Mysteries Revealed...

CUCV Dual Voltage Battery Charging Circuit

by Gary Wearley

This article describes and illustrates the dual voltage battery charging circuit for the CUCV (all except M1010). Emphasis is placed on the path taken by charging current arriving at the batteries from the alternators.

A TWO-BATTERY SYSTEM

The CUCV is based on the standard production, mid-1980s Chevrolet Pickup and Blazer, both of which have 12-volt electrical systems. The requirement for 24-volt compatibility with other military vehicles forced General Motors (GM) to make design alterations.

The manufacture was able to meet this 24-volt requirement by adding a second 12-volt battery and a second isolated 12-volt alternator with interconnecting wiring. GM also added some relays and diodes to provide isolation between the two voltages, resulting in a functional dual-voltage electrical system.

Most of the electrical components operate on 12 volts with the exception of the voltmeter, starter, diesel engine glow plug circuit, slave receptacle for jump-starting, and other 24-volt auxiliary service equipment.

The dual alternators and dual batteries are electrically connected in a way that allows each 12-volt alternator to provide on-demand charging current

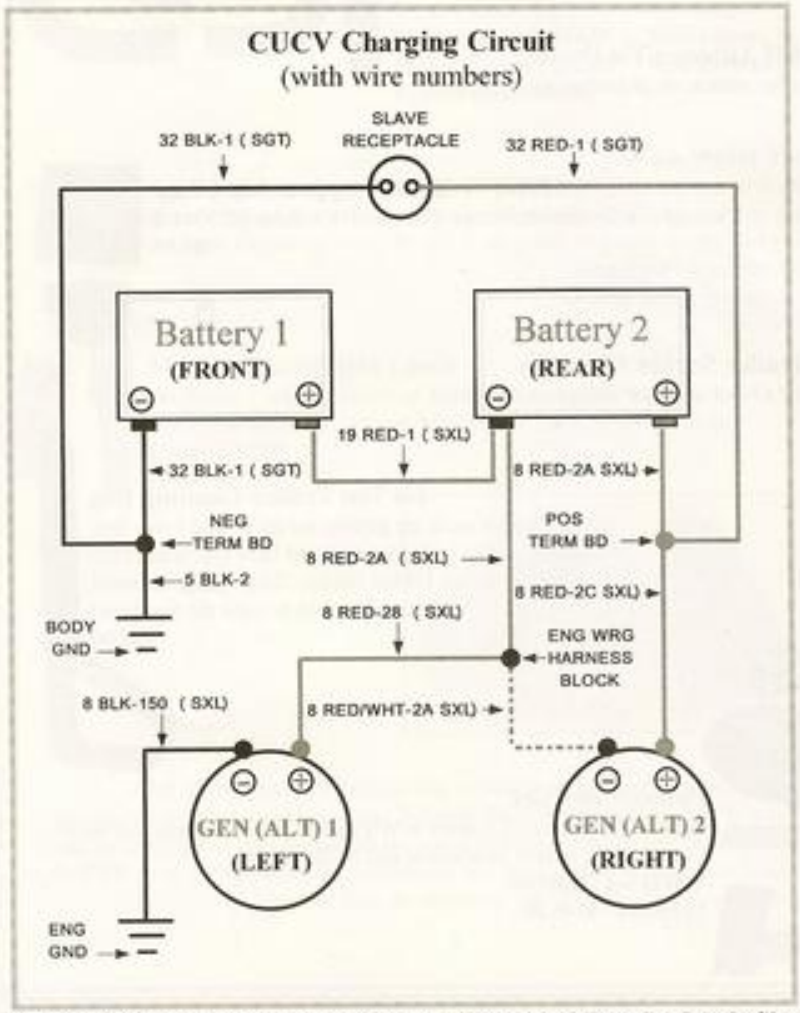

Figure 2. The theory of operation for the CUCV charging circuit is easily viewed with a simplified pictorial circuit diagram. The wire numbers and connections between devices are depicted just as they are connected on a correctly-wired M1009.

Figure 1. A battery load tester removes energy from a storage battery in much the same way starting an engine would. The experiment uses the load tester to draw the batteries down to a less than fully charged condition. DC current flow is measured using a simple hand-held low-current inductive ammeter.

to its respective 12-volt battery independent of the other alternator at times. However, under certain circumstances, both alternators are in series at 24 volts servicing both batteries at the same time in a 24-volt series configuration.

ILLUSTRATING THE PROCESS

The following information describes and illustrates the various conditions encountered during normal vehicle operation. This article provides illustrations presenting the theory of DC charging current flow, photographs showing actual observations, a description of test experiments followed by results and conclusions. All tests were made at the batteries, down stream and independent of vehicle load. Current is assumed to flow from positive to negative and is illustrated as such.

The hardware used for the test experiment:

*1985 M1009 (Blazer) with factory correct-charging circuit wire terminations

*12-volt battery load tester

*Inductive low-current DC ammeter

The battery load tester is designed to test the condition of a battery under load. When connected to a battery it can be switched on to draw a substantial amount of current from the battery. The current flow drains some of the stored energy resulting in a lower stored charge and can potentially result in the battery needing a charge.

The low-current inductive ammeter is a simple hand-held device designed to indicate the presence or lack of DC current flowing through a conductor. The inductive capabilities allow it to operate without circuit modifications as it is simply placed alongside an existing wire.

The meter indicates DC current flowing through a conductor by measuring the intensity and direction of the magnetic field produced by this current.

Figures 2 through 6 are pictorial circuit diagrams made from the wiring diagram "Figure F-9" in the Army technical manual, *TM 9-2320-289-20* and by physically tracing and identifying the wires on a 1985 M1009 CUCV. The truck's charging circuit wiring was found to be factory-correct matching the wiring diagram in the technical manual. The wire numbering system is described in the Trouble Shooting Electrical Malfunctions section of the technical manual. Fusible links and excitation circuits are intentionally omitted for clarity.

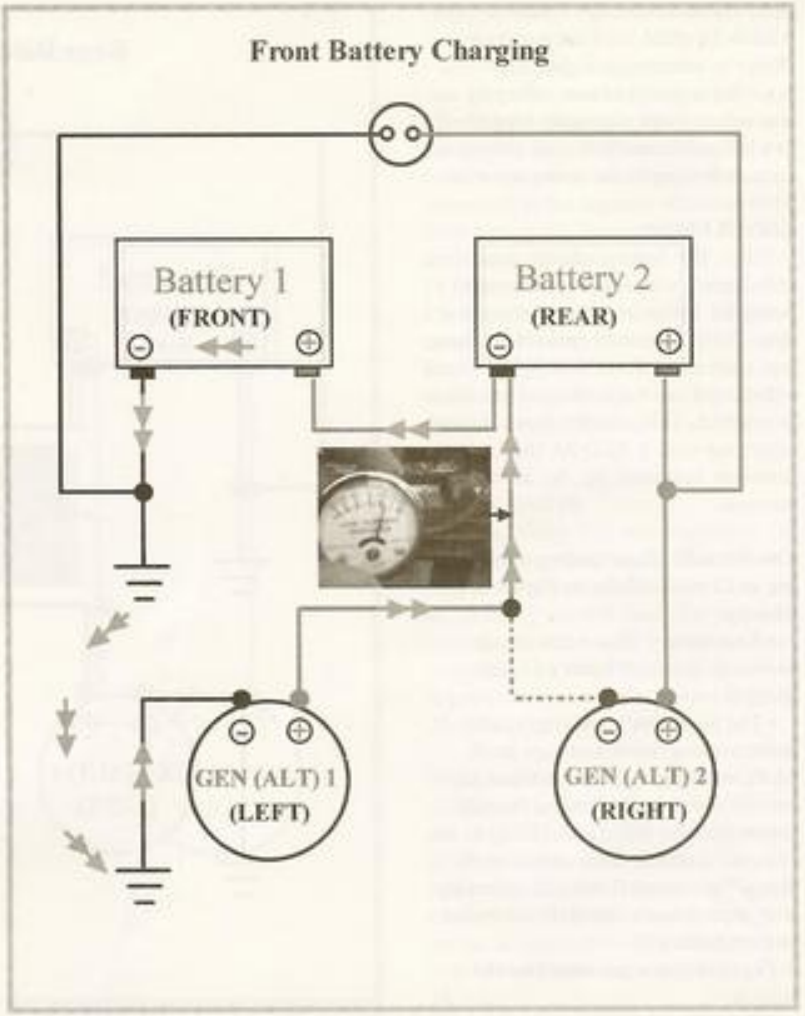

Figure 3. The driver's side (left) Alternator #1 monitors the charge condition of Battery #1 (front) and delivers 12-volt charging current, based on demand, through a common center-tap wire.

Condition #1 – Front battery only charging at 12 volts. (Refer to Figure 3)

Theory:

• Front battery #1 in a low charge level with the rear battery #2 fully charged.

• The driver's side (left) alternator, sensing this low charge level, produces charging current to front battery #1 with current flowing through center-tap wire 8 RED-2A (SXL). No current flowing in center-tap wire from passenger's side (right) alternator to rear battery #2.

Physical test experiment on the vehicle:

1. The test vehicle was started and allowed to run long enough for both batteries to come up to a full, or near fully-charged condition.

2. The low-current ammeter was placed on the various battery wires to confirm little or no charge current flowing.

3. The low-current ammeter was placed on center-tap wire 8 RED-2A (SXL)

4. The battery load tester was connected to the front battery #1 and a load was applied for a short period of time.

Observation Results:

• After the battery was loaded, heavy current flowed from the driver's side

(left) alternator through center-tap wire 8 RED-2A (SXL) to front battery #1. (Refer to ammeter in Figure 3)

• After a period of time, charging current reduced and eventually leveled off to a balanced condition with little or no current flowing in the center-tap wire.

CONCLUSION:

When the battery charge levels are unbalanced with the front battery #1 being the lower of the two, the driver's side (left) alternator provides charging current to front battery #1, until a balanced or fully charged condition is reached. This current flows through center-tap wire 8 RED-2A (SXL) in the direction indicated by the arrows and ammeter.

Condition #2 –Rear battery only charging at 12 volts. (Refer to Figure 4)

Theory:

• Rear battery #2 in a low charge level with the front battery #1 fully charged.

• The passenger's side (right) alternator, sensing this low charge level, produces charging current to rear battery #2 with current flowing through center-tap wire 8 RED-2A (SXL) in the opposite direction from condition #1 above. No current flowing in center-tap wire from driver's side (left) alternator to front battery #1.

Physical test experiment on the vehicle:

1. The test vehicle was again allowed to run long enough for both batteries to come up to a full, or near fully-charged condition.

2. The low-current ammeter was placed on the various battery wires to confirm little or no charge current flowing.

3. The low-current ammeter was placed on center-tap wire 8 RED-2A (SXL)

4. The battery load tester was connected to the rear battery #2 and a load was applied for a short period of time.

Observation Results:

• After the battery was loaded, heavy current flowed from the passenger's side (right) alternator through center-tap wire 8 RED-2A (SXL) to rear battery #2. (See ammeter in Figure 4) Notice the needle is in the opposite direction from condition #1 above.

• After a period of time, charging current reduced and eventually leveled off to a balanced condition with little or no current flowing in the center-tap wire.

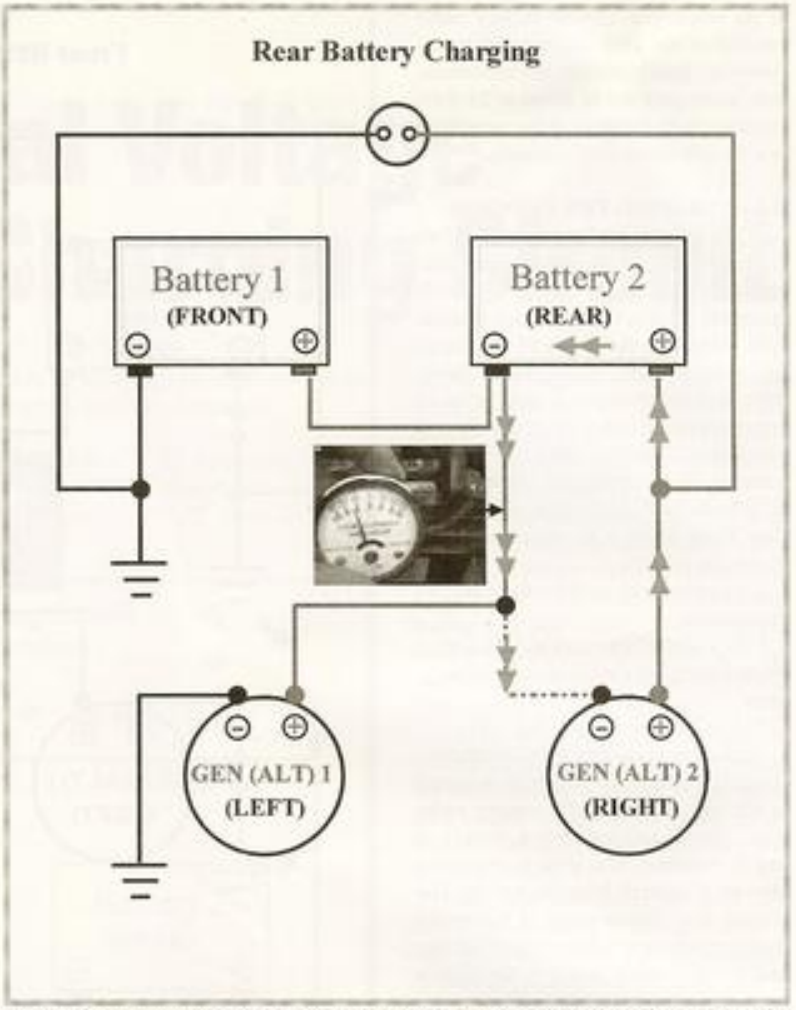

Figure 4. The passenger's side (right) Alternator #2 monitors the charge condition of Battery #2 (rear) and delivers 12-volt charging current, based on demand, through a common center-tap wire.

CONCLUSION

When the battery charge levels are unbalanced with the rear battery #2 being the lower of the two, the passenger's side (right) alternator provides charging current to rear battery #2, until a balanced or fully-charged condition is reached. This current flows through center-tap wire 8 RED-2A (SXL) in the opposite direction from condition #1 above in the direction indicated by the arrows and ammeter.

The center-tap wire is shared by both alternators and carries current produced by both. However, DC current can only flow in one direction at a time in a single conductor. This means both alternators cannot service both batteries simultaneously at 12 volts using the center-tap conductor.

Condition #3 –Both batteries charging in series at 24 volts. (Refer to Figure 5)

Theory:

• Both batteries at a low, but equal charge level.

• Each alternator, sensing a low charge level of its respective battery, produces charging current to its positive output terminal. Since both batteries are at an equal level, the load is balanced on each side of the center-tap. No charg-

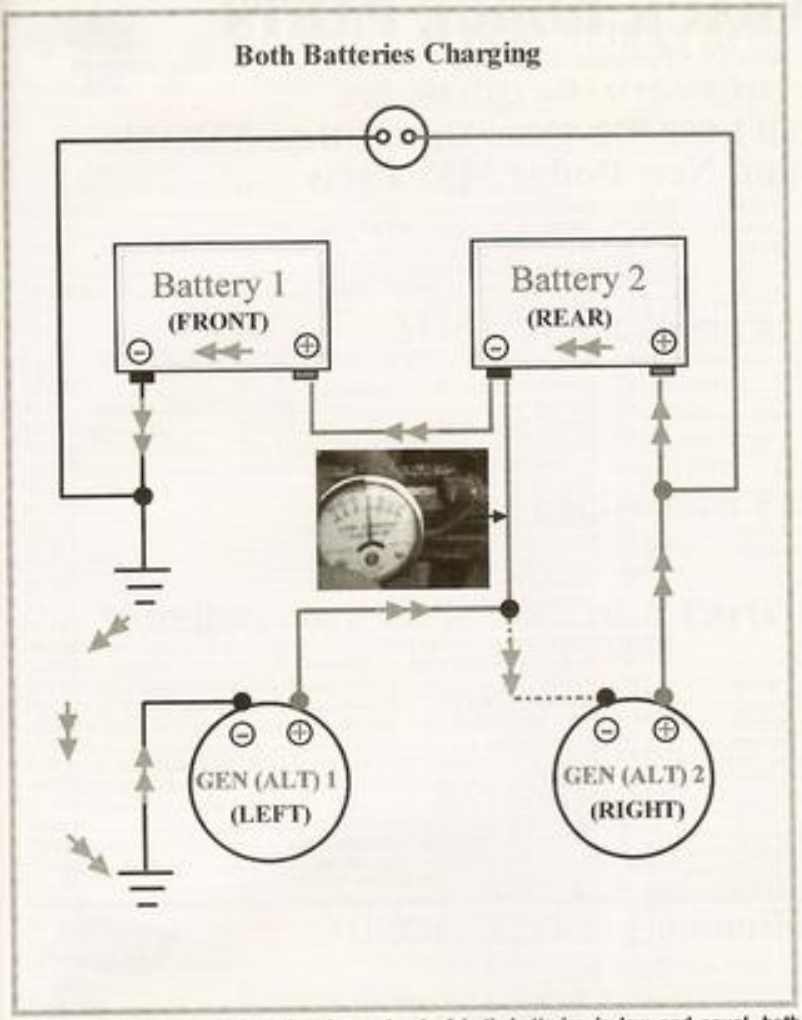

Figure 5. During times when the charge level of both batteries is low and equal, both alternators deliver charging current to both batteries at 24 volts with no current flowing in the common center-tap wire.

ing current flows in the center-tap wire. Charging current instead flows from alternator #1, through alternator #2, through battery #2, through battery #1, to ground.

Physical test experiment on the vehicle:

1. The test vehicle was slave-connected to a M35A2 having a 24-volt electrical system with its batteries at a lower charge level than the test vehicle. This connection allowed batteries in the test vehicle to drain some of their stored energy. The headlights in the M35A2 were turned on to further assist the process of draining battery energy from the test vehicle. They remained connected for one hour resulting in both batteries being at a low charge level with enough battery power remaining to start the test vehicle.
2. The slave cable was disconnected.
3. The test vehicle was started
4. The low-current ammeter was placed on the various battery wires to confirm heavy charge current flowing to both batteries. Minimal current was flowing through the center-tap wire to the front battery #1 indicating a slightly lower charge level.
5. The battery load tester was connected to the rear battery #2 and a load was applied for a short period of time while monitoring the current flowing through the center-tap wire. This was done until no center-tap current was detected, indicating a totally balanced battery condition. At this point both batteries were at a low, but equal, charge level.
6. The low-current ammeter was placed on the positive cable at the rear battery #2, the cable connecting the two batteries together, and the ground cable connected to the negative terminal at the front battery #1. Heavy current flow was detected at all locations.

Observation Results:

• After achieving a low, but balanced, condition for both batteries, by discharging to a balanced condition, both batteries received heavy charging current with no current flowing in the center-tap wire.

CONCLUSION

In a totally balanced condition, the batteries receive charging current in a series configuration at 24 volts. Any and all charging current flows through both batteries, in series, and both alternators, in series, at 24 volts. No charging current is present in the center-tap wire 8 RED-2A (SXL).

Both alternators send current through the center-tap wire 8 RED-2A (SXL) at separate times in different directions. Each 12-volt alternator will, at times, maintain the charge level of its respective 12-volt battery independent of the other. Both alternators are in series, at times, providing charging current to both batteries simultaneously at 24 volts.

This dual voltage battery charging circuit functions in the same way as the dual-voltage domestic 240/120 volt distribution system having a neutral wire (center-tap). When the 120-volt load, on each side of the line, is uneven (as measured in amps) the neutral conductor carries the difference. When the load is balanced, on each side of the line, no current flows in the neutral conductor. In the event of jump-starting another 24-volt vehicle using a slave cable, with the primary one running, both alternators are in series, supplying charging current at 24 volts.

The above conclusions were arrived at by actual tests made on a correctly-wired M1009 vehicle, thereby confirming the various theories by direct observation. Videos of the actual tests can be viewed at **www.froadin.com/cucv** ✪