Electrical fault finding

Modern vehicles have an impressive and increasing number of electrical systems. The mechanic cannot ignore electrics because there are not auto-electricians waiting in the wings.

Increasingly, the mechanic will be expected to do electrical fault finding. So it is important to understand what the mechanic can be expected to do and when the specialist (the auto electrician or specialist supplier) should be called in. This article presents a guide to electrical fault finding on heavy vehicles. Let's begin with some basis:

Voltage V:

The force of electricity. North American type trucks have nominal 12 V electrical systems and Europeans and Japanese vehicles have nominal 24V. The voltage is constant (DC). Measure voltage between points using a multimeter. Make sure it is reading DC.

Current I:

The flow of electricity. The current flows in a circuit because the voltage is pushing it through the resistance of the circuit. mMeasure current by inserting the multimeter into a circuit. Using a clamp ammeter is conjunction with a multimeter is a great combination.

Resistance R:

The property of a component that limits the current flow. Zero resistance allows short-circuit. Ohms Law is that V = I x R however, resistance will change as the circuit heats up.

Power P:

Power = V x I. A 100W globe will draw about 100 / 12 = 8.3 A

Alternator:

The alternator generates an alternative voltage (AC) that is converted to the direct voltage (DC) by the rectifier inside the alternator. The terminal voltage is kept about constant by a regulator in the alternator. The output of the alternator is usually set to 14.2 V for vented batteries and 14.8V for sealed batteries. An alternator can deliver a short-circuit current of slightly more than its rating.

Batteries:

Vented lead-acid batteries are fully charged when the open terminal voltage is 12.8 V and fully discharged at 11V (20oC). These voltages rise with temperature. Cool batteries perform better.

Batteries are rated according to their ability to crank the starter motor (CCA rating) and their ability to provide a steady load current (reserve capacity). Batteries can be designed to be better at one or other but not both.

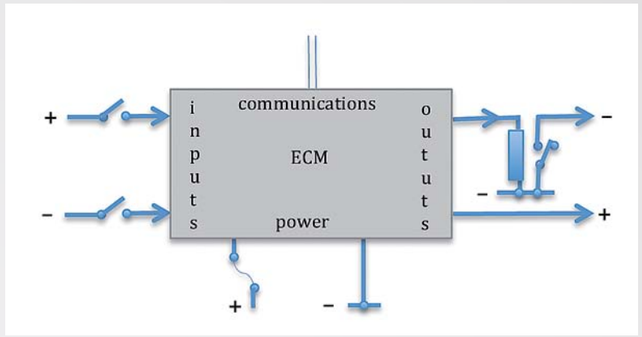
The short-circuit capability of a truck battery (N70Z, 650CCA and 70AH reserve capacity) is about 1500A. Four batteries in series can deliver a short-circuit current of 6000A, which is about 40 times what the alternator can deliver. Serious short-circuits are mainly fed by the batteries.

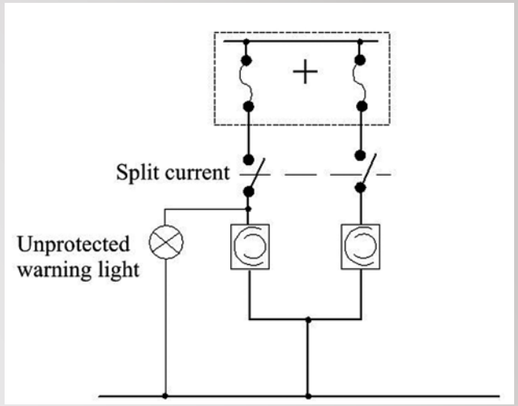
Return, Ground, Earth:

The part of a circuit that returns the current to the battery negative side. The chassis is also connected to the battery negative. 'Ground' and 'Earth' are commonly used, but incorrect, terms as the truck is not electrically connected to earth. If a truck touches an overhead power line, the metalwork will become live and lethal.

General fault finding:

- The electrical diagnoses time is often long. The repair time is usually short. This is in contrast to mechanical repairs, which are often easy to diagnose and hard to repair.
- If you can get a schematic drawing, look at it.
- Time spent understanding the circuit and the nature of the fault will be well spent.
- Is the fault permanent or intermittent? Intermittent problems come from bad connections or earth system faults.
- Do the minimum amount of testing to identify a fault. Start at the relay or switch because you can do multiple tests there. Measure voltage, current and resistance.
- Most problems are simple and do not involve a failed ECM. Use a multimeter to check power, earth, continuity. Trust the meter readings.
- A vehicle electrical system will run on the alternator only if the batteries are disconnected when the engine is running. The lights will flicker.
- Electronic Control Modules (ECMs) are difficult to kill. But they don't like voltages on the earth system (e.g. welding) or high voltages (e.g. sparks).
- Apparently unrelated faults (e.g. radio, left-turn light, heated mirror) have something in common. Think earth fault, or wiring loom fault.
- Small voltages (a few millivolts) occur across circuit breakers and fuses when current flows. These can be measured and they show what circuits are providing current. Alternately a clamp ammeter can be used to measure current without breaking the circuit.
- Voltage drops occur throughout the electrical system. The voltage might be 12.8 V at the battery and 11.5 V at the light. The thicker the wiring, the lower the voltage drop.
- Hot joints sometimes occur at blade terminals on circuits that deliver heavy current. The voltage drop may only be ~ 0.5V but this may cause 5W heating. In time, that will degrade the contact. Even small drops can matter.
- Thick wires absorb heat at spade terminals. Wiring is rated at about 10A / square millimetre. Choose thick wires for heat absorption and strength.
- A ¼" (6.3 mm) spade terminal should be limited to 15A. This advice also applies to cube relays despite them being rated at 30 A.
- When jump starting, always connect the positive jumper lead first because an unintended touch to the vehicle metalwork will not cause a short-circuit. Connect the negative battery lead second. Take the negative lead off first when finished.
- Rub faults can get worse when the vehicle cools down.





- Use fire-retardant conduit to protect main cables. If a fire occurs, the conduit will not spread the fire.

Black-Box fault finding

It always helps to make a simple sketch of a complex control system. Use the multimeter to find out:

- Is power present and is the earth connection good?
- What functions are not working ?
- Are all the connections in place ?
- Are the inputs sensible ?
- Are the outputs expected ?
- Is there evidence that the ECM is communicating / live ?
- Assuming the ECM is OK, what would cause the function to not work ?
- Be systematic. Eventually the problem will become obvious.

Until all these possibilities are investigated it is unsafe to conclude that the ECM is the problem.

Fuse and circuit breaker protection:

The starter motor circuit usually has no circuit breaker protection. This is because the peak current is so great that a huge CB would be needed. This circuit needs first class mechanical protection. Alternator and cabin cables are often taken off the starter motor terminals. They may not be protected by any circuit breaker and they are vulnerable.

Fuse or circuit breaker protection does not always protect against short-circuit. Sometimes a thin wire is used off a heavy circuit. The thin wire will not be adequately protected.

Earth Switching v Power Switching:

On 240 V AC circuits, such as at home, the power wire is the switched wire. This is not necessarily so on a vehicle. Earth-side switching is common on US engine circuits and less common on European engine circuits. It can give better protection because the consequence of a short-circuit fault may only be that the device comes on, not molten copper.

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