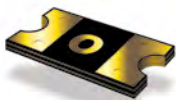


# Application Note

## Protecting Powerful USB 3.0 Interfaces



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High speed data transfer has become a required feature of electronics, and existing standards are continually upgraded to meet the demands of the end user. The Universal Serial Bus (USB) interface is an example of a protocol that has been updated to enhance its data transfer capabilities. Significant changes were made to the standard, including a tremendous increase in speed and power, and the addition of simultaneous bidirectional data flow. Along with these changes comes the need for updated circuit protection to ensure that requirements for the overcurrent and ElectroStatic Discharge (ESD) threats are met for the new standard. At the same time it must remain backward compatible with previous designs. The combination of Bourns® Multifuse® and ChipGuard® devices provide effective, reliable protection for USB 3.0 as it has for the preceding revisions of this well-used standard interface. Using Bourns® Multifuse® and ChipGuard® products offers a cost-effective solution that is both compact and seamless as it does not change the overall structure of the circuit protection implementation.

### Protection for USB Ports

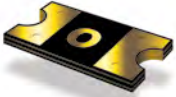
In addition to overcurrent and ESD protection, the USB interface must withstand the threats of hot plugging, short circuits, faulty equipment, and user error. Polymer Positive Temperature Coefficient (PPTC) devices have typically been used to help protect the power port from overcurrent conditions, and have also employed diodes to protect data ports from overvoltage in a wide range of computer, memory, and data communication applications. On the device side, the same type of protection is used. One requirement of USB is that the overcurrent solution be resettable. Bourns® Multifuse® Resettable Fuses - the company's PPTC product line - meets the resettable requirement when inserted in series with the voltage line. Overvoltage protection is not expected to be resettable, which makes diodes and Bourns® ChipGuard® devices suitable for the data lines. A Bourns® ChipGuard® device is inserted from each data line to ground.

## USB 3.0 in Action

The operating characteristics of USB 3.0 demand more from a circuit protection solution than its USB 2.0 predecessor. The transition from USB 2.0 to USB 3.0 requires a faster protection solution to handle increasing speeds from 480 Mbps to 5 Gbps. This enhanced performance dictates that the allowable capacitance of the protection must decrease to maintain data integrity at significantly increased speeds. Current will also increase from 500 mA to 900 mA on each line. Table 1 compares the operating characteristics of USB 2.0 & USB 3.0. The USB 3.0 specification (section 11.4.1.1.1) specifically recognizes polymeric PTCs as an overcurrent protection solution.



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Parameter	USB 2.0	USB 3.0
Operating Voltage	4.4 VDC - 5.25 VDC	4.45 VDC - 5.25 VDC
V <sub>BUS</sub> Short Circuit Current	UL60950 - TTT < 5 A/60 sec	UL60950 - TTT < 5 A/60 sec
Max. Operating Current: Low Power Port	100 mA	150 mA
Max. Operating Current: High Power Port	500 mA	900 mA
Total Data Line Capacitance	< 10 pF	< 1 pF

Arguably the most significant change in the USB standard is its data transfer capability. In addition to the unidirectional differential data channel available in USB 2.0, the USB 3.0 interface offers two additional differential pairs for dedicated receive and transmit activity. This creates simultaneous bidirectional data flow between the host and the device to reach the blazing new data transfer rates in the multiple gigahertz range. Figure 1 shows the USB 3.0 cable, which is backward compatible with previous versions of USB, and host and device ports for USB 3.0 and USB 2.0.

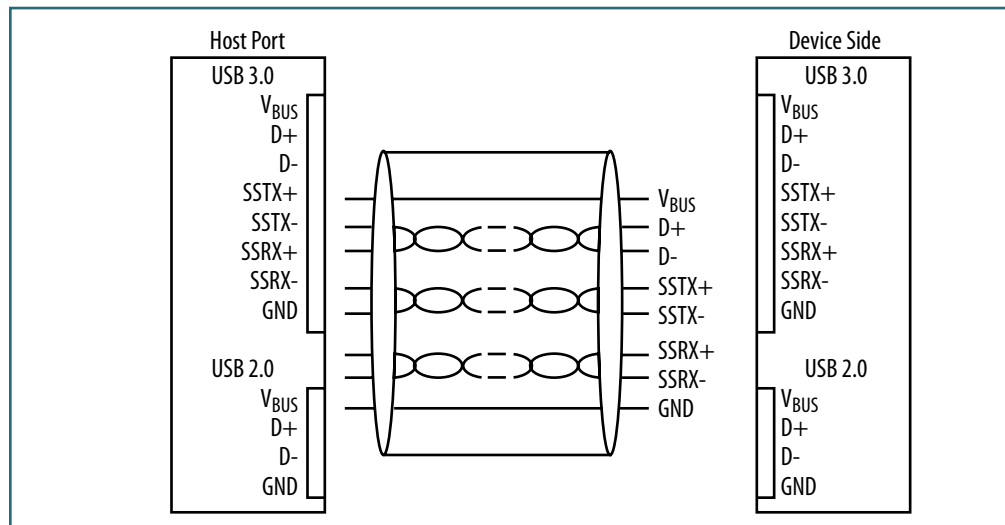


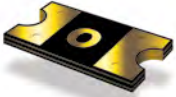
Figure 1 | USB 2.0 and USB 3.0 Signal Routing

## Selecting the Devices

The solution for USB 3.0 is not inherently different from previous versions other than the capacitance, voltage, and quantity of the protection devices have changed. The PPTC device on the V<sub>BUS</sub> port of the USB power source limits current in the event of a short circuit. It prevents the inrush current from going through the circuit and causing damage. Bourns® ChipGuard® devices have extremely low capacitance with fast clamping and recovery response to protect from ESD and overvoltage on the data lines of USB 3.0. Protection from the higher current, higher voltage and ESD transients in USB 3.0 applications is illustrated in the Figure 2 schematic.



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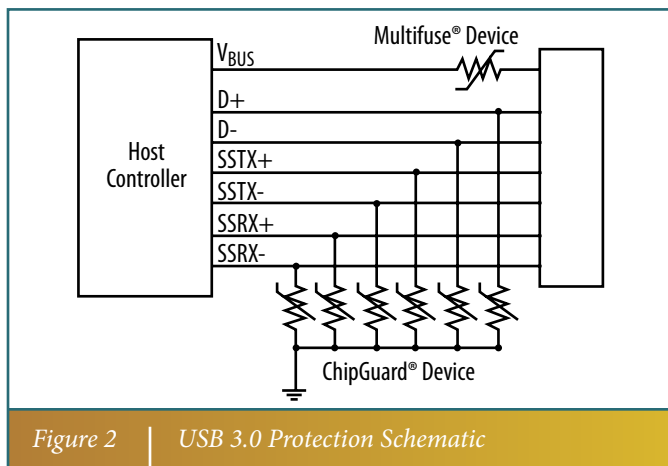


Figure 2 | USB 3.0 Protection Schematic

Bourns® Multifuse® and ChipGuard® devices are available in several standard package sizes and models to meet the needs of USB 3.0 and USB 2.0 applications. The compact size of Bourns® Multifuse® and ChipGuard® devices helps designers exceed protection levels while meeting board real estate requirements. This solution is also straightforward to implement. Depending on the application and its requirements, specific Bourns® Multifuse® and ChipGuard® devices from table 2 and table 3 can be inserted in the schematic where indicated in figure 2.

USB Host Protocol	Max. Allowed Current per Port	Port of Protection	Recommended Part Number		
			1812 Size	1206 Size	0805 Size
USB 2.0	500 mA	Single Port	MF-MSMF075	MF-NSMF075	MF-PSMF075X
		2 Ports	MF-MSMF110	MF-NSMF110	MF-PSMF110X
		4 Ports	MF-MSMF200	MF-NSMF200	–
USB 3.0	900 mA	Single Port	MF-MSMF110	MF-NSMF110	MF-PSMF110X
		2 Ports	MF-MSMF200	MF-NSMF200	–

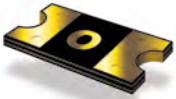
USB Host Protocol	Recommended Part Number	
	0603 Size	0402 Size
USB 2.0	CG0603MLC-05LE	CG0402MLC-05LG
USB 3.0	–	CG0402MLU-05G

## Advantages of Bourns® Multifuse® and ChipGuard® Devices

Some of the Bourns® Multifuse® devices in USB 3.0 applications incorporate Bourns® freeXpansion™ technology which allows the polymer in the device to expand without restriction. Conventional designs stress the active polymer matrix by restricting expansion which, over several operating cycles, causes the resistance to rise. freeXpansion™ technology also allows designers to use smaller packages with increased performance. Application testing shows the non-trip resistance to be stable after hundreds of test cycles and trip resistance remaining in tolerance over the life cycle. This part has been tested to handle thousands of plugging and power cycles. See the life cycle curve below:



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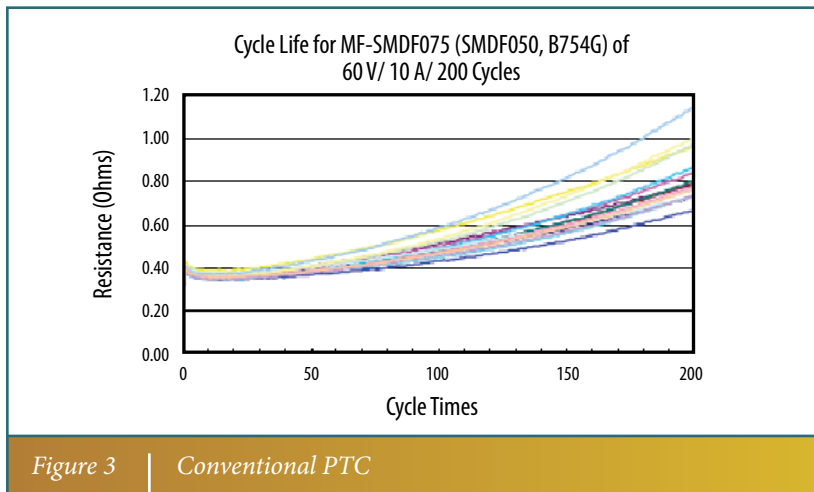
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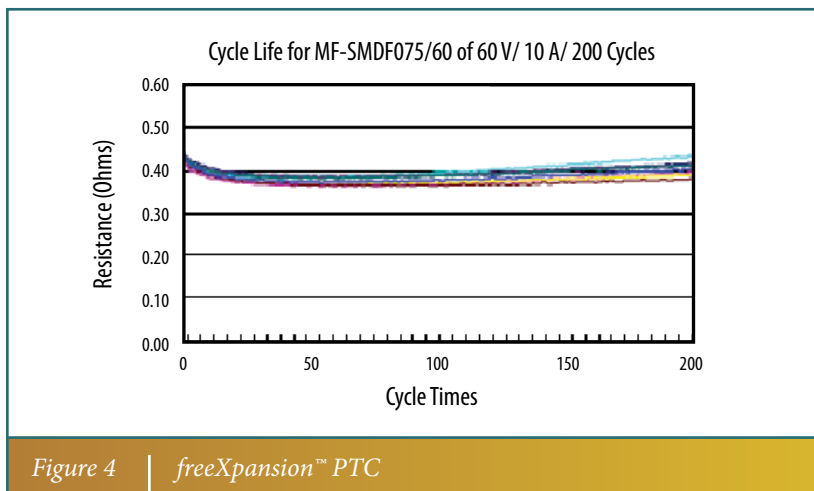
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The Bourns® ChipGuard® device has a smaller package size for USB 3.0, and the 0402 package may be used as the primary solution. Lower capacitance helps maintain data integrity for the high speed transmission, with an allowance below 1 pF compared to the maximal 10 pF allowable with USB 2.0. Bourns® ChipGuard® devices meet IEC 61000-4-2 standards for ESD protection at level 4 for 8 kV/15 kV surges.

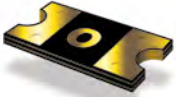


## Why Partner with Bourns?

Bourns has been a leader in the circuit protection industry for several decades. Its commitment to quality, innovation, and customer service are evident in solutions for emerging standards like USB 3.0. The combination of Bourns® Multifuse® and ChipGuard® technologies provides a cost-effective single solution for USB 3.0 overcurrent and overvoltage protection. Continued operation and reliable results have been engineered into all Bourns® circuit protection solutions. Designers can be assured that this solution will meet IEC standards and withstand a short to ground within rated limits, thus allowing them to focus their design effort on the application at hand.



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More information on Bourns® ChipGuard® and Multifuse® components can be found online at:

[www.bourns.com](http://www.bourns.com)

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