4G/5G Radio Access Network Equipment

Data Center and
Communication Infrastructure

Littelfuse®

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

Market trends and drivers

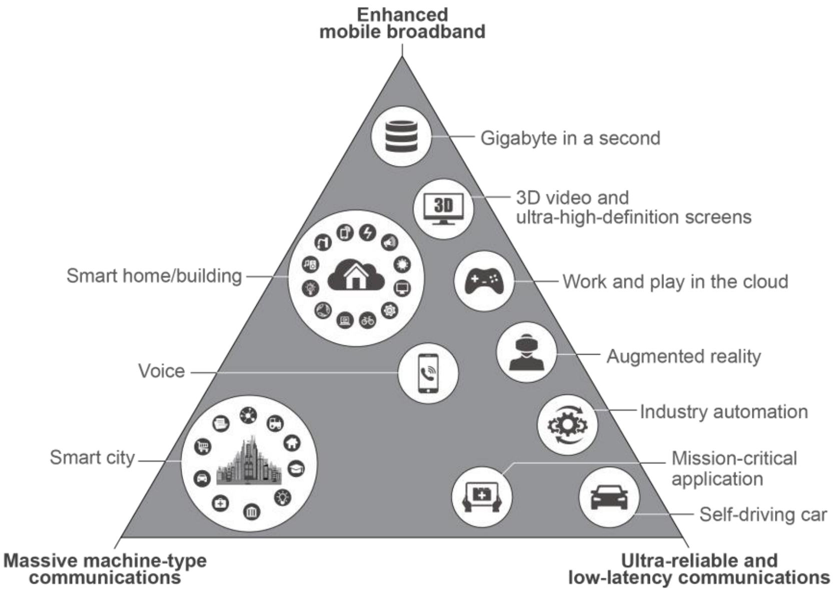
Massive growth in 5G infrastructure:
The global 5G base station market is projected to reach approximately $468.9 billion by 2032, growing at a compound annual growth rate (CAGR) of 29.3% from 2023 to 2032.

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.

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.

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.

5G builds on 4G & creates opportunities for new applications



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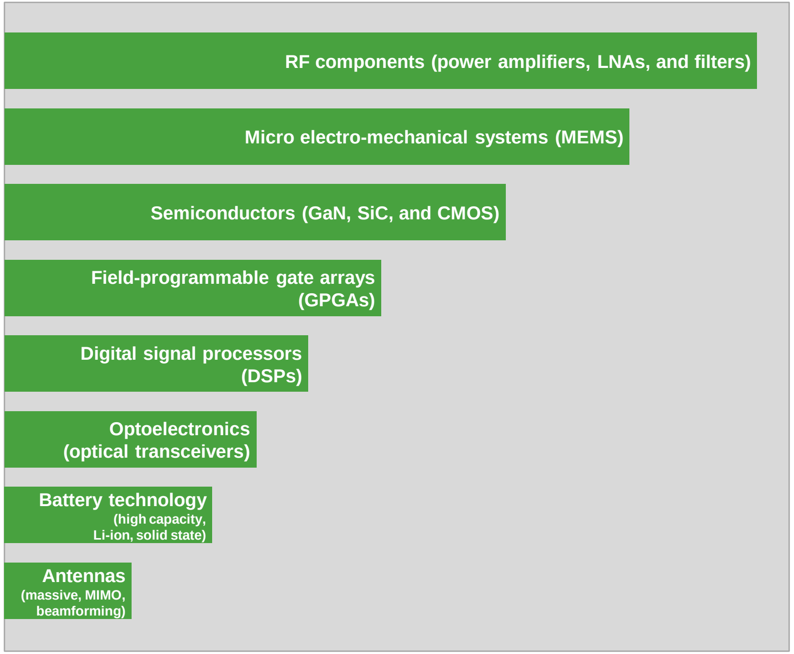
Key 5G network equipment applications

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)



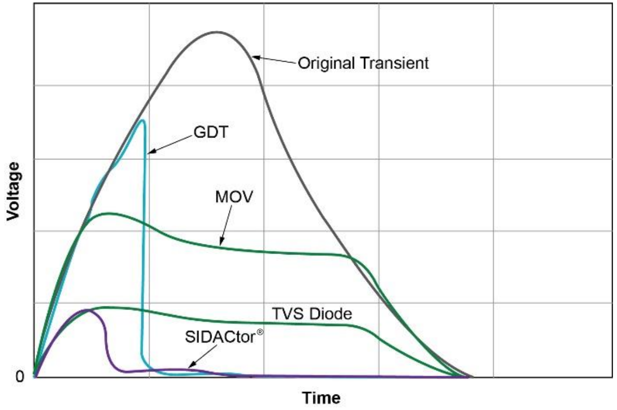
Importance of circuit protection

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

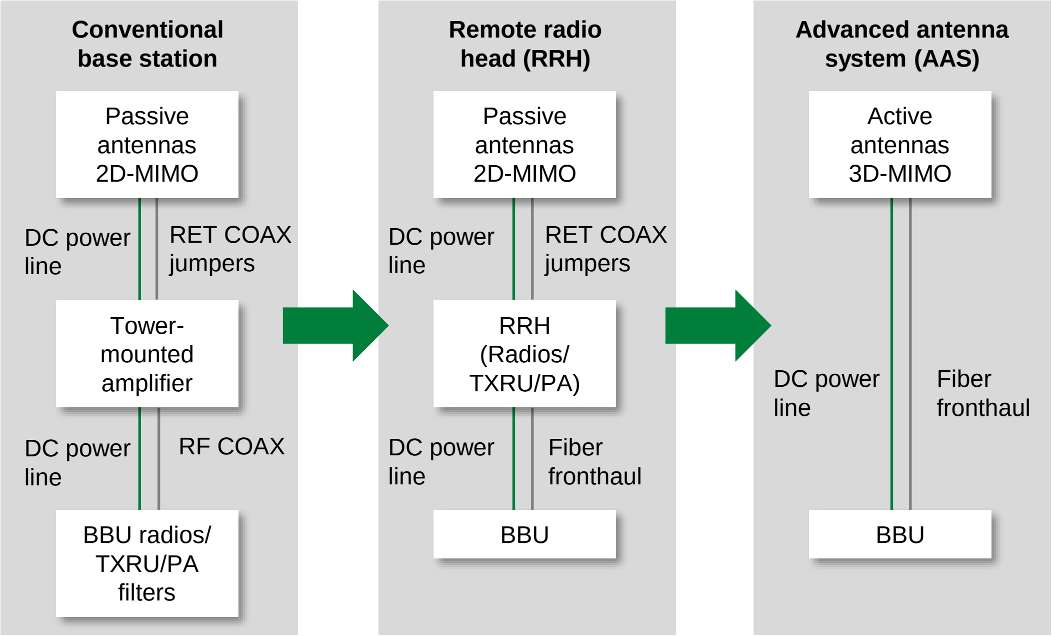
Select voltage protection based on hazard level, frequency of occurrence, and sensitivity of equipment

- 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	SIDACtor®
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:

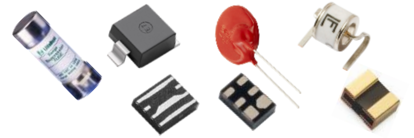
- Reduced footprint
- More efficient delivery of power
- Higher capacity for 5G
- Faster data transmission to network

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

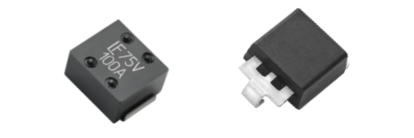
Protecting DC power lines is critical for high-reliability antennas.

Macro base station with active antenna

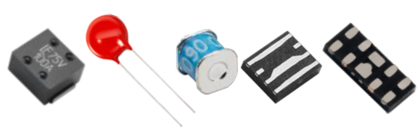
1 Advanced antenna
Fuse, TVS Diode, MOV, GDT,
SIDACtor®, TVS Diode Array, PPTC

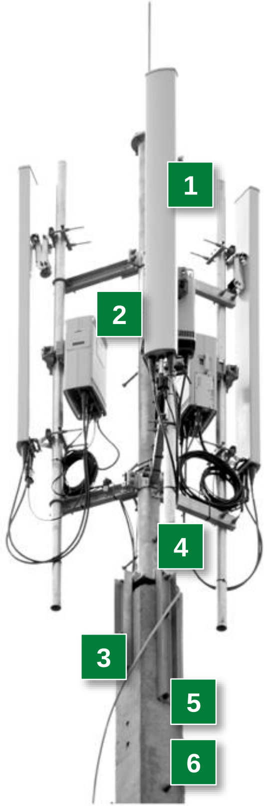


2 Tower mount amplifier
Fuse, TVS Diode

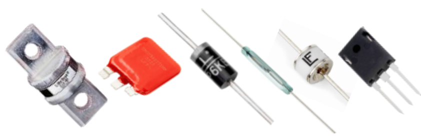


3 Baseband unit
Fuse, MOV, SIDACtor®
GDT, TVS Diode Array





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

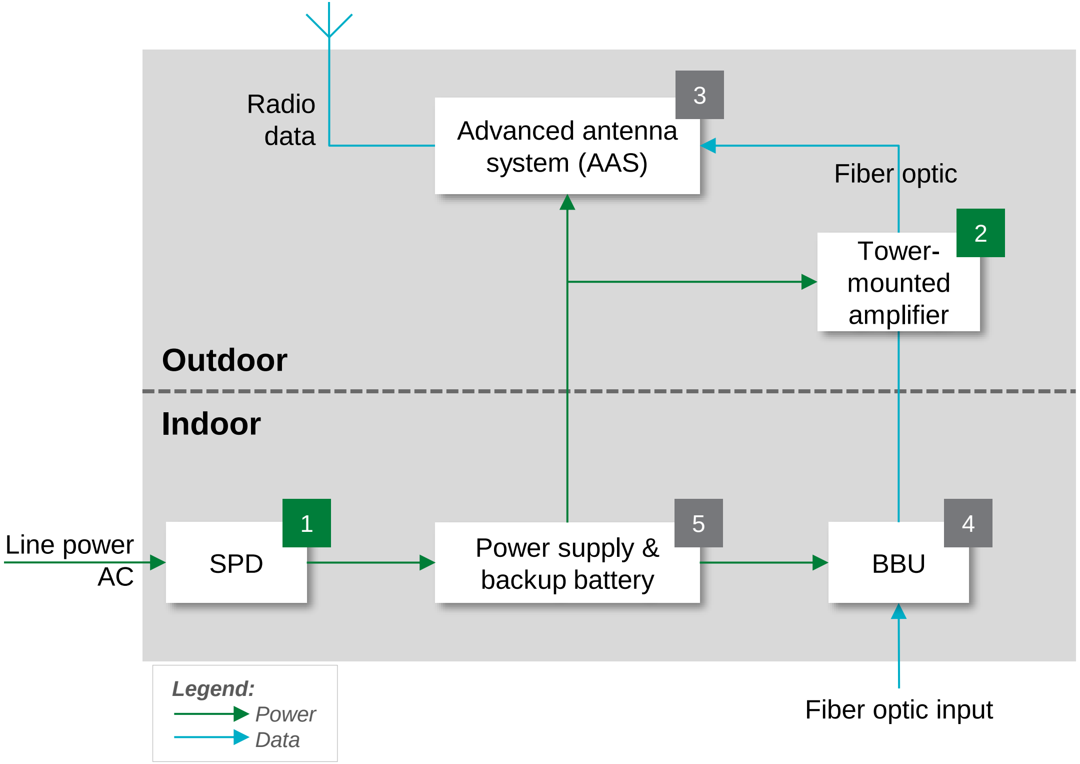


5 Battery backup
TVS Diode, Fuse, TVS Diode Array
Polymer ESD, Battery Protector

6 Surge protection device
Fuse, MOV, TVS Diode

Click the product series in the table below for more info

Cellular tower with active antenna block diagram



	Technology	Product series
1	MOV	TMOV, LST
1	GDT	CG2, CG3
1	TVS Diode	LTKAK10, SMTOAK2, DFNAK3
1	Fuse	LVSP
2	TVS Diode	LTKAK10, SMTOAK2, DFNAK3
2	Fuse	871, 456, TLS
3	Advanced antenna system (AAS) block diagram	
4	Baseband unit (BBU) block diagram	
5	Power supply and battery backup block diagram	

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Click the product series in the table below for more info

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, DFNAK3	Low clamping voltage, allowing lower voltage rating components downstream	High transient current rating (10 kA; 8/20 µs) 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, DFNAK3	Low clamping voltage, allowing lower voltage rating components downstream	High transient current rating (10 kA; 8/20 µs) 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				

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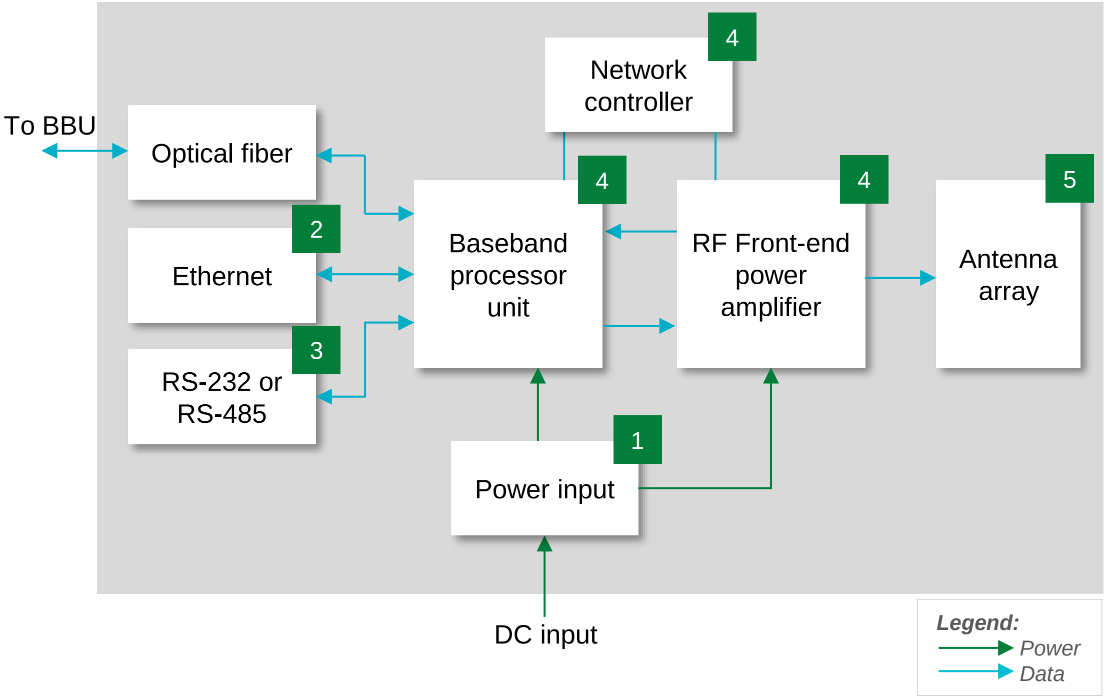
Advanced antenna system (AAS) block diagram



	Technology	Product series
1	Fuse	871, 456, TLS
	MOV	LV UltraMOV
	GDT	CG
	TVS Diode	LTKAK10, SMTOAK2, DFNAK3
2	Fuse	461
	SIDACtor®	SEP
	TVS Diode Array	SP3400
	GDT	SL0902A090SM
3	GDT	GTCxx
	SIDACtor®	P0220S4BLRP
	PPTC	PolySwitch T-Line
4	TVS Diode	SMBJ, SMCJ, SMDJ
5	GDT	CG

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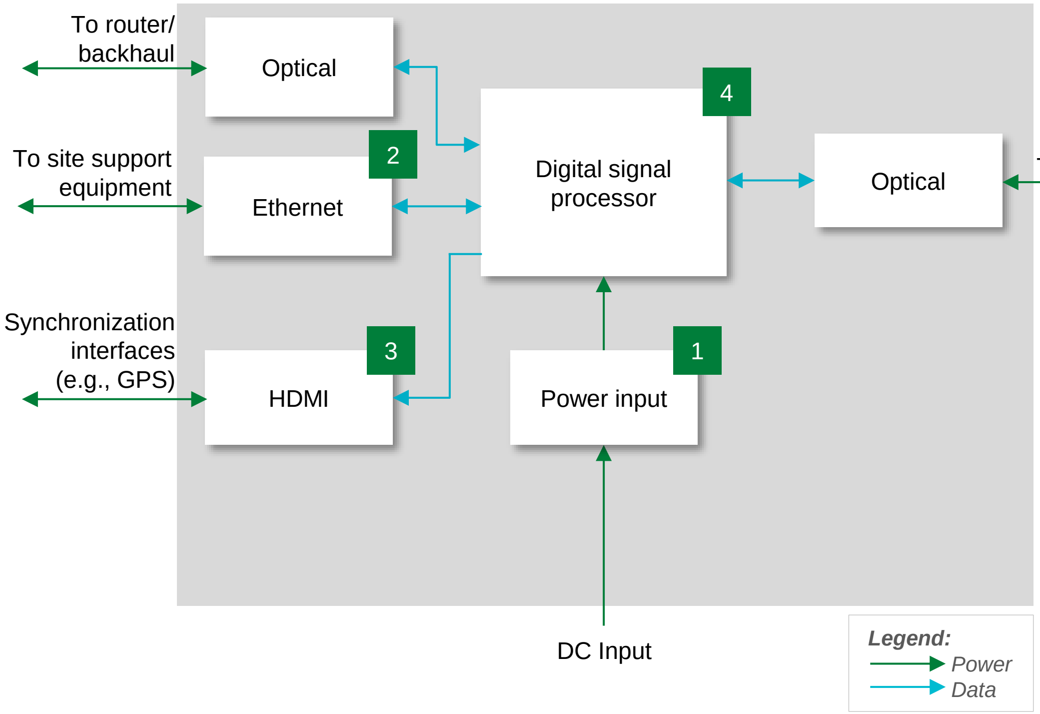
Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	871, 456, 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	Clamps high voltage effectively	Meet both GR-1089–CORE (NEBS) and ITU-T K-series test methods
	TVS Diode	Clamps transient voltages	LTKAK10, SMTOAK2, DFNAK3	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

Click the product series in the table below for more info

Baseband Unit (BBU) block diagram



	Technology	Product series
1	Fuse	871, 456, TLS
	MOV	LV UltraMOV
	GDT	CG
	TVS Diode	LTKAK10, SMTOAK2, DFNAK3
2	Fuse	461
	SIDACtor®	SEP
	TVS Diode Array	SP3400
	GDT	SL0902A090SM
3	TVS Diode Array	SP1004U-ULC-04UTG
4	TVS Diode	SMBJ, SMCJ, SMDJ

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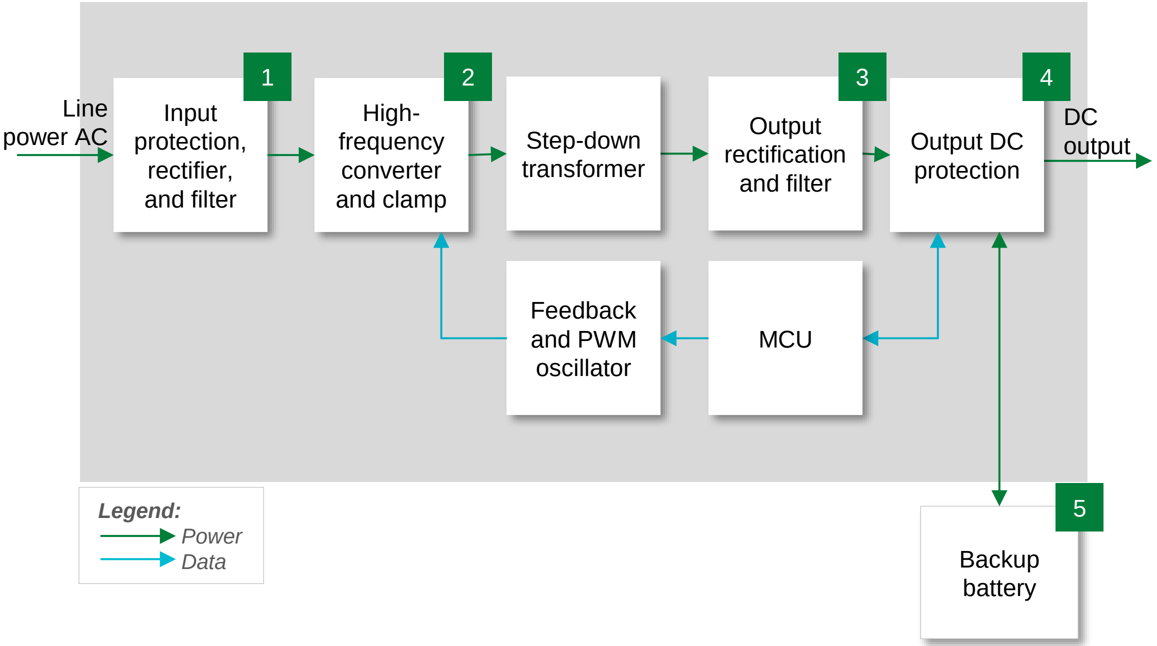
Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	871, 456, 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
1	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)
1	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.
1	TVS Diode	Clamps transient voltages	LTKAK10, SMTOAK2, DFNAK3	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
2	SIDACtor®	Surge protection for PoE	SEP	Space-saving design with integrated overvoltage and steering diodes	Compatible with 1000BASE-T and PoE
2	TVS Diode Array	Multistage, coordinated, surge protection for data port	SP3400	Continued operation of PHY after surge events	Fast clamping and low capacitance
2	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 µs); 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

Click the product series in the table below for more info

Power supply and backup battery



	Technology	Product series
1	Fuse	JLLN, PSR
	MOV	TMOV34S
	GDT	CG3
	TVS Diode	LTKAK10, SMTOAK2, DFNAK3
	Magnetic Sensor	MDCG
2	TVS Diode	P6KE, 1.5SMB, SMF4L
	MOSFET	X2-Class
3	Schottky Diode	MBR, DST
4	Fuse	463, 881, TLS, PSR
5	Fuse	463, 881, TLS, PSR
	Temperature Sensor	RB
	TVS Diode Array	AQ05C
	PPTC	zeptoSMDC
	Battery Protector	ITV
	Battery Mini-Breaker	MHP-TAM

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Click the product series in the table below for more info

Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	**827**, **828**, 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, DFNAK3	Increases surge immunity and long-term reliability	Up to 10 kA (8/20 µs) transient current rating with lower clamping voltage
	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
2	TVS Diode	Transient voltage suppression	P6KE, 1.5SMB, SMF4L, **SZSMF6L**	Improves system reliability by protecting downstream components from transients	Peak pulse capability of 600 W; compatible with lead-free solder reflow temperature profile
	MOSFET	High switching speed in power supply units	X2-Class	Fast response time and low heat signature	Low $R_{ds(on)}$; dv/dt ruggedness
3	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
4	Fuse	Output overcurrent protection	463, 881, TLS, PSR	Meets exact needs of design with multiple options	Wide range of sizes and electrical ratings
5	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^2C 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

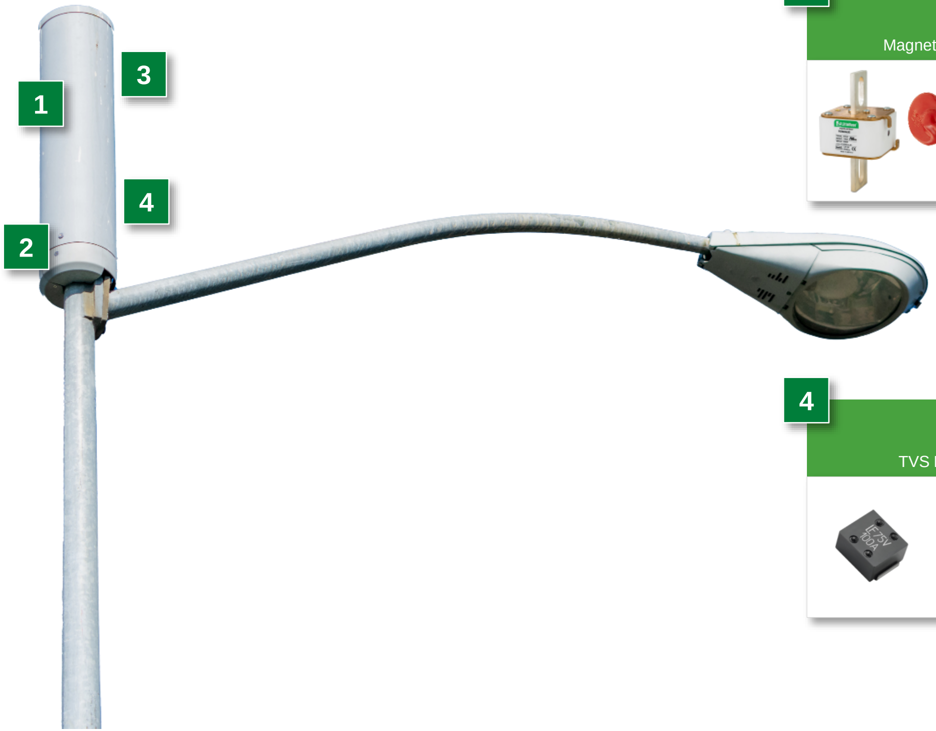
Small cell antenna site

1

Advanced array
Fuse, Polymer ESD

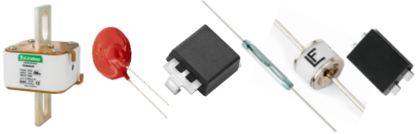
2

Baseband processor and RF amplifier
TVS Diode



3

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

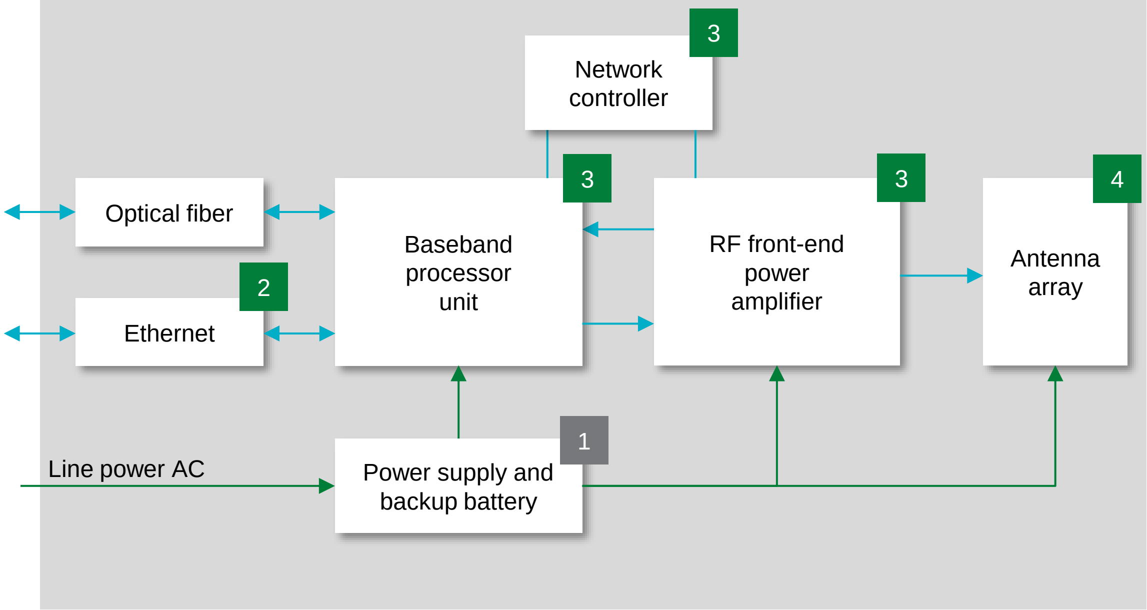


4

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

Click the product series in the table below for more info

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

Click the product series in the table below for more info

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
	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 & transient test requirements	Global

Additional information can be found at Littelfuse.com

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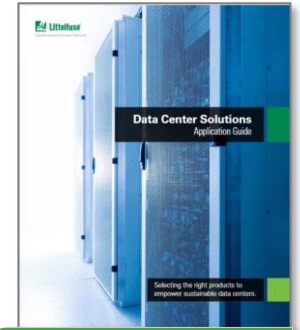
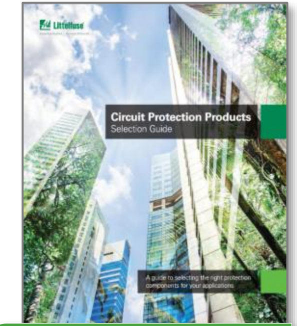
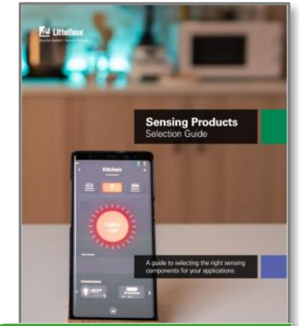


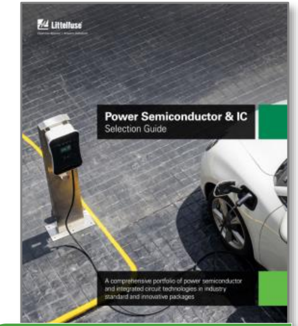
Data Center Application Guide



Circuit Protection Selection Guide



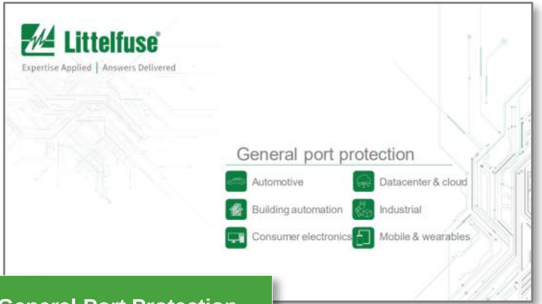
Sensing Products Selection Guide



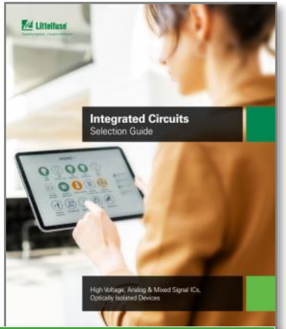
Power Semiconductor & IC Selection Guide

Industrial Fuses Catalog

Click the images for more information



General Port Protection



Integrated Circuits Selection Guide

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Local resources supporting our global customers

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Partner for tomorrow’s electronic systems

Broad Product Portfolio

We are an industrial technology manufacturing company empowering a sustainable, connected, and safer world

Testing Capabilities

We help customers get products to market faster, we offer certification testing to global regulatory standards

Application Expertise

Our engineers partner directly with customers to help speed up product design and meet their unique needs

Compliance & Regulatory

We help customers in the design process to account for requirements set by global regulatory authorities

Global Customer Service

Our global customer service team is with you to anticipate your needs and ensure a seamless experience

Global Manufacturing

High-volume manufacturing that is committed to the highest quality standards

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