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# 4G/5G Radio Access Network Equipment



Data Center and  
Communication Infrastructure

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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.

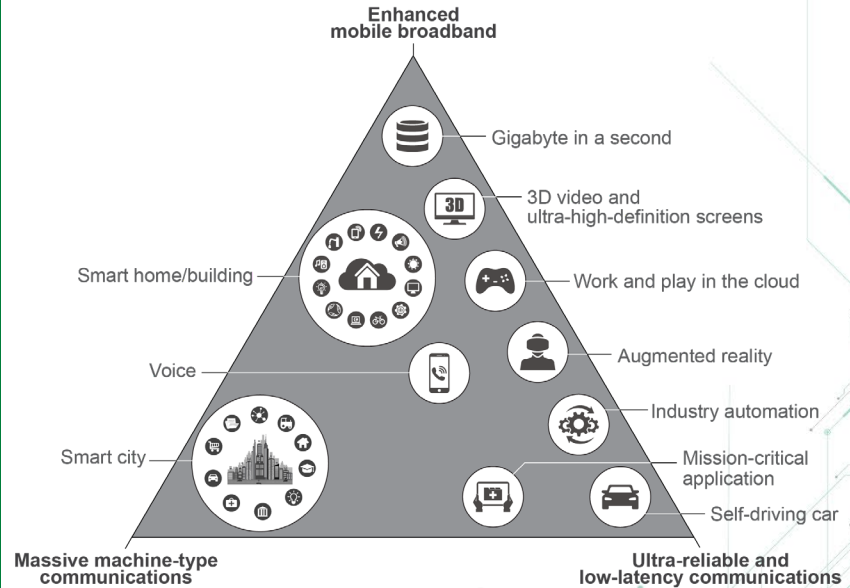
**Adoption of advanced technologies:** 5G base stations will increasingly incorporate advanced technologies such as massive multiple input multiple output (MIMO), beamforming, and millimeter-wave spectrum utilization. These technologies will enhance network capacity, efficiency, and coverage.

### 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

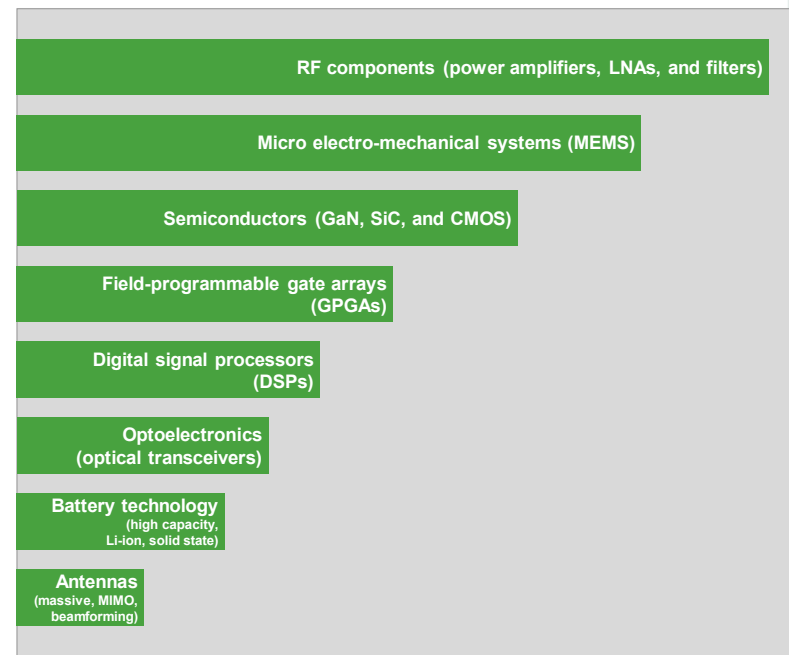


# Key 5G network equipment applications

## 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)



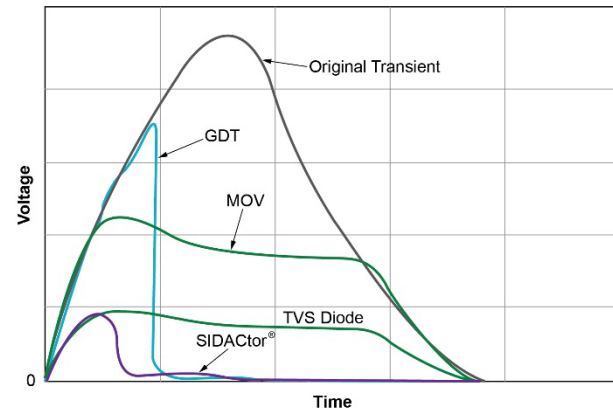
# Importance of circuit protection

**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

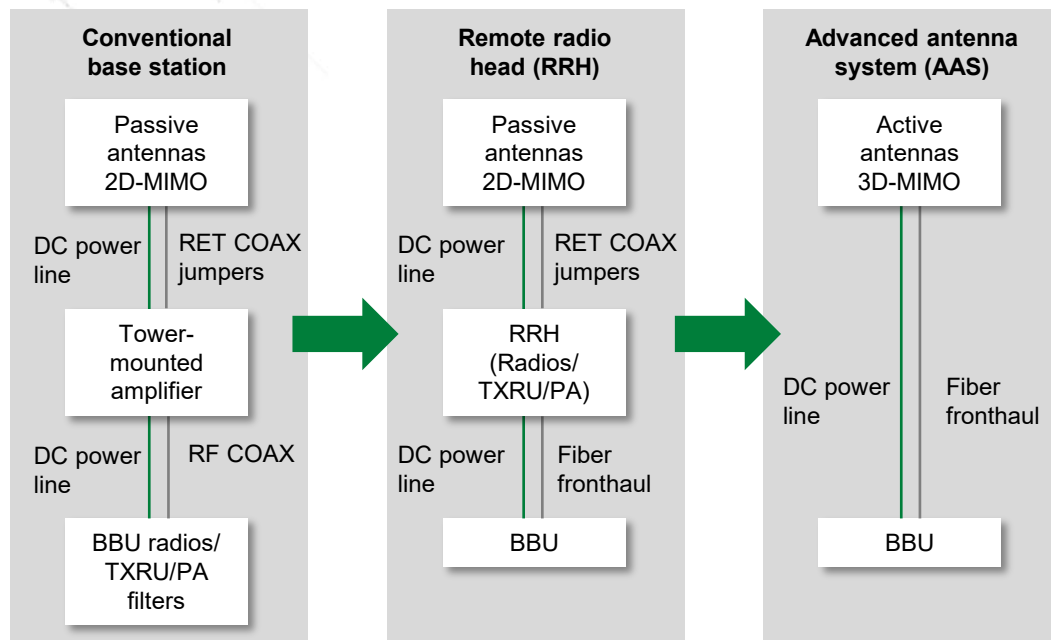
# Select voltage protection based on hazard level, frequency of occurrence, and sensitivity of equipment

- 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

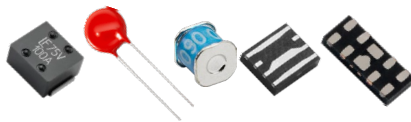
Fuse, TVS Diode



3

## Baseband unit

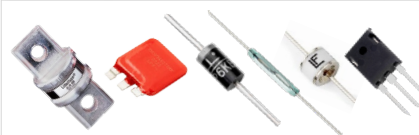
Fuse, MOV, SIDActor®, GDT, TVS Diode Array



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

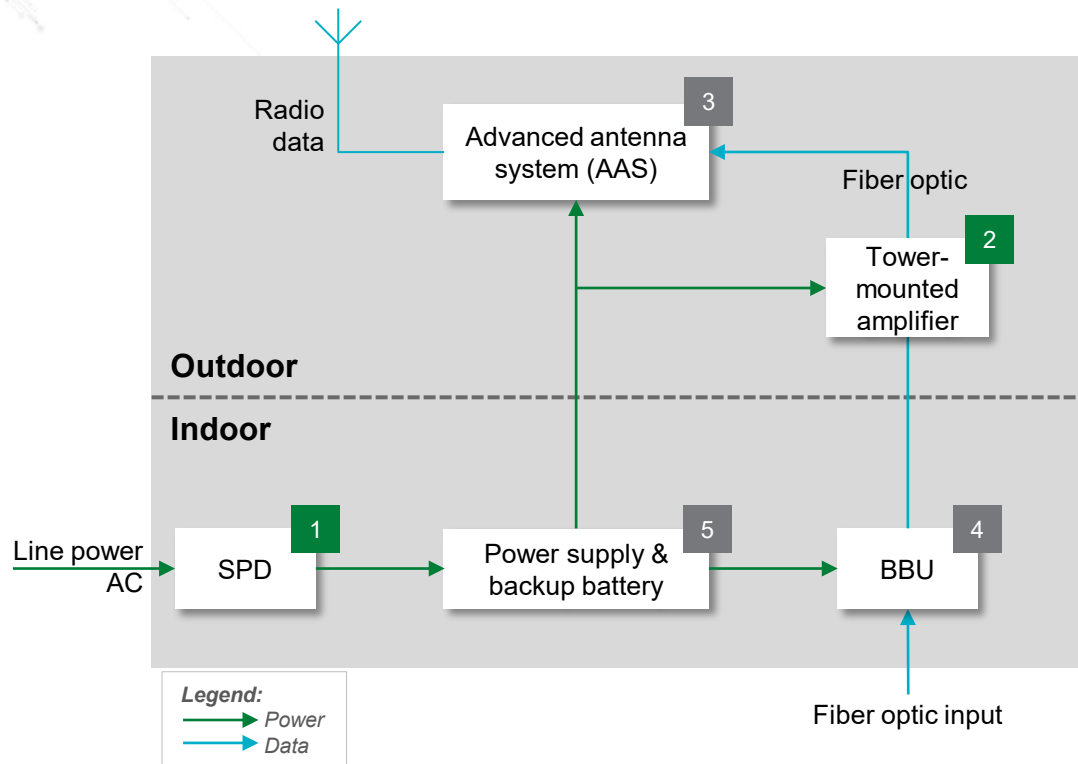
Fuse, MOV, TVS Diode





Click the product series in the table below for more info

# Cellular tower with active antenna block diagram



	Technology	Product series
1	MOV	<a href="#">TMOV</a> , <a href="#">LST</a>
	GDT	<a href="#">CG2</a> , <a href="#">CG3</a>
	TVS Diode	<a href="#">LTKAK10</a> , <a href="#">SMTOKA2</a>
	Fuse	<a href="#">LVSP</a>
2	TVS Diode	<a href="#">LTKAK10</a> , <a href="#">SMTOKA2</a>
	Fuse	<a href="#">871</a> , <a href="#">456</a> , <a href="#">TLS</a>
3	<a href="#">Advanced antenna system (AAS) block diagram</a>	
4	<a href="#">Baseband unit (BBU) block diagram</a>	
5	<a href="#">Power supply and battery backup block diagram</a>	





Click the product series in the table below for more info

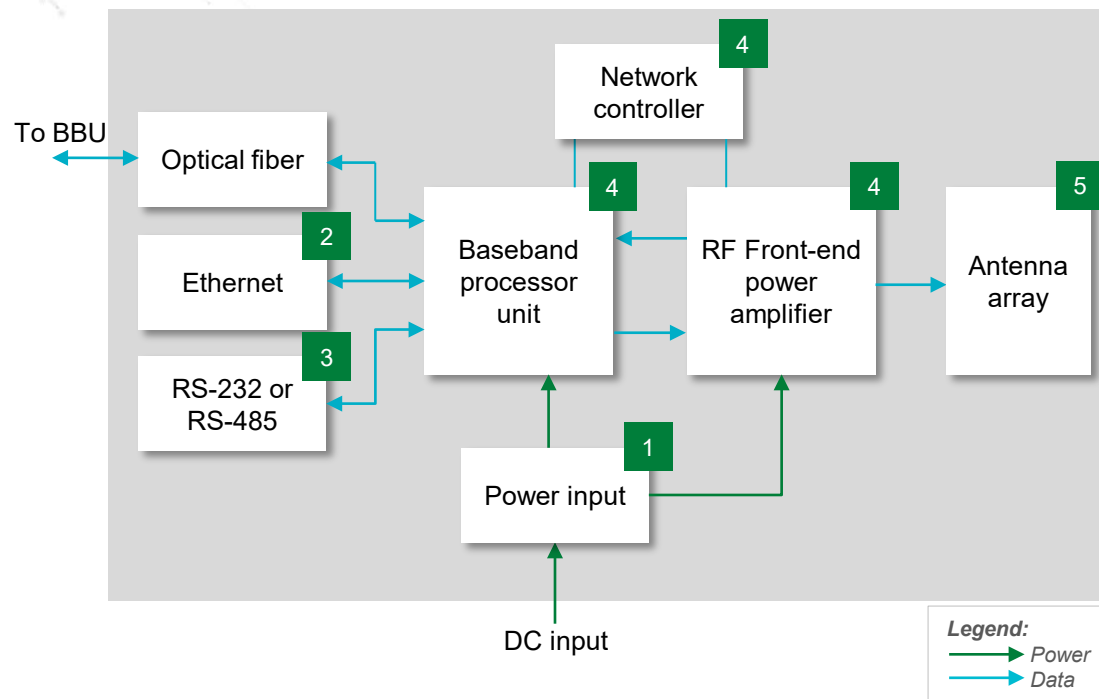
# Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	MOV	Voltage surge protection with thermal disconnect	<a href="#">TMOV</a> , <a href="#">LST</a>	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	<a href="#">CG2</a> , <a href="#">CG3</a>	Surge protection for AC lines	Rugged ceramic metal construction
	TVS Diode	Transient voltage protection	<a href="#">LTKAK10</a> , <a href="#">SMTOKA2</a>	Low clamping voltage, allowing lower voltage rating components downstream	High transient current rating (10 kA; 8/20 $\mu$ s) with lower clamping voltage compared to alternative technologies
	Fuse	Overcurrent protection specifically for SPD products	<a href="#">LVSP</a>	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	<a href="#">LTKAK10</a> , <a href="#">SMTOKA2</a>	Low clamping voltage, allowing lower voltage rating components downstream	High transient current rating (10 kA; 8/20 $\mu$ s) with lower clamping voltage compared to alternative technologies
	Fuse	Overcurrent protection	<a href="#">871</a> , <a href="#">456</a> , <a href="#">TLS</a>	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	<a href="#">Advanced antenna system (AAS) block diagram</a>				
4	<a href="#">Baseband unit (BBU) block diagram</a>				
5	<a href="#">Power supply and battery backup block diagram</a>				



Click the product series in the table below for more info

# Advanced antenna system (AAS) block diagram



	Technology	Product series
1	Fuse	<a href="#">456</a> , <a href="#">871</a> , <a href="#">TLS</a>
	MOV	<a href="#">LV UltraMOV</a>
	GDT	<a href="#">CG</a>
	TVS Diode	<a href="#">LTKAK10</a> , <a href="#">SMTOKA2</a>
2	Fuse	<a href="#">461</a>
	SIDACtor®	<a href="#">SEP</a>
	TVS Diode Array	<a href="#">SP3400</a>
	GDT	<a href="#">SL0902A090SM</a>
3	GDT	<a href="#">GTCxx</a>
	SIDACtor®	<a href="#">P0220S4BLRP</a>
	PPTC	<a href="#">PolySwitch T-Line</a>
4	TVS Diode	<a href="#">SMBJ</a> , <a href="#">SMCJ</a> , <a href="#">SMDJ</a>
5	GDT	<a href="#">CG</a>



Click the product series in the table below for more info

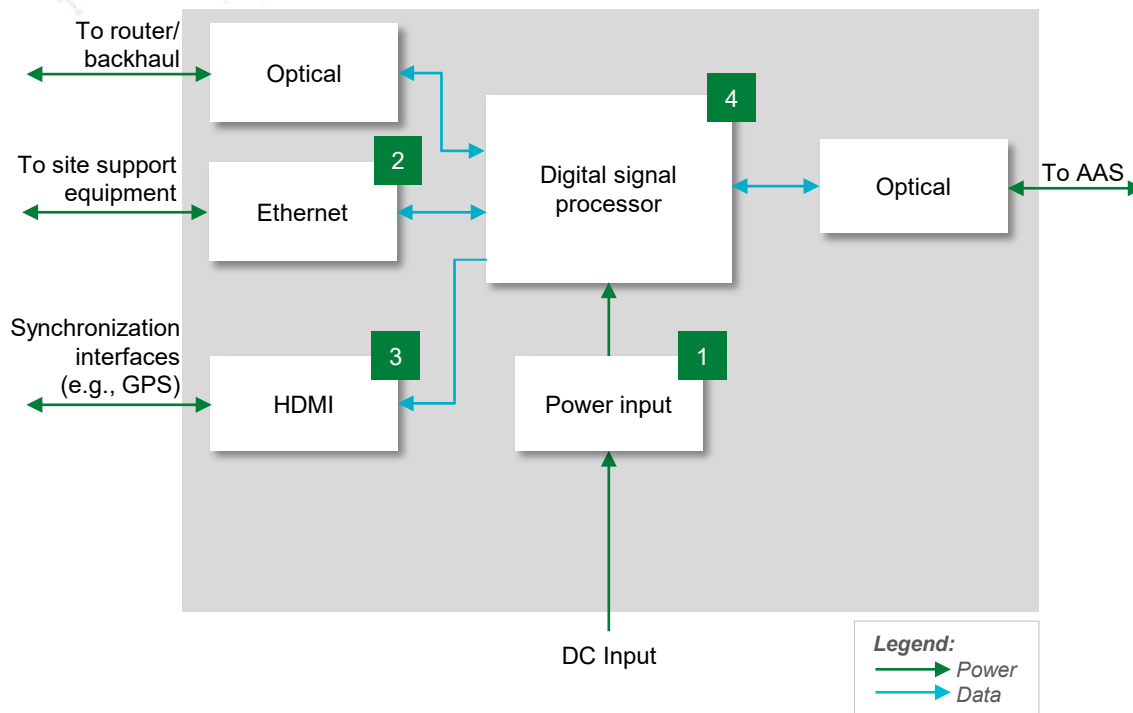
# Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	<a href="#">456</a> , <a href="#">871</a> , <a href="#">TLS</a>	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	<a href="#">LV UltraMOV</a>	Saves board space without compromising surge-handling capability	High peak surge current rating up to 10 kA (8/20 $\mu$ s pulse)
	GDT	Voltage surge protection with no significant leakage current	<a href="#">CG</a>	Surge protection for AC lines	Rugged ceramic metal construction
	TVS Diode	Clamps transient voltages	<a href="#">LTKAK10</a> , <a href="#">SMTOKA2</a>	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	<a href="#">461</a>	Enables compliance with regulatory standards	Surface mount; surge-tolerant fuse designed specifically for high-speed telecom applications
	SIDACTor®	Surge protection for PoE	<a href="#">SEP</a>	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	<a href="#">SP3400</a>	Continued operation of PHY after surge events	Fast clamping and low capacitance
	GDT		<a href="#">SL0902A090SM</a>	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	<a href="#">GTCxx</a>	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®		<a href="#">P0220S4BLRP</a>		
	PPTC	Protects equipment from short circuits and power-cross faults	<a href="#">PolySwitch T-Line</a>	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	<a href="#">SMBJ</a> , <a href="#">SMCJ</a> , <a href="#">SMDJ</a>	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	<a href="#">CG</a>	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	<a href="#">456, 871, TLS</a>
	MOV	<a href="#">LV UltraMOV</a>
	GDT	<a href="#">CG</a>
	TVS Diode	<a href="#">LTKAK10, SMTOK2</a>
2	Fuse	<a href="#">461</a>
	SIDACtor®	<a href="#">SEP</a>
	TVS Diode Array	<a href="#">SP3400</a>
	GDT	<a href="#">SL0902A090SM</a>
3	TVS Diode Array	<a href="#">SP1004U-ULC-04UTG</a>
4	TVS Diode	<a href="#">SMBJ, SMCJ, SMDJ</a>



Click the product series in the table below for more info

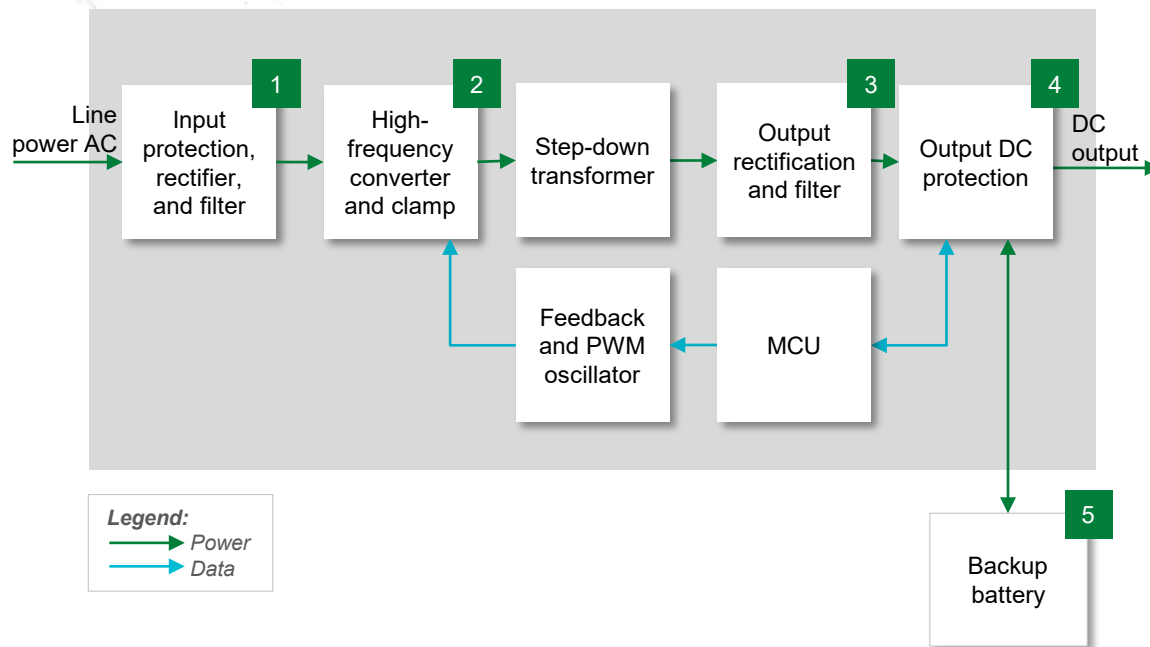
# Benefits of recommended Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent protection	<a href="#">456</a> , <a href="#">871</a> , <a href="#">TLS</a>	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	<a href="#">LV UltraMOV</a>	Saves board space without compromising surge handling capability	High peak surge current rating up to 10 kA (8/20 $\mu$ s pulse)
	GDT	Voltage surge protection with no significant leakage current	<a href="#">CG</a>	Clamps high voltage effectively	Meet both GR-1089 –CORE (NEBS) and ITU-T K-series test methods.
	TVS Diode	Clamps transient voltages	<a href="#">LTKAK10</a> , <a href="#">SMTQAK2</a>	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	<a href="#">461</a>	Enables compliance with regulatory standards	Surface mount; surge-tolerant fuse designed specifically for high-speed telecom applications
	SIDACtor®	Surge protection for PoE	<a href="#">SEP</a>	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	<a href="#">SP3400</a>	Continued operation of PHY after surge events	Fast clamping and low capacitance
	GDT		<a href="#">SL0902A090SM</a>	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	<a href="#">SP1004U-ULC-04UTG</a>	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 $\mu$ s); industry standard DFN footprint
4	TVS Diode	Voltage transient protection	<a href="#">SMBJ</a> , <a href="#">SMCJ</a> , <a href="#">SMDJ</a>	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	<a href="#">JLLN</a> , <a href="#">PSR</a>
	MOV	<a href="#">TMOV34S</a>
	GDT	<a href="#">CG3</a>
	TVS Diode	<a href="#">LTKAK10</a> , <a href="#">SMT0AK2</a> , <a href="#">SMFA</a>
	Magnetic Sensor	<a href="#">MDCG</a>
2	TVS Diode	<a href="#">P6KE</a> , <a href="#">1.5SMB</a> , <a href="#">SMF4L</a>
	MOSFET	<a href="#">X2-Class</a>
3	Schottky Diode	<a href="#">MBR</a> , <a href="#">DST</a>
4	Fuse	<a href="#">463</a> , <a href="#">881</a> , <a href="#">TLS</a> , <a href="#">PSR</a>
5	Fuse	<a href="#">463</a> , <a href="#">881</a> , <a href="#">TLS</a> , <a href="#">PSR</a>
	Temperature Sensor	<a href="#">RB</a>
	TVS Diode Array	<a href="#">AQ05C</a>
	PPTC	<a href="#">zeptoSMDC</a>
	Battery Protector	<a href="#">ITV</a>
	Battery Mini-Breaker	<a href="#">MHP-TAM</a>



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	<a href="#">JLLN</a> , <a href="#">PSR</a>	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	<a href="#">TMOV34S</a>	Enables product to comply with IEC 62368-1	High energy absorption capability; integrated thermal protection
	GDT		<a href="#">CG3</a>		
	TVS Diode	SiC MOSFET protection and Transient voltage suppression	<a href="#">LTKAK10</a> , <a href="#">SMTOAK2</a> , <a href="#">SMFA</a>	Increases surge immunity and long-term reliability	Up to 10 kA (8/20 $\mu$ s) transient current rating with lower clamping voltage
	Magnetic Sensor	Detects when equipment is open	<a href="#">MDCG</a>	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	<a href="#">P6KE</a> , <a href="#">1.5SMB</a> , <a href="#">SMF4L</a>	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	<a href="#">X2-Class</a>	Fast response time and low heat signature	Low $R_{ds(on)}$ ; dv/dt ruggedness
3	Schottky Diode	Rectification and blocking in power supply units	<a href="#">MBR</a> , <a href="#">DST</a>	Enables the design of high-efficiency power supply units	Ultra-low forward voltage drop; high-frequency operation
4	Fuse	Output overcurrent protection	<a href="#">463</a> , <a href="#">881</a> , <a href="#">TLS</a> , <a href="#">PSR</a>	Meets exact needs of design with multiple options	Wide range of sizes and electrical ratings
5	Fuse	Input overcurrent protection	<a href="#">463</a> , <a href="#">881</a> , <a href="#">TLS</a> , <a href="#">PSR</a>	Meets exact needs of design with multiple options	Wide range of sizes and electrical ratings
	Temperature Sensor	Monitors battery temperature	<a href="#">RB</a>	Enables robust system operation	Tight tolerance; wide range of temperature sensing
	TVS Diode Array	Transient voltage suppression	<a href="#">AQ05C</a>	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 <sup>2</sup> C lines	<a href="#">zeptoSMDC</a>	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	<a href="#">ITV</a>	Space saving and reliable protection	Low internal resistance; surface mount
	Battery Mini-Breaker	Secondary overtemperature and overcurrent protection for battery	<a href="#">MHP-TAM</a>	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



1

3

4

2

2

## Baseband processor and RF amplifier

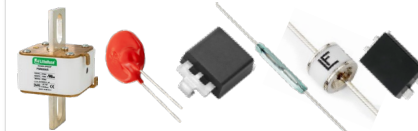
TVS Diode



3

## Power supply

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



4

## Battery backup

Fuse, TVS Diode,  
TVS Diode Array, Battery Protector

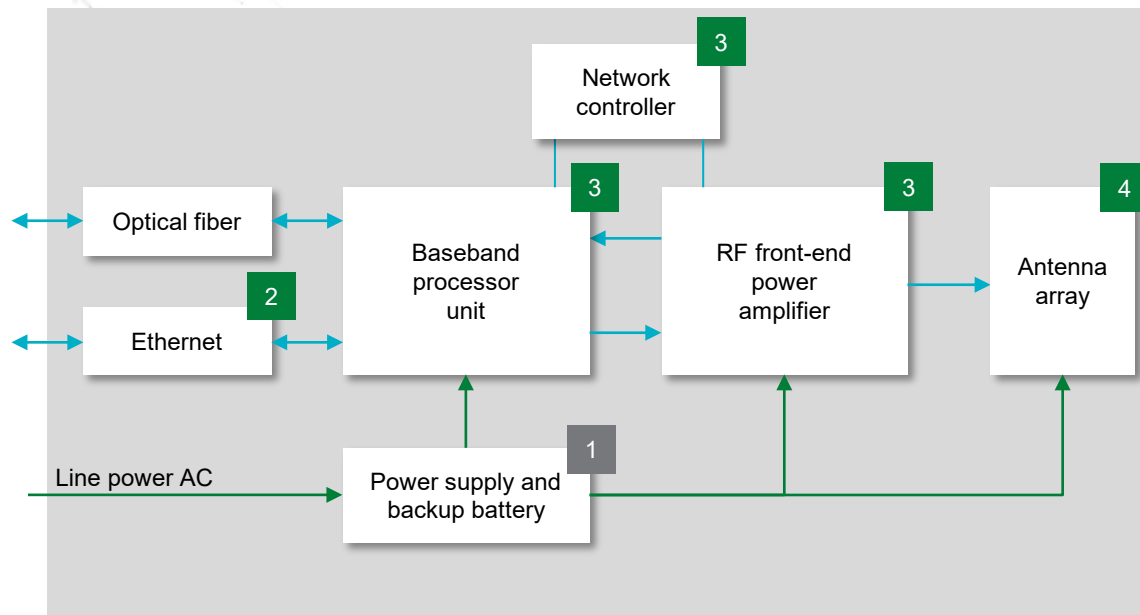






Click the product series in the table below for more info

# Small cell block diagram



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



Click the product series in the table below for more info

# Benefits of recommended Littelfuse solutions

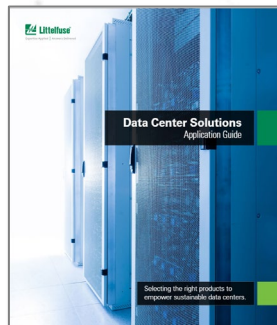
	Technology	Function in application	Product series	Benefits	Features
1	See <a href="#">Power Supply and Battery Backup Block Diagram</a>				
2	Fuse	Protects against power-cross faults	<a href="#">461</a>	Enables compliance with regulatory standards	Surface mount; surge-tolerant fuse designed specifically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

# Select safety standards for wireless communication

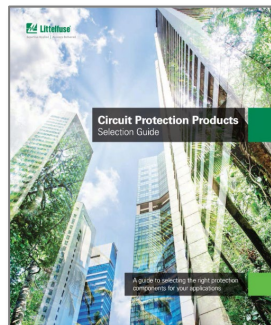
Standard	Title of standard	General scope	Region
GR 1089	Electromagnetic compatibility (EMC) and electrical safety– Generic criteria for network telecommunications equipment	ESD, EFT, lightning, and power fault test requirements for telecom equipment	Global
ITU-T K.20	Resistibility to overvoltage and 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

# Additional information can be found at [Littelfuse.com](https://www.littelfuse.com)

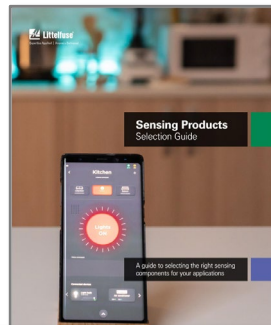
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Data Center  
Application Guide



Circuit Protection  
Selection Guide



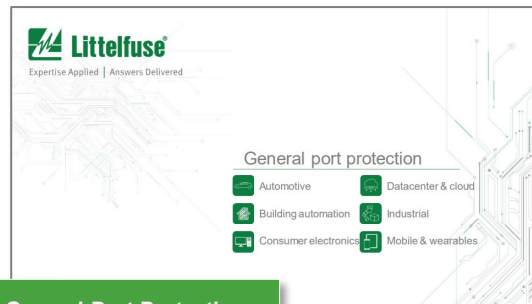
Sensing Products  
Selection Guide



Power Semiconductor & IC  
Selection Guide



Industrial Fuses  
Catalog



General Port Protection



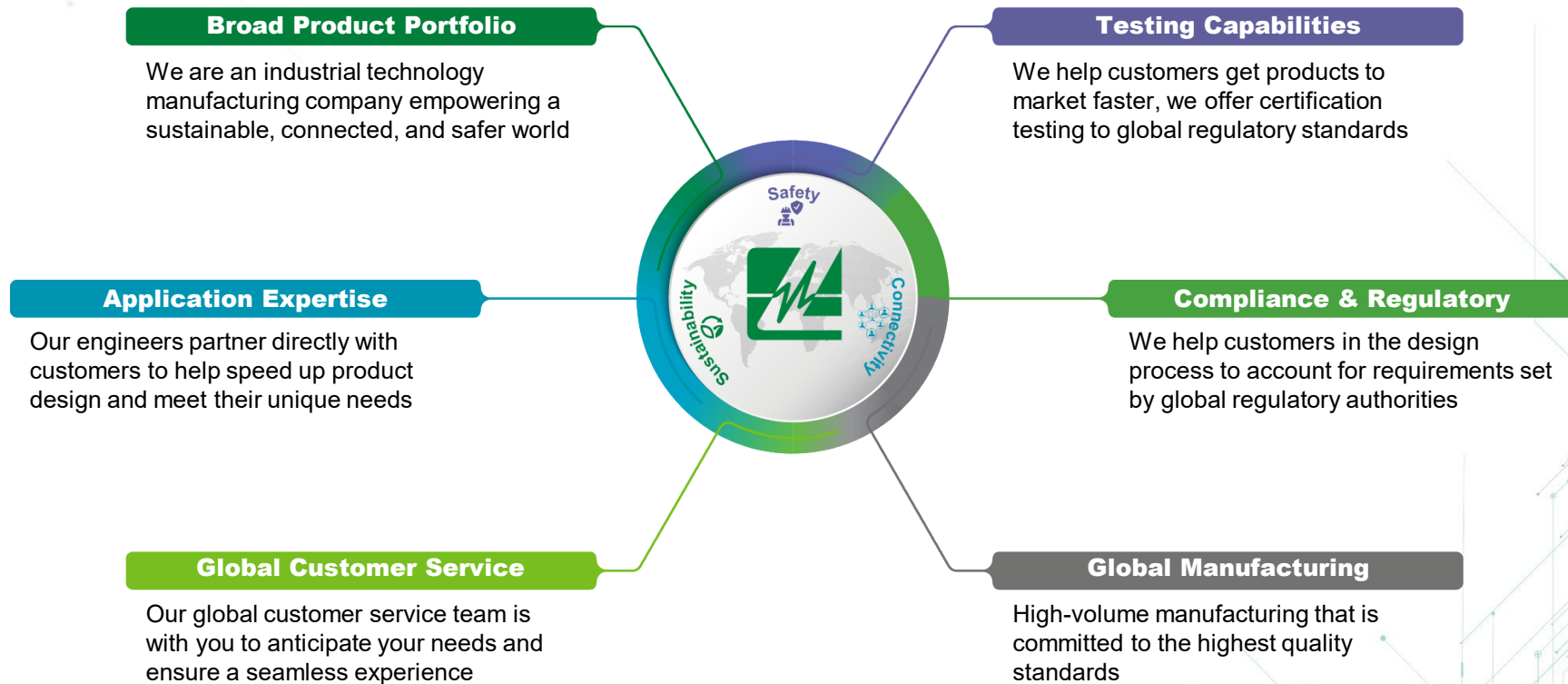
Integrated Circuits  
Selection Guide



# Local resources supporting our global customers



# Partner for tomorrow's electronic systems



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