DC FUSE AND PYROFUSE FOR EV / HEV
BATTERY AND AUXILIARY OVERCURRENT PROTECTION
December 2020
Mersen Solutions – EV fuse & pyrofuse – Dec 2020

Mersen in Brief
A France-headquartered publicly listed company with global positions

Sales
€950M

Staff
7,000

Geographies

- 33% North America
- 34% Europe
- 33% Asia and RotW

Advanced Materials

- Anticorrosion Equipment
  World’s no. 1-2 in graphite equipment

- Graphite Specialties
  World’s no. 1-2 in high-temperature applications

- Power Transfer Technologies
  World’s no. 1-2 in brushes for industrial motors

Electrical Power

- Electrical Protection & Control
  World’s no. 2 in industrial fuses

- Solutions for Power Management
  World’s no. 2 in passive components for power electronics

* As of December 31, 2019
OVER 130 YEARS OF EXPERIENCE

1885 - Shawmut Fuse Wire Company formed in Boston, Massachusetts

1889 - Boston Fire Underwriters require fuses (later known as NFPA)

1928 - Ferraz Fuse found by Lucien Ferraz in France

1946 - M Schneider founded

1952 - Eldre Founded
1953 - Laminated Bus Bar introduced by Eldre

1958 - Chase Shawmut acquired by I-T-E Imperial

1981 - R-Theta founded

1982 - Ferraz acquired by Telemecanique

1988 - First heatsinks by R-Theta

1999 - Carbone Lorraine acquires Gould-Shawmut and forms Ferraz Shawmut

2007 - Power fuse
2008 - Mingrong
2008 - R-Theta
2010 - M. Schneider

2010 - Carbone Lorraine becomes

Mersen acquisitions:
2012 - Eldre
2014 - Cirprotec
2015 - ASP
2018 - Idealec
2019 - FTCap

Mersen Solutions – EV fuse & pyrofuse – Dec 2020
**Mersen Product Portfolio for Power Electronics and EV**

**High-speed Fuse and Hybrid Pyro-fuse**
- UL Round and Square Body
- British Standard AC Protection
- IEC Cylindrical and Square Body (French / DIN)
- AC Low and Medium Voltage
- DC Rated For Traction
- DC protection for EV and EES

**Cooling Solutions**
- Air and Liquid Cooled Heatsinks
- Embedded Heat-Pipe Heatsinks
- Heat-pipe Assemblies

**Bus Bar**
- Laminated / Multi-layer
- Flexible / High T° / Low L
- Battery cell connection
- Powder Coated

**Capacitors**
- Customized capacitors:
  - Film
  - Electrolytic
  - Sub-assembly

**SiC Semiconductors**
- Protection devices
- Custom designs
MERSEN
A GLOBAL AND DEDICATED MANUFACTURING FOOTPRINT

Rochester, USA
~150 pers.

Juarez, Mexico
~700 pers.

Angers, France
~100 pers.

La Mure, France
~70 pers.

Saint-Bonnet, France
~425 pers.

Husum, Germany
200 pers.

Yverdon, Switzerland
24 pers.

Shanghai, China
~ 170 pers.

Pontarlier, France
~ 35 pers.

Bangalore, India
~ 60 pers.

Tunis, Tunisia
~ 200 pers.
**EV/HEV MARKET SEGMENT PERFORMANCE ADDED-VALUES**

Bubble diameter: relative market size by 2020

- **Electric Power**
  - > 250kW
  - 200kW
  - 100kW
  - 10kW
  - Low

- **Duty-cycle severity**
  - (Request for fast charge/discharge)

- **Busbar**
  - Improved cooling
  - Advanced DC protection (Fuse or Hybrid)

- **Laminated Busbar**
  - Advanced cooling
  - Hybrid over-current protection (Xp)

- **BEV**
  - Premium luxury car
  - e-truck
  - Sport car
  - e-bus

- **HEV**
  - Non-premium car BEV
  - Non-premium car HEV

- **Cable connection**
  - Standard cooling
  - Standard fuse

- **Non-premium car HEV**

- **Premium luxury car**

- **e-truck**

- **Sport car**

- **e-bus**

- **Mersen Solutions**
  - EV fuse & pyrofuse
  - Dec 2020
Mersen Solutions – EV fuse & pyrofuse – Dec 2020

MerSEN Solutions in EV/HEV Applications

- Battery Module:
  - Cooling Plate
  - Monitoring Busbar
  - Module Fuse

- Battery Pack / BDU / MSD:
  - Main DC fuse
  - Auxiliaries
  - Hybrid pyro-fuse

- Charging Station:
  - SPD
  - Fuse
  - Coolant
  - Capacitor

- Inverter / PDU:
  - Coolant
  - Busbar
  - Capacitor

Illustration courtesy of Renault™

PDU: Power Distribution Unit
BDU: Battery Disconnect Unit
MSD: Maintenance Safety Disconnect
OCPD: Over Current Protection Device
SPD: Surge Protection Device
DC BATTERY OVER CURRENT PROTECTION

MAIN AND AUXILIARY FUSE AND PYRO-FUSE
## DC Protection for EV Battery

### 2 Technology Paths

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<th>Monolithic technology</th>
<th>Hybrid Pyrofuse Technology</th>
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<tr>
<td><strong>Product Range</strong></td>
<td>EV pack-fuse M-fuse</td>
<td>Xp series</td>
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<tr>
<td><strong>Core Technology</strong></td>
<td>DC-Fuse</td>
<td>Pyro actuator + Fuse</td>
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<tr>
<td><strong>Value Proposition</strong></td>
<td>Ultra fast-acting fuses (for large fault currents) Cost-effective &amp; proven technology DC specific design</td>
<td>Fast-acting protection &lt; 1ms Low-cost technology Close-to-zero conduction loss Operates for small or large fault current Fully configurable. Self-triggering option Very compact size High cycling performances High inrush current capabilities</td>
</tr>
<tr>
<td><strong>Visuals</strong></td>
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</tbody>
</table>
**EV TYPICAL PROTECTION SCHEME**

**Main battery pack**
1 to 16 battery modules assembled in series/parallel

**Main protection**
(main fuse + DC contactor)
- 500 to 1,000 Vdc
- Up to 600 A

**Aux. protection**
- Pre-charge
- Air Conditioning
- Heater/PTC
- DC/DC
- Charger
- 500 → 1,000 V

- 500V or 1000Vdc
- 4x to 8x
- 1x (or 2x)
- or

- Up to 150A for charger

- 10 → 50 A for aux.

**Inverter + Motor**
2 FAMILIES OF PROTECTION AND OPERATING DEVICES FOR DC APPLICATIONS

- **Battery Module Protection**
- **EVpack-fuse**
- **Hybrid DC protection**

**Parameters:**
- **I_n (Amp)**
- **V (Volt)**

**Types of Protection Devices:**
- **M-fuse**
- **χp series**
- **MSD / BDU / Junction Box**

**Applications:**
- **Battery Module Protection**
- **EV Battery Pack fuse Protection**

**Graph:**
- Grid with axes labeled: I_n (Amp) on the x-axis and V (Volt) on the y-axis.
- A shaded area indicating the range of voltages and currents for battery protection.
8 DC FUSE SERIES FOR BATTERY PROTECTION

- **MEV70 series**
  - 1,000 V\(_{\text{DC}}\) - 350 to 600 Amp
- **MEV100 series**
  - 1,000 V\(_{\text{DC}}\) - 8 to 350 Amp
- **MEV80 series**
  - 800 V\(_{\text{DC}}\) - 100 to 350 Amp
- **MEV100V series**
  - Designed for large inrush current
- **MEV50 series**
  - 700 V\(_{\text{DC}}\) - 35 to 600 Amp
- **MEV50A**
  - 500 V\(_{\text{DC}}\) - up to 800 Amp
- **MF series**
  - 100V\(_{\text{DC}}\) - 50 to 200A
- **Battery Module Fuse**
  - 500 V\(_{\text{DC}}\) - up to 800 Amp

**Graphical Representation**

- Voltage (Volts) range from 48 to 1000 V\(_{\text{DC}}\)
- Current (Amp) range from 150 to 800 Amp
FEATURES & BENEFITS

- Voltage: 500VDC - L/R ≤2.5ms
- Ratings from 60 to 800A
- 5 compact sizes
- Long life cycle
- Visual identification code & serial number for traceability
- Customizable design
- Tested and validated with market leading contactors (Panasonic, Hongfa, TE, etc…)

PRODUCT HIGHLIGHT: MEV50A SERIES – 500Vdc EV FUSE

PERFORMANCE

- Low Minimum Breaking Capacity (4x In or 2kA) to secure contactor protection
- High interrupting rating of 30kA to address all types of battery
- Highly energy efficiency with low power losses
- Excellent cycling capability
- Compliant with ISO 8820 and international electrical standards

Now available
Mersen EVpack-fuse have been designed to match DC contactor operation.

**MBC value matters...**

- Matching DC contactor with DC fuse is not trivial. Contactors offer a limited max. breaking capacity value beyond which the fuse must clear the circuit in the eventuality of a default. Typical matching scheme looks like:

  - **EV pack-fuse** line-up has been designed to protect DC contactors, offering **MBC** values <3kA over the full range.

![Diagram](image-url)
HYBRID PYRO-FUSE (XP-SERIES) FUNDAMENTALS

**How Pyrofuse allows better coordination with contactor whatever the voltage & current**

- **Within EV battery protection scheme**, fuse and contactor should coordinate together whatever current and voltage conditions.

- **In reality it’s not!** A “grey zone” remains where none of them can safely operate.

- **Pyrofuse allows extending the “fusing” operation towards smaller current and enables full coordination**

- **Pyrofuse is now also requested to operate even if no current (0-AMP)**
HYBRID PYRO-FUSE (XP-SERIES) FUNDAMENTALS

MAIN SPECIFICATIONS

**HIGHLIGHTS**

- DC application focused design, up to 1000 Vdc
- In up to 800A. From 0 to 30kA breaking operation
- Extremely low watt losses (~20W / 400A)
- Excellent cycling performance
- Ultra-fast acting (300 μs)
- Small footprint
- Large inrush current: 15x In for 100 ms
- Self-triggered and/or external triggering
- Tunable Time-Current curve and Minimum Breaking Capacity (MBC) value

**APPLICATIONS**

- EV/HEV main battery fuse
- EV/HEV charging fuse
- Battery Energy Storage
- PV installations
- Supercapacitors bank
- DC General Purposes
## HIGHLIGHTS
- Design for EV battery pack
- Approvals
  - UL recognized, CE, RoHS
  - Power Cycling & Vibrations: JASO D622
  - IATF - ISO/TS 16949 Quality Management

## APPLICATIONS
- EV/HEV
- Electrical Energy Storage
- Battery pack protection
- Battery Disconnect Unit (BDU)
- Battery Junction Box for auxiliaries
- Battery charger

### TABLE

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<thead>
<tr>
<th>SIZE</th>
<th>SERIES</th>
<th>AMPERE RATING L (A)</th>
<th>RATED VOLTAGE VN (V)</th>
<th>INTERRUPTING RATING DC (A)</th>
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</thead>
<tbody>
<tr>
<td>MEV50A Round Body Fuse</td>
<td>EVpack-fuse MEV50</td>
<td>60 - 800</td>
<td>500</td>
<td>30</td>
</tr>
<tr>
<td>MEV55C Ferrule Fuse</td>
<td>EVpack-fuse MEV55</td>
<td>5 - 50</td>
<td>550</td>
<td>20</td>
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<tr>
<td>MEV55C - S Surface Mount Fuse</td>
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</tr>
<tr>
<td>MEV55C - P PC Board Mount</td>
<td></td>
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</tr>
<tr>
<td>MEV70V - S Surface Mount Fuse</td>
<td>EVpack-fuse MEV70</td>
<td>30 - 175</td>
<td>700</td>
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<tr>
<td>MEV70A Round Body Fuse</td>
<td>EVpack-fuse MEV70</td>
<td>50 - 600</td>
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</tr>
<tr>
<td>MEV80S - S Surface Mount Fuse</td>
<td>EVpack-fuse MEV80</td>
<td>100 - 350</td>
<td>800</td>
<td>30</td>
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<tr>
<td>MEV100C Ferrule Fuse</td>
<td>EVpack-fuse MEV100</td>
<td>8 - 30</td>
<td>1000</td>
<td>20</td>
</tr>
<tr>
<td>MEV100C - S Surface Mount Fuse</td>
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<tr>
<td>MEV100A Round Body Fuse</td>
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<tr>
<td>MEV100J Round Body Fuse</td>
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</tbody>
</table>

Fuse holders available – contact Mersen for more info.
M-fuse – Battery Module Fuse

100Vdc / 50-200 Amp

**Highlights**
- Design for battery module DC applications
- Low watt losses
- Up to 100VDC
- Current rating (In) = 50 to 200A
- Interrupting Rating (IR) = 20kA, L/R ≤1.5ms
- Minimum Breaking Capacity (MBC) < 1kA.
- Approvals
  - UL recognized, CE, RoHS
  - Power Cycling & Vibrations: JASO D622
  - IATF - ISO/TS 16949 Quality Management System

**Applications**
- Battery modules protection
- EV/HEV
- Electrical Energy Storage
- Supercapacitor module protection

<table>
<thead>
<tr>
<th>Series</th>
<th>Ampere Rating $I_n$ (A)</th>
<th>Rated Voltage $V_n$ (V) (IEC)</th>
<th>Maximum Interrupting Rating</th>
<th>Mounting</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-fuse MF 100VDC</td>
<td>50 – 200</td>
<td>100VDC</td>
<td>-</td>
<td>20kA, Bolt-In</td>
</tr>
<tr>
<td></td>
<td>50 - 180</td>
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</table>

JASO D622
Mersen services for fuse development and selection
IN-HOUSE HIGH POWER TESTING CAPABILITIES

Up to 1500 Vdc / 350 kA / 5000 A/ms

- 2 Test Labs:
  - Mersen Newburyport-MA, USA
  - Mersen Saint-Bonnet-de-Mure, France

- Tests Available to:
  - Qualify products or a design concept, to check selectivity, to validate a critical step in a project
  - Inspect production
  - Customer checking procedure
  - Accreditation / agency approval

- Test Lab Expertise:
  - AC/DC High Power, up to 1,500Vdc / 350kA
  - High di/dt up to 5000 A/ms
  - Electrical Performance
  - Mechanical
  - Environmental and process
  - Photovoltaic

- Accreditations:
  - Accreditation and approvals from all the main global agencies, including ISO, IEC, COFRAC, ASEFA, LCIE, VDE, UL, CSA etc.
TECHNICAL SUPPORT

TECHNICAL EXPERTS TO ASSIST IN FUSE SELECTION

- For more detailed product information, application details, white papers, and other specific information, explore our website or consult your local sales representative.

- For technical and applications support and to help you select the best protection which meets specific standards, our technical services team is at your disposal.
  - North America: technicalservices.nby@mersen.com
  - Europe: ts.sbm@mersen.com
  - Asia: ts.epchina@mersen.com
SPECIAL FUSE BUSINESS (SFB)
TAILOR-MADE FUSE DESIGN FOR CUSTOMER-SPECIFIC NEEDS

WHAT IS THE SFB PROCESS?
- Rapid prototyping of custom products
- Modifications to existing products
- Helps our customers with new system designs
- Helps us secure and maintain aftermarket business
- Includes High Speed Fuses, PV and MV fuses, and more

GOAL
- To bring our expertise to our customers with custom products and solutions to help secure business long term

Addresses needs such as:
- Special testing
- Certification compliance
- Mounting customization
- Extended Ratings
LITERATURE

- High-Speed Fuses Brochure
- Semiconductor Fuse Application Guide
- E-Mobility Fuse Application Guide
- Test Lab Brochure North America Europe
- Tech Topics
- White Papers