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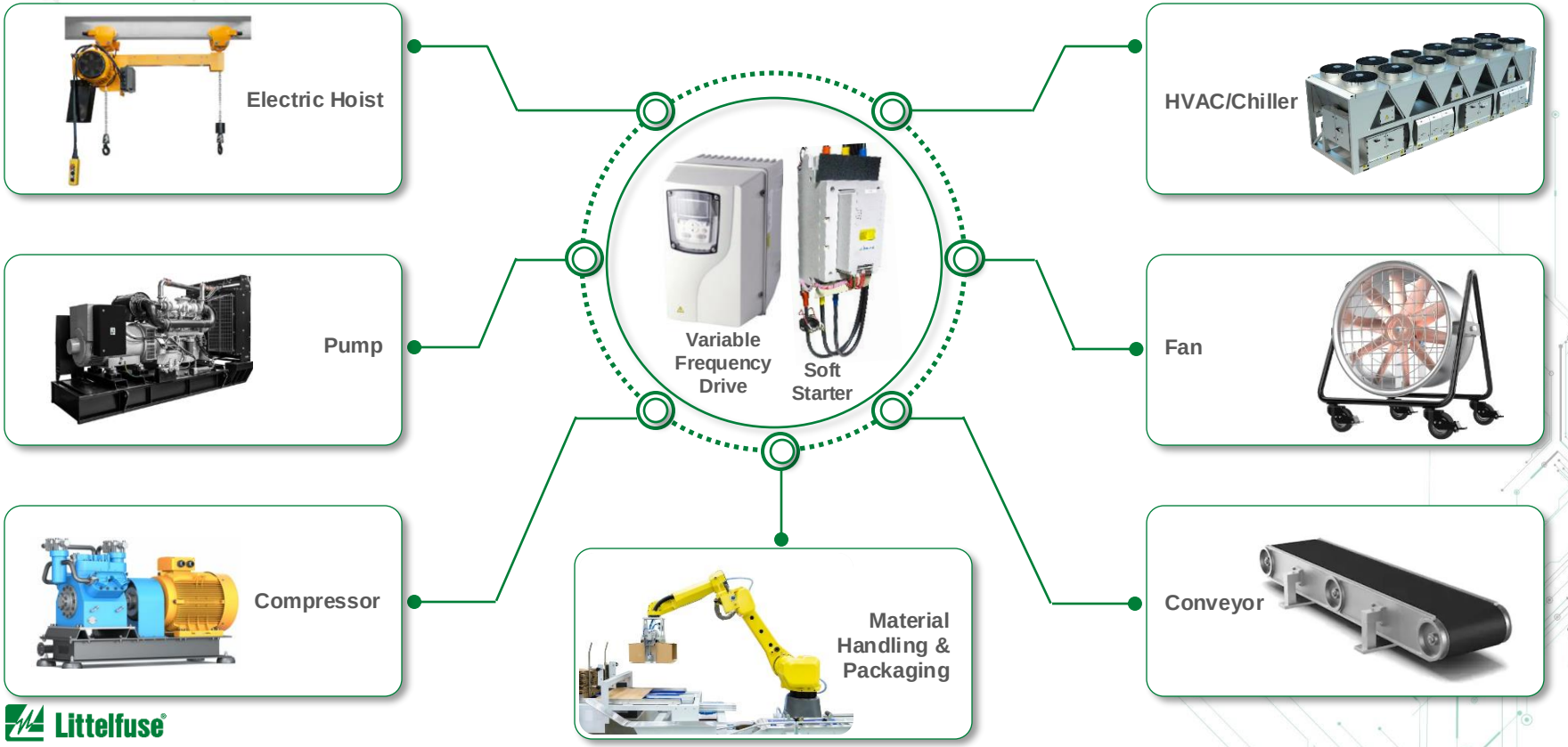
Low-Voltage Industrial Motor Drives and Soft Starters

General Industrial & Electrical Equipment

REV1024

Variable Frequency Drives and Soft Starters in industrial applications



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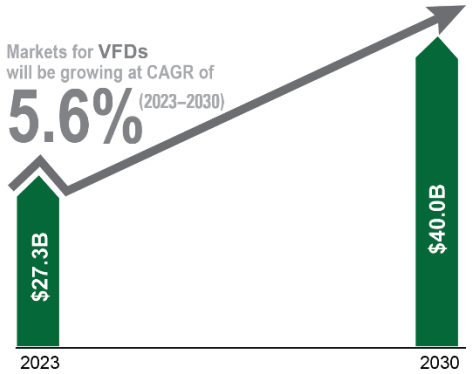
Variable Frequency Drives and Soft Starters application usages

Variable Frequency Drive (VFD)	Soft Starter
	
▪ Controls AC motor speed and torque by varying motor input voltage and frequency.	▪ Offers smooth start and stop operation for a motor.
▪ Can be programmed to vary the speed of the motor based on factors such as flow, pressure, etc.	▪ In some Soft Starters the SCR's get bypassed by a mechanical contactor as motor reaches its full speed.
▪ Control over motor speed and torque independently.	▪ Initial cost is lower than a variable frequency drive.
▪ Performance often more important than cost and size.	▪ Effectively reduces inrush current during motor start.
▪ Energy saving is a principal advantage.	▪ No harmonics are generated after start-up.
▪ Examples of applications: elevators, escalators, conveyors, crushers, and mixers.	▪ Examples of applications: pumps, fans, and other constant speed applications.

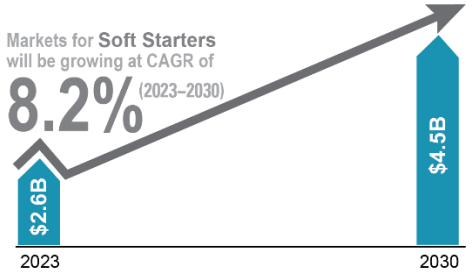
Variable Frequency Drives and Soft Starters market overview

Market Trends
Variable Frequency Drive (VFD)
– The global VFD market is projected to grow @ 5.6% CAGR between 2023 and 2030
– Market is expected to reach $40B by 2030
– Low-power range (6–40 kW) type dominated the power range segment in terms of revenue share
– A key factor driving the growth is the need for higher energy efficiency
– Energy savings estimated to be over 20%
– Integrating IoT with VFDs for remote monitoring and controlling the devices
Soft starter
– The global soft starter market is expected to grow at 8.2% CAGR between 2023 and 2030
– Market is expected to reach $4.5B by 2030
– Increased use of industrial pumps and fans are key driving factors

VFDs market will be growing at a CAGR 5.6% (2023-'30)



Soft starters market will be growing at a CAGR 8.2% (2023-'30)



Sources: *Littelfuse Estimates, GrandViewResearch, CoherentMarketInsights*

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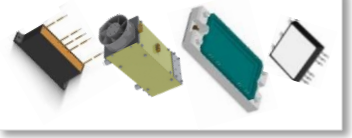
Protection, power semiconductor, and switch solutions used in VFD systems

1 AC input protection
AC Fuse, Fuseholder, MOV

2 Input rectifier and brake
Rectifier Diode, Rectifier Stack, Brake Chopper Module or SMPD



3 Inverter
Fuse, IGBT Module or SMPD, IGBT Discrete, NTC, TVS Diode

4 Auxiliary power supply
Si/SiC MOSFET, HV IGBT, Gate Driver, TVS Diode

5 Switches
DIP, Rotary, Slide, Tactile

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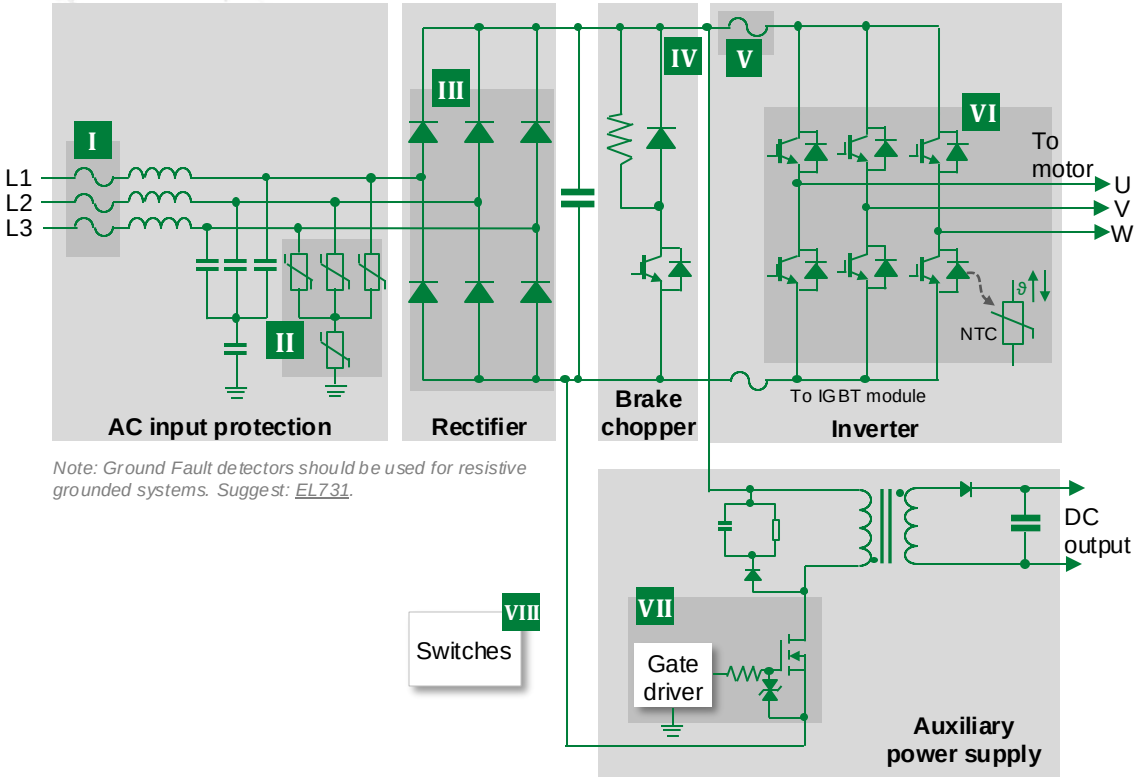
Protection and control solutions for VFDs and auxiliary power supplies

Click the product series in the table below for more info



Note: Ground Fault detectors should be used for resistive grounded systems. Suggest: EL731.

	Technology	Product Series
I	Fuse	JLS, JLLS, JLLN, LDC, 606, 504, 505, 607
	Fuseholder	LFT, LFJ
II	MOV	TMOV, UltraMOV
III	Rectifier Diode	AC Bridges, Diode Modules, Discrete Devices
	Rectifier Stack	High Power Stacks
IV	E2/E3-Module ***OR*** SMPD	Boost Chopper IGBT Modules ***OR*** IXA20RGxx, IXA30RGxx, IXA40RGxx
V	Semiconductor Fuse	PSR, L50QS, L70QS, L60QS
VI	IGBT Module ***OR*** SMPD	XPT IGBT Modules, Six Pack IGBT Modules, CBI Modules ***OR*** IXA20PGxx, IXA30PGxx, IXA40PGxx
	IGBT Discrete	XPT IGBT Discrete
	NTC	USUR1000, SM
	TVS Diode	SMBJ, SMF4L, 1.5SMC
VII	SiC MOSFET ***OR*** Si HV MOSFET ***OR*** HV IGBT	SiC MOSFET ***OR*** Si HV MOSFET ***OR*** HV IGBT
	Gate Driver	IXD_609, IX4310T, IX4352NE
	TVS Diode	SMF, SMFA
VIII	Switch	TDA, RTE, RTA, AYZ, KSC2, KSC3, KSC4

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Click the product series in the table below for more info

Features and benefits of Littelfuse components

	Technology	Function in Application	Product series	Benefits	Features
I	Fuses	Protects the equipment from overload and short-circuit	JLS, JLLS, JLLN, LDC, 606, 504, 505, 607	Reduces damage to equipment caused by heating and magnetic effects of short circuit currents; compact design	Small footprint; 200 kA interrupting rating; smallest available package
	Fuseholder	Secures mounting of fuses; allows easy fuse replacement; available with optional indication for determine fuse operation status	LFT, LFJ	Modular design with reinforced clips; accommodates HEX and slot screw terminations; DIN rail-mountable	Space saving design, low resistance connection; ease of maintenance with enhanced safety; UL listed
II	MOV	Protects against damage due to lightning-induced voltage surges	TMOV, UltraMOV	Integrated thermal disconnect enhances safety by disconnecting during MOV EOL caused by frequently recurring abnormal overvoltage from miswiring or loss of neutral connection	UL-recognized Type 4 surge protection devices; integrated thermal disconnect
III	Rectifier Diode	Converts AC line voltage to DC	AC Bridges, Diode Modules, Discrete Devices	Small footprint; multiple package options such as high-voltage, isolated, and standard packages	Planar passivated chips; very low leakage current and forward voltage drop; improved thermal behavior; high commutation robustness
	Rectifier Stack		High Power Stacks	Over 50 years of experience, our stack products cover a broad range of application; global manufacturing and design resources help reduce time to market, free up resources and control costs	Simulation resources, qualified supplier base and a dedicated engineering team focusing on mechanical, electrical and thermal design and management
IV	E2/E3-Module ***OR*** SMPD IGBT	Limits the DC bus voltage by switching the braking energy to a resistor	Boost Chopper IGBT Modules	Easy paralleling	Positive temperature coefficient; sonic diode for fast and soft recovery
			IXA20RGxx, IXA30RGxx, IXA40RGxx	Easy paralleling; compact design; superior thermal behavior	Positive temperature coefficient; integrated $V_{CE(SAT)}$ detection diode; isolated back surface
V	Semiconductor Fuse	Protects the application from catastrophic failures caused by short circuit event	PSR, L50QS, L70QS, L60QS	Best-in-class DC performance; reduces peak let-through current and energy protects the inverter from catastrophic events; flexible mounting offering quick and easy field replacement	Extremely current limiting; universal blade mounting

Click the product series in the table below for more info

Features and benefits of Littelfuse components

	Technology	Function in Application	Product series	Benefits	Features
VI	IGBT Module ***OR*** SMPD IGBT	Power inverter	XPT IGBT Modules, Six Pack IGBT Modules, CBI Modules	Short circuit rated for 10 µsec; low gate charge; low EMI and competitive low $V_{CE(SAT)}$	Rugged XPT design with thin wafer technology
			IXA20PGxx, IXA30PGxx, IXA40PGxx	Easy paralleling; compact design; superior thermal behavior	Positive temperature coefficient; integrated $V_{CE(SAT)}$ detection diode; isolated back surface
	IGBT Discrete		XPT IGBT Discrete	Reduced effort in thermal design; simplified paralleling of devices; high power density; wide range of package options	Low thermal resistance, R_{thJC}; positive thermal coefficient of $V_{CE(SAT)}$; low gate charge, Q_G; high current carrying capability; isolated and non-isolated package option
	NTC	Indirectly measures the temperature of the power inverter semiconductor switches	USUR1000, SM	Rapid thermal response and long-time reliability	USUR is a UL-recognized NTC sensor with ring lug mounting; SM NTCs are in a hermetically sealed MELF package suitable for operation at up to 220 °C
	TVS Diode	Protects semiconductor switches from voltage transient	SMBJ, SMF4L, 1.5SMC	Improves system reliability by clamping the voltage at safe levels during transients	600 W peak pulse power capability; excellent clamping capability; small footprint
VII	SiC MOSFET ***OR*** Si HV MOSFET ***OR*** HV IGBT	Semiconductor switch	SiC MOSFET ***OR*** Si HV MOSFET	Higher switching frequency; higher efficiency; increased robustness; SiC technology allows for smaller die size per voltage/current rating	Optimized for high-frequency applications; extremely low gate charge and output capacitance; ultra-low on-resistance
			HV IGBT	Eliminates the needs of multiple series-connected devices	High blocking voltage
	Gate Driver	Drives SiC MOSFETs and discrete IGBTs	IXD_609	Quick turn-on/turn-off of power SiC MOSFET and IGBT	Separate 9 A peak source and sink outputs
			IX4310T	Versatile device	Output Capable of sourcing and sinking 2 A; CMOS and TTL compatible Inputs
			IX4352NE	Eliminates the need for separate negative supply; quick turn-on and turn-off of power SiC MOSFET and IGBT	Separate 9 A peak source and sink outputs; internal negative charge pump regulator for selectable negative gate drive bias
	TVS Diode	Protects semiconductor switches from voltage transient	SMF, SMFA	Improves system reliability by clamping the voltage at safe levels during transients	200 W peak pulse power capability; excellent clamping capability; low profile
VIII	Switch	Various functions (drive configuration, on/off, test button, parameter setting, mode selection, input/output selection, etc.)	TDA, RTE, RTA, AYZ, KSC2, KSC3, KSC4	High reliability	IP67; long electrical life

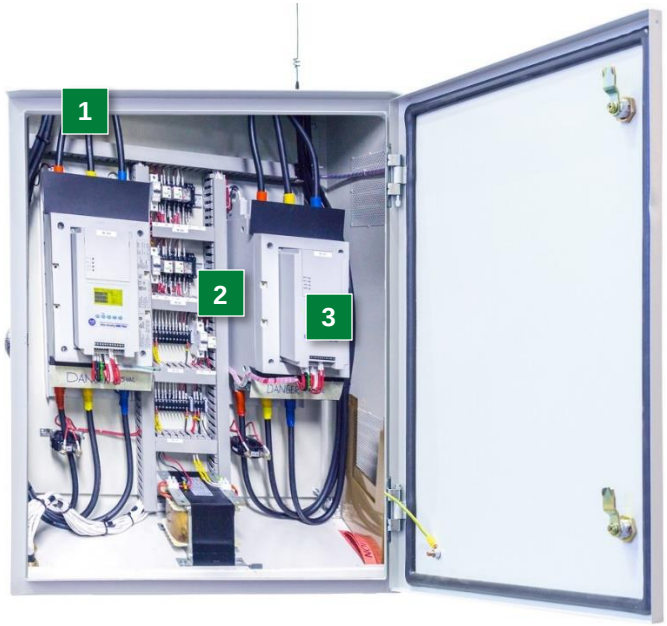
Protection and control solutions for soft starters

1

AC input protection
AC Fuse, Fuseholder, MOV

2

Phase control
Dual SCR Module, Discrete SCR, Stack, NTC



3

Switches
DIP, Rotary

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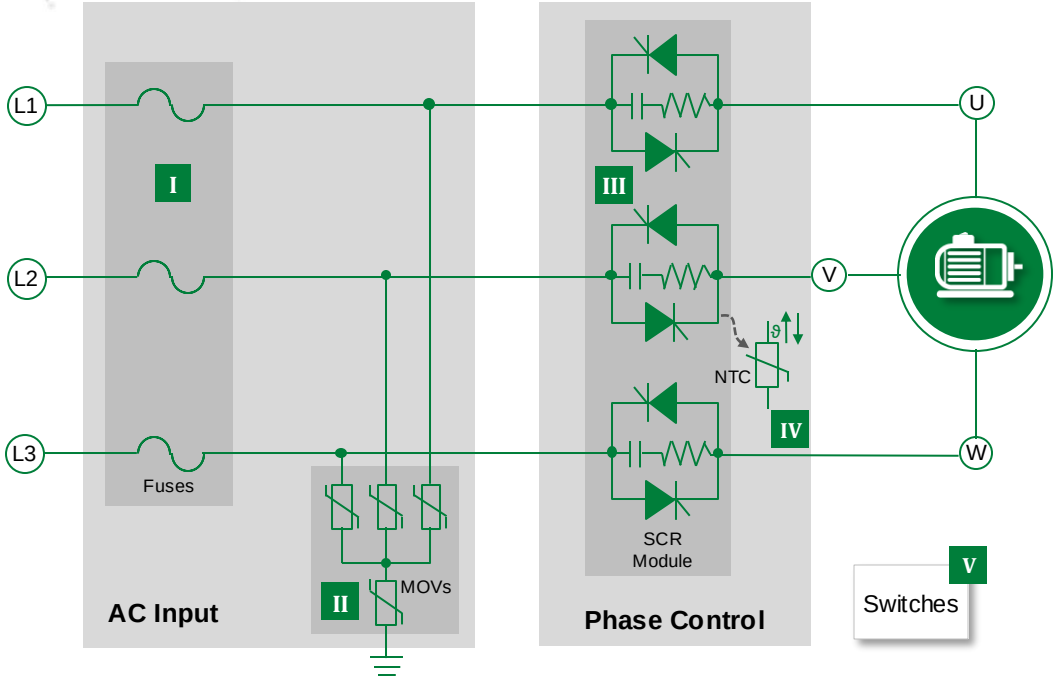
Protection and control components for soft starter topology

Click the product series in the table below for more info



	Technology	Product series
I	AC Fuse	L50QS, L70QS, JLS, JLLS
	Fuseholder	LSCR, LFT, LFJ
II	MOV	TMOV
III	Dual SCR Module	MCC
	Discrete SCR	SCR Thyristors, B Series, N Series
	Stack	High Power Stacks
IV	NTC	USUR1000, SM
V	Switch	RTE, RTA

Click the product series in the table below for more info

Benefits of Littelfuse components in soft starters

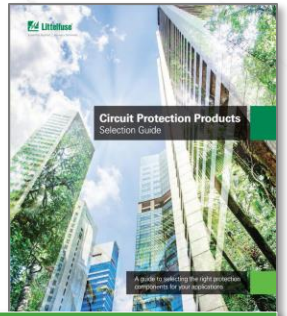
	Technology	Function in application	Product series	Benefits	Features
I	AC Fuse	Designed specifically for supplementary protection of semiconducting devices SCRs, Diodes, IGBTs, and so on	L50QS, L70QS, JLS, JLLS	Reliable interruption of all over-currents; less heating and power consumption	Extremely current limiting; less energy wasted during operations; excellent cycling capabilities; UL recognized; RoHS and Reach compliant
	Fuseholder	Secure mounting of fuses; allows easy fuse replacement; available with optional indication for determine fuse operation status	LSCR, LFT, LFJ	Space saving design, low resistance connection; ease of maintenance with enhanced safety; UL certified	Modular design with reinforced clips; supplied with necessary hardware; DIN rail-mountable
II	MOV	Protects against damage due to lightning-induced surges or harmonic voltage disruptions from the power line	TMOV	Integrated thermal disconnect enhances safety by disconnecting during MOV EOL caused by continuous abnormal overvoltage from miss-wiring or loss of neutral	TMOVs are UL recognized Type 4 surge protection devices; integrated thermal disconnect reduces risk of MOV overheating and catastrophic failures
III	Dual SCR Module	Controls the application of supply voltage to the motor	MCC	Multiple solutions in size, interconnection and power density. Isolated devices with optimized thermal performance; excellent voltage and current long-term stability	Wide range of recognized industry standard packages with DCB-base and Copper-base housings; planar passivated thyristor
	Discrete SCR		SCR Thyristors	The ease of replacement, coupled with a flexible design and fewer points of failure; enhances system-level reliability and robustness	In standard Through-Hole Technology (THT) and Surface-Mount Device (SMD) packages exhibit proven thermal performance and efficient heat dissipation
			B Series	Excellent choice for new projects where highest levels of performance are required whilst keeping costs down	Delivers optimized manufacturing cycle times with high levels of performance are required from 470 A up to 6900 A
			N Series	One of the most comprehensive ranges of standard phase control thyristors in the industry	Optimized to give low conduction losses and the highest levels of performance. From 470 A up to 8800 A
	Stack		High Power Stacks	Covers a broad range of application; global manufacturing and design resources help reduce time to market, free up resources and control costs	Simulation resources, qualified supplier base and a dedicated engineering team focusing on mechanical, electrical and thermal design and management
IV	NTC	Indirectly measures the temperature of the semiconductor switches	USUR1000, SM	Rapid thermal response and long-time reliability	USUR is UL recognized NTC sensor with ring lug mounting; SM NTC is in hermetically sealed MELF package suitable for operation up to 220 °C
V	Switch	Various functions (motor current setting, mode selection, etc.)	RTE, RTA	Miniature size with robust metal cover in black or silver nickel finish (applicable to the RTE series); large choice of coding; vertical or reverse versions	**RTE:** IP54; long electrical life (20,000 cycles); operation temperature -25 ºC to +85 ºC. **RTA:** PCB or hand soldering; electrical life: 10,000 cycles

Safety standards for machinery VFDs and soft starters

Standard	Title	General scope	Region
IEC 61800-5-2	Adjustable speed electrical power drive systems–Part 5-2: Safety requirements–Functional	IEC 61800-5-2 specifies requirements and makes recommendations for the design and development, integration, and validation of safety-related power drive systems (PDS(SR)) in terms of their functional safety considerations.	Global
IEC 60204-1	Safety of machinery–Electrical equipment of machines–Part 1: General requirements	IEC 60204-1 covers both electrical safety and functional safety, and in respect of the latter, it specifies requirements for electrical control devices, circuits, and functions.	Global
IEC 62061	Safety of machinery–Functional safety of safety-related electrical, electronic and programmable electronic control systems	IEC 62061 specifies requirements and makes recommendations for the design, integration, and validation of safety-related electrical, electronic, and programmable electronic control systems for machines.	Global
ISO 13849-1	Safety of machinery–Safety-related parts of control systems–Part 1: General principles for design	ISO 13849-1 provides safety requirements and guidance on the principles for the design and integration of safety-related parts of control systems, including the design of software.	Global
IEC 60947-4-2	Low-voltage switchgear and control gear–Part 4-2: Contactors and motor-starters–AC semiconductor motor controllers and starters	IEC 60947-4-2:2011 applies to AC semiconductor motor controllers and starters, which may include a series mechanical switching device, intended to be connected to circuits, the rated voltage of which does not exceed 1000 VAC.	Global
UL508/CSA C22.2 No. 14	Standard for Industrial Control Equipment	UL508/CSA C22.2 No. 14 covers industrial control devices, and devices accessory thereto, for starting, stopping, regulating, controlling, or protecting electric motors, the rated voltage of which does not exceed 1500 VAC.	North America
GB14048.6	Low-voltage switchgear and control gear–Part 4-2: Contactors and motor-starters. AC semiconductor motor controllers and starters (including soft starter)	The Chinese GB14048.6-2008 standard is based on the IEC standard IEC 60947-4-2.	China

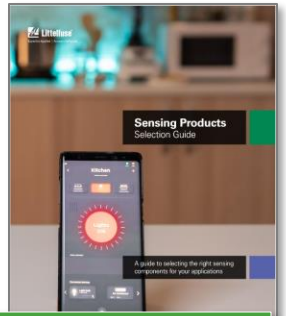
Additional information can be found at Littelfuse.com

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



Circuit Protection Products Selection Guide

Power Semiconductor & IC Selection Guide

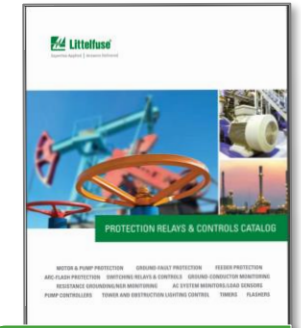


Sensor Products Selection Guide

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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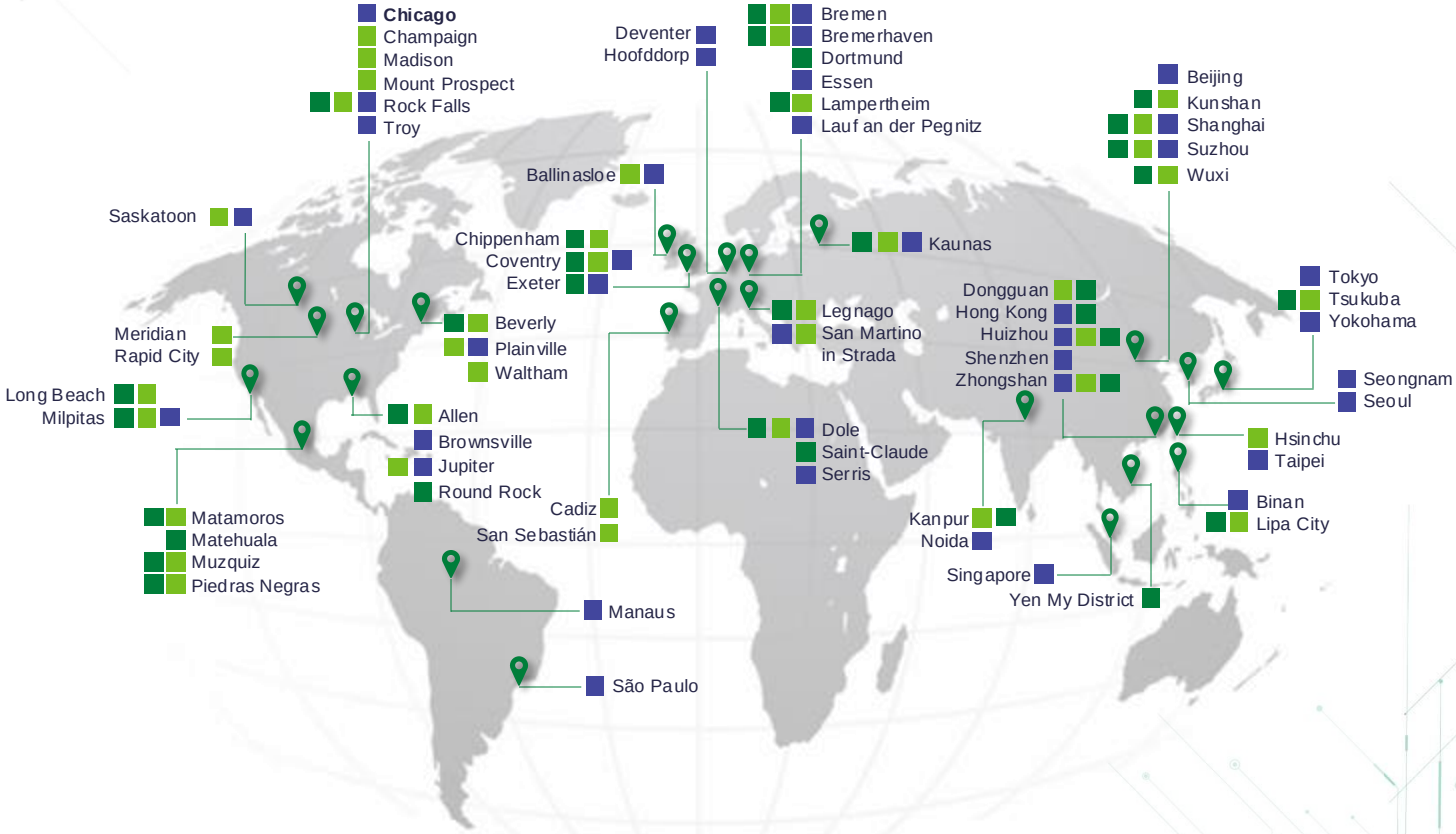
Local resources supporting our global customers



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