

## Truck/Bus Harness Protection in 24V Battery Systems



The wiring-harness architecture found in trucks, buses and other vehicles with electrical systems based on 24V technology has undergone considerable change as electrical and electronic content has increased. Conventional functions, such as the HVAC (Heating, Ventilating & Air Conditioning)

system, continue to be converted to electronic control while many new features, such as GPS (Global Positioning Systems) and entertainment systems, are being added to the electrical load.

Optimized vehicle harness architecture has a hierarchal structure resembling that of a tree with its main power trunks dividing into smaller and smaller branches that use overcurrent protection at each node. Because a hierarchal architecture can use smaller wires and relays on its “smaller branches,” the resulting harness is smaller and lighter, resulting in a cost savings — both in materials and fuel. In addition, a hierarchal or distributed architecture can provide system protection together with fault isolation, thereby reducing warranty costs and increasing customer satisfaction.

Figure 1 shows a simplified version of a partially distributed architecture with each junction box either directly feeding a module or feeding another nodal module which supplies peripheral loads. Unfortunately the sheer number of circuits found in today’s vehicles has made the optimized system hard to realize in practice. With many tens of circuits emanating from the primary power distribution center, it has become almost impossible to position all the subsequent junction boxes so that they are readily accessible and close to the electronics they are intended to feed.

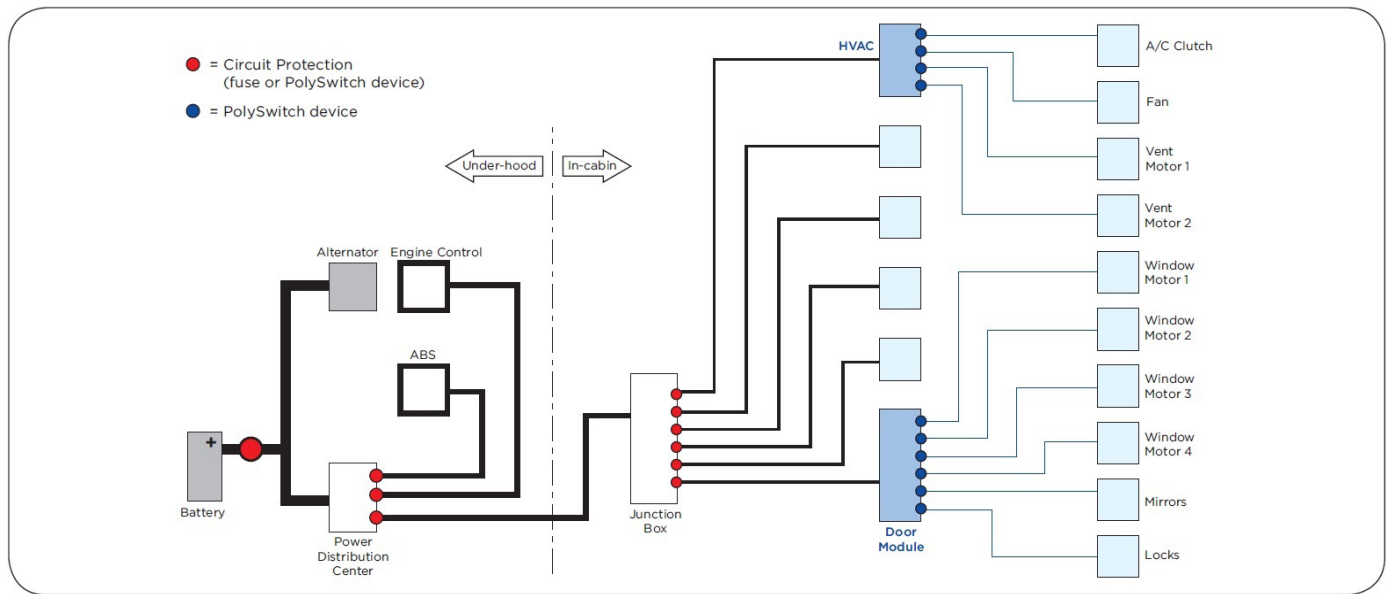


Fig 1. In a partially distributed architecture, where a module supplies a number of peripheral loads, PPTC devices can allow shorter and smaller wires to be used. Door and HVAC module examples are shown here.

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As a result, system designers have resorted to harness design solutions that negate some of the desired end-benefits, such as:

1. Sacrificing wire size optimization and fault isolation by combining loads into one circuit;
2. Locating electrical centers where they are only accessible by trained service personnel, at increased cost; and
3. Routing back and forth between various functional systems, increasing wiring length, size and cost.

For example, due to the necessity for fuse accessibility, a conventional door module would have separate power feeds for windows, locks, LEDs (Light Emitting Diodes) and mirror functions, each protected by a separate fuse in the junction box. By incorporating PolySwitch resettable PPTC (Polymeric Positive Temperature Coefficient) devices in the door module itself, a single power feed can be used. This helps save wire and reduce the cost and size of the junction box.

Using a resettable circuit protection design that does not need to be driver accessible offers a number of solutions that can be used separately or in combination to better optimize harness designs. For example, a single junction box located in the instrument panel can still be employed. Instead of positioning the PPTC devices close to the conventional fuses on the front panel, they can be located inside the box, close to the connectors or on the bottom face of the box. This saves both frontal area as well as reducing the box's volume, as shown in Figure 2.

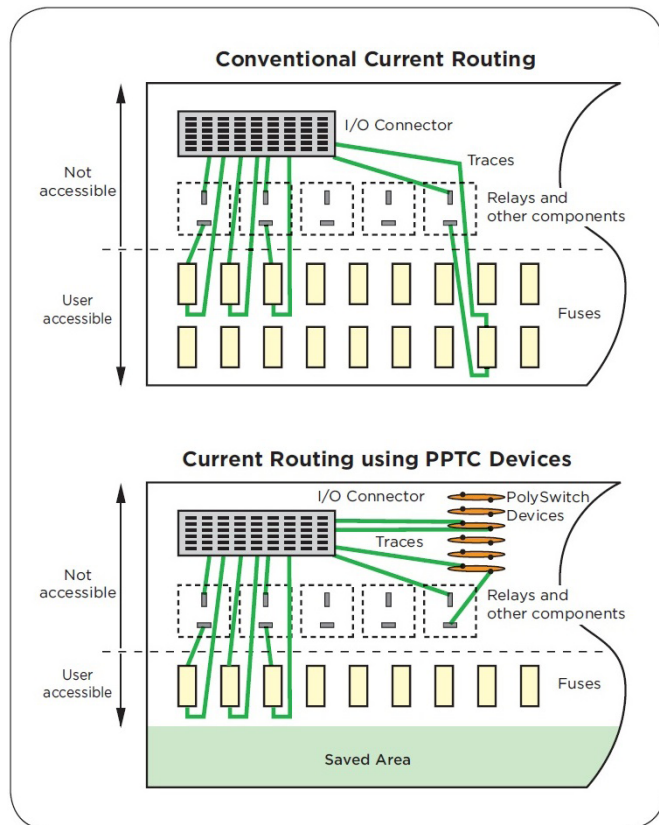


Fig 2. With PPTC devices one can design smaller PCBs (printed circuit boards), use less copper, have less voltage drop and heat and reduce the accessible area.

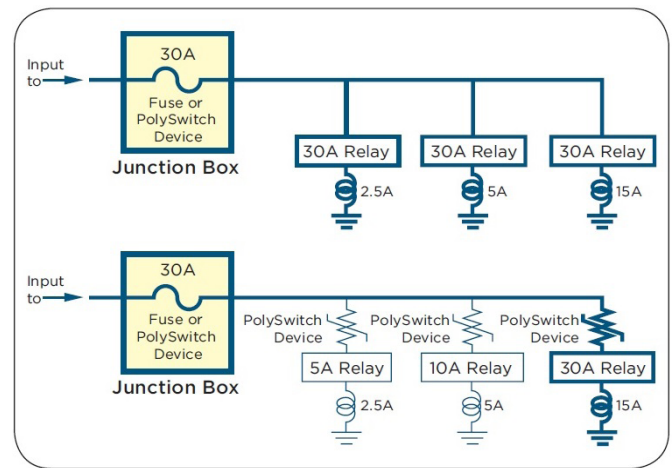


Fig 3. The wire gauges and relays can be downsized with the use of PolySwitch devices

Figure 3 illustrates yet another advantage of replacing conventional fuses with resettable PolySwitch devices. Indeed, using a PPTC device in a dedicated manner (delocalized or not) can allow wire and relay downsizing, thus helping save cost, space and weight.

The through-hole PolySwitch devices lend themselves for use in boxes using circuit boards or IDC (Insulation Displacement Connector) wired busses. Since there is no need for fuse holders, there is added design and assembly flexibility. In addition, cost savings is possible through use of automated pick-and-place assembly technology. An added feature, with use of PPTC devices, is that they are available in lower current ratings than conventional fuses. Therefore, they may be more appropriate for use in protecting command functions. Moreover, the PPTC devices offer smaller increments in current ratings, which allows selection of a device with characteristics that are closer to the actual application current.

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For higher optimization, instead of using a single junction box, the electrical centers can be divided into smaller units and relocated around the vehicle. With the availability of resettable circuit protection devices and reliable relays, modules can switch and protect their own output loads. And, they can be positioned without consideration for user access.

However, until recently, there was a caveat. 24V modules with resettable circuit protection devices could not be located under the hood in high temperature environments. Fortunately, this has changed with the introduction of 32V PPTC devices rated from -40°C to 125°C. Now, PPTC devices allow the harness' electrical architecture to be designed more closely to reflect the optimized tree structure with its accompanying size, weight, and cost benefits.

### Typical Protection Requirements

Truck and bus wiring harnesses must be protected from damage caused by a thermal event, such as a short-circuit in the vehicle wiring. Circuits typically require 0.10 to 20A of current at system voltages of 28V with operation to 32V.

### Technology Comparison

Fuses are single-use devices that must be replaced when they blow. This requires that fuses be mounted in accessible fuse boxes — a requirement that dictates system architecture and forces packaging and system layout compromises.

PolySwitch resettable devices latch into a high-resistance state when a fault occurs. Once the fault is removed and power is cycled, the device will reset and is ready for normal operation.

Using PPTC devices has the added advantage of making overcurrent protection less susceptible to misuse and tampering. Automotive fuses that have nominal current ratings from 2A to 30A are all packaged in the same form factor. A fuse can be incorrectly replaced by one of a higher value, offering no protection at all. When located in remote modules, PPTC devices cannot be readily accessed, changed or abused by the user.

### Device Selection

When designing 24V harness protection, one should consider using the AHEF series of PolySwitch resettable devices with current ratings from 0.5A to 10A. These devices offer a lower thermal derating than standard PolySwitch devices and are suitable for an operational temperature range of -40°C to +125°C.

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