How Connections Affect Voltage Drop

Wire used in today's vehicles is made from materials that pass current easily. In automotive circuits, most of the conductors are copper wires, some are aluminum. When new, the resistance value of wire used is not high enough to cause a voltage drop large enough to affect the operation of any load in the vehicle.

Connections can include the mechanical connections between mating terminals or where fuses, circuit breakers, relays, or bussed electrical connectors plug into fuse boxes. They also include: soldered splices where parallel circuit branches split, points of contact where conducting wires physically attach to a component, terminal, or eyelet, and point of contact where an eyelet attaches to sheet metal, the frame, or a block ground return, and the metal-to-metal mating surfaces where an alternator or starter motor is mounted. All of these connections are *conductors* and are designed to pass current easily. Since they are not resistors, none of them, when new, should offer any excessive resistance or cause voltage drops of any concern. Conductors and connections are part of the non-resistive elements that provide a “bridge” path from the battery to the load and from the load back to the battery.

Manufacturers know how much voltage each of their connections, switch contacts, or lengths of wire will drop. Connectors are listed as having a voltage drop across them based on each amp that flows through them. Small connectors can cause a voltage drop of 4mVolts per amp, whereas, large connectors can cause a voltage drop of 10mVolt per amp. Each connector is rated to handle a certain amount of amperage based on the physical size of their blades or pins. Vehicle connector blade sizes used today range from .8mm (.032 Inches) to 8.0mm (.315 inches). Their amperage carrying ratings range from 0 to 15A, 25A, and 33A for the most common connectors in use.

A small connector rated to drop 4mVolts per amp would drop .060Volts (60mV) with 15amps flowing (.004V X 15A = .060V, E=IR). A large connector rated to drop 10mVolt per amp would drop .300V (300mV) with 30 amps flowing (.010V X 30A = .300V, E=IR). Voltage drop is always proportional to current flow.

The voltage feed side of any circuit contains most of the connectors. This is due to the wire feed arrangement of the current paths between the battery positive terminal and the input pin to any load. We anticipate these minor or “insignificant” individual connector voltage drops, and, under most conditions, allow for no more than a total accumulation of .500V drop for low current loads, and no more than 1.5V drop for high current loads. Low current loads include any fuse terminal fed voltage, ignition switch, headlamp switch, and windshield wiper motor. High current loads include the rear window defogger, and power seats.

The more conducting material, connections and contacts between the battery and the load, the higher the voltage drop will be. Since the ground path is usually a short piece of wire, or a case ground connected to the frame or sheet metal, the acceptable voltage drop on the groundside is always lower than the feed side. This is why the allowable voltage drop between the exit pin of a load and the battery negative terminal is only .100V for most circuits.

The higher the amperage is in any circuit, the higher the voltage drop will be across any wire or cable:

- conductor length,
- connection (male to female terminals used to connect the positive side of the battery to the load, fuse blades to female holder, ground eyelets to sheet metal, frame, block, or case ground housing to sheet metal, frame, or block), and
- contact (mechanical switch, relay, solenoid, or circuit breaker).

In any circuit, the only connections, contacts, and conducting wire affected by the amperage draw of the load are those providing the “bridge” to and from the battery located in the same current path as the load. When new, the rated voltage drop of the connections, contacts, or wire should not cause any problem in any circuit. If any connection, contact, or length of wire develops excessive resistance, it will cause excessive voltage drop. This voltage drop prevents the load from getting all of the source voltage that exists across the battery terminals. This happens because a current path that contains excessive resistance is no longer a pathway of only conducting material, but has converted itself into a resistive path that is in series with the load.

The most common cause of intermittent electrical and electronic problems on any vehicle is with connections; not only the physical connection between a pin and its mate, or a fuse leg and the female receptacle when first assembled, but also conditions that can develop between the initial connection over time. A lot of research and testing goes into getting the connectors, connector position assurance, as well as terminal position assurance locks right. Some times its wrong from the start and a bulletin will be issued to correct it. Over time, with flexing and moving, as well as temperature extremes, some connections will loosen, oxygen in the loose space will then cause corrosion, and the corrosion causes resistance. The end result is a voltage drop. *Connections are critical.*

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