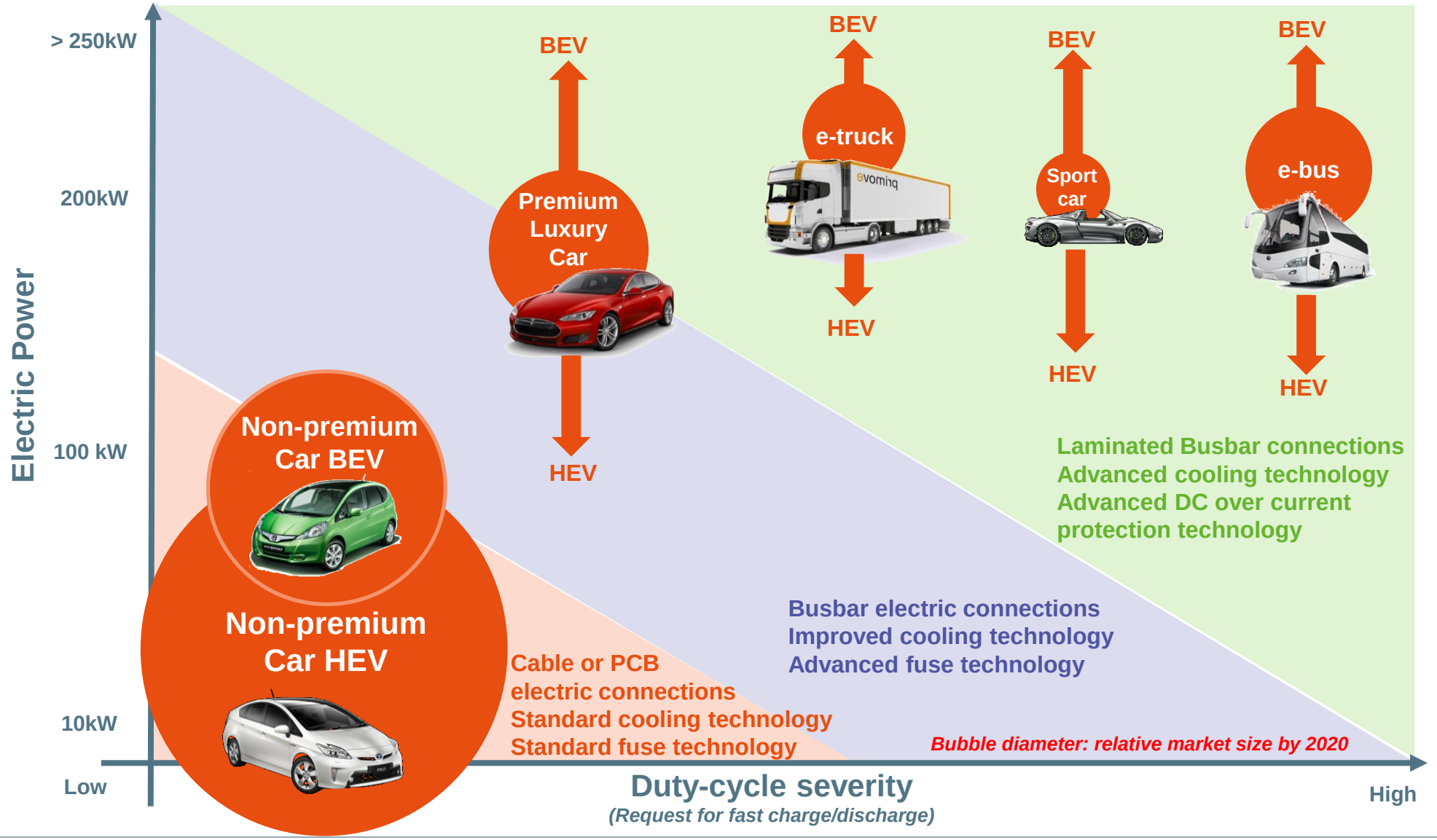
MERSEN SOLUTIONS FOR EV/HEV

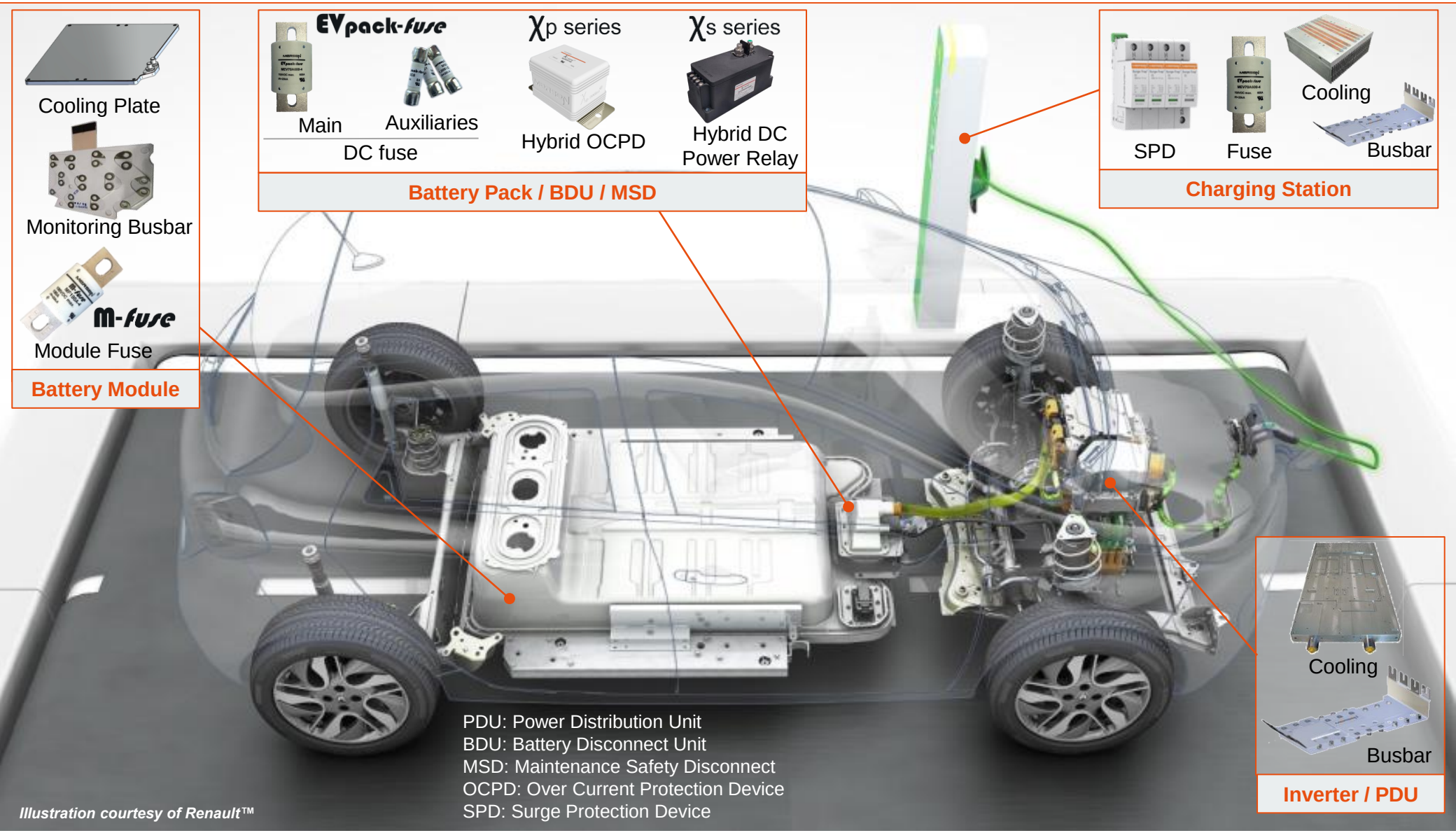
Thomas Edison electric car (1913)

☑ Public
☐ Internal
☐ Confidential

EV/HEV MARKET SEGMENT PERFORMANCE ADDED-VALUES



WHAT MERSEN PRODUCT FOR WHAT FUNCTION IN EV?



Cooling Plate

Monitoring Busbar

Module Fuse

Battery Module

EVpack-fuse

Main

Auxiliaries

DC fuse

χp series

Hybrid OCPD

χs series

Hybrid DC Power Relay

Battery Pack / BDU / MSD

SPD

Fuse

Cooling

Busbar

Charging Station

Cooling

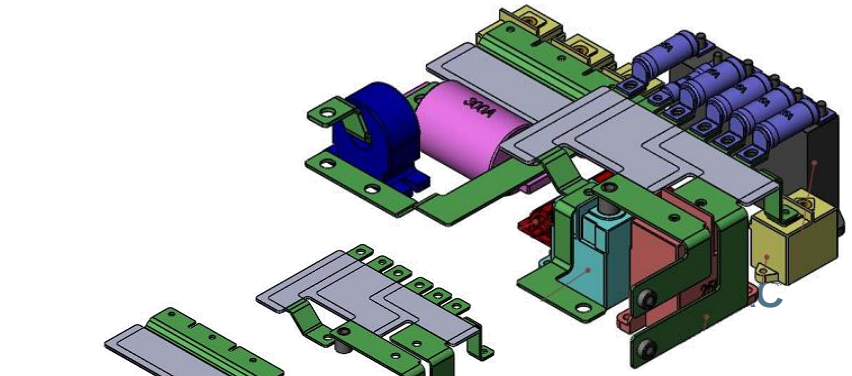
Busbar

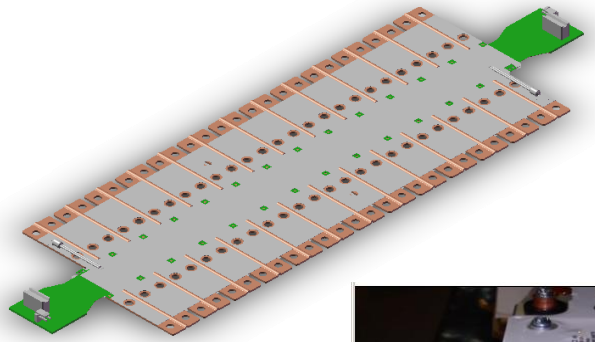
Inverter / PDU

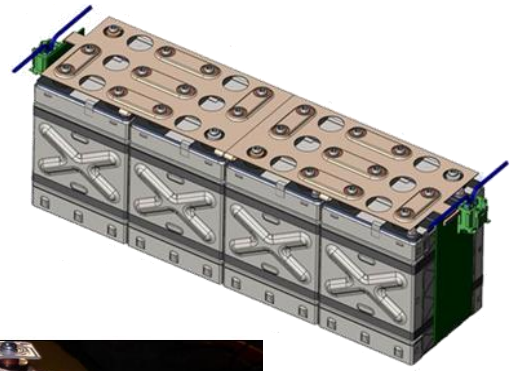
PDU: Power Distribution Unit
BDU: Battery Disconnect Unit
MSD: Maintenance Safety Disconnect
OCPD: Over Current Protection Device
SPD: Surge Protection Device

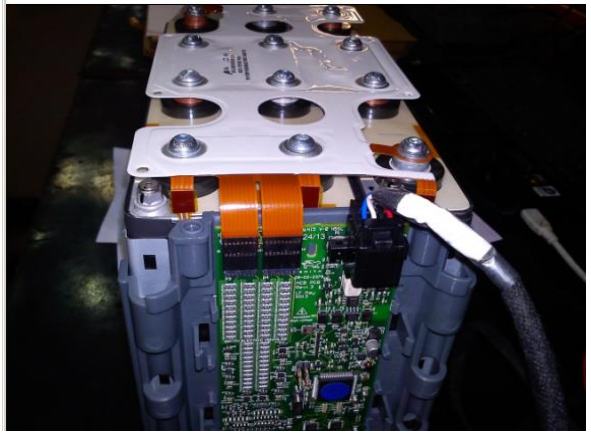
Illustration courtesy of Renault™

LAMINATED BUSBAR



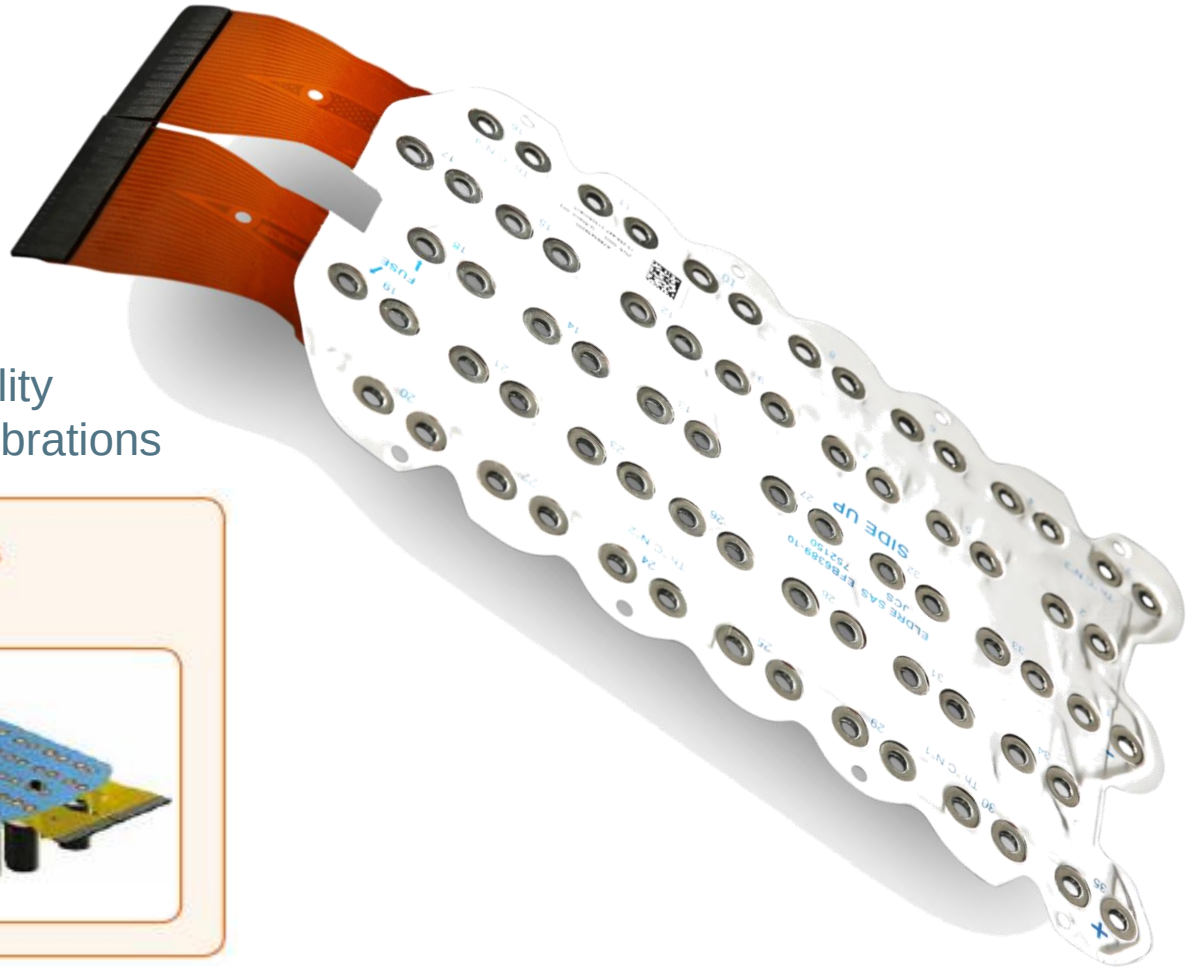






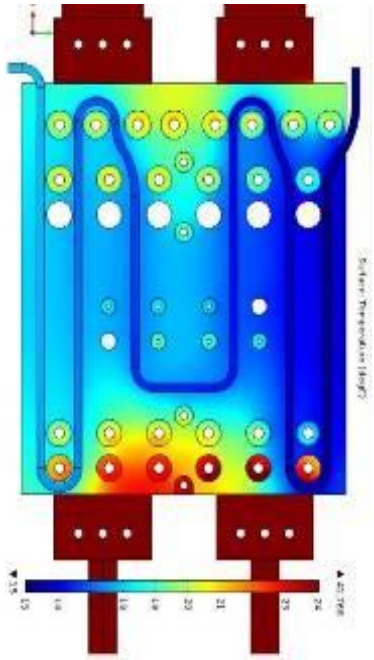
SMART MONITORING BUSBAR TO HANDLE BOTH HIGH POWER AND SMALL SIGNAL IN A SINGLE CONNECTION SOLUTION

- **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



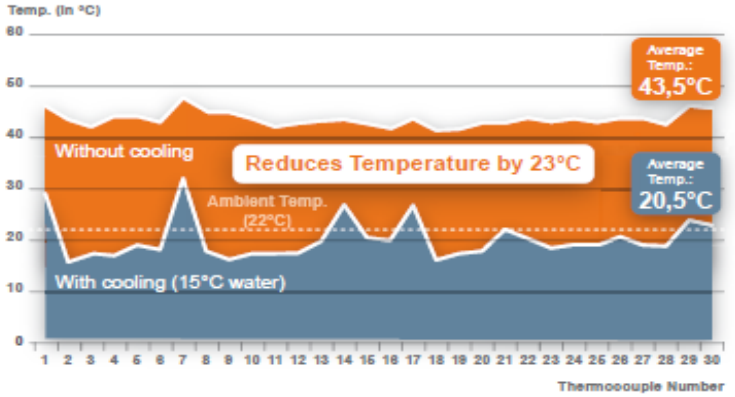
WATER-COOLED BUSBAR TO HANDLE CRITICAL THERMAL APPLICATIONS

- **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)



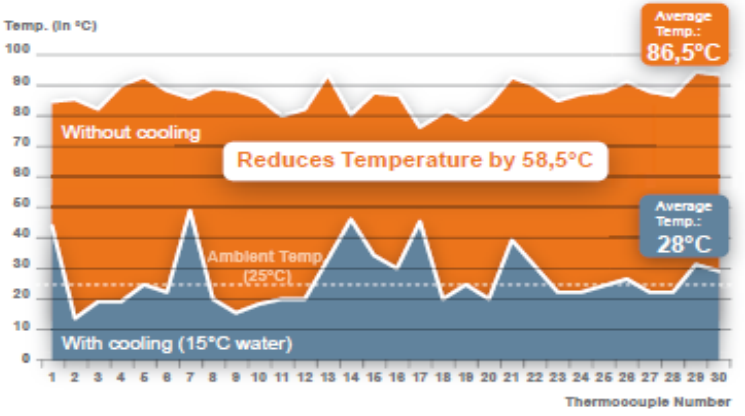
Copper 3mm

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



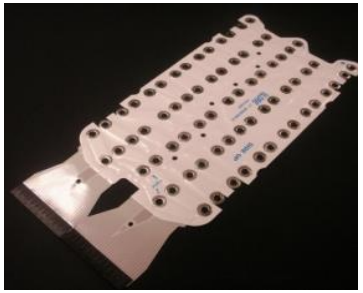
Copper 0,8mm

Comparison of the temperature (in °C)
between 2 busbars of 0,8 mm with cooling & without cooling



MERSEN BUSBAR IN EV/HEV INDUSTRY

MERSEN SMART-BUSBAR IN MERCEDES S400 HYBRID



39 cells in series, 4 thermal sensors, voltage sensor on each cell

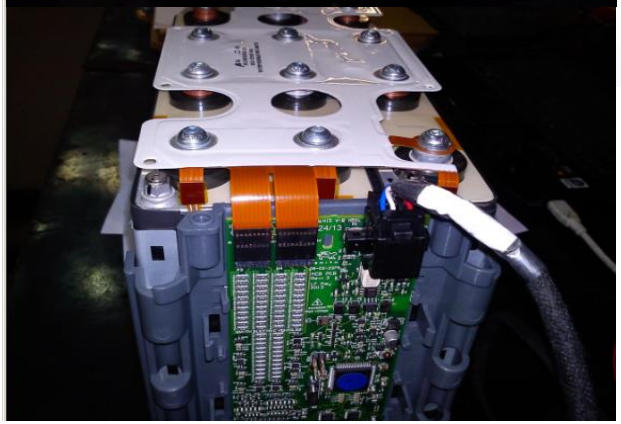
MERSEN BUSBAR IN EV/HEV INDUSTRY

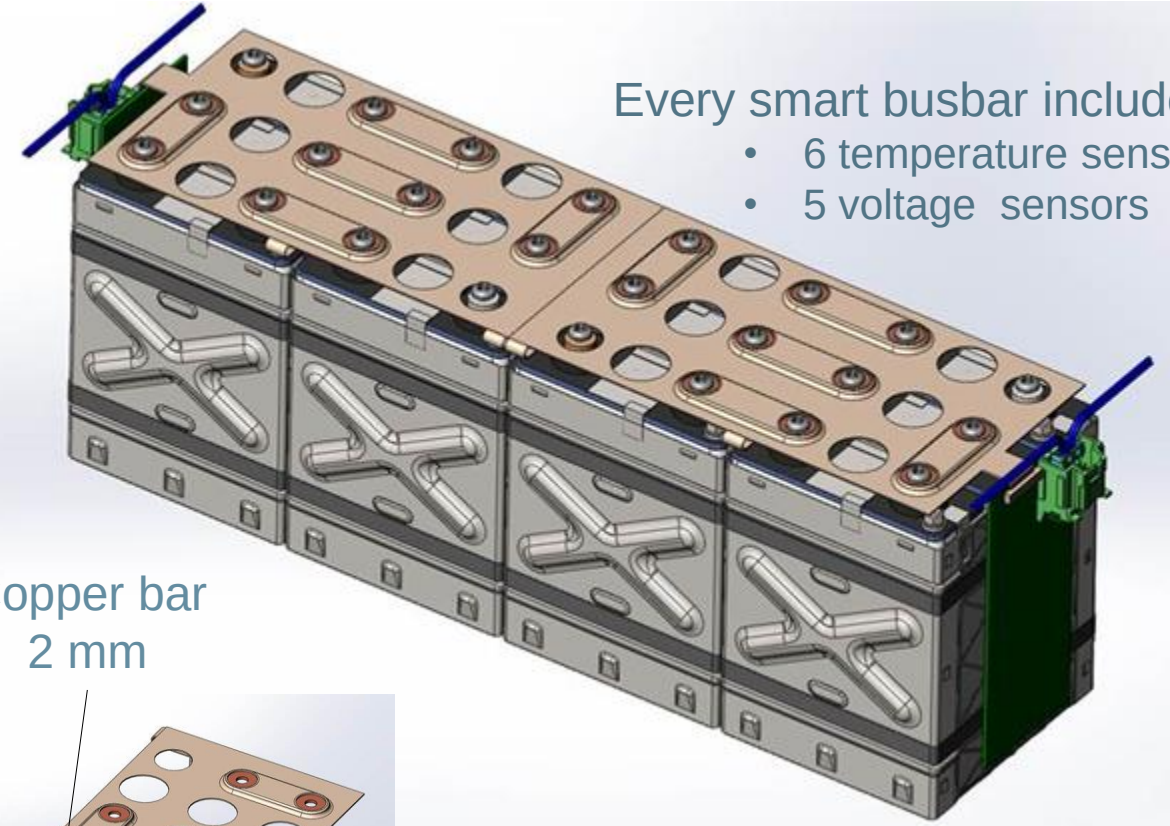
MERSEN LAMINATED BUSBAR FOR BOSCH / PORSCHE 918 SPYDER BATTERY PACK

385 VDC battery pack, **6.8 KWH**, up to **600A** peak

MERSEN BUSBAR IN EV/HEV INDUSTRY

MERSEN BUSBAR IN EV TRUCKS (15 TONS / 400VDC)

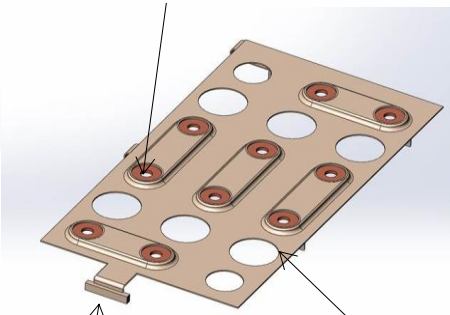




Every smart busbar includes:

- 6 temperature sensors
- 5 voltage sensors

Copper bar
2 mm



Small signal connector

PET dielectric

Temperature sensors

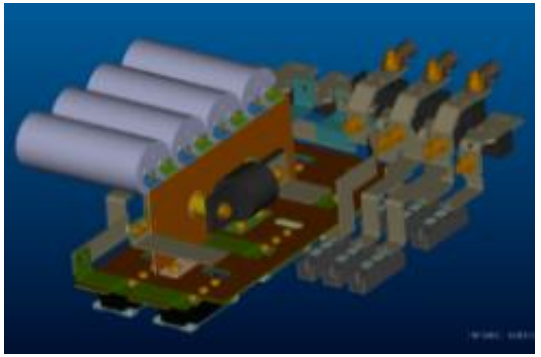
Mersen Busbar in EV/HEV industry

Mersen busbar for supercapacitor bank in stationary storage

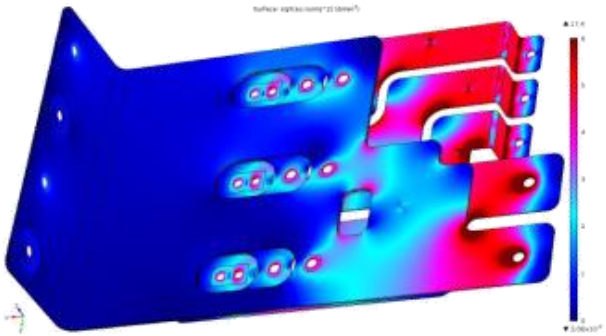
- Busbar for 4x5 cells
- Tin plated
- 54V
- 150A
- -40/+65°C
- Laser welding
- Easy of installation

LBB DESIGN: A COMPLETE SIMULATION TOOL-SET

- **MECHANICAL SIMULATION**
  - Optimization of part placement to save space in the final assembly
  - Ensure mechanical constraints of heterogonous materials

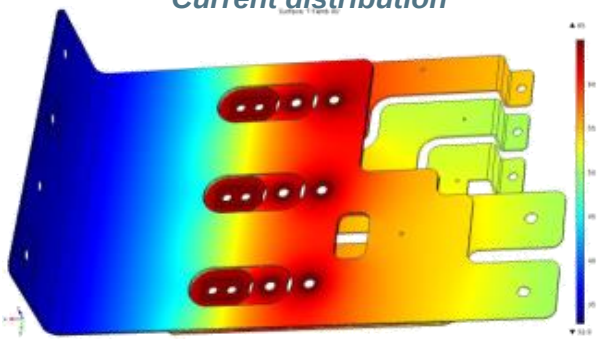


- **ELECTRICAL SIMULATION**
  - Contact routing to meet clearance & creepage
  - Current distribution compliant with admissible current density (A/mm²) to limit self-heating
  - Inductance simulation



Current distribution

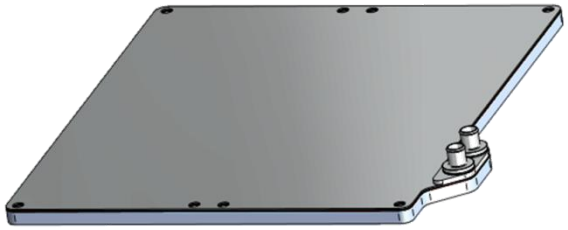
- **THERMAL SIMULATION**
  - Current flow heating-up by Joule effect in the conductors
  - Power Modules create hot-spots at top terminals level
  - Prevent too many heat at capacitor ends



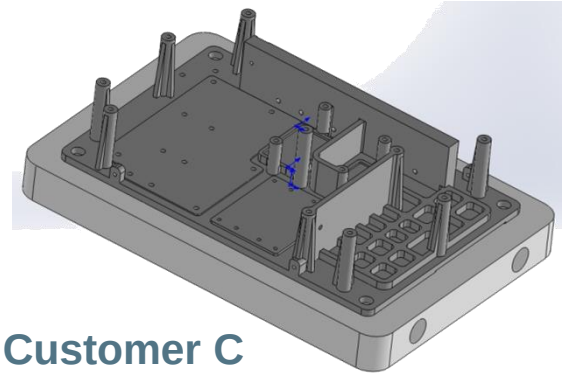
T° increase

COOLING

BATTERY & INVERTER

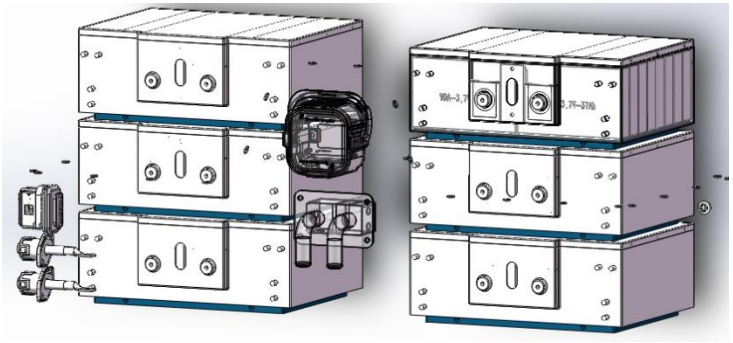


Customer A



Customer C

Customer B

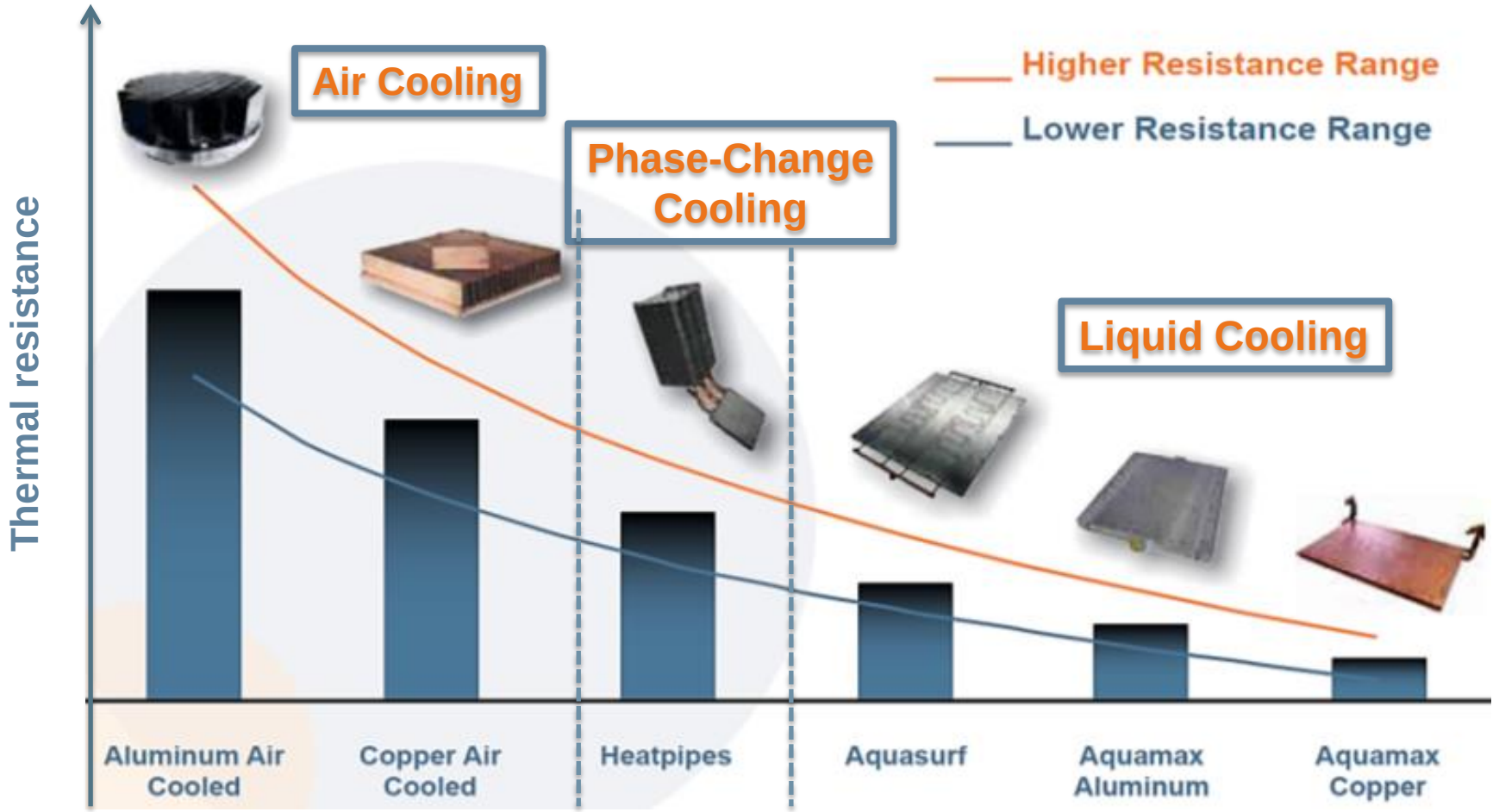


Customer D

MERSEN

THREE COOLING TECHNOLOGIES

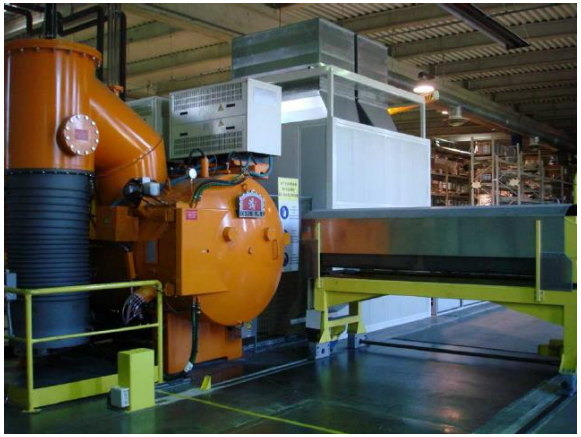
- To meet customer's needs at the closest



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

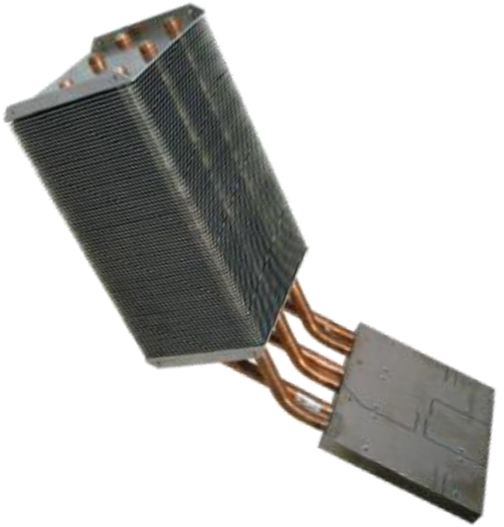


Swaging: a cost-effective and reliable technology for heat-sink fins assembly

- 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

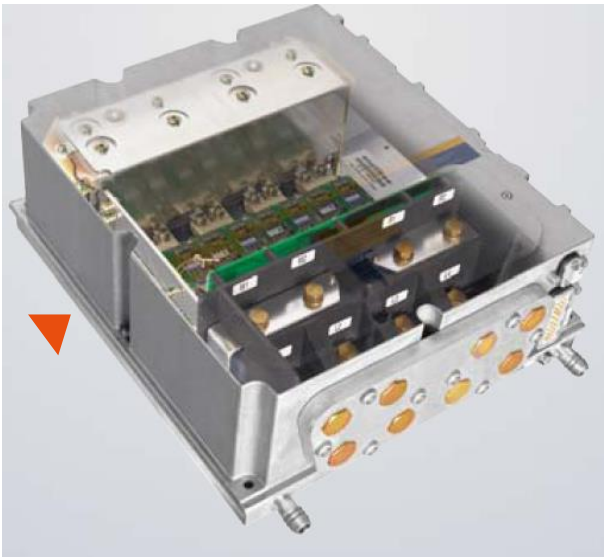
- High thermal performance
- Temperature homogeneity for power module baseplates
- Instant cooling
- Smoothen temperature peaks
- Maintenance-free

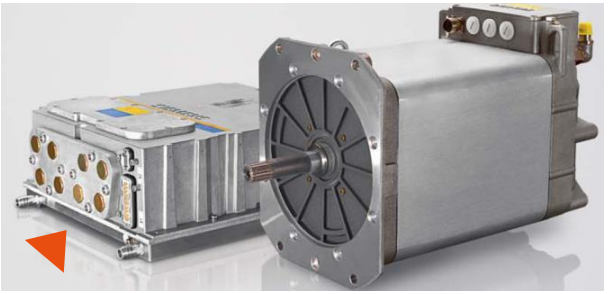


MERSEN COOLING IN EV/HEV INDUSTRY

MERSEN COOLING-PLATE FOR SIEMENS ELFA HYBRID-BUS DRIVES

Liquid cooling plate for hybrid-bus **50 kW** to **180 kW** motor inverter





Mersen Cooling in EV/HEV industry

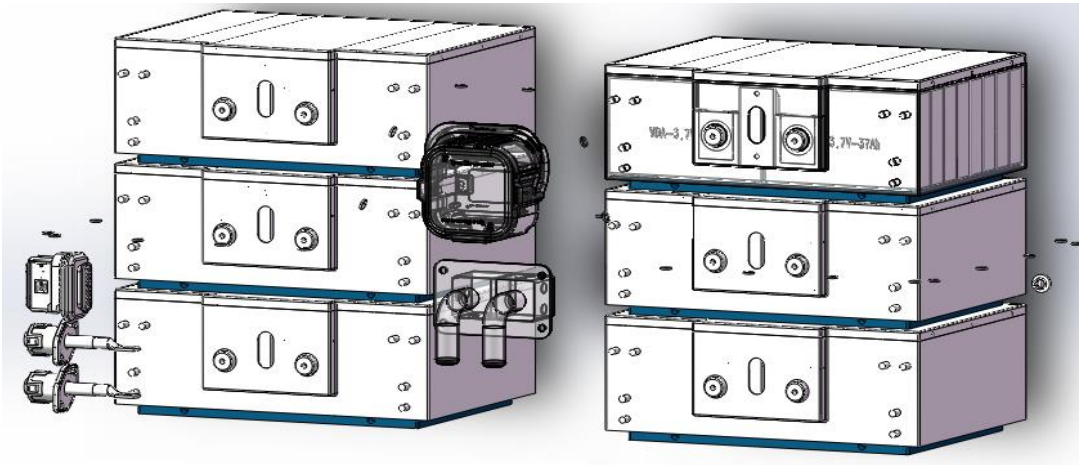
Mersen cooling plate for EV battery pack

- Chinese manufacturer
- passenger cars
- Pin Fin plates to cool down 24 cells single-sided
- 4 plates per battery pack per car
- Brazed connectors

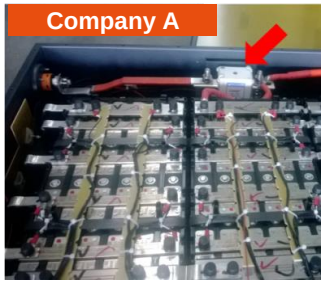
MERSEN COOLING IN EV/HEV INDUSTRY

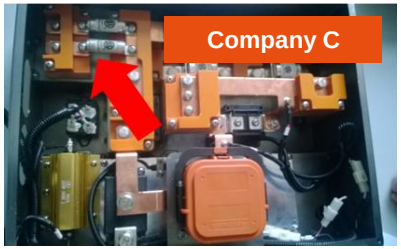
MERSEN COOLING PLATE FOR EV BATTERY PACK

- COOLS DOWN 12 CELLS ON EACH PLATE
- CHINESE CAR MANUFACTURER
- 6 PLATES PER PACK PER CAR



DC Over Current Protection





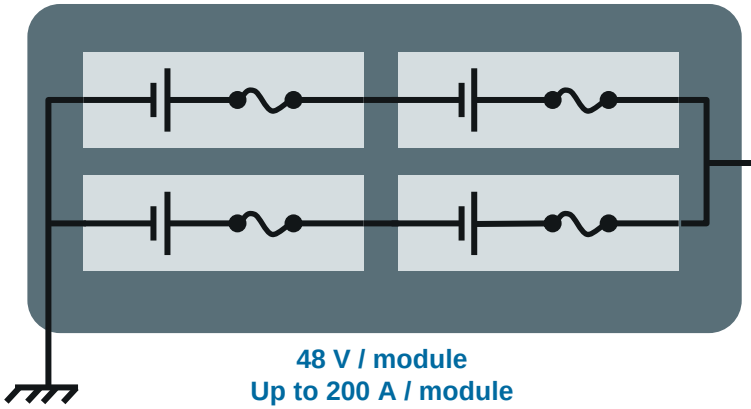
DC PROTECTION AT MERSEN: 3 TECHNOLOGY PATHS

	Monolithic technology	Hybrid technology	
Product range	EVpack-fuse M-fuse	Xp series	Xs series
Core technology	*DC-Fuse*	*Pyro + clearing elements*	*Semiconductor + Switch*
Value-proposition	Ultra fast-acting fuses (for large fault currents) Cost-effective & proven technology DC specific design	Fast-acting protection < 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	Fast-acting protection Close-to-zero conduction loss Fully configurable Resettable Arc-less
Visuals			

TYPICAL EV/HEV PROTECTION TOPOLOGY AND DEVICES

Main battery pack

1 to 16 battery modules assembled in series/parallel
(1 fuse per module → up to 16 fuses)



48 V / module
Up to 200 A / module

Maintenance Safety Disconnect MSD

(1 fuse + DC contactor)

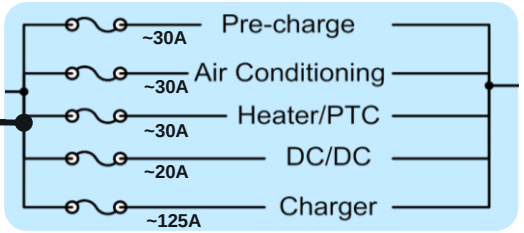
450 → 1,000 V
Up to 800 A

Inverter + Motor

450 → 1,000 V
Up to 800 A

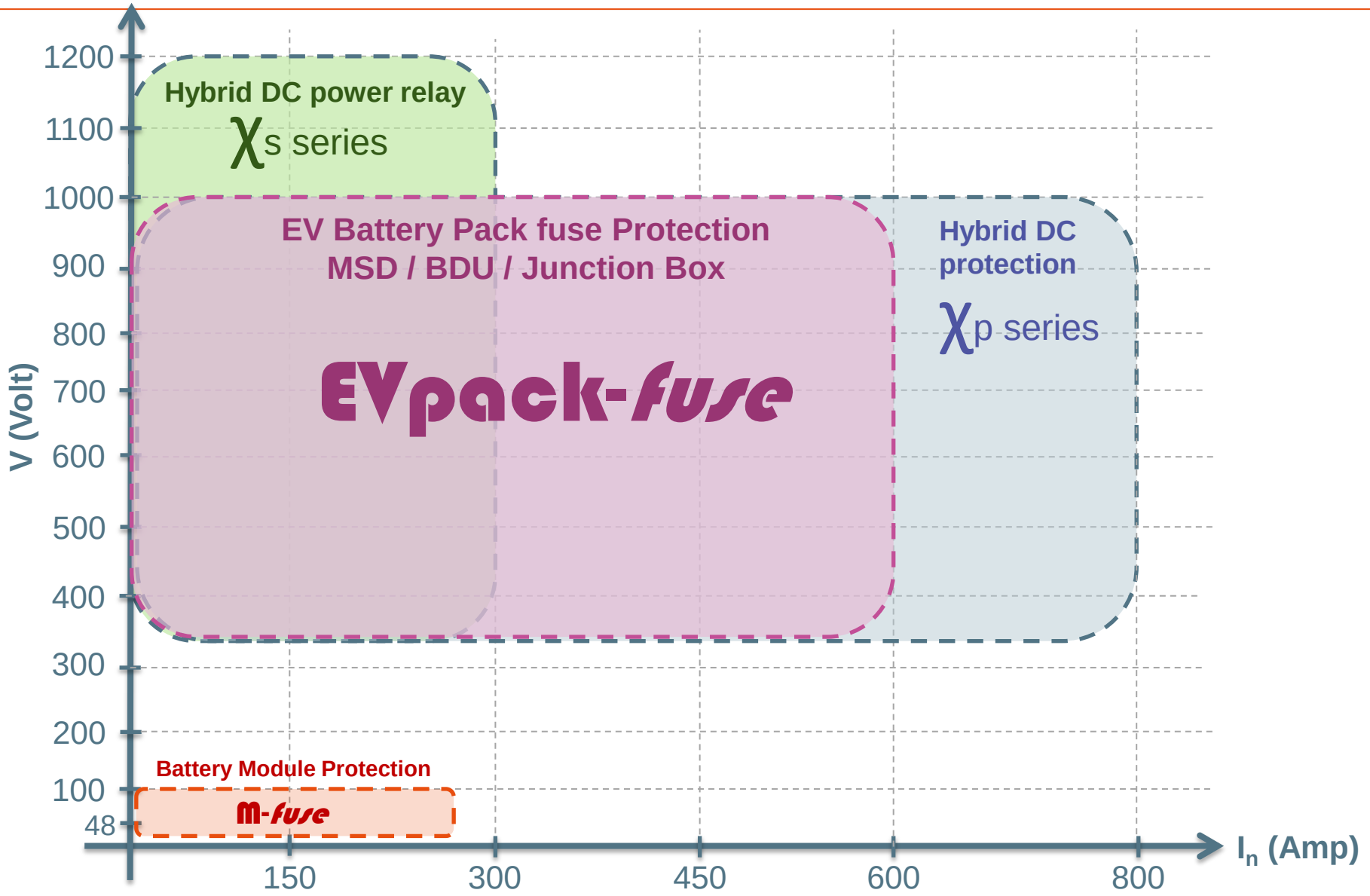
Junction Box / Battery Disconnect Unit BDU

(4 to 8 fuses)

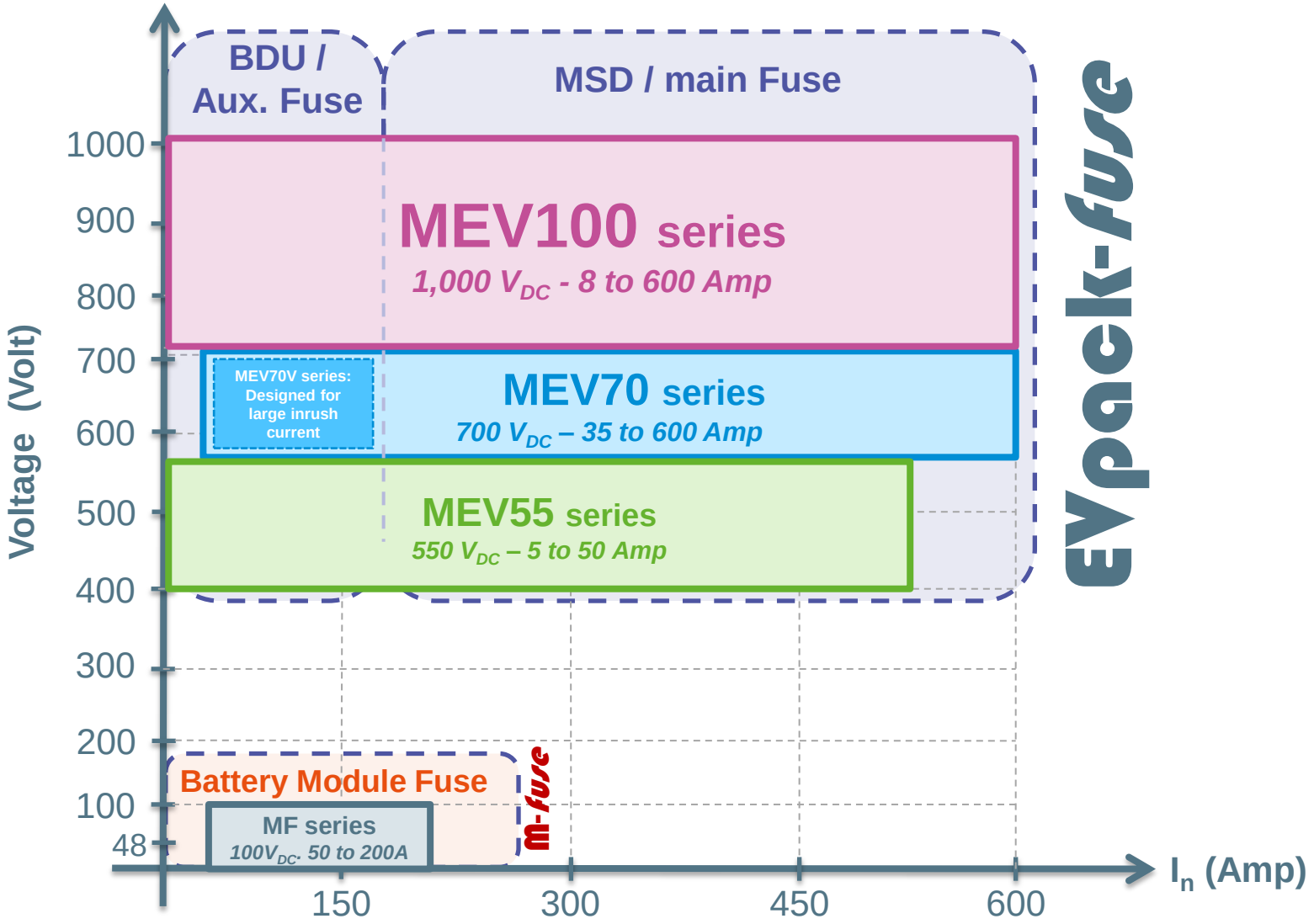


450 → 1,000 V
10 → 200 A

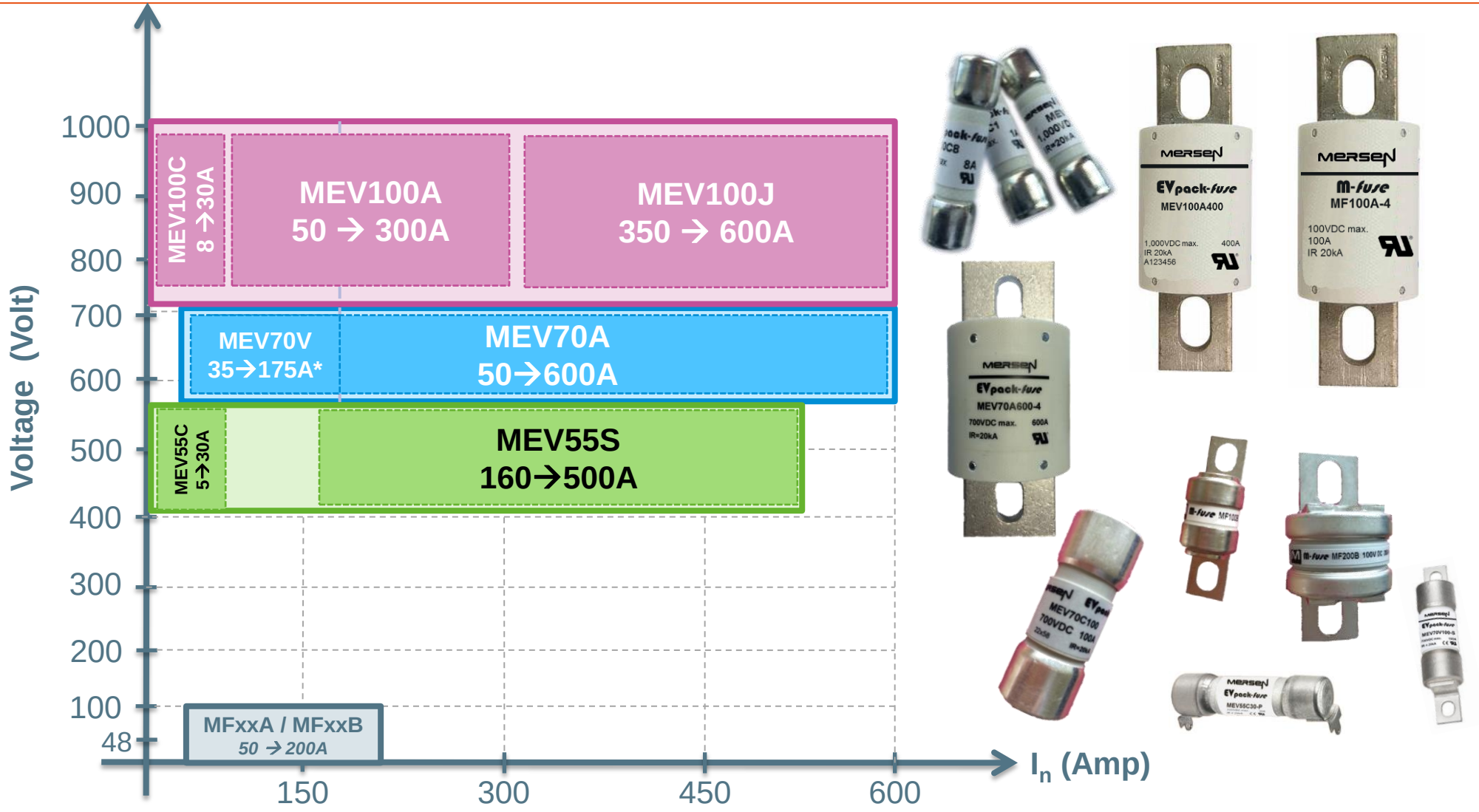
3 FAMILIES OF PROTECTION AND OPERATION DEVICES FOR DC APPLICATIONS



4 DC FUSE SERIES FOR BATTERY PROTECTION



9 FUSE PRODUCTS LINE-UP FOR BATTERY DC PROTECTION



*: MEV70V. Specifically designed for large inrush current

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:**

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

χ_P : Hybrid Over Current Protection Device

- **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_{DC} in less than 1 ms !

Electric data – main circuit	
Nominal Voltage	Up to 1,000 V_{DC}
Nominal Ampere In	Up to 800 A
Max breaking capacity	15 kA @ 1000 V_{DC} with L/R = 2 ms
L/R max	5 ms
Power dissipation at In	20W @ 25°C
Gate Control current	2A – 10A (2ms)
Gate Control resistance	2.2 Ω
Temperature range	-40°C to +90°C

χ_S EV: Hybrid DC Power Relay

- **XsEV have been engineered to provide high DC switching performances versus conventional mechanical power relay.**
- **XsEV 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 designed specially for electrical vehicle applications.**
- **Main features and Benefits**
  - Designed for DC applications
  - Bidirectional
  - Arc-less
  - Reduced footprint & mass
  - 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 that can repetitively clear up to 2kA at 1,000 V_{DC} !

Electric data – main circuit	
Device current polarity	Bidirectional
Nominal voltage	500 / 1000 V_{DC} (1200 V_{DC} soon available)
Continuous current	300 A
Max. ON switching current	1000 A
Max. OFF switching current	500 / 1000 / 1500 / 2000 A
L/R max.	≤ 5 ms (for higher ratings please consult Mersen)
Overvoltage during current clearing	Typ. 1400 V @ 500V_{DC} – 2000 V @ 1000V_{DC}
Number of cycles versus current and L/R	> 20 cycles at 2000 A / 500 V_{DC} / L/R = 0.5 ms
Lifetime (mechanical)	> 100 000 cycles
Insulation resistance	> 100 MΩ (initially)
Dielectric strength	3000 V_{DC}
Internal contact gap	3 mm (2x1.5 mm)
Contact voltage drop	150 mV

DC PROTECTION OFFER AT MERSEN: SUMMARY

	Monolithic technology	Hybrid technology	
Family	*DC-Fuse*	*Pyro + clearing elements*	*Semiconductor + Switch*
	EVpack-fuse M-fuse 	 Xp series	 Xs series
Resettable			Yes
Time to clear high fault current	Excellent, 10 of µS	Good, 100's of µs	Good, a few ms
Time to clear low fault current	Slow to melt 10's of seconds	Excellent Down to 100's of µs	Excellent, a few ms
Cycling performance	Application dependent	Excellent	Excellent
Conduction losses	80W (400A)	20 W (400A)	45 W (300A)
Tunable Time-Current curve	Limited	Yes	Yes
Self-triggered	Yes	Yes	No

MERSEN: ESTABLISHING DC PROTECTION RULES…