Littelfuse®

Expertise Applied | Answers Delivered

Electric Two-Wheeler & Three-Wheeler Solutions

Transportation

REV1022

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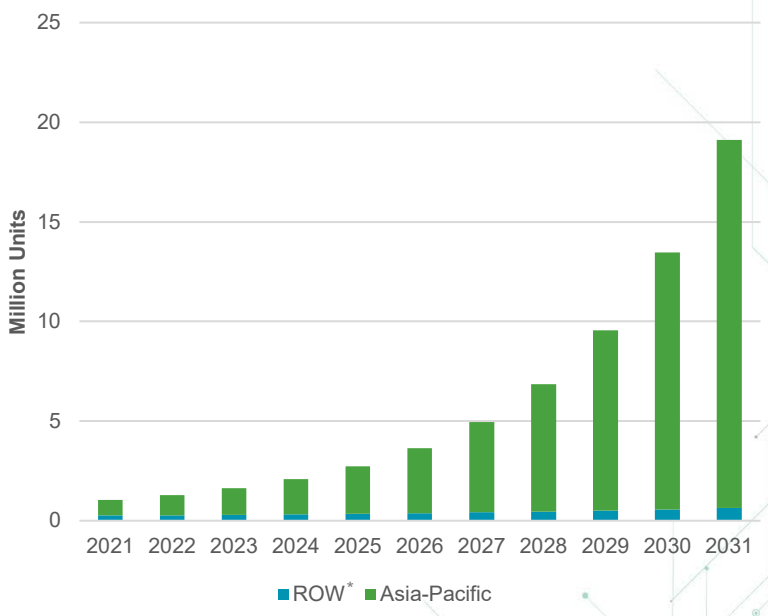
Electric two-wheeler and three-wheeler market trends and drivers

Market trends and drivers
The global electric two-wheeler and three-wheeler market is projected to grow from 1.05 M units in 2021 to 19.11 M units by 2031, at a CAGR of ~34%
The global electric two-wheeler 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 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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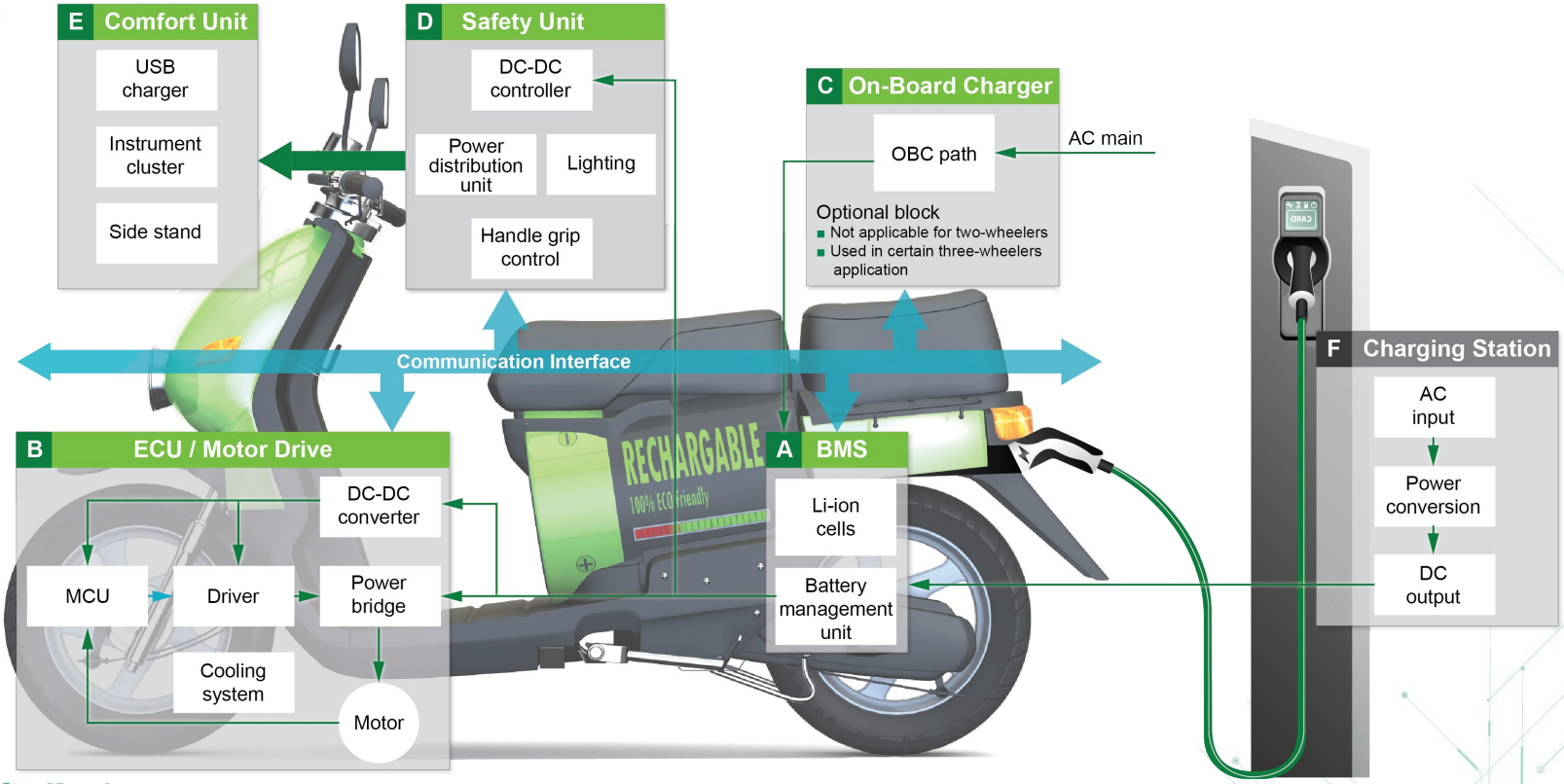
Electric two-wheeler and three-wheeler system architecture



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Littelfuse solutions for electric two-wheelers

Comfort Unit

1 USB / Charging Port
- TVS Diode
- PPTC

2 Cluster
- TVS Diode
- PPTC

3 Side Stand
- Reed Switch

4 ECU / Motor Drive
- TVS Diode
- MOSFET
- Rectifier Diode
- Hall Effect
- NTC

Safety Unit

5 Lighting
- TVS Diode
- MOV

6 Power Distribution Unit
- Fuse
- Fuse Holder

7 Handle Grip Control
- C&K Tactile Switch
- C&K KeySwitch

8 BMS
- Fuse
- TVS Diode
- Diode Array
- NTC
- Reed Switch
- C&K Snap Switch

9 On-Board Charger
- Fuse
- MOV
- TVS Diode
- SCR
- Diode
- NTC

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
- TVS Diode
- SCR
- Diode
- NTC

1 ECU / Motor Drive

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

1 BMS

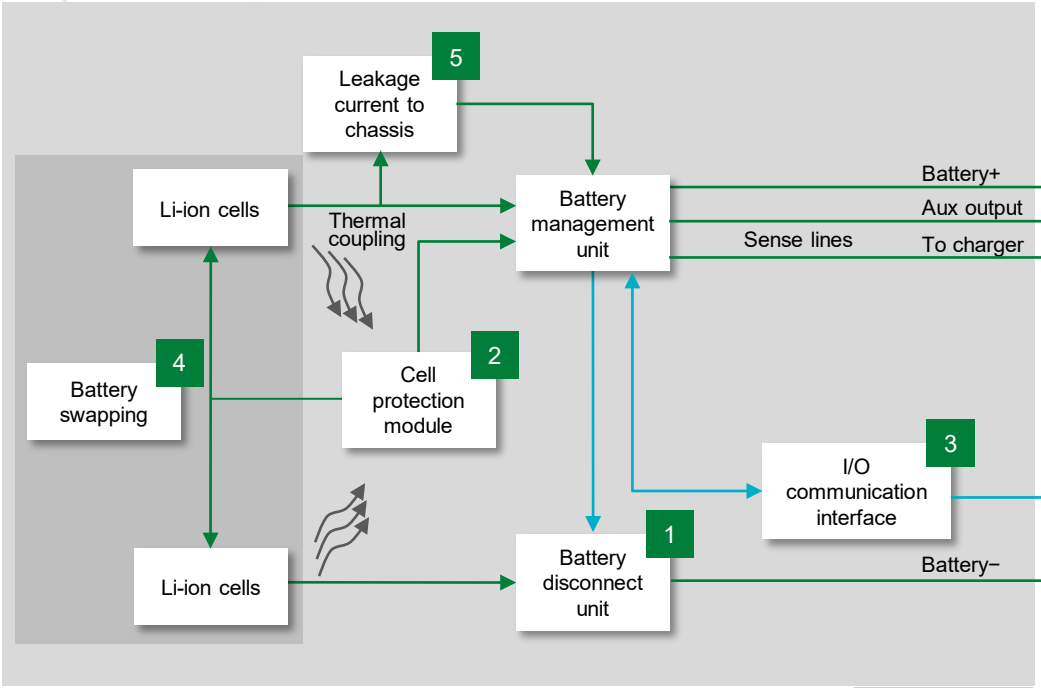
- Fuse
- TVS Diode
- TVS Diode Array
- NTC, Reed Switch
- HV DC Contactor Relay

Acronyms:

TVS: Transient-Voltage Suppression
MOV: Metal Oxide Varistor
NTC: Negative Temperature Coefficient
SCR: Silicon Controlled Rectifier (Thyristor)
HV DC: High Voltage Direct Current

Click the product series in the table below for more info

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, DCNLR
2	NTC**	Leaded, Surface Mount
3	TVS Diode Array	AQ24CANA
4	Reed Switch	MDSR-10
	C&K Switch	ZMS, ZMSM, LCS, KSC, ZMV, ZMW
5	Solid State Relay***	CPC1009N

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

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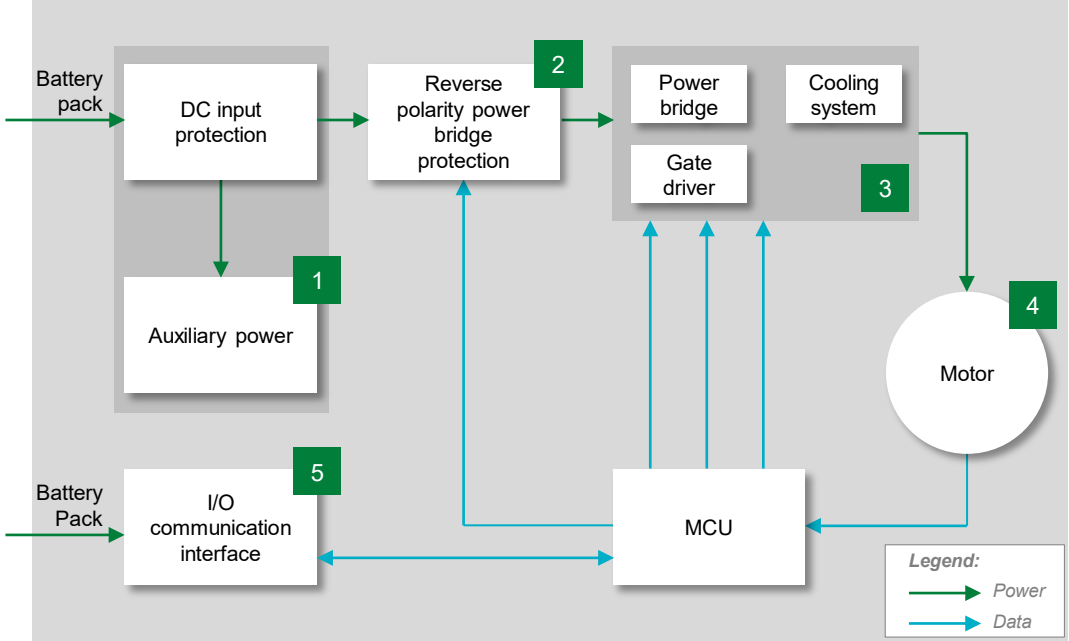
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	Fuse	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	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 voltage spikes
	Fuse	Protects cells and downstream BMS parts 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	Meets new AEC-Q specification; fast response to fault current; surface mount device
	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 from tens of amps to thousands of amps, and tens of volts to thousands of volts
2	NTC	Measures semiconductor temperature	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
3	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage spikes	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
	C&K Switch	Enables battery detection switching	ZMS, ZMSM, LCS, KSC, ZMV, ZMW	Long electrical and mechanical life; ideal when space is limited	IP65/IP67; SPST NO/SPST NC/SPDT; compact size
5	Solid State Relay	Normally open, single pole relay	CPC1009N	Robust operation in a small four-pin package	1500-V I/O isolation; low drive requirements; no arching

Click the product series in the table below for more info

ECU / Motor Drive



Acronyms:

AC: Alternate Current
DC: Direct Current
I/O: Input/Output

MCU: Microcontroller Unit
PPTC: Polymeric Positive Temperature Coefficient Device
Si / SiC: Silicon / Silicon Carbide

	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	Si / SiC MOSFET	X4 Class, LSICMOxx
	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

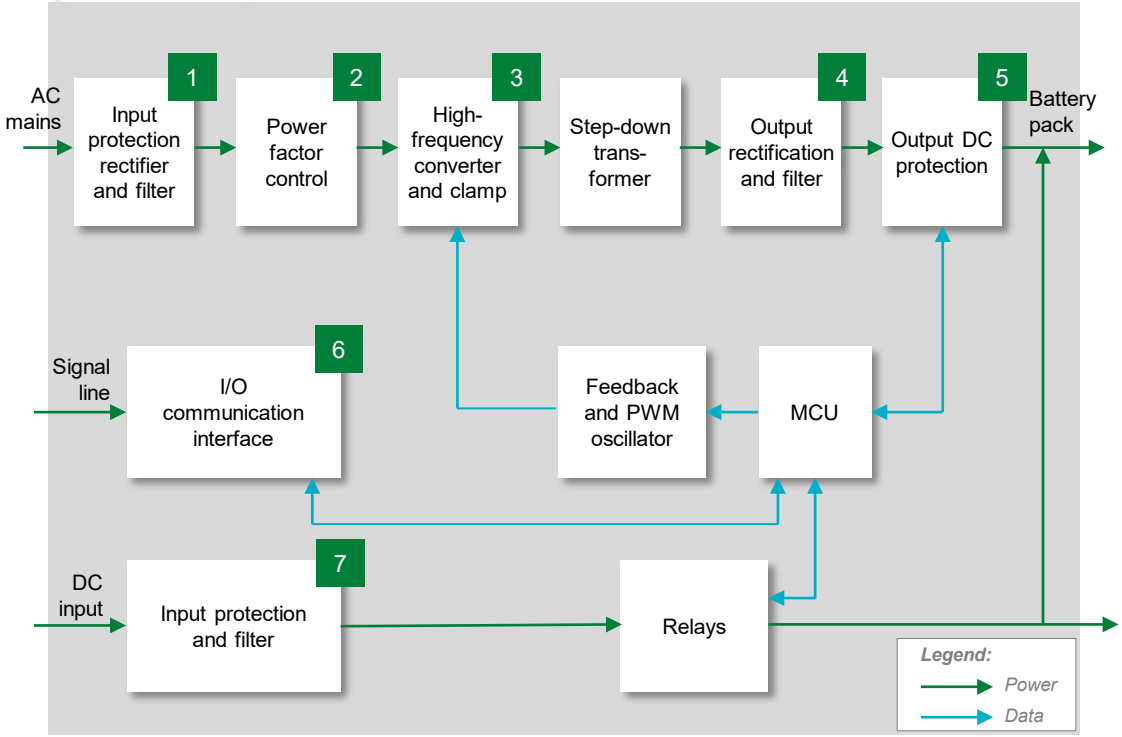
Click on the product series in the table below for more info

Benefits of recommended Littelfuse products

	Technology	Function in application	Product series	Benefits	Features
1	High-Current Fuse	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	Excellent temperature stability; compact design	Meets new AEC-Q specification; fast response to fault current; surface mount device
	PPTC	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	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	Si / SiC MOSFET	Enables high switching speed in power supply units	X4 Class, LSICMOxx	Fast response time and low heat signature	Low $R_{ds\ (on)}$, dv/dt ruggedness
	MOSFET Module	Enables 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; compatible to compact design	Resettable; low resistance; compact 0805 outline
	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	NTC	Measures semiconductor temperature	Leaded, Surface Mount	Allows for high-precision temperature measurement in harsher environments	
	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	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
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

** Recommended for three-wheeler vehicles*
*** Contact Littelfuse sales*

Acronyms:
PWM: Pulse Width Modulation
GDT: Gas Discharge Tube

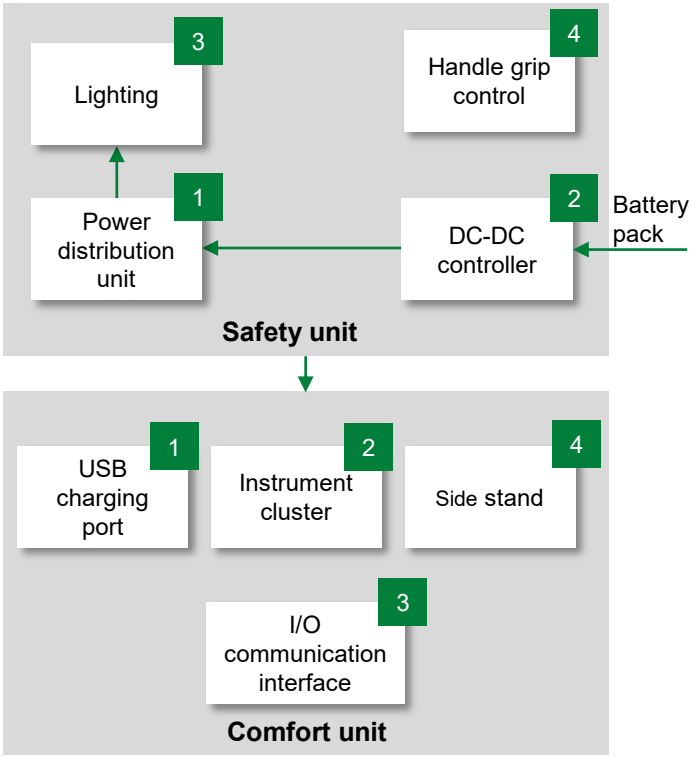
Click on the product series in the table below for more info

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 and SMD form factors; high breaking capacity; meets ISO 8820/new AEC qualifications
	Thyristor	Rectifies AC-DC	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®	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
2	Si / SiC MOSFET	Enables high switching speed in power supply units	X2 Class, LSICMOxx	Reduces switching and conduction losses; increases efficiency	Low $R_{ds(on)}$, dv/dt ruggedness
	TVS Diode	Suppresses voltage spikes	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 voltage spikes
3	Si / SiC MOSFET	Enables high switching speed in power supply units; uses SiC for speed and efficiency	X2 Class, LSICMOxx	Reduces switching and conduction losses; increases efficiency	Low $R_{ds(on)}$, dv/dt ruggedness
	TVS Diode	Suppresses voltage spikes	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 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**, 525	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 qualifications
6	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage spikes	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	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



	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 Tactile Switch & Keyswitch	K12S***, KSC, RKX

	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

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

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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	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	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 Tactile Switch & Keyswitch	Handle grip control	K12S***, KSC, 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

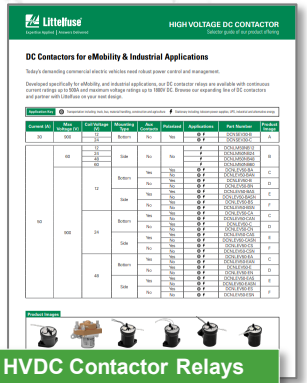
	Technology	Function in application	Product series	Benefits	Features
1	Temperature Indicator	Protects USB C plugs and receptacles from overheating	setP™	Auto-resets after over-temperature condition is removed; compatible to compact design	Resettable; low resistance; compact 0805 outline
	PPTC	Provides 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	PPTC	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	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	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-wheelers and three-wheelers

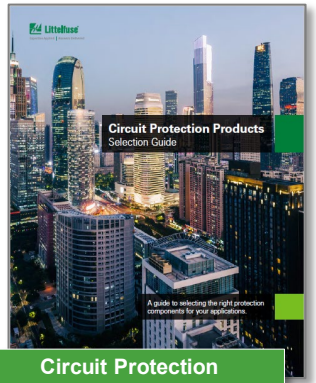
Standard	Title	General scope	Region
UL 2849	Outline of Investigation for Electric Bicycles, Electrically Power Assisted Cycles (EPAC Bicycles), Electric Scooters, and Electric Motorcycles	Standard covers the on-board electrical system, and vehicle systems (including the chargers and batteries) of eBikes, 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	Defines 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	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 on Littelfuse.com

Explore the world of Littelfuse with the electronics eCatalogs (electronicscatalogs.littelfuse.com)

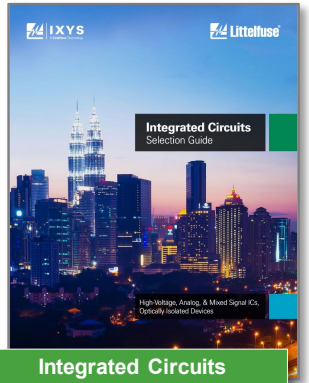


HVDC Contactor Relays Selection Guide



Circuit Protection Selection Guide

Sensing Products Selection Guide

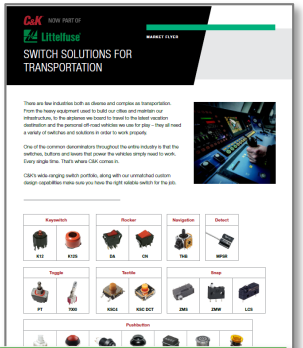


Integrated Circuits Selection Guide

Power Semiconductor Catalog

Click on images for more information

Integrated Circuits Product Catalog



C&K Transportation Flyer

Two-/Three-Wheeler Charging Solutions

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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

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 and 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 provide high-volume manufacturing that is committed to the highest quality standards

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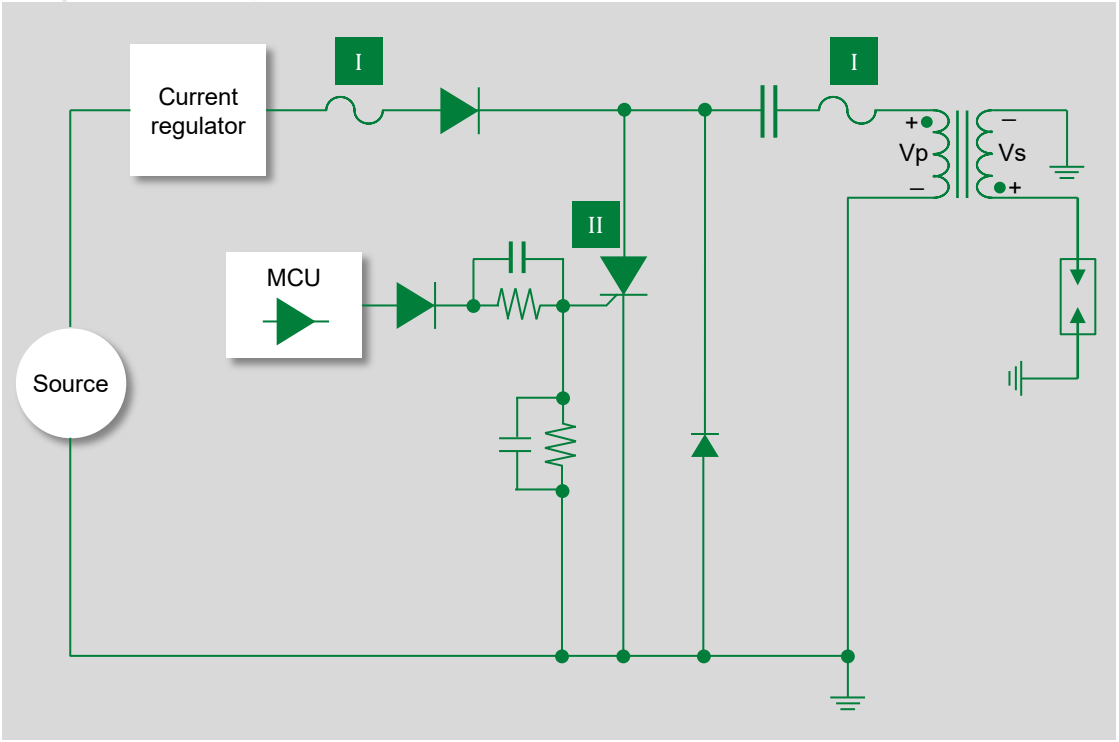
Internal Combustion Engine Solutions

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

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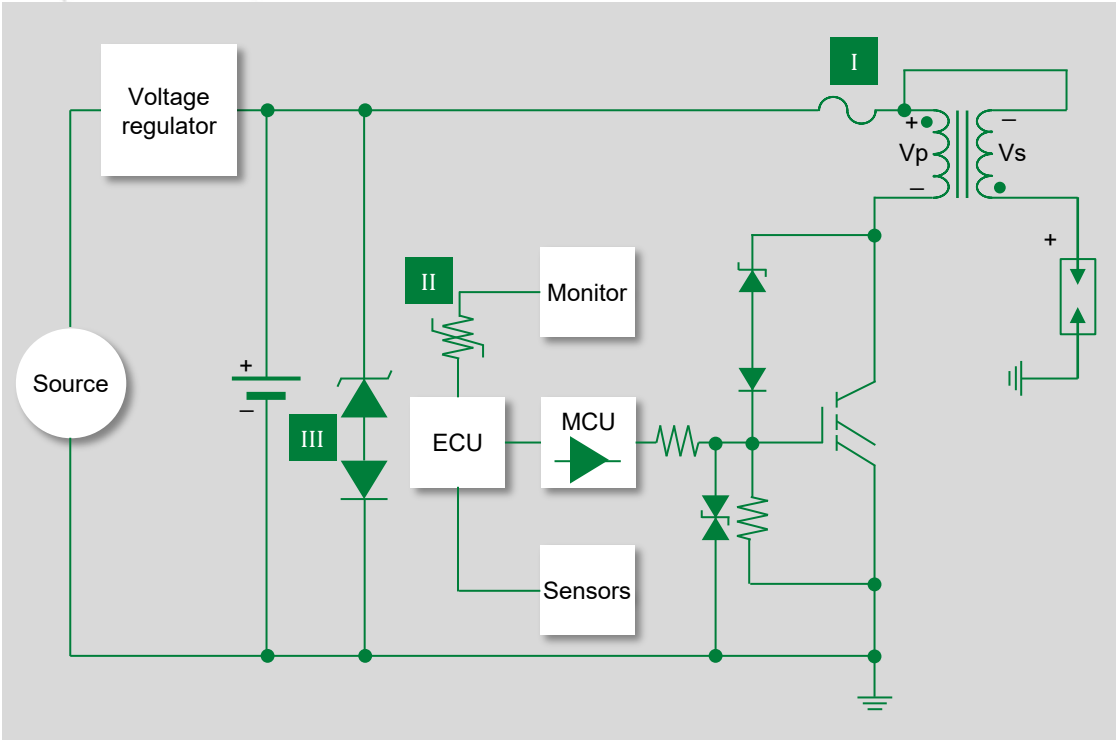
Electronic Fuel Injection (EFI)
Newer, more fuel efficient, and less polluting

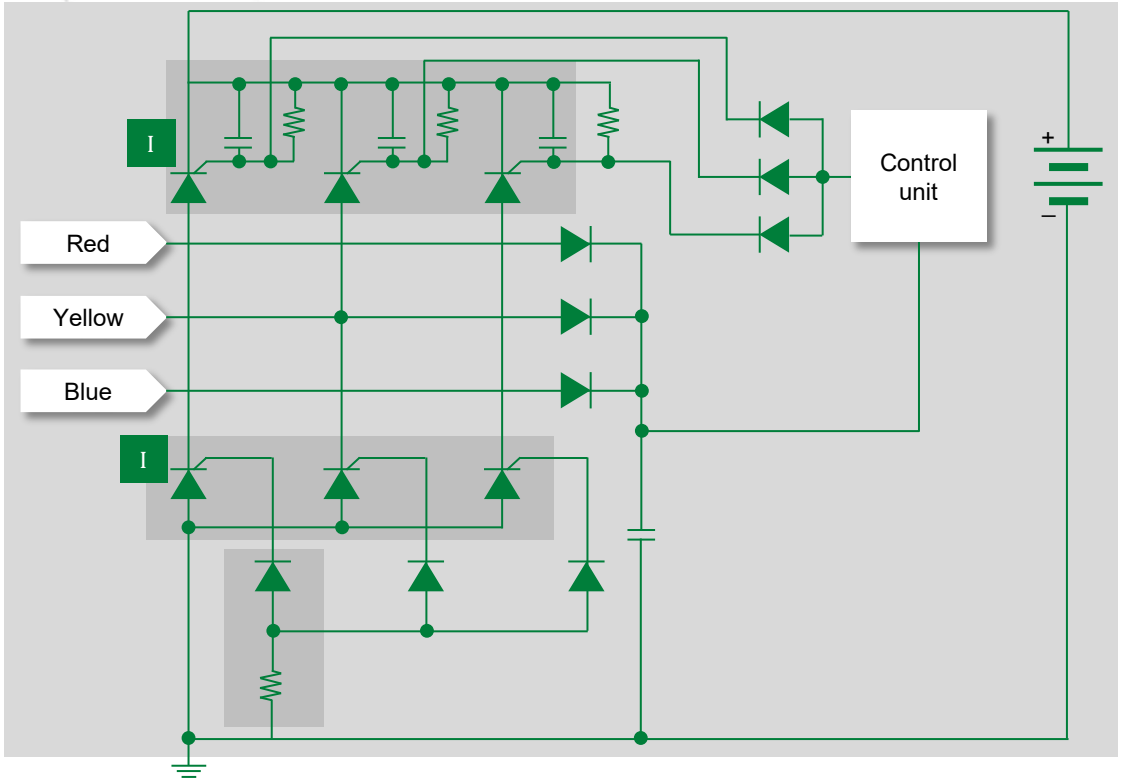
Click the product series in the table below for more info



	Technology	Series
I	Fuse	440A, 441A
II	PPTC	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 18-pole,
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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