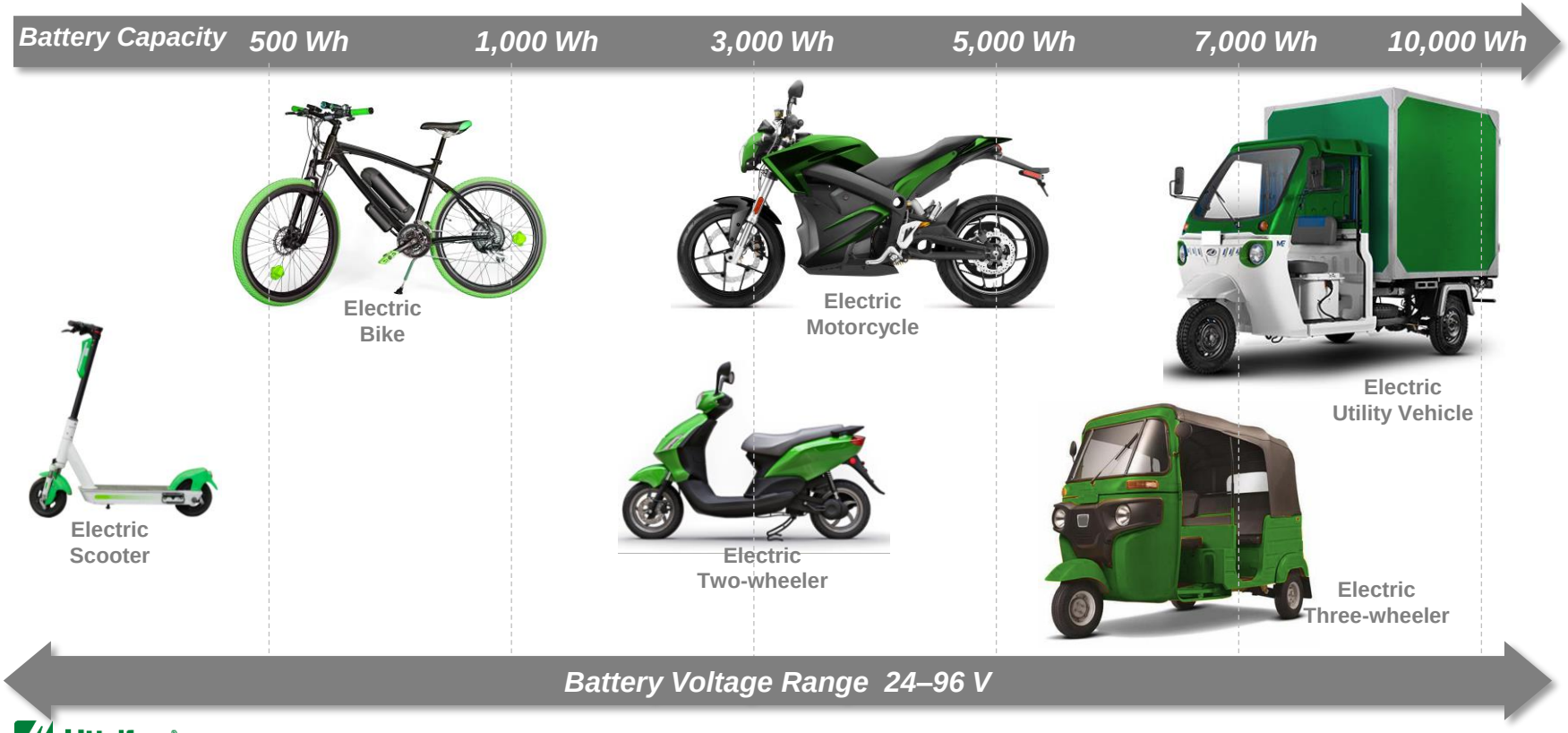
Electric Two-/Three-Wheeler Solutions

Transportation

Littelfuse®

Expertise Applied | Answers Delivered

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

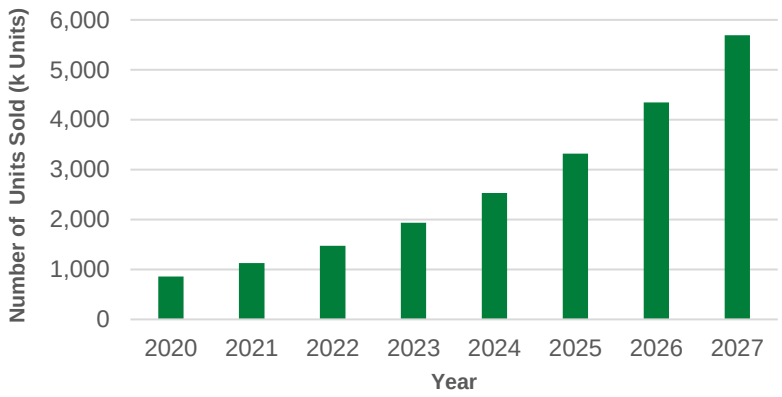


Electric two- & three-wheeler market trends and drivers

Market trends and drivers

The global electric scooter and motorcycle market is projected to grow from 861 thousand units in 2020 to 5,948 thousand units by 2027, at a CAGR of 31.8%
The electric three-wheeler market is expected to grow from $28.90 billion in 2020 to $32.65 billion in 2027
The global electric two-/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 lithium-ion batteries
Li-ion batteries are lightweight, which helps maintain the energy to weight ratio of the vehicle
48-volt battery packs comprise the largest share; higher-end models also come with 60-volt and 72-volt battery packs
Asia Pacific is expected to be the largest market. China spent approximately $2.4 billion by till 2020 to improve its charging facility infrastructure
The Indian government has undertaken initiatives such as FAME-II, offering subsidies and tax exemptions to buyers to promote electric two-/three-wheelers
27 European countries have imposed taxes on carbon dioxide emissions related to vehicles

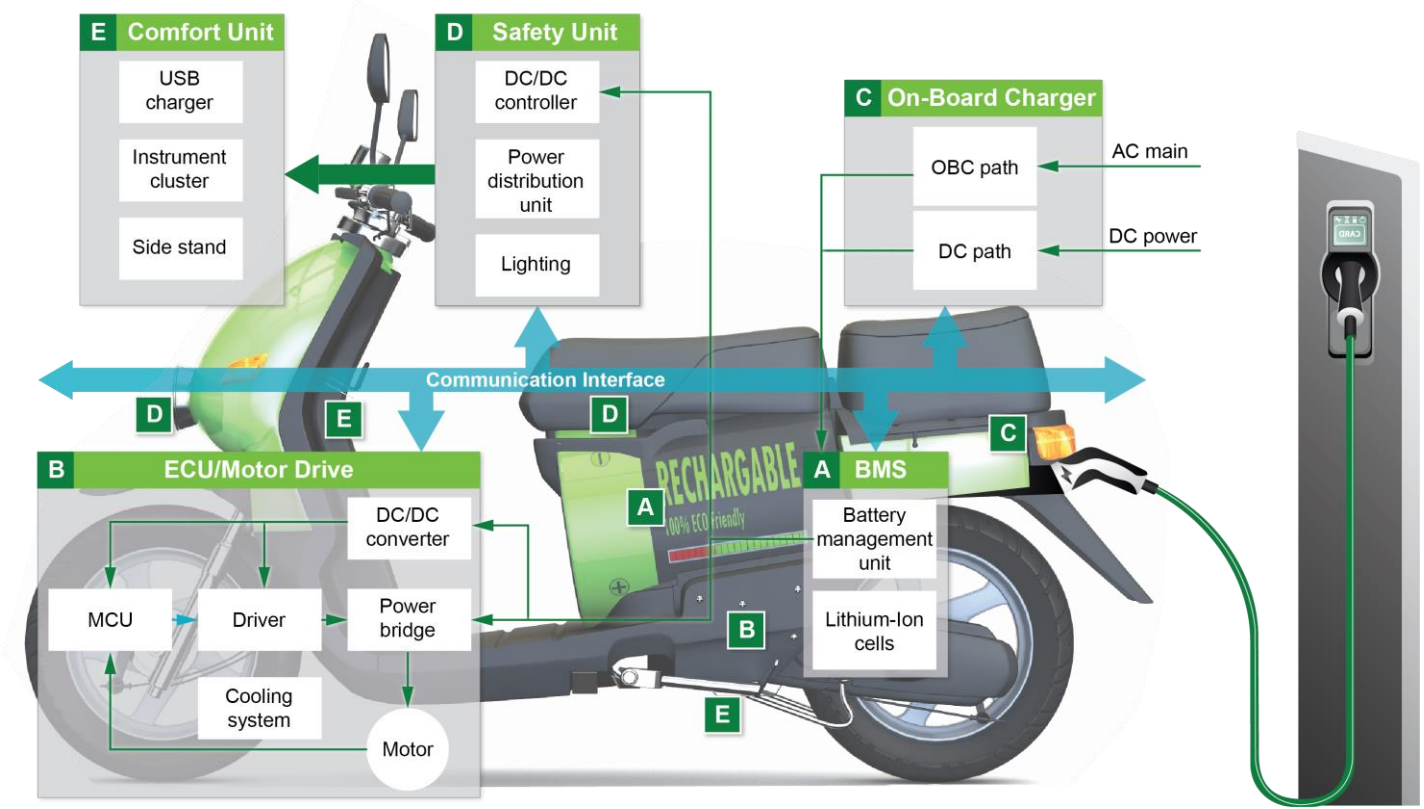
Rapid growth for electric two-wheeler



Source: Data Bridge, MarketsandMarkets, Expert Market Research, Fortune Business Insights

Littelfuse
Expertise Applied | Answers Delivered

Electric two- & three-wheeler system architecture



Littelfuse
Expertise Applied | Answers Delivered

Littelfuse solutions for electric two-wheeler

Comfort Unit

USB/charging port
- TVS Diode
- PPTC

Cluster
- TVS Diode
- PPTC

Side stand
- Reed Switch

ECU/motor drive
- TVS Diode
- MOSFET
- Rectifier Diode
- Hall Effect
- NTC

Safety Unit

Lighting
- TVS Diode
- MOV

Power distribution unit
- Fuse
- Fuse Holder

BMS
- Fuse
- TVS Diode, TVS Diode Array
- NTC
- Reed Switch

On-Board charger
- Fuse
- MOV, TVS Diode
- SCR, Diode
- NTC

BMS: Battery Management System
ECU: Engine Control Unit

Protect Control Sense

Littelfuse solutions for electric three-wheeler

Lighting

- TVS Diode
- MOV

Power distribution unit

- Fuse
- Fuse Holder
- Fuse box

On-Board Charger

- Fuse
- MOV, TVS Diode
- SCR, Diode
- NTC

ECU/motor drive

- TVS Diode
- MOSFET
- Rectifier Diode
- Hall Effect
- NTC

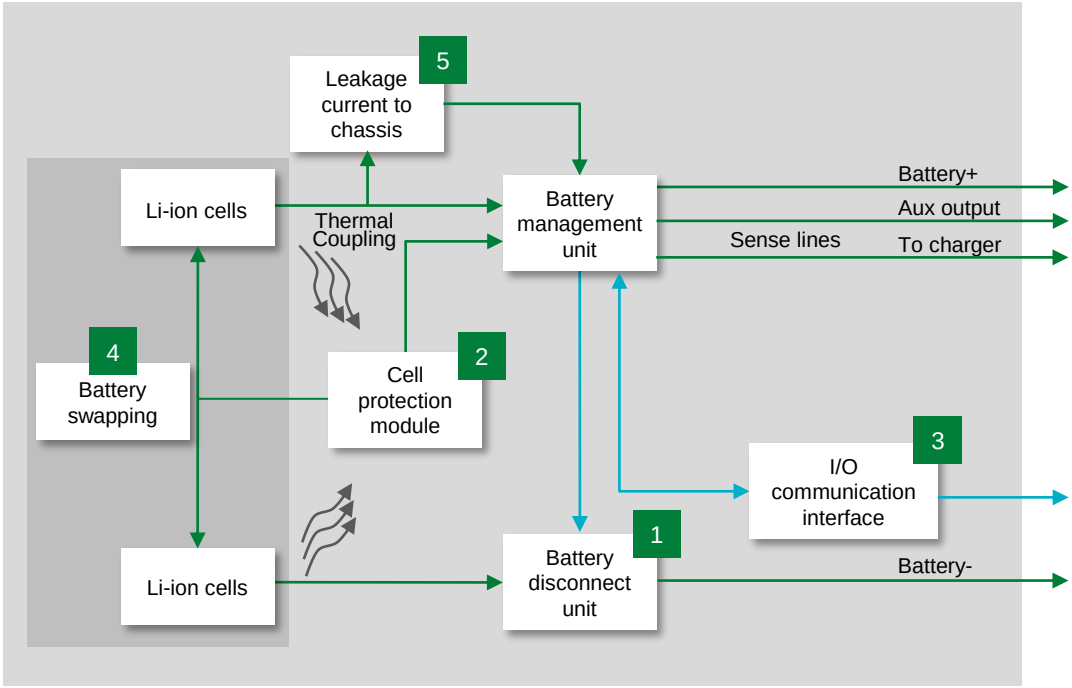
BMS

- Fuse
- TVS Diode
- TVS Diode Array
- NTC, Reed Switch
- HV DC Contactor Relay

BMS: Battery Management System
ECU: Engine Control Unit

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

A Battery Management System



	Technology	Series
1	Fuse	MIDI 70V, Mega, BF1 32V, 881, LP Jcase, ATO
	TVS Diode	TPSMB
	Fuse	438A, 437A, MINI, 521
	HV DC Contactor Relay*	DCNEV, DCNLEV
2	NTC **	Leaded , Surface Mount
3	TVS Diode Array	AQ24CANA
4	Reed Switch	MDSR-10
5	Solid State Relay ***	CPC1009N

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

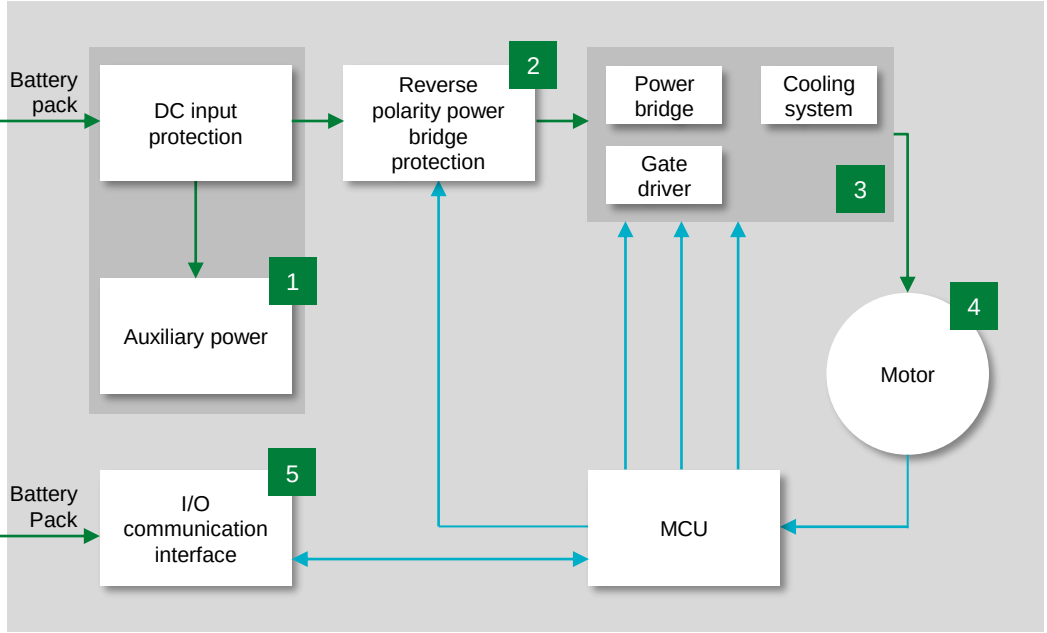
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	Short-circuit protection; overload circuit protection	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; qualified to ISO 8820 standard or new AECQ specification
	TVS Diode	Suppression of transient voltage	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges
	Fuse	Protects cells and downstream BMS components from high fault currents due to external shorts	438A, 437A, MINI, 521	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
	HV DC Contactor Relay	Connect and disconnect battery from main circuitry	DCNEV, DCNLEV	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
2	NTC	Semiconductor temperature measurement	Leaded , Surface Mount	Allows for high-precision temperature measurement in harsher environments	UL Recognized with ring lug mounting; SM NTCs is in hermetically sealed MELF package suitable for operation up to 220 °C
3	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage transients	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 the control signal for the battery pack	MDSR-10	Contamination resistant; compact design	Switches up to 200 Vdc or 0.5 A at up to 10 W, 10^{12} Ω insulation resistance
5	Solid State Relay	Normally open, single pole relay	CPC1009N	Robust operation in a small four-pin package	1500 V input/output isolation; low drive requirements; no arching

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

B ECU/Motor Drive



	Technology	Series
1	High Current Fuse	881, MIDI 70V, Mega
	Low Current Fuse	438A, 437A
	PPTC	RXEF, RKEF
	TVS Diode	TPSMB
2	Schottky Diode	DST
	Thermal Protector	HCRTP-mini
3	MOSFET	X4 Class
	MOSFET Module	MTI200WX75GD/ MTI145WX100GD
	Gate Driver	IXD_6xxSI, IX4340NE
	Temperature Detection	setP™
	NTC	Surface Mount, USUR1000
4	NTC	Leaded , Surface Mount
	Hall Effect Sensor	55100
5	TVS Diode Array	AQ24CANA

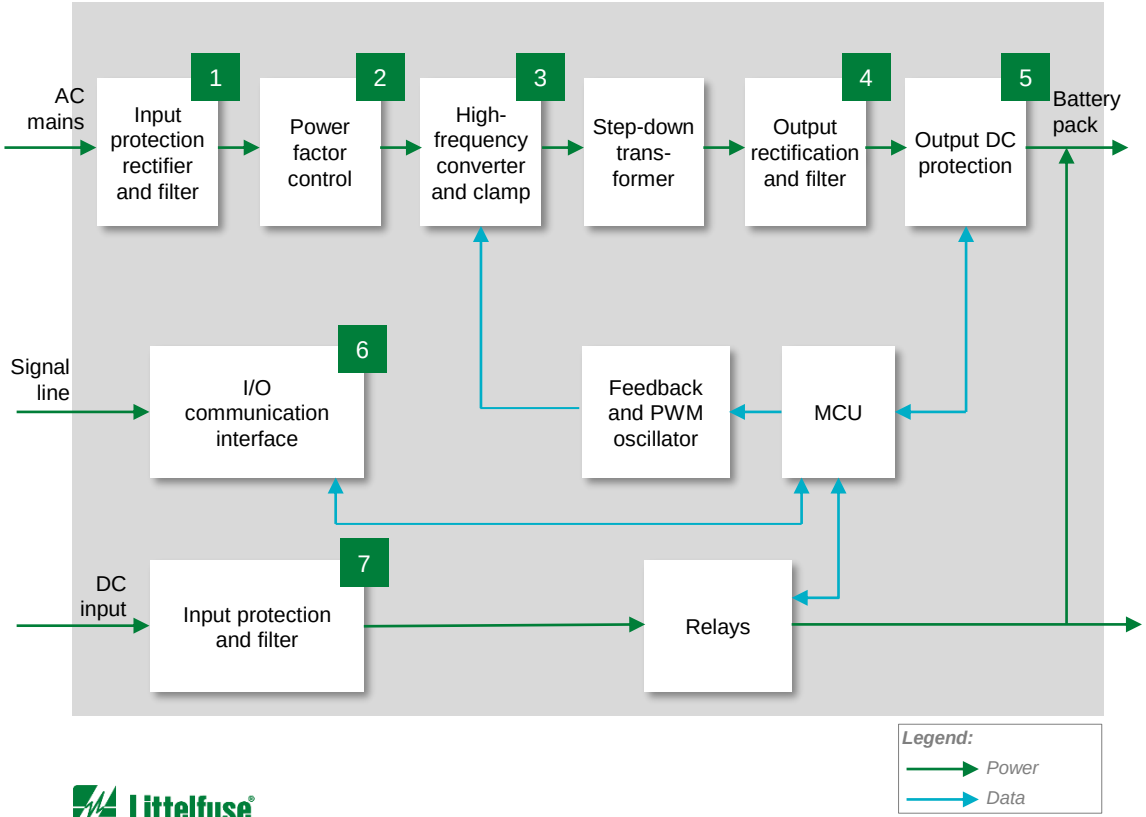
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	High Current Fuse	Short-circuit protection; overload circuit protection	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; qualified to ISO 8820/new AEC
	Low Current Fuse	Protects auxiliary power supply components from high fault currents due to external shorts	438A, 437A	Excellent temperature stability; compact design	Tested to new AECQ specification; fast response to fault current; surface mount device
	PPTC	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	Suppression of transient voltage	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges
2	Schottky Diode	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	Over-temperature thermal protector	HCRTP-mini	Disconnects the circuit from the supply in the event of over-temperature event	Surface mount, can be installed during reflow process, 16 V rated, can break up to 500 A
3	MOSFET	High switching speed in power supply units	X4 Class	Fast response time and lower heat signature	Low $R_{ds\ (on)}$, dv/dt ruggedness
	MOSFET Module	High switching speed in power supply units	MTI200WX75GD/ MTI145WX100GD	Fast response time and lower heat signature	Low $R_{ds\ (on)}$, dv/dt ruggedness
	Gate Driver	Controls switching MOSFETs	IXD_6xxSI, IX4340NE	Dual outputs provide space efficient design, high immunity to latch-up; rise/fall times <10 ns	Tight tolerance, small form factor; fast thermal response
	Digital temperature indicator	Protects motor circuit from overheating	setP™	Auto resets after over-temperature condition is removed; allows for compact design	Resettable; low resistance; compact 0805 outline
	NTC	Semiconductor temperature measurement	Surface Mount, USUR1000	Allows for high-precision temperature measurement in harsher environments	UL recognized with ring lug mounting; SMD NTCs is in hermetically sealed MELF package suitable for operation up to 220 °C
4	NTC	Semiconductor temperature measurement	Leaded , Surface Mount	Allows for high-precision temperature measurement in harsher environments	
	Hall Effect Sensor	Speed measurement of the motor and position detection of the rotor	55100	Available in two- or three-wire versions; miniature flange mount design; wide range of sensitivity	Up to 10 kHz switching speed, unaffected by harsh environments, up to 20 billion operations
5	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage transients	AQ24CANA	Ensures reliability of the equipment without performance degradation of communication lines	AEC-Q101 qualified; low leakage current and clamping voltage

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

C On-Board Charger



	Technology	Series
1	AC Fuse	10EV**, 526**
	Thyristor	HS4040xAQx, S8016xA
	MOV, SIDACtor®	AUMOV P3800FNL
2	Si/SiC MOSFET	X2 Class LSICMOxx
	TVS Diode	TPSMB
3	Si/SiC MOSFET	X2 Class LSICMOxx
	TVS Diode	TPSMB
4	Si/SiC Diode	DPG LSIC2SDxx
5	DC Fuse	10EV**, 525**
6	TVS Diode Array	AQ24CANA
7	TVS Diode	SLD8S, SLD6S, SLD5S

** These products are recommended for three-wheeler vehicles*
*** Please contact Littelfuse sales*

Littelfuse
Expertise Applied | Answers Delivered

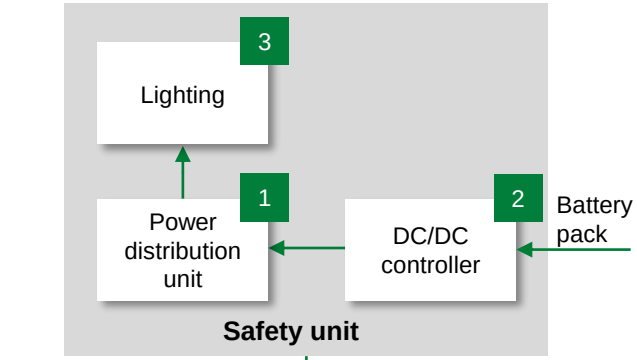
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	AC Fuse	Short-circuit protection; overload circuit protection	10EV**, 526**	Provides safety protection in low- and medium-voltage environments; full range fuses	Bolt down and SMD form factors; high breaking capacity; qualified to ISO 8820/new AEC
	Thyristor	AC/DC rectification	HS4040xAQx, S8016xA	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®	Suppression of transient voltage	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
2	Si/SiC MOSFET	High switching speed in power supply units	X2 Class LSICMOxx	Reduces switching and conduction losses; higher efficiency	Low $R_{ds(on)}$, dv/dt ruggedness
	TVS Diode	Suppression of transient voltage	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges
3	Si/SiC MOSFET	High switching speed in power supply units; SiC for speed and efficiency	X2 Class LSICMOxx	Reduces switching and conduction losses; higher efficiency	Low $R_{ds(on)}$, dv/dt ruggedness
	TVS Diode	Suppression of transient voltage	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges
4	Si/SiC Diode	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	Short-circuit protection; overload circuit protection	10EV**, 525**	Provides safety protection in low- and medium-voltage environments; full range fuses	Bolt down and SMD form factors; high breaking capacity; qualified to ISO 8820/new AEC
6	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT and voltage transients	AQ24CANA	Ensures reliability of the equipment without performance degradation of communication lines	AEC-Q101 qualified; low leakage current and clamping voltage
7	TVS Diode	Suppression of transient voltage	SLD8S, SLD6S, SLD5S	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges

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

D E Safety and Comfort Unit



** These products are recommended for three-wheeler vehicles*
*** Littelfuse also offers custom power distribution modules*

	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

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

Littelfuse
Expertise Applied | Answers Delivered

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	Short-circuit protection; overload circuit protection	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, qualified to ISO 8820 standard
	Fuse Box and Fuse Holder (12–24 V)	Short-circuit protection; overload circuit protection	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, qualified to ISO 8820 standard
	Fuse Box and Fuse Holder (12–70 V)	Short-circuit protection; overload circuit protection	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, qualified to ISO 8820 standard
2	TVS Diode	Suppression of transient voltage	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges
3	Temperature Indicator	Protects lighting circuit from overheating of LEDs	setP™	Auto resets after over-temperature condition is removed; allows for compact design	Resettable; low resistance; compact 0805 outline
	NTC	Semiconductor temperature measurement	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	Suppression of transient voltage	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection and ISO for in-vehicle transient surges
	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

Click on 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; allows for compact design	Resettable; low resistance; compact 0805 outline
	PPTC	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	PPTC	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	Short circuit protection; overload circuit protection	438A, 437A	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
3	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage transients	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	Contamination resistant: 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-/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	Standard covers the on-board electrical system, vehicle systems (which include the combination of 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 electrolyte, under intended use and reasonably foreseeable misuse.	Global
UL 1642	Lithium Batteries	Both are safety standard that 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	Defines safety standards for portable cells and batteries. It is specific to two distinct chemistry systems: lithium-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 lithium-ion).	Global
BATSO 01	Manual for Evaluation of Energy Systems for Light Electric Vehicle (LEV) Secondary Lithium Batteries	Specifies test methods for secondary lithium batteries for safe use in LEV. Transport safety tests are specified in addition.	Global

Additional information can be found on Littelfuse.com

Explore the world of Littelfuse with the Electronics eCatalogs (http://electronicscatalogs.littelfuse.com/)

DC Power Distribution Selection Guide

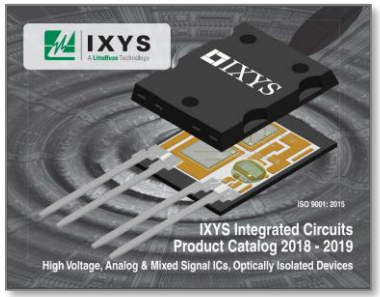
Circuit Protection Selection Guide

Passenger and Commercial Products

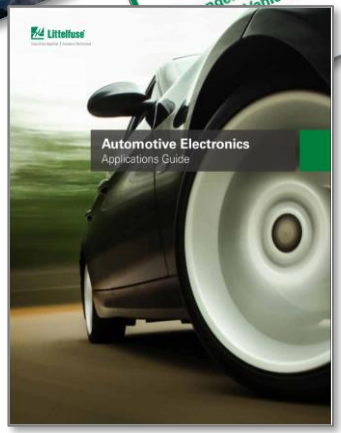
Commercial Vehicle Product

Click on images to open the catalogs

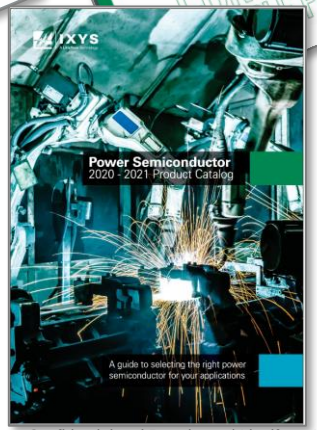
Integrated Circuits Product Catalog



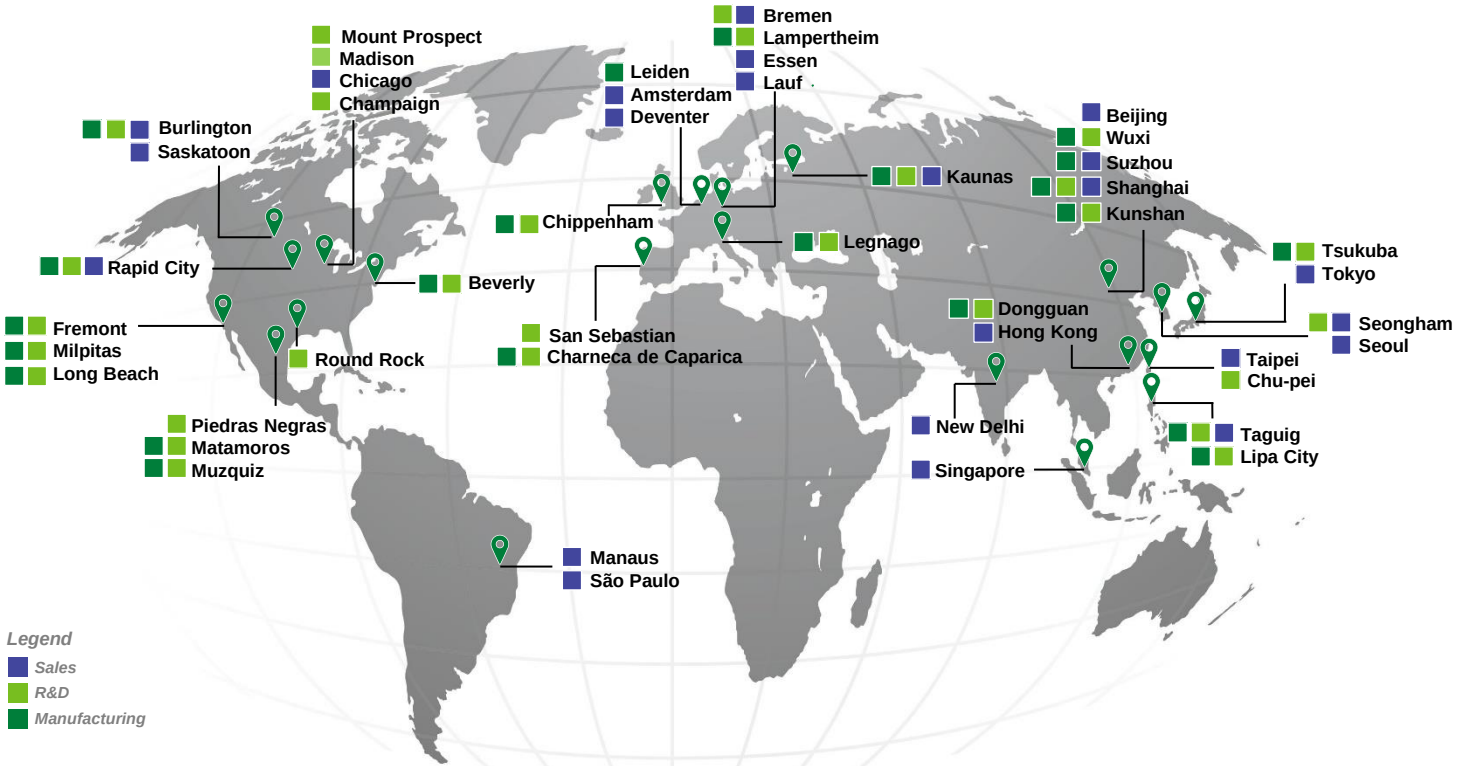
Automotive Electronics Application Guide



Power Semiconductor Selection Guide



Local resources supporting our global customers



Littelfuse
Expertise Applied | Answers Delivered

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 market faster; we offer certification testing to global regulatory standards

Global manufacturing

We offer high-volume manufacturing that is committed to the highest quality standards

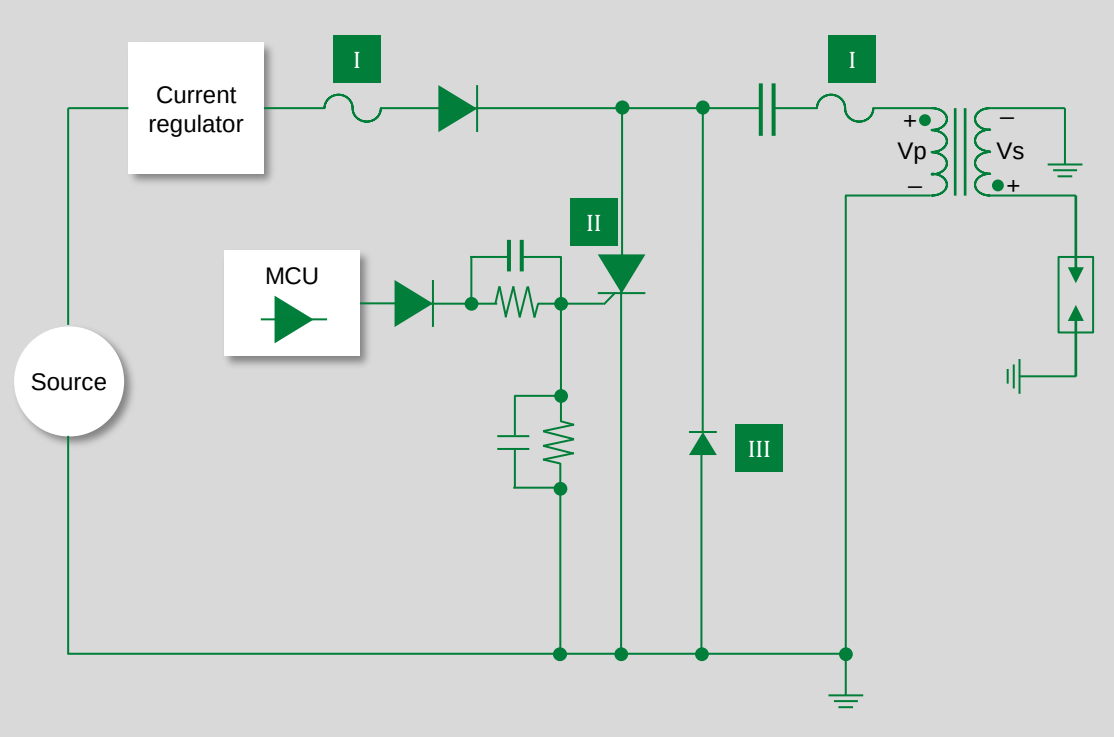
Littelfuse.com

Internal Combustion Engine Solutions

Capacitive Discharge Ignition (CDI)

Current and older ignition system design

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

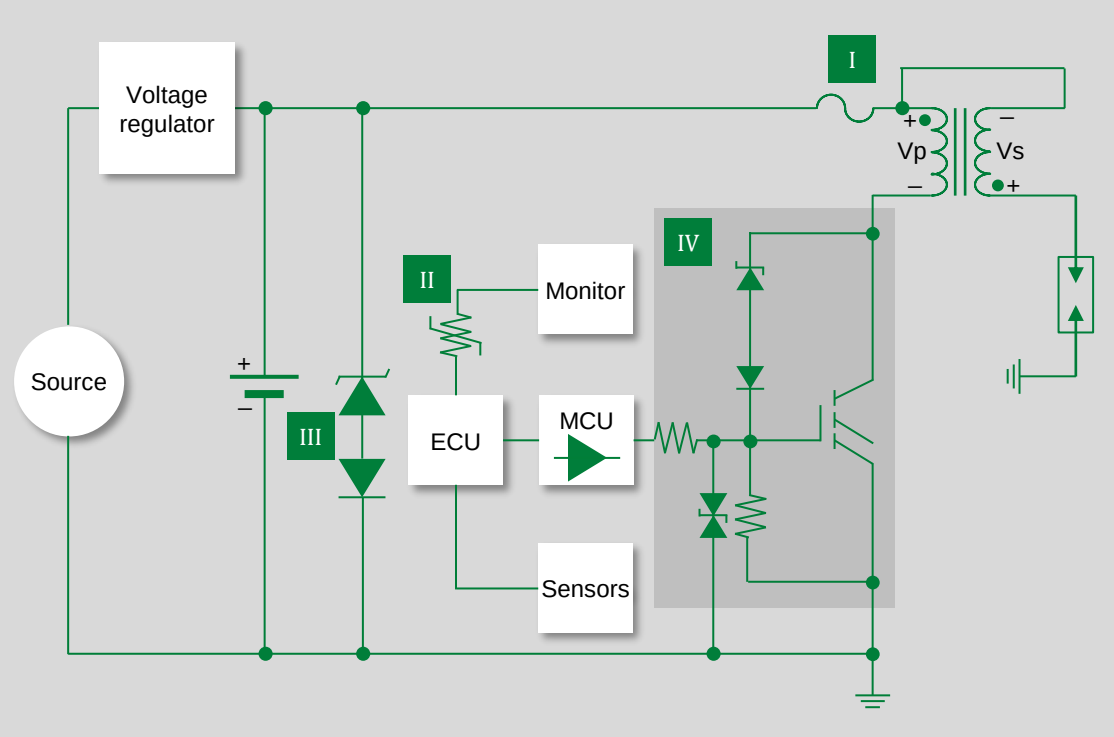


	Technology	Series
I	Fuse	440A, 441A
II	SCR	S6004DS2RP, S6008DS2RP, MCR12DSMT4G

Electronic Fuel Injection (EFI)

Newer, more fuel efficient and less polluting

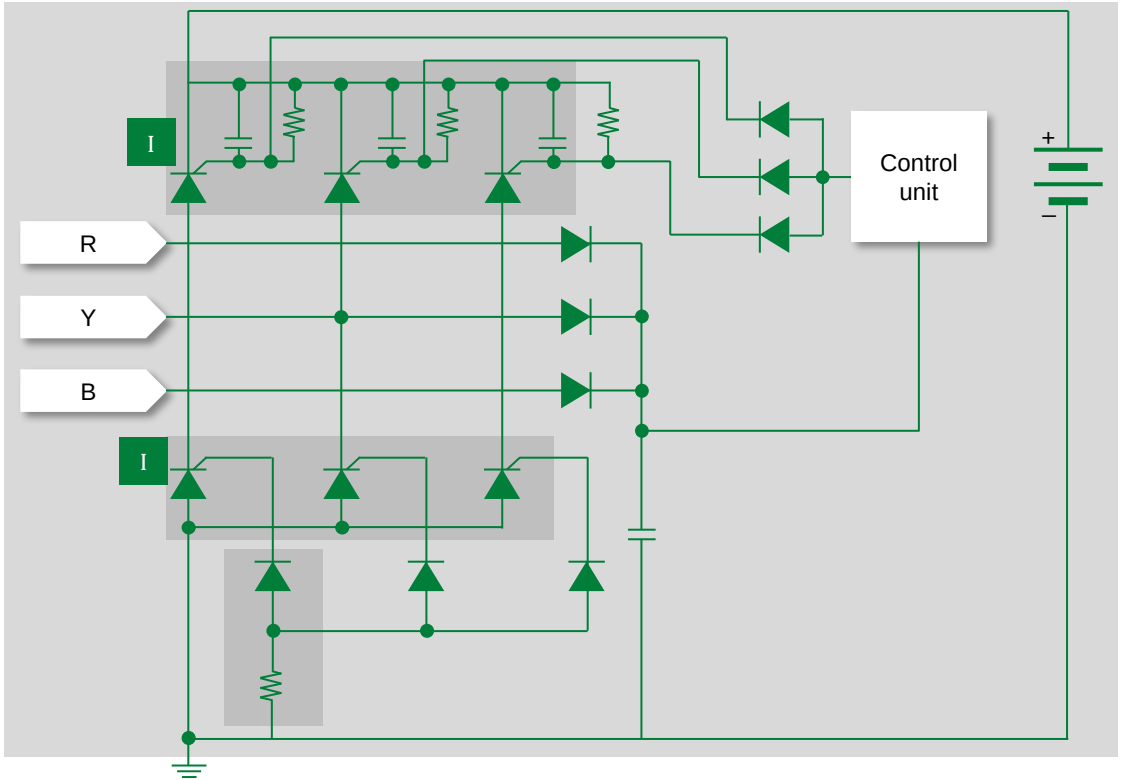
Click on the product series in the table below for more info



	Technology	Series
I	Fuse	440A, 441A
II	PPTC	ASMDC, miniASMDC
III	TVS Diode	TPSMB
IV	Ignition IGBT	LGBxx, LGDxx

Rectifier and regulator (2 W and 3 W) converts AC to DC for electrical systems

Click on 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 18-pole, 3-phase output
18-pole generator at 6000 rpm that produces 900 Hz AC output
(f = RPM/120 x poles)

Littelfuse
Expertise Applied | Answers Delivered

Littelfuse®

Expertise Applied | Answers Delivered

IXYS

A Littelfuse Technology

Littelfuse.com