MERSEN SOLUTIONS FOR EES
EES is a battery-based technology to manage and regulate electrical power generated by heterogeneous non-permanent sources (e.g. renewables Wind & Solar)

It also acts as a buffer to compensate Production-Consumption discrepancies

It is a key component of “Smart Grid” concept

EES is spread over the entire grid, from the main high power generation devices (PV or wind farms) down to the industrial & residential installation having its own PV capability.

In some cases, EV/HEV batteries are also considered as an EES component that may buffer power fluctuations
**WHAT MERSEN PRODUCT FOR WHAT FUNCTION?**

3 main functions:
- Connect and monitor battery cells together
- Cool battery down
- Protect battery against over-current

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**Battery Modules**

- Monitoring Busbar
- Cooling plates and Module fuses

**Battery Pack / Container**

(assembly of several battery modules)

- Main fuses: M-fuse
- and/or Xp, Xs-ES

**Fuses / Hybrid DC protection**

**DC-AC bidirectional inverter**

- Busbar / Cooling / Semicond Fuses / SPD

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**Detected Redactions:**
- Battery Module
- Monitoring Busbar
- Cooling plates and Module fuses
- Battery Pack / Container
- (assembly of several battery modules)
- Main fuses: M-fuse
- and/or Xp, Xs-ES
- Fuses / Hybrid DC protection
- DC-AC bidirectional inverter
- Busbar / Cooling / Semicond Fuses / SPD
LAMINATED BUSBAR
SMART MONITORING BUSBAR TO HANDLE BOTH HIGH POWER AND SMALL SIGNAL IN A SINGLE CONNECTION SOLUTION

- **ALL-IN-ONE CONNECTION SOLUTION:**
  - Connect Li-ion or supercap cells together
  - Monitor small signals such as
    - Individual cell voltage
    - Local temperature

- **CUSTOMER’S BENEFITS:**
  - Ease assembly process
  - No wiring errors
  - Reduced voltage drop
  - Increase current carrying capability
  - High resistance to shocks and vibrations

MONITORING LAMINATED BUSBARS SOLUTIONS

- LI-ION BATTERY PACKS
- SUPERCAPACITORS
**WATER-COOLED BUSBAR TO HANDLE CRITICAL THERMAL APPLICATIONS**

- **TEMPERATURE RISE MANAGEMENT FOR:**
  - Battery modules
  - Capacitor bank
  - High power density inverter

- **CUSTOMER’S BENEFITS:**
  - Hot-spot elimination
  - Dielectric extended life-time
  - Metal cost saving (can use thinner copper)

### Comparison of temperature (in °C) between 2 busbars of 3 mm with cooling & without cooling

<table>
<thead>
<tr>
<th></th>
<th>Without cooling</th>
<th>With cooling (15°C water)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temp. (in °C)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average Temp.</strong></td>
<td>43.5°C</td>
<td>20.5°C</td>
</tr>
<tr>
<td><strong>Ambient Temp.</strong></td>
<td>22°C</td>
<td>28°C</td>
</tr>
</tbody>
</table>

Reduces Temperature by 23°C

### Comparison of temperature (in °C) between 2 busbars of 0.8 mm with cooling & without cooling

<table>
<thead>
<tr>
<th></th>
<th>Without cooling</th>
<th>With cooling (15°C water)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temp. (in °C)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average Temp.</strong></td>
<td>86.5°C</td>
<td>28°C</td>
</tr>
<tr>
<td><strong>Ambient Temp.</strong></td>
<td>22°C</td>
<td>28°C</td>
</tr>
</tbody>
</table>

Reduces Temperature by 58.5°C

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Copper 3mm

Copper 0.8mm
Mersen Busbar in EES Industry

Mersen Busbar for Supercapacitor Bank in EES

- Busbar for 4x5 cells
- Tin plated
- 54V
- 150A
- -40/+65°C
- Very large quantities
- Laser welding
- Easy of installation
Mersen Smart Busbar in Battery Industry

Mersen Smart-busbar for Battery Connection

39 cells in series, 4 Thermal sensors, Voltage sensor on each cell by Flex

380VDC / 300A
Copper 2mm. Tin plated
Voltage measurement across each cell
On each Flex bus bar 6 temperature sensors and 5 voltage sensors.

Copper bar 2 mm

Flex connector PET dielectric

Thermal sensors

Mersen Smart Busbar in Battery Industry

Details on Smart Busbar Main Features (400VDC).
LBB Design: A Complete Simulation Tool-Set

- **Mechanical Simulation**
  - Optimization of part placement to save space in the final assembly
  - Ensure mechanical constraints of heterogeneous materials

- **Electrical Simulation**
  - Contact routing to meet clearance & creepage
  - Current distribution compliant with admissible current density (A/mm²) to limit self-heating
  - Inductance simulation

- **Thermal Simulation**
  - Current flow heating-up by Joule effect in the conductors
  - Power Modules create hot-spots at top terminals level
  - Prevent too many heat at capacitor ends
THREE COOLING TECHNOLOGIES

To meet customer’s needs at the closest
THREE CORE INDUSTRIAL KNOW-HOW TO MANUFACTURE BEST-IN-CLASS COOLING PRODUCTS

Vacuum brazing: a key step to seal our liquid cold-plates

- High thermal performance in a monolithic piece
- Perfect water-tightness guarantee
- High pressure withstanding (70 bars and up!)
- No risk of corrosion
- Long lifetime > 20 years

Swaging: a cost-effective and reliable technology for heat-sink fins assembly

- Increase heat transfer surface area over extruded profiles
- Swaged heat sinks offer 14% performance increase over glued fin solution
- Different standard spacing are developed to address challenging thermal applications

Heat-pipe assembly: a phase-change technology for most-demanding applications

- High thermal performance
- Temperature homogeneity for power module baseplates
- Instant cooling
- Smoothen temperature peaks
- Maintenance-free
**Mersen Cooling in EES Industry**

**Mersen Cooling Plate for Battery Pack**

- **Pin Fin plates to cool down 24 cells single-sided**
- **4 plates per battery pack**
- **Brazed connectors**
COOLS DOWN 12 CELLS ON EACH PLATE
6 PLATES PER PACK
DC Over Current Protection
3 FAMILIES OF PROTECTION AND OPERATION DEVICES FOR DC APPLICATIONS UP TO 1,500 $V_{DC}$

- Hybrid DC power relay (with backup fuse) $\chi_s$ series
- High performance DC fuse $\chi_p$ series
- Battery Module Protection M-fuse

Voltage (Volt) vs. $I_n$ (Amp) graph:

- Hybrid DC power relay (with backup fuse) $\chi_s$ series
- High performance DC fuse $\chi_p$ series
- Battery Module Protection M-fuse

Voltage values: 48, 100, 140, 150, 200, 300, 450, 600, 800, 1000, 1200, 1300, 1400, 1500

Current values: 150, 300, 450, 600, 800
**TYPICAL PROTECTION SCHEME IN EES SYSTEM**

- **Module Fuse**
- **Battery Module**
- **Mersen EVpack-fuse**
- **Protistor® Xp series**
- **Protistor® χ-x series**
- **Protistor® χ-s-ES series**
- **Protistor®**
- **AC fuse (aR)**
- **SPD**

Diagram showing:
- String 1: 1000 - 1500V DC, 400 A
- String 2: 50 - 400 A
- DC bus 1: 1000 - 1500V DC, 400 - 2500 A
- DC bus n: 1000 - 1500V DC, 400 - 2500 A
- Transformer: 11 kV, 50kHz, 2.5 MVA
- Transformer: DC bus, 1000 - 1500V DC, 400 A
- Transformer: DC bus n, 1000 - 1500V DC, 400 A
- Transformer: 400 - 2500 A
- Transformer: 50 - 400 A
- Transformer: DC-DC
- Transformer: DC-AC
- Transformer: Hybrid DC Power Relay (+ fuse)
- Transformer: Under development
- Transformer: DC<>AC bidirectional inverter
## DC Protection at Mersen: 3 Technology Paths up to 1,500 Vdc

<table>
<thead>
<tr>
<th></th>
<th>Monolithic Technology</th>
<th>Hybrid Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product range</strong></td>
<td><strong>EV pack-fuse m-fuse Protistor®</strong></td>
<td><strong>χ&lt;sub&gt;p&lt;/sub&gt; series</strong></td>
</tr>
<tr>
<td><strong>Core technology</strong></td>
<td><strong>DC-Fuse</strong></td>
<td><strong>Pyro + clearing elements</strong></td>
</tr>
<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 Very compact size High cycling performances High inrush current capabilities</td>
</tr>
<tr>
<td><strong>Visuals</strong></td>
<td><img src="image1.png" alt="Visuals" /> <img src="image2.png" alt="Visuals" /> <img src="image3.png" alt="Visuals" /> <img src="image4.png" alt="Visuals" /></td>
<td><img src="image5.png" alt="Visuals" /> <img src="image6.png" alt="Visuals" /> <img src="image7.png" alt="Visuals" /> <img src="image8.png" alt="Visuals" /></td>
</tr>
</tbody>
</table>
The Xp system is composed by fast acting pyro element, controlled by a gate current, plus a parallel clearing element.

This protection meets custom requirements of very fast operating time and very high overload current.

Main features and Benefits:
- DC application focused design
- Extremely low watt losses (~20W / 400A)
- Excellent cycling performance
- Ultra-fast acting (300 µs)
- Small footprint
- Large inrush current: 15 In for 100 ms
- Self-triggered and/or external triggering
- Tunable Time-Current curve and Minimum Breaking Capacity (MBC) value

A high cycling performance DC protection device that can clear both high and low-fault current at 1,000 V<sub>DC</sub> in less than 1 ms!

Electric data – main circuit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Voltage</td>
<td>Up to 1,000 V&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Nominal Ampere In</td>
<td>Up to 800 A</td>
</tr>
<tr>
<td>Max breaking capacity</td>
<td>15 kA @ 1000 V&lt;sub&gt;DC&lt;/sub&gt; with L/R = 2 ms</td>
</tr>
<tr>
<td>L/R max</td>
<td>5 ms</td>
</tr>
<tr>
<td>Power dissipation at In</td>
<td>20W @ 25°C</td>
</tr>
<tr>
<td>Gate Control current</td>
<td>2A – 10A (2ms)</td>
</tr>
<tr>
<td>Gate Control resistance</td>
<td>2.2 Ω</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-40°C to +90°C</td>
</tr>
</tbody>
</table>
Xs ES: HYBRID DC POWER RELAY WITH BACKUP FUSE

- Xs-ES have been engineered to provide high DC switching performances versus conventional mechanical power relay.
- Xs-ES provides maximum flexibility in equipment design and ultimate DC operation performance. This Power Relay is a Hybrid technology with the capability of switching both high voltage and high current specially designed for Electrical Energy Storage applications.

Main features and Benefits
- Designed for DC applications
- Built-in backup fuse
- Bidirectional
- Arc-less
- Low conduction losses
- Repeatable current make/break capability for resistive & inductive loads at full rated voltage and current
- Enhanced cycling performances
- Built-in turn ON fault detection

A DC power relay with backup fuse that can repetitively clear up to 2kA at 1,500 Vdc!

Available up to 1,200 Vdc. 1,500 Vdc with built-in fuse under development Contact Mersen for more information
4 DC FUSE SERIES FOR BATTERY PROTECTION UP TO 1,500 $V_{DC}$

- **Protistor® high performance DC - Size 12x series**
  - 1,500 to 2,000 $V_{DC}$ - 20 to 800 Amp

- **Protistor® high performance DC - Size 7x series**
  - 1,200 $V_{DC}$ - 20 to 840 Amp

- **MEV100 series**
  - 1,000 $V_{DC}$ - 8 to 600 Amp

- **Battery Module Fuse**
  - MF series
    - 100 $V_{DC}$ - 50 to 200 Amp
## DC PROTECTION OFFER AT MERSEN: SUMMARY

<table>
<thead>
<tr>
<th>Feature</th>
<th>Monolithic technology</th>
<th>Hybrid technology</th>
</tr>
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<tr>
<td><strong>Family</strong></td>
<td><strong>DC-Fuse</strong></td>
<td><strong>Pyro + clearing elements</strong></td>
</tr>
<tr>
<td>Resettable</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time to clear high fault current</td>
<td>Excellent, 10 of µS</td>
<td>Good, 100’s of µs</td>
</tr>
<tr>
<td>Time to clear low fault current</td>
<td>Slow to melt 10’s of seconds</td>
<td>Excellent Down to 100’s of µs</td>
</tr>
<tr>
<td>Cycling performance</td>
<td>Application dependent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Conduction losses</td>
<td>80W (400A)</td>
<td>20 W (400A)</td>
</tr>
<tr>
<td>Tunable Time-Current curve</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Self-triggered</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Monolithic technology**
- **Family**: DC-Fuse
- **Resettable**: Yes
- **Time to clear high fault current**: Excellent, 10 of µS
- **Time to clear low fault current**: Slow to melt 10’s of seconds
- **Cycling performance**: Application dependent
- **Conduction losses**: 80W (400A)
- **Tunable Time-Current curve**: Limited
- **Self-triggered**: Yes

**Hybrid technology**
- **Family**: Pyro + clearing elements
- **Resettable**: Yes
- **Time to clear high fault current**: Good, 100’s of µs
- **Time to clear low fault current**: Excellent Down to 100’s of µs
- **Cycling performance**: Excellent
- **Conduction losses**: 20 W (400A)
- **Tunable Time-Current curve**: Yes
- **Self-triggered**: Yes

**Semiconductor technology**
- **Family**: Semiconductor + Switch + fuse
- **Resettable**: Yes
- **Time to clear high fault current**: Good, a few ms
- **Time to clear low fault current**: Excellent, a few ms
- **Cycling performance**: Excellent
- **Conduction losses**: 45 W (300A)
- **Tunable Time-Current curve**: Yes
- **Self-triggered**: No