Uninterruptable Power Supply (UPS) & Energy Storage System (ESS)

- Data Center
- Industrial
- Renewable Energy

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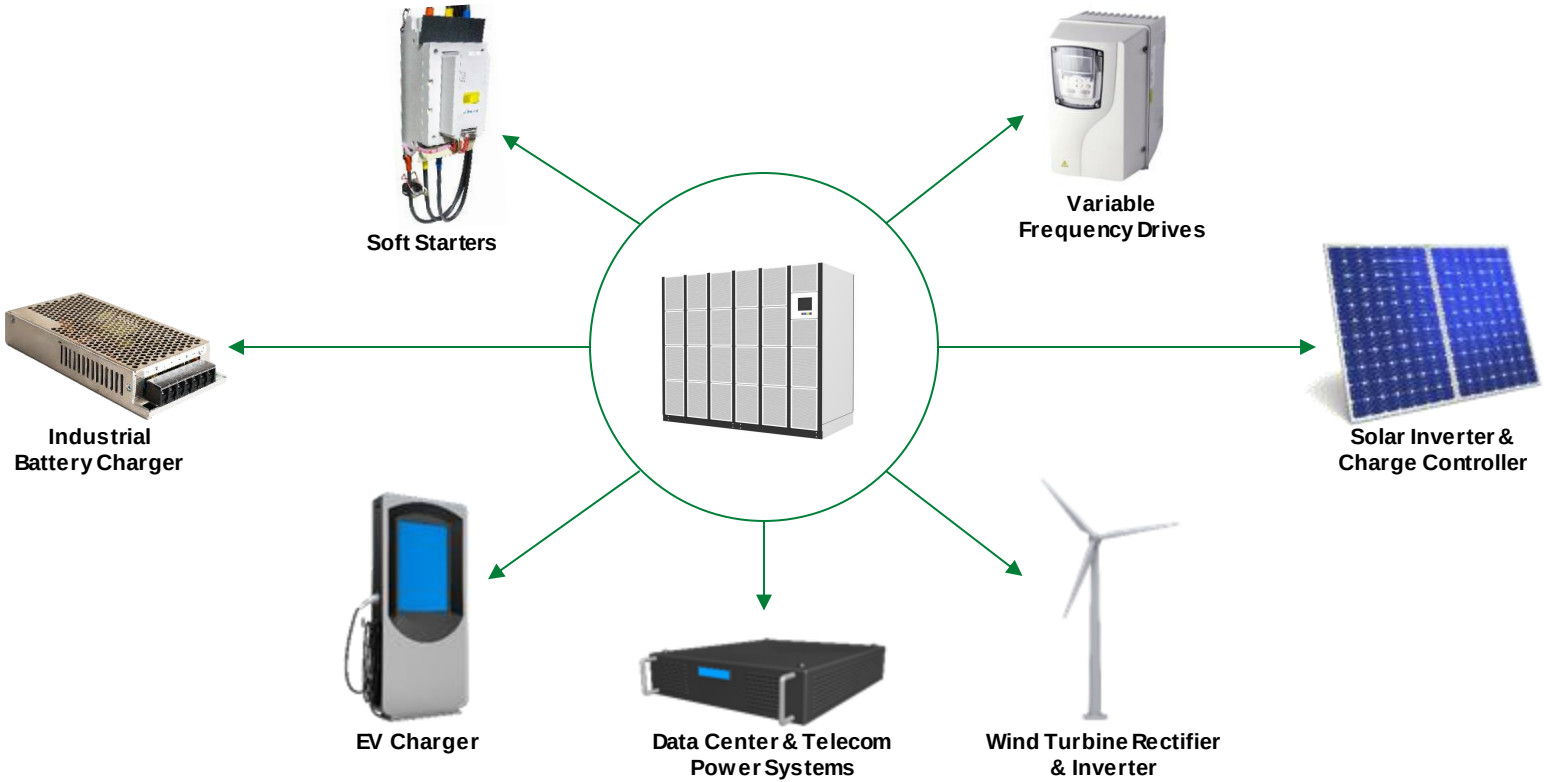
UPS shares similar architecture with multiple industrial and renewable energy systems



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Energy efficiency and reliability continue to drive UPS market sales

Market trends and drivers

Global UPS market estimated to grow at 5% CAGR for next 5 years

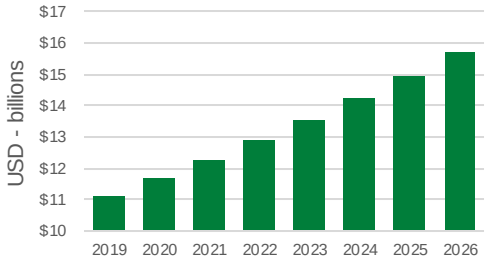
Need for reliable electrical energy is driving increased sales to data centers, medical, industrial, and consumer markets

Increasing energy-efficiency requirements are causing data centers to prefer multi-mode, line-interactive UPS

Power surges and failures are key growth drivers for UPS in Europe

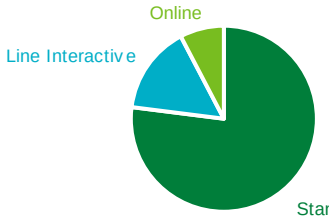
Lithium-ion batteries are the preferred energy storage system for UPS due to high energy density and long shelf life

Global UPS market sales



Source: Global UPS Market (360ResearchReports, 2020), marking estimates

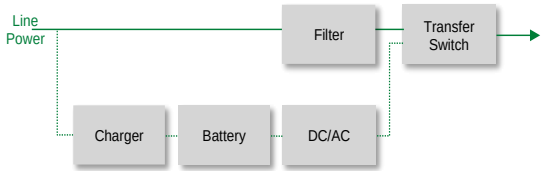
Data center UPS by type



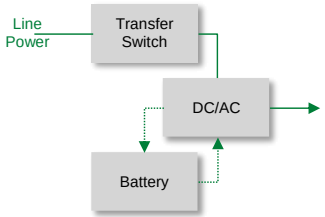
Source: Data center UPS market (Global Market Insights, 2019), marking estimates

Ideal UPS type depends on system priority of key characteristics

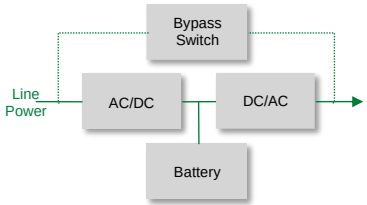
Standby



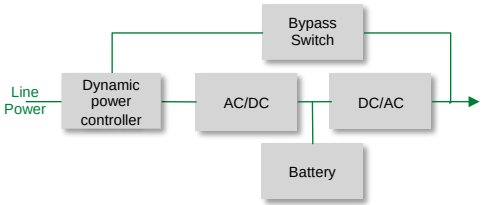
Line interactive



Double conversion on-line



Multi-mode



	Standby	Line interactive	Double conversion on-line	Multi-mode
Energy efficiency	Very high	Very high	Medium – Power conversion causes some loss	Medium – Power conversion causes some loss
Switching time	High – Switching from line power to battery takes a few electrical cycles	Low	Zero – Power always flows through inverter	Zero – Power always flows through inverter
Filtering	Medium	High	Very High	Very High
Cost per VA	Low	Medium	Medium	Medium

Littelfuse solutions for UPS

AC input

- Fuse
- MOV

AC/DC converter

- Rectifier module
- IGBT/MOSFET
- Gate driver
- Temperature sensor

DC/AC converter

- IGBT module
- Gate driver
- Temperature sensor

Bypass switch

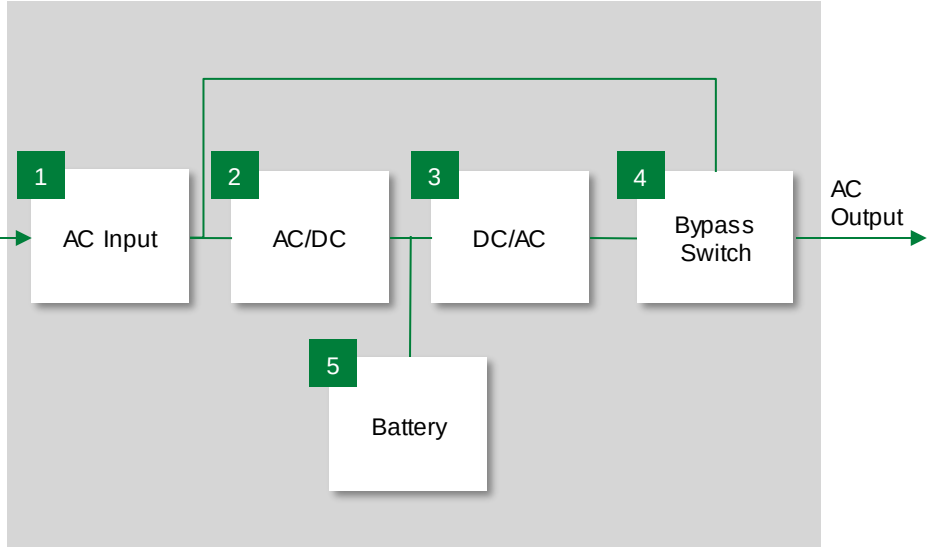
- Thyristor module

Battery and ESS

- Fuse
- TVS diode
- Diode array
- Gate driver
- MOSFET
- Temperature sensor

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

UPS Block Diagram



	Technology	Product series
1	Fuse II	PSR, JLLS, 505
	MOV III	TMOV
2	Rectifier module IV	MDD, VUO, MDMA
	IGBT and MOSFET	XPT and Ultra junction X-Class
	Gate driver V	IXD_6xx
	Temperature sensor	USP10976
3	IGBT module	MIXA, MIXG
	Gate driver V	IXD_6xx
	Temperature sensor	USP10976
4	Thyristor module	MCC, MCMA
5	See BESS block diagram (link to page)	

Notes:

I. *Double conversion on-line UPS diagram used as representative model. Other topologies will have similar solution needs at common power levels.*

II. *Many other fuse options available based on system attributes such as current, voltage, available fault current, surge withstand, and sensitivity of semiconductors.*

III. *For faster response, consider P6KE or a combination of a SIDACtor® and an MOV (P3500SCLRP + LA series).*

IV. *Rectifier diodes can potentially be substituted with active rectification through IGBT for improved efficiency.*

V. *Gate drivers may require an isolator. Contact factory for recommendations.*

Acronyms:

UPS: uninterruptible power supply
MOV: metal oxide varistor
TVS: transient voltage suppressor
SMD: surface mount device

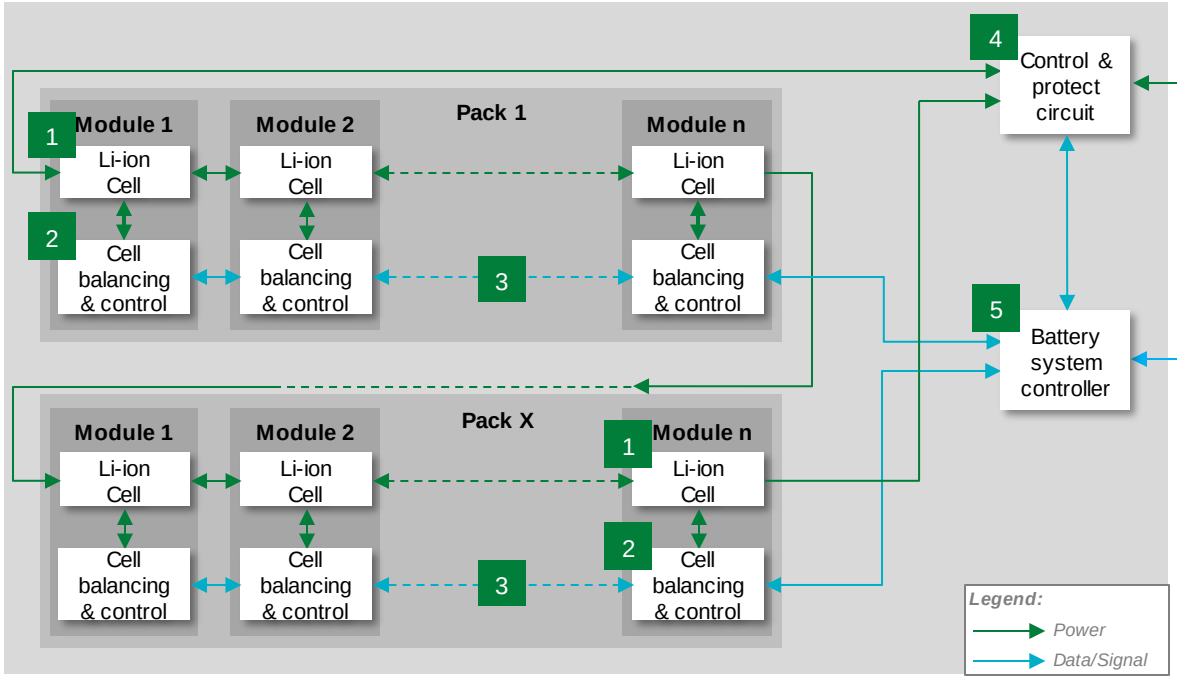
Click on the product series in the table below for more info

Features and benefits of Littelfuse solutions for UPS

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent fault protection	PSR, JLLS, 505	Fast opening to protect the power conversion semiconductor components	Compact design; 200 kA interrupting rating; available with PCB mounts
	MOV	Surge voltage protection	TMOV	Promotes robust operation	Thermally protected; high peak surge current rating up to 10 kA; wave solderable
2	Rectifier module	Rectify AC to DC	MDD, VUO, MDMA	High efficiency system operation with low heat generation	Improved temperature and power cycling; very low forward voltage drop; very low leakage current
	IGBT and MOSFET	Power factor correction	XPT and Ultra junction X-Class	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
	Gate driver	Controls the IGBT/MOSFET	IXD_6xx	Dual outputs provide space-efficient design; high immunity to latch-up; rise/fall times less than 10 ns	Tight tolerance; small form factor; fast thermal response
	Temperature sensor	Monitoring rectifier for optimal performance	USP10976	Enables robust system operation	Tight tolerance; wide range of temperature sensing
3	IGBT module	Invert DC to AC	MIXA, MIXG	Low power loss; high efficiency operation	Very low gate charge; low EMI, fast and soft reverse recovery - low operating forward voltage
	Gate driver	Controls the IGBT inverter	IXD_6xx	Dual outputs provide space efficient design; high immunity to latch-up; rise/fall times less than 10 ns	Tight tolerance, small form factor; fast thermal response
	Temperature sensor	Monitoring inverter for optimal performance	USP10976	Enables robust system operation	Tight tolerance; wide range of temperature sensing
4	Thyristor module	Switching power source	MCC, MCMA	Space saving; low thermal loss; high efficiency operation	Low forward voltage drop; leads suitable for PCB soldering; improved temperature and power cycling
5	See BESS block diagram (link to page)				

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

BESS array block diagram



	Technology	Product Series
1	SMD fuse	501A, 881
	TVS diode	TPSMC, SZ1SMC, SZ1.5SMC
	Temperature sensor	USP16673, RB
2	SMD or In-line fuse	438A, 441A, 521
	TVS diode	TPSMB, SZ1SMB, SZP6SMB
3	Diode array	AQ05C
	TVS diode	TPSMA6L, SZ1SMA
4	High-voltage fuse	PSR, PSX
	MOSFET	X3 Class
	Gate driver	IXD_6xxSI
5	Diode array	AQ24CAN
	SMD fuse	885
	TVS diode	TPSMB, TPSMC

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Acronyms:
BESS: battery energy storage system
MOV: metal oxide varistor
TVS: transient voltage suppressor
SMD: surface mount device

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

Potential Littelfuse products for BESS protection

	Technology	Function in application	Series	Benefits	Features
1	SMD fuse	Protects cells and downstream BMS components from high fault currents due to external shorts	501A, 881	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment	Fast response to fault current; surface mount device
	TVS diode	Transient voltage suppression	TPSMC, SZ1SMC, SZ1.5SMC	Excellent clamping capability; fast response time	Meets IEC standards for ESD protection and ISO for in-vehicle transient surges
	Temperature sensor	Monitoring the system for optimal charging conditions	USP16673, RB	Promotes robust operation; allows design flexibility	Tight tolerance; ultra-thin
2	SMD or In-line fuse	Protect cells and BMS components from overcurrent	438A, 441A, 521	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment	Fast response to fault current; surface mount device
	TVS diode	Transient voltage suppression	TPSMB, SZ1SMB, SZP6SMB	Excellent clamping capability; fast response time	Meets IEC standards for ESD protection and ISO for in-vehicle transient surges
3	TVS diode	Transient voltage suppression	AQ05C	Excellent clamping capability; fast response time	Meets IEC standards for ESD protection and ISO for in-vehicle transient surges
	Diode array	Protects sensitive electronic ICs from ESD, EFT, and voltage transient	TPSMA6L, SZ1SMA	Ensures reliability of the equipment without performance degradation	Meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current and clamping voltage
4	High-voltage fuse	Short-circuit and overload current protection	PSR, PSX	Lower I^2t performance allows for quick response to protect devices from higher heat energy	High DC voltage rating up to 1500 VDC extremely fast-acting; compact form-factor
	MOSFET	Output power control switch	X3 Class	Low power loss; design flexibility; high efficiency	Low $R_{DS(ON)}$; fast soft recovery body; multiple mounting packages
	Gate driver	Controls the switching MOSFETs	IXD_6xxSI	Dual outputs provide space-efficient design; high immunity to latch-up; rise/fall times less than 10 ns	Tight tolerance; small form factor; fast thermal response
5	Diode array	Protect CAN bus from ESD, EFT, and voltage transient	AQ24CAN	Ensures reliability of the equipment without performance degradation	Meets ESD protection levels specified under IEC 61000-4-2; ISO10605; low leakage current and clamping voltage
	SMD fuse	Protects cells and BMS components from overcurrent	885	High-voltage SMD form-factor allows for compact design; ceramic body ensures compatibility with high-temperature environment	Fast response to fault current; surface mount device
	TVS diode	Transient voltage suppression	TPSMB, TPSMC	Excellent clamping capability; fast response time	Meets IEC standards for ESD protection and ISO for in-vehicle transient surges

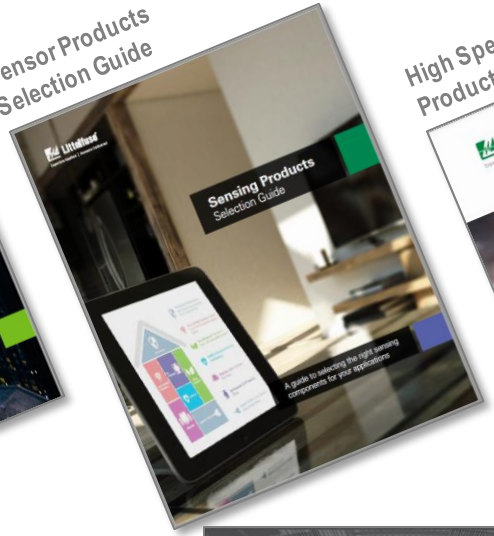
Select standards for UPS system and ESS

Standard	Title	General scope	Region
IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	This part of IEC 60204 applies to electrical, electronic and programmable electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a coordinated manner	Global
IEC 62061	Safety of machinery: Functional safety of electrical, electronic and programmable electronic control systems	Provides requirements that are applicable to the system level design of all types of machinery safety-related electrical control systems and also for the design of non-complex subsystems or devices	Global
UL 508	Standard for Industrial Control Equipment	These requirements cover industrial control devices, and devices accessory thereto, for starting, stopping, regulating, controlling, or protecting electric motors as well as industrial control devices or systems that store or process information and are provided with an output motor control function(s)	North America
UL 1778	Uninterruptible Power Systems	These requirements cover uninterruptible power supplies (UPS) rated 600 volts or less ac or dc that are intended for installation in accordance with the National Electrical Code, NFPA 70	North America
IEC 62040	Uninterruptible power systems (UPS) - Part 1: Safety requirements	This standard applies to movable, stationary, fixed or built-in UPS for use in low-voltage distribution systems, that deliver fixed frequency AC output voltage with port voltages not exceeding 1 000 V AC or 1 500 V DC and that include an energy storage device	Global
UL 9540A	Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems	This document evaluates the fire characteristics of a battery energy storage system that undergoes thermal runaway	North America

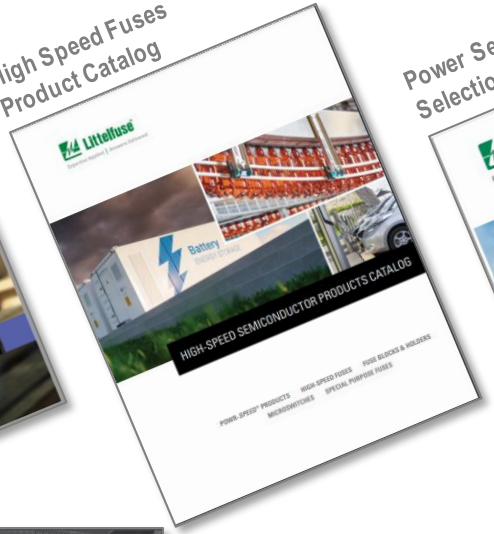
Additional information can be found on Littelfuse.com

Circuit Protection Selection Guide

Sensor Products Selection Guide

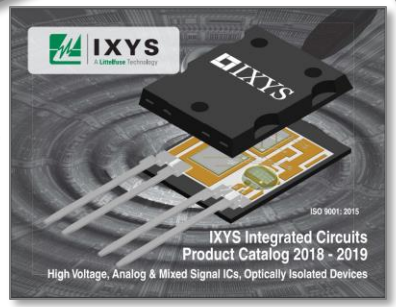


High Speed Fuses Product Catalog



Power Semiconductor Selection Guide

Integrated Circuits Product Catalog



Click on images to open the catalog

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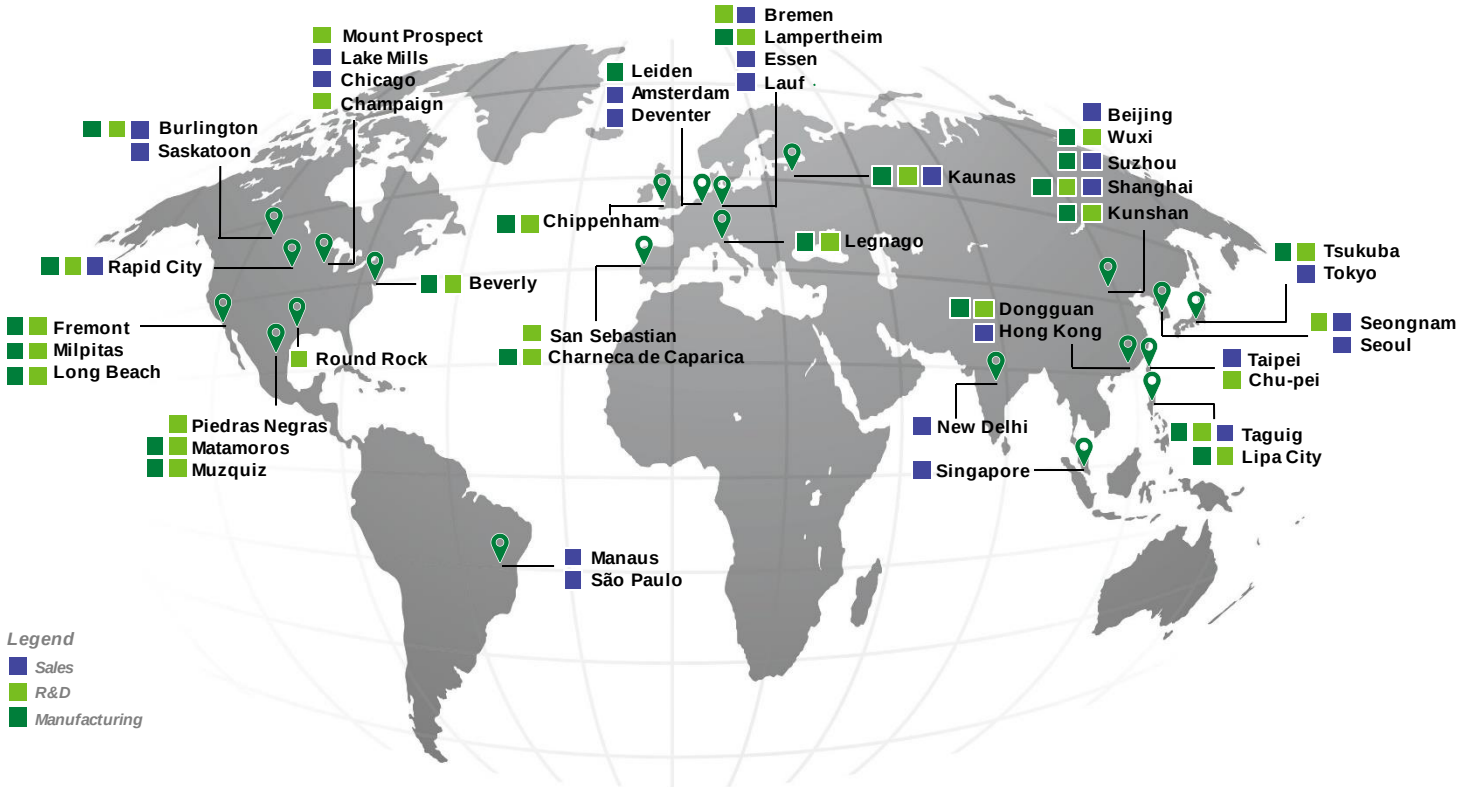
Local resources supporting our global customers



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Partner for tomorrow's electronic systems

Broad product portfolio

A global leader with a broad product portfolio, covering every aspect of protection, sensing, and control

Application expertise

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

Global customer service

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

Compliance & regulatory expertise

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

Testing capabilities

We help customers get products to the market faster and offer certification testing to global regulatory standards

Global manufacturing

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

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