






Electric Two- and Three-Wheeler Solutions

Transportation

Littelfuse®

Expertise Applied | Answers Delivered

By fulfilling zero-emission mandates, electric two-wheelers and three-wheelers help improve air quality

Battery capacity: 500 Wh | 1,000 Wh | 3,000 Wh | 5,000 Wh | 7,000 Wh | 10,000 Wh

Electric bike
(250–900 W)

Electric motorcycle
Asia: (3–25 kW)
Rest of the world: (20–200 kW)

Electric utility vehicle
(5–20 kW)

e-Kick scooter
(600 W–1.5 kW)

Electric two-wheeler
(400 W–4 kW)

Electric three-wheeler
(2–8 kW)

Battery voltage range: 24–96 V

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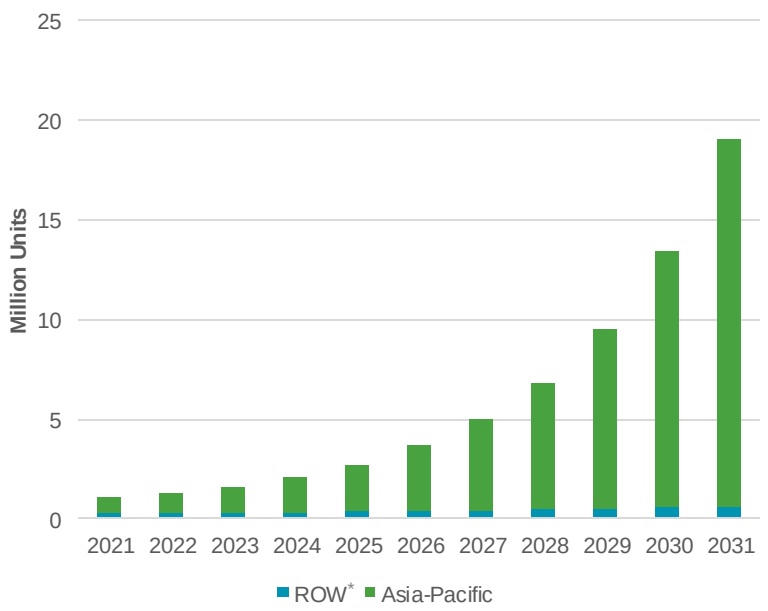
Electric two-wheeler and three-wheeler market trends and drivers

Market trends and drivers

The global electric two-wheeler and three-wheeler market is projected to grow from 1M-units in 2021 to 19M-units by 2031, at a CAGR of ~34%.
The global electric two- and three-wheeler Li-ion battery pack market has shown double-digit growth. The limited life cycle and usable capacity are likely to shift the focus from lead acid batteries to Li-ion batteries.
Li-ion batteries are lightweight, which helps maintain the energy-to-weight ratio of the vehicle.
Most battery packs are 48 V; higher-end models (> 20 kW) also come with 60−96 V battery pack.
Asia Pacific is expected to be the largest market. China had spent about $2.4 B by 2020 to improve its charging facility infrastructure.
The Indian government has undertaken initiatives such as FAME-II, offering subsidies and tax exemptions to encourage buyers to change from ICE bikes to electric two-wheeler and three-wheeler to reduce Carbon emissions.
Currently, 27 European countries have imposed taxes on Carbon Dioxide emissions related to vehicles.

Rapid growth of electric two-wheelers and three-wheelers



Source: *CEEW, Littelfuse estimates (does not include kick scooter, electric bike, or Chinese electric two-wheeler forecast)*
** Rest of the world*

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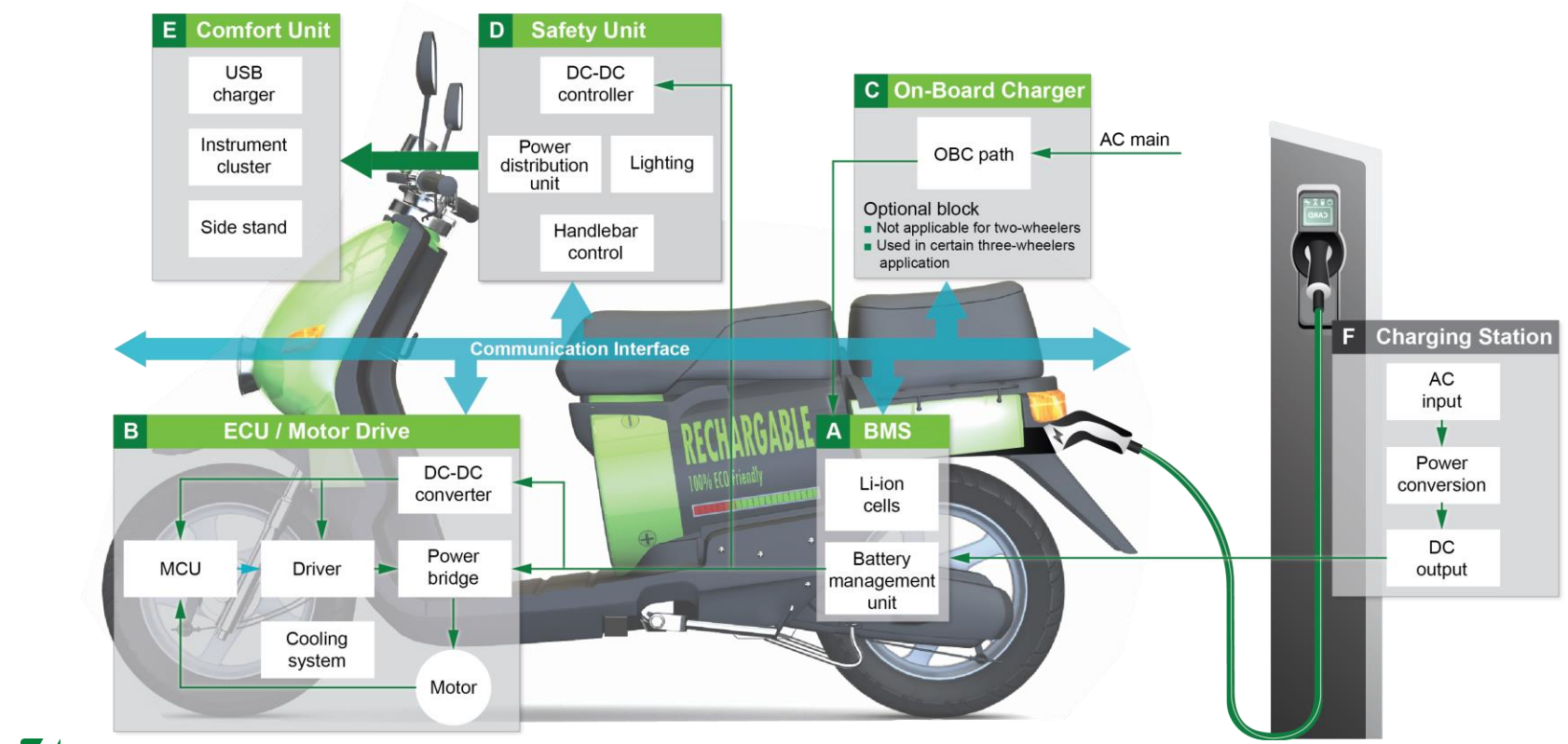
Electric two-wheeler and three-wheeler system architecture

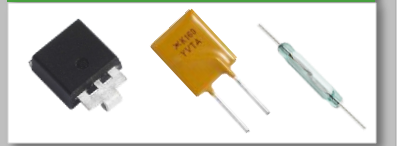


Littelfuse solutions for electric two-wheelers

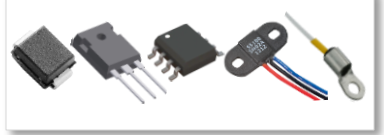
Comfort Unit

1 USB/Charging Port
TVS Diode, PolySwitch® Device

2 Cluster & Side Stand
TVS Diode, PolySwitch® Device, Reed Switch



3 ECU/Motor Drive
TVS Diode, MOSFET, Gate Driver, Hall Effect Sensor, NTC

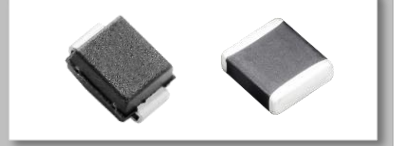


8 On-Board Charger
Fuse, MOV, GDT, TVS Diode, NTC, MOSFET, Gate Driver, Diode

7 Battery Management Unit
Fuse, PolySwitch® Device, TVS Diode, Switch TVS Diode Array, NTC, TTape™, Reed Switch

Safety Unit

4 Lighting
TVS Diode, MOV



5 Power Distribution Unit
Fuse, Fuse Holder

6 Handlebar Control
Tactile Switch, KeySwitch

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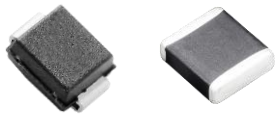
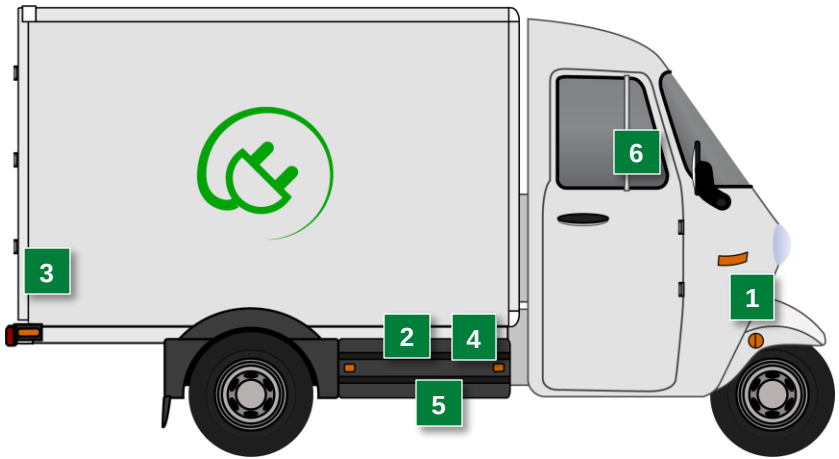
Littelfuse solutions for electric three-wheelers

1 Lighting
TVS Diode, MOV



2 Power Distribution Unit
Fuse, Fuse Holder, Fuse box

3 On-Board Charger
Fuse, MOV, GDT, TVS Diode, NTC, MOSFET, Gate Driver, Diode



4 ECU/Motor Drive
TVS Diode, MOSFET, Gate Driver, Hall Effect Sensor, NTC

5 Battery Management Unit
Fuse, PolySwitch® Device, TVS Diode, Switch, Relay, TVS Diode Array, NTC, TTape®, Reed Switch,

6 Handlebar/Steering Control
Tactile Switch, KeySwitch

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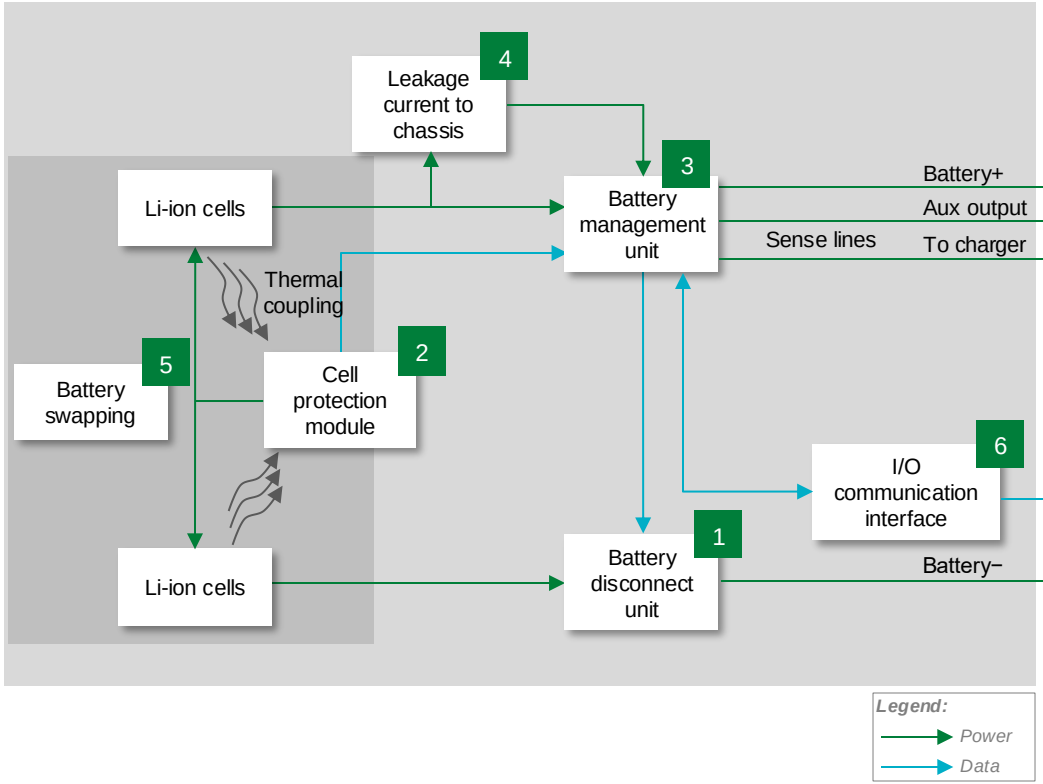
Click the product series in the table below for more info

BMS (Battery Management System)



	Technology	Product series
1	Fuse, Fuseholder	MIDI 70V, Mega, BF1 32V, 881, LP Jcase, ATO
	TVS Diode	TPSMB
	HV DC Contactor Relay*	DCNEV, DCNLEV, DCNLR
2	NTC**	Leaded, Surface Mount
	TTape™ Platform	TTP
3	Fuse **OR** PolySwitch® Device	438A, 437A, MINI, 521
		1812L050-60
	Battery Protector	ITV
4	Solid State Relay***	LAA110, LCA701, CPC1009N, CPC1117N
5	Reed Switch	MDSR-10
	C&K® Switches	ZMS, ZMSM, LCS, KSC, ZMV, ZMW
6	TVS Diode Array	AQ24COM-02, AQ24CANA

** Recommended for three-wheeler vehicles*
*** Thermally coupled with Li-ion cells*
**** Suitable for high-end two wheelers with V_{bat} > 60 V*

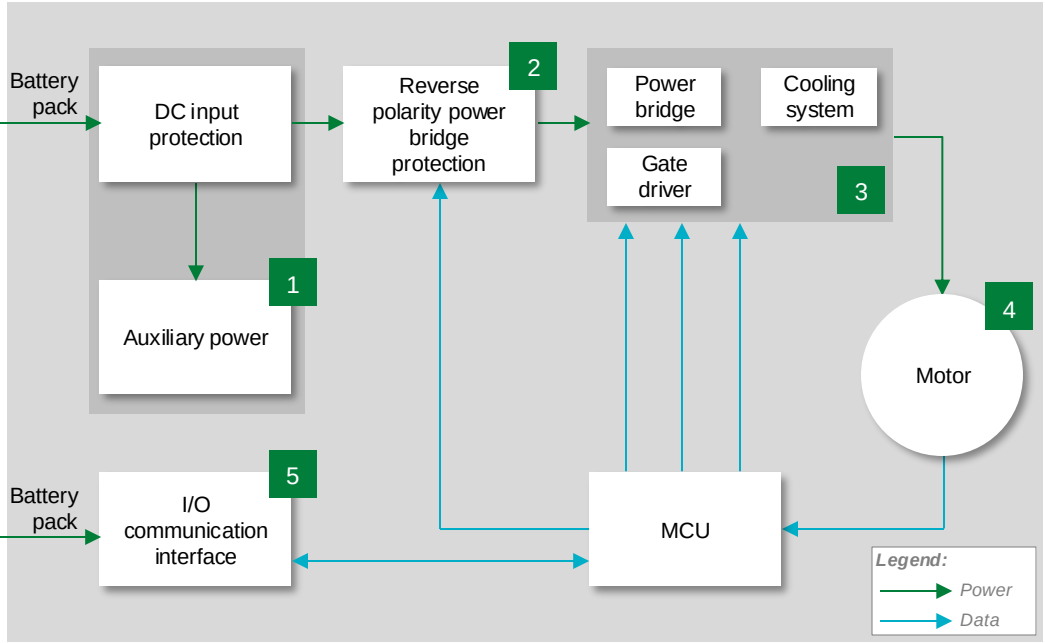
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	Fuse, Fuseholder	Protects from short circuits and overloaded circuits	MIDI 70V, Mega, BF1 32V, 881, LP Jcase, ATO	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt down, bladed, and SMD form factors; high breaking capacity; meets ISO 8820 standard or new AEC-Q specification
	TVS Diode	Suppress transient voltage	TPSMB	Provides an excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes
	HV DC Contactor Relay	Connects and disconnects battery from main circuitry	DCNEV, DCNLEV, DCNLR	Allows a low-voltage signal to switch the contacts for a high-voltage signal	Wide range of capabilities: can switch up to thousands of amps, and thousands of volts
2	NTC	Analog temperature monitoring to facilitate functional control of batteries	Leaded, Surface Mount	Allows for high-precision temperature measurement in harsher environments	UL Recognized with ring lug mounting; SMD NTCs in hermetically sealed MELF package suitable for operation up to 220 °C
	TTape™ Platform	Managing battery lifetime and helping identify hazardous temperature levels	TTP	Simple integration with existing BMS architectures + enables enhanced BMS control systems	Trip temperature of 58±3 °C, up to 50 sensing points on one string; enable BMS wakeup and single GPIO port usage
3	Fuse **OR** PolySwitch® Device	Sense-line protection	438A, 437A, MINI, 521	Ensures excellent temperature stability and performance reliability; ceramic substrate ensures compatibility with high-temperature environment	Meets new AEC-Q specification; fast response to fault current; surface mount device
			1812L050-60	Compact design saves board space; resettable protection	Low-profile; fast response to fault currents; low resistance
	Battery Protector	Offers secondary protection for battery pack	ITV	Allows overcurrent and overcharge protection; controlled disconnection can be activated by BMS	Surface mountable; UL and TUV certified; three-pin device; controlled fusible element
4	Solid State Relay	Isolation monitoring	LAA110, LCA701, CPC1009N, CPC1117N	Allows robust operation in a small four-pin package	1500 V I/O isolation; low drive requirements; no arching
5	Reed Switch	Provides the control signal for the battery pack	MDSR-10	Ensures contamination resistance and a compact design	Switches up to 200 VDC or 0.5 A at up to 10 W, 10^{12} Ω insulation resistance
	C&K® Switches	Enables battery detection switching	ZMS, ZMSM, LCS, KSC, ZMV, ZMW	Confers long electrical and mechanical life; ideal when space is limited	IP65/IP67; SPST NO/SPST NC/SPDT; compact size
6	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage spikes	AQ24COM-02, AQ24CANA	Ensures reliability of the equipment without performance degradation of communication lines	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2 and ISO 10605; low leakage current and clamping voltage

Click the product series in the table below for more info

ECU/Motor Drive



	Technology	Series
1	High-Current Fuse	881, MIDI 70V, Mega
	Low-Current Fuse	438A, 437A
	PolySwitch® Device	RXEF, RKEF
	TVS Diode	TPSMB
2	Schottky Diode	DST
	Thermal Protector	HCRTP-mini
3	MOSFET	X4 Class
	Gate Driver	IXD_6xxSI, IX4340NE
	NTC	Surface Mount, USUR1000
4	Hall Effect Sensor	55100
5	TVS Diode Array	AQ24COM-02, AQ24CANA

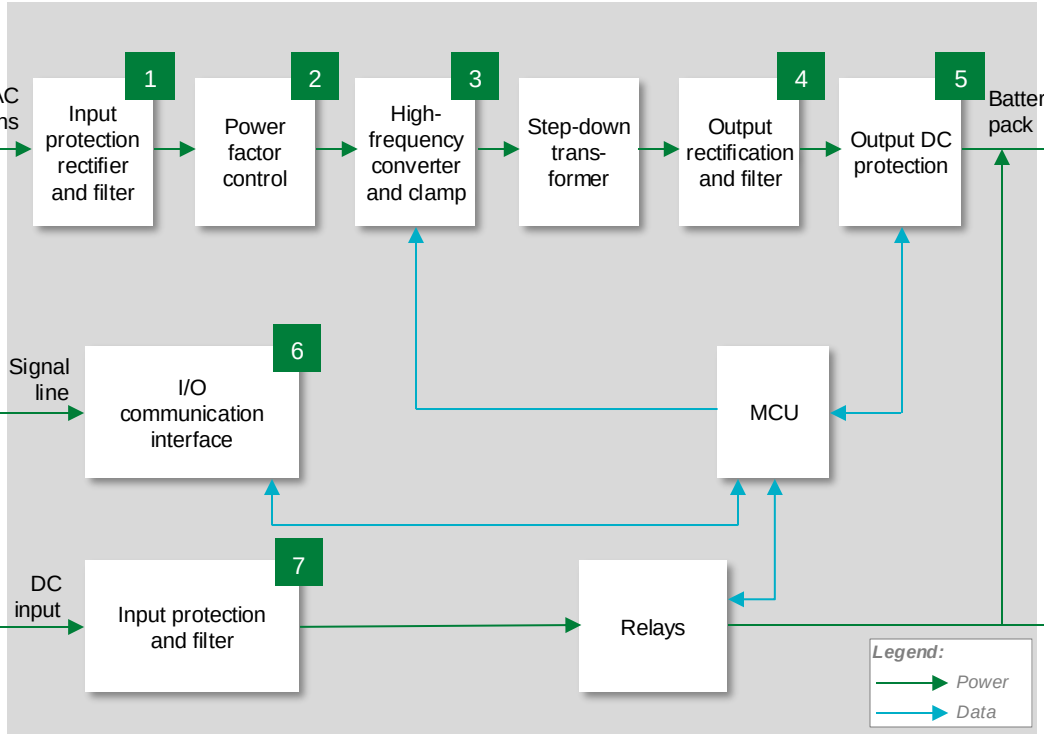
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	High-Current Fuse	Protects from short circuits and overloaded circuits	881, MIDI 70V, Mega	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt down and SMD form factors; high breaking capacity; meets ISO 8820 / new AEC
	Low-Current Fuse	Protects auxiliary power supply parts from high fault currents due to external shorts	438A, 437A	Ensures excellent temperature stability; compact design	Meets new AEC-Q specification; fast response to fault current; surface mount device
	PolySwitch® Device	Provides resettable overload circuit protection	RXEF, RKEF	Resets to normal operation after fault is cleared; saves space due to small footprint	Maximum electrical rating: 60 VDC; operating current up to 15 A; SMD and leaded options
	TVS Diode	Suppresses voltage spikes	TPSMB	Offers excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes
2	Schottky Diode	Provides rectification and reverse polarity protection in power supply units	DST	Enables the design of high-efficiency power supplies with Trench MOS technology	Ultra-low forward voltage drop; high-frequency operation; small TO-277B package
	Thermal Protector	Provides over-temperature thermal protection	HCRTP-mini	Disconnects the circuit from the supply in the event of overheating	Surface mount; can be installed during reflow process; 16 V rated; can break up to 500 A
3	MOSFET	Enables high switching speed in power supply units	X4 Class	Provides fast response time and low heat signature	Low $R_{ds(on)}$, dv/dt ruggedness
	Gate Driver	Controls switching MOSFETs	IXD_6xxSI, IX4340NE	Offers dual outputs that provide space-efficient design, high immunity to latch-up; rise/fall times < 10 ns	Tight tolerance; small form factor; fast thermal response
	NTC	Measures semiconductor temperature	Surface Mount, USUR1000	Allows for high-precision temperature measurement in harsher environments	UL recognized with ring lug mounting; SMD NTCs in hermetically sealed MELF package suitable for operation up to 220 °C
4	Hall Effect Sensor	Measures speed of the motor and position detects of the rotor	55100	Available in two- or three-wire versions; miniature flange mount design; wide sensitivity range	Up to 10 kHz switching speed; unaffected by harsh environments; up to 20 B operations
5	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage spikes	AQ24COM-02, AQ24CANA	Ensures reliability of the equipment without performance degradation of communication lines	AEC-Q101 qualified; low leakage current and clamping voltage

Click the product series in the table below for more info

On-board charger



	Technology	Series
1	AC Fuse	10EV, 526
	Thyristor	HS4040xAQx, S8016xA
	MOV, SIDACtor®	AUMOV P3800FNL
	GDT	CG2, CG3
2	MOSFET	X4 Class
	Gate Driver	IXD_6xxSI, IX4340NE, IXD2012
	TVS Diode	TPSMB
3	MOSFET	X4 Class
	Gate Driver	IXD_6xxSI, IX4340NE, IXD2012
	TVS Diode	TPSMB
4	Si/SiC Diode	DPG, LSIC2SDxx
5	DC Fuse	10EV, 526
6	TVS Diode Array	AQ24COM-02, AQ24CANA
7	TVS Diode	SLD8S, SLD6S, SLD5S

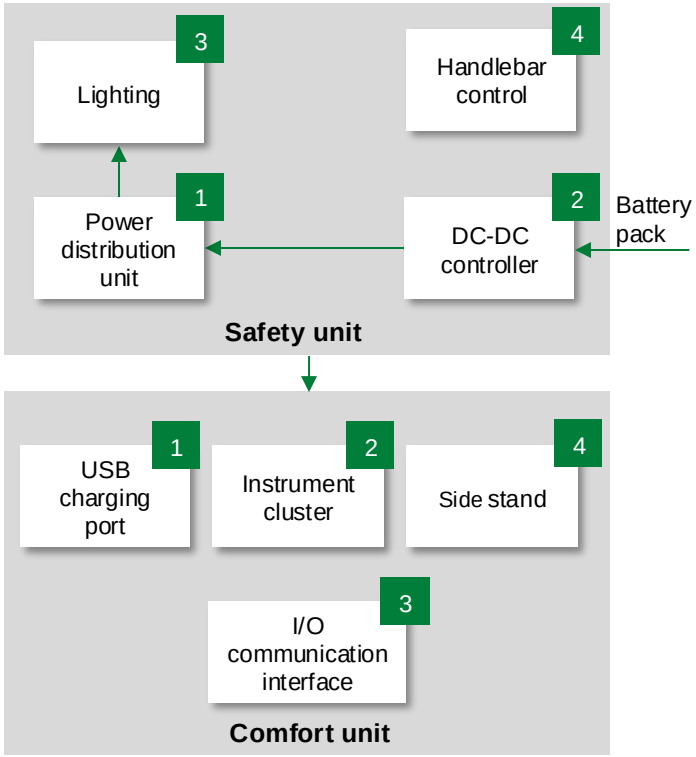
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	AC Fuse	Protects against short circuits and overloaded circuits	10EV, 526	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt-down & through-hole form factors; high breaking capacity; meets ISO 8820/AEC-Q200 standards
	Thyristor	Rectifies AC-DC	HS4040xAQx, S8016xA	Provides solid-state switching with no audible noise during operation; enables power-efficient operation; compact design	High voltage withstand capability (800 V); high surge capability up to 225 A; solid-state switching eliminates contact bounce
	MOV, SIDACtor®	Suppresses voltage spikes	AUMOV P3800FNL	Ensures the reliable performance of the circuitry; when paired together, offers lower clamping voltage	Wide range of surge current ratings, disk sizes, and lead options
	GDT	Offers surge protection	CG2, CG3	Provides high degree of surge protection in a small package size	Rugged ceramic-metal construction; low capacitance; meets REA PE-80; available in surface mount, and a variety of lead options
2	MOSFET	Enables high-speed switching	X4 Class	Reduces switching and conduction losses; increases efficiency	Low $R_{ds(on)}$, dv/dt ruggedness
	Gate Driver	Controls switching MOSFETs	IXD_6xxSI, IX4340NE, IXD2012	Dual outputs provide space-efficient design, high immunity to latch-up; rise/fall times < 10 ns	Tight tolerance; small form factor; fast thermal response
	TVS Diode	Suppresses voltage spikes	TPSMB	Offers excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes
3	MOSFET	Enables high-speed switching	X4 Class	Reduces switching and conduction losses; increases efficiency	Low $R_{ds(on)}$, dv/dt ruggedness
	Gate Driver	Controls switching MOSFETs	IXD_6xxSI, IX4340NE, IXD2012	Dual outputs provide space-efficient design, high immunity to latch-up; rise/fall times < 10 ns	Tight tolerance; small form factor; fast thermal response
	TVS Diode	Suppresses voltage spikes	TPSMB	Offers excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes
4	Si/SiC Diode	Provides high-frequency switching and rectification	DPG, LSIC2SDxx	Reduces switching losses; increases efficiency	High surge capability; negligible I_{RR}; junction temperature of Tj 175 °C
5	DC Fuse	Protects against short circuits and overloaded circuits	10EV, 526	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt-down & through-hole form factors; high breaking capacity; meets ISO 8820/AEC-Q200
6	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage spikes	AQ24COM-02, AQ24CANA	Ensures reliability of the equipment without performance degradation of communication lines	AEC-Q101 qualified; low leakage current and clamping voltage
7	TVS Diode	Suppresses voltage spikes	SLD8S, SLD6S, SLD5S	Offers excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes

Click the product series in the table below for more info

Safety and comfort unit



** Recommended for three-wheeler vehicles*
*** Littelfuse also offers custom power distribution modules*
**** K12S series recommended for high-end electric motorcycles*

	Technology	Series
1	Fuse	Jcase, MINI MIDI Bolt-Down*, Mega*, LP Jcase*, LP MINI*,ATO*
	Fuse Box and Fuse Holder** (12–24 V)	MIDI 498, MIDI Flex, HWB, POWR-BLOK
	Fuse Box and Fuse Holder** (12–70 V)	J Case-FHJ MEGA-298, MEGA-Flex, SN, MDB5*, CF8-799*
2	TVS Diode	TPSMB
3	Temperature Indicator	setP™
	NTC	Surface Mount
	TVS Diode	TPSMB
	MOV	AUML
4	C&K® Switches	K12S***, KSC, EL2, RKX

	Technology	Series
1	Temperature Indicator	setP™
	PolySwitch® Device	ASMD, miniASMDC
2	PolySwitch® Device	miniASMDC
	Fuse	438A, 437A
3	TVS Diode Array	AQ24COM-02, AQ24CANA
4	Reed Switch	MDSR-10

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

Benefits of recommended Littelfuse products

Safety Unit

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Protects against short circuits and overloaded circuits	Jcase, MINI MIDI Bolt-Down*, Mega*, LP Jcase*, LP MINI*,ATO*	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt down and bladed form factors; high breaking capacity; meets ISO 8820 standard
	Fuse Box and Fuse Holder (12–24 V)	Protects against short circuits and overloaded circuits	MIDI 498, MIDI Flex, HWB, POWR-BLOK	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt down and bladed form factors; high breaking capacity; meets ISO 8820 standard
	Fuse Box and Fuse Holder (12–70 V)	Protects against short circuits and overloaded circuits	J Case-FHJ MEGA-298, MEGA-Flex, SN, MDB5*, CF8-799*	Provides safety protection in low- and medium-voltage environments; full-range fuses	Bolt down and bladed form factors; high breaking capacity; meets ISO 8820 standard
2	TVS Diode	Suppresses voltage spikes	TPSMB	Offers excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes
3	Temperature Indicator	Protects lighting circuit from overheating of LEDs	setP™	Auto resets after over-temperature condition is removed; compatible to compact design	Resettable; low resistance; compact 0805 outline
	NTC	Measures semiconductor temperature	Surface Mount	Allows for high-precision temperature measurement in harsher environments	SMD NTCs is in hermetically sealed MELF package suitable for operation up to 220 °C
	TVS Diode	Suppresses voltage spikes	TPSMB	Provides excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle voltage spikes
	MOV	Suppression of transient voltage	AUML	Clamps transient surge to ensure the reliable performance of the circuitry	Wide range of surge current ratings, disk sizes, and lead options
4	C&K® Switches	Handlebar control	K12S, KSC, EL2, RKX	Abuse-proof design; long lifecycles; robust design, and saves board space	Multiple contact configurations (SPST, DPST, N0/NC); IP67; small form factor; illumination option

Click the product series in the table below for more info

Benefits of recommended Littelfuse products

Comfort Unit

	Technology	Function in application	Product series	Benefits	Features
1	Temperature Indicator	Protects USB C plugs and receptacles from overheating	setP™	Auto-resets after over-temperature condition is removed; compatible to compact design	Resettable; low resistance; compact 0805 outline
	PolySwitch® Device	Provides resettable overload circuit protection	ASMD, miniASMDC	Resets to normal operation after fault is cleared; saves space due to small footprint	Maximum electrical rating: 60 VDC; operating current up to 15 A; SMD and leaded options
2	PolySwitch® Device	Provides resettable overload circuit protection	miniASMDC	Resets to normal operation after fault is cleared; saves space due to small footprint	Maximum electrical rating: 60 VDC; operating current up to 15 A; SMD and leaded options
	Fuse	Protects against short circuits and overloaded circuits	438A, 437A	Offers excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment	Meets new AEC-Q specification; fast response to fault current; surface mount device
3	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage transients	AQ24COM-02, AQ24CANA	Ensures reliability of the equipment without performance degradation of communication lines	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2 and ISO 10605; low leakage current and clamping voltage
4	Reed Switch	Provides control signal for the side stand	MDSR-10	Offers contamination resistance; compact design	Switches up to 200 Vdc or 0.5 A at up to 10 W; 10^{12} Ω insulation resistance

Safety standards for electric two-wheelers and three-wheelers

Standard	Title	General scope	Region
UL 2849	Outline of Investigation for Electric Bicycles, Electrically Power Assisted Cycles (EPAC Bicycles), Electric Scooters, and Electric Motorcycles	This standard covers the on-board electrical system, and vehicle systems (including the chargers and batteries) of eBikes, electric scooters, and electric motorcycles.	North America
IEC 62133-2 and UL 62133-2	Safety standards for Li-ion Secondary Cells and Batteries	IEC 62133-2:2017 specifies requirements and tests for the safe operation of portable sealed secondary Lithium cells and batteries containing non-acid electrolytes, under intended use and reasonably foreseeable misuse.	Global
UL 1642	Lithium Batteries	Both safety standards deal with cells and small portable batteries. UL1642 deals with individual cells, while UL2054 is for small rechargeable battery packs.	North America
UL 2054	Household and Commercial Batteries		North America
IEC 62281	Safety of Primary and Secondary Lithium Cells and Batteries During Transport	This standard specifies test methods and requirements for primary and secondary (rechargeable) Lithium cells and batteries to ensure their safety during transport other than for recycling or disposal.	Global
JIS C8714	Safety Tests for Portable Li-Ion Secondary Cells and Batteries	Covers safety testing of Li-ion storage batteries (single cell and multiple cell) for portable electronic devices.	Japan
ANSI C18.2M	Portable Rechargeable Cells and Batteries	This code indicates safety standards for portable cells and batteries. It is specific to two distinct chemistry systems: Li-ion and nickel.	North America
UN 38.3	Recommendations on Transportation of Dangerous Goods (Li-Ion Batteries)	This standard applies to batteries transported either on their own or installed in a device (UN codes 3090/3091 for Lithium, 3480/3481 for Li-ion).	Global
BATSO 01	Manual for Evaluation of Energy Systems for Light Electric Vehicle (LEV) Secondary Lithium Batteries	This specifies test methods for secondary Lithium batteries for safe use in light EVs. Transport safety tests are also specified.	Global

Additional information can be found at Littelfuse.com

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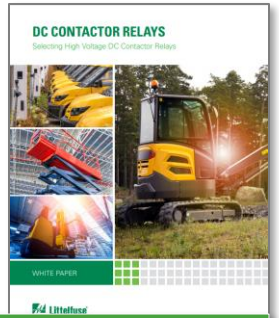
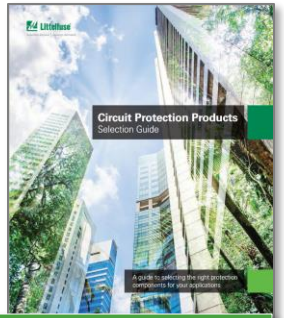
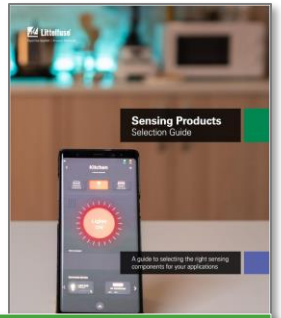


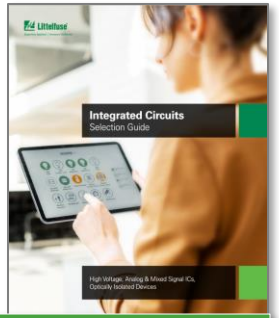
HVDC Contactor Relays Selection Guide



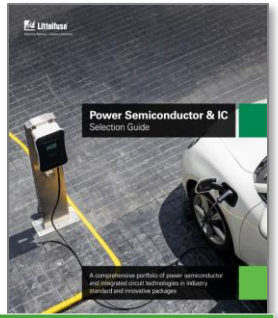
Circuit Protection Selection Guide



Sensing Products Selection Guide

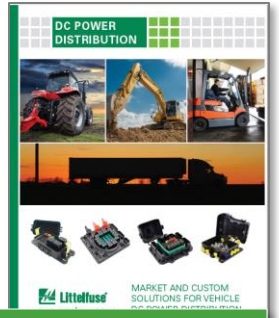


Integrated Circuits Selection Guide



Power Semiconductor Catalog

Click on images for more information



DC Power Distribution Catalog

C&K® Switches Products Selection Guide

Two-/Three-Wheeler Charging Solutions

Scan the code to learn more!

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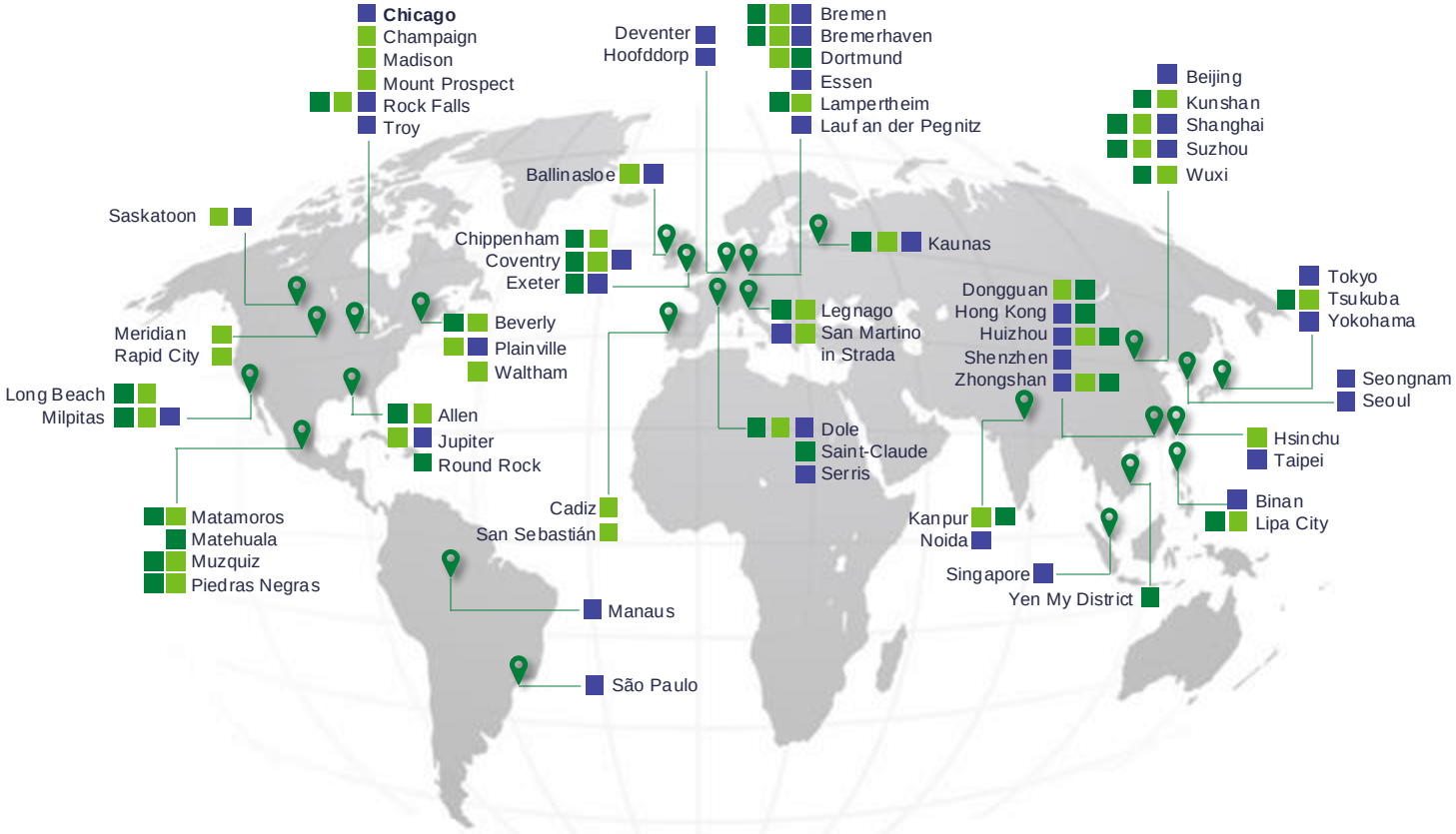
Local resources supporting our global customers



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Partner for tomorrow’s electronic systems

Broad Product Portfolio

We are an industrial technology manufacturing company empowering a sustainable, connected, and safer world.

Testing Capabilities

We help customers get products to market faster, and we offer certification testing to global regulatory standards.

Application Expertise

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

Compliance and Regulatory

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

Global Customer Service

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

Global Manufacturing

Our high-volume manufacturing is committed to the highest quality standards.

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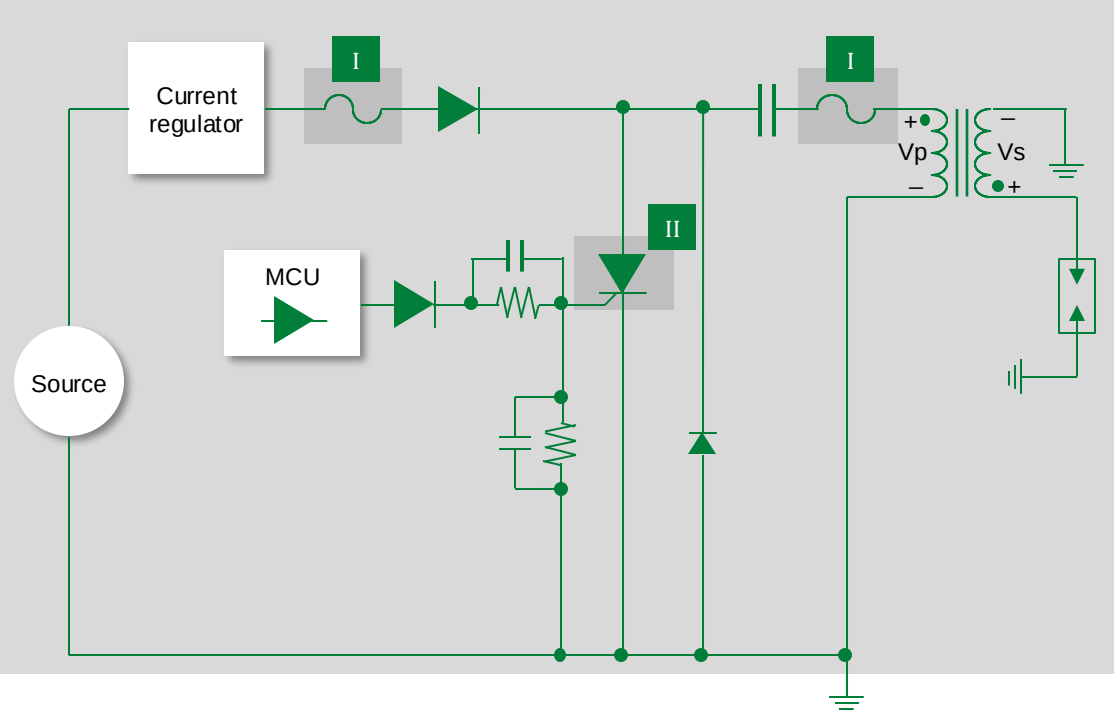
Internal combustion engine solutions

Capacitive Discharge Ignition (CDI)

Current and older ignition system design

Click the product series in the table below for more info

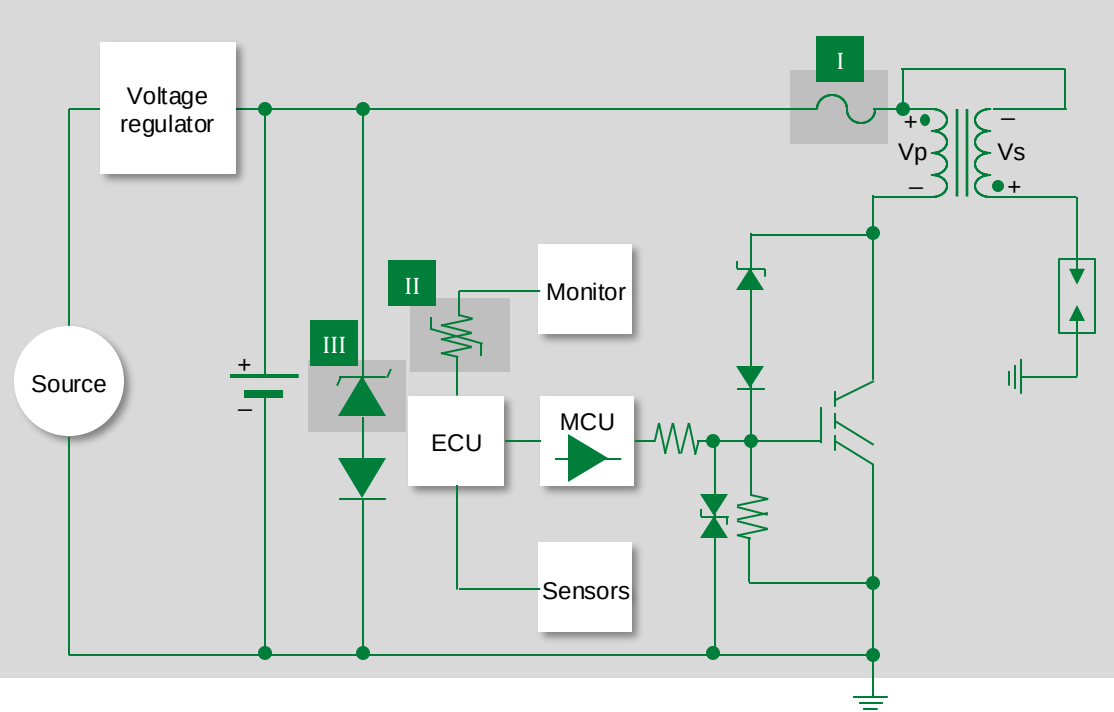


	Technology	Series
I	Fuse	440A, 441A
II	SCR	S6004DS2RP, S6008DS2RP, MCR12DSMT4G

Electronic Fuel Injection (EFI)

Newer, more fuel efficient, and less polluting design

Click the product series in the table below for more info

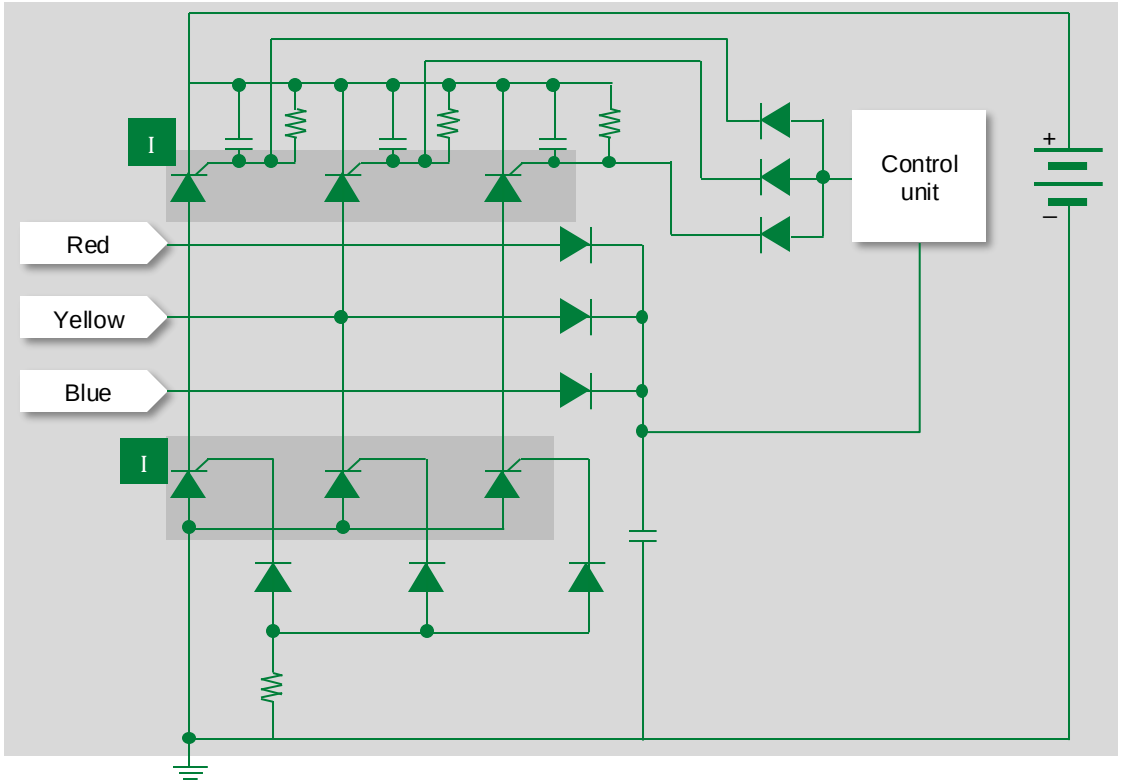


	Technology	Series
I	Fuse	440A, 441A
II	PolySwitch® Device	ASMDC, miniASMDC
III	TVS Diode	TPSMB

Rectifier and regulator (2 W and 3 W)

Converts AC to DC for electrical systems

Click the product series in the table below for more info



	Technology	Series
I	SCR (x6)	SJxx25xxA, SJxx20xx, SVxx25xx, SVxx20xx

R/R module
Rectifier/regulator bridge
+ Filter
+ SCR control circuit

AC generator
An example of a three-phase output 18-pole generator at 6000 rpm that produces 900 Hz of AC output
(f = RPM/120 x number of poles)

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