Multi-technology solutions for electronic designs

Thinking the obvious: *Think easy; Think more money faster*

Littelfuse®

Expertise Applied | Answers Delivered

Agenda

- Littelfuse overview
- Thinking the obvious: *“Think easy; Think more money faster”*
  - Commonly used building blocks in electronic designs
  - Target multiple technologies with Littelfuse in electronic designs
- TechPoint: A single destination for all ESBU technical resources
- Discovery questions

Empowering a sustainable, connected, and safer world

WHO WE ARE

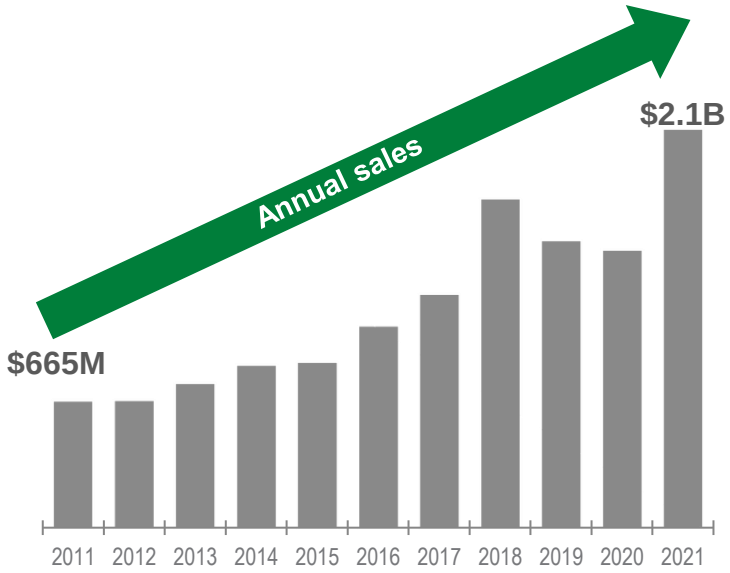
- **$2.10B** industrial technology company*
- **12,000** innovative employees across **15 countries** worldwide
- **Designer & manufacturer** of leading technologies that improve the safety, reliability, & performance of our customers' products

WHAT WE DO

- We **partner with global customers** to design and deliver innovative, reliable solutions
- We collaborate to provide **technical & application expertise**

WHO WE SERVE

- Serving over **100,000 end customers**; our products are found in a variety of industrial, transportation, and electronics end markets−everywhere, every day



** 2021 fiscal year*

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Littelfuse solutions overview

CIRCUIT PROTECTION SOLUTIONS

Fuses | Industrial Fuses | Solar Fuses | Resettable PPTCs | Varistors | GDTs | SIDACtor® | TVS Diodes | Diode Arrays | Surge Protection

POWER SEMICONDUCTOR SOLUTIONS

Discrete Thyristors | Discrete Diodes | Discrete IGBTs | Discrete MOSFETs | Silicon Carbide | Power Modules | High-Power Devices | Gate Drivers | Ignition IGBTs

SWITCHING & CONTROL SOLUTIONS

Reed Relays | Solid State Relays | Arc-Flash Relays | Ground-Fault Relays | Motor & Pump Protection | Voltage/Current Monitoring | Industrial GFCIs | DC Disconnect Switches | Contactors

SENSING SOLUTIONS

Reed Sensors | Hall Effect Sensors | TMRs | NTCs | RTDs | Temperature Indicators | Motion Sensors

TRANSPORTATION SOLUTIONS

Automotive Fuses | Fuse Holders | Automotive Sensors | Power Distribution Modules | Switches | DC Solenoid Relays

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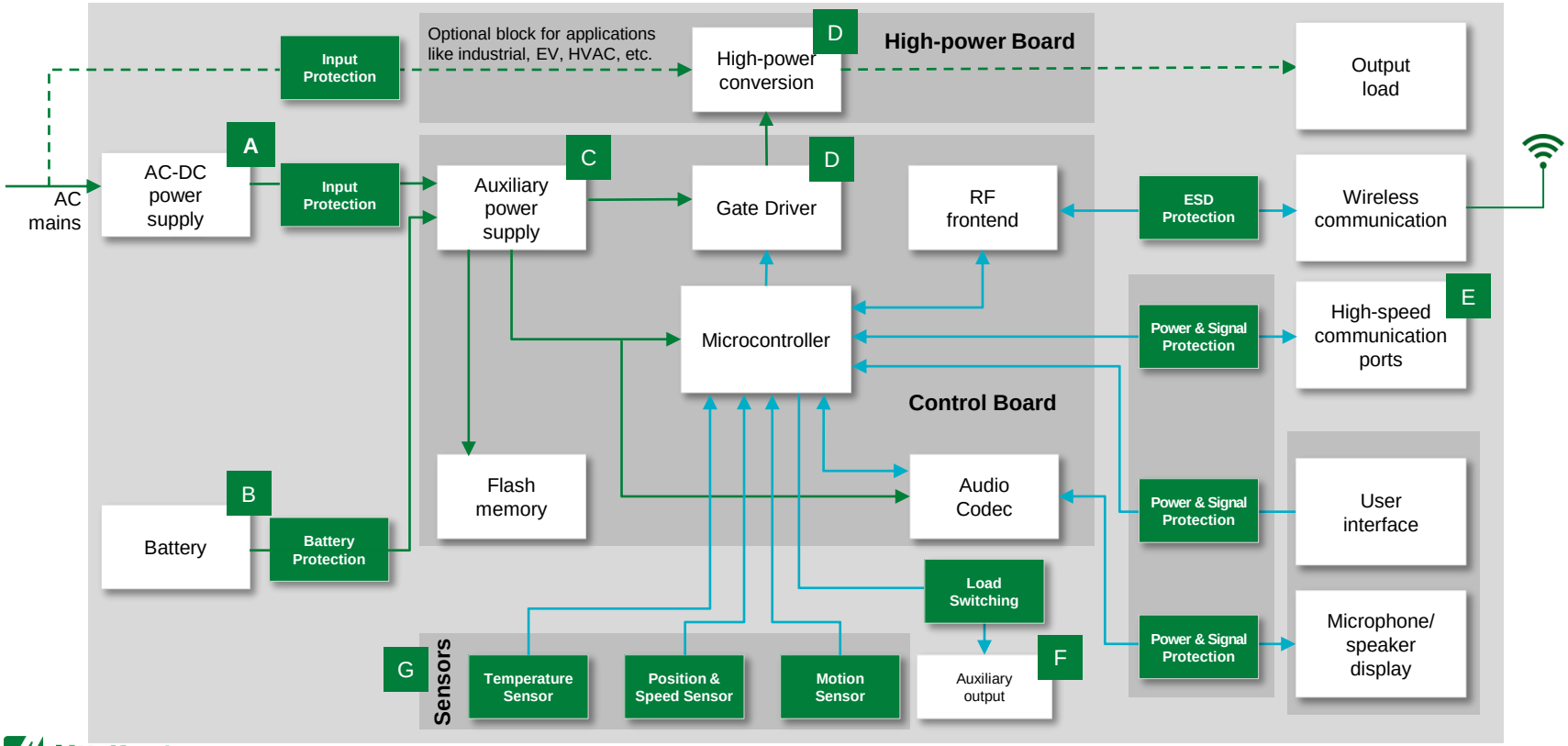
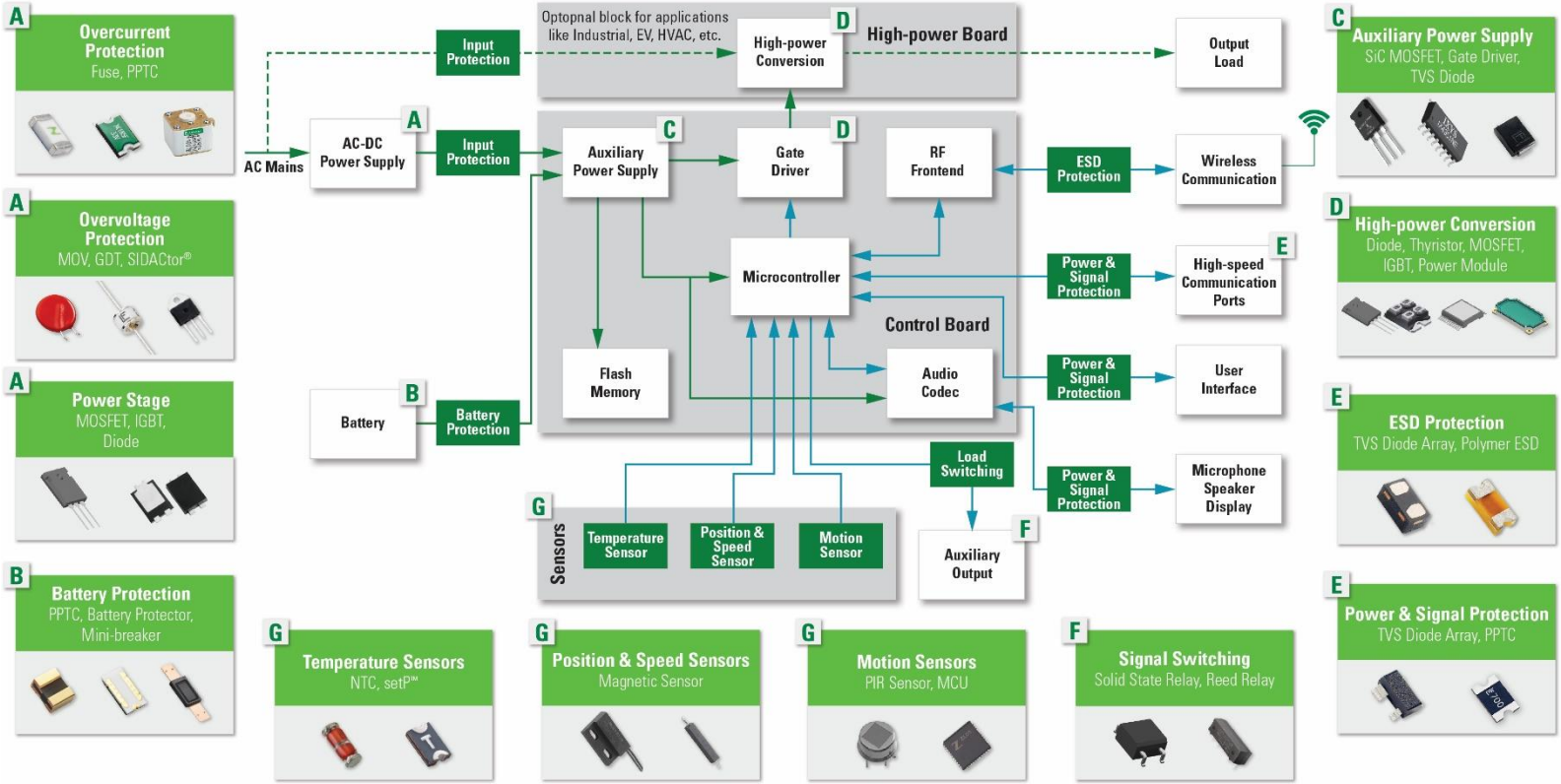
Building blocks discussed in this presentation are applicable in many markets & applications

Sl. No.	Slides	Slides
1.	Commonly used building blocks in electronic designs	6−7
	▪ AC-DC Power Supply	8−12
	▪ Battery protection	13−16
	▪ Auxiliary Power Supply	17−19
	▪ High-power Conversion	20−24
	▪ High-Speed Communication Port Protection	25−31
	▪ Sensors & Other Technologies	32−36
2.	TechPoint	37−38
3.	Appendix	43−60

Commonly used building blocks in an electronic system



Many sockets for various Littelfuse technologies in customer systems



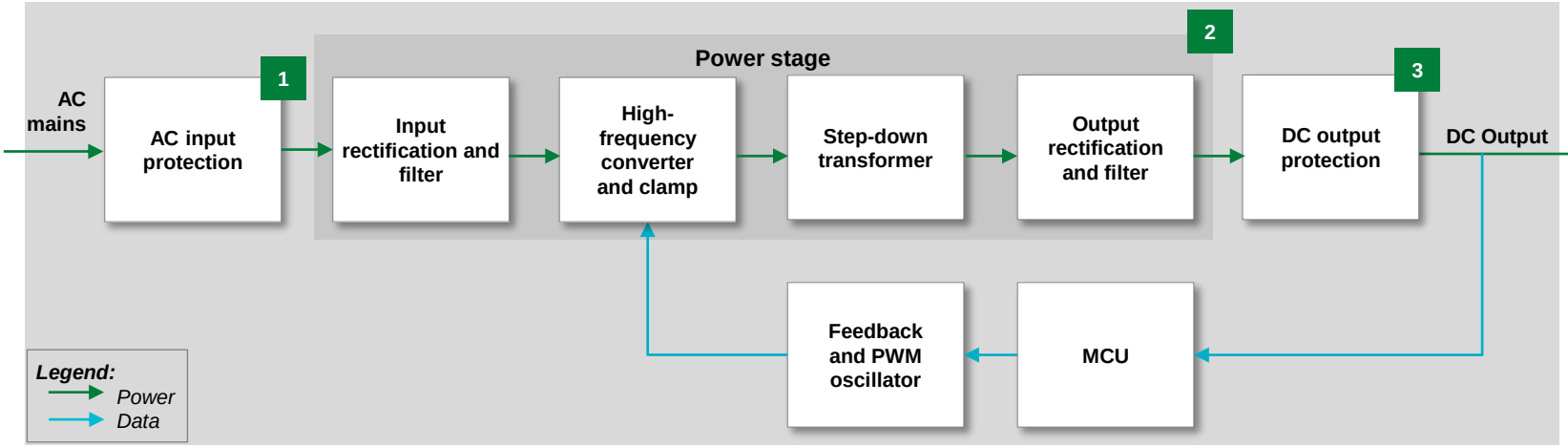
A

AC/DC Power Supply

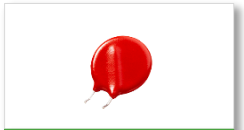
A

AC/DC Power Supply

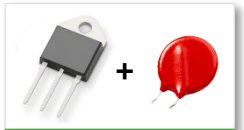
Opportunity to sell multiple circuit protection and power semiconductor products



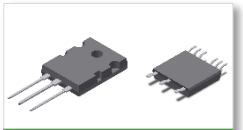

Fuse + Fuseholder


MOV


GDT


SIDACtor® + MOV


Diode / Thyristor


MOSFET / IGBT


TVS Diode

1 Overcurrent protection

1 Overvoltage protection

2 Power stage

3 Output protection

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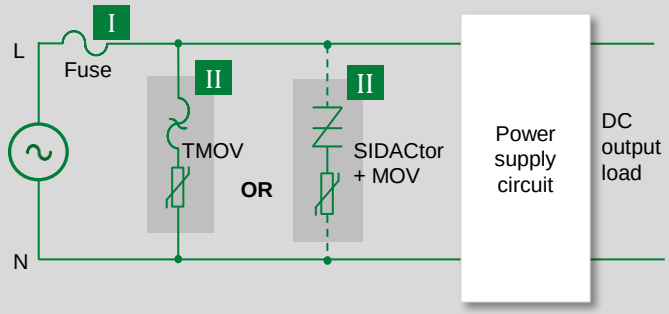
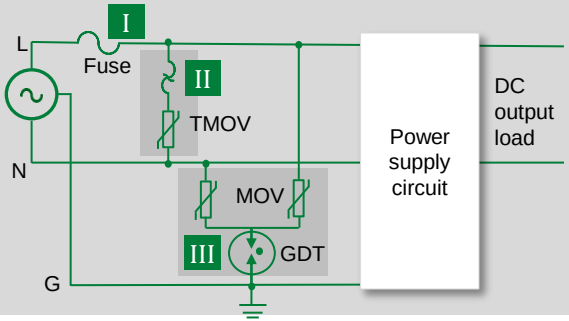
Input protection

Differential mode



Differential & Common mode



Function	Technology (With Series Examples)
I Overcurrent protection	Fuse + Fuseholder 215, JLS, JLLS + LFT, LFJ
II Overvoltage protection	MOV or SIDACtor® + MOV TMOV or P2300 + V10E300P
III Common mode protection	MOV + GDT V10E300P + CG3 3.3

Opportunity to sell multiple circuit protection:

- ✓ Fuse (Fuseholder) + MOV *or*
- ✓ Fuse (Fuseholder) + SIDACtor + MOV
- ✓ Fuse (Fuseholder) + MOV and MOV + GDT

For part # suggestions

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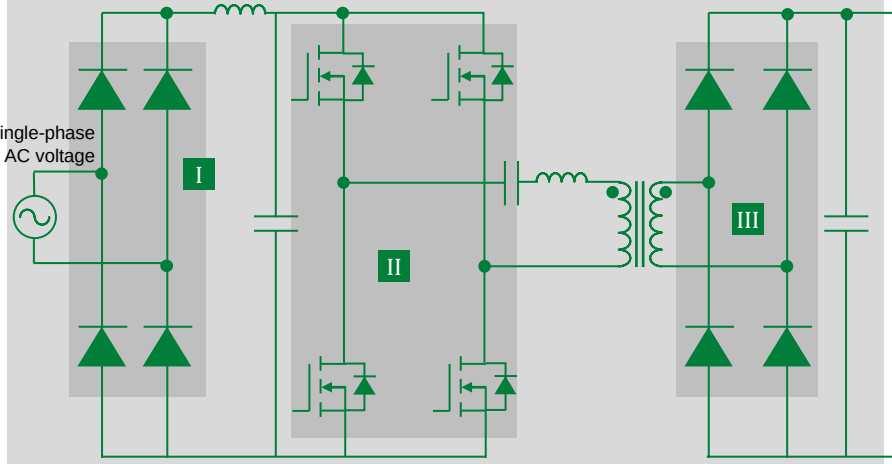
Power Stage

Single Phase AC/DC Power Supply Power Conversion



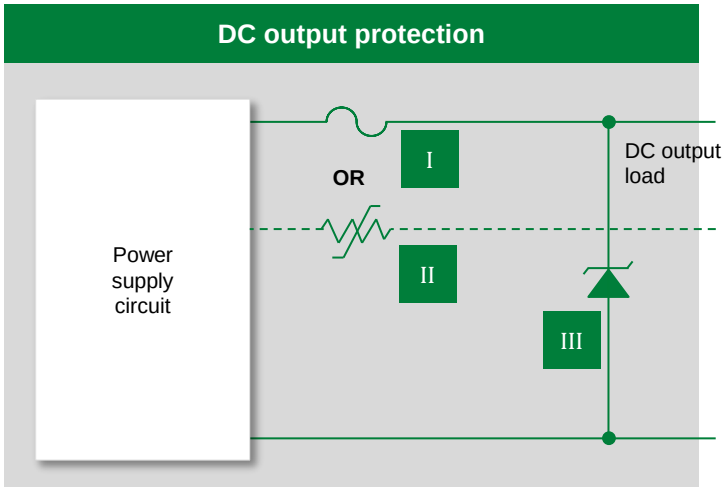
Function	Technology (With Series Examples)
I Input rectification	Diode DST, DSA, DSB
II High-frequency switching	SiC/Si MOSFET of IGBT X2-class, XPT
III Output rectification	Schottky Diode, SiC Diode MBR, DST

Opportunity to sell multiple power semiconductors:

- ✓ Diode
- ✓ MOSFET or IGBT
- ✓ Schottky Diode

For part # suggestions

DC output protection



Function	Technology (With Series Examples)
I Short circuit protection	Fuse *or* 253, 276
II Short circuit protection	Resettable PPTC Low Rho
III Surge protection	TVS Diode SMBJ

Opportunity to sell multiple power semiconductors:

- ✓ Fuse or Resettable PPTC
- ✓ TVS Diode

For part # suggestions

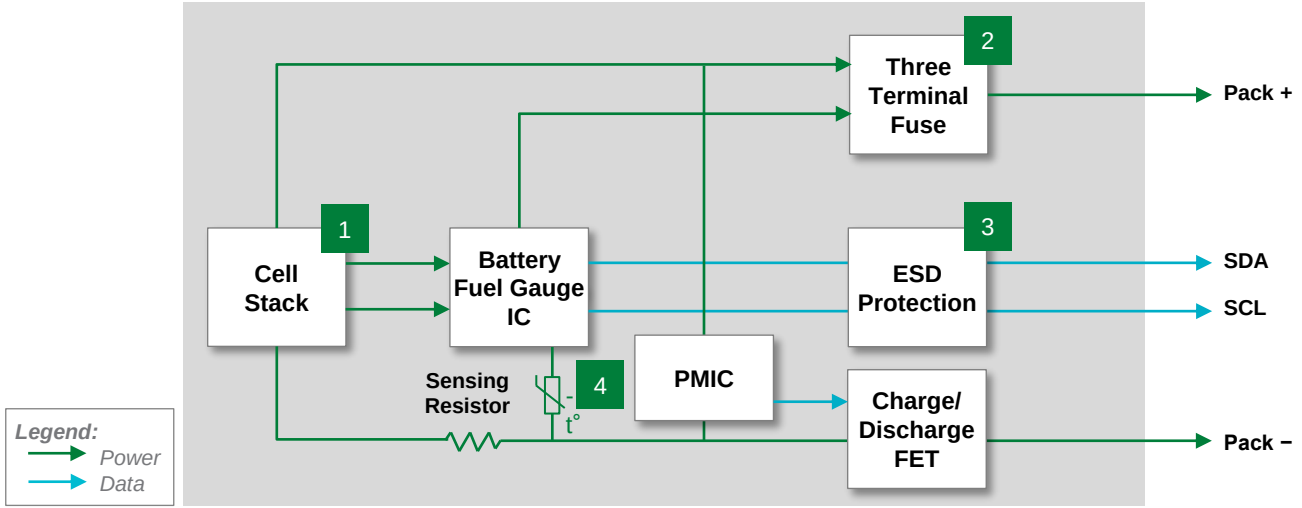
B

Battery protection

B

Battery protection

Opportunity to sell Battery Protection Device, Diode Array, and Temperature Sensor



PPTC

Battery Mini-Breaker

1 Battery protection

Three Terminal Fuse

2 Secondary protection

TVS Diode Array

3 ESD protection

Thermistor

4 Temperature sensing

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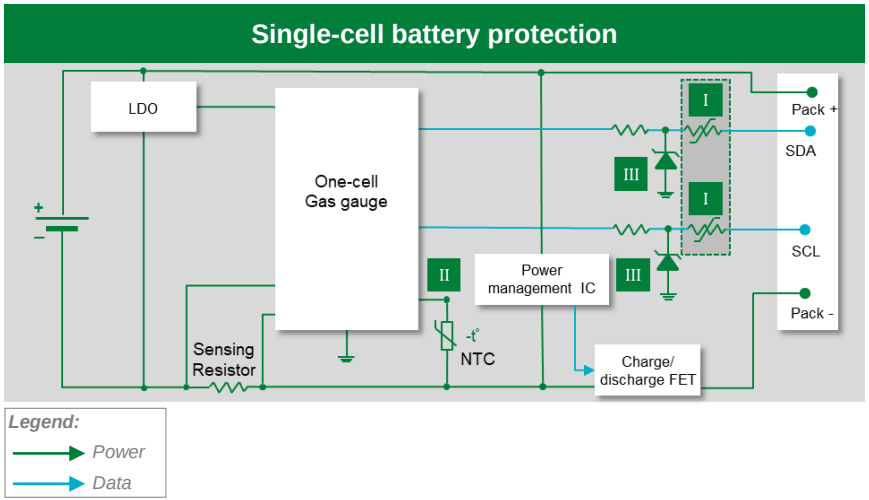
Single-cell battery protection



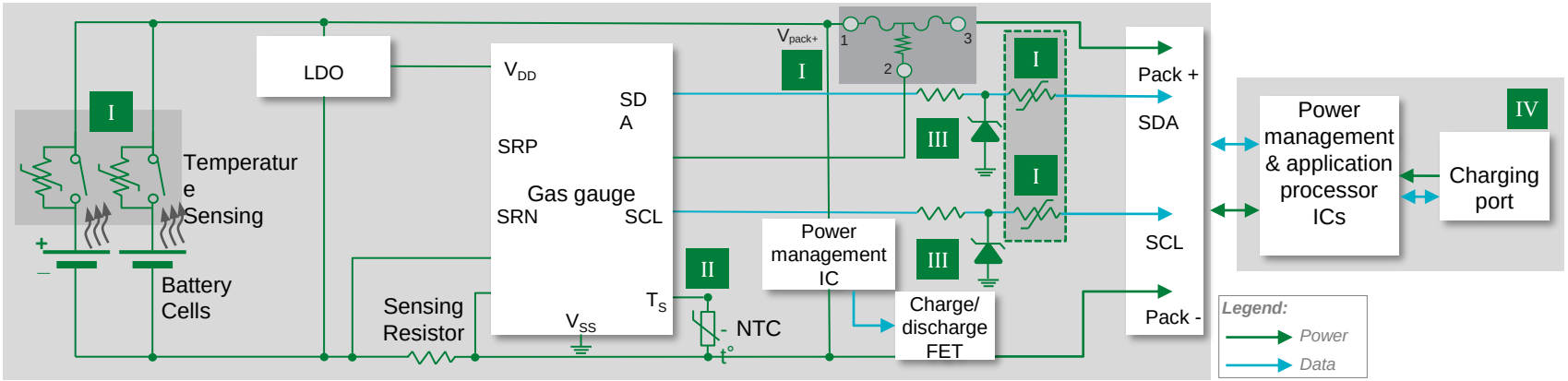
Function	Technology (With Series Examples)
I Overcurrent protection	PPTC zeptoSMDC
II Temperature sensing	NTC RA, RB, KR
III ESD protection	TVS Diode Array SP1006

Opportunity to sell protection and temp. sensing:

- ✓ PPTC
- ✓ NTC
- ✓ TVS Diode Array

For part # suggestions

Multicell battery protection



Function	Technology (With Series Examples)	Opportunity to sell protection and temp. sensing:
I Overcurrent & overtemperature	PPTC, Battery Mini-Breaker zeptoSMDC, MHP-TAC	✓ PPTC, Battery Mini-Breaker, Protector
II Secondary protection	Battery Protector ITV module	✓ NTC
III ESD protection	TVS Diode Array SP1006	✓ TVS Diode Array
IV Temperature sensing	NTC RA, RB, KR Digital Temp Indicator setP™	✓ setP™

For part # suggestions

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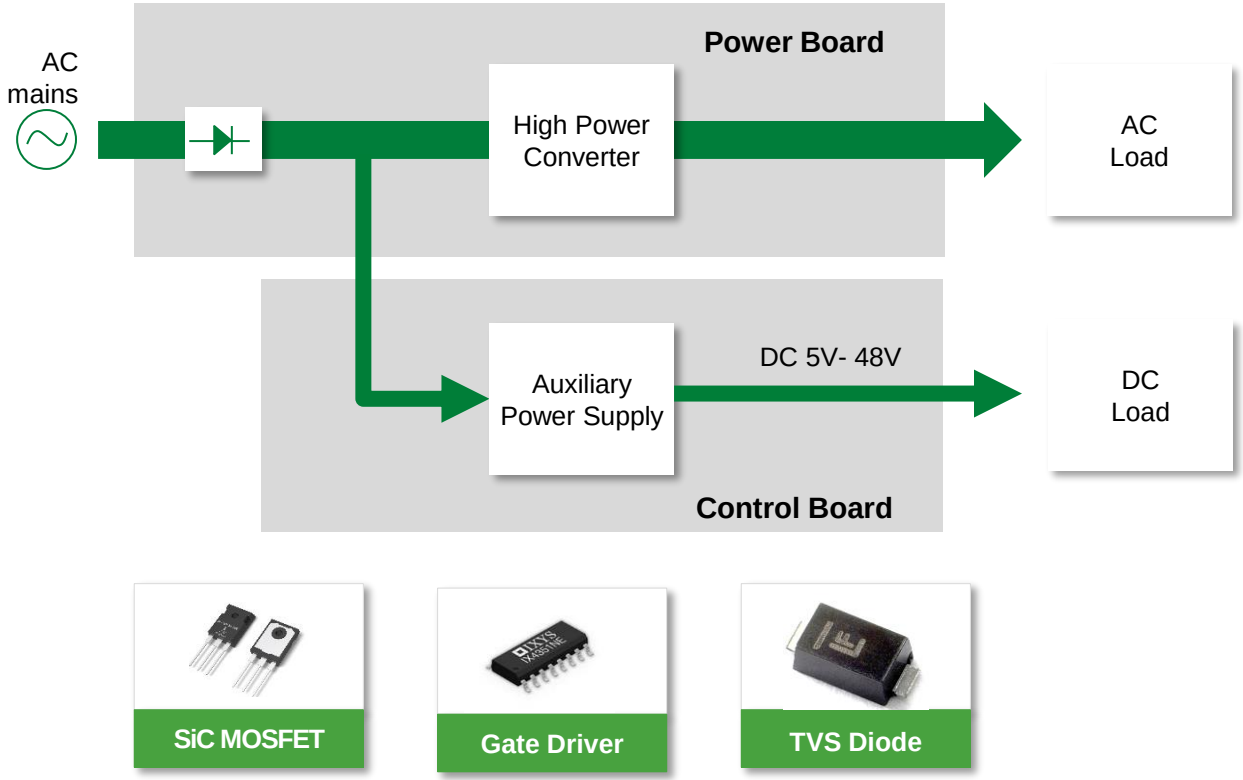
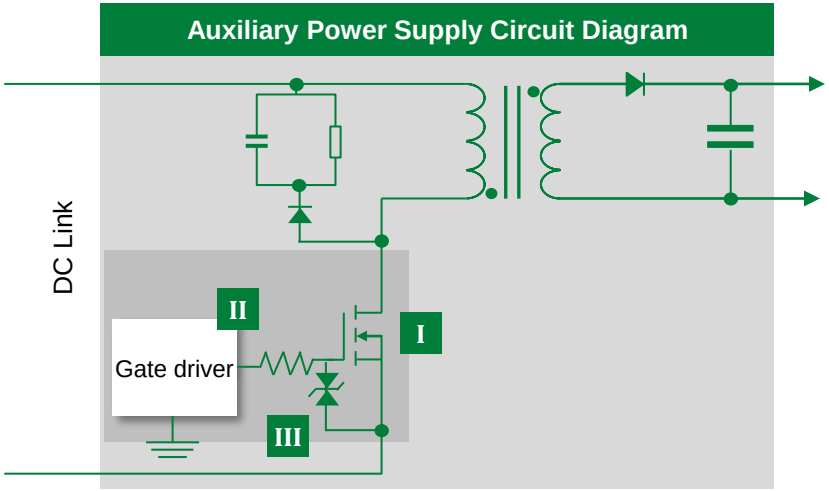
Auxiliary Power Supply

Auxiliary power supply

Opportunity for Si/SiC MOSFET+ Gate Driver + TVS Diode



Auxiliary power supply



Function	Technology (With Series Examples)
I High-frequency switching	SiC MOSFET LSIC1MO170T0750
II Drive SiC MOSFETs	Gate Driver IX4351NE
III Protect from voltage transients	TVS Diode SMF, 1.5SMC

Opportunity for power semiconductor & protection:

- ✓ SiC MOSFET
- ✓ Gate Driver
- ✓ TVS Diode

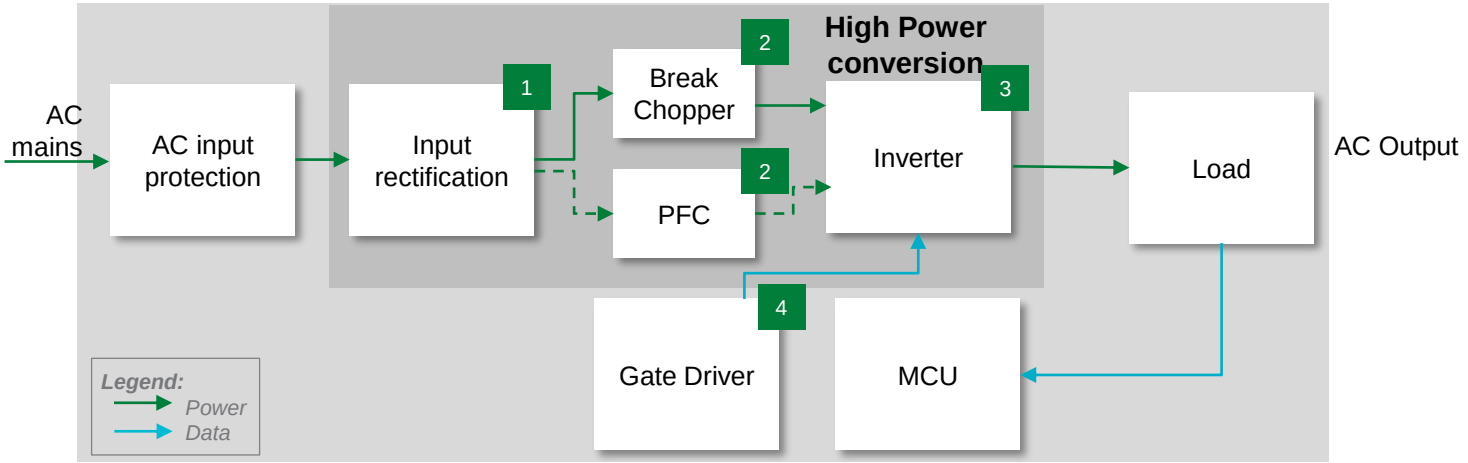
For part # suggestions

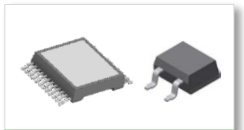
D

High-power Conversion

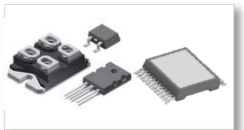
High-power Conversion

Opportunities for power semiconductors + Gate Driver+ High-speed fuse + TVS Diode



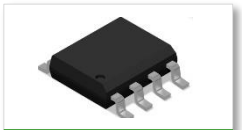


Diode or Thyristor



MOSFET or IGBT

Power Modules



Gate Driver

High-speed Fuse

TVS Diode

NTC

1 Rectification

2 Break chopper or PFC

3 Inverter

4 Drive IGBT

3 Semiconductor protection

3 Temperature Sensing

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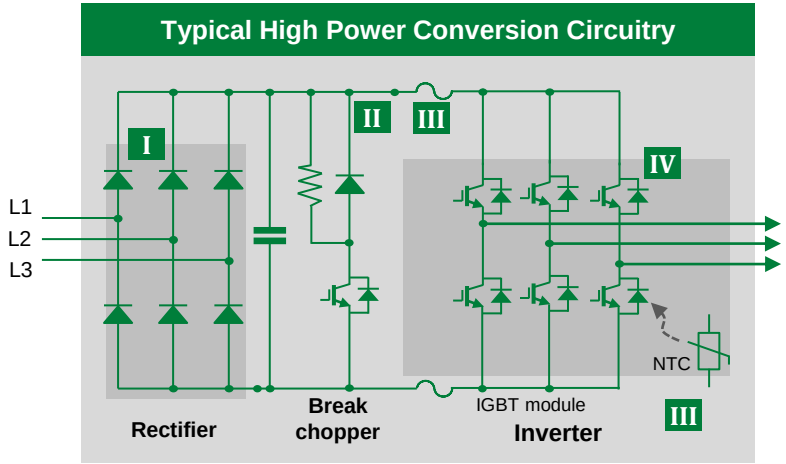
High Power Conversion



Function	Technology (With Series Examples)
I Rectifier	Diode. Thyristor or Module Module Offerings, Discrete Devices
II Break Chopper or PFC	Diode, MOSFET or Module Boost Chopper IGBT Modules
III Inverter	IGBT/ Power Module XPT Modules, 6 Pack Modules
IV Semiconductor protection	High Speed fuse PSR TVS Diode SMBJ, NTC SM

Opportunity for power semiconductor & protection:

- ✓ Diode, Thyristor or Module
- ✓ MOSFET or IGBT, Module, Gate Driver
- ✓ High-speed Fuse, TVS Diode, NTC

For part # suggestions

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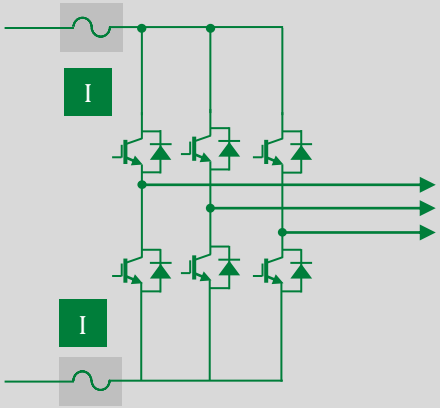
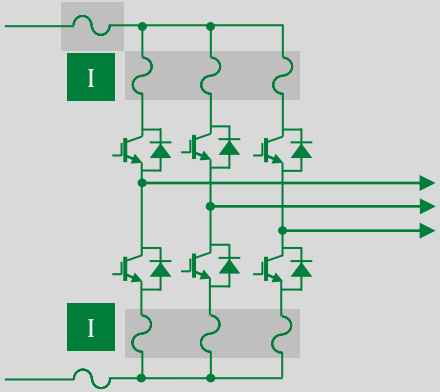
D

High-speed(semiconductor) fuses designed to protect power electronics devices

Low-power applications: Fuses typically in the DC Bus

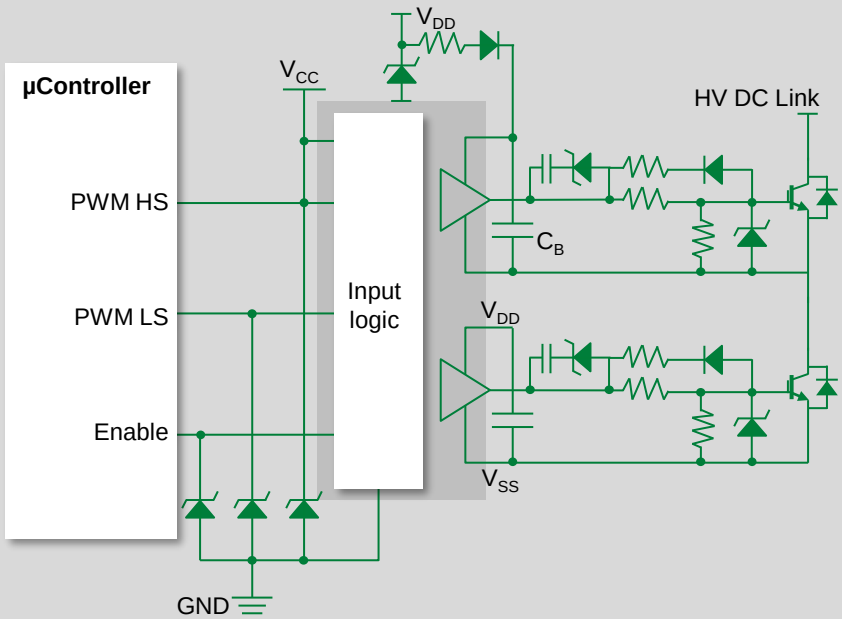


High-power applications: Fuses located in DC Bus and/or individually in semiconductor arm

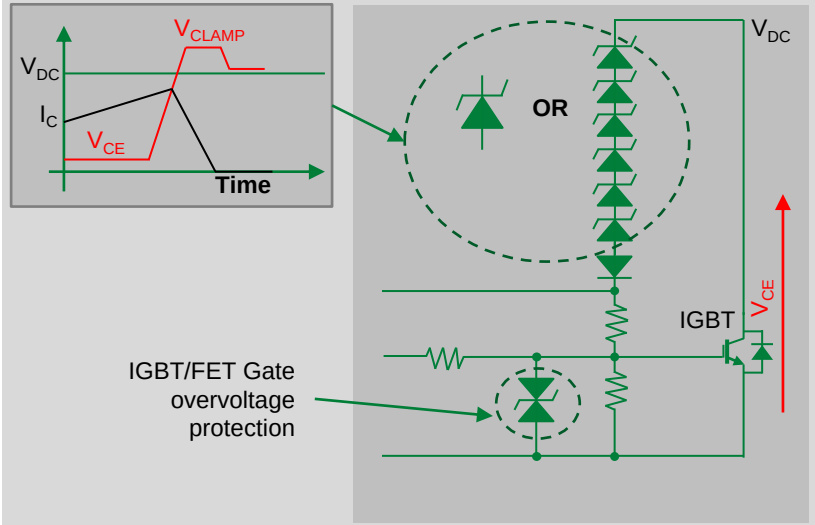


TVS Diode for IGBT/MOSFET protection and active clamping

IGBT/MOSFET Protection



Active Clamping

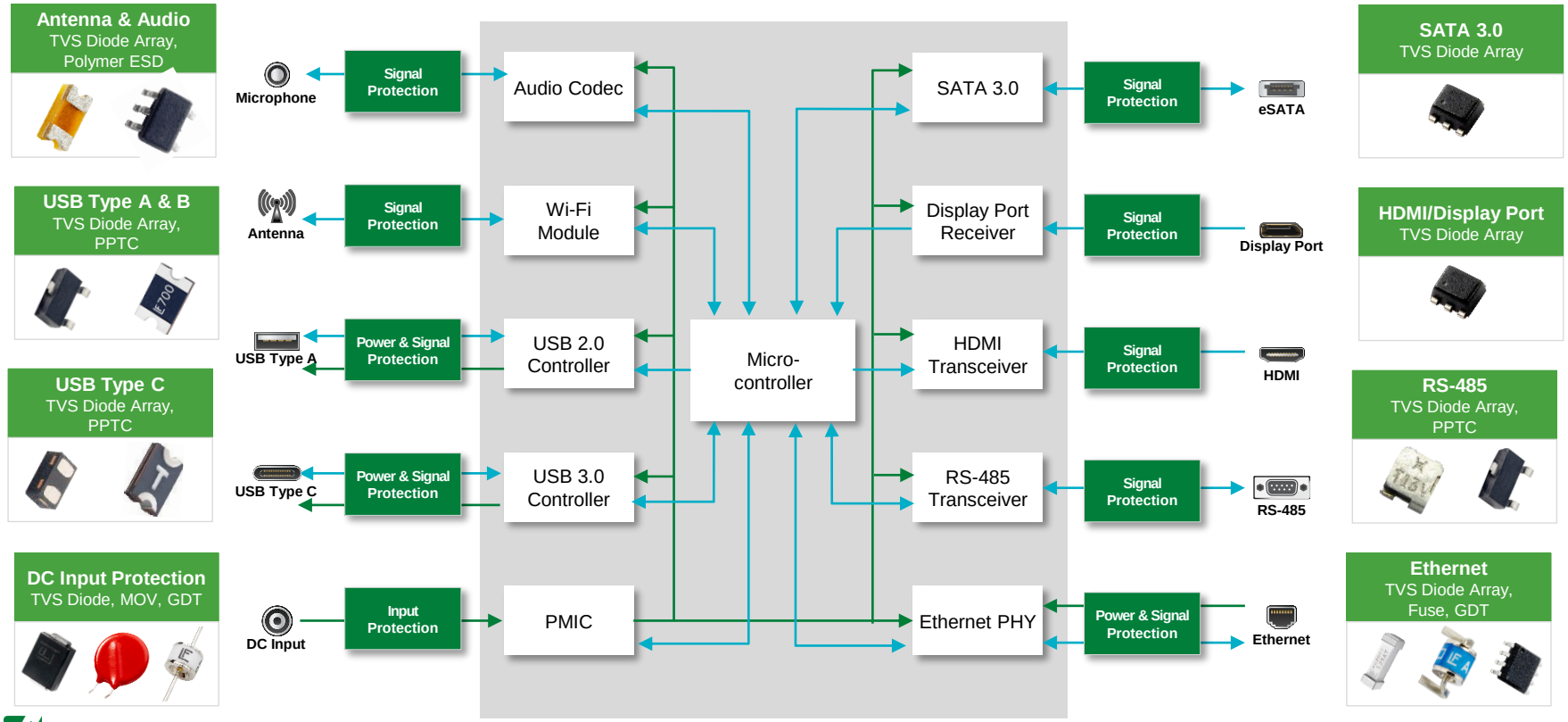


E

High-speed
Communication Port Protection

Common high-speed communication ports

Opportunities for multiple circuit protection solutions



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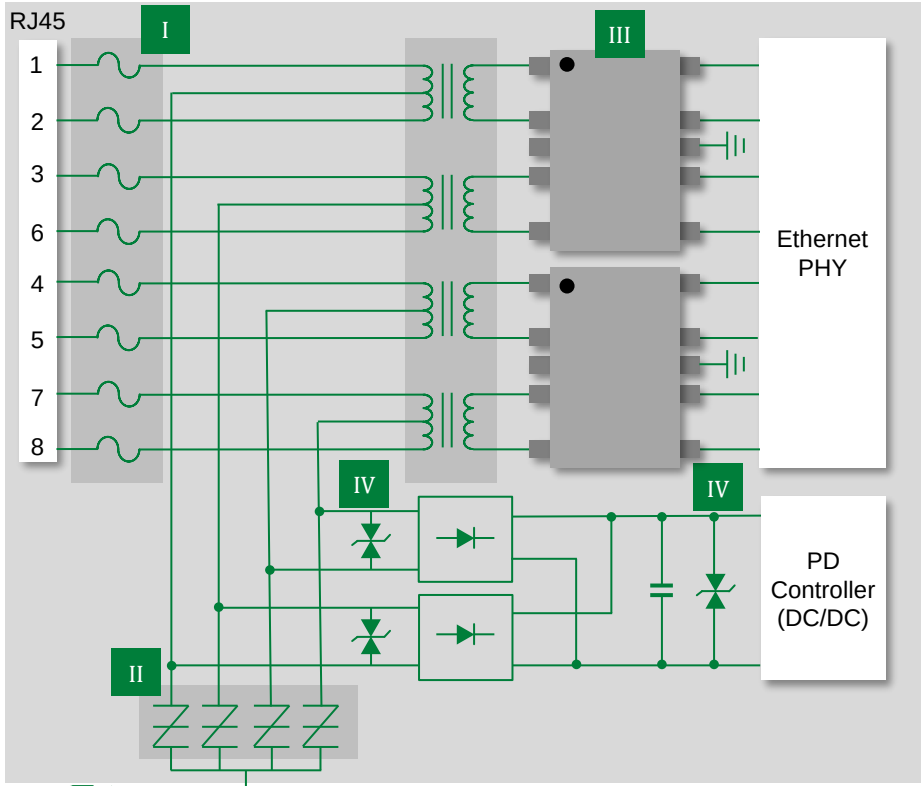
Ethernet (PoE++) protection



Function	Technology (With Series Examples)
I Overcurrent protection	Fuse 0461002
II Overvoltage/transient protection	SIDACtor® P4500SCLRP
III ESD protection	TVS Diode Array SP2555NUTG
IV Secondary protection	TVS Diode SMCJ58CA

Opportunity for multiple circuit protection:

- ✓ Fuse
- ✓ SIDACtor®
- ✓ TVS Diode, TVS Diode Array

For part # suggestions

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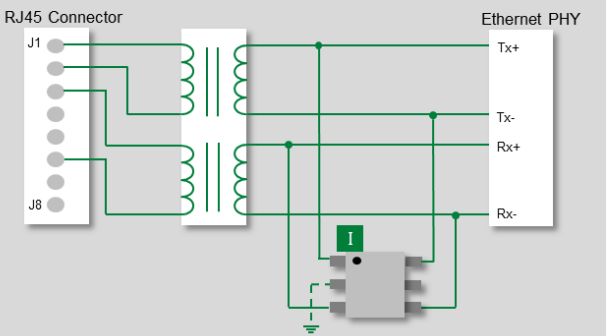
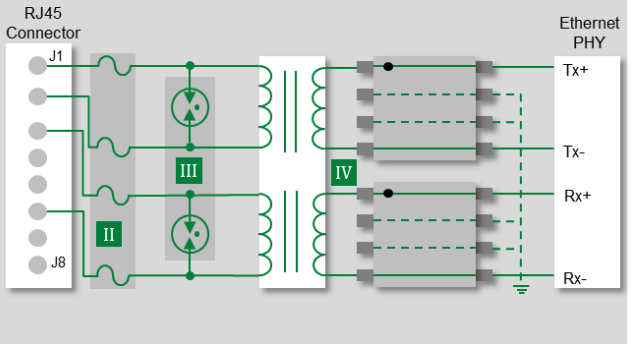
Ethernet port protection

Intra-building



Outdoor and harsh environment



Function	Technology (With Series Examples)
I ESD protection	TVS Diode Array SRV05-04HTG-D
II Overcurrent protection	Fuse 0461xxx
III Lightning protection	GDT + TVS Diode Array SG, CG6 + LC03xx, SP40xx

Opportunity for multiple circuit protection:

- ✓ TVS Diode Array
- ✓ Fuse
- ✓ GDT + TVS Diode Array

For part # suggestions

Note: *1Gbps or greater will require an additional two twisted pair and the diode array solution should be replicated.*

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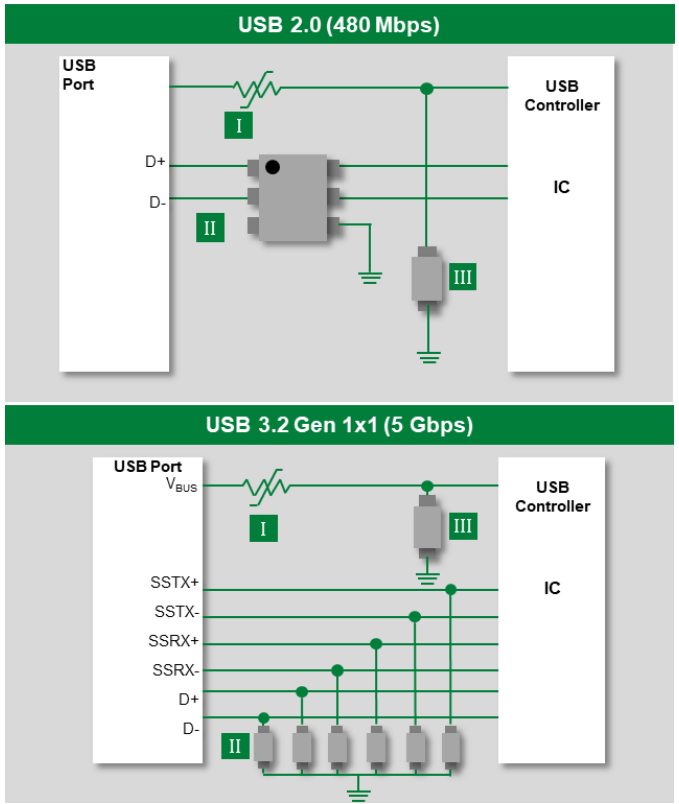
USB Type A and Type B protection



Function	Technology (With Series Examples)
I Overcurrent & Overtemperature protection	PPTC Low Rho
II ESD Protection: Data Bus	TVS Diode Array SP3213-01UTG
III ESD Protection: Power Bus	TVS Diode Array SP1006-01UTG

Opportunity for multiple circuit protection:

- ✓ PPTC
- ✓ TVS Diode Array

For part # suggestions

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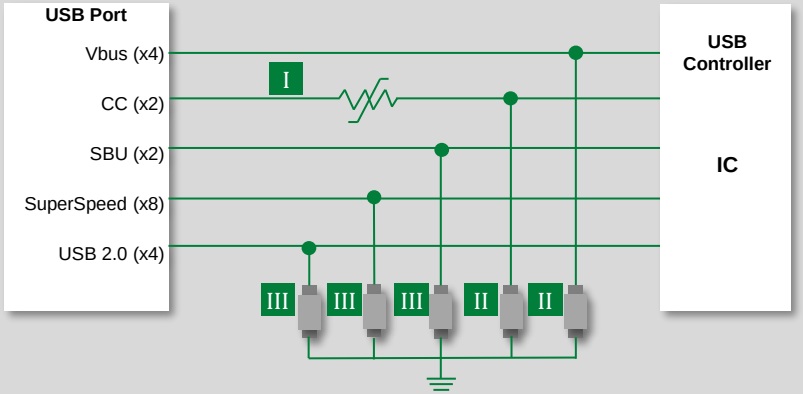
USB Type C protection

USB 3.2 Gen 2x1 (10 Gbps), USB 3.2 Gen 2x2 (20 Gbps) & USB 4.0 (40 Gbps)



Function	Technology (With Series Examples)
I Digital Temperature Indicator	Temperature Indicator setP™
II ESD Protection: Power Bus	TVS Diode Array SPHV24-01ETG
III ESD Protection: Data Bus	TVS Diode Array SP1006-UTG, SP3213-01UTG

Opportunity for multiple circuit protection:

- ✓ Digital Temperature Indicator
- ✓ TVS Diode Array

For part # suggestions

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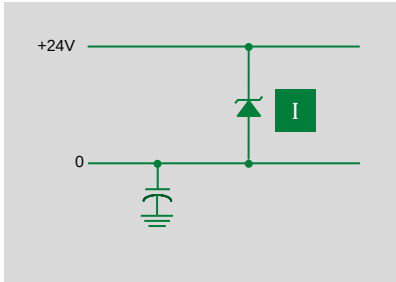
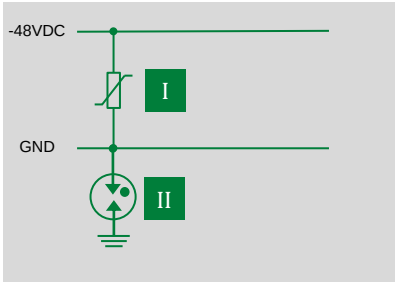
DC input protection

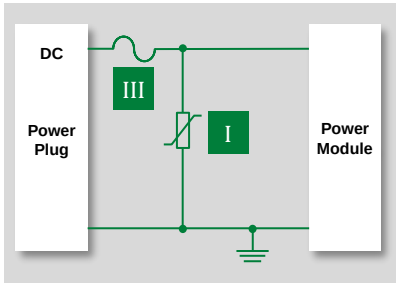
DC Input 12 V/24 V DC



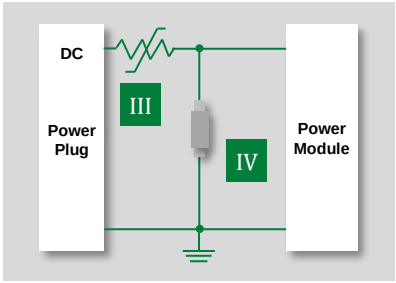
DC Input 48 V DC



DC Input (PFC circuit)



DC Input (portable devices)



Function	Technology (With Series Examples)
I Surge protection	TVS Diode or Varistor SMDJ or LV Ultra MOV
II Ground isolation protection	GDT CG
III Overcurrent protection	Fuse or PPTC 477 or Low Rho
IV ESD protection	TVS Diode Array SP11xx

Opportunity for multiple circuit protection:

- ✓ TVS Diode or Varistor
- ✓ GDT
- ✓ Fuse or PPTC
- ✓ TVS Diode Array

For part # suggestions

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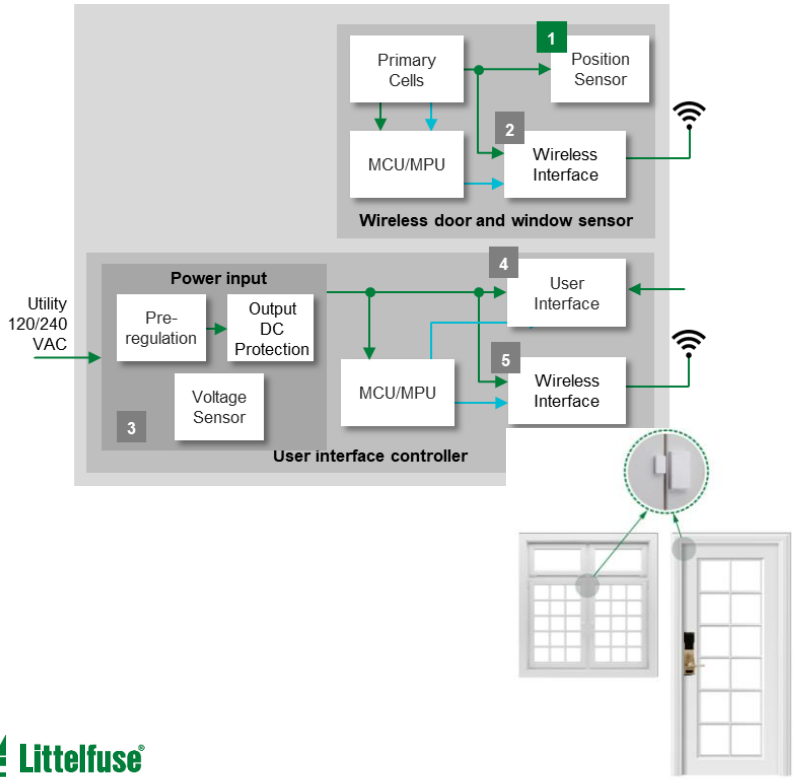
Sensors & Other Technologies

Sensing opportunity: Reed Switch, Reed Sensor, TMR, and Magnetic Actuator

Example: Door/window sensor security



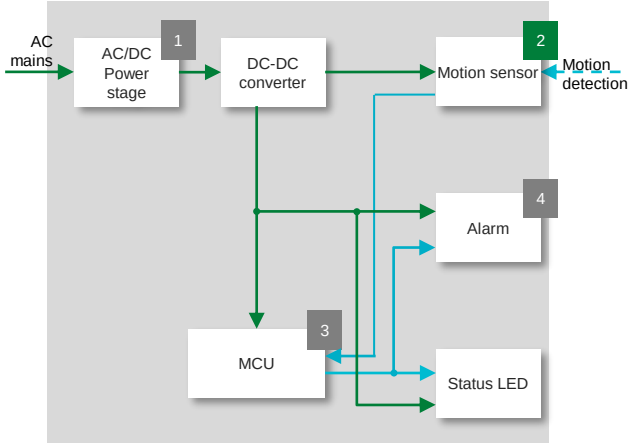
Function	Technology (With Series Examples)
1 Position sensing	Reed Sensor + Actuator 59140 + 57140
OR	
1 Position sensing	TMR Sensor TMR Switch
OR	
1 Position sensing	Reed Switch + Actuator MDSM-10 + H-36

Opportunity for multiple circuit protection:

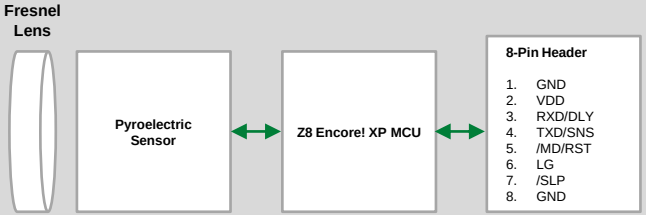
- ✓ Reed Sensor + Magnetic Actuator
- ✓ TMR Sensor
- ✓ Reed Switch + Magnetic Actuator

Sensing opportunity: PIR Sensor + ZMOTION™

Example: PIR Motion detector



ZMOTION™ block diagram



Function	Technology (With Series Examples)
1 Motion sensing	PIR Sensor + MCU ZSFG469711, ZRE200GE+ ZMOTION™

Opportunity for multiple circuit protection:

✓ PIR Sensor + MCU

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Sensing opportunities: Thermistors, RTDs, Probe Assemblies

Application examples

HVAC System

Renewable Energy

Industrial

Medical

EV Charging

Function	Technology (With Series Examples)
1 Temperature sensing	Thermistor KC, RA, SM
OR	
2 Temperature sensing	RTD PPGxxxJx
OR	
3 Temperature sensing	Custom Sensors

Opportunity for multiple circuit protection:

- ✓ Thermistor (NTC or PTC)
- ✓ RTD
- ✓ Custom Sensors

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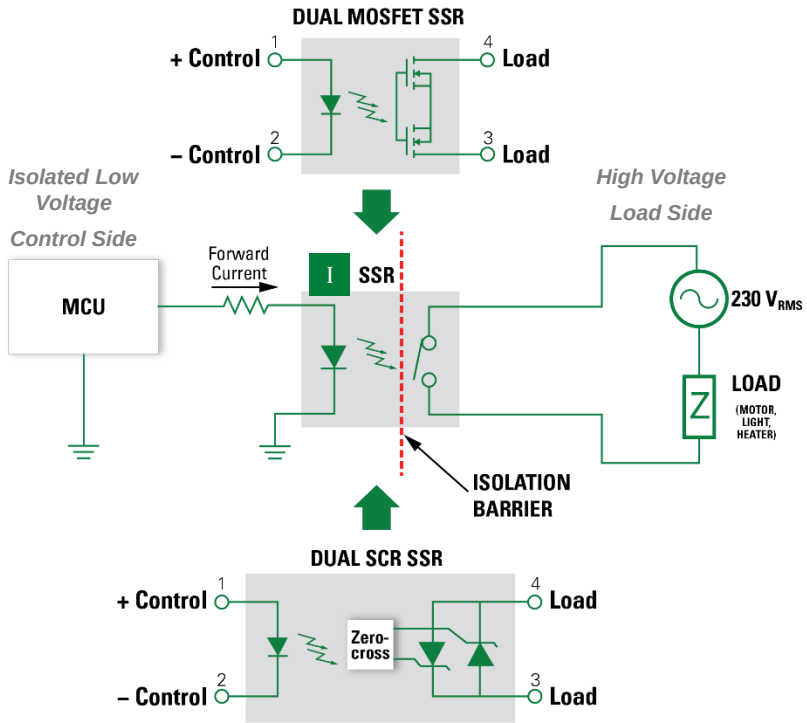
Solid State Relay for AC/DC loads switching

Example: Power Mains Switch



Function	Technology (With Series Examples)
1 Bi-directional switching of AC/DC loads	Solid State Relay CPC1394GR, PLA192, CPC1983Y

Opportunity for multiple circuit protection:

✓ Solid State Relay

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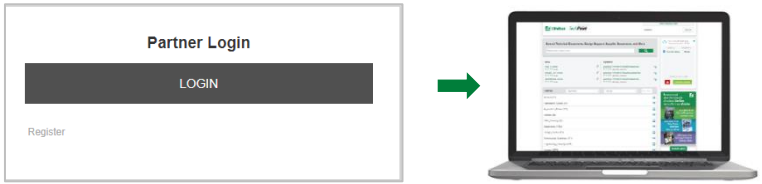

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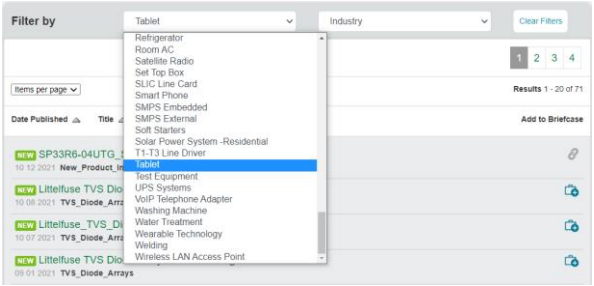

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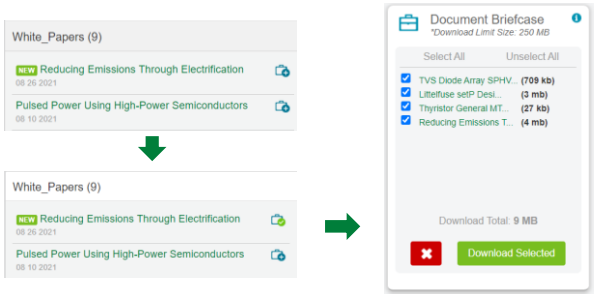

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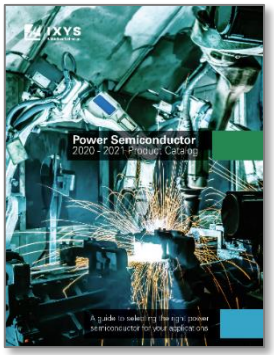
Circuit Protection Catalog

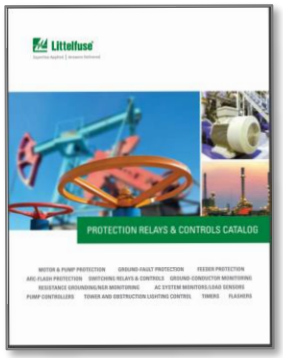
Sensor Selection Guide

Power Semiconductor Catalog



Industrial Fuses Catalog

Power Relay & Control Catalog

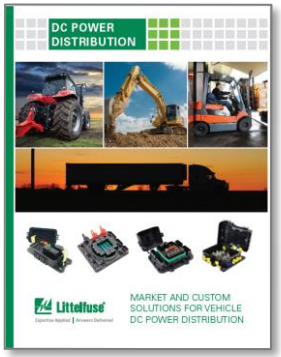


Click on images to open the catalogs

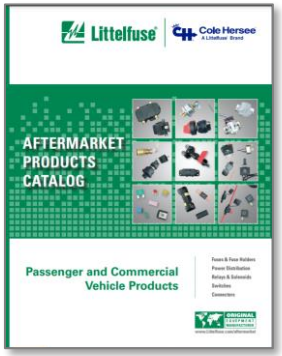
Integrated Circuits Catalog

Surge Protection Devices Catalog

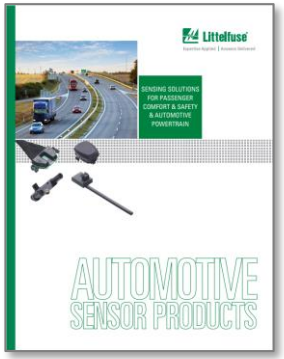
DC Power Distribution Catalog



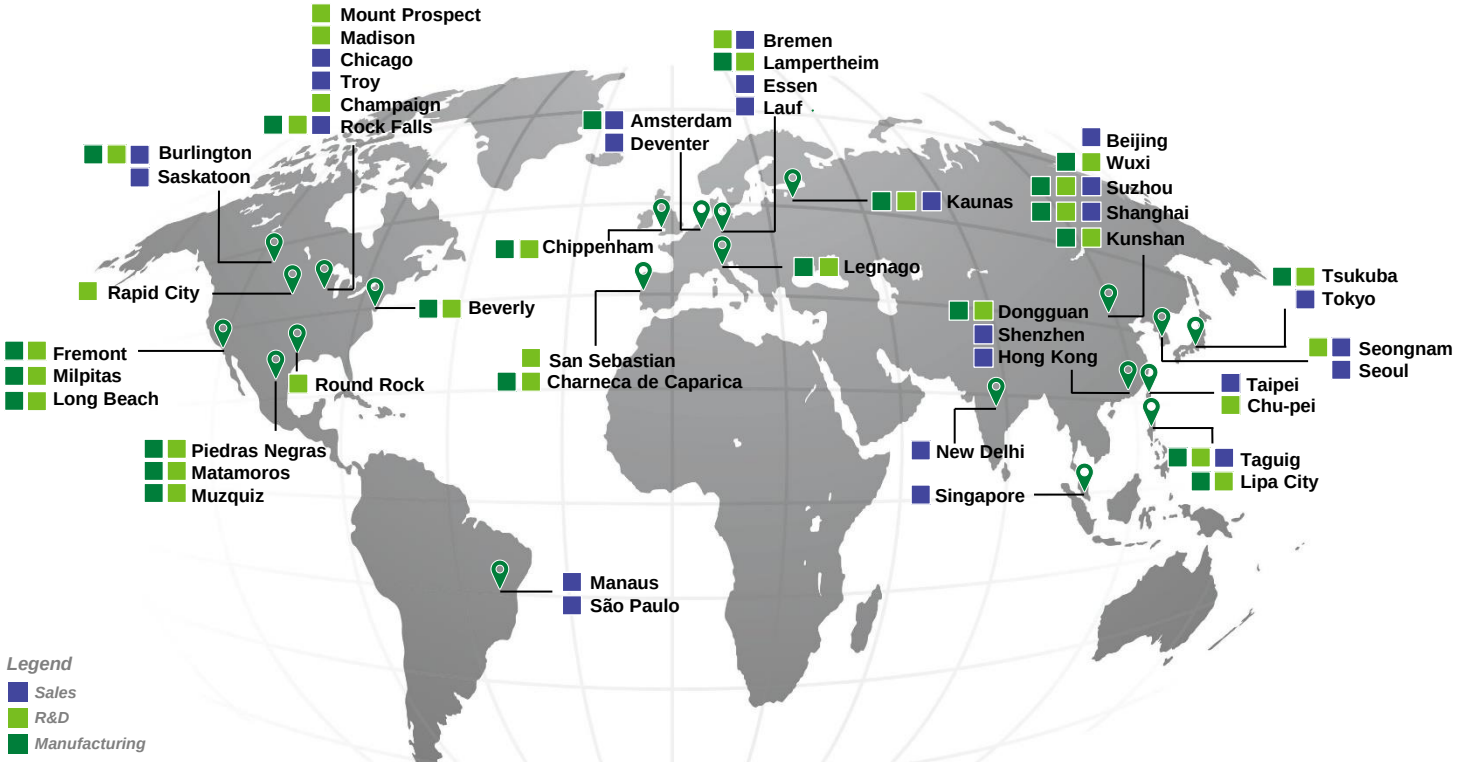
Passenger & Commercial Vehicles



Automotive Sensor Products



Local resources supporting our global customers



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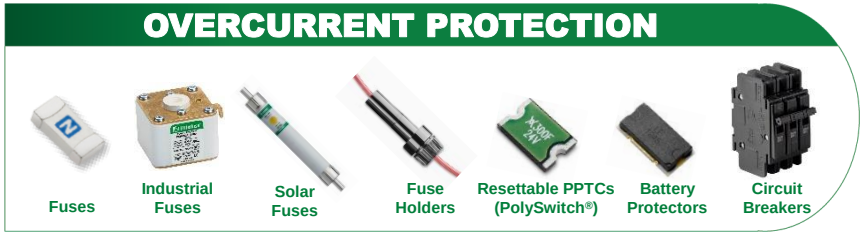
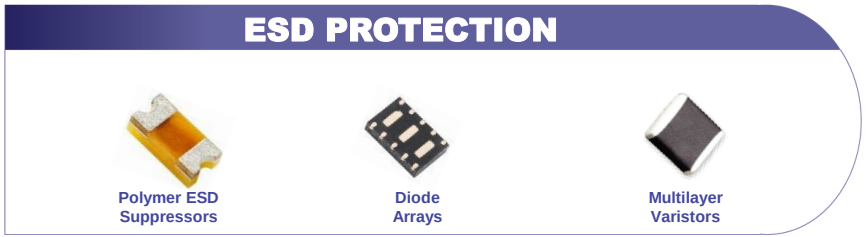
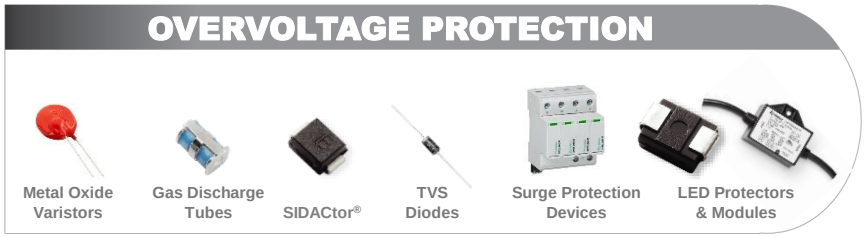
Appendix

Discovery Questions

Circuit Protection: Questions to Ask?

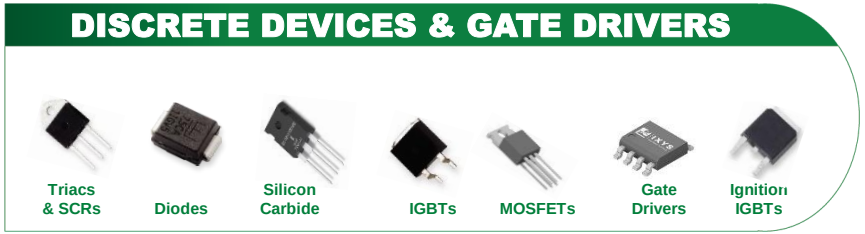


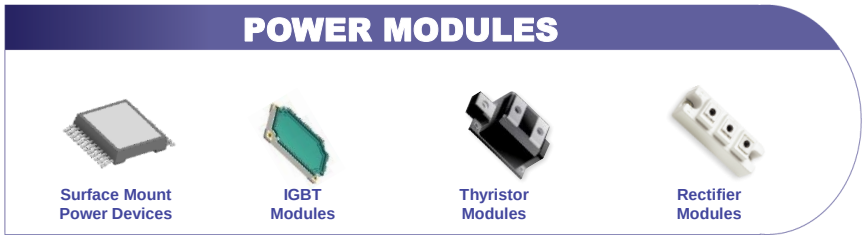




- **Overcurrent**
  - What is the normal operating current?
  - What is the application voltage?
  - What is the maximum available fault current?
  - What is the ambient temperature?
- **Overvoltage**
  - What safety standards do you have to meet?
  - What type of transient are you protecting against (ESD, surge, etc.)?
  - What is the normal operating voltage of the protected device?
  - What is the max allowable voltage of the protected device?
  - What is the max expected surge current and number of hits?

Power Semiconductor: Questions to Ask?





- **Gate Drivers**
  - How are you driving IGBT's or SiC FET's
  - How much isolation do you require?
  - Non-Isolated or Isolated
  - Do you require AECQ-100
  - SiC MOSFETs need +15 to +20V turn-on voltage and a -3V to -5V negative turn-off voltage is "recommended"
- **Power Semiconductor**
  - What is the Power Level – kW?
  - What form of converter is used in the design? (DC-DC, DC-AC, AC-DC, AC-AC)
  - What is the input voltage? (120/220/480/600Vac)? (1ph, 3ph, Bidi-AFE)
  - PFC Stage? (Synch/NonSynch boost/buck, voltage/fsw?)
  - What is the DC bus voltage?
  - Inverter/DC-DC? (FB, HB, Fsw?)
  - What is the Output Voltage? MOSFET or Diode rec?

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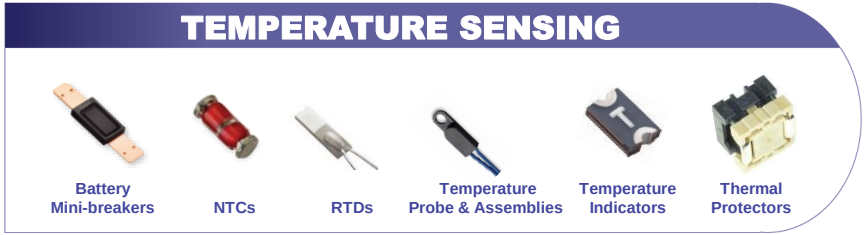
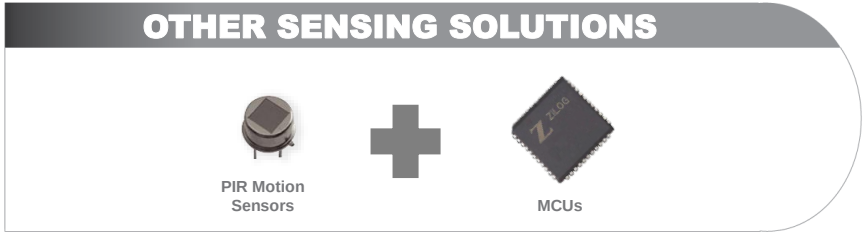
Sensing Solutions: Questions to Ask?



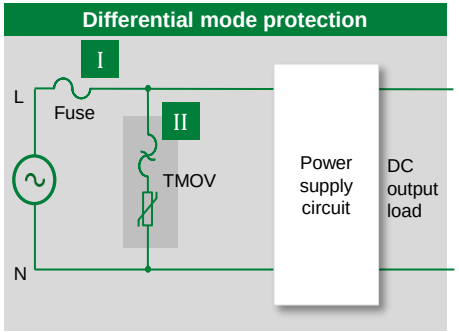


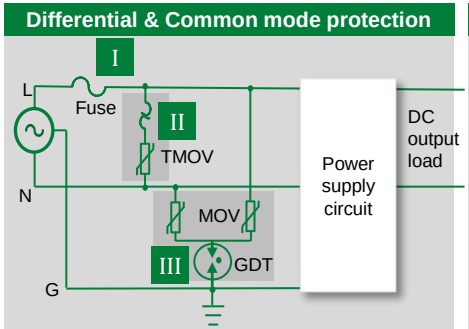
- **Magnetic**
  - Are you sensing position (speed/direction/open/close)?What is the switching voltage and current?
  - What is the desired sensor activation distance?
  - Is customer interested in Littelfuse providing the magnet?
  - Is customer interested in having Littelfuse supply a fully packaged assembly?
- **Temperature**
  - What temperature range are you sensing?
  - What is the max temperature the sensor will be exposed to?
  - What is the accuracy required?
  - Is customer interested in having Littelfuse supply a fully packaged assembly?

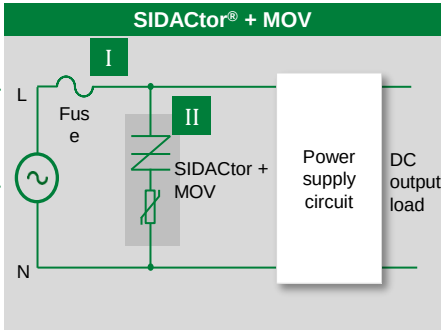
Additional Slides

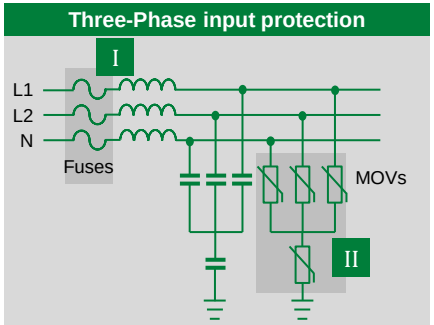
A

Input protection: Opportunities for Fuse + Fuse Holder/Clips, MOVs, or MOV + GDT, or SIDACtor + MOV









	Technology	Function in Application	Series	Benefits	Features
I	Fuses	Protects the power stage from overcurrent events	2153.15*, 39213150000	Reduces customer qualification time by complying with regulatory safety standards, such as UL/IEC	Compliant with UL/IEC standards; low internal resistance; shock-safe; vibration resistant
		AC line fuses for overcurrent or short circuit protection	JLS, JLLS, LDC, L70QS 606, 504, 505	Reduces damage to equipment caused by heating and magnetic effects of short circuit currents	Extremely current-limiting; small footprint; 200 kA interrupting rating
	Fuseholder	Supports fuse protection	LFT, LFJ	DIN rail mountable	Low resistance connection
II	TMOV or MOV	Protects the power supply unit from voltage transients and lightning	TMOV14RP300E*, V10E420P	Integrated thermal disconnect enhances safety by disconnecting during MOV EOL caused by continuous abnormal overvoltage	UL-recognized Type 4 surge protection devices; integrated thermal disconnect
	SIDACtor® + MOV		P2300 + V10E300P	Lower clamping provides robust protection to downstream components (capacitors, bridge, etc.)	Lower clamping voltage, lower leakage current (NA level)
	TVS Diode		AK3-380C-Y	Good clamping and fast response time for high-energy transient protection	High power TVS 8/20 µs rating from 1 kA to 20 kA in axial-lead or SMT form factor
III	MOV + GDT	Protects the power supply unit from voltage transients and lightning	V10E300P + CG3 3.3*	Only permitted solution for common mode protection; lowest leakage current	

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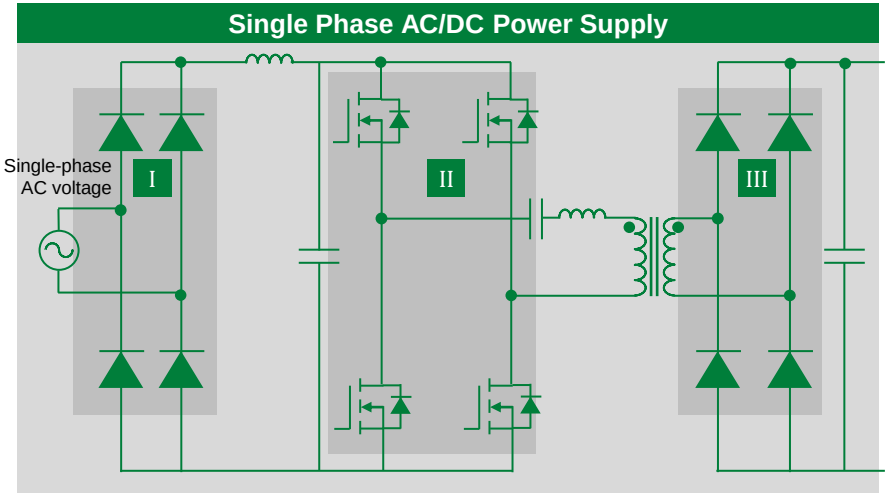
A

Power Conversion examples: Opportunities for Rectifier Diodes, Si/SiC MOSFET or IGBT, Schottky Diodes



	Technology	Function in application	Series	Benefits	Features
I	Rectifier Diode	Rectification			
II	MOSFET	High switching speed in power supply units	X2-class	Fast response time and low heat signature	Low $Rds_{(on)}$; dv/dt ruggedness
	IGBT		XPT	Low power consumption; high efficiency system operation	Ultra low on-resistance $R_{DS(ON)}$ and gate charge Q_g; fast body diode dv/dt ruggedness
III	Schottky diode	Rectification and blocking in power supply units	MBR, DST	Enables the design of high efficiency power supplies	Ultra-low forward voltage drop; high-frequency ope

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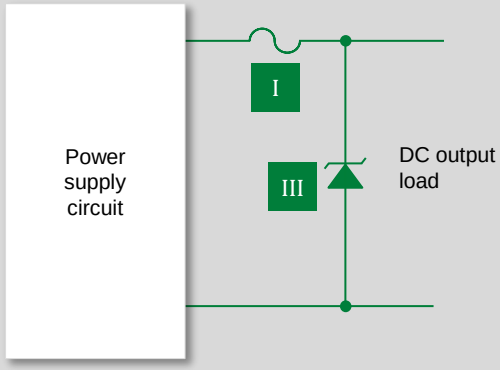
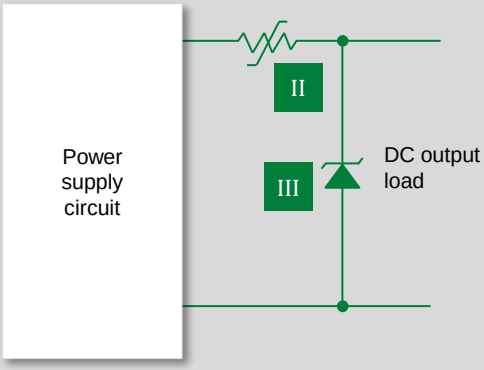
A

DC output protection: Opportunities for Fuse + TVS Diode or PPTC + TVS Diode

DC output protection: Fuse + TVS Diode



DC output protection: PPTC + TVS Diode



	Technology	Function in application	Series	Benefits	Features
I	Fuse	Front end protection from external shorts	253, 276	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	Very fast-acting; small form factor; wide current rating range
II	Resettable PPTC	Protection against short circuit and overload current conditions	Low Rho	Offers fast response to over current events; suitable for compact portable devices;	Ultra-low internal resistance; higher current holding in smallest SMD package
III	TVS Diode	Overvoltage surge protection	SMBJ	Improves system reliability by protecting downstream components from transients on power lines	Excellent clamping capability

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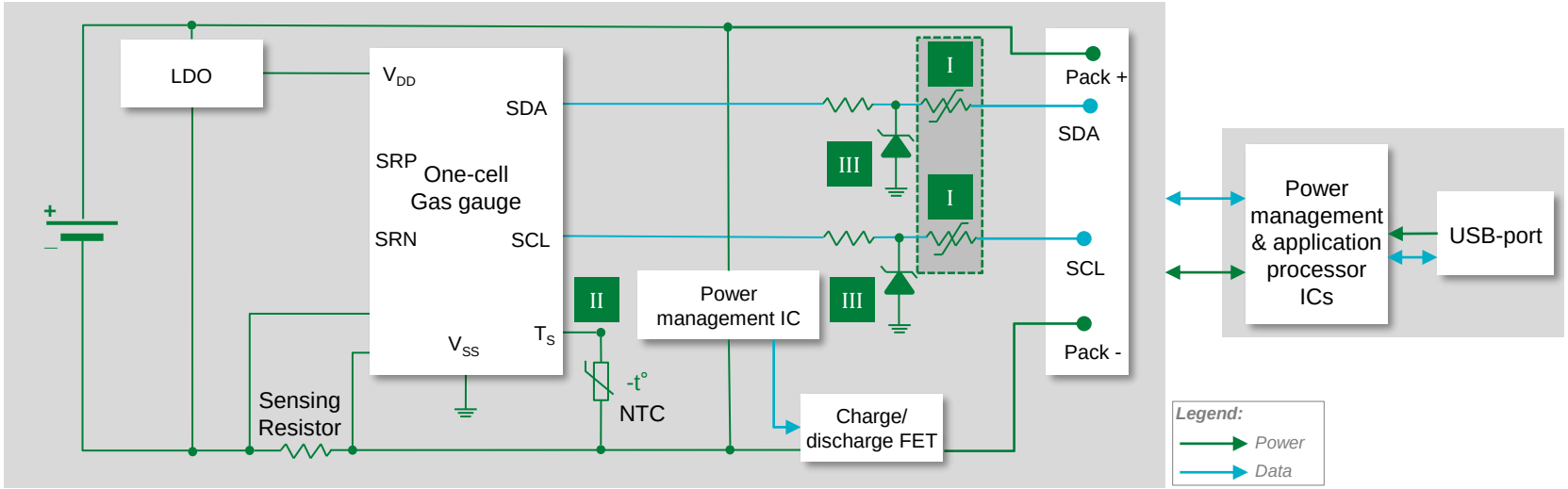
Single-cell battery protection: Opportunities for PPTC+ Temperature Sensor + TVS Diode Array



	Technology	Function in Application	Series	Benefits	Features
I	PPTC	Overcurrent & overtemperature protection for battery management ICs & fuel gauges	zeptoSMDC	Resets to normal operation after fault is cleared; saves space due to small footprint	Maximum electrical rating: 13 VDC; short circuit current: 82~200 mA; small footprint 0201 size
II	NTC	Ambient temperature measurement and temperature compensation for safe charge/discharge battery cycle	RA, RB, KR	Provides safe operation of battery; smaller footprint saves space	Surface mountable; small form-factor
III	TVS diode array	ESD Protection of I^2C input	SP1006	Small space-saving design; low capacitance to prevent signal disruption	µDFN-2 (0201) footprint ±30 kV ESD withstand voltage

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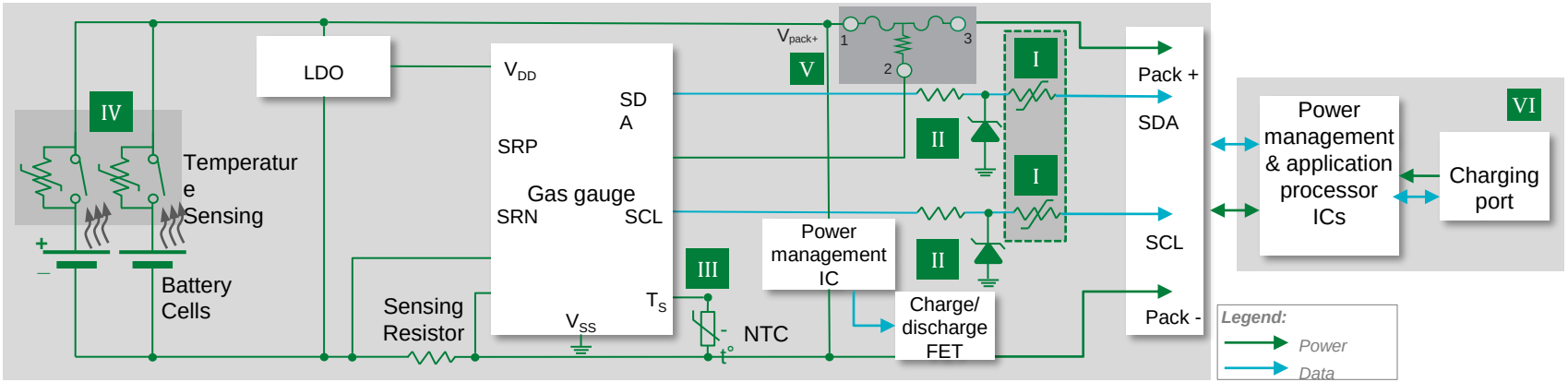
Click on the product series in the table below for more info

Typical multicell battery protection reference system



	Technology	Function in Application	Series	Benefits	Features
I	PPTC	Overcurrent and overtemperature protection for battery management ICs and fuel gauges	zeptoSMDC	Resets to normal operation after fault is cleared; smaller footprint saves space	Maximum electrical rating: 13 VDC; short circuit current: 82~200 mA; small footprint 0201 size
II	TVS diode array	ESD Protection of I^2C input	SP1006	Small space saving design; low capacitance to prevent signal disruption	µDFN-2 (0201) footprint ±30 kV ESD withstand voltage
III	NTC	Ambient temperature measurement and temperature compensation for safe charge/discharge battery cycle	RA, RB, KR	Provides safe operation of battery; smaller footprint saves space	Surface mountable; small form-factor
IV	Battery Mini-breaker	Secondary overtemperature and overcurrent protection	MHP-TAC	Longer battery life; sensitive thermal protection	I_{hold} up to 15 A, milliohm resistance, 72 to 90° C cutoff temperature
V	Battery protectors	Dual trip on demand and overcurrent protection	ITV module	Increases assemble efficiency	Lower on-state resistance, surface mountable; UL and TUV certified
VI	Digital temperature indicator	Provides an indication signal to help protect USB-C plugs and receptacles from overheating	setP™	Helps improve reliability and user experience by reducing the risk of thermal damage; simple 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

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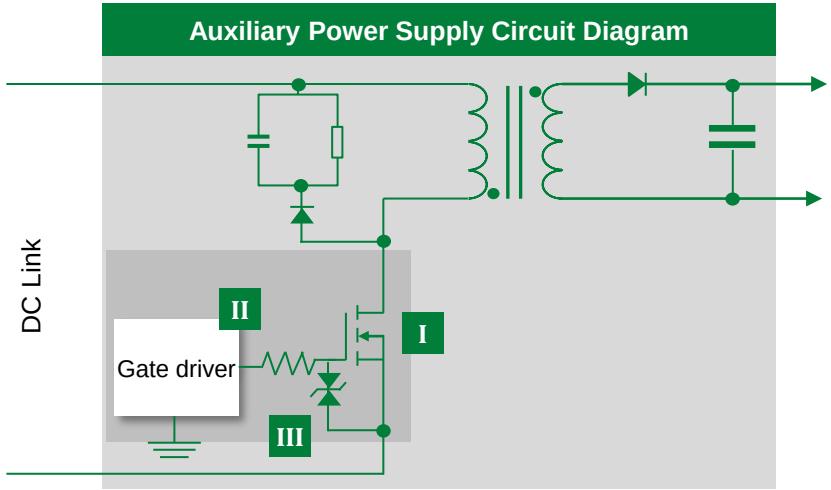
Auxiliary power supply: Opportunity for Si/SiC MOSFET+ Gate Driver + TVS Diode



	Technology	Function in Application	Series	Benefits	Features
I	SiC MOSFET	High-frequency switching	LSIC1MO170E1000	Higher switching frequency; higher efficiency; increased robustness; smaller die size per voltage/current rating	Optimized for high-frequency applications; extremely low gate charge and output capacitance; ultra-low on-resistance
II	Gate Driver	Drives SiC MOSFETs and high-power IGBTs	IX4351NE	Eliminates the need for separate negative supply; quick turn-on and turn-off of power SiC MOSFET and IGBT	Separate 9 A peak source and sink outputs; internal negative charge pump regulator for selectable negative gate drive bias
III	TVS Diode	Protects SiC MOSFET from voltage transient	SMF, 1.5SMC	Improves system reliability by clamping the voltage at safe levels during transients	200 W peak pulse power capability; excellent clamping capability; low profile

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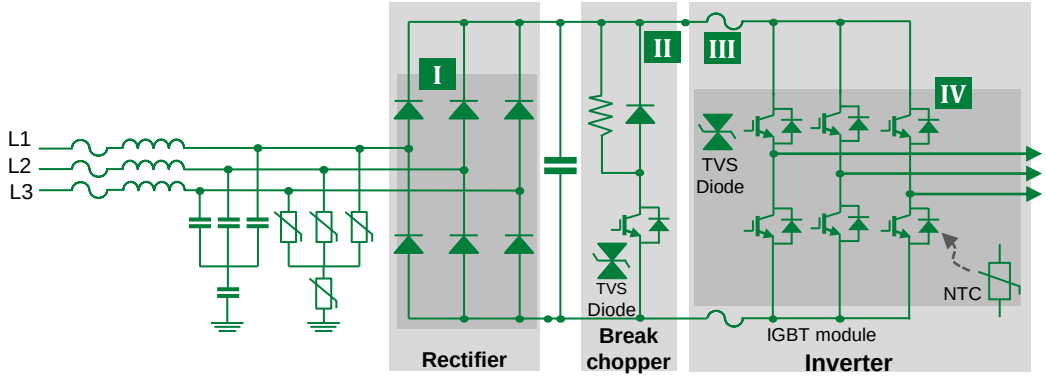
D

Industrial motor drive circuit diagram: multiple socket opportunities



	Technology	Function in Application	Series	Benefits	Features
I	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	Module Offerings, Discrete Devices	Small footprint; multiple package options (high-voltage, isolated, and standard packages)	Planar passivated chips; very low leakage current and forward voltage drop; improved thermal behavior; high commutation robustness
II	Brake Chopper Module	Overvoltage protection of DC bus	Boost Chopper IGBT Modules	Easy to parallel due to positive temperature coefficient	Sonic diode for fast and soft recovery
III	Semiconductor Fuse	Overcurrent protection	PSR	Best-in-class DC performance	Busbar mount
IV	IGBT Module	Switching power supplies	XPT IGBT Modules Six Pack IGBT Modules CBI Modules	Short circuit rated for 10 µsec; low gate charge; low EMI and competitive low $V_{CE(SAT)}$	Rugged XPT design with thin wafer technology
	NTC	Semiconductor temperature measurement	USUR1000, SM	Rapid thermal response and long-time reliability	USUR is a UL-recognized NTC sensor with ring lug mounting; SM NTCs are in a hermetically sealed MELF package suitable for operation at up to 220 °C
	TVS diode	Protects IGBTs from an event of transient overload	SMBJ, SMF4L, 1.5SMC	Improves system reliability by clamping the voltage at safe levels during transients	600 W peak pulse power capability; excellent clamping capability; small

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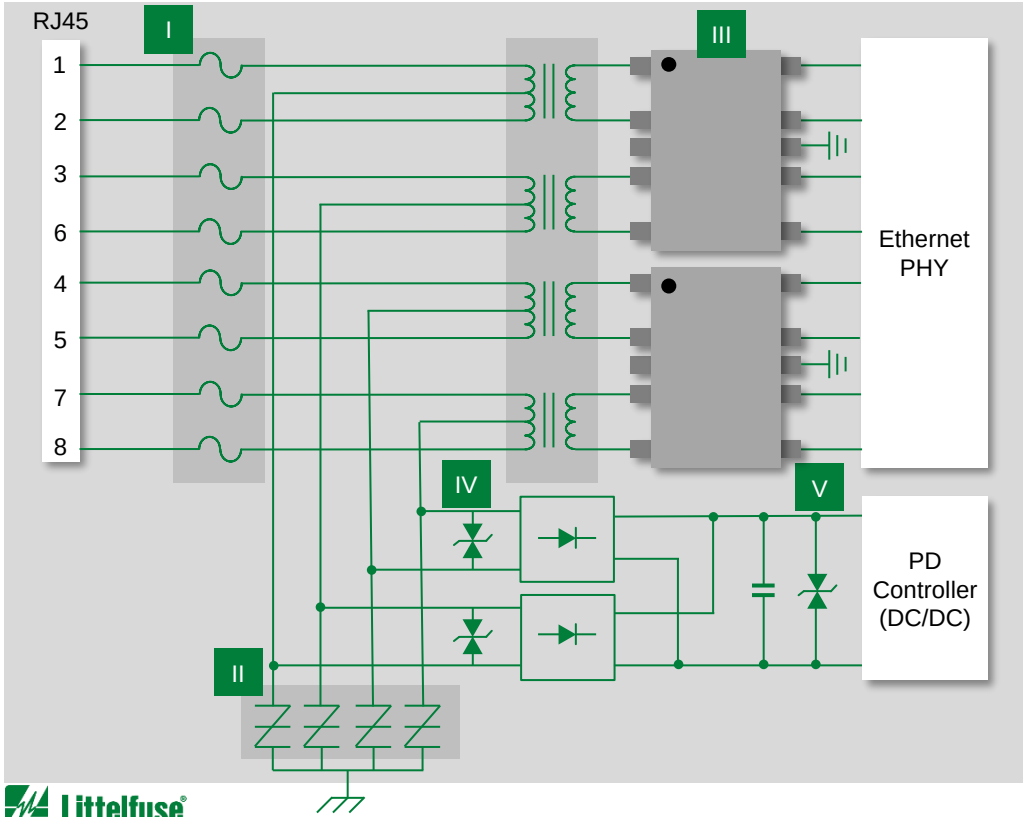
PoE++ protection: Opportunities for Lightning, ESD, and power fault protection



	Technology	Series
I*	Fuse (x8)	0461002
II	SIDACtor® (x4)	P4500SCLRP
III	Diode Array (x2)	SP2555NUTG
IV*	TVS Diode (x2)	SMCJ58CA
V*	TVS Diode (x1)	SMCJ58CA

I TeleLink® fuses can help protect power fault overcurrent. These fuses are designed specifically for high-speed telecom applications.

IV A single TVS diode (bi-directional) across the center tap data pair and second TVS diode across the center tap spare pair. The TVS diode can be chosen based on surge requirements for 400 W, 600 W, 1500 W, or 3000 W.

V Outdoor facing ports should consider higher surge protection device such as 5.0SMDJ

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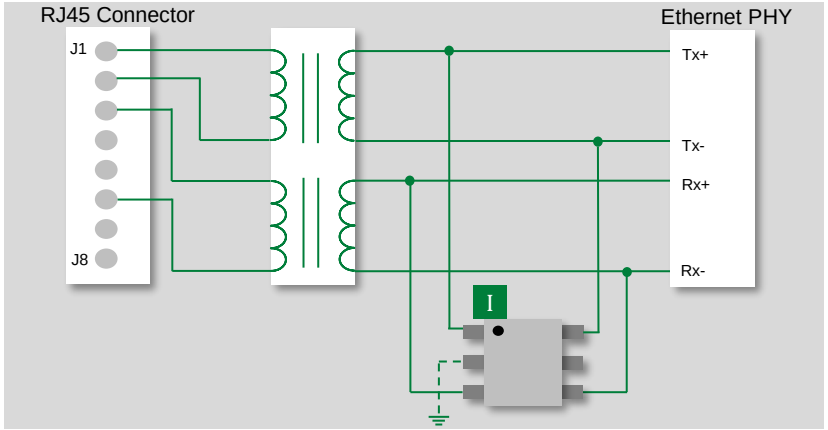
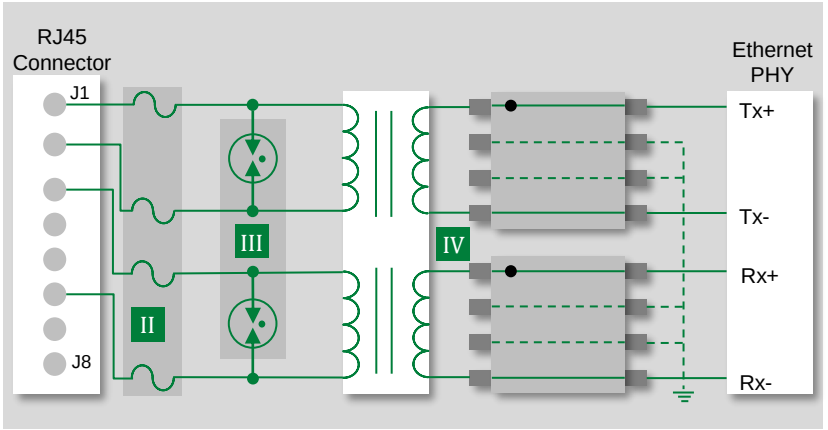
Ethernet port protection: Opportunities for Fuse, GDT & TVS Diode Array

Intra-building



Outdoor and harsh environment



Note: *1Gbps or greater will require an additional two twisted pair and the diode array solution should be replicated.*

	Technology	Function in application	Series	Benefits	Features
I	Diode Array	Protection from ESD and EFT	SRV05-04HTG-D	Ensures design meets with all regulatory requirements; preserves signal integrity	Low capacitance; low leakage current; small design; four lines of protection
II	Fuse	Overcurrent protection	0461xxx	Ensures design meets with all regulatory requirements; compact design	Surface mount; surge tolerant fuse designed specifically for high-speed telecom applications.
III	GDT	Lightning protection uses GDT with diode array to meet standard requirements	SG, CG6, CG5	Ensures safety and reliability of the equipment and helps design meet regulatory requirements	High surge rating; low capacitance; UL recognized
IV	Diode Array		LC03xx, SP40xx		Low capacitance; and low leakage current

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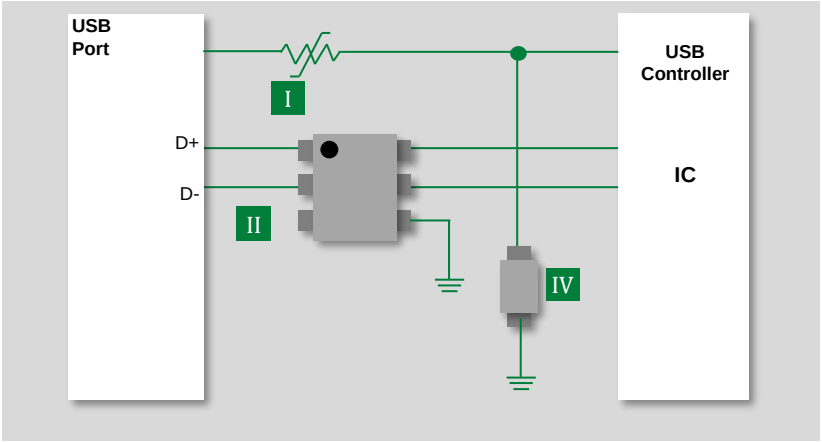
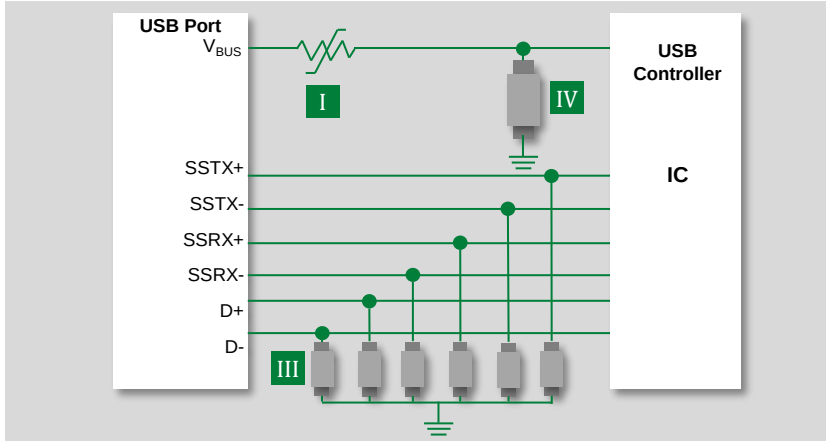
USB Type A and Type B protection: Opportunities for PPTC+ TVS Diode Array

USB 2.0 (480 Mbps)



USB 3.2 Gen 1x1 (5 Gbps)



	Technology	Function in application	Series	Benefits	Features
I	Resettable PPTC	Protect 5 VDC power supply from over current & over temperature	Low Rho	Offers fast response to over current events; suitable for compact portable devices;	Ultra-low internal resistance; higher current holding in smallest SMD package
II	Diode Array	Protection of data lines against ESD	SP3019-04HTG; SP3400-02UTG	Clamp transient to a safe level preventing catastrophic failure; compact design	Low capacitance 0.3 pF & leakage current (0.01 µA); small form factor µDFN
III	Diode Array (6x)	Protection of data lines against ESD	SP3213-01UTG	Low capacitance ideal for USB; small form factor allows designers layout flexibility	Very low capacitance of 0.09 pF; small form factor µDFN
IV	Diode Array	Protection of power bus against ESD	SP1006-01UTG	Ensure safety of equipment from repetitive ESD strikes without performance degradation	Low leakage current of 100 nA; small form factor

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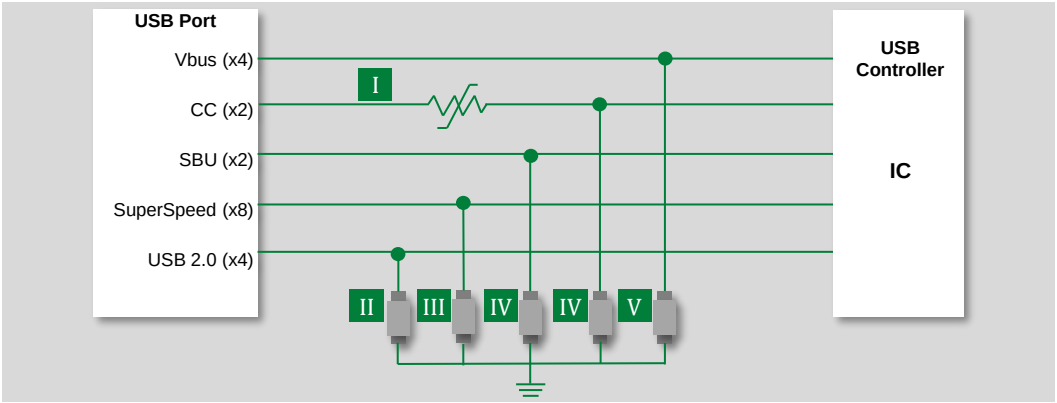
USB Type C protection: Opportunities for PPTC or Digital Temperature Indicator + Diode Array

USB 3.2 Gen 2x1 (10 Gbps), USB 3.2 Gen 2x2 (20 Gbps) & USB 4.0 (40 Gbps)



	Technology	Function in application	Series	Benefits	Features
I	Digital Temperature Indicator	Protect cable-connectors against overheating	setP™	Reliable over-heating protection, regardless of power being delivered	Fully compliant with USB Type-C plugs
II	Diode Array	Protect against ESD on USB 2.0 speed data lines	SP3530-01UTG	Space efficient; reliable ESD protection	0201 footprint; extremely low dynamic resistance
III	Diode Array	Protect against ESD on high-speed data lines	SP3213-01UTG	Maintain signal integrity of high-speed data lines; reliable ESD protection	Low parasitic capacitance
IV	Diode Array	Protect against ESD	SP1006-UTG	Space efficient	AEC-Q101 qualified; small footprint
V	Diode Array	Protect power bus against ESD	SPHV24-01ETG	Reliably protect charge controller	AEC-Q101 qualified; low dynamic resistance

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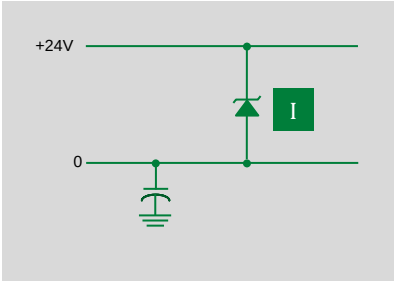
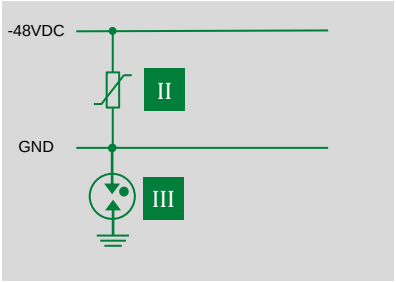
DC input protection: Opportunities for MOV + GDT, Fuse + MOV or PPTC + Diode Array

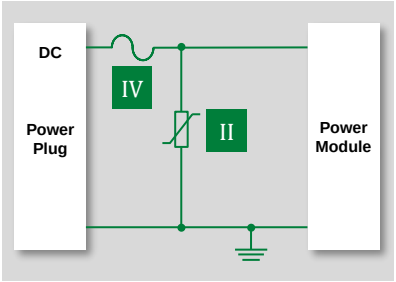
DC Input 12 V/24 V DC



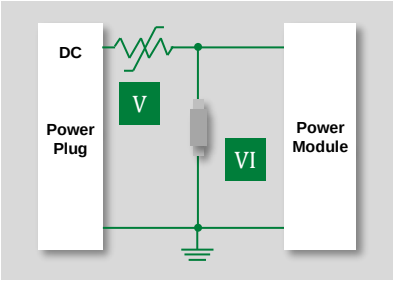
DC Input 48 V DC



DC Input (PFC circuit)



DC Input (portable devices)



	Technology	Function in application	Series	Benefits	Features
I	TVS Diode	Protect against voltage transients	SMDJ	Improves system reliability by protecting downstream components from transients on power lines	Excellent clamping capability
II	Varistor	Protect against voltage transients	LV Ultra MOV	Increased long-term reliability; more board space; higher surge handling density	High peak surge current rating; high operating temperature range up to 125° C
III	GDT	Ground isolation protection	CG	Extremely low leakage current to ground	High peak surge current ratings; wide operating voltage range
IV	Fuse	Overcurrent protection	477, 505	Reduces damage to equipment; compact design	Small footprint with high breaking capacity;
V	Resettable PPTC	Protection against short circuit and overload current conditions	Low Rho	Offers fast response to over current events; suitable for compact portable devices;	Ultra-low internal resistance; higher current holding in smallest SMD package
VI	Diode array	Surge and ESD protection	SP11xx	Ensure safety of equipment from repetitive ESD strikes without performance degradation	Low leakage current of 100 nA; small form factor; multiple voltages available

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