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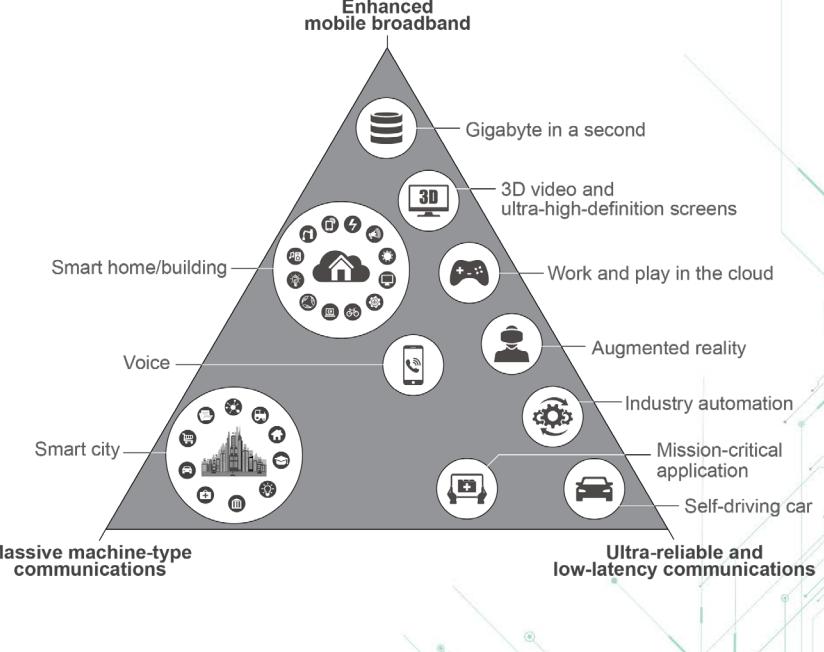
4G/5G Radio Access Network Equipment



Data Center and
Communication Infrastructure

Users must independently evaluate the suitability of and test each product selected for their own specific applications. It is the User's sole responsibility to determine fitness for a particular system or use based on their own performance criteria, conditions, specific application, compatibility with other parts, and environmental conditions. Users must independently provide appropriate design and operating safeguards to minimize any risks associated with their applications and products. Littelfuse products are not designed for, and may not be used in, all applications. Read complete Disclaimer Notice at littelfuse.com/disclaimer-electronics.

New radio access network (RAN) installations required to realize the promise of 5G

Market trends and drivers	5G builds on 4G & creates opportunities for new applications
<p>Massive growth in 5G infrastructure: The global 5G base station market is projected to reach approximately \$468.9 billion by 2032, growing at a compound annual growth rate (CAGR) of 29.3% from 2023 to 2032.</p> <p>Adoption of advanced technologies: 5G base stations will increasingly incorporate advanced technologies such as massive multiple input multiple output (MIMO), beamforming, and millimeter-wave spectrum utilization. These technologies will enhance network capacity, efficiency, and coverage.</p> <p>Integration with smart cities and industrial automation: The deployment of 5G technology will be closely tied to the development of smart cities and the expansion of industrial automation. 5G's ability to handle a vast number of connected devices will make it a critical component in smart city infrastructure.</p> <p>Continued evolution of 4G infrastructure: While 5G is set to dominate, 4G LTE will remain important, especially in areas where 5G is not fully deployed.</p>	 <p>5G builds on 4G & creates opportunities for new applications</p> <ul style="list-style-type: none">Enhanced mobile broadband<ul style="list-style-type: none">Gigabyte in a second3D video and ultra-high-definition screensWork and play in the cloudSmart home/building<ul style="list-style-type: none">Smart cityVoiceMassive machine-type communications<ul style="list-style-type: none">Self-driving carUltra-reliable and low-latency communicationsIndustry automationAugmented realityMission-critical applicationSelf-driving car

Key 5G network equipment applications

Major applications and number of components used

5G Network Device	Components		
Macro base station with active antenna	1. Advanced antenna 2. Amplifier 3. Baseband unit	4. Primary protection 5. Battery backup 6. Surge protection devices	
Small cell base station	1. Compact antenna 2. Integrated amplifier 3. Baseband unit	4. Heat management 5. Power supply unit 6. Surge protection devices	
Distributed antenna system (DAS)	1. Antenna array 2. Amplifiers 3. Signal controllers	4. Fiber optic distribution 5. Backup power 6. Signal conditioning units	
5G core network equipment	1. Routing equipment 2. Network processors 3. Virtualization platforms	4. Security modules 5. Power supply units 6. Cooling systems	
Millimeter wave equipment	1. Millimeter wave antenna 2. High-frequency amplifiers 3. Baseband processor	4. Beamforming technology 5. Power management unit 6. Surge protection devices	
5G customer-premises equipment (CPE)	1. External antenna 2. Integrated amplifier 3. Modem	4. Router 5. Battery backup 6. Overvoltage protection devices	
Massive MIMO system	1. Multiple antenna elements 2. Amplifiers 3. Beamforming processor	4. Baseband unit 5. Backup power 6. Surge protection devices	

Key electronics used in 5G applications (based on number)

RF components (power amplifiers, LNAs, and filters)
Micro electro-mechanical systems (MEMS)
Semiconductors (GaN, SiC, and CMOS)
Field-programmable gate arrays (FPGAs)
Digital signal processors (DSPs)
Optoelectronics (optical transceivers)
Battery technology (high capacity, Li-ion, solid state)
Antennas (massive, MIMO, beamforming)

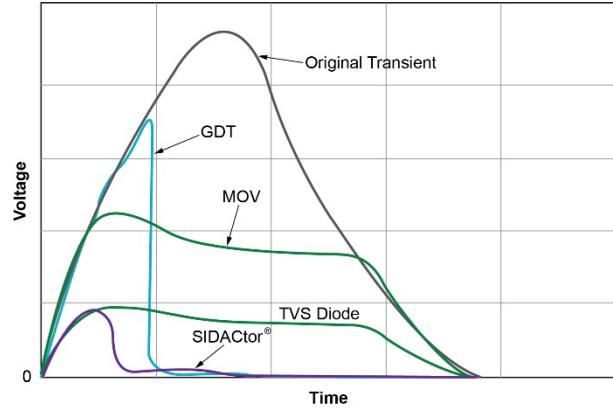
Importance of circuit protection

Five sources of electrical hazards affect the lifetime and reliability of communications infrastructure equipment:

- Lightning-induced surges
- Transient voltage surge from load switching
- Electrostatic discharge (ESD)
- Overload current
- Short-circuit current

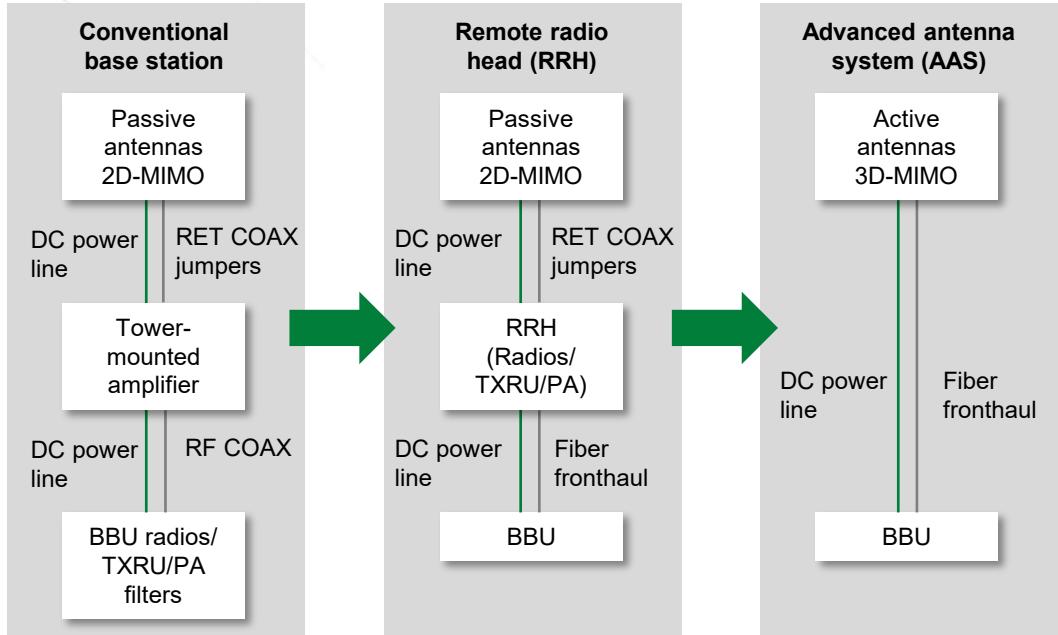
Select voltage protection based on hazard level, frequency of occurrence, and sensitivity of equipment

- Voltage protection will absorb transient energy during abnormal high-voltage conditions.
- Reaction time and energy-handling capability varies based on technology.
- Using multiple technologies together can help maximize features and benefits.



Selection criteria	GDT	MOV	TVS Diode	SIDAActor®
Protection mechanism	Crowbar	Clamping	Clamping	Crowbar
Response time	Medium	Fast	Faster	Fastest
Peak let-through voltage	High	Medium	Low	Low
Max surge-handling capability	High	High	Low	Medium
Leakage current	No	Low	Low	Low
Surge life	Good	Good	Excellent	Excellent
Follow-on current	Yes	No	No	Yes
Capacitance	Very low	High	High	Medium

4G and 5G use advanced antennas



Advantages of antenna evolution:

- Reduced footprint
- More efficient delivery of power
- Higher capacity for 5G
- Faster data transmission to network

Acronyms:

RET = remote electrical tilt
COAX = coaxial cable
AAS = advanced antenna system
RRH = remote radio head
BBU = baseband unit
TXRU/PA = transceiver unit/power amplifier

Protecting DC power lines is critical for high-reliability antennas.

Macro base station with active antenna

1

Advanced antenna
Fuse, TVS Diode, MOV, GDT,
SIDACtor®, TVS Diode Array, PPTC



2

Tower mount amplifier
Fuse, TVS Diode



3

Baseband unit
Fuse, MOV, SIDACtor®
GDT, TVS Diode Array



4

Primary protection
Fuse, MOV, TVS Diode,
Magnetic Sensor, GDT, Schottky Diode



5

Battery backup
TVS Diode, Fuse, TVS Diode Array
Polymer ESD, Battery Protector

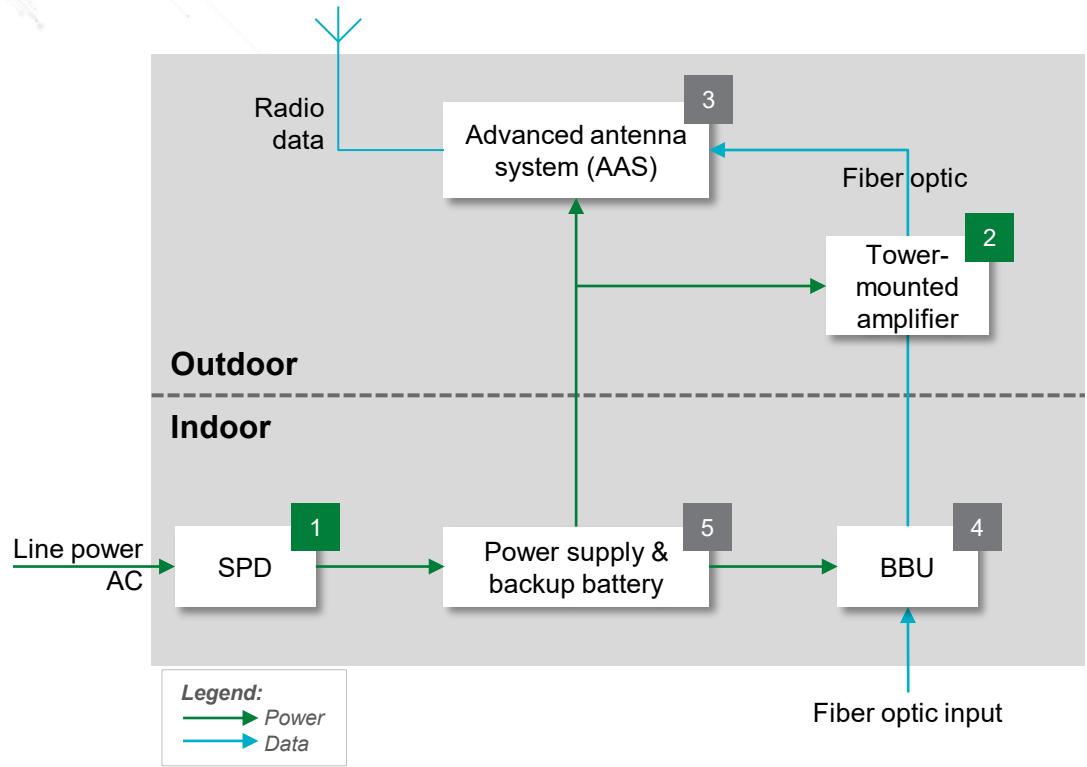


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Surge protection device
Fuse, MOV, TVS Diode



Cellular tower with active antenna block diagram

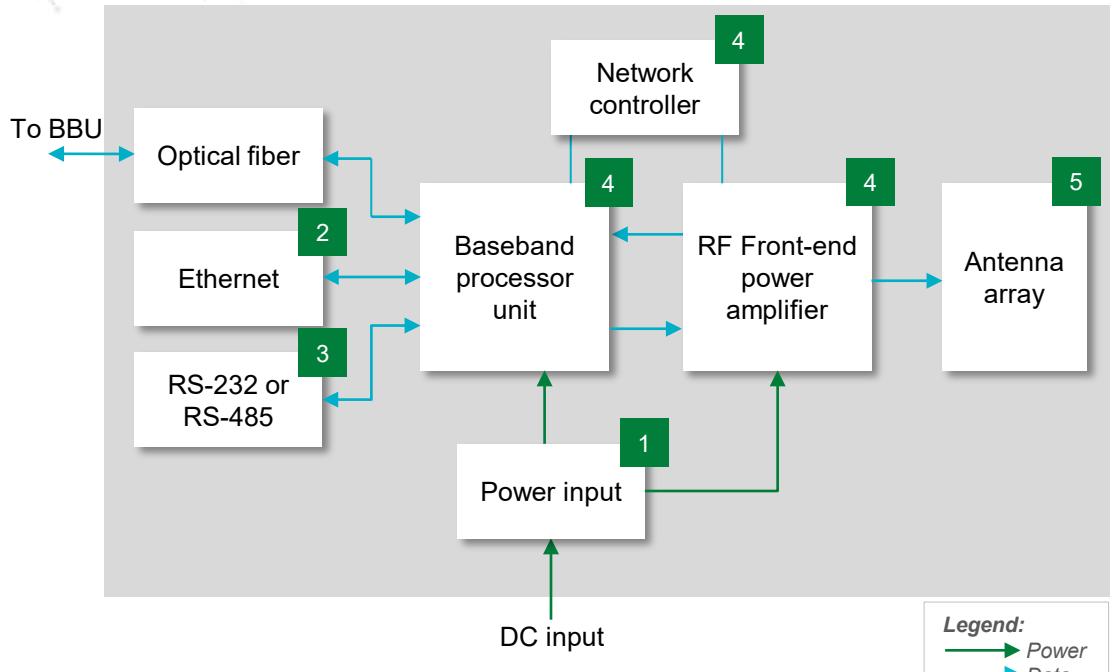


	Technology	Product series
1	MOV	TMOV , LST
	GDT	CG2 , CG3
	TVS Diode	LTKAK10 , SMTOAK2
	Fuse	LVSP
	TVS Diode	LTKAK10 , SMTOAK2
2	Fuse	871 , 456 , TLS
	Advanced antenna system (AAS) block diagram	
3	Baseband unit (BBU) block diagram	
4	Power supply and battery backup block diagram	
5		

Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	MOV	Voltage surge protection with thermal disconnect	TMOV , LST	Same footprint for 50 kA and 75 kA I_{max} for same PCB layout (LST)	Normally open and normally closed options for remote indication
	GDT	Voltage surge protection with no significant leakage current	CG2 , CG3	Surge protection for AC lines	Rugged ceramic metal construction
	TVS Diode	Transient voltage protection	LTKAK10 , SMTOAK2	Low clamping voltage, allowing lower voltage rating components downstream	High transient current rating (10 kA; 8/20 μ s) with lower clamping voltage compared to alternative technologies
	Fuse	Overcurrent protection specifically for SPD products	LVSP	Designed to survive surges caused by lightning as described in IEC and UL standards	Complements Littelfuse MOVs and high-power TVS Diodes
2	TVS Diode	Clamps transient voltages	LTKAK10 , SMTOAK2	Low clamping voltage, allowing lower voltage rating components downstream	High transient current rating (10 kA; 8/20 μ s) with lower clamping voltage compared to alternative technologies
	Fuse	Overcurrent protection	871 , 456 , TLS	Flexible design options with multiple form factors, sizes, and current rating, and voltage ratings	Surface mount versions up to 115 Vdc; up to 170 Vdc rated in cartridge and leaded options
3	Advanced antenna system (AAS) block diagram				
4	Baseband unit (BBU) block diagram				
5	Power supply and battery backup block diagram				

Advanced antenna system (AAS) block diagram

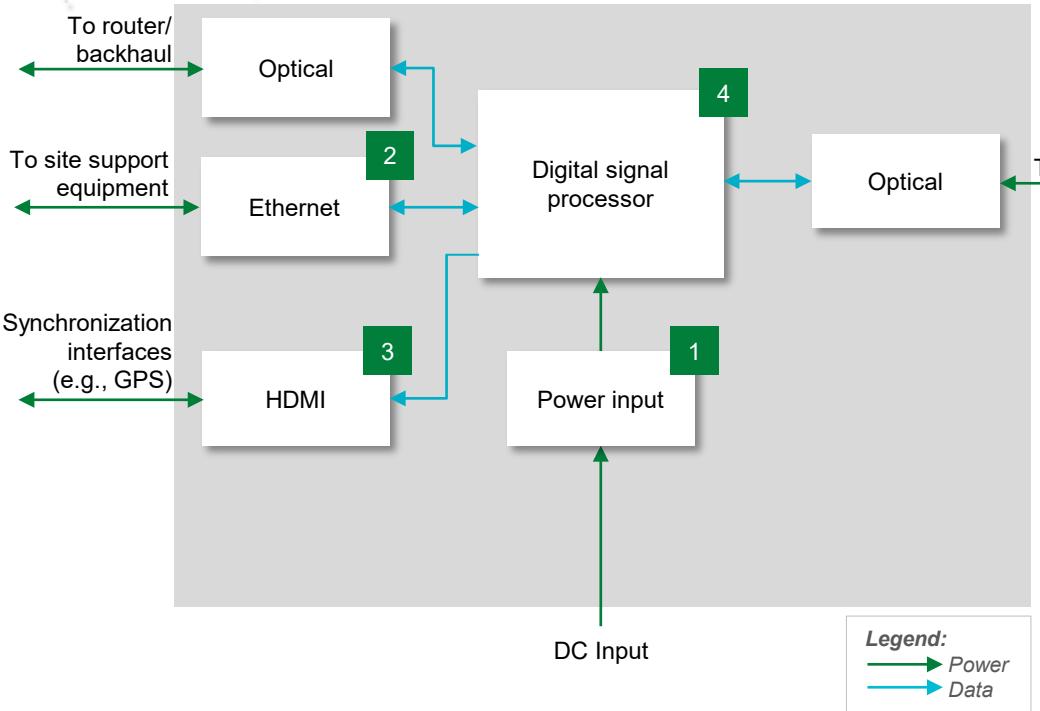


Technology	Product series
1	Fuse 456, 871, TLS
	MOV LV UltraMOV
	GDT CG
	TVS Diode LTKAK10, SMTOAK2
	Fuse 461
2	SIDACtor® SEP
	TVS Diode Array SP3400
	GDT SL0902A090SM
	GDT GTCxx
	SIDACtor® P0220S4BLRP
3	PPTC PolySwitch T-Line
	TVS Diode SMBJ, SMCJ, SMDJ
	GDT CG
4	
5	

Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	456 , 871 , TLS	Flexible design options with multiple form factors, sizes, and current and voltage ratings	Surface mount versions up to 115 Vdc; up to 170 Vdc rated in cartridge and leaded options
	MOV	Surge protection	LV UltraMOV	Saves board space without compromising surge-handling capability	High peak surge current rating up to 10 kA (8/20 µs pulse)
	GDT	Voltage surge protection with no significant leakage current	CG	Surge protection for AC lines	Rugged ceramic metal construction
	TVS Diode	Clamps transient voltages	LTKAK10 , SMTOAK2	Low clamping voltage, allowing lower voltage rating components downstream, leading to reduced overall design costs	High transient current rating with lower clamping voltage compared to alternative technologies
2	Fuse	Protects against power-cross faults	461	Enables compliance with regulatory standards	Surface mount; surge-tolerant fuse designed specifically for high-speed telecom applications
	SIDACtor®	Surge protection for PoE	SEP	Space-saving design with integrated overvoltage and steering diodes	Compatible with 1000BASE-T and PoE
	TVS Diode Array	Multistage, coordinated surge protection for data port	SP3400	Continued operation of PHY after surge events	Fast clamping and low capacitance
	GDT		SL0902A090SM	Withstands high surge levels with protection on primary side of isolation transformer	High surge rating; UL recognized
3	GDT	Lightning protection using a GDT with SIDACtor®; when lightning occurs, the SIDACtor® will react first, causing voltage to increase across PPTC until GDT fires	GTCxx	Coordinated protection against high surge levels; low clamping voltage	Wide range of voltages and form factors; low capacitance and insertion loss; low voltage overshoot; low on-state voltage
	SIDACtor®	P0220S4BLRP			
	PPTC	Protects equipment from short circuits and power-cross faults	PolySwitch T-Line	Product choices give engineers increased design flexibility; helps improve line balance	Available in various form factors; low parasitic capacitance
4	TVS Diode	Voltage transient protection	SMBJ , SMCJ , SMDJ	Helps protect the most sensitive parts of design from surge events	Multiple sizes and multiple surge capabilities
5	GDT	Voltage surge protection with high current capability	CG	Clamps high voltage effectively	Meet both GR-1089 –CORE (NEBS) and ITU-T K-series test methods

Baseband Unit (BBU) block diagram

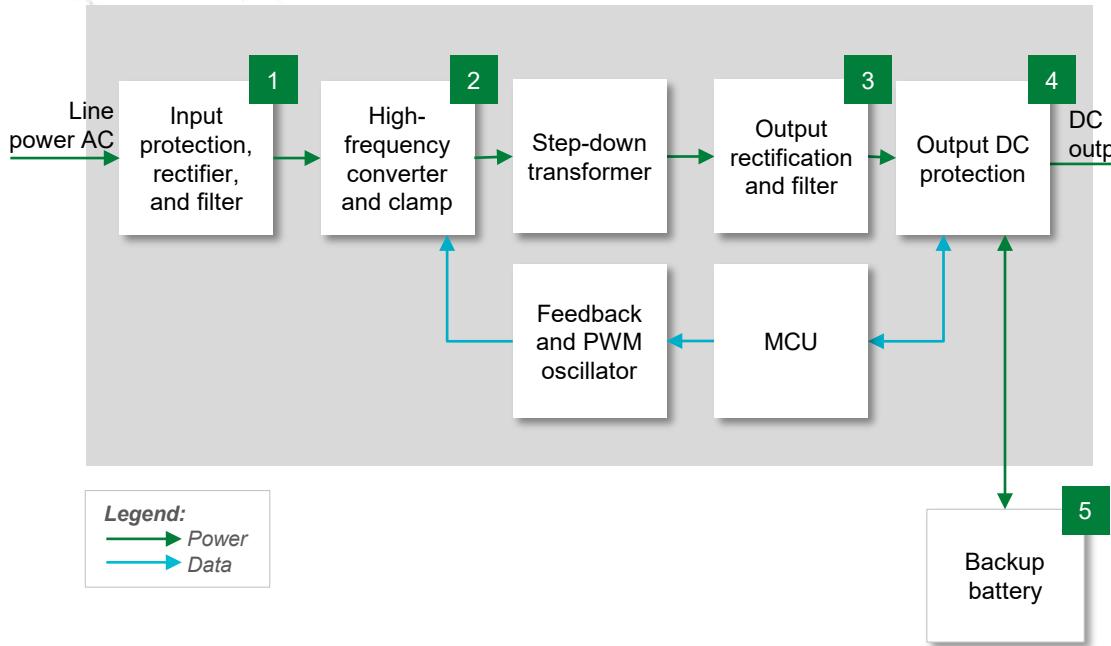


Technology	Product series
1	Fuse
	456 , 871 , TLS
	MOV
	LV UltraMOV
GDT	CG
TVS Diode	LTKAK10 , SMTOAK2
2	Fuse
	461
	SIDACtor®
	SEP
TVS Diode Array	SP3400
GDT	SL0902A090SM
3	TVS Diode Array
	SP1004U-ULC-04UTG
4	TVS Diode
	SMBJ , SMCJ , SMDJ

Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	456, 871, TLS	Flexible design options with multiple form factors, sizes, and current and voltage ratings	Surface mount versions up to 115 Vdc; up to 170 Vdc rated in cartridge and leaded options
	MOV	Surge protection	LV UltraMOV	Saves board space without compromising surge handling capability	High peak surge current rating up to 10 kA (8/20 μ s pulse)
	GDT	Voltage surge protection with no significant leakage current	CG	Clamps high voltage effectively	Meet both GR-1089 –CORE (NEBS) and ITU-T K-series test methods.
	TVS Diode	Clamps transient voltages	LTKAK10, SMTOAK2	Low clamping voltage, allowing lower voltage rating components downstream, leading to reduced overall design costs	High transient current rating with lower clamping voltage compared to alternative technologies
2	Fuse	Protects against power-cross faults	461	Enables compliance with regulatory standards	Surface mount; surge-tolerant fuse designed specifically for high-speed telecom applications
	SIDACTor®	Surge protection for PoE	SEP	Space-saving design with integrated overvoltage and steering diodes	Compatible with 1000BASE-T and PoE
	TVS Diode Array	Multistage, coordinated, surge protection for data port	SP3400	Continued operation of PHY after surge events	Fast clamping and low capacitance
	GDT		SL0902A090SM	Withstands high surge levels with protection on primary side of isolation transformer	High surge rating; UL recognized
3	TVS Diode Array	Protection of data signal lines from ESD	SP1004U-ULC-04UTG	Low capacitance; small form factor allows designers layout flexibility	Low capacitance of 0.2 pF; low clamping voltage of 9.2 V @ IPP = 2.0 A (t_p = 8/20 μ s); industry standard DFN footprint
4	TVS Diode	Voltage transient protection	SMBJ, SMCJ, SMDJ	Helps protect the most sensitive parts of design from surge events	Multiple sizes and surge capabilities

Power supply and backup battery



Click the product series in the table below for more info

Technology	Product series
1	Fuse JLLN, PSR
	MOV TMOV34S
	GDT CG3
	TVS Diode LTKAK10, SMTOAK2, SMFA
	Magnetic Sensor MDCG
2	TVS Diode P6KE, 1.5SMB, SMF4L
	MOSFET X2-Class
3	Schottky Diode MBR, DST
4	Fuse 463, 881, TLS, PSR
	Fuse 463, 881, TLS, PSR
	Temperature Sensor RB
	TVS Diode Array AQ05C
	PPTC zeptoSMDC
5	Battery Protector ITV
	Battery Mini-Breaker MHP-TAM

Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	JLLN , PSR	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	Compliance with third-party safety standards such as UL/IEC; low internal resistance
	MOV	GDT and TMOV connected in series to protect against voltage transients	TMOV34S	Enables product to comply with IEC 62368-1	High energy absorption capability; integrated thermal protection
	GDT		CG3		
	TVS Diode	SiC MOSFET protection and Transient voltage suppression	LTKAK10 , SMTOAK2 , SMFA	Increases surge immunity and long-term reliability	Up to 10 kA (8/20 μ s) transient current rating with lower clamping voltage
2	Magnetic Sensor	Detects when equipment is open	MDCG	Helps to ensure power is off when equipment is opened	Normally open switch capable of switching 200 Vdc or 0.5 A at up to 10 W
	TVS Diode	Transient voltage suppression	P6KE , 1.5SMB , SMF4L	Improves system reliability by protecting downstream components from transients	Peak pulse capability of 600 W; compatible with lead-free solder reflow temperature profile
3	MOSFET	High switching speed in power supply units	X2-Class	Fast response time and low heat signature	Low $R_{ds(on)}$; dv/dt ruggedness
4	Schottky Diode	Rectification and blocking in power supply units	MBR , DST	Enables the design of high-efficiency power supply units	Ultra-low forward voltage drop; high-frequency operation
5	Fuse	Output overcurrent protection	463 , 881 , TLS , PSR	Meets exact needs of design with multiple options	Wide range of sizes and electrical ratings
	Fuse	Input overcurrent protection	463 , 881 , TLS , PSR	Meets exact needs of design with multiple options	Wide range of sizes and electrical ratings
	Temperature Sensor	Monitors battery temperature	RB	Enables robust system operation	Tight tolerance; wide range of temperature sensing
	TVS Diode Array	Transient voltage suppression	AQ05C	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection
	PPTC	Protects battery fuel gauge I ² C lines	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
	Battery Protector	Overcurrent and overvoltage protection	ITV	Space saving and reliable protection	Low internal resistance; surface mount
	Battery Mini-Breaker	Secondary overtemperature and overcurrent protection for battery	MHP-TAM	Extends battery life; sensitive thermal protection	I_{hold} up to 15 A milliohm resistance; 72 to 90 °C cutoff temperature

Small cell antenna site

1

Advanced array
Fuse, Polymer ESD



2

**Baseband processor and
RF amplifier**
TVS Diode



1

2

3

4

3

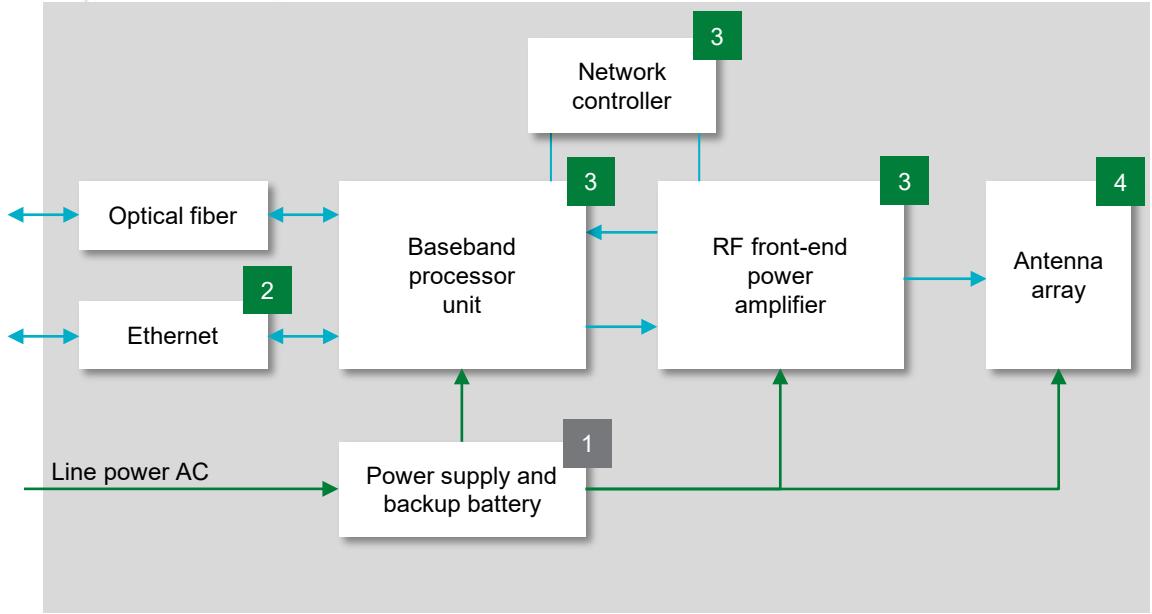
Power supply
Fuse, MOV, TVS Diode,
Magnetic Sensor, GDT, Schottky Diode

4

Battery backup
Fuse, TVS Diode,
TVS Diode Array, Battery Protector



Small cell block diagram



	Technology	Product series
1	See Power Supply and Battery Backup Block Diagram	
2	Fuse	461
	SIDACtor®	SEP
	TVS Diode Array	SP3400
	GDT	SL0902A090SM
3	TVS Diode	SMBJ , SMCJ , SMDJ
4	Polymer ESD Suppressor	XGD

Legend:
 Power
 Data

Benefits of recommended Littelfuse solutions

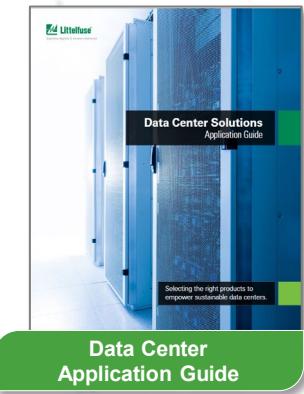
	Technology	Function in application	Product series	Benefits	Features
1	See Power Supply and Battery Backup Block Diagram				
2	Fuse	Protects against power-cross faults	461	Enables compliance with regulatory standards	Surface mount; surge-tolerant fuse designed specifically for high-speed telecom applications
	SIDACtor®	Surge protection for PoE	SEP	Space-saving design with integrated overvoltage and steering diodes	Compatible with 1000BASE-T and PoE
	TVS Diode Array	Multistage, coordinated, surge protection for data port	SP3400	Continued operation of PHY after surge events	Fast clamping and low capacitance
	GDT		SL0902A090SM	Withstands high surge levels with protection on primary side of isolation transformer	High surge rating; UL recognized
3	TVS Diode	Voltage transient protection	SMBJ , SMCJ , SMDJ	Helps protect the most sensitive parts of design from surge events	Multiple sizes and surge capabilities
4	Polymer ESD Suppressor	ESD protection of antenna	XGD	Protection without signal distortion	Extremely low capacitance and small size

Select safety standards for wireless communication

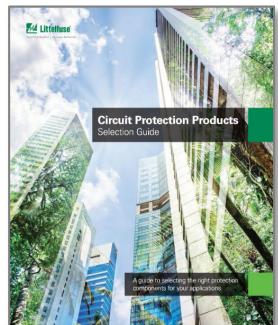
Standard	Title of standard	General scope	Region
GR 1089	Electromagnetic compatibility (EMC) and electrical safety—Generic criteria for network telecommunications equipment	ESD, EFT, lightning, and power fault test requirements for telecom equipment	Global
ITU-T K.20	Resistibility to overvoltage and overcurrent of telecommunication equipment installed in a telecommunications center	Lightning surge and power fault test requirements	Global
ITU-T K.45	Resistibility to overvoltage and overcurrent of telecommunication equipment installed in the access and trunk networks	Lightning surge and power fault test requirements	Global
IEC 62368-1	Audio/video, information and communication technology equipment—Part 1: Safety requirements	This part of IEC 62368 is a product safety standard that classifies energy sources, prescribes safeguards against those energy sources, and provides guidance on the application of, and requirements for, those safeguards	Global
ETSI EN 300 132	Environmental Engineering (EE); Power supply interface at the input of information and communication technology (ICT) equipment	Multiple parts provide guidance for various voltage applications including -48 Vdc, AC, and 400 Vdc	Global
ITU-T L.1200	Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment	Voltage surges and transient test requirements	Global

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Data Center Application Guide



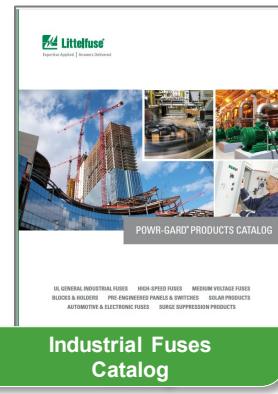
Circuit Protection Selection Guide



Sensing Products Selection Guide



Power Semiconductor & IC Selection Guide



Industrial Fuses Catalog



General Port Protection



Integrated Circuits Selection Guide



Local resources supporting our global customers



Legend

- Sales
- R&D
- Manufacturing

Partner for tomorrow's electronic systems



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