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USB-C Protection Solutions: Charger, Device, and Cable



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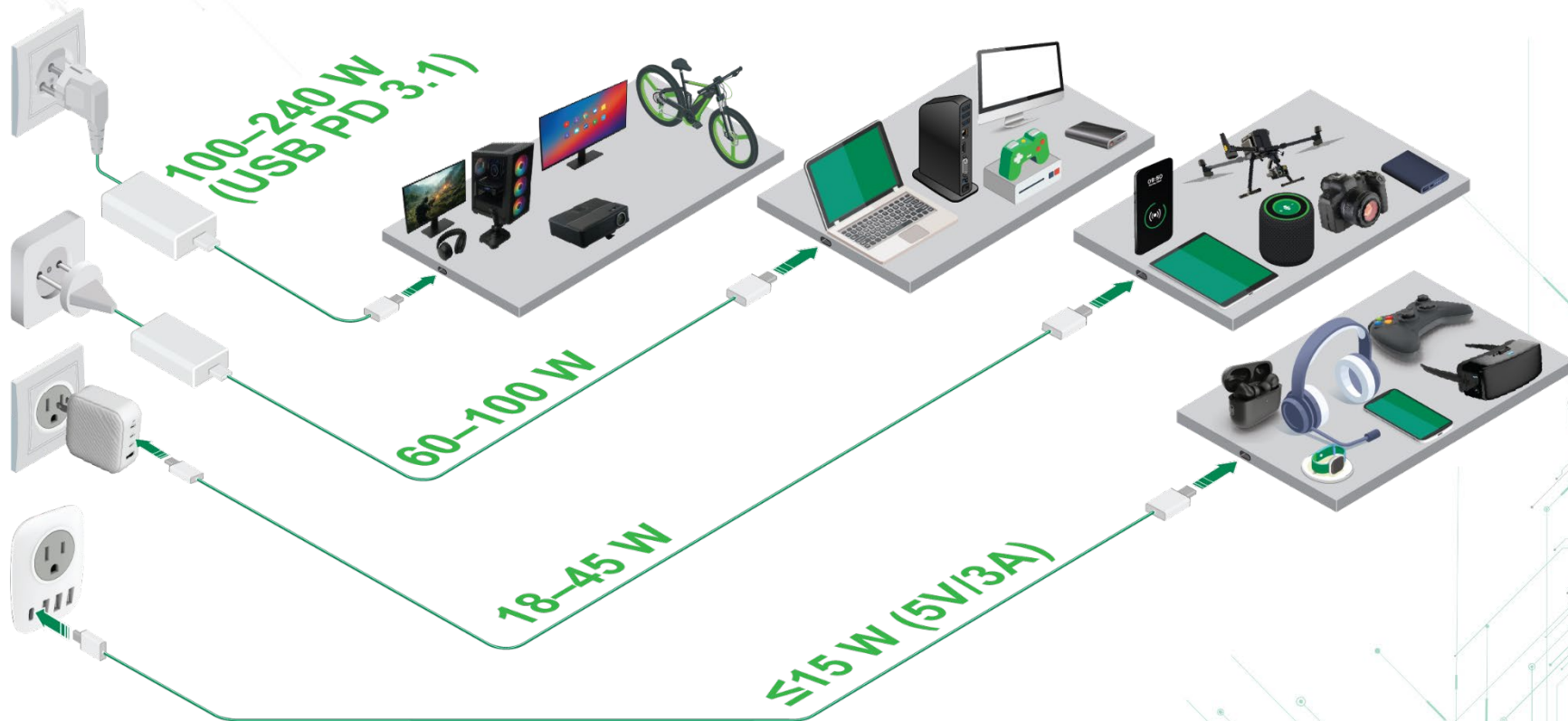


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USB-C is ubiquitous

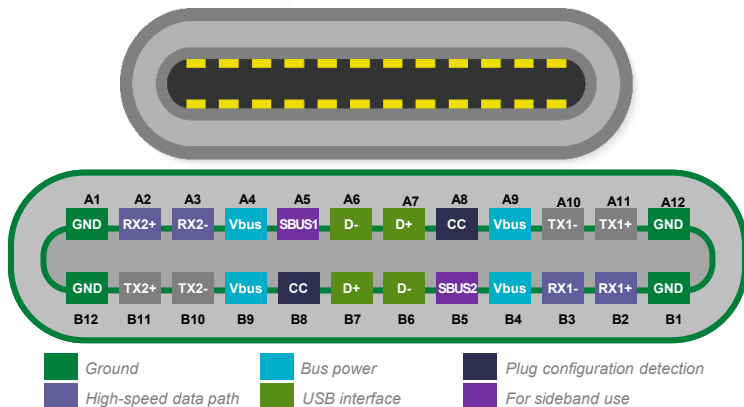
One connector for everything: power, data, and audio/video



USB-C full-featured Type-C plug interface overview

Increased power increases the risk of overheating; increased data speeds are more sensitive to ESD

USB Type-C receptacle pin configuration



Evaluation of USB standard

USB Version	Connector Type	Speed (Max)	Charging Power
USB 2.0	Type A & B	480 Mbps	2.5 W
USB 3.0	Type A & B	5 Gbps	4.5 W
USB 3.2 Gen 1	Type C	5 Gbps	100 W
USB 3.2 Gen 2	Type C	10 Gbps	100 W
USB 3.2 2 x 2	Type C	20 Gbps	100 W
USB 4.0	Type C	40 Gbps	240 W
USB 4.0 Version 2	Type C	80 Gbps	240 W

- The USB standard has been evolving since 1996 with **higher speeds and more power-carrying capacity**.
- The latest USB4 supports a bit rate of **80 Gbps**.
- The maximum power capacity increased **from 2.5 W → 100 W → an extended power range of 240 W (48 V @ 5 A)**.
- The Universal Connector provides **a single, reversible connector for power, data, and video across devices**.
- **Power Delivery Negotiation:** Communicate over the CC (Configuration Channel) to negotiate optimal voltage and current.
- **Flexible Power Levels:** Supports multiple power profiles (up to 48 V), enabling fast charging and powering larger devices.
- **Data and Power Separation:** Simultaneous high-speed data transfer and power delivery up to 80 Gbps.

Littelfuse solutions for USB-C protection (charger, cable, and device)

USB-C charger

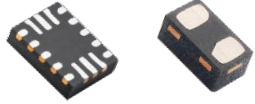
Fuse, MOV, TVS Diode, Optocoupler, Diode



USB-C device side

(V_{BUS} , CC/SBU* line protection)

eFuse, TVS Diode Array



USB-C cable protection

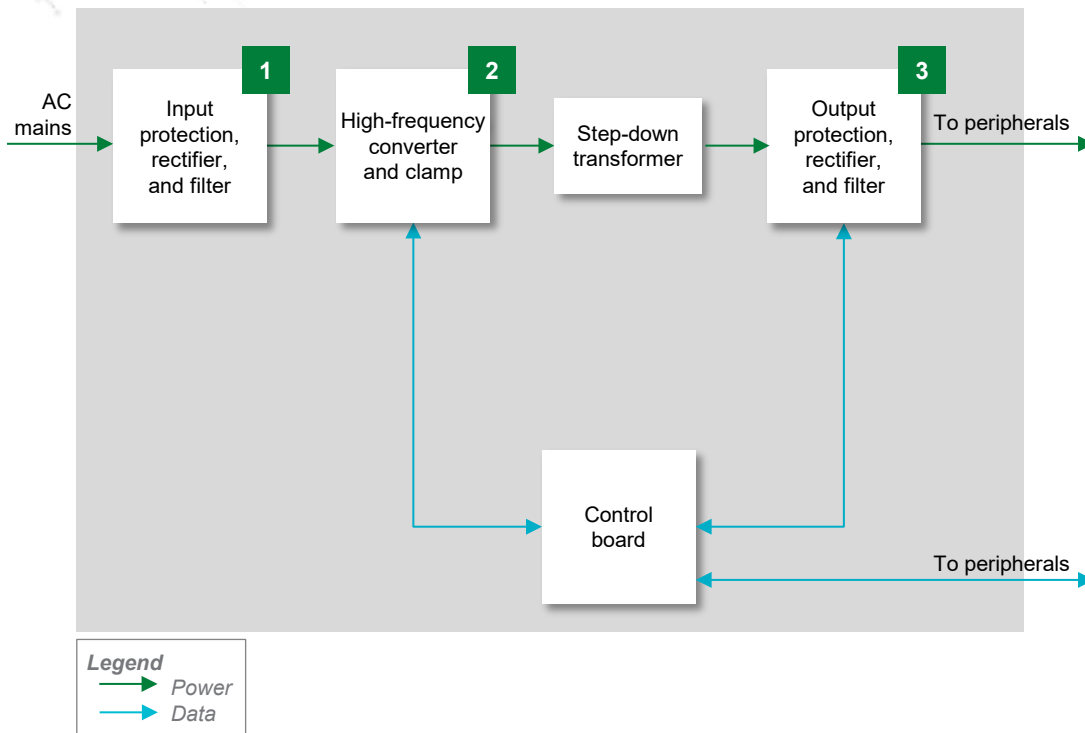
PolySwitch Resettable Device, Battery Protector, Digital Temperature Indicator, TVS Diode Array





Click the product series in the table below for more info.

USB-C charger block diagram



	Technology	Product series
1	Fuse	218 , 373 , 443E
	MOV	LA , M3
2	Optocoupler	CPC1301
	TVS Diode	P6KE , P6SMB , 8.0SMDJ , 1.5SMB , SMF4L
	Bridge Diode	Dxx15L
3	Schottky Diode	MBR , DST
	Temperature Indicator	SETP0805-100-CC
	Protection IC (eFuse)	LS Series

Features and benefits of Littelfuse products for USB-C chargers



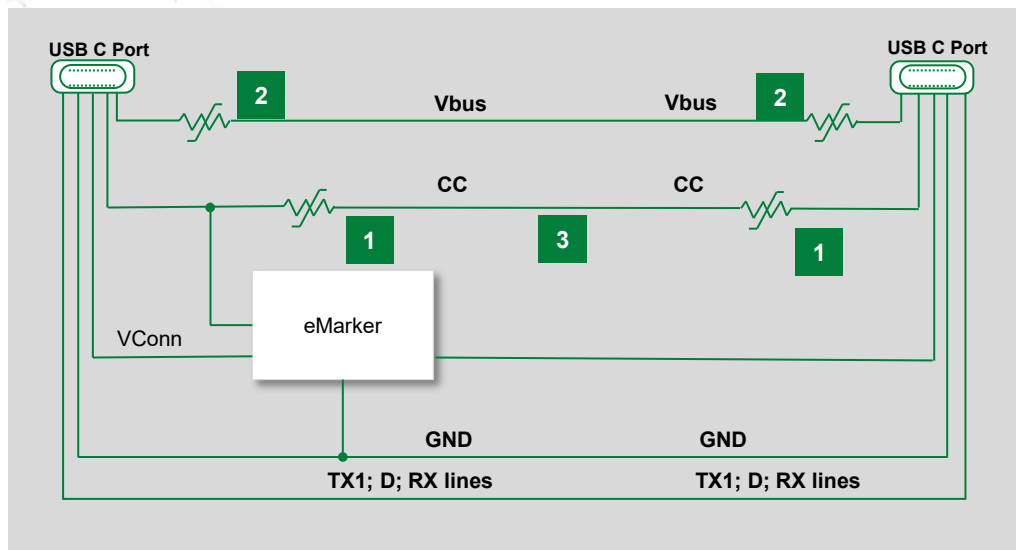
Click on the product series in the table below for more info

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Protects the power stage from an overcurrent	218 , 373 , 443E	Operating up to 125 °C	Designed to International (IEC) marking T3.15AL250V; meets the IEC 60127-2, Sheet 3 specification for TimeLag fuses, convenient mounting available in cartridge and axial lead form
	MOV	Surge protection	LA , M3	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	High energy absorption capability: 40–530 J (2 ms)
2	Optocoupler	Input/output isolation	CPC1301	High current transfer ratio in a small 4-pin package designed to UL1577 provides 5000 V _{rms} I/O Isolation	Low input current; high current transfer ratio; high output voltage capability; large isolation barrier rating
	TVS Diode	Protects the power supply unit from voltage transients induced by lightning and voltage transient events	P6KE , P6SMB , 8.0SMDJ , 1.5SMB , SMF4L	Improves a system's reliability by protecting peripherals from transients on power lines	600 W peak pulse capability; fast response time (<1 ps); compatible with the high reflow temperature profile (260 °C, 40 s)
	Bridge Diode	Rectifies 50 or 60 Hz main currents	Dxx15L	RoHS compliant; glass-passivated junctions; voltage capability up to 1000 V; surge capability up to 350 A	Meet UL, available in L package
3	Schottky Diode	Provides rectification and blocking in the power supply units	MBR , DST	Improves power supply unit efficiency	Low forward voltage drop; high-frequency operation; high junction temperature capability
	Temperature Indicator	Provides high-temperature indications to help protect USB-C plugs and receptacles from overheating	SETP0805-100-CC	Helps improve reliability and the user experience by reducing the risk of thermal damage; easy integration into existing USB-C systems	Fast response to thermal events; small form factor; zero IR loss contribution; protects systems with a 100 W or higher power rating
	Protection IC (eFuse)	Provides overcurrent protection, overvoltage protection, overtemperature protection, and reverse current blocking	LS Series	High integration with multiple protections in compact size; prevents failure during hot-plug and hot-swap events	Wide operation voltage range (3 to 24 V); 28 V maximum input/output voltage; integrate a 24 mΩ ultralow on protection switch; external adjustable current limit (1–6 A)



Click the product series in the table below for more info.

USB-C cable protection against overheating



	Technology	Product series
1	Temperature Indicator	setP™
2	Battery Mini-breaker	MHP
	OR PolySwitch® Resettable Device	Low Rho
3	TVS Diode Array	SP3213-01UTG

- eMarker – Could integrate TCO
 - Negotiates source with end device max current & voltage
- ESD protection recommended for active cables
- Cable cannot reach touch-safe temperatures

Features and benefits of Littelfuse products for USB-C cable protection



Click on the product series in the table below for more info

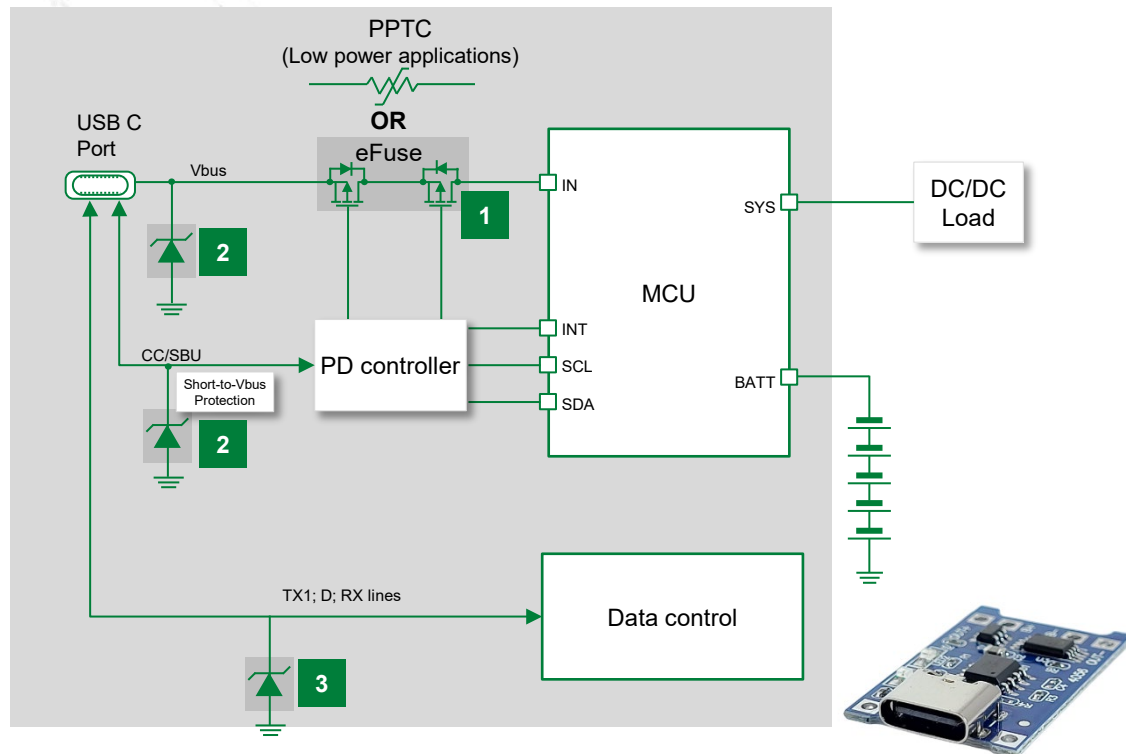
	Technology	Function in application	Product series	Benefits	Features
1	Temperature Indicator	Monitors cable temperature at the CC line to prevent overheating during high-power charging and ensures USB-C connector safety	setP™	Prevents connector overheating, enhances user safety and system reliability, easy integration into USB-C designs	Fast thermal response; compact 0805 SMD package; zero IR loss contribution
2	Battery Mini-breaker OR PolySwitch® Resettable Device	Provides resettable overcurrent and overtemperature protection on VBUS. MHP is used for high-power cables, while Low Rho suits low-power (≤ 5 V, 10 W) applications like IoT and wearables.	MHP	Prevents cable damage and fire risk; protects VBUS circuits across power ranges, improves safety, reliability, and reusability	Compact, resettable design; high current capacity
			Low Rho		Ultra-low resistance; compact SMD footprint; self-resetting after fault
3	TVS Diode Array	Protects CC, SBU, and data lines from ESD and surge transients that occur during hot-plug or handling events; essential for active cables to maintain signal integrity and prevent IC damage	SP3213-01UTG	Prevents eMarker and PD controller failure; preserves high-speed data performance; enhances overall cable reliability	± 30 kV ESD protection (IEC 61000-4-2); low clamping voltage; low capacitance design

USB-C device-side protection solutions

V_{BUS} , CC/SBU, and data line protection



Click on the product series in the table below for more info



	Technology	Product series
1	PolySwitch® Resettable Device (Low-power application)	Low Rho
	Protection IC (eFuse) (V_{BUS} -CC/SBU Short)	LS05006VPQ33
	Protection IC (eFuse) (Overcurrent/ overvoltage control)	LS12052BD33 (V_{BUS} power: 9 V/30 W), LS24062RQ23 (V_{BUS} power: 20 V/100 W)
2	TVS Diode Array (V_{BUS} Surge/ESD protection)	SP1250-01ETG (V_{BUS} power: 5 V/10 W), SP1224-01UTG (V_{BUS} power: 20 V/100 W), SC1236-01UTG* (V_{BUS} power: 48 V/240 W), SP3118E-01WTG
	TVS Diode Array (CC/SBU Surge/ESD protection)	SP3130E-01WTG-1 (V_{BUS} power: 20 V/100 W), SP36-01WTG-C-HV (V_{BUS} power: 28 V/140 W), SP48-01WTG-C-HV* (V_{BUS} power: 36 V/180 W), (V_{BUS} power: 48 V/240 W)
3	TVS Diode Array (Data line protection)	SP3522 (USB2.0 D+/D-), SP4337-01WTG (USB3.x), SP4315-01WTG*/ SP001R4-01WTG* (USB4/Thunderbolt)

* New product. Contact Littelfuse Sales for more details.

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Features and benefits of Littelfuse products for V_{BUS} , CC/SBU, and data line protection



Click on the product series in the table below for more info

	Technology	Function in application	Product series	Benefits	Features
1	PolySwitch® Resettable Device	Overcurrent protection for low-power applications (5 V/10 W)	Low Rho	Minimizes power loss in small form factors; protects against overcurrent without replacement; ideal for compact USB-C devices	Ultra-low resistance and compact 1206/1210 SMD package; resettable PTC polymer technology; trip current range 0.2–3.0 A
	Protection IC (eFuse)	Protects CC/SBU lines from V_{BUS} short circuits; prevents damage during faults or misconnection events	LS05006VPQ33	Prevents CC/SBU line damage from V_{BUS} faults; ensures safe operation during USB-C plug-in events	Integrated short-to- V_{BUS} and reverse-current protection; 3–24 V operation; 6 A current limit
	Protection IC (eFuse)	Provides overcurrent and overvoltage protection for 9 V/30 W USB-C PD power; ensures efficient, safe delivery	LS12052BD33	Reduces heat and power loss in PD paths; safeguards USB-C chargers and devices against overloads	Programmable current limit (1–6 A); 24 mΩ on-resistance; 9 V/30 W V_{BUS} protection; reverse-current blocking
		Enables stable protection for 20 V/100 W USB-C PD; safeguards against high-current and high-voltage faults	LS24062RQ23	Enables stable protection for high-power PD ports; simplifies design with integrated fault management	Operates up to 20 V/100 W; adjustable current limit; built-in overvoltage and thermal shutdown
2	TVS Diode Array	Protects 5 V/10 W V_{BUS} from surge and ESD events; improves power line robustness	SP1250-01ETG	Protects 5 V V_{BUS} from transient surges without distorting signal quality or affecting PD negotiation	5 V standoff voltage; ±30 kV ESD protection (IEC 61000-4-2); <1 pF capacitance
		Protects 20 V/100 W V_{BUS} from transient surges; enhances USB PD safety	SP1224-01UTG	Ensures robust surge suppression for 20 V V_{BUS} lines in USB Power Delivery applications	20 V standoff; low dynamic resistance; ±30 kV ESD capability
		Provides surge and ESD protection for 48 V/240 W systems; ensures PD reliability at high voltages	SC1236-01UTG*		
		Protects CC/SBU lines from surge and ESD events during hot-plug operations	SP3118E-01WTG	Prevents PD controller and CC/SBU interface failure during cable hot-plug or ESD events	20 V standoff; ±30 kV ESD; 1.2 pF capacitance
		Shields CC/SBU lines from transient voltages; preserves communication integrity	SP3130E-01WTG-1	Maintains USB-PD signal integrity while shielding CC/SBU lines from transients	28 V standoff; <1.5 pF capacitance; ±30 kV ESD
		Provides robust CC/SBU surge and ESD protection up to 36 V; ideal for higher PD profiles	SP36-01WTG-C-HV	Provides reliable surge protection for high-power PD and industrial USB-C designs	36 V working voltage; <1.5 pF capacitance; ±30 kV ESD
		Protects 48 V/240 W CC/SBU lines from surge and ESD stress; improves high-power cable reliability	SP48-01WTG-C-HV*		

Features and benefits of Littelfuse products for V_{BUS} , CC/SBU and data line protection



Click on the product series in the table below for more info

	Technology	Function in application	Product series	Benefits	Features
3	TVS Diode Array	Protects USB 2.0 D+/D- data lines from ESD; maintains data integrity	SP3522	Ensures reliable USB 2.0 data transfer by shielding D+/D- lines from ESD and noise	±30 kV ESD (IEC 61000-4-2); <2 pF capacitance; 5 V standoff
		Prevents ESD damage on USB 3.x high-speed data lines; maintains signal quality	SP4337-01WTG	Maintains USB 3.x SuperSpeed signal quality under ESD exposure	3.3 V standoff; 0.25 pF capacitance; ±30 kV ESD protection
		Provides ESD protection for USB 4 and Thunderbolt interfaces; ensures error-free communication	SP4315-01WTG*/ SP001R4-01WTG*		

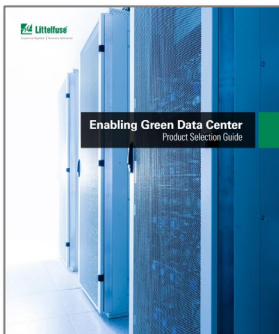
* New product. Contact Littelfuse Sales for more details.

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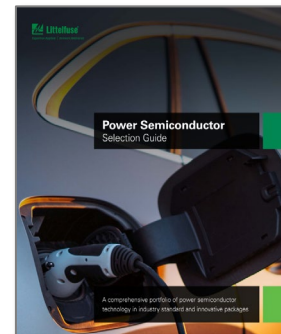
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Design Guide



ESD Protection
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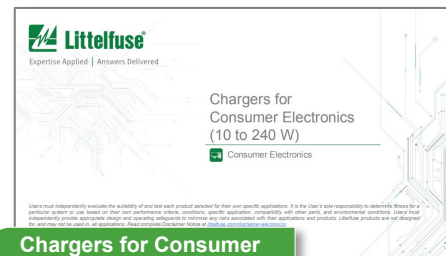


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