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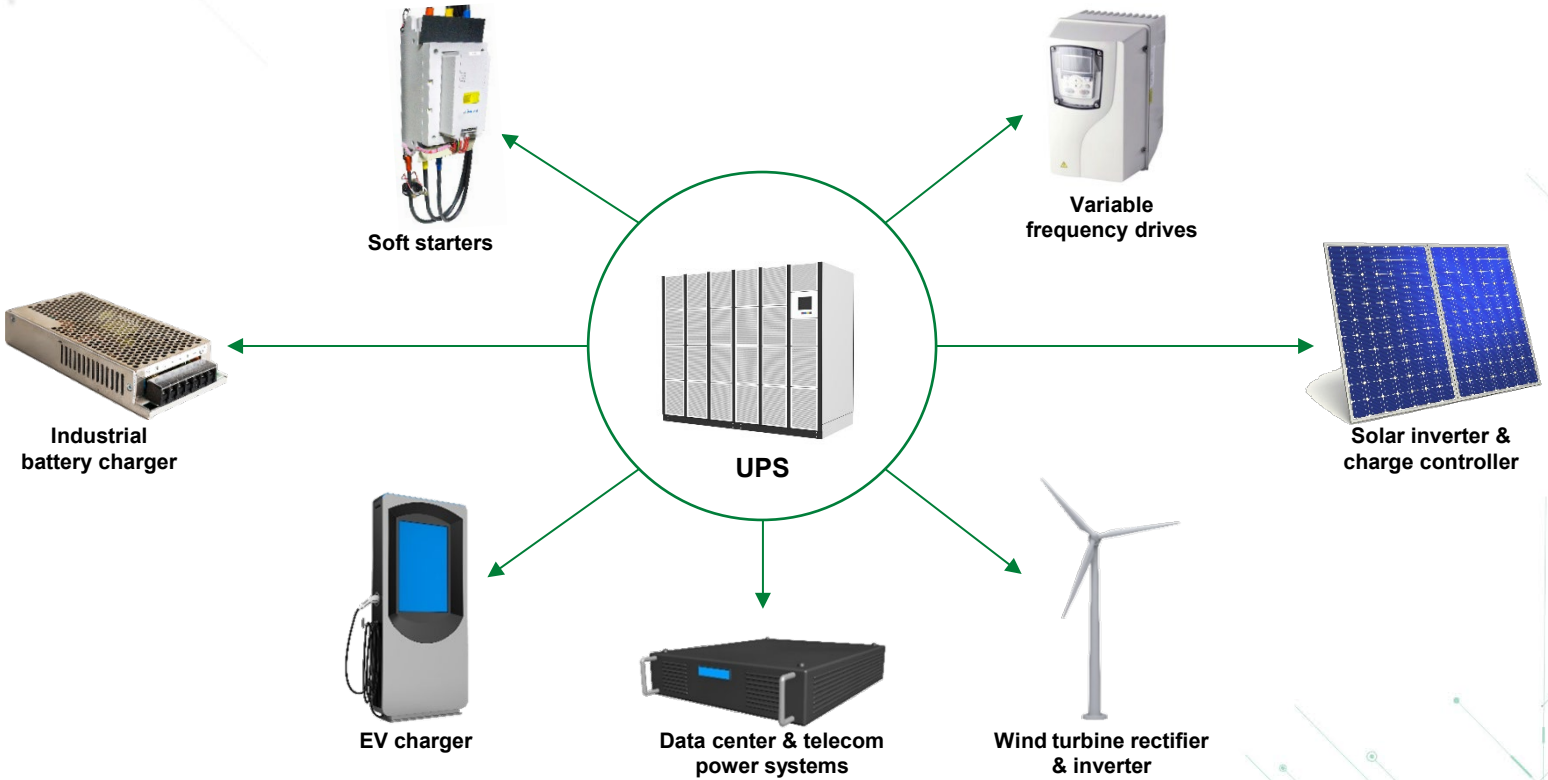
Uninterruptible Power Supply (UPS) & Battery Energy Storage System (BESS)

- Datacenter Infrastructure
- Industrial
- Renewable Energy

REV1025

UPS shares similar architecture with multiple industrial and renewable energy systems



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

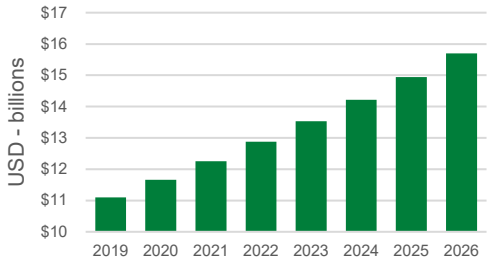
Need for reliable electrical energy is driving increased sales to data centers, medical, industrial, and consumer markets

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

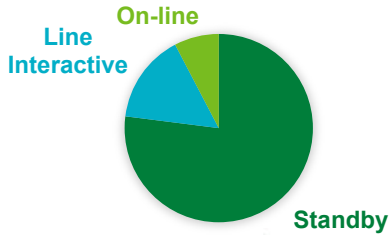
Lithium-ion batteries are the preferred energy storage system for UPS due to high energy density and long shelf life

Global UPS market sales



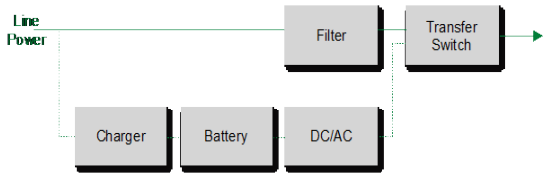
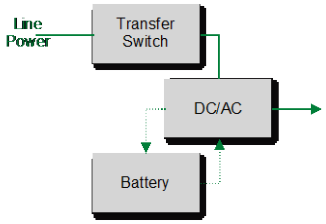
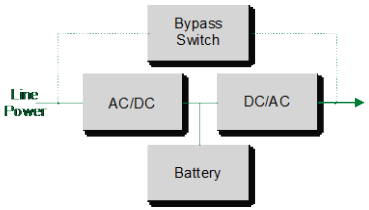
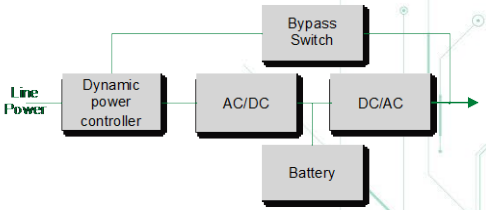
Source: Global UPS Market (360ResearchReports, 2020), marking estimates

Data center UPS by type



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

Ideal UPS type depends on system priority of key characteristics

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
Typical UPS size	< 0.5 kVA	0.5 to 5 kVA	> 5 kVA	> 5 kVA

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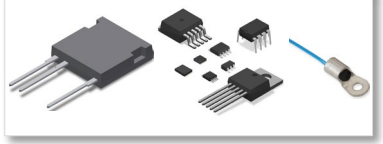
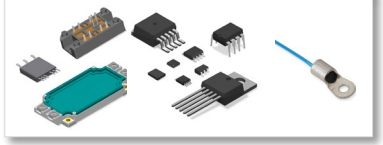
Littelfuse solutions for UPS

1 AC Input
Fuse, MOV

2 AC-DC Converter
IGBT, MOSFET, Rectifier Module,
Gate Driver, Temperature Sensor



3 DC–AC Converter
IGBT Module, Gate Driver,
Temperature Sensor



4 Bypass Switch
Thyristor Module

5 BESS
Fuse, TVS Diode, TVS Diode Array,
Arc Flash Relay, SPD, Ground Fault Relay

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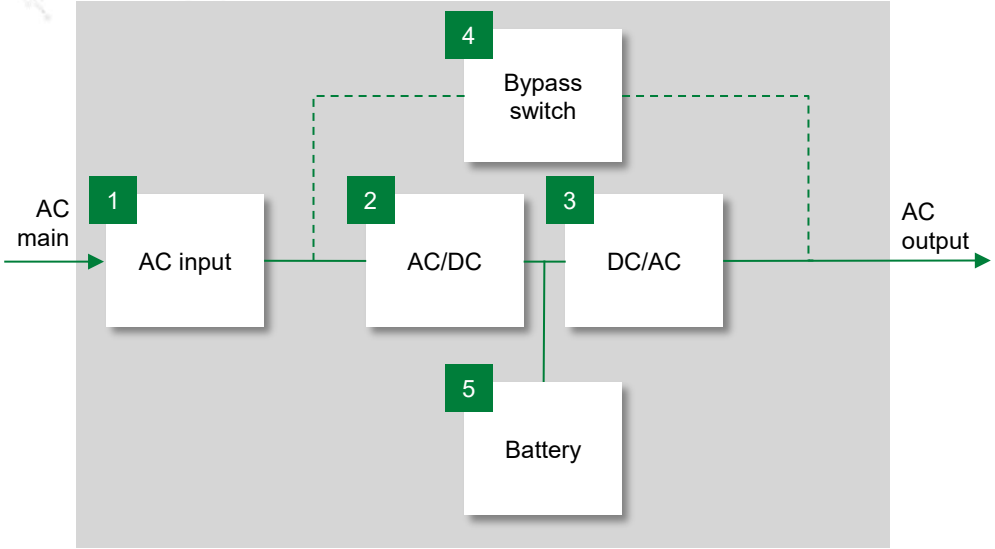
Click on the product series in the table below for more info

UPS block diagram



	Technology	Product series
1	Fuse [II]	PSR, JLLS, 505, 607
	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 functionality.

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

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Acronyms:

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

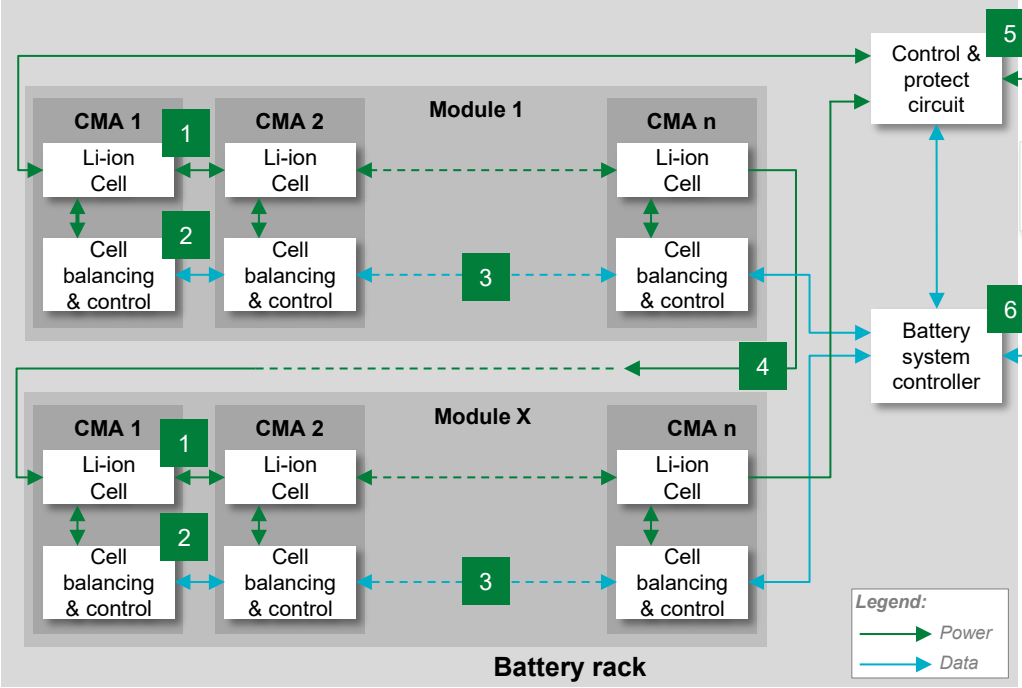
Click on the product series in the table below for more info

Features and benefits of Littelfuse solutions for UPS

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Overcurrent fault protection	PSR, JLLS, 505, 607	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 architecture for residential* and commercial



	Technology	Product Series
1	Fuse	501A, 881
	TVS Diode	TPSMC, SZ1SMC, SZ1.5SMC
	Temperature Sensor	USP16673, RB
2	SMD or In-line fuse	438A, 441A, 521, 483A
	TVS Diode	TPSMB, SZ1SMB, SZP6SMB
3	TVS Diode Array	AQ05C
	TVS Diode	TPSMA6L, SZ1SMA
4	Fuse	TLS, JLLN, CNN
5	High-speed Fuse	PSR, PSX, ESR
	MOSFET	X3 Class
	Gate Driver	IXD_6xx
	HVDC Contractor Relays	DCNxx
	Arc Flash Relays***	AF0100
	DC Disconnect Switch	LS7xx, LS6xx
6	TVS Diode Array	AQ24CAN
	Fuse	885
	TVS diode	TPSMB, TPSMC

** Residential BESS has similar architecture, but the # of packs will be limited depending on the kVA ratings*
*** Large industrial or utility scale BESS system, multiple battery racks are stacked together through a combiner box*
**** Arc Flash Relays are used in large commercial and higher applications*

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Acronyms:
CMA: Cell Module Assembly
BESS: Battery Energy Storage System
Li-ion: Lithium- ion

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

Potential Littelfuse products for BESS

	Technology	Function in application	Series	Benefits	Features
1	Fuse	Protects cells/BMS components from high-fault currents due to external shorts	501A, 881	Excellent temperature stability and performance reliability; compact design	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
	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	Front end protection due to shorting of power and sense line	438A, 441A, 521, 483A	Excellent temperature stability and performance reliability; compact design	Fast response to fault current; surface mount device
	TVS Diode	Protects from transients induced due to assembly and maintenance of batteries	TPSMB, SZ1SMB, SZP6SMB	Excellent clamping capability; fast response time	Meets IEC standards for ESD protection
3	TVS Diode Array	Transient voltage suppression	AQ05C	Excellent clamping capability; fast response time	Meets IEC standards for ESD protection
	TVS Diode	Protects sensitive electronic ICs from ESD, EFT, and voltage transient	TPSMA6L, SZ1SMA	Ensures reliability of the equipment without performance degradation	Meets IEC standards for ESD protection; low leakage current and clamping voltage
4	Fuse	Protects from short-circuits and overloads between two packs	TLS, JLLN, CNN	Reduces damage to equipment caused by short circuit currents; compact design	Extremely current-limiting; small footprint; 200 kA interrupting rating

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

Potential Littelfuse products for BESS

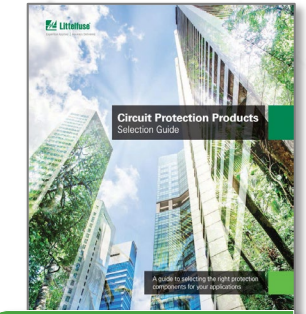
	Technology	Function in application	Series	Benefits	Features
5	High-speed Fuse	Short-circuit and overload protection resulting due to high-power system	PSR, PSX, ESR	Lower I^2t performance allows for quick response to protect devices from higher heat energy	High DC voltage rating up to 1500 VDC; extremely 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
	Gate Driver	Controls the switching MOSFETs	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
	HVDC Contractor Relays	The main contactors connect and disconnect the battery system	DCNxx	Allows a low voltage signal to switch the contacts for a high voltage signal	Wide range of capabilities–can switch from 10's of amps to 1000's of amps, and 10's of volts to 1000's of volts
	Arc Flash Relays	Reduces damage by detecting the light from an arc flash and rapidly tripping	AF0100	Fits into a wide range of arc-flash applications; monitor two arc-flash sensors; compact design	Input voltage: 100-240 VAC/VDC, 24-48 VDC, dual sensor input; surface mounting DIN RAIL
	DC Disconnect Switch	Help quickly break or resume the flow of current safely to prevent shock hazards when trying to isolate circuits or repair systems	LS7xx, LS6xx	energy-efficient, compact size; decreases installation and maintenance time; increase product reliability and longevity	High-level disconnection insulation; self-cleaning blade contacts; meets UL 98B, UL 94, and IEC 60947-3 standards
6	TVS Diode Array	Protects from ESD, EFT, and voltage transient	AQ24CAN	Ensures reliability of the equipment without performance degradation	Meets IEC standards for ESD protection; low leakage current and clamping voltage
	Fuse	Protects cells and BMS components from overcurrent	885	Compact design; 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

Select standards for UPS system and BESS

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 1000 V AC or 1500 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

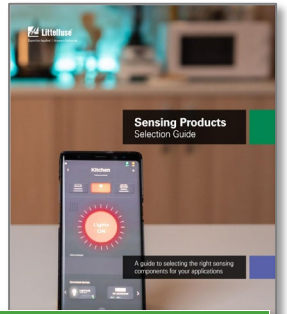
Additional information can be found at Littelfuse.com

Explore the world of Littelfuse products and applications with ecatalogs (ecatalogs.littelfuse.com)



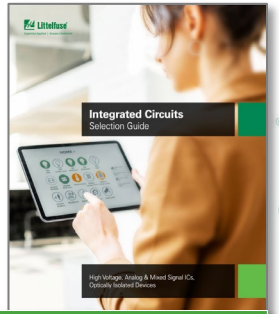
Circuit Protection Products Selection Guide

Power Semiconductor & IC Selection Guide



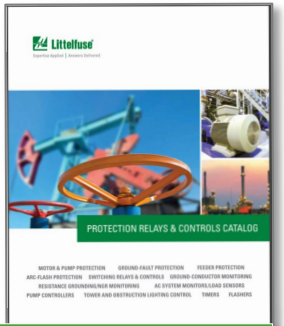
Sensor Products Selection Guide

Industrial Fuses Catalog



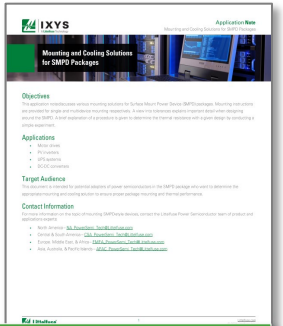
Integrated Circuits Selection Guide

Click the images for more information



Power Relay & Control Catalog

VFDs Ground-Fault Protection White Paper



SMPD Packages Application Note

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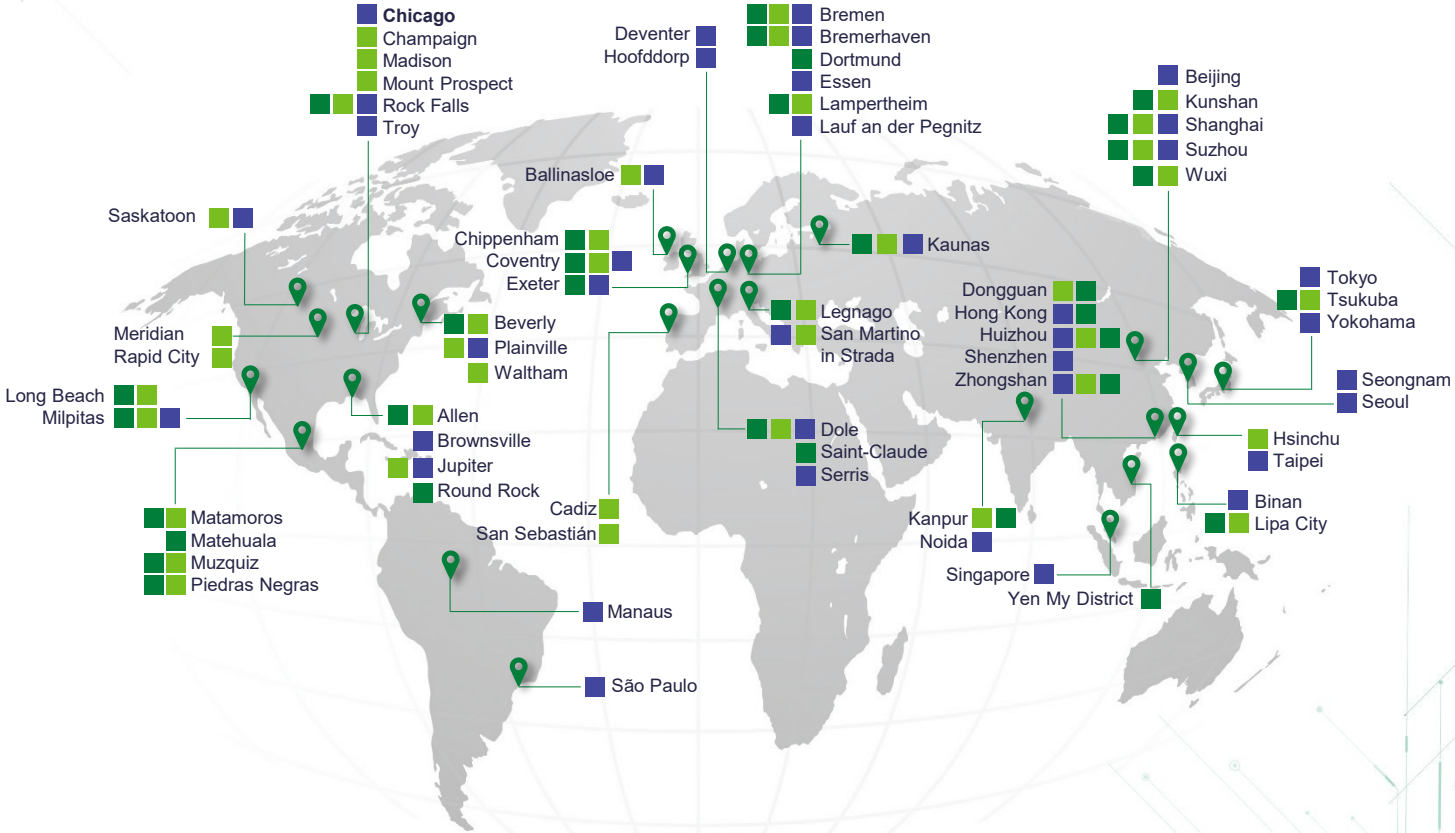
Local resources supporting our global customers



Legend

- ***Sales***
- ***R&D***
- ***Manufacturing***

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Partner for tomorrow’s electronic systems

Broad Product Portfolio

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 meet 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 the requirements set by global regulatory authorities

Global Customer Service

Our global customer service team is here for 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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