H-Bridge Protection from Reverse Battery Damage

Application Overview

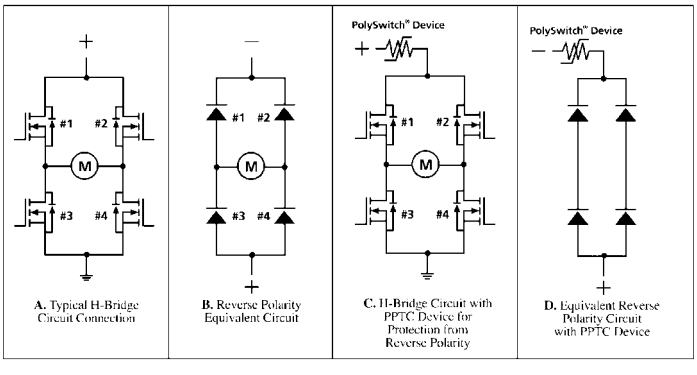
Automotive electronics must be protected from reverse polarity power sources, that may occur when jumper cables are connected to the wrong polarity of a dead or excessively discharged battery, or when a new battery is installed backwards. Without protection, excessive heating can lead to failures in electronic modules or inadvertent activation of vehicle loads such as solenoids and motors, which can lead to unsafe conditions. Traditional protection techniques can be expensive or cause an excessive voltage drop, affecting the performance of some systems. New techniques that use polymeric positive temperature coefficient (PPTC) devices, such as PolySwitch PPTC devices, address both of these shortcomings and provide additional advantages.

H-Bridge/Motor Protection

Most of the fractional horsepower motors used in vehicles for comfort and convenience are brush DC motors. The solid-state method for driving bi-directional motors such as power windows, power seats, and power locks is to use an "H-bridge" configuration consisting of four Power MOSFETs connected as shown in Figure 1A.

To rotate the motor in the positive direction, MOSFETs 1 and 4 are turned on simultaneously. To rotate the motor in the negative direction, MOSFETs 2 and 3 are turned on simultaneously. The reverse-polarity connection to an H-bridge circuit produces the equivalent circuit of two series intrinsic diodes connected in parallel between the positive and negative terminals of the power source (Figure 1B), which essentially creates a short circuit.

Figure 1.



For the same reasons as stated earlier, the use of a series blocking diode, may not be economically feasible. However, the use of a series PPTC device helps provide reverse-polarity protection economically while minimizing the voltage loss in the system (Figure 1C). The equivalent circuit in a reverse-polarity condition is shown in Figure 1D. Generally, the FETs intrinsic diode will easily provide the momentary surge current necessary to cause the PPTC device to trip within milliseconds.

For certain circuits, the diodes that created the current path under the reverse-polarity conditions must have surge capacity ratings that will cause the PPTC device to trip while staying within the Safe Operating Area (SOA) of the diode. In other words, the "time-to-trip" of the PPTC device must not exceed the diode's surge current-time capability. PPTC devices are available with a range of current and maximum time-to-trip ratings to satisfy most applications.

Device Selection

Radial-leaded or Surface-mount devices

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