

APPLICATION NOTE

Protecting USB Type-C Cable Connectors Featuring Higher Power & Tighter Pin Spacing



Bourns® Polymeric Thermal Cutoff Device - Model P-TCO Series



Bourns® Thermal Cutoff Device - Model SC Series Mini-Breaker

INTRODUCTION

The now ubiquitous Universal Serial Bus (USB) standard was initially developed in 1994 with the intent of providing a communication standard to improve and simplify communication between the PC and peripheral devices. An updated version of the USB interface standard is the USB 3.1 Superspeed+, which doubles the data rate to 10 Gbps – a 2x improvement of the previous generation USB 3.0 Superspeed. USB 3.1 Superspeed+ is backwards compatible with USB 1.1, 2.0 and 3.0 with a power delivery projected at 100 W. This gives users enhanced data encoding for more efficient data transfer offering higher throughput and improved I/O power efficiency.

In addition to the increased power capability and bandwidth achieved in this updated USB standard, the connector has been changed. The original simple 4 pin D+/ D- Power and GND format has been upgraded and now combines multiple connector functions into one. The new USB Type-C connector features 24 pins in a smaller form factor.

A downside to this combination of increased power and the extremely tight pin spacing is heightened concern about potential safety and fire hazards due to the possibility of thermal runaway at the connector. To deal with these potential threats, it is recommended that electronic equipment manufacturers and connector and cable manufacturers integrate overcurrent and overtemperature protection into the Type-C connector.

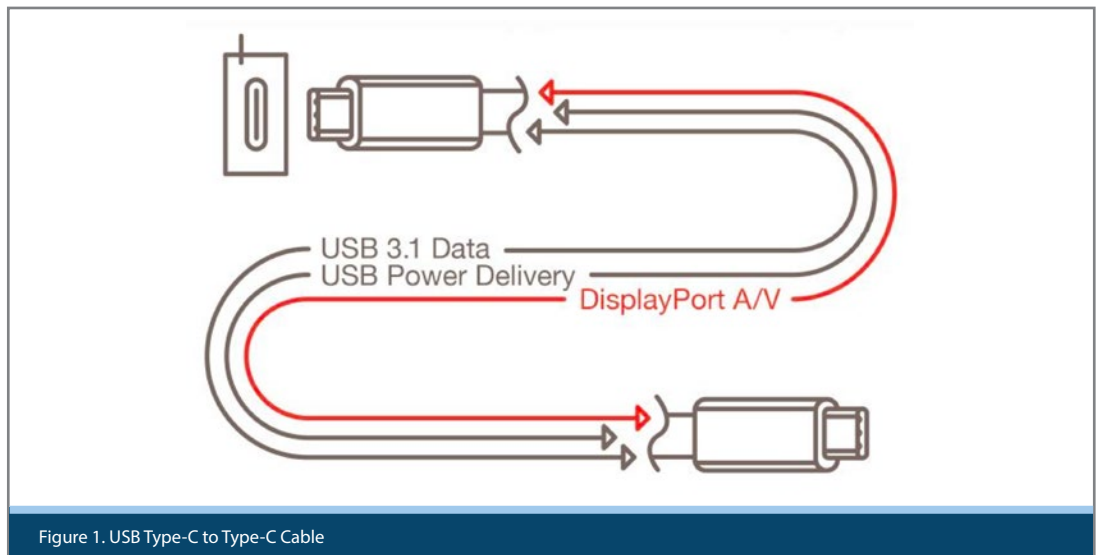


Figure 1. USB Type-C to Type-C Cable

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INTRODUCTION (CONTINUED)

Thermal runaway at the connector can lead to a fire hazard resulting in destruction of the equipment and possibly even more serious events. Pin spacing at the Type-C connector is 0.50 mm, increasing the potential for shorting. Small debris such as dust or liquid entering the connector could cause a full short. The Mobile Computing Promotion Consortium (MCPC) in Japan has even outlined the risks and dangers associated with such tight pin spacing and high power transfer in their publication “MCPC TR-021 Safety Design Guideline for USB Interface for Charging” ([http://www.mcpc-jp.org/news/pdf/TR-021_\(E\)20190425.pdf](http://www.mcpc-jp.org/news/pdf/TR-021_(E)20190425.pdf)). In order to prevent such events, Bourns has developed two solutions that can be easily designed into Type-C cables. This application note will present how the company’s Thermal Cutoff (TCO) and Polymeric Thermal Cutoff (P-TCO) devices deliver the overtemperature and overcurrent protection necessary to help avert thermal runaway conditions.

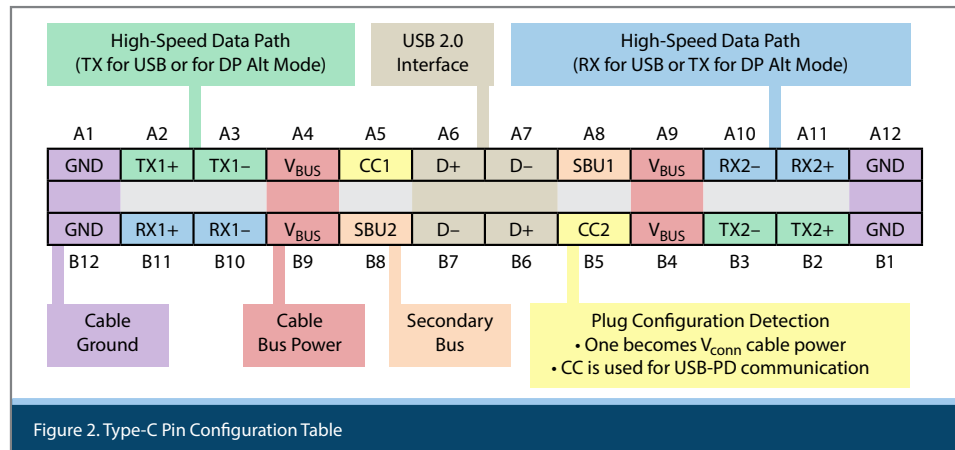


Figure 2. Type-C Pin Configuration Table

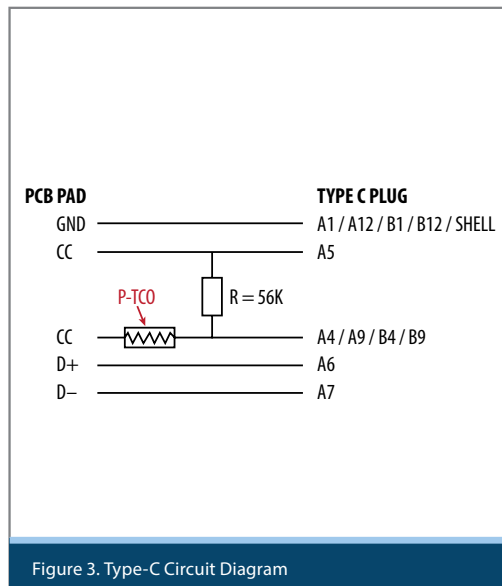


Figure 3. Type-C Circuit Diagram

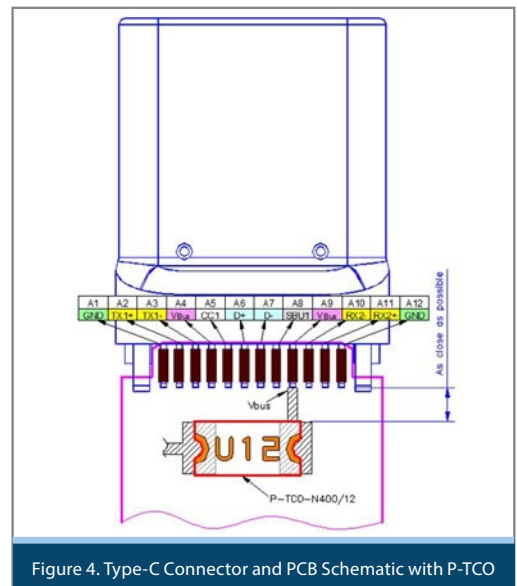


Figure 4. Type-C Connector and PCB Schematic with P-TCO

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USB 3.1 BACKGROUND

USB 3.1 is compatible with USB Type-C and is the latest cable connector design being adopted in next-generation devices. It also supports the USB Power Delivery specification with the capability to support a maximum of 20 volts at 5 amps for a total of 100 watts of power. The power categories for USB 3.1 are shown in Figure 3 where Profile 1 at 10 W is set aside for handheld devices and peripherals, and Profile 5 at up to 100 W has the ability to accommodate workstations, hubs and expansion docks.

Handheld Devices, Peripherals	Profile 1 5 V @ 2 A	10 W
Tablets, Notebooks, Peripherals	Profile 2 5 V @ 2 A 12 V @ 1.5 A	18 W
Thinner Notebooks, Larger Peripherals	Profile 3 5 V @ 2 A 12 V @ 3 A	36 W
Larger Notebooks, Hubs, Docks	Profile 4 5 V @ 2 A 12 V @ 1.5 A 20 V @ 3 A	60 W
Workstations, Hubs, Docks	Profile 5 5 V @ 2 A 12 V @ 5 A 20 V @ 5 A	100 W

Figure 5. USB 3.1 Power Categories

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BOURNS® THERMAL CUTOFF (TCO) DEVICES

Thermal Cutoff (TCO) devices - also known as mini-breakers - offer an effective overtemperature protection solution for USB Type-C cables. These TCO devices incorporate existing technology in such a way to enhance their protection capabilities. TCO devices are constructed using both a bimetal disc and ceramic PTC in parallel. The overheating of the USB connector causes the bimetal to open at a very accurate temperature. Once open, the current passes through the PTC which generates sufficient heat to keep the bimetal open and prevents nuisance resetting.

Understanding the need for both temperature sensing capability and the low resistance of the bimetal switch, Bourns designed these additional benefits into a hybrid TCO device that is available in several temperature ranges and has 100 percent in-line inspection of the trip temperature.

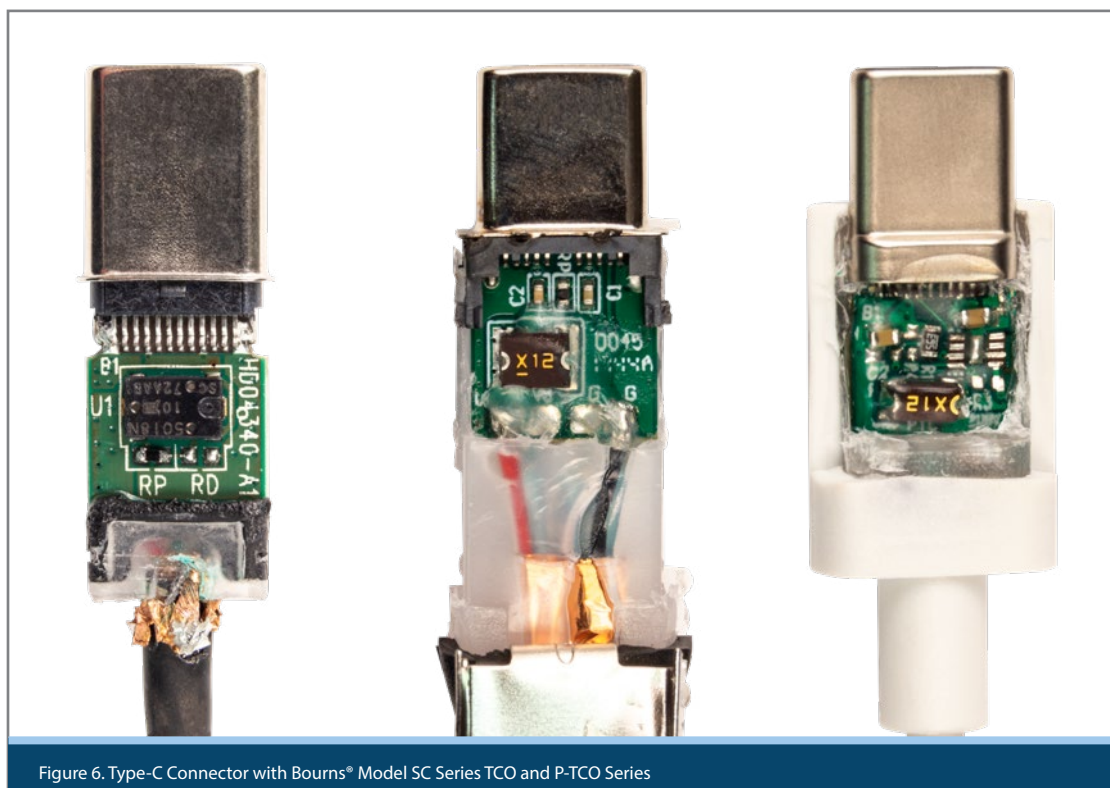


Figure 6. Type-C Connector with Bourns® Model SC Series TCO and P-TCO Series

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BOURNS® THERMAL CUTOFF (TCO) DEVICES (CONTINUED)

The construction of a Bourns® TCO device is shown in Figure 5. It is composed of a base terminal, PTC, bimetal disc, base, arm terminal, arm, cover plate, contact and cover.

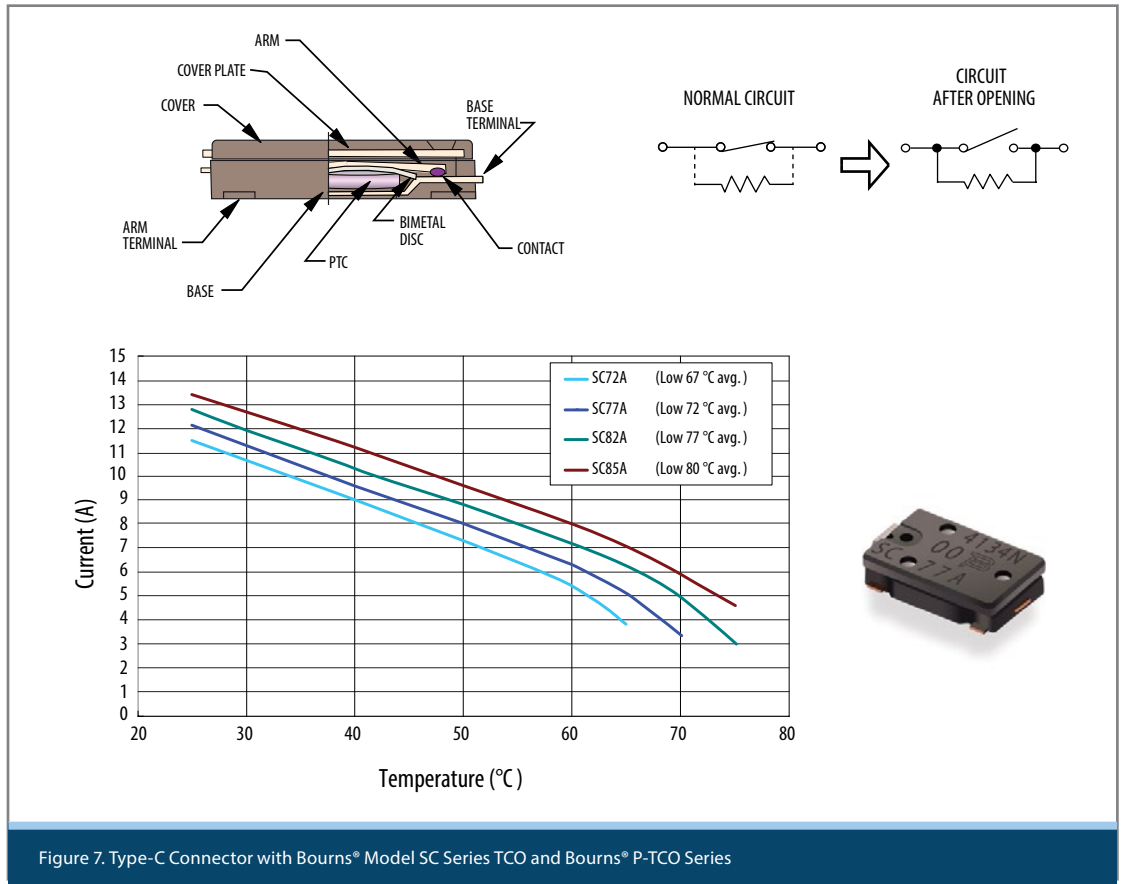


Figure 7. Type-C Connector with Bourns® Model SC Series TCO and Bourns® P-TCO Series

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BOURNS® POLYMERIC THERMAL CUTOFF (P-TCO) DEVICES

Bourns developed its P-TCO device as an overtemperature protection solution that can be specifically calibrated to trip and go into a highly resistive state dependent on ambient temperature.

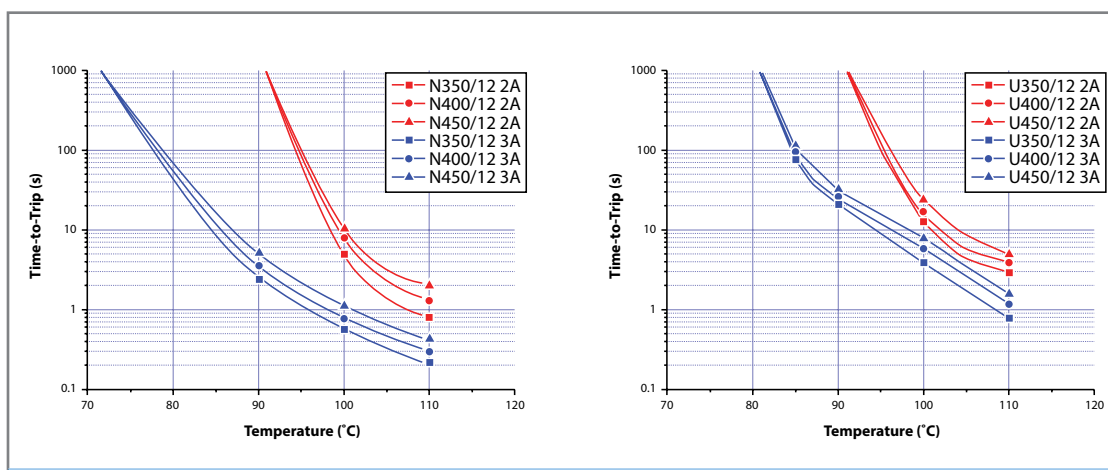


Figure 8. P-TCO Resistance Temperature Curve and Time-Temperature-Transformation

Table 1. P-TCO Specifications

Part Number	Footprint (EIA)	I _{hold} (A)	V _{max} (V _{dc})	I _{max} (A)	Resistance		Max. Time to Trip		Polymeric Thermal Cutoff @ 3 A	
					R1 _{min.} (Ω)	R1 _{max.} (Ω)	Current (A)	Time Sec.	AT 3A (°C)	AT 2A (°C)
P-TCO-N350/12	1206	3.50	12	50	0.002	0.022	8.00	5.00	75 ± 20	90 ± 15
P-TCO-N400/12	1206	4.00	12	50	0.002	0.018	10.00	5.00	80 ± 15	95 ± 15
P-TCO-N450/12	1206	4.50	12	50	0.002	0.014	22.50	2.00	85 ± 15	100 ± 10
P-TCO-U350/12	1210	3.50	12	50	0.002	0.022	17.00	5.00	75 ± 20	90 ± 20
P-TCO-U400/12	1210	4.00	12	50	0.002	0.018	20.00	5.00	80 ± 15	95 ± 15
P-TCO-U450/12	1210	4.50	12	50	0.002	0.014	22.50	2.00	85 ± 15	100 ± 10

Model P-TCO trip temperatures are specified between 75 °C to 85 °C (±15 °C to 20 °C) at 3 A, and 90 °C to 100 °C (±10 °C to 20 °C) at 2A with derating values for a wider temperature range. Bourns® Model P-TCO offers a cost-effective small form factor solution for USB Type-C cable overtemperature threats.

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RESULTS AND BENEFITS

Adding Bourns® TCO and P-TCO overtemperature devices in USB Type-C cable connectors provides an additional level of protection and safety that is not available in many cable designs today. The two solutions also provide added cost and space savings with precise protection and activation benefits.

Table 2. Benefits of using P-TCO Devices in USB-C Cables





Model	P-TCO Device Used in USB-C Cable	Benefits
		<ol style="list-style-type: none"> 1. Space Saving 2. Cost Saving 3. Thermal/Current Protection

Table 3. Benefits of using TCO Devices in USB-C Cables

Model	P-TCO Device Used in USB-C Cable	Benefits
		<ol style="list-style-type: none"> 1. Precise Temperature Protection 2. Repeatable over thousands of cycles 3. Can operate in all Power Categories up to 100 W

In addition, TCO and P-TCO solutions allow designers to create a more reliable USB Type-C cable design that provides vital network protection encompassing the host, dock, hub and peripherals. Users will appreciate the faster performance and power delivered from USB Type-C technology with significant protection against overheating or risk of fire.

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