Wiring Faults

The doors won't lock, the fuel pump doesn't turn on, my starter won't crank, … These scenarios have a few things in common. It could be electrical and if so, it may be the power or ground circuit, fuse, relay, **OR** the load. Also, you don't yet have a definitive diagnosis confirming root cause of the failure. Lastly, you need to test the circuit at full amperage draw for net voltage at the load, especially for high current devices. So what does that mean?

The load only sees the net voltage that arrives at its connection terminals or wire leads and it needs adequate voltage so that it functions, does not overheat and does not fail. No load sees the net voltage that you measure at the battery terminals. Ground isn't ground and battery voltage is not battery voltage. Why? Ohms law: V=I*R. Every conductor and connector has losses, it's not a perfect conductor. Wire has a specification for how many ohms of resistance there is per foot. There will be a voltage loss equal to the current running through that section of wire and the resistance of that section of wire: I*R. That's why you need a thicker gauge (lower gauge number) cable or wire for higher current loads or longer runs, to keep the voltage loss acceptable. That's why there are specs for maximum current carrying capability and maximum round trip run lengths for a given gauge. The tables usually state a maximum voltage loss like 3% and the entire reason for that is so that inductive loads such as motors don't struggle due to marginal net voltage at the load. This is why a dual voltage motor for say a table saw runs stronger if wired for 220V instead of 110V because the power is roughly the same; P = I * V and since you just doubled the voltage, the current drops in half and the wiring losses dropped in half. There is more net power to the load. Why is all of this relevant to us on this forum?

You measure the positive voltage at the load and connect your negative meter lead to the batteries ground post. Is your circuit OK? You don't know yet. You connect the negative and positive meter leads right at the load but the load is off. Is your circuit OK? You don't know yet. You have natural voltage drops all the way from the positive battery terminal back to the negative battery terminal. There is resistance in the wires, fuses, connectors, relay contacts, even internally in the battery. This is why your highest current load, the starter, when energized is not seeing the 12.6V of your properly charged battery. At 150 cranking amps there are losses even in those big cables, connectors and the internal battery plates. Your starter usually sees around 10 volts. And the kicker is that almost every fault causes even more voltage losses in the circuit. A loose connection, green copper corrosion, a frayed wire, etc – they all result in additional voltage loss. If you have a corroded connection under your fuse box, you may see 12.5V at the fuel pump with the pump off but the pump doesn't care about the voltage when its off, drawing no power. It cares about the net voltage at full load when it's doing its thing. Let's say that corroded connection measures 0.5 ohms and a load draws 10 amps. Well you measure the voltage at the load when it's off and its 12.4V, pretty typical but there is zero current running through that load. Now you energize that load and 10 amps through that 0.5 ohm corrosion results in a 5 volt drop across the corroded connector and only 7.4 volts arrives at the load (or less). Wait there's more. That same current has to leave the load and return to the battery through the ground wire and connection. What if there is corrosion, a cold solder joint or a frayed wire there? More voltage drop. Say another 5 V of drop through another 0.5 ohm loose ground and bingo, the load only sees a net 2.4 volts. The ground is "lifted" by 5V. This example would have the same result with 1 amp and 5 ohms of corrosion. Think of the total round trip circuit from battery positive to battery negative as a bunch of series resistors (each wire, connector, fault, etc) and there is a voltage drop (loss) across every resistor. You won't know what your net voltage is at the load unless you measure there at full current draw and if the voltage is too low, you won't know where the loss is unless you start measuring sections of the circuit at full load to find the excessive voltage drop, including the ground leg. Meter on DCV and leads across 2 points.

Another thing to consider is that a point in the circuit can get worst with time and heat so an intermittent problem might not show up unless you stress everything a bit. Also, fun fact: heat accelerates failure that why a motor burns out with low voltage. That's how component manufacturers can quote a mean time between failures (MTBF) spec for electrical components. You don't run a batch of say semiconductors for 2 million hours to see when they fail. You crank up the heat and make then fail quickly and compute the equivalent MTBF at normal operating temperatures. Pretty tricky, huh?