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Battery Disconnect and Protection

Automotive

REV0821

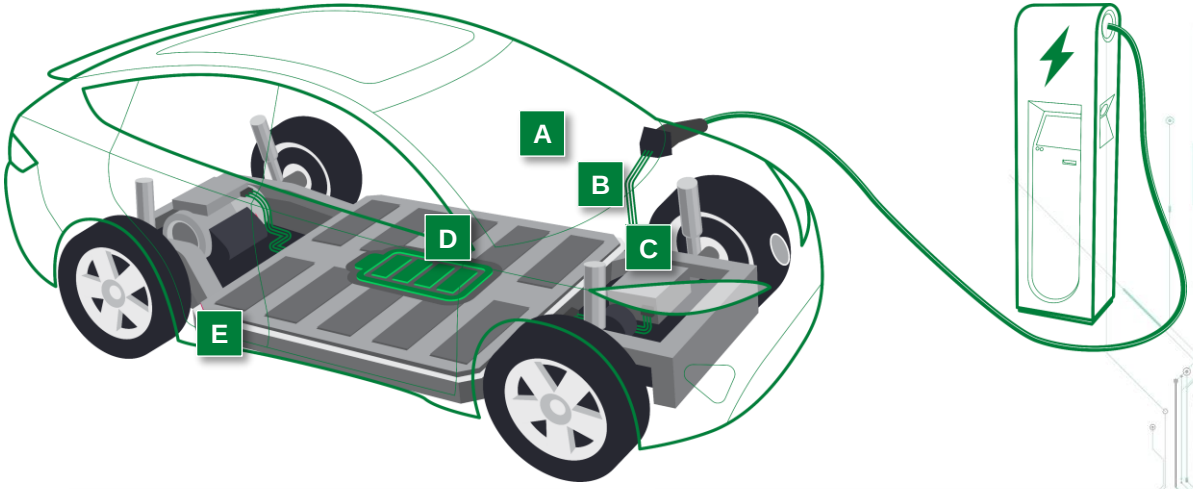
Advanced electronics are driving 80% of the innovation in multiple automotive applications

A Infotainment & Communication

- Smart infotainment
- Navigation
- Multipurpose camera
- Telematics box

B Network Systems & Body Electronics

- CAN, LIN
- USB, Wireless
- Keyless entry
- Lighting control



C Advanced Driver Assistance System

- V2X Communication
- Radar
- eCall
- Sensor fusion

D Power Train

- Battery management system
- On-board charger
- Traction motor inverter
- DC/DC converter

E Chassis & Safety System

- Seatbelt safety
- Tire pressure monitoring
- Battery disconnect
- Fuel level detection

Increased need for circuit protection, power control, and sensing products to ensure safety and reliability

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xEV market overview

Market Trends

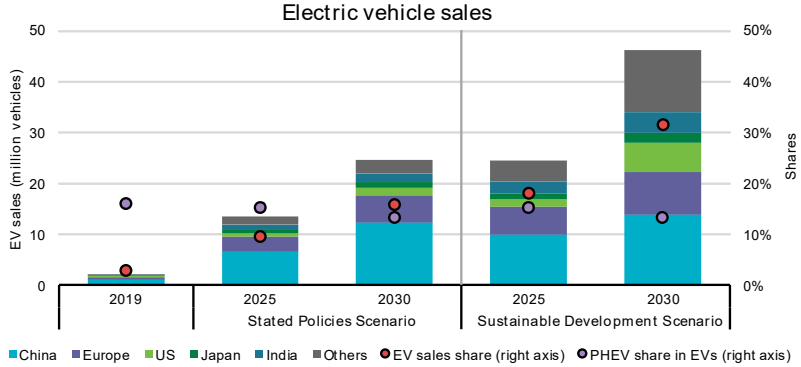
Global sales of passenger cars were sluggish in 2019, but electric cars had another banner year. The global electric car fleet consisted of 7.2 million (2019) versus 5.1 million (2018). By 2030, global EV sales will reach 25 million units. China will continue to dominate the EV market.

The infrastructure for electric-vehicle charging continues to expand. There were 7.3 million chargers worldwide in 2019 (6.5 million were private). Convenience, cost-effectiveness, and a variety of support policies (such as preferential rates, equipment purchase incentives, and rebates) are the main drivers.

Electric car sales drive cost reductions in batteries, boosting deployment across all road vehicle categories.

Policies continue to support electric vehicle deployment and are evolving to a more holistic policy portfolio. Environmental and sustainability objectives drive electric vehicle policy support at all governance levels.

Market Projections



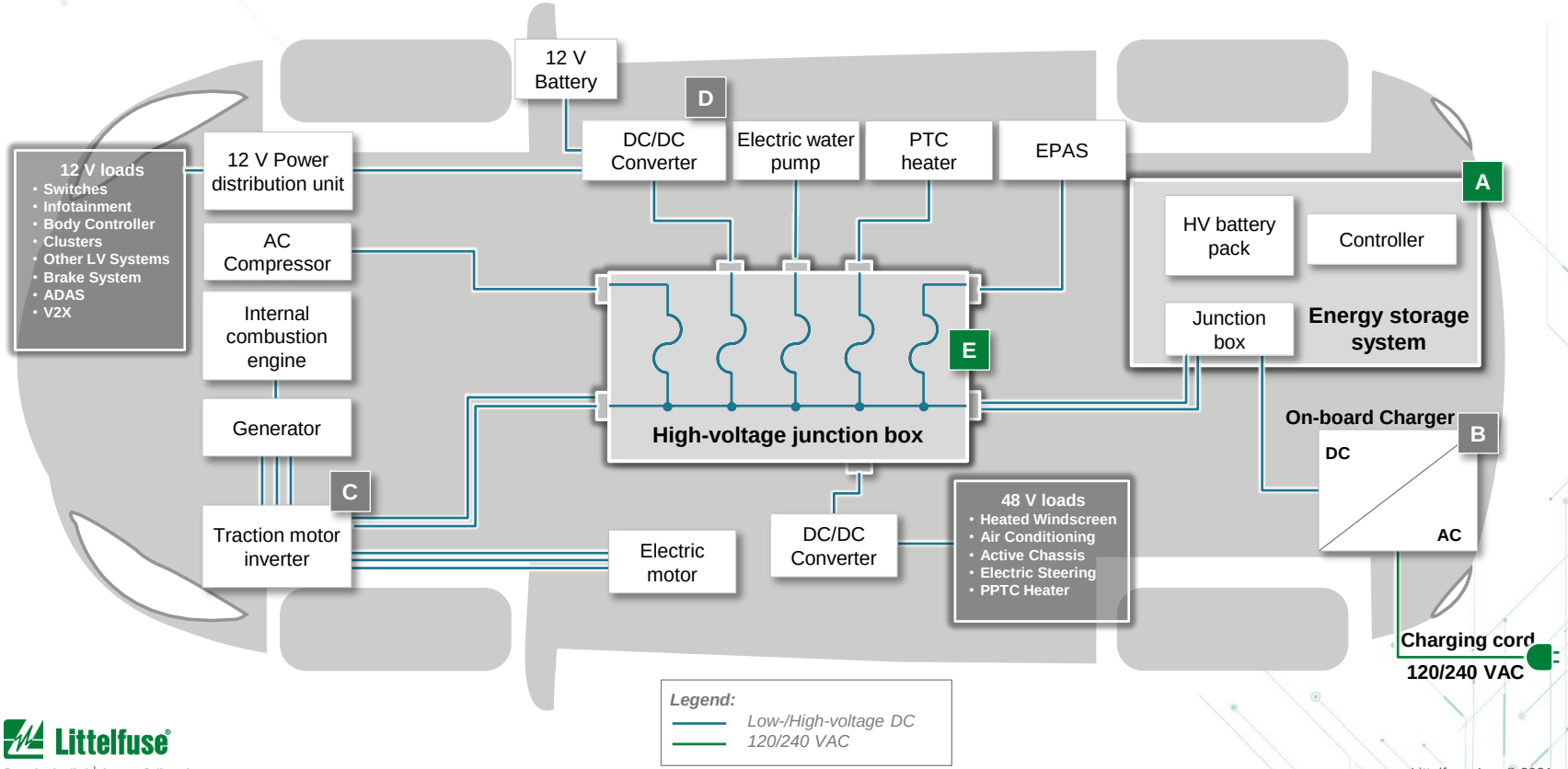
Stated Policy Scenario *includes aims to illustrate the likely consequences of existing and announced policy measures.*

Sustainable Development Scenario *aims at ensuring universal energy access for all by 2030, bringing about sharp reductions in emissions of air pollutants and meeting global climate goals in line with the Paris Agreement. It is based on limiting the global temperature rise to below 1.7–1.8 degrees Celsius with a 66% probability, reaching net zero emissions by 2070.*

Source: Global EV Outlook 2020

Government regulations, environmental concerns, and performance drive shift to EV

Overview of the powertrain for electric vehicle



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Electric vehicles (passenger and commercial) share many functional blocks including common powertrain architectures

A Battery Management System

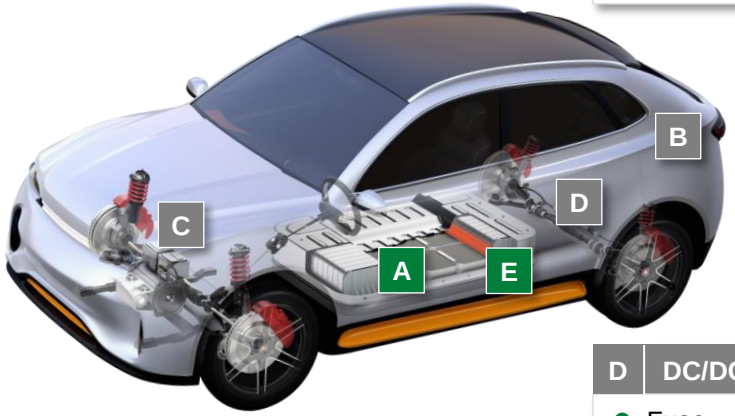
- Fuses
- TVS Diode
- Solid State Relay
- Diode Array

B On-board Charger

- Fuses
- MOV
- SIDACtor®
- SCR
- TVS Diode
- Diode Array

C Traction motor inverter

- TVS Diode
- Diode Array
- Reflowable Thermal Protectors (RTP)
- Gate Driver



E Battery Distribution Unit

- Bolt-down Fuses
- Contactors
- Pyro Fuse

D DC/DC Converter

- Fuse
- TVS Diode, Diode Array
- Gate Driver
- Reflowable Thermal Protectors (RTP)

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A

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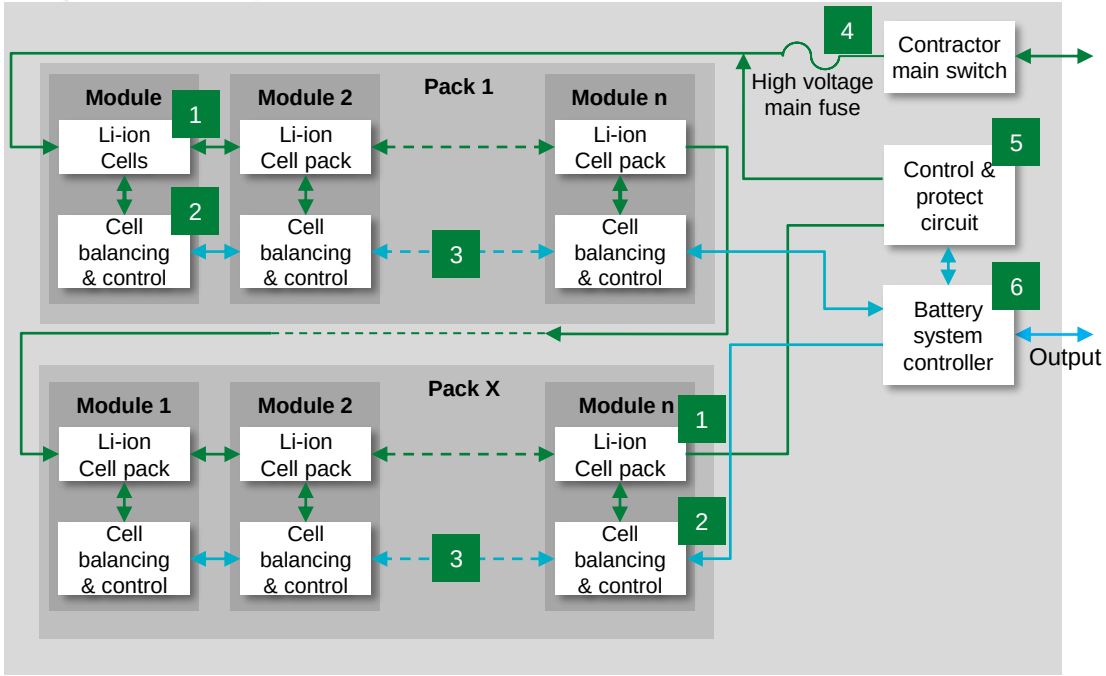
Battery Management System (BMS)

- Battery Management System
- Battery Module

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

Battery management system block diagram



	Technology	Product Series
1	SMD Fuse	501A, 881A
	TVS Diode	TPSMC, SZ1SMC, SZ1.5SMC
2	SMD or In-line Fuse	438A, 441A, 521
	TVS Diode	TPSMB, SZ1SMB, SZP6SMB
3	Diode Array	AQ05C
	TVS Diode	TPSMA6L, SZ1SMA
4	High-voltage fuse	SHEV, 20HEV
5	Gate Driver	IXD_6xxSI
6	Diode Array	AQ24CANA
	Fuse	885
	TVS Diode	TPSMB, TPSMC

Acronyms:
MOV: Metal Oxide Varistor
TVS: Transient Voltage Suppressor
SMD: Surface Mount Device

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A

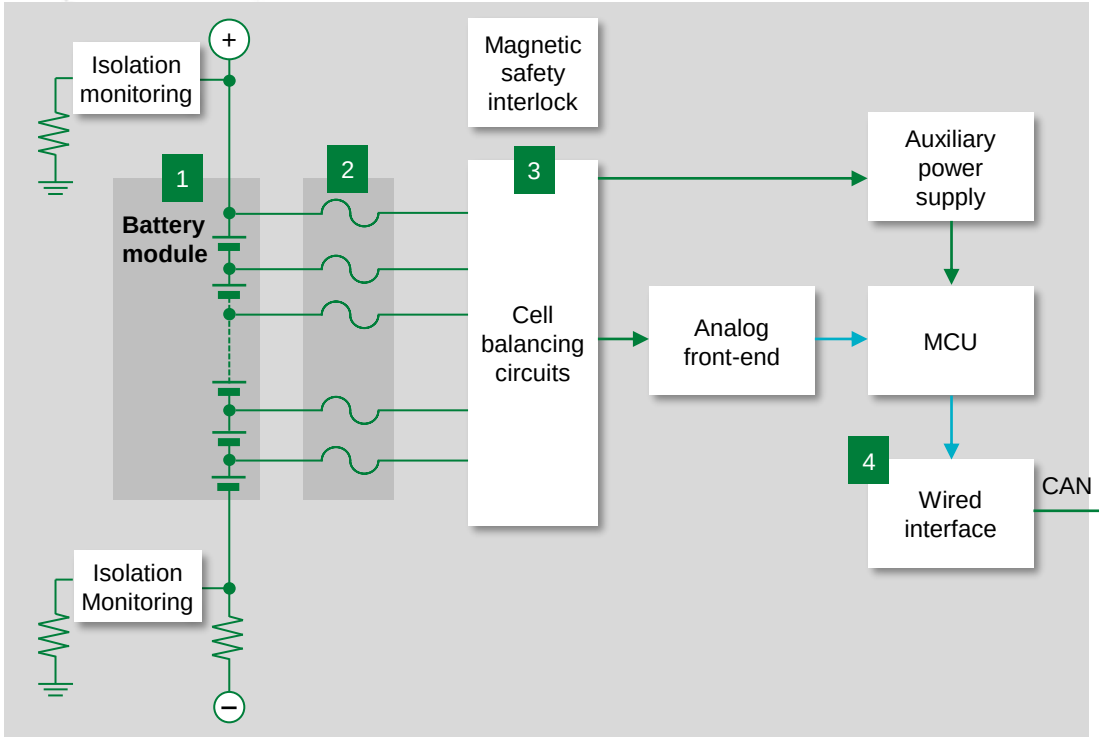
Potential Littelfuse products for cell/module level protection

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

	Technology	Function in application	Series	Benefits	Features
1	SMD Fuse	Protects cells and downstream BMS components from high fault currents due to external shorts	501A, 881A	Ceramic substrate excellent temperature stability and performance reliability; compact design	Tested to new AEC-Q specification; fast response to fault current; surface mount device
	TVS Diode	Transient voltage suppression	TPSMC, SZ1SMC, SZ1.5SMC	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection an ISO for in-vehicle transient surges
2	SMD or In-Line Fuse	Protects cells and BMS components from overcurrent	438A, 441A, 521	Ceramic substrate excellent temperature stability and performance reliability; compact design	Tested to new AECQ specification; fast response to fault current; surface mount device
	TVS Diode	Transient Voltage Suppression	TPSMB, SZ1SMB, SZP6SMB	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	TVS Diode	Transient Voltage Suppression	AQ05C	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
	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT, and voltage transient	TPSMA6L, SZ1SMA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current and clamping voltage
4	High-Voltage Fuse	Short Circuit Protection Overload Circuit Protection	SHEV, 20HEV	Provides safety protection in high-voltage environments, full range fuse	Bolt down form factor; high breaking capacity; qualified to ISO8820 standard
5	Gate Driver	Controls the switching MOSFETs	IXD_6xxSI	Dual outputs provide space efficient design; high immunity to latch-up, rise/fall times less than 10 ns	Tight tolerance; small form factor; fast thermal response
6	Diode Array	Protects CAN bus from ESD, EFT and voltage transient	AQ24CANA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current and clamping voltage
	SMD Fuse	Protects cells and BMS components from over current	885	High voltage SMD form-factor allows for compact design; ceramic body ensures compatibility with high temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
	TVS diode	Transient Voltage Suppression	TPSMB, TPSMC	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

Battery module block diagram



	Technology	Series
1	HV Fuse	885, 521
2	LV Fuse	440A, 437A, 438A
3	TVS Diode	TPSMB, SZ1SMB
4	Diode Array	AQ24CANA

Acronyms:
HV: High Voltage
LV: Low Voltage

Legend:
Power
Data

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

Protection and sensing solutions for battery packs

	Technology	Function in application	Series	Benefits	Features
1	HV Fuse	Protects battery pack module and cable from over current	885, 521	Reduces customer qualification time by complying with third-party safety standards such as ISO	Third-party compliance UL/ISO; low internal resistance; shock safe; vibration resistant
2	LV Fuse	Analog front-end protection of user and environment in case of external short, overload between power-sense line	440A, 437A, 438A	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC; SMD form-factor allows for compact design	Surface mountable; compatible with lead-free solder process per IEC standards; high reliability
3	TVS Diode	Protects sensitive electronic components from voltage transients	TPSMB, SZ1SMB	Improves system reliability by protecting downstream components from transients on power lines	600 W peak pulse capability; compatible with lead-free solder reflow temperature profile
4	Diode Array	Protects can bus sensitive electronic ICs from ESD, EFT, and voltage transient	AQ24CANA	Smaller form-factor and multi-line protection enables ease of design	AECQ-101 qualified; low capacitance; low leakage current

E

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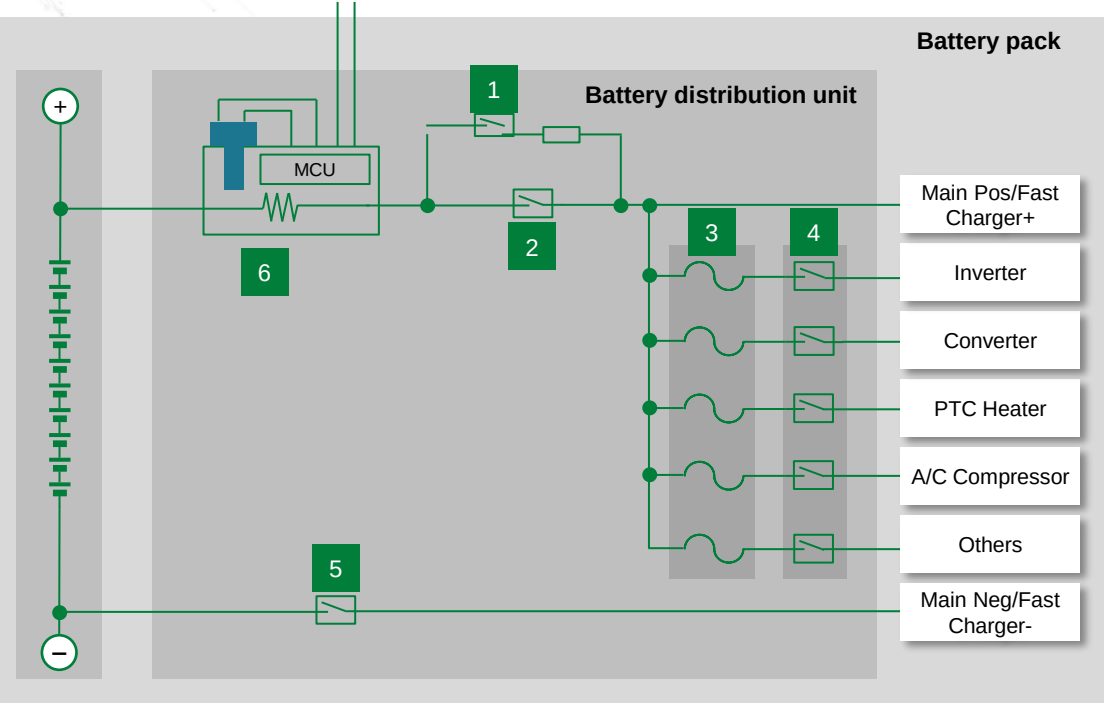
Battery Distribution Unit (BDU)

- Battery Distribution Unit Architecture
- High Voltage DC Contactor Relays
- Pyro Safety Module

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

Battery distribution unit block diagram



	Technology	Series
1	Pre-Charge Contactor	DCNSEV, DCNLEV
2	Main Positive Contactor	DCNEV
3	Auxiliary Fuse	10EV*, 20EV, SHEV
4	Auxiliary Contactor	DCNEV, DCNLEV
5	Main Negative Contactor	DCNEV
6	Pyro Safety Module	PSM*

** Please contact Littelfuse Associates for details*

E

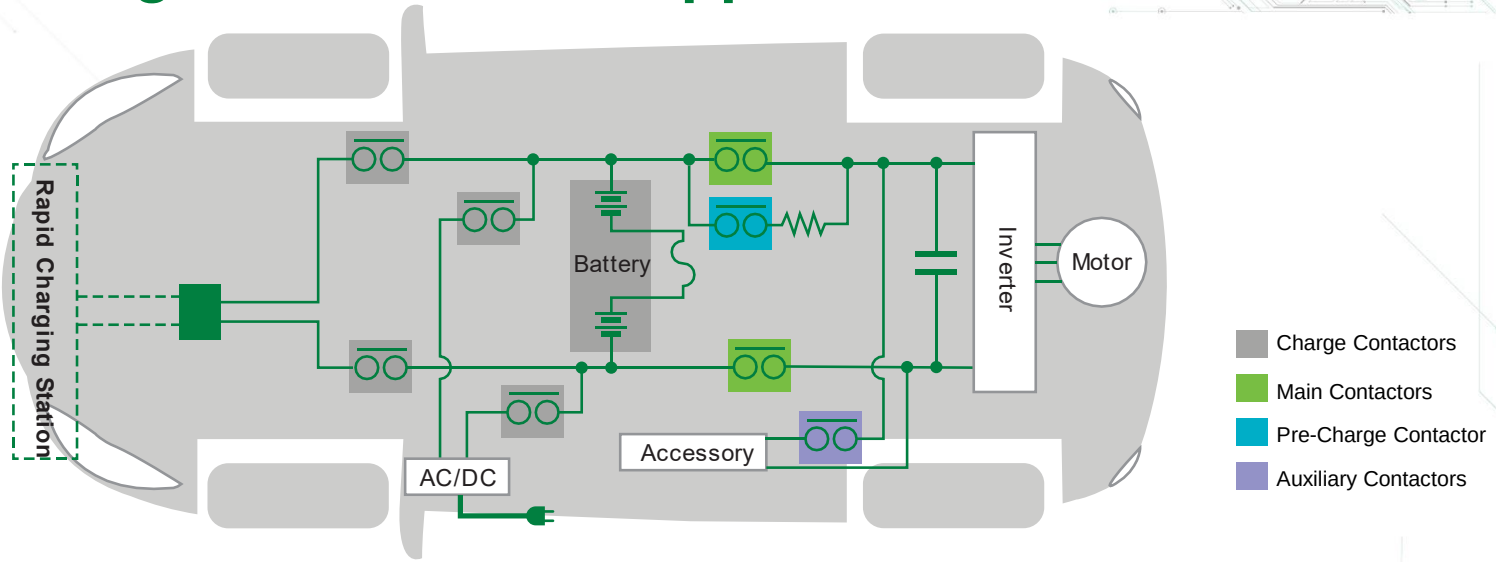
Benefits of Littelfuse products in battery distribution unit

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

	Technology	Function in application	Series	Benefits	Features
1	Pre-Charge Contactor	Used to protect the main contactors from an excess inrush current, a pre-charge contactor is used together with a pre-charge resistor to charge the capacitors of the power inverter to a level of typically 90–98% of the battery voltage	DCNSEV, DCNLEV	Allows a low-voltage signal to switch the contacts for a high voltage signal	Wide Amperage Rating 30 A−100 A; gas filled contact chamber and magnetic blowouts for arc suppression; available direct switched auxiliary circuit for status indication
2	Main Positive Contactor	The main contactors connect and disconnect the traction battery from the entire electric drivetrain in the vehicle	DCNEV	Allows a low voltage signal to switch the contacts for a high-voltage signal	Wide Amperage Rating 100 A−500 A; gas filled contact chamber and magnetic blowouts for arc suppression; integrated coil economizer included in many models; available direct switched auxiliary circuit for status indication
3	Auxiliary Fuse	Short circuit protection; overload circuit protection	10EV*, 20EV, SHEV	Provides safety protection in high-voltage environments, full range fuse; can protect the entire pack's voltage and short circuit current	Bolt down form factor; high breaking capacity; qualified to ISO 8820 standard
4	Auxiliary Contactor	Control other electrical loads in the vehicle that are operated by the HV battery (for example, electric heater, blower, A/C compressor, power steering pump, and so on)	DCNEV, DCNLEV	Allows a low voltage signal to switch the contacts for a high-voltage signal	Wide Amperage Rating 100 A−500 A; gas filled contact chamber and magnetic blowouts for arc suppression; integrated coil economizer included in many models; available direct switched auxiliary circuit for status indication
5	Main Negative Contactor	The main contactors connect and disconnect the traction battery from the entire electric drivetrain in the vehicle	DCNEV	Allows a low voltage signal to switch the contacts for a high-voltage signal	Wide Amperage Rating 100 A−500 A; gas filled contact chamber and magnetic blowouts for arc suppression; integrated coil economizer included in many models; available direct switched auxiliary circuit for status indication
6	Pyro Safety Module	Replaces a discrete fuse as the main protection of the entire battery pack	PSM*	Provides tighter control over the current level at with power is cut; can also be controlled through an external communication bus	500 VDC operating voltage and up to 400A operating current; self triggered or controlled externally; ASIL-D version available

** Please contact Littelfuse Associates for details*

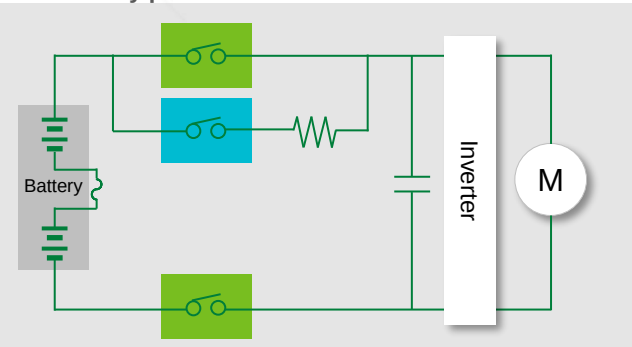
High-voltage DC contactor applications in EV



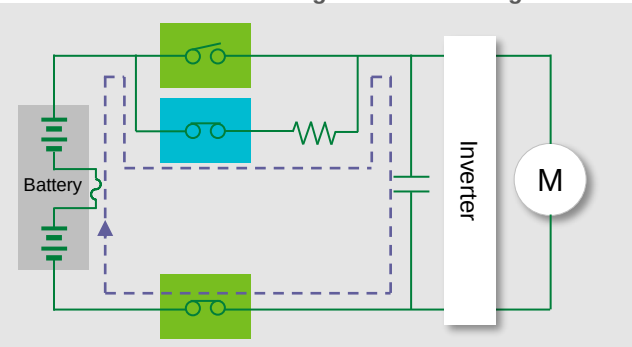
- ***Main Contactor:*** *Used in both lines (positive and negative) of the traction battery. The main contactors connect and disconnect the traction battery from the entire electric drivetrain in the vehicle.*
- ***Pre-charge Contactor:*** *Used to protect the main contactors from an excess inrush current, a pre-charge contactor is used together with a pre-charge resistor to charge the capacitors of the power inverter to a level of typically 90–98% of the battery voltage.*
- ***Charger Contactor:*** *Used to establish connection between the battery charger and the traction battery when the vehicle is connected to a charging station.*
- ***Auxiliary Contactors:*** *Control other electrical loads in the vehicle that are operated by the HV battery (for example, electric heater, blower, A/C compressor, pneumatic brake compressor, power steering pump, and so on).*

Operating sequence of Main Contactor Relays

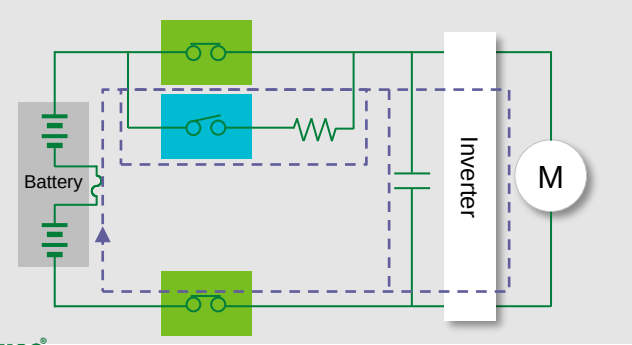
1 All relays open
battery pack isolated



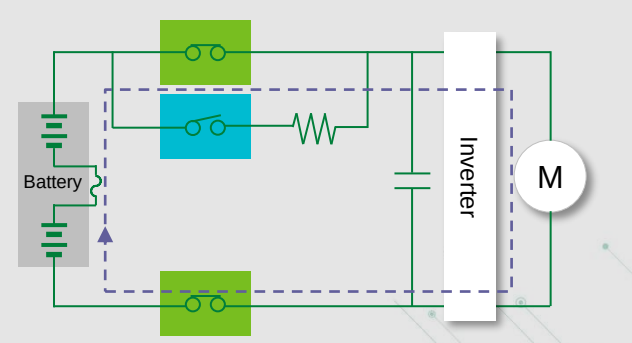
2 Close Pre-Charge and Ground Relay to charge capacitive loads in Inverter through current limiting resistor



3 Close Main + Relay



4 Open Pre-charge Relay



Charge Contactors — *Pre-Charge Contactor*

Main Contactors — *Auxiliary Contactors*

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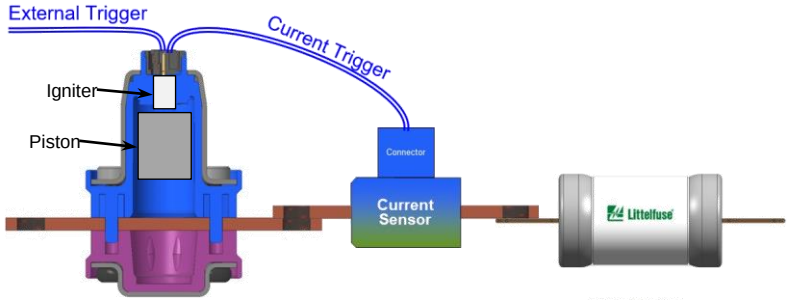
Pyro Safety Module–integration of many components

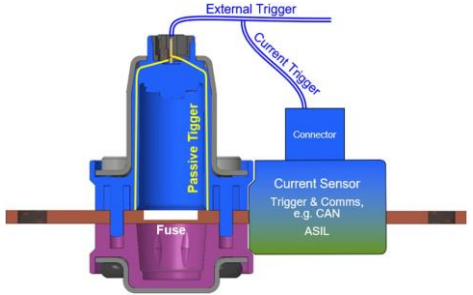
Traditional Architecture



Individual components are used. They need to be coordinated carefully for proper functioning.

- Pyro Fuse Module
- Current Sensor
- Discrete Fuse
- External Control (trigger)

Pyro Safety Module (PSM)



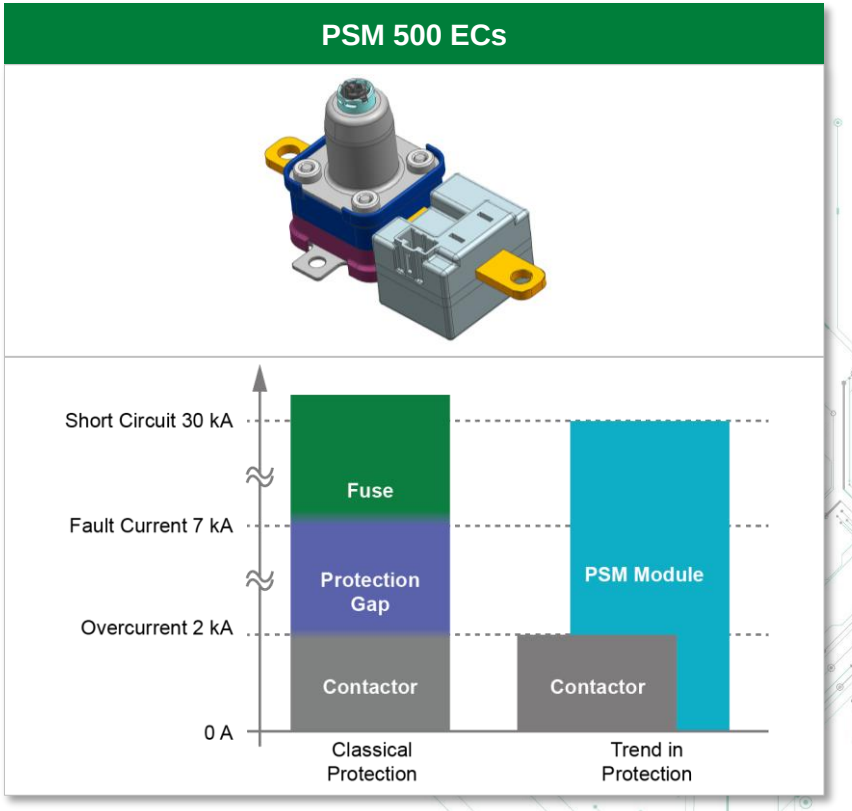
In the new solution, the components are not simply replaced– they are fully integrated and optimally aligned with each other!

Pyro-based circuit breaker, current sensor, microprocessor, and fuse in one Module

PSM−the solution for advanced EV protection

The PSM consists of individual components that are optimally aligned with each other, resulting in a **fully integrated** product with **higher performance at lower system costs**. In addition, it requires **less installation space**. The PSM's most important advantage over other products in the market is its even **faster detection of the overcurrent event and thus a significantly faster and safer disconnection** of the battery from the rest of the vehicle.

- Controlled disconnection within 1 ms
- Very high disconnecting capability
- Multiple and adjustable trigger levels
- High current-sensing accuracy
- High level of integration
  (Pyro-based Circuit Breaker, Current Sensor, MCU, and Fuse)
- Low internal resistance
- Low space and low weight
- Functional Safety up to ASIL-D
- Communication interface, for example, CAN
- Enabler for reduced system costs at OEM



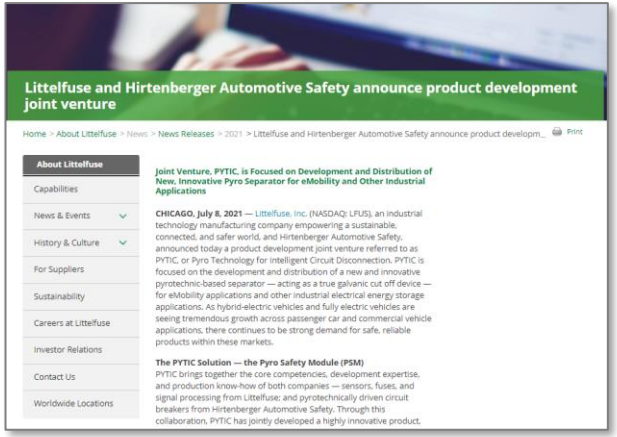
Select standards for automotive applications

Standard	Title	General scope	Littelfuse Technology	Region
ISO7637-2	Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only	Specifies test methods and procedures to ensure the compatibility to conducted electrical transients of equipment installed on passenger cars and commercial vehicles fitted with 12 V or 24 V electrical systems. It describes bench tests for both the injection and measurement of transients. It is applicable to all types of road vehicles independent of the propulsion system (For example, spark ignition or diesel engine, electric motor).	TVS Diode	Global
ISO16750-2	Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads	This standard applies to electric and electronic systems/components for road vehicles. It describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the road vehicle.	TVS Diode	Global
ISO 10605:2008	Road vehicles – Test methods for electrical disturbances from electrostatic discharge	This standard specifies the electrostatic discharge (ESD) test methods necessary to evaluate electronic modules intended for vehicle use. It includes these sources of ESD: in assembly, by service staff, by vehicle occupants.	Diode Array PulseGuard® (AXGD) Multilayer Varistor	Global

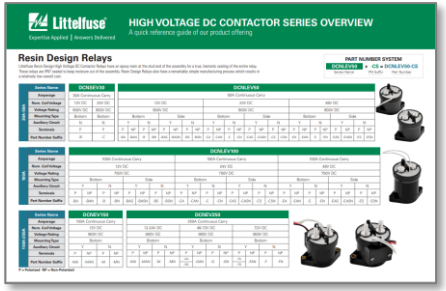
Additional information can be found on Littelfuse.com

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

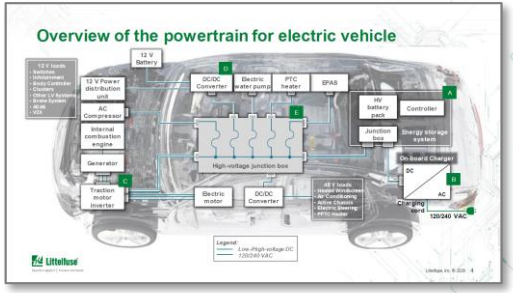
Littelfuse Littelfuse and Hirtenberger Automotive Safety Announce Product Development Joint Venture



HVDC Contactor Relays Selection Guide



Littelfuse Power Train Spotlight Presentation

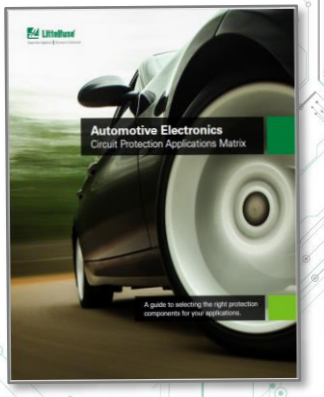


Click on the images to open the catalogs

HVDC Contractor Relays Brochure

Circuit Protection Solutions Selection Guide

Automotive Electronics Application Guide



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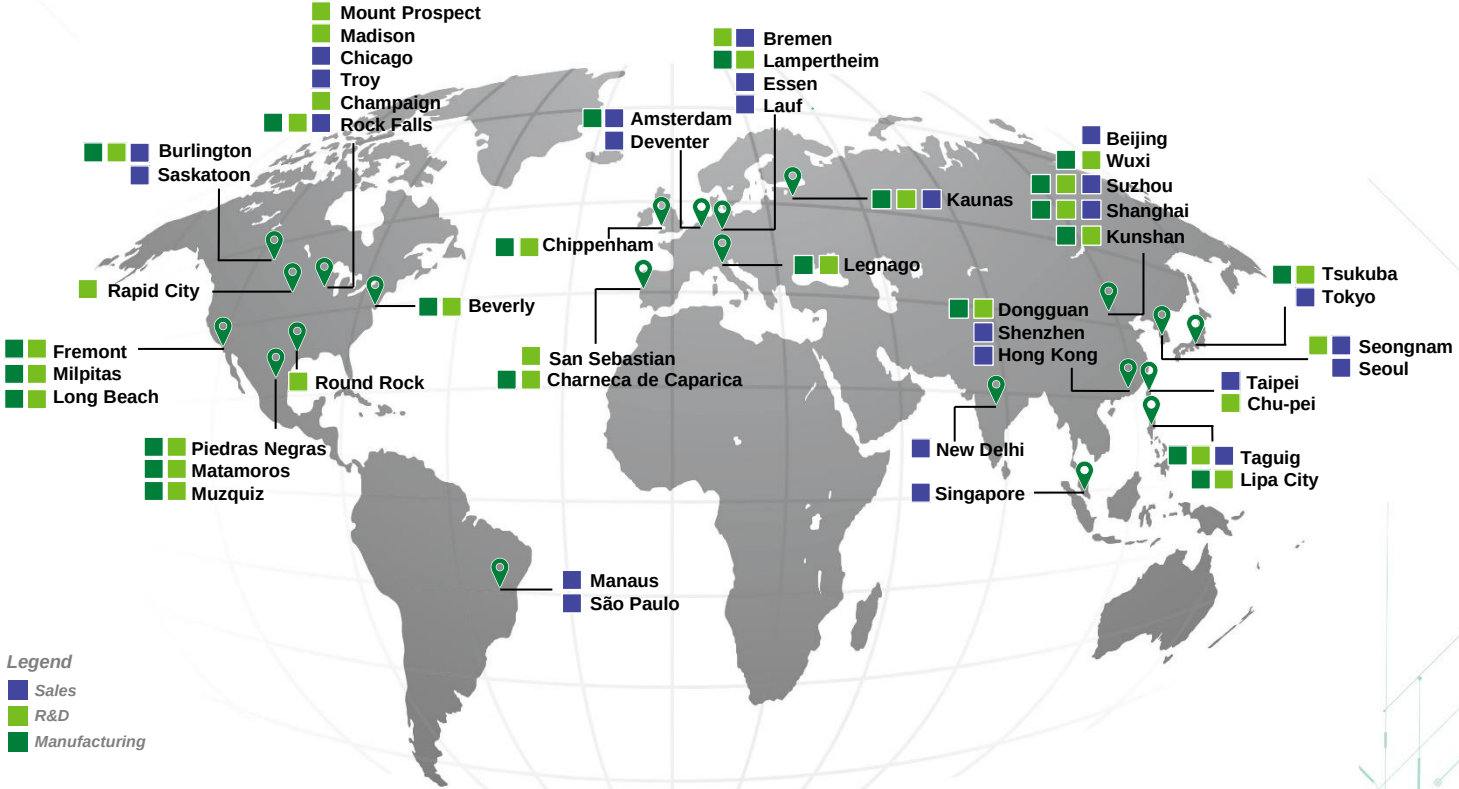
Local resources supporting our global customers



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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

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

TESTING CAPABILITIES

We offer certification testing to global regulatory standards to help customers get products to market faster

GLOBAL MANUFACTURING

High-volume manufacturing committed to the highest quality standards

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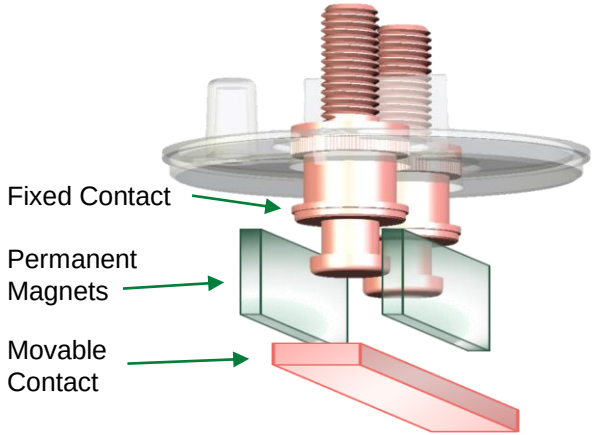
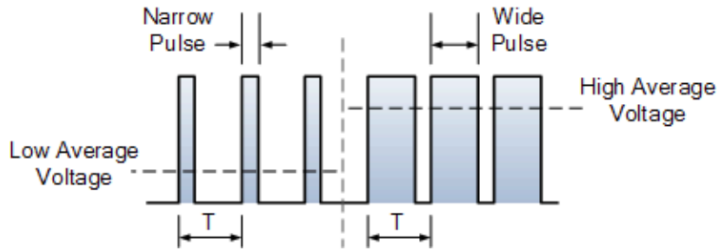
Supplementary Slides

- High Voltage DC Contactor Relays
- Pyro Safety Module

DC Contactor features

High Voltage DC Contactor

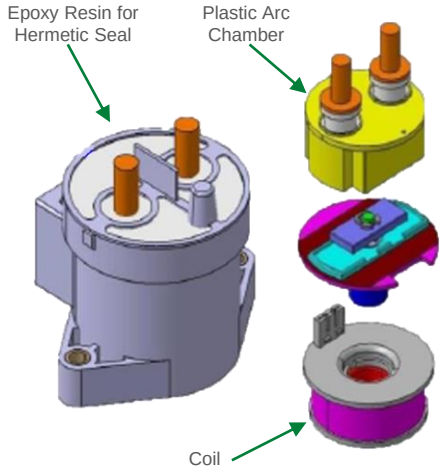




Parameter	Description
HIGH CURRENT AND HIGH VOLTAGE	Using a magnetic arc blow-out design in combination with inert gas filled contact chamber allows it to make/break higher voltages
COIL ECONOMIZER	▪ Greatly reduces coil power and heating after the contactor is energized ▪ Takes minimal coil power to keep the contacts closed due to Pulse Width Modulation (PWM) reducing the average power delivered by pulsing the electrical signal
COMPACT STRUCTURE, LOW NOISE	Contact design yields reduced unit size, low noise while carrying and switching current
HIGH SAFETY	There is no arc leakage due to the sealed design of the arc chamber
HIGH RELIABLE CONTACT	Stable contact resistance no matter how harsh the environment with sealed contacts
NO SPECIAL REQUIREMENT FOR MOUNTING	▪ Lightweight actuator is less impacted by gravity with no special mounting orientation requirements ▪ Side mounting and bottom mount styles are available on some models
CONTACT POLARIZATION	▪ Polarized contacts ▪ Non-polarized contacts

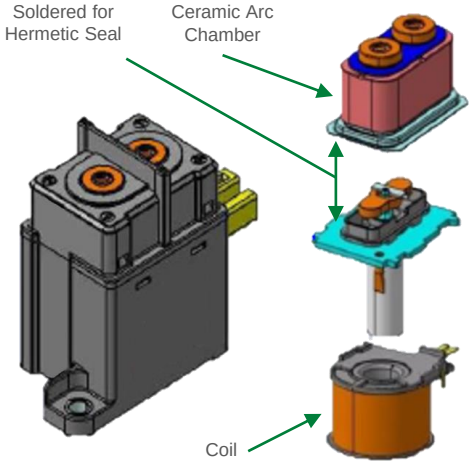
Basic construction of a High-Voltage DC Contactor

Resin Design



Benefits:
- Lower cost
- Simple manufacturing process
- Can include Non-Polar options

Ceramic Design

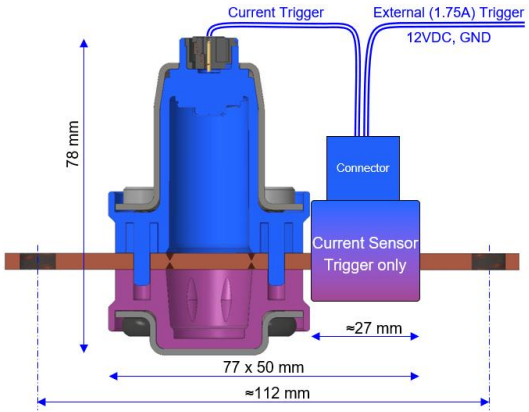


Benefits:
- Better Arc chamber seal
- Higher contact voltage capability
- Withstand higher pressures and temperatures longer

Pyro Safety Module: Self- and Externally Triggered

500 V Pyro Fuse + External Trigger + Current Trigger (without Communications)

PSM 500 ECt



Benefits:

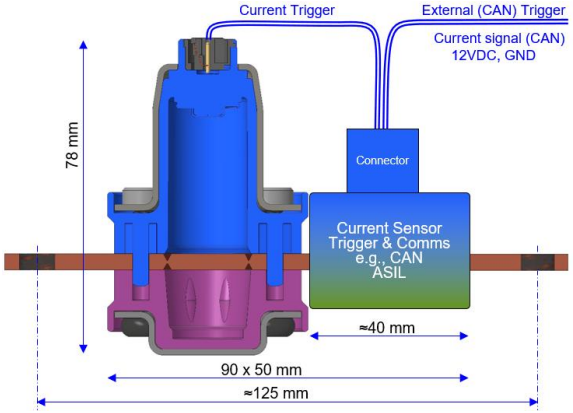
- Trigger at defined current level
- Durability/aging; size
- Low internal resistance/power losses (compared to discrete components)
- Current limiting: Very high interrupting capability

Parameter	PSM/No Communication
Dimensions (L x W x H without busbar)	Mounting holes: 112 mm L x W x H: 77 x 50 x 78 mm
Weight	350 g
Prospective Interrupting Capacity	Mode: “Ct”: 30 kA @ 500 VDC @ 20 µH Mode: “E”: 16 kA @ 500 VDC @ 20 µH
Separation Time	<1 ms
Nominal Current	400 A DC/AC @ 85 °C
Pyrotechnics/Interface	GTMS Igniter (AK-LV16)/Pin type
Open State Resistor	>5 MΩ
Environmental Temperature	-40 °C to 85 °C
Internal Resistance	<50 µΩ
Current Trigger Level	Pre-determined level, for example, 2000 A ±5%
Communication	N/A
Functional Safety	FIT rate (no ASIL−not connected)

Pyro Safety Module: with comm. bus and ASIL D Rating

500 V Pyro fuse + external trigger + current trigger; current sensor with communications (CAN; ASIL)

PSM 500 ECs



Benefits:

- Current measurement & trigger at defined current level
- Durability/aging; size
- Low resistance/power losses
  (compared to discrete components)
- Current limiting: Very high interrupting capability

Parameter	PSM/No Communication
Dimensions (L x W x H without busbar)	Mounting holes: 125 mm L x W x H: 90 x 50 x 78 mm
Weight	350 g
Prospective Interrupting Capacity	Mode: **Cs**: 30 kA @ 500 VDC @ 20 µH Mode: **E**: 16 kA @ 500 VDC @ 20 µH
Separation Time	<1 ms
Nominal Current	400 A DC/AC @ 85 °C
Pyrotechnics / Interface	GTMS Igniter (AK-LV16) / Pin type
Open State Resistor	>5 MΩ
Environmental Temperature	- 40 °C to 85 °C
Internal Resistance	<80 µΩ
Current Trigger Level	Pre-determined level, e.g., 2000A ±5% Optional 3 levels selectable via CAN: e.g., 100 A, 800 A, and 2000 A ±5%
Current sensor Accuracy	2% @±2000 A; 0.5% @ ±800 A
Communication	CAN bus
Functional Safety	ASIL D

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