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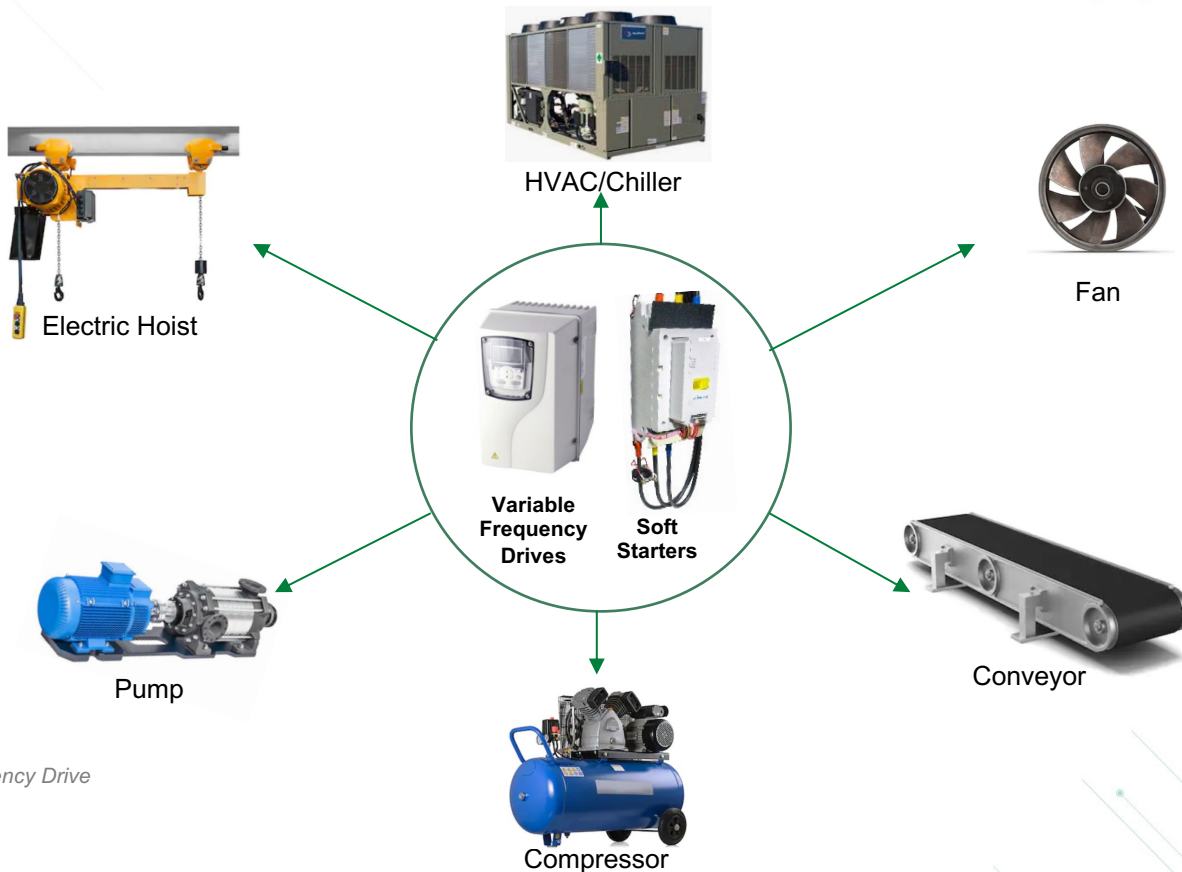
Low-Voltage Industrial Motor Drives and Soft Starters



Industrial

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VFDs* and Soft Starters in industrial applications: help improve motor life and energy efficiency



* VFD: Variable Frequency Drive

VFDs and Soft Starters work on the same principles but have different architectures and application usages

Variable Frequency Drive



- Controls AC motor speed and torque by varying motor input voltage and frequency
- Can be programmed to vary the speed of the motor based on factors such as flow, pressure, etc.
- Control over motor speed
- Performance often more important than cost and size
- Energy saving is principal advantage
- Examples of applications: elevators, escalators, crushers, mixers, etc.

Soft Starter



- Offers smooth start and stop operation for a motor
- Gets bypassed by a contractor overload circuit as motor reaches its full speed
- Initial cost is lower than a variable frequency drive
- Effectively reduces inrush current during motor start
- No harmonics are generated
- Examples of applications: conveyors, pumps, and other belt-driven applications

Variable Frequency Drives (VFDs) and Soft Starters—market overview

Market Trends

Variable Frequency Drive (VFD)

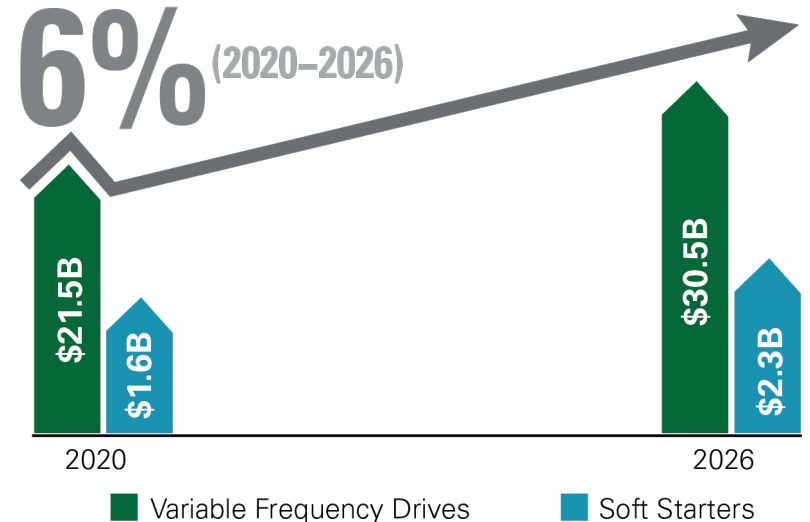
- The global VFD market is projected to grow at 6% CAGR between 2020 and 2026
- Market is expected to reach \$30.5B by 2026
- 35% growth will come from APAC
- A key factor driving the growth is the need for more energy efficiency
- Energy savings estimated to be over 20%
- Integrating IoT with VFDs for remote monitoring and controlling the devices

Soft Starter

- The global soft starter market is expected to grow at 6% CAGR between 2020 and 2026
- Market is expected to reach \$2.3B by 2026
- Increased use of industrial pumps and fans are key driving factors

Market Projections

Markets for VFDs and Soft Starters will be growing at CAGR of



Source: [GrandViewResearch](#), [GlobeNewsWire](#)

Protection and control solutions used in VFD systems

1 AC input protection

- AC Fuse
- MOV

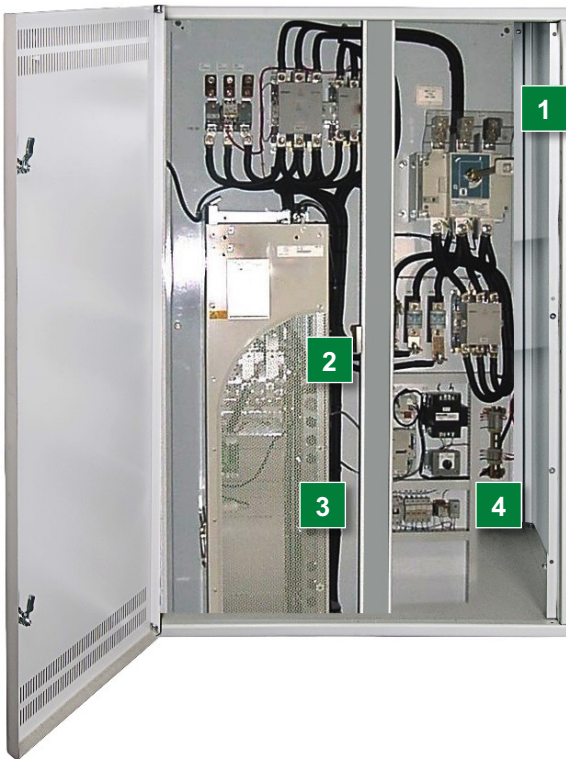
2 Input Rectifier and Brake

- Rectifier Module
- Brake Chopper Module

3 Inverter

- High-speed Fuse
- TVS Diode
- IGBT Module
- Temperature Sensor

MOV: Metal Oxide Varistor
TVS: Transient-Voltage Suppression
IGBT: Insulated-Gate Bipolar Transistor

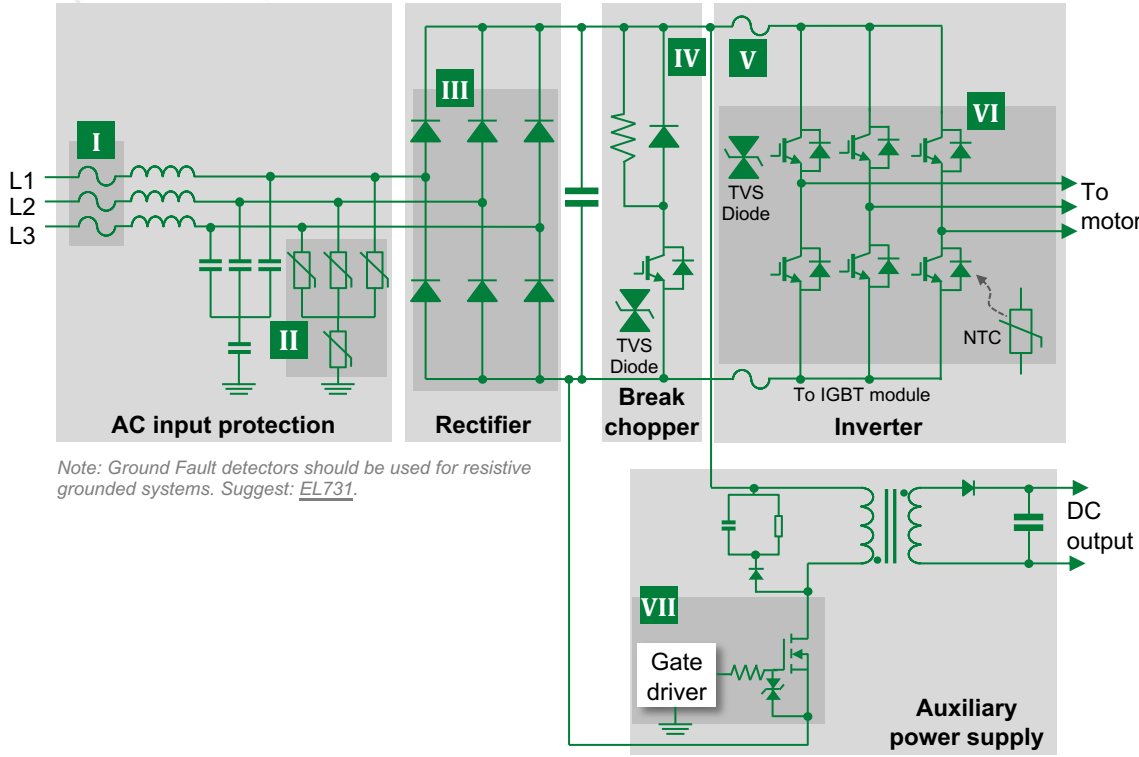


4 Auxiliary Power Supply

- SiC MOSFET
- Gate Driver
- TVS Diode

Protection and control solutions for VFD and Auxiliary Power Supply

Click on 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 , LDC , L70QS , 606 , 504 , 505
	Fuseholder	LFT , LFJ
II	MOV	TMOV , UltraMOV
III	Rectifier Diode	Module Offerings , Discrete Devices
IV	Brake Chopper Module	Boost Chopper IGBT Modules
V	Semiconductor Fuse	PSR
VI	IGBT Module	XPT IGBT Modules , Six Pack IGBT Modules , CBI Modules
	NTC	USUR1000 , SM
	TVS Diode	SMBJ , SMF4L , 1.5SMC
VII	SiC MOSFET	LSIC1MO170E1000
	Gate Driver	IX4351NE
	TVS Diode	SMF , 1.5SMC

Features and benefits of Littelfuse components

	Technology	Function in Application	Series	Benefits	Features
I	Fuses	AC line fuses for overcurrent or short circuit protection	JLS, JLS, LDC, L70QS 606, 504, 505	Reduces damage to equipment caused by heating and magnetic effects of short circuit currents; Compact design	Extremely current-limiting; small footprint; 200 kA interrupting rating; smallest available package
	Fuseholder	Supports fuse protection	LET, LEJ	DIN rail mountable	Low resistance connection
II	MOV	Protects against damage due to lightning-induced surges or harmonic voltage disruptions from the power line	TMOV, UltraMOV	Integrated thermal disconnect enhances safety by disconnecting during MOV EOL caused by continuous abnormal overvoltage from miswiring or loss of neutral	UL-recognized Type 4 surge protection devices; integrated thermal disconnect
III	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	Module Offerings, Discrete Devices	Small footprint; multiple package options (high-voltage, isolated, and standard packages)	Planar passivated chips; very low leakage current and forward voltage drop; improved thermal behavior; high commutation robustness
IV	Brake Chopper Module	Overvoltage protection of DC bus	Boost Chopper IGBT Modules	Easy to parallel due to positive temperature coefficient	Sonic diode for fast and soft recovery
V	Semiconductor Fuse	Protects power semiconductor components from overcurrent	PSR	Best-in-class DC performance	Busbar mount
VI	IGBT Module	Switching power supplies	XPT IGBT Modules Six Pack IGBT Modules CBI Modules	Short circuit rated for 10 μ sec; low gate charge; low EMI and competitive low $V_{CE(SAT)}$	Rugged XPT design with thin wafer technology
	NTC	Semiconductor temperature measurement	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 IGBTs from an event of transient overload	SMBJ, SME4L, 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	High-frequency switching	LSIC1MO170E1000	Higher switching frequency; higher efficiency; increased robustness; smaller die size per voltage/current rating	Optimized for high-frequency applications; extremely low gate charge and output capacitance; ultra-low on-resistance
	Gate Driver	Drives SiC MOSFETs and high-power IGBTs	IX4351NE	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 SiC MOSFET from voltage transient	SME, 1.5SMC	Improves system reliability by clamping the voltage at safe levels during transients	200 W peak pulse power capability; excellent clamping capability; low profile

Protection and control solutions for Soft Starters

1 AC input protection

- AC Fuse
- MOV

2 Phase control

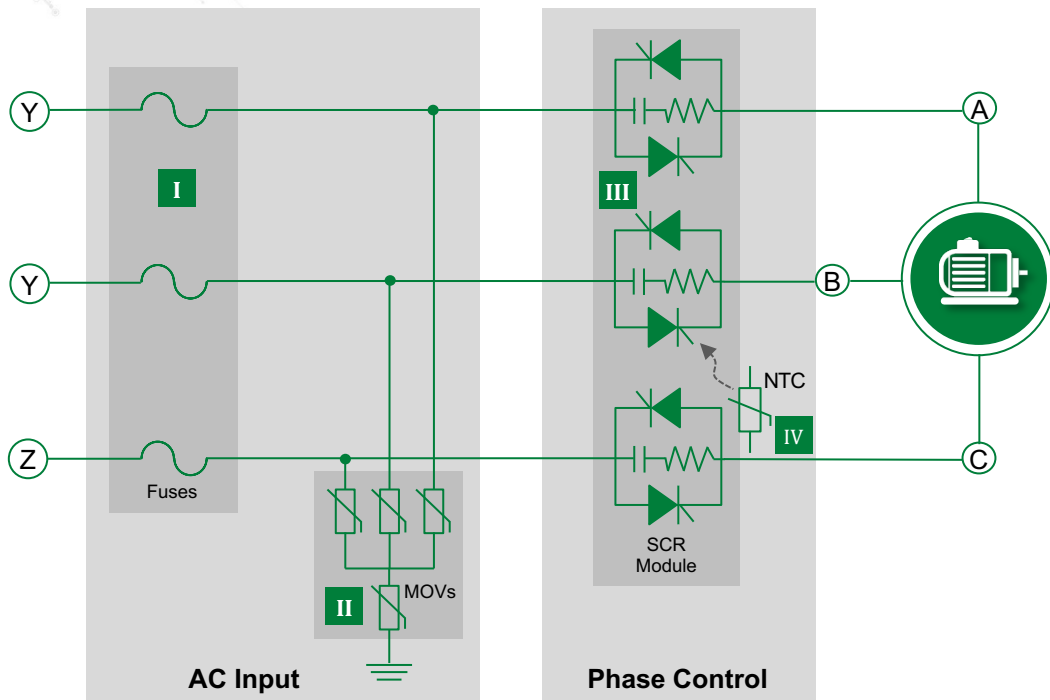
- SCR Module
- Discrete SCR
- Temperature Sensor

SCR: Silicon Controlled Rectifier
MOV: Metal Oxide Varistor



Protection and control components for Soft Starter topology

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



	Technology	Product Series
I	Fuse	L50QS , L70QS , JLS , JLLS
	Fuseholder	LSCR , LFT , LFJ
II	MOV	TMOV
III	Dual SCR Module	MCC
	Discrete SCR	N Series
IV	NTC	USUR1000 , SM

Benefits of Littelfuse components in Soft Starters

	Technology	Function in Application	Series	Benefits	Features
I	Fuse	Designed specifically for supplementary protection of semiconducting devices—SCRs, diodes, IGBTs, and so on	L50QS , L70QS , JLS , JLS	Reliable interruption of all over currents; less heating and power consumption; helps to reduce semiconductor failures from overvoltage events	Extremely current limiting; low watt losses; controlled transient overvoltage events; UL recognized
	Fuseholder	Supports fuse protection	LSCR , LFT , LFJ	DIN rail mountable	Low-resistance connection
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 miswiring 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	Space and weight savings; simple mounting with two screws; improved temperature and power cycling; reduced protection circuits	International standard package; JEDEC TO-240 AA; isolation voltage 3600 V; UL recognized
	Discrete SCR		N Series		
IV	NTC	Semiconductor temperature measurement	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

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 (SRECS) 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 (SRP/CS), 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

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Power Semiconductor Catalog



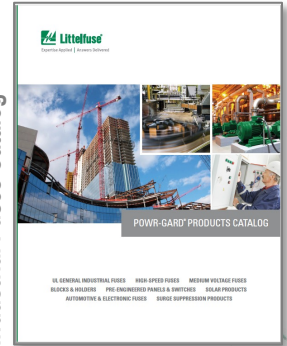
Circuit Protection Catalog



Sensor Selection Guide



Industrial Fuses Catalog

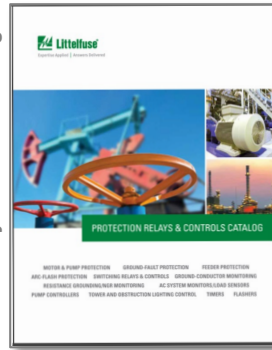


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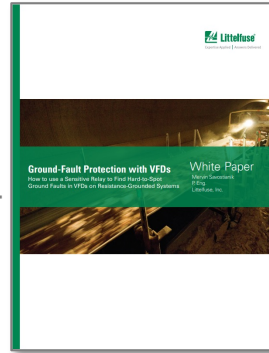
Integrated Circuits Catalog



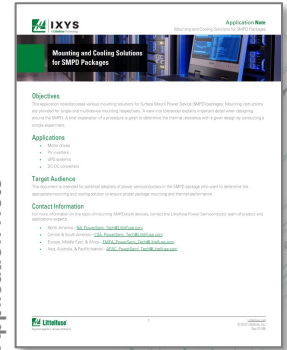
Power Relay & Control Catalog



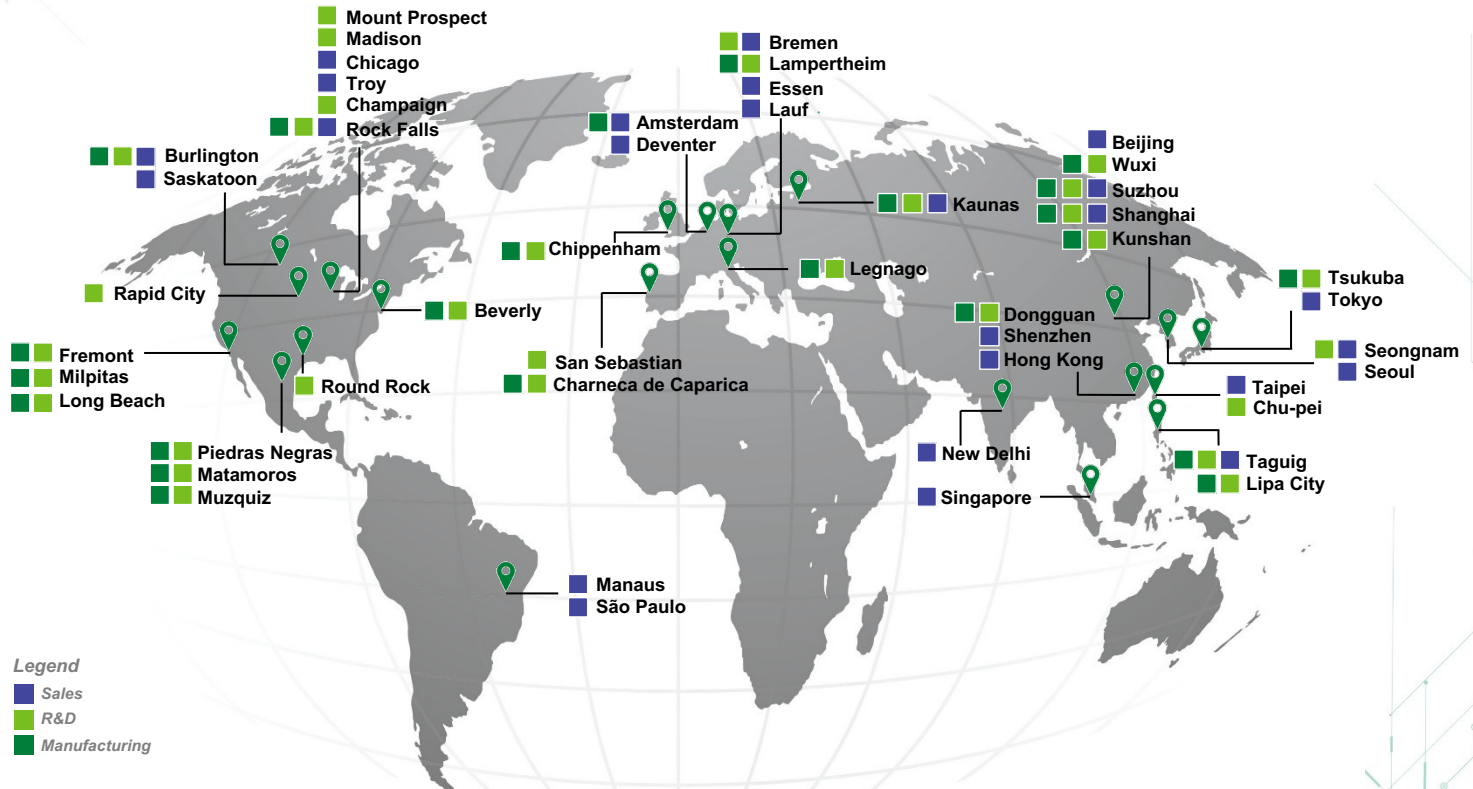
Ground-Fault Protection with VFDs White Paper



Surface Mount Power Devices Application Note



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