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Battery Charging Conditions

The following conditions may be observed during cold-start voltage tests until temperatures of electrical system components stabilize. The time it takes to reach optimum voltage and amps will vary with engine speed, load, and ambient temperature.

Maintenance/Low Maintenance Lead-Acid Battery:

Traditional lead acid batteries require lowest charge voltage of all vehicle battery chemistries. Battery cells must be maintained by periodically topping off with distilled water as required.

Maintenance-free Lead-Acid Battery:

Maintenance-free batteries are similar to Maintenance/ Low Maintenance batteries, but may require slightly higher charge voltage.

Deep-cycle/Marine Maintenance-free Battery:

Charge acceptance of these batteries may display characteristics similar to maintenance-free batteries and may charge faster due to generally lower capacity relative to size.

AGM (Absorbed Glass Mat) Maintenance-free Battery:

These dry-cell batteries respond better than standard maintenance-free batteries. If battery state of charge (SOC) drops to 75% or less, batteries should be recharged to 95% or higher separately from engine charging system to avoid damaging charging system components and to provide best overall performance. Charge acceptance of these batteries may display characteristics similar to maintenance batteries, but may require higher charge voltage and will draw significant current (<100 amps) when under 50% SOC.

Lithium Battery:

Lithium batteries have unique charging characteristics that differ from lead acid. These batteries require charging systems configured specifically for lithium battery chemistries. Contact CEN for more information on lithium battery charging systems and components.

Testing Guidelines

Professional service technicians rely on the following guidelines when testing electrical components.

Voltage testing:

- Set meter to proper scale and type (AC or DC).
- Be sure to zero the meter scale or identify the meter burden by touching meter leads together. Meter burden must be subtracted from final reading obtained.
- Be sure the meter leads touch source area only. Prevent short circuit damage to test leads or source by not allowing meter leads to touch other pins or exposed wires in test area.
- Be sure to use CEN tools designed especially for troubleshooting CEN alternators when available.

Resistance (ohm) testing:

- Set meter to proper scale.
- Be sure to zero the meter scale or identify the meter burden by touching meter leads together. Meter burden must be subtracted from final reading obtained.
- Be sure meter leads touch source area only. Allowing fingers or body parts to touch meter leads or source during reading may alter reading.
- Be sure reading is taken when source is at 70°F. Readings taken at higher temperatures will increase the reading. Conversely, readings taken at lower temperatures will decrease the reading.
- Be sure to test directly at the source. Testing through extended harnesses or cable extensions may increase the reading.
- "OL" as referenced in this document refers to open circuit: "infinite" resistance, typically in very high kilo- or megaohm range depending on meter and settings.

Diode testing:

- Diodes allow current to flow in one direction only. Typical voltage drop in forward bias can range from 0.1-0.85V. Meter should read OL in reverse bias. Check meter user manual for meter-specific testing guidelines.

Voltage drop testing:

- Measure voltage between B+ on alternator or power source and B- (ground) on alternator or source. Record reading. Move to batteries or other power source and measure again between B+ and B- terminals on battery or other power source. The difference between the two readings represents voltage lost within circuit due to, but not limited to, inadequate cable gauge or faulty connections.
- Voltage drop measurements must be taken with all electrical loads or source operating.

Dynamic/Live testing (Connecting power and ground to component to test operation/function out of circuit):

- Connect jumper leads directly and securely to power source contacts of component being tested.
- Make any connection to power and ground at power supply or battery source terminals. Do not make connection at component source terminals, as that may create an arc and damage component source terminals.

CEN N1509 and N1511 Dual Voltage Alternator Description and Operation

N1509 and **N1511** 100 A (28 /14 V) dual voltage alternators are internally rectified. All windings and current-transmitting components are non-moving, so there are no brushes or slip rings to wear out. Energize switch (commonly an oil pressure switch) activates regulator. Field coil is then energized. Upper voltage (28 V) is rectified with standard diodes. Lower voltage (14V) circuit output current is controlled by SCRs in the drive end housing. Alternator output current is self-limiting and will not exceed rated capacity of alternator.

N3207 regulator used with some units:

- maintains alternator output voltage at regulated settings as vehicle electrical loads are switched on and off.
- maintains equal voltage across battery terminals of series-connected batteries.

N2003 load and battery control device (LBCD) used with these units provides dual-voltage reverse polarity protection and independant control of battery-charging current.

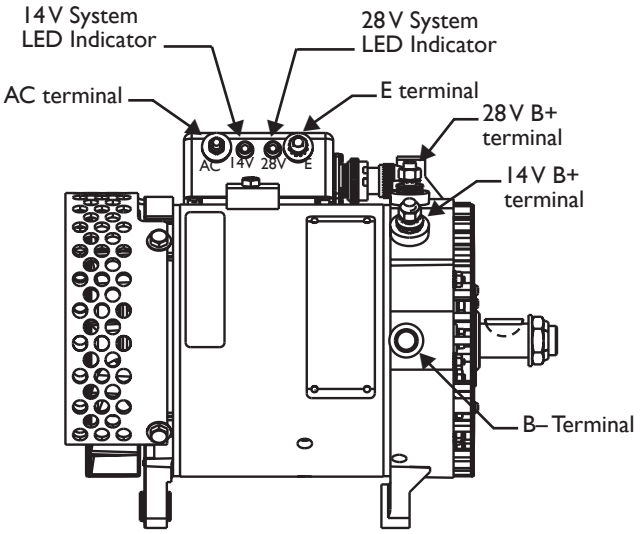


Figure 1 — N1509 Alternator and N3207 Regulator Terminals

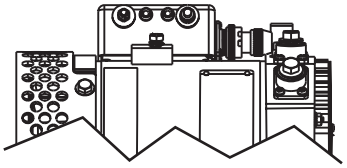


Figure 1 — N1511 Alternator and N3207 Regulator Terminals

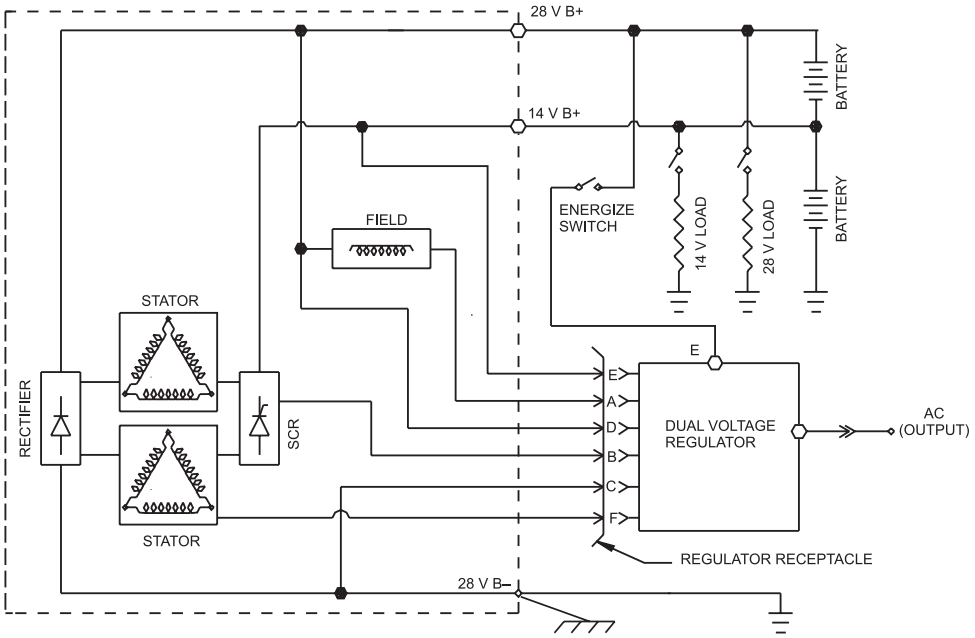


Figure 2 — N1509 and N1511 Alternators with Regulator

A. Tools and Equipment for Job

- Digital Multimeter (DMM)
- Ammeter (digital, inductive)
- Jumper wires

If no tools are available, monitor LED code.

B. Identification Record

List the following for proper troubleshooting:

❑ Alternator model number _____

❑ Regulator model number _____

❑ Setpoint listed on regulator _____

❑ LBCD model number _____

C. Preliminary Check-out

Check symptoms in Table 1 and correct if necessary.

TABLE 1 – System Conditions

SYMPTOM	ACTION
Low Voltage Output	Check: loose drive belt; low battery state of charge. Check: current load on system is greater than alternator can produce. Check: defective wiring or poor ground path; low regulator setpoint. Check: defective alternator and/or regulator.
High Voltage Output	Check: wrong regulator. Check: high regulator setpoint. Check: defective regulator. Check: alternator.
No Voltage Output	Check: presence of energize signal. Check: battery voltage at alternator output terminal. Check: defective alternator and/or regulator.
No 14 V Output	Go to "Flashing Amber" in Table 2, page 6.

D. Basic Troubleshooting

1. **Inspect charging system components**
   Check connections at ground cables, positive cables, and regulator harness. Repair or replace any damaged component before troubleshooting.

2. **Inspect load and battery control device connections**
   Connections must be in proper sequence and clean and tight. See Figure 5, page 7.

3. **Inspect connections of vehicle batteries**
   Connections must be clean and tight.

4. **Determine battery type, voltage and state of charge**
   Batteries must be all the same type for system operation. If batteries are discharged, recharge or replace batteries as necessary. Electrical system cannot be properly tested unless batteries are charged 95% or higher. See page 1 for details.

5. **Connect meters to alternator**
   Connect red lead of DMM to alternator 28 V B+ terminal and black lead to alternator B– terminal. Clamp inductive ammeter on 28 V B+ cable.

6. **Operate vehicle**
   Observe charge voltage.

   CAUTION If charge voltage is above 33 volts for 28 V system or 16 V for 14 V system, immediately shut down system. Electrical system damage may occur if charging system is allowed to operate at excessive voltage. Go to Table 1 at left.

   If voltage is at or below regulator setpoint, let charging system operate for several minutes to normalize operating temperature.

7. **Observe charge volts and amps in each circuit**
   Charge voltage should increase and charge amps should decrease. If charge voltage does not increase within ten minutes, continue to next step.

8. **Batteries** are considered fully charged if charge voltage is at regulator setpoint and charge amps remain at lowest value for 10 minutes.

9. **If charging system** is not performing properly, go to Chart 1, page 5.

N3207 Regulator

DESCRIPTION AND OPERATION

N3207 Regulator with OVCO is attached directly to the outside of alternator. Regulator setpoint has negative temperature compensation. At 75ºF, the setting is 28.2 V for 28 V system and 14.1 V for 14 V system.

Main diagnostic feature of N3207 regulator consists of two tricolored (red, amber, green) LEDs located on the side of the regulator. One LED indicates 28 V system performance, the other LED indicates 14 V system performance. The two LEDs work independently of each other. See Table 2 for diagnostic features and LED explanations.

OVCO (overvoltage cutout) will trip at any of the following conditions:

- 14 V side trips at voltage **higher** than regulator setpoint that exists longer than 3 seconds of reading voltage above 16 V. OVCO feature detects overvoltage and reacts by signaling relay in F– alternator circuit to open. This turns off alternator (14 V LED is steady RED light). OVCO circuit will reset by either:
  - — Restarting engine (regulator regains control of alternator output voltage) OR
  - — System falling below 11 V. OVCO will automatically reset.
- 28 V side trips at voltage **higher** than regulator setpoint that exists longer than 2 seconds of reading voltage above 32 V. OVCO feature detects overvoltage and reacts by signaling relay in F– alternator circuit to open. This turns off alternator (28 V LED is steady RED light). OVCO circuit will reset by either:
  - — Restarting engine (regulator regains control of alternator output voltage) OR
  - — System falling below 22 V. OVCO will automatically reset.

TROUBLESHOOTING

Shut down vehicle and restart engine. If alternator functions normally after restart, a “no output condition” was normal response of voltage regulator to overvoltage condition. Inspect condition of electrical system, including loose battery cables, both positive and negative. If battery disconnects from system, it could cause overvoltage condition in electrical system, causing OVCO circuit to trip.

If you have reset alternator once, and electrical system returns to normal charge voltage condition, there may have been a one time, overvoltage spike that caused OVCO circuit to trip.

If OVCO circuit repeats cutout a second time in short succession and shuts off alternator F– circuit, try third restart. If OVCO circuit repeats cutout a third time, check color of LED while engine is running.

28 V RED LED - go to Chart 3, page 6.

14 V RED LED - go to Chart 4, page 6.

TABLE 2 – N3207 Regulator LED Diagnostics

LED COLOR	STATUS
OFF	Regulator is not energized. Measure E terminal voltage. If voltage above 21 V, regulator is defective.
FLASHING Green	Respective system voltage is at regulated setting and operating under control.
Amber	Respective system voltage is below regulated setting. Alternator is not producing power or circuit is overloaded. See Chart 1 on page 5 for 28 V systems, Chart 2 for 14 V systems.
Red	Respective system voltage is above regulated setting. This may occur intermittently with voltage transients or with system faults.
STEADY Red	Alternator is shut down and is not producing power for either voltage. 28 V side trips after 2 seconds of reading voltage above 32 V. 14 V side trips after 3 seconds of reading voltage above 16 V. Regulator remains in this mode until reset by restarting engine or if system voltage drops below 22 V or 11 V, respectively. See Chart 3 on page 6 for 28V systems, Chart 4 for 14 V systems.

Chart 1 – 28 V LED Flashing AMBER – No 28V Alternator Output – Test Charging Circuit

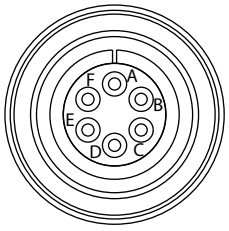
STATIC TEST – MASTER SWITCH ON, KEY ON, ENGINE OFF

Test for battery voltage at alternator 28 V B+ terminal. Does battery voltage exist?

- Yes
- No → Repair vehicle wiring as necessary. Continue test.

Jumper 28 V B+ terminal on alternator to E terminal on regulator. Wait 10 seconds. Run engine. Does alternator charge and is 28 V LED flashing GREEN?

- Yes → Turn off engine, leave key on. Remove jumper wire. Go to E terminal on regulator. Test for battery voltage going into E terminal from battery. Does battery voltage exist?
  - Yes → Run engine and re-test charging circuit for operation.
  - No → Repair vehicle circuit to E terminal. Vehicle charging circuit test is complete.
- No → Turn off engine, leave key on. Connect jumper wire from pin A in harness plug to B– terminal on alternator. Spark will occur. Touch steel tool to shaft to detect significant magnetism. is shaft magnetized?
  - No → Alternator is defective.
  - Yes → Test for battery voltage at pin D in harness plug. Does battery voltage exist?
    - No → Alternator is defective.
    - Yes → Connect DMM red lead to pin C on harness plug. Connect black leak to alternator B– terminal. Does continuity exist?
      - No → Alternator is defective.
      - Yes → Set DMM to diode test. Connect DMM red lead to pin F on harness plug. Connect black leak to alternator B+ terminal. Reverse leads. Meter should read OL in one direction, and voltage drop in the other direction. Do tests prove out?
        - No → Alternator is defective.
        - Yes → Regulator is defective.



PIN CONNECTIONS

Pin A	F–
Pin B	SCR Gate
Pin C	B–
Pin D	28 V B+
Pin E	14V B+
Pin F	AC

Figure 3 – Alternator-to-Regulator Harness Plug

Chart 2 – 14 V LED Flashing AMBER – No 14 V Alternator Output – Test Circuit

Run engine. Is 28 V LED on regulator flashing GREEN?

- Yes → With engine off, is battery voltage present at alternator 14 V B+ terminal?
  - Yes → Connect DMM red lead to pin E on alternator-to-regulator harness plug. Connect black lead to pin C on same plug. Does battery voltage exist?
    - Yes → Substitute a known good regulator. Run engine. Is regulator setpoint voltage present and is 14 V LED flashing GREEN?
      - Yes → Original regulator was defective.
      - No → Alternator is defective.
    - No → Alternator is defective.
  - No → Repair vehicle wiring as necessary. Continue test.
- No → Go to Chart 1.

Chart 3 – 28 V LED Steady RED– No Alternator Output – Test OVCO Circuit

Remove 28 V and 14 V positive battery cables AT BATTERY PACK before proceeding.

Unplug alternator-to-regulator harness from regulator. Connect red lead from DMM to socket A in plug. Connect black lead to socket D in plug. Does resistance read 2.2 ± 0.2 ohms?

- Yes → Set DMM to **manual ohms scale**. Connect red lead from DMM to socket A in plug. Connect black lead to B– terminal. Does meter read OL (out of limits)? Then connect red lead to socket D and black lead to B– terminal. Does meter read OL (out of limits)?
  - Yes → Reconnect cables. Replace existing regulator with known good regulator. Run engine. Does OVCO trip?
    - Yes → Alternator is defective.
    - No → Original regulator is defective.
  - No → Alternator is defective.
- No → Alternator is defective.

Chart 4 – 14 V LED Steady RED– No Alternator Output – Test OVCO Circuit

Run engine. Is 28 V LED on regulator flashing GREEN?

- Yes → Replace regulator with known good regulator. Run engine. Does OVCO trip?
  - Yes → Alternator is defective.
  - No → Original regulator is defective.
- No → Go to Chart 3.

N2003 Load & Battery Control Device
DESCRIPTION AND OPERATION

Main diagnostic feature of the LBCD is an LED display located on the side of the device. The LBCD monitors alternator output and vehicle electrical system and regulated voltage. If system voltage falls below 20.5 volts, N2003 will disconnect batteries and supply trickle charge. See Table 3 for diagnostic features and LED display explanations.

TABLE 4 – N2003 Harness Plug Pin Functions

Pin	Function
A	Battery Ground
B	Chg. System Indicator Ground Signal
C	Battery Disconnect Ground Signal
D	AC In from Regulator AC Terminal
E	Battery Voltage Sense/Trickle Charge

TABLE 3 – N2003 Load & Battery Control Device Diagnostics

CHARGING SYSTEM LED STATUS	N2003 LED COLOR	N2003 STATUS
ON	Unlit (Clear)	Alternator not charging.
ON	Solid Amber	Alternator RPM below 1500 rpm.
OFF	Solid Green	System operating properly. Batteries are connected to system. Alternator charging.
OFF	Solid Red	Batteries are disconnected from system and battery voltage is less than 24.5 V. Alternator 28 V B+ output terminal is at regulated voltage.

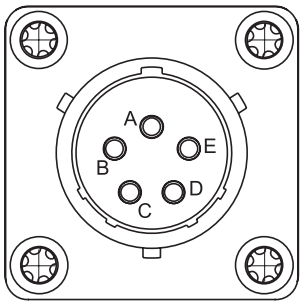
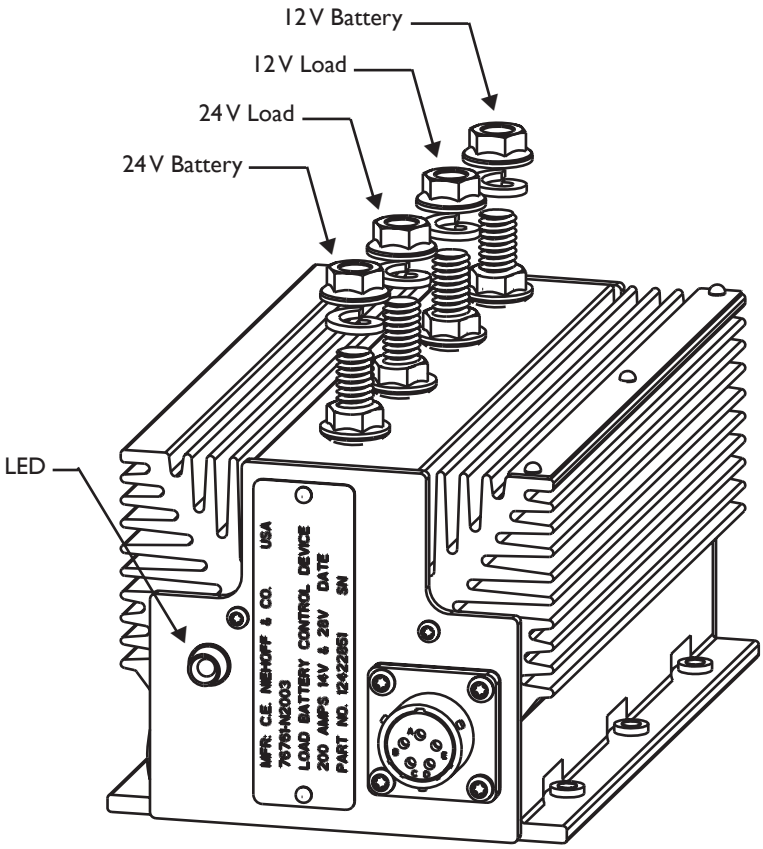


Figure 4 – N2003 Control Harness Receptacle



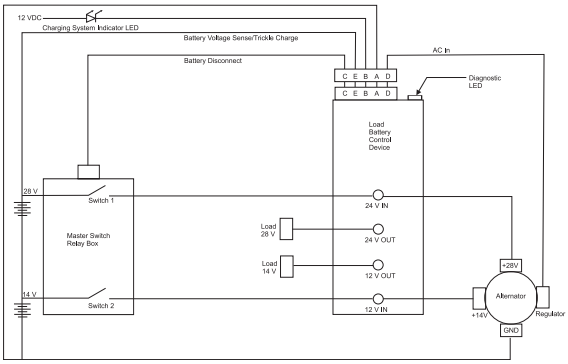


Figure 5 – N2003 Load & Battery Control Device

Chart 5 – 28V Only – N2003 Sequence of Operation