCOM - Generator Command): this is the PCM's command signal to the alternator, requesting a specific charging rate. This signal will vary with electrical load.
- Pin 3 (Reference Voltage): this wire provides a reference voltage to the alternator.

6. Testing the Communication Signals

- **GENCOM** Signal Analysis:
  - With the engine running, turn on various electrical consumers (headlights, blower fan, heated screens). You should observe a change in the square wave pattern on the GENCOM line as the PCM requests more output from the alternator. The duty cycle of the signal will increase with the load.
    - If there is no change in the signal with changing loads, the PCM may not be sending the correct commands.

- **GENMON** Signal Analysis:
  - The GENMON signal should be a consistent square wave.
    - If the GENMON signal mirrors the GENCOM signal, it indicates a fault within the smart charging function of the alternator.

7. Load Testing the System

A practical way to assess the smart charging system's response is to perform a load test.

- With all connections restored and the engine running, monitor the battery voltage.
- Turn on all major electrical consumers (high beams, fog lights, interior blower on high, rear defroster, etc.).
  - The battery voltage should initially dip slightly and then recover to a stable charging voltage, and will vary depending on the battery's state of charge and temperature.
  - If the voltage drops significantly and does not recover, it points to a problem with the alternator's ability to meet the electrical demand, which could be, for example, an internal fault or an issue with the command signal from the PCM.

VALEO disclaims any and all liability for damage resulting from improper installation, handling, or operation of the product. In the event that the conditions outlined herein are not fully adhered to, VALEO reserves the right to refuse warranty coverage in the case of any failure of the alternator.