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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 C651 and C654 Alternators Description and Operation

**C651** 28 V (240 A)/14 V (100 A) and **C654** 28 V (260 A) /14 V (100 A) 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 activates regulator. Regulator cycles field coil off and on until system voltage is is reached. Upper voltage (28 V) is rectified with standard diodes. Lower voltage (14 V) 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.

**A2-306** regulator used with these units:

- is for use with batteries connected in series, not parallel.

  **CAUTION** Regulator is designed to control system through series not parallel circuits. See Figures 2 and 3 for connections.

- maintains alternator output voltage at regulated setting as vehicle electrical loads are switched on and off.
- monitors low and high batteries in system separately.
- limits 14 V alternator output current to 100 A. 14 V source from R terminal on regulator is limited to 1 A when alternator is rotating.

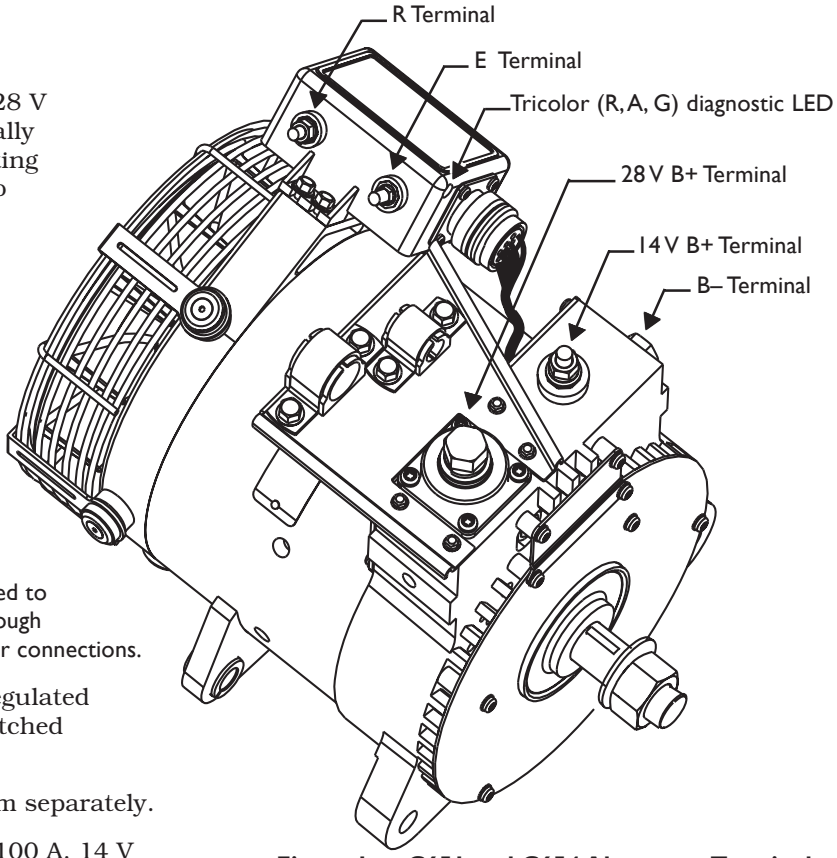


**Figure 1 — C651 and C654 Alternator Terminals**

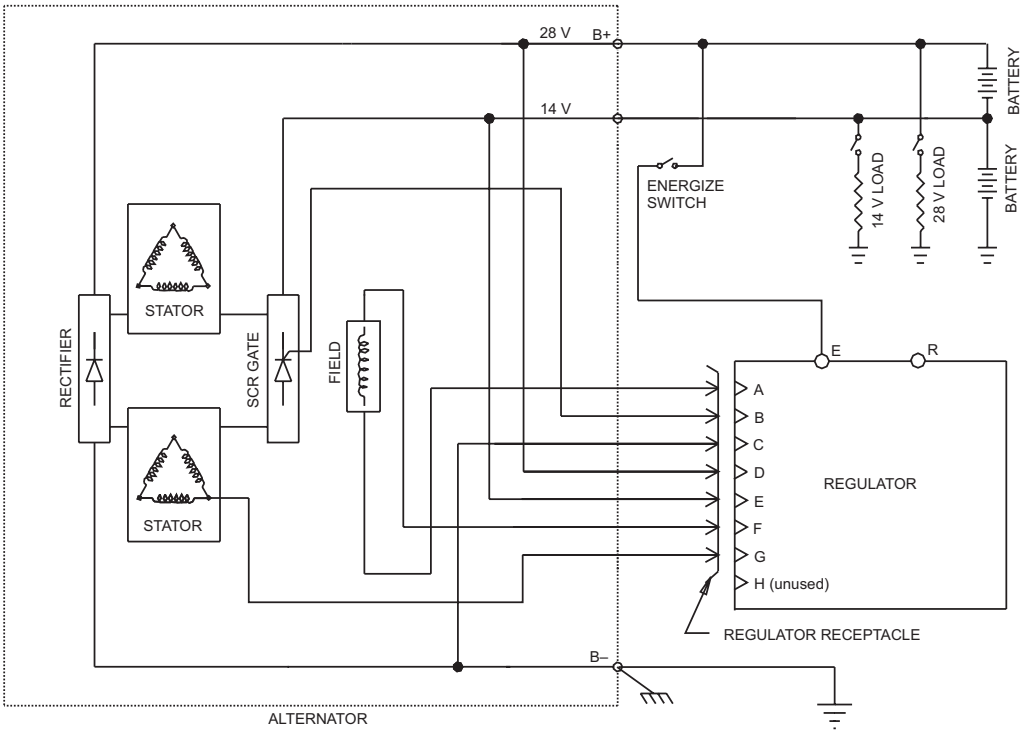


**Figure 2 — C651 and C654 Alternator with Regulator**

## A. Tools and Equipment for Job

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

## B. Identification Record

List the following for proper troubleshooting:

❑ Alternator model number _____

❑ Regulator model number _____

❑ Setpoints listed on regulator _____

## 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.<br>Check: current load on system is greater than alternator can produce.<br>Check: defective wiring or poor ground path; low regulator setpoint.<br>Check: defective alternator and/or regulator. |
| High Voltage Output | Check: wrong regulator.<br>Check: high regulator setpoint.<br>Check: defective regulator.<br>Check: alternator. |
| No Voltage Output | Check: broken drive belt.<br>Check: battery voltage at alternator output terminal.<br>Check: defective alternator and/or regulator. |
| No 14 V Output | Check: defective regulator. Go to Chart 3, page 6. |

## D. Basic Troubleshooting

1. **Inspect charging system components for damage**
   Check connections at B– cable, B+ cables, and regulator harness. Repair or replace any damaged component before troubleshooting.

2. **Inspect vehicle battery connections**
   Connections must be clean and tight.

3. **Determine battery voltages and states of charge**
   If batteries are discharged, recharge or replace batteries as necessary. Electrical system cannot be properly tested unless batteries are charged 95% or higher. In addition, open circuit voltages must be within ± 0.2 V.

4. **Connect meters to alternator**
   Connect meters as shown in Figure 3, page 4.

5. **Operate vehicle**
   Observe charge voltage.

   **CAUTION** If charge voltage is above 16 V on either high or low battery, immediately shut down system. Electrical system damage may occur if charging system is allowed to operate at high voltage. Go to Table 1 at left.

   Regulator setpoints indicate two different voltage measurements for this system. First setpoint is sum of low battery and high battery voltage measurements. Second setpoint is voltage measured across low battery only.

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

6. **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.

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

8. **If charging system** is not performing properly, go to Chart 4, page 7.

## A2-306 Regulator

### DESCRIPTION AND OPERATION

A2-306 Regulator with OVCO is attached directly to the outside of alternator.

Main diagnostic feature of A2-306 regulator is tricolored (red, amber, green) LED next to harness receptacle on regulator. LED works like a voltmeter, measuring charging voltage. See Table 2 on page 5 for diagnostic features and LED explanations.

Regulator with OVCO (overvoltage cutout) will trip at one of the following conditions:

- Voltage **higher** than regulator setpoint that exists longer than 3 seconds at low battery. OVCO feature detects high voltage and reacts by signaling relay in F+ alternator circuit to open. This turns off alternator (LED is steady AMBER light). Restarting engine resets OVCO circuit. Regulator regains control of alternator output voltage.
- Voltage **lower** than regulator setpoint that exists longer than 3 seconds at low battery. OVCO feature detects low voltage and reacts by signaling relay in F+ alternator circuit to open. This turns off alternator (LED is steady RED light). Restarting engine resets OVCO circuit. Regulator regains control of alternator output voltage.
- Voltage **higher** than regulator setpoint that exists longer than 3 seconds at high battery. OVCO feature detects high voltage and reacts by signaling relay in F+ alternator circuit to open. This turns off alternator (LED is steady RED light). Restarting engine resets OVCO circuit. Regulator regains control of alternator output voltage.

### TROUBLESHOOTING

Before troubleshooting, make sure batteries are connected in series, not parallel circuits. See Figures 2 and 3 for connections.

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

AMBER LED - go to Chart 1, page 5.

RED LED - go to Chart 2, page 5.

Listed regulator setpoints:

Position #1 - 27.5 V ± 0.2 V/13.8 V ± 0.1 V

Position #2 - 28.0 V ± 0.2 V/14.0 V ± 0.1 V

Position #3 - 28.5 V ± 0.2 V/14.2 V ± 0.1 V

Position #4 - 29.0 V ± 0.2 V/14.5 V ± 0.1 V

**NOTICE** Measurement from A to C is not used by regulator to control voltage. Regulator measures A to B and B to C separately.

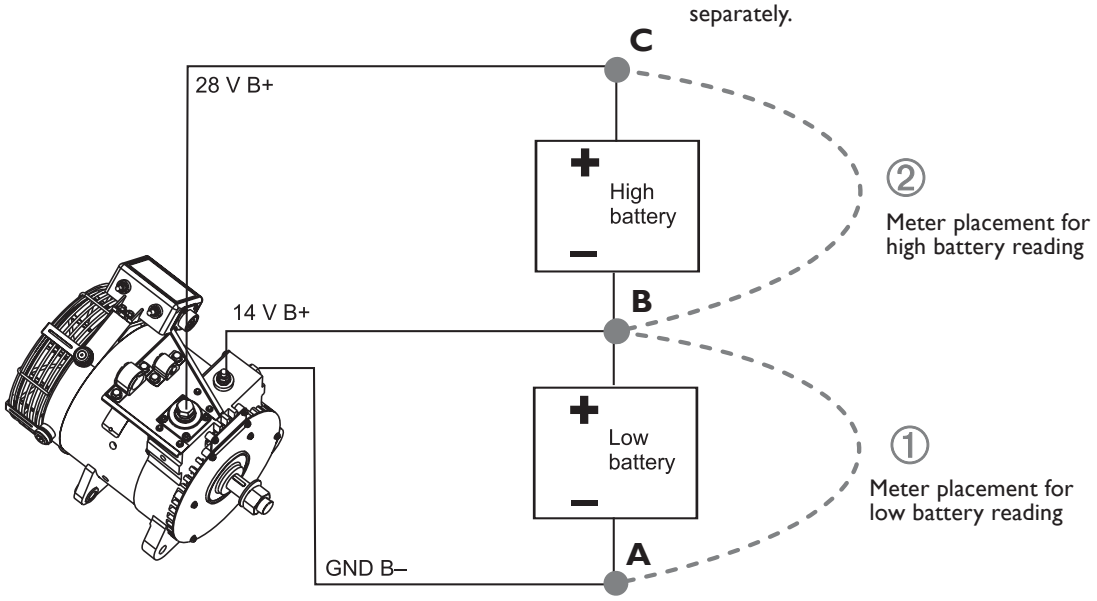


**Figure 3 – Meter Placement**

| TABLE 2 – A2-306 Regulator Diagnostics | | | |
|---|---|---|---|
| **LED COLOR** | | **STATUS** | **ACTION** |
| GREEN | Flashing (key on, engine running) | Alternator and regulator operating normally. | No action required. |
| AMBER | Steady (key on, engine off) | Low battery tripped OVCO. | See Chart 1 below. |
| | Flashing | Alternator not rotating or 14 V output voltage unstable. | |
| RED | Steady (key on, engine off) | High or low battery tripped OVCO. | See Chart 2 below. |
| | Flashing | 28 V output voltage unstable. | |
| GREEN/ AMBER | Flashing both colors | Low battery amp draw exceeds 125 amps. | 1. Check battery, system cable connections and grounds.<br>2. Perform load analysis.<br>3. If OK, replace alternator. |

## Chart 1 – AMBER LED On Steady – No Alternator Output – Test OVCO Circuit

**Make sure batteries are properly charged before proceeding.**

Replace regulator with known good regulator. Run engine. Does OVCO trip?

| Yes | No |
|---|---|
| Alternator is defective. | Original regulator is defective. |

## Chart 2 – RED LED On Steady – No Alternator Output – Test OVCO Circuit

**Make sure batteries are properly charged before proceeding.**

With engine running, measure voltage at low battery B+ terminal. See ① in Figure 3 on page 4. Is voltage equal to regulator set point or no more than 1 V below set point?

| Yes | No |
|---|---|
| Replace existing regulator with known good regulator. Run engine. Does OVCO trip? | System is overloaded. Check for excessive draw from accessories. |

| Yes | No |
|---|---|
| Alternator is defective. | Original regulator is defective. |

## Chart 3 – No 14 V Alternator Output – Test Circuit

With engine off, is battery voltage present at alternator 14 V B+ terminal?

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

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
- No → Alternator is defective.

Substitute a known good regulator. Run engine. Is regulator setpoint voltage present?

- Yes → Original regulator was defective.
- No → Alternator 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 | F+ |
| Pin G | AC Signal |
| Pin H | Not Used |

**Figure 4 – Alternator-to-Regulator Harness Plug**

## Chart 4 – No Alternator Output – Test Charging Circuit

### STATIC TEST – ENGINE OFF, BATTERY SWITCH ON, KEY ON

Test for battery voltage at both alternator 28 V and 14 V B+ terminals. Does battery voltage exist at both terminals?

- No → Repair vehicle wiring as necessary. Continue test.
- Yes → Jumper 28 V B+ terminal on alternator to E terminal on regulator. Run engine. Does alternator charge?

Jumper 28 V B+ terminal on alternator to E terminal on regulator. Run engine. Does alternator charge?

- 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?
- No → Turn off engine, leave key on. Connect jumper wire from pin F in harness plug to 28 V B+ terminal on alternator. Does spark occur?

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.

Repair vehicle circuit to E terminal. Vehicle charging circuit test is complete.

Run engine and re-test charging circuit for operation.

Turn off engine, leave key on. Connect jumper wire from pin F in harness plug to 28 V B+ terminal on alternator. Does spark occur?

- Yes → Alternator is defective.
- No → With previous jumper still in place, connect another 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?

Alternator is defective.

With previous jumper still in place, connect another 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?

- Yes → Disconnect jumper wires. Connect DMM red lead to pin D in alternator-to-regulator harness plug. Connect black lead to pin C in same plug. Does 24 V battery voltage exist?
- No → Alternator is defective.

Alternator is defective.

Disconnect jumper wires. Connect DMM red lead to pin D in alternator-to-regulator harness plug. Connect black lead to pin C in same plug. Does 24 V battery voltage exist?

- Yes → Connect DMM red lead to pin E in alternator-to-regulator harness plug. Connect black lead to pin C in same plug. Does 12 V battery voltage exist?
- No → Alternator is defective.

Alternator is defective.

Connect DMM red lead to pin E in alternator-to-regulator harness plug. Connect black lead to pin C in same plug. Does 12 V battery voltage exist?

- Yes → Regulator is defective.
- No → Alternator is defective.

Regulator is defective.

Alternator 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 | F+ |
| Pin G | AC Signal |
| Pin H | Not Used |

**Figure 5 – Alternator-to-Regulator Harness Plug**

If you have questions about your alternator or any of these test procedures, or if you need to locate a Factory Authorized Service Distributor, please contact us at:
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