APPLICATION NOTE

PolySwitch Resettable Devices Help Protect Automotive Driver-Side Control Switch Consoles

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The switch console on the driver-side door allows control of multiple functions, including up and down control for all four windows, side mirror control, and the power door lock.

The design and function of automotive driver-side console electronic switches are segmented into two major automobile categories: high-content and low-content. Whether control-bus managed or mechanically actuated, automotive control systems require a fused power supply bus. However, low-content vehicles are particularly susceptible to damage of the mechanical switch actuator contacts caused by overcurrent events.

Automakers must protect the copper traces needed for these control functions from potential short-circuit and overload conditions that may result from miswiring or a collision. The potential consequences of not protecting against these events may include damage to the control module and, possibly, a damaging thermal event.

PolySwitch resettable PPTC (Polymeric Positive Temperature Coefficient) devices can be used in these automotive electronics designs to help protect traces from potential short-circuit events by rapidly, and effectively, limiting current to safe levels.

PolySwitch Devices Help Protect Power Window and Mirror Control Circuits

Figures 1a and 1b show a design where PolySwitch devices are being used to help protect the power window control and side mirror modules in the driver-side console. This design uses three PolySwitch devices for each power window and one for the side mirror adjustment switch.

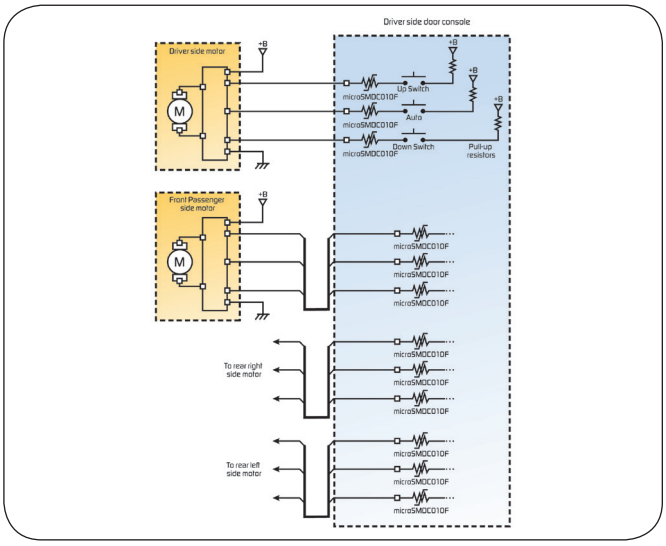

Figure 1a. PolySwitch devices help protect multiple circuits on the power window control module.

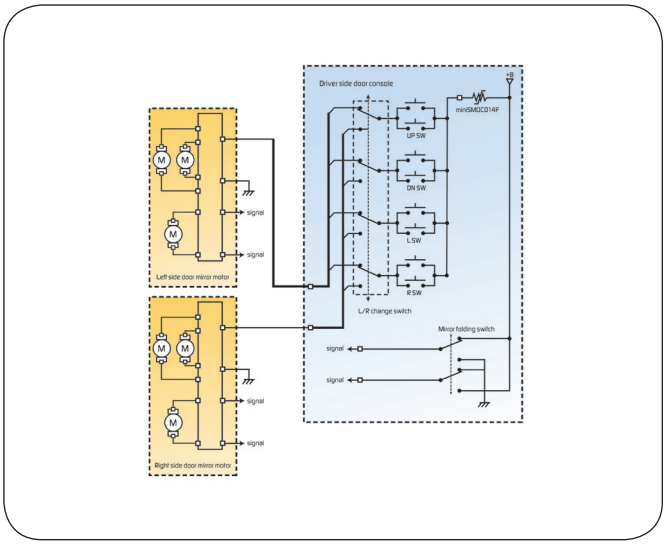

Figure 1b. PolySwitch devices help protect multiple circuits on the side mirror control.

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In this design the PolySwitch devices help protect PCB traces, pull-up resistors, switch buttons (rubber-based contacts), and the wire harness going to the doors or side mirror motors.

Potential faults include short circuits, miswiring, smart motor failure, pull-up resistor shorting and misassembly. In addition, Printed Circuit Board (PCB) components or traces can be the location of a fault situation.

Depending on its cross-sectional area, each trace can only carry so much current before the heat generated by I^2R losses cause it to fuse open. Even before it melts, a trace may get hot enough to damage the printed circuit board or the components mounted on it.

A PPTC device has a low resistance value while operating under nominal currents and will not affect the module's operation. As soon as a fault condition occurs, the device very quickly exhibits an increase in resistance and limits the current to a level that the corresponding traces can safely carry. When the fault is cleared and the power is cycled, the PolySwitch device resets. This allows current flow to resume and restores the circuit to normal operation.

Additionally, the very small form factor of the PolySwitch surface-mount device makes it easy to use in designs with space-limited PCBs.

PolySwitch Devices Help Protect Carbon Contact Micro-Switches

Suppliers of automotive switches used in power window circuits offer universal application switches designed for use in both low-current (managed bus controllers) and high-current applications (direct mechanical actuation). The primary design requirement of high-content applications is to supply very low resistance for the necessary control voltage/current. To accommodate this, many switch manufacturers incorporate carbon-based contacts for actuation. Although generally suited for high-content applications, the carbon membrane must be considered "fragile" when used in the non-electronic, high-current environment.

The micro-switch used in power window control systems utilizes four carbon contacts to activate the window lift motor and a decoder to determine the desired speed and direction. Pull down resistors are used to limit the current when contact is made. As depicted in Figure 2, the nominal loop current is approximately 15mA under normal operating conditions.

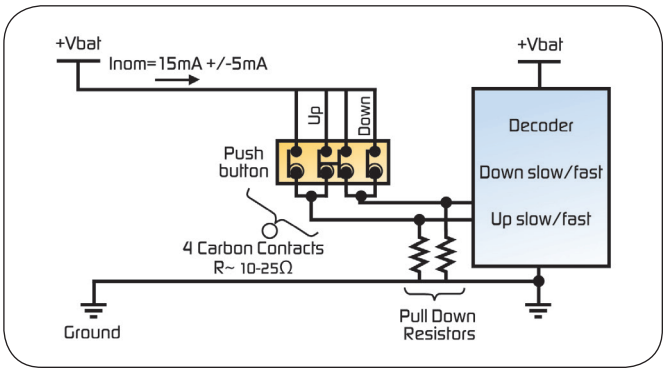

Figure 2. Typical carbon contact based micro-switch window lift design.

As noted previously, the carbon contacts are the most fragile elements of this design concept. In case of miswiring, wire pinching or a collision, a short circuit may connect the contacts to ground, shunting the pull down resistors. If this occurs, the current may rise rapidly, as soon as a button is pressed, causing the carbon contacts to fail. This can damage the PCB and traces, and potentially generate a damaging thermal event in the vehicle cabin. Sometimes a fuse can be used on the power input. However, as a single-use device, a fuse must be replaced after a short-circuit event. Furthermore, if the damaged fuse is surface-mounted on the PCB, the entire board must be repaired or replaced.

PolySwitch devices provide a practical and effective solution for micro-switch circuit protection since they are resettable, available in a small form factor, and are easy to reflow onto the PCB. As shown in Figure 3, installing a PolySwitch device in series with the switch helps limit current in the event of a short circuit. Under normal conditions, the device exhibits very low resistance. In a short circuit event, the PolySwitch device "trips" into a high-resistance state to limit the current and protects both the carbon contacts and the PCB. Once the fault has been removed and the power is cycled, the switch is restored to a functional condition.

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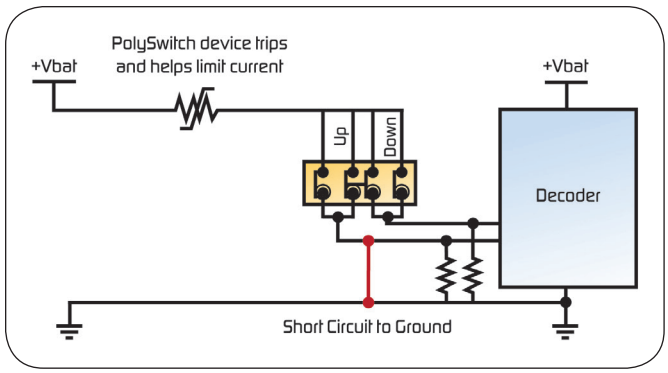

Figure 3. In response to a short circuit, the PolySwitch device helps limit current to the carbon contacts.

Testing of small surface-mount PolySwitch devices in a simulated short circuit to ground scenario, shows that these devices' time-to-trip is typically in the 20-50ms range at 25°C. Figure 4 illustrates how a PolySwitch microSMD010F device quickly and effectively responds to a short circuit condition applied to the micro-switch.

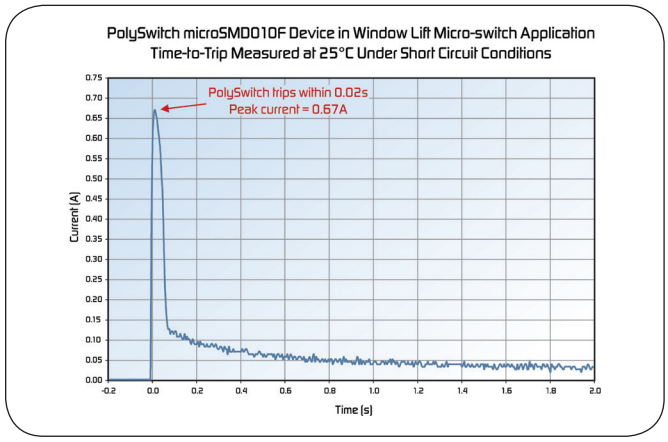

Figure 4. The fast time-to-trip of the PolySwitch device helps protect delicate PCB traces.

PolySwitch Devices Help Protect LED Backlighting Circuit

Frequently, power window switches are illuminated by LEDs during night driving. In these applications, a common design to power and control these LEDs includes a CPU and transistors.

In this design, the transistors can overheat if a short circuit condition occurs due to miswiring a collision or a faulty repair. The possible result of overheating can include the failure of the transistors and, in the worst-case scenario, a catastrophic thermal event. Figure 5 shows how PolySwitch devices can be placed at each of the output transistors to help protect against potentially harmful short circuit events.

In this application, self-protected smart FET devices can be used in lieu of simple transistors. However, PolySwitch devices combined with simple transistors offer a lower cost, well protected design option.

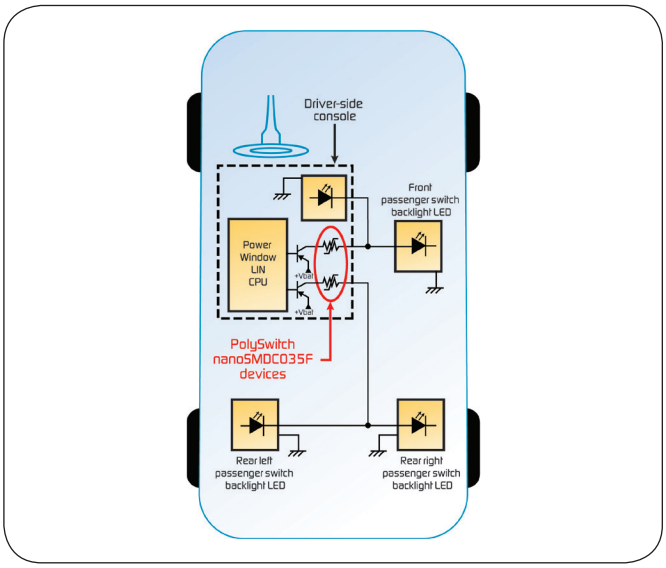

Figure 5. Two PolySwitch devices help protect the transistor from short circuit in LED backlight applications.

Specifying PolySwitch Devices for Automotive Driver-side Control Switch Applications

Device selection for vehicle driver-side control switch applications must be based on the maximum current that the traces and components in the design can withstand, and each application should be evaluated independently.

Power Window and Side Mirror Switch Applications

A collection of three PolySwitch devices per power window can be used to help protect power window switch console traces against potential short circuits. The small surface-mount PolySwitch microSMD010F device is well suited for this application. Similarly, side mirror adjustment may utilize a PolySwitch miniSMDC014F device to help ensure protection under such events.

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Carbon Contact Micro-switch Applications

The surface-mount devices most commonly used to protect power window micro-switches, using carbon contacts, include PolySwitch microSMD010F and nanoSMDC012F devices. These devices are easy to install and consume minimum real estate on the PCB.

LED Backlighting Applications

To help protect the output transistor in the LED backlighting system, a PolySwitch nanoSMDC035F device can be used.

All PolySwitch devices mentioned above are RoHS-compliant and available in tape and reel packaging for compatibility with high-volume manufacturing. They have been tested to the Automotive AECQ200 specification and are suitable for automotive applications.

Note: only limited levels of load dump can be applied to small surface-mount devices from Littelfuse PolySwitch's miniSMD, microSMD, and nanoSMD families. Test data available upon request.

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