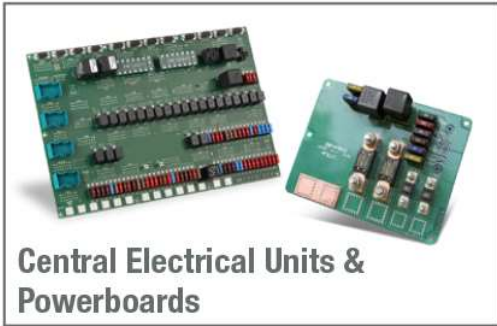




High current, high voltage: PDUs and EMC filters for vehicles



Würth Elektronik ICS Agenda



Central Electrical Units & Powerboards



Power Boxes



Controllers

**HIGH-PERFORMANCE COMPONENTS
FOR A WIDE
APPLICATION SPECTRUM**

**SYSTEMS FOR
MOBILE MACHINES
AND COMMERCIAL
VEHICLES**



HMI Solutions



HV Solutions



Powerelements



Plug Connection Technology



High current, high voltage: PDUs and EMC filters for vehicles

- Introduction of High Voltage Power Distribution solutions
- Press-fit technology and integration of components on the PCB
- Application of High Voltage Power Distribution Units
- Filter box example
- Questions and answers

High current, high voltage: PDUs and EMC filters for vehicles

Introduction of High Voltage Power Distribution solutions



Power Distribution Unit

1

Distribute safely the energy within the vehicle by switching loads when needed

2

Protect the vehicle electrical network and provide measurements to vehicle controllers

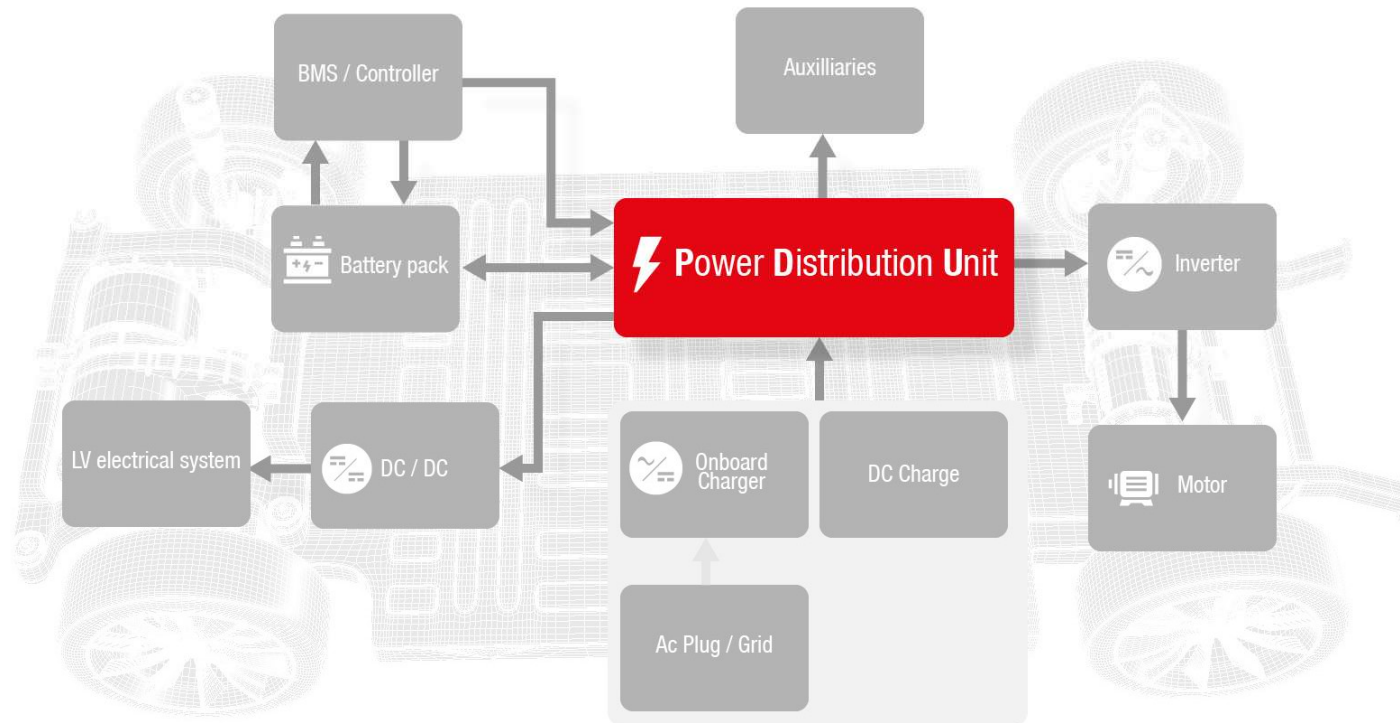
3

Enable safe and easy maintenance

High current, high voltage: PDUs and EMC filters for vehicles

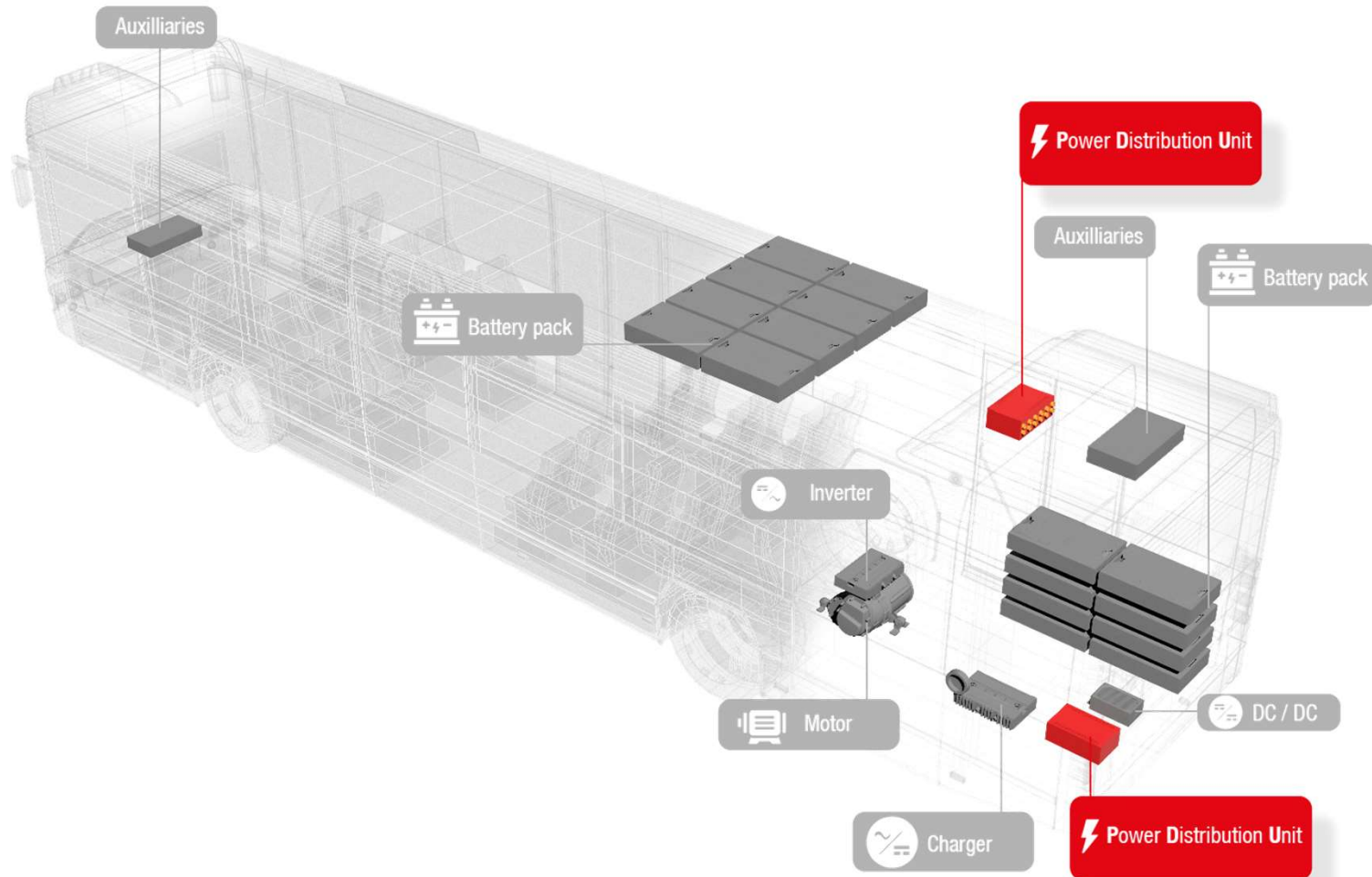
Introduction of High Voltage Power Distribution solutions

Battery electric vehicle architecture



High current, high voltage: PDUs and EMC filters for vehicles Introduction of High Voltage Power Distribution solutions

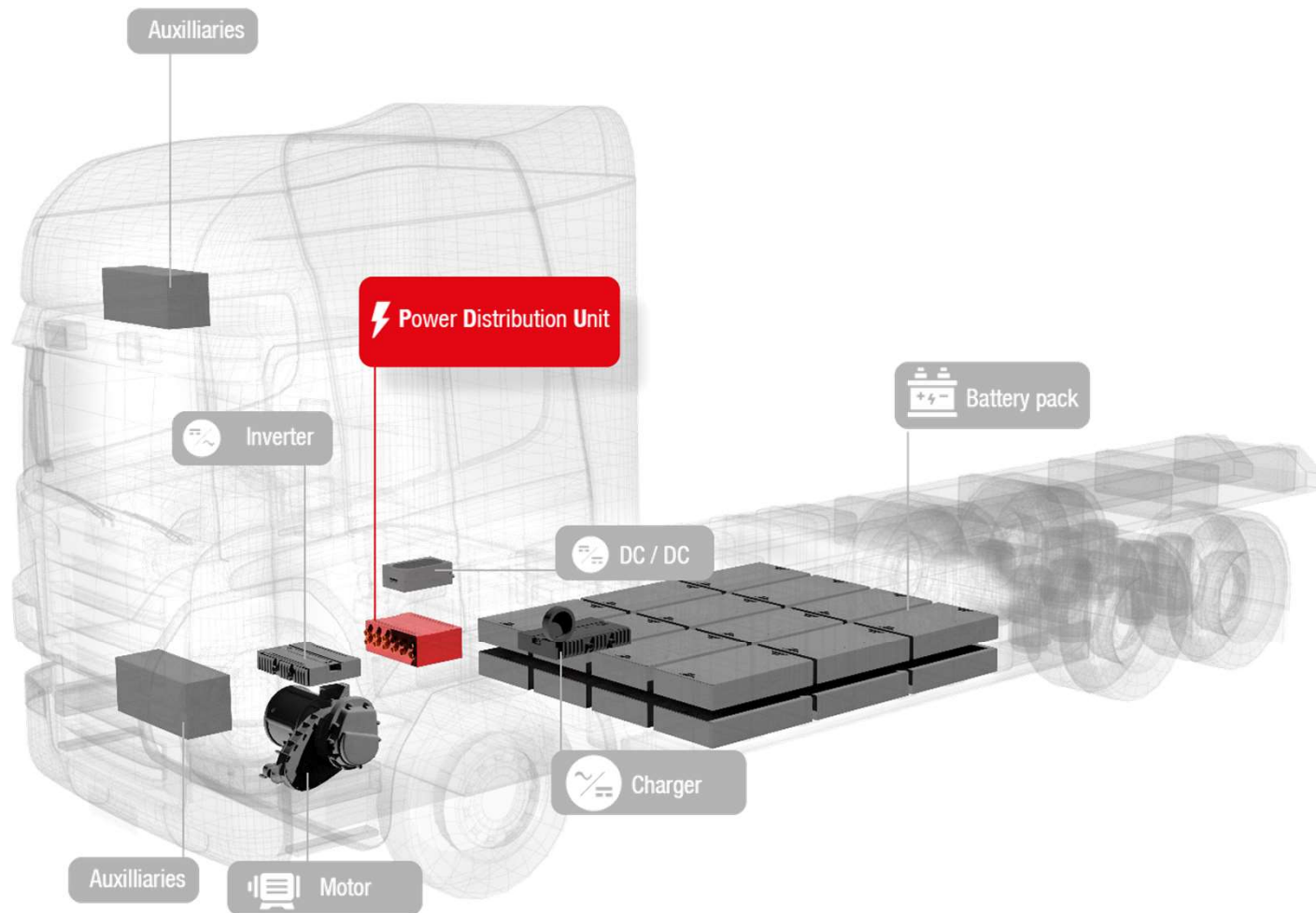
Bus



High current, high voltage: PDUs and EMC filters for vehicles

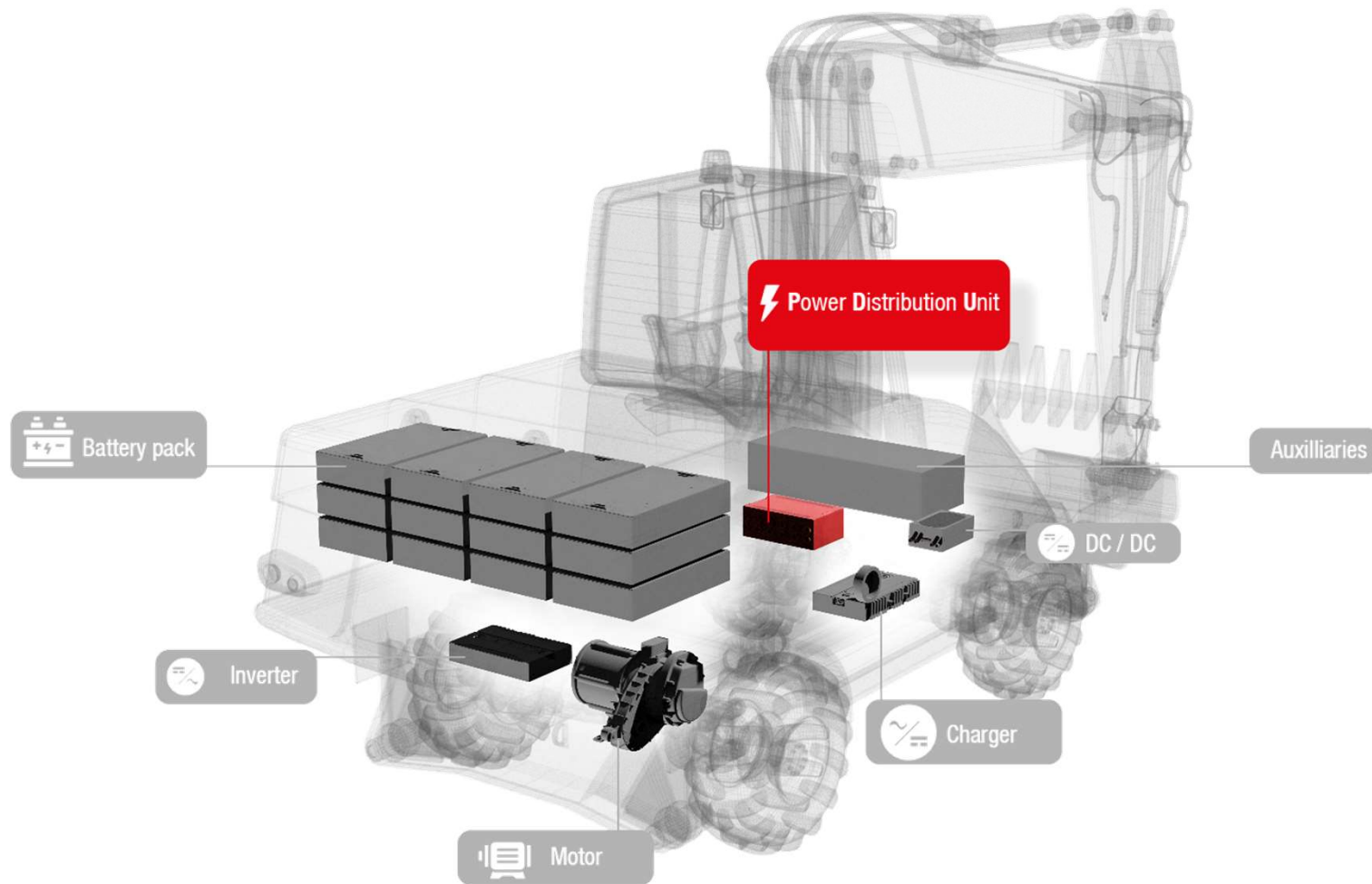
Introduction of High Voltage Power Distribution solutions

Truck



High current, high voltage: PDUs and EMC filters for vehicles Introduction of High Voltage Power Distribution solutions

Construction



High current, high voltage: PDUs and EMC filters for vehicles

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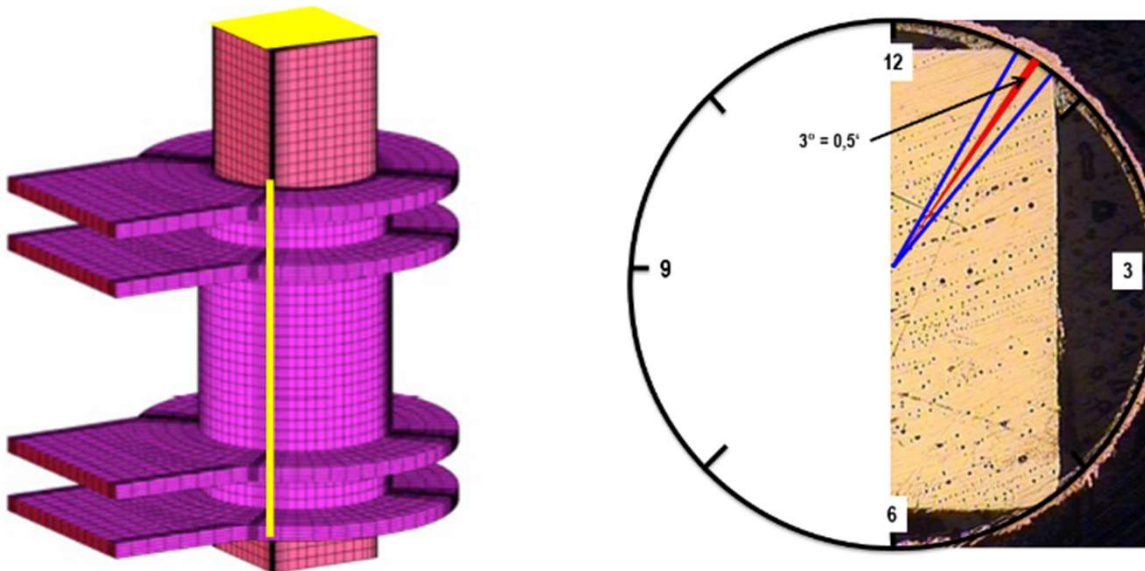
High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



What is solid press-fit ?

- Solid press-fit allows important contact surface between conductors and PCB metal holes.
- 3° of contact on the sides of the pin with PCB hole are theoretically enough to achieve a similar section of the pin. In reality the contact surface is more than 3° .

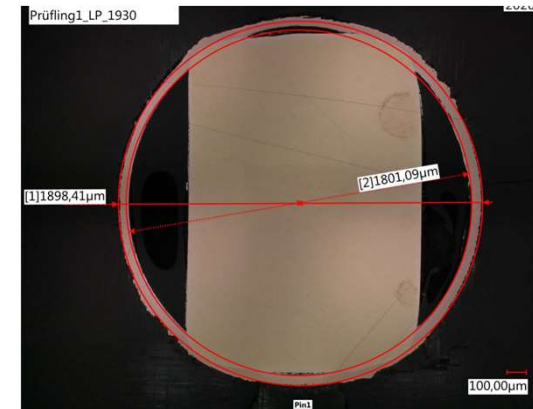
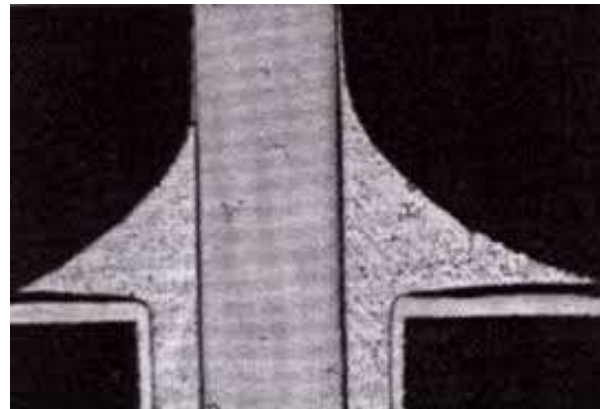
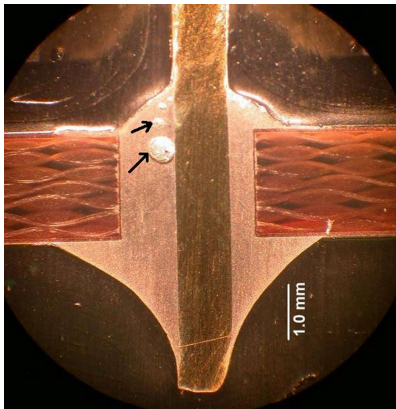


High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



Comparison with soldering



- In case of soldering, more interfaces have to be taken in account pin-solder material and solder material-PCB.
- These interfaces could be impacted by pollution or oxidation for example.
- The tin alloy used for soldering material is also a poor conductor.
 - Cu: 100 % IACS, CuZn37: 26 % IACS, Soldering material: 9 – 14 % IACS
- Press-fit technology avoid these troubles in terms of contact surface quality.
 - There is a direct contact between the pin and the PCB metal hole and so lower resistance.

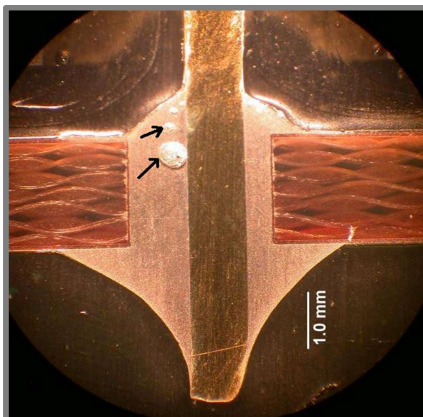
High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB

Advantages regarding cross section

- Usually solder pins are thin to avoid thermal inertia in the process. Limits are quickly achieved in terms of cross section, PCB thickness, copper layers thickness ...
- Press-fit technology doesn't have these limitations. This is possible to use bigger conductor's cross sections, higher number of conductors, thicker PCB, thicker copper layers and higher number of layers.

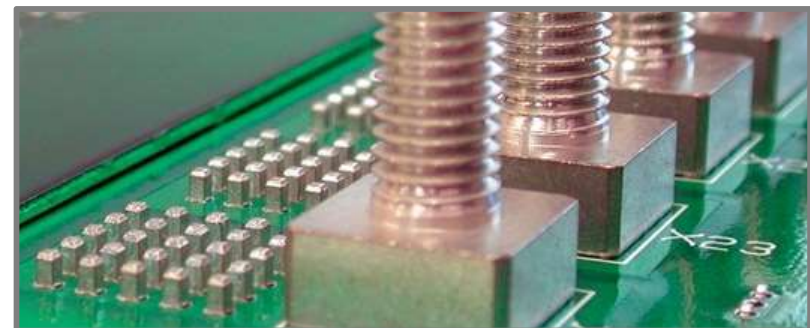
→ The result is that press-fit contacts can handle really high current in a PCB



Cut view of soldering point



Cut view of press-fit area

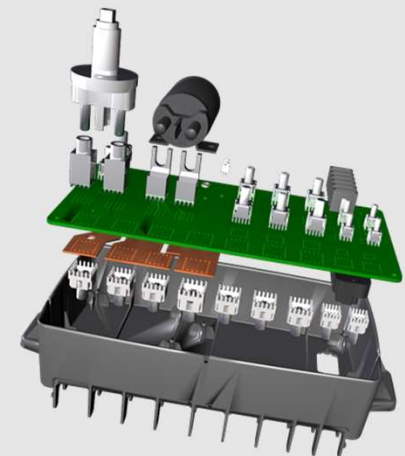
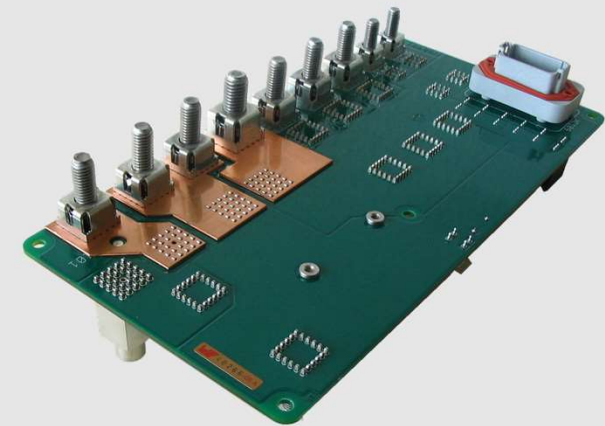


High current, high voltage: PDUs and EMC filters for vehicles

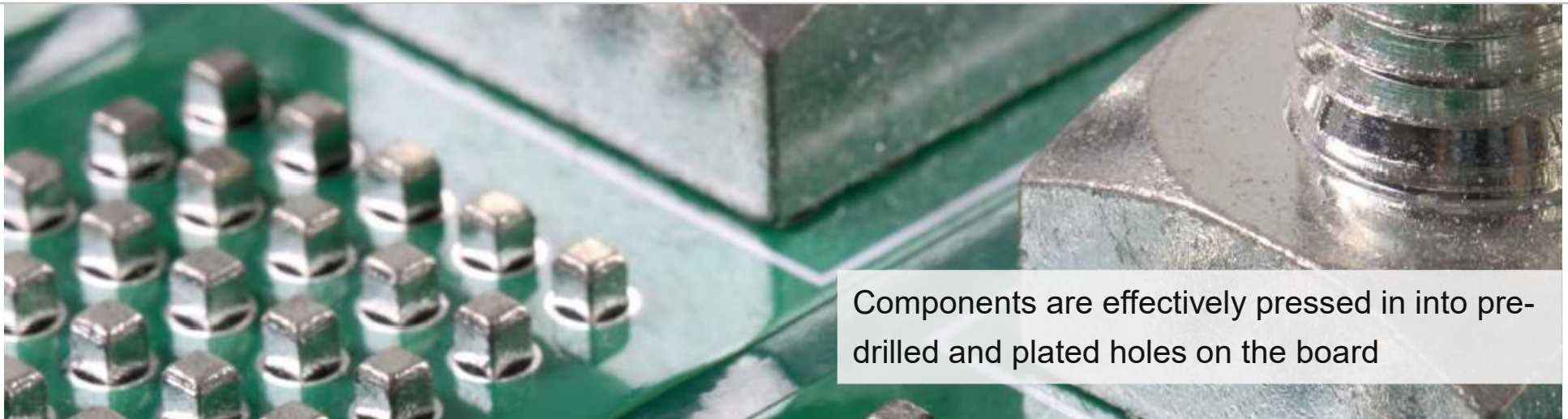
Press-fit technology and integration of components on the PCB

Design advantages

- **2 sides equipment possible with some advantages:**
 - Compactness
 - User interface optimised and clean
 - Optimal position of the components to answer system constraints
- Specific design of Powerelements can be realised to simplify the connections and be adapted to system constraints
- Allows big wire size connection or big component without additional interface
- Possibility to reinforce locally some connections by adding press fitted busbar



High current, high voltage: PDUs and EMC filters for vehicles Press-fit technology and integration of components on the PCB



Components are effectively pressed in into pre-drilled and plated holes on the board

Solid press-fit technology is most notably suitable for **high-current applications** and for the use under **harsh environmental conditions**:

- Excellent electrical characteristics
- Ultra low electrical resistance → Low thermal elevation
- Excellent mechanical properties of solid press-fit zone (regarding shock and vibrations)

High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



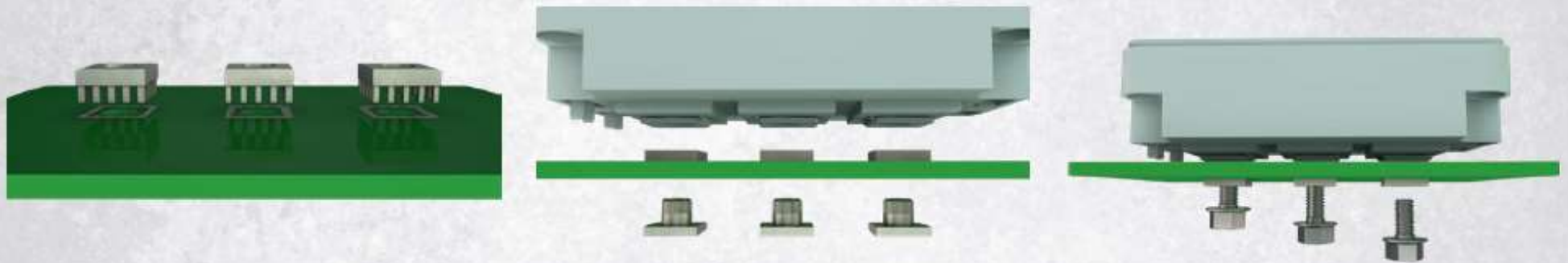
PowerOne



High current, high voltage: PDUs and EMC filters for vehicles Press-fit technology and integration of components on the PCB



PowerTwo



Connection of an IGBT module with **LF PowerTwo**

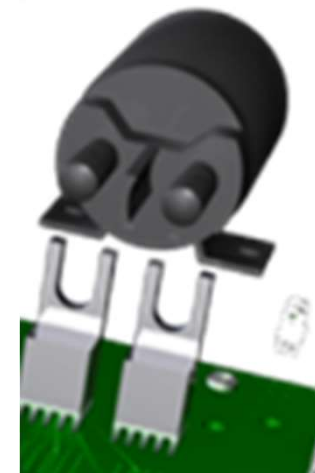
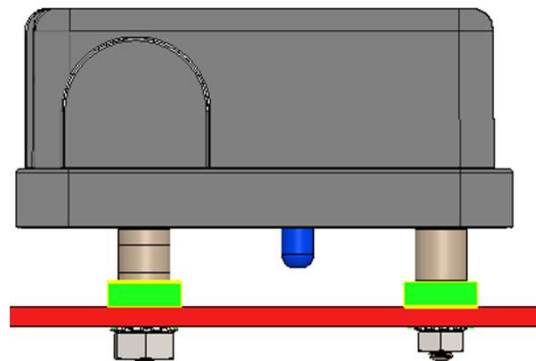
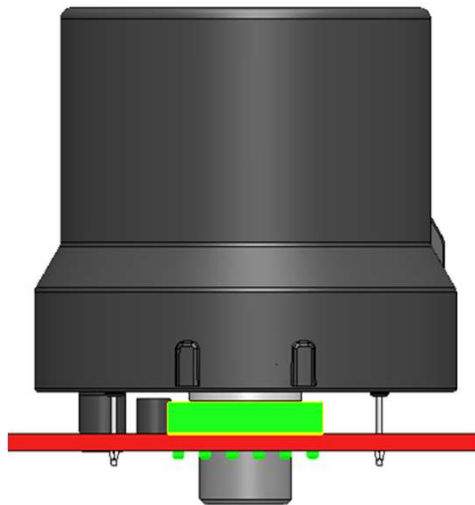
WE ICS

High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



Design blocks: contactor examples

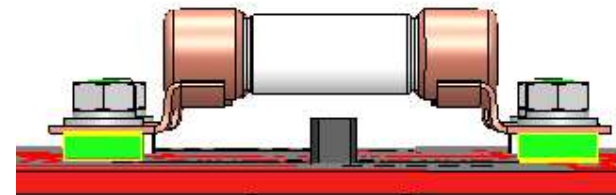
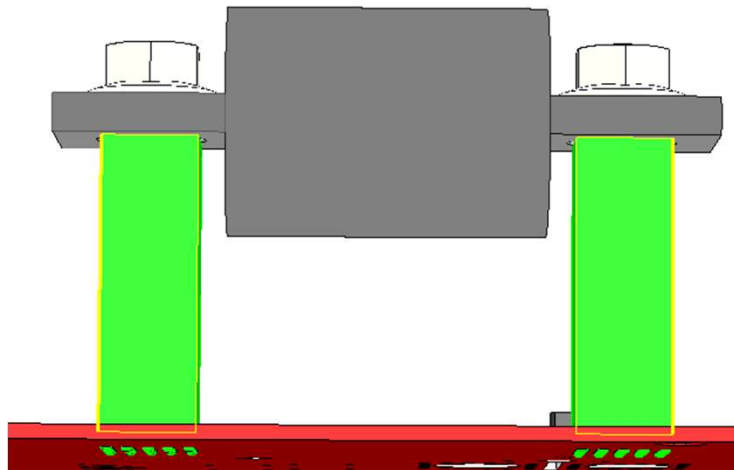


High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



Design blocks: fuse examples

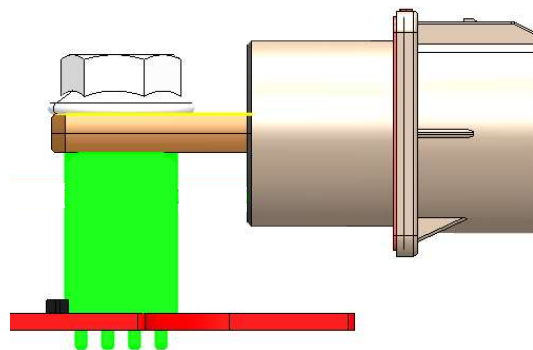
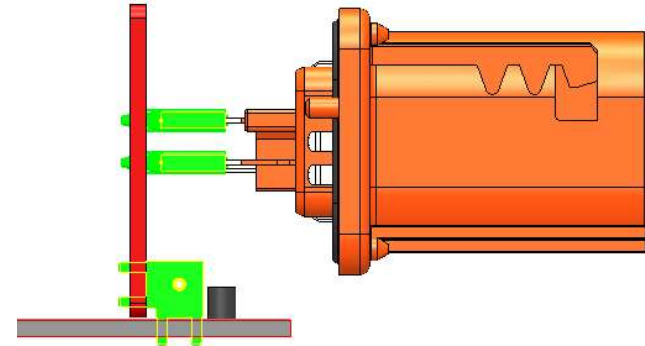
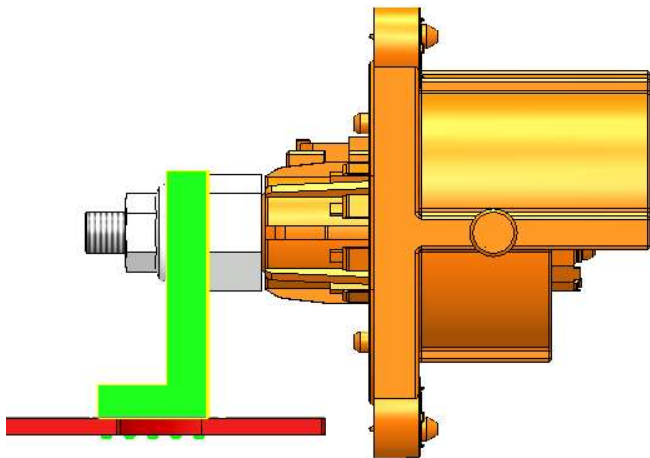


High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



Design blocks: connector examples

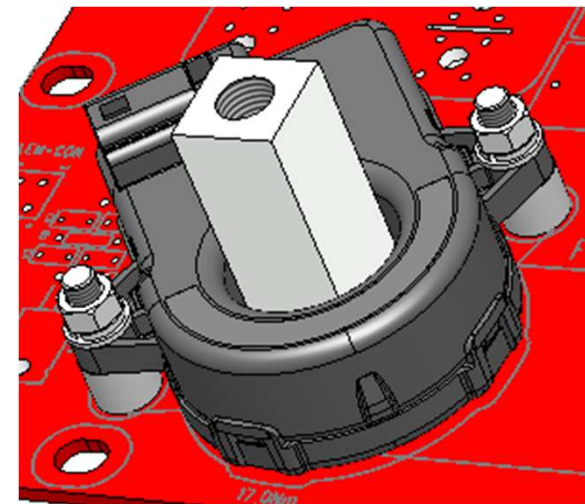
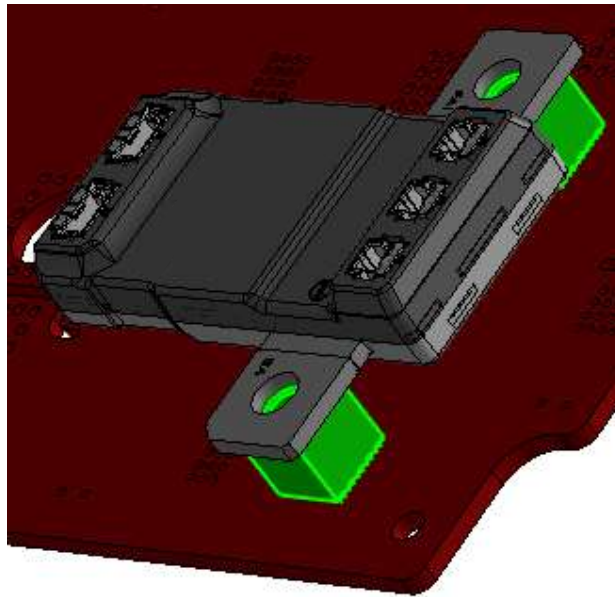
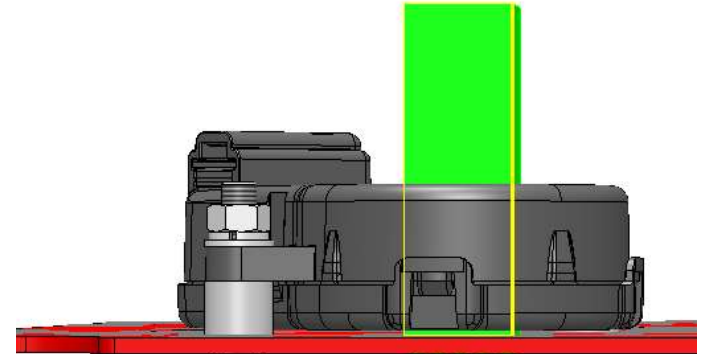


High current, high voltage: PDUs and EMC filters for vehicles

Press-fit technology and integration of components on the PCB



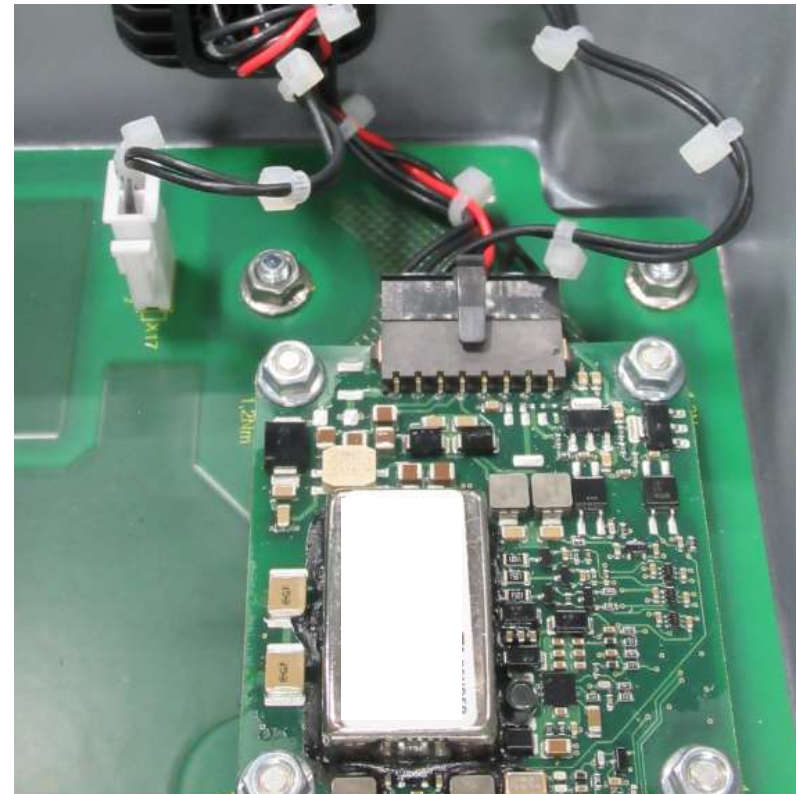
Design blocks: current sensor examples



High current, high voltage: PDUs and EMC filters for vehicles Press-fit technology and integration of components on the PCB



Design blocks: isolation monitoring examples



High current, high voltage: PDUs and EMC filters for vehicles

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High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units



Requirements for PDU



Mechanical

- Compactness to fit to limited space
- Limited weight
- Adapted to routing of cables



Electrical

- Withstand high voltage and high power
 - Insulation and thermal management
- Safety mechanisms
 - High voltage interrupt line
 - Equipotential bonding



Environmental

- Limited temperature (60 °C – 85 °C)
- Medium / High vibration level
- High IP protection required
- Qualification of the product



Components

- Big fuses
- Big contactors
- Specific connectors
- Voltage / current measurement

High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units



Norms and Testing

- **We are designing according**
 - ECE R100
 - LV123
 - DIN EN 60664 for insulation coordination
- **ISO 16750 for environmental test and LV123 for electrical characteristics**

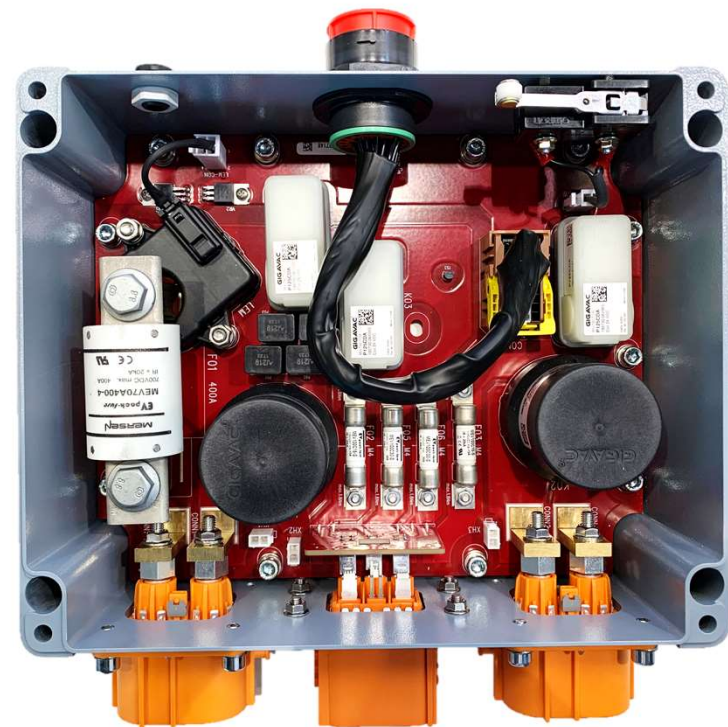
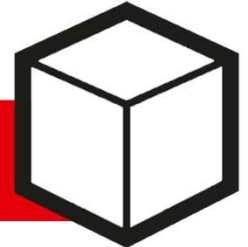
High current, high voltage: PDUs and EMC filters for vehicles Application of High Voltage Power Distribution Units



CUSTOMER SPECIFIC DESIGN



DEMONSTRATOR PRODUCT

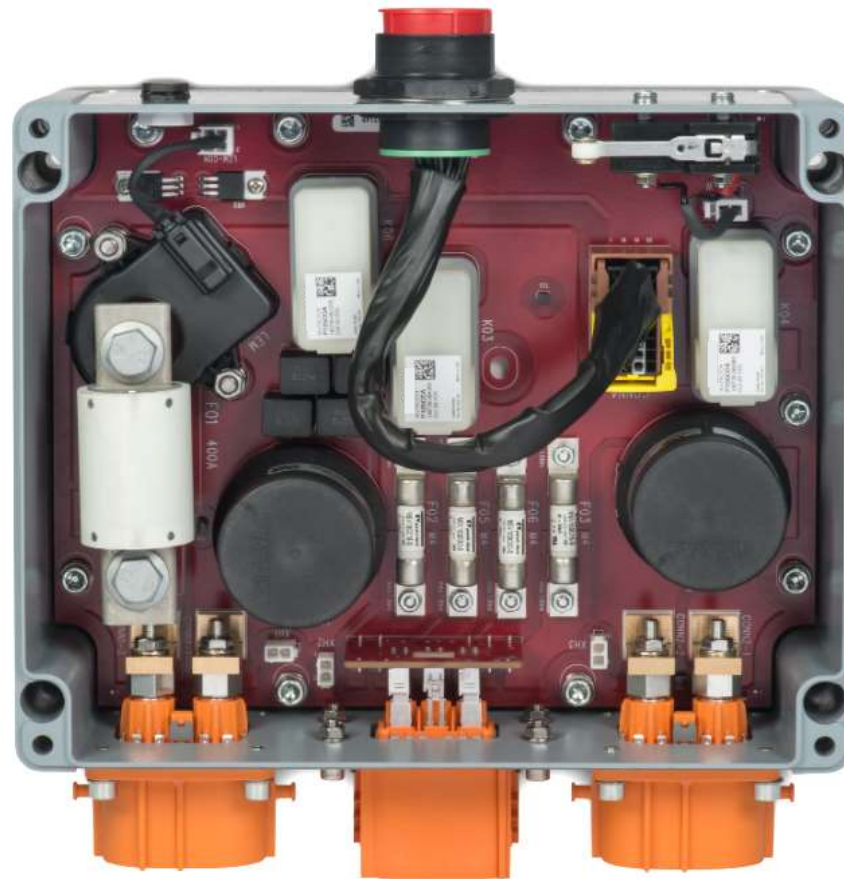


High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units



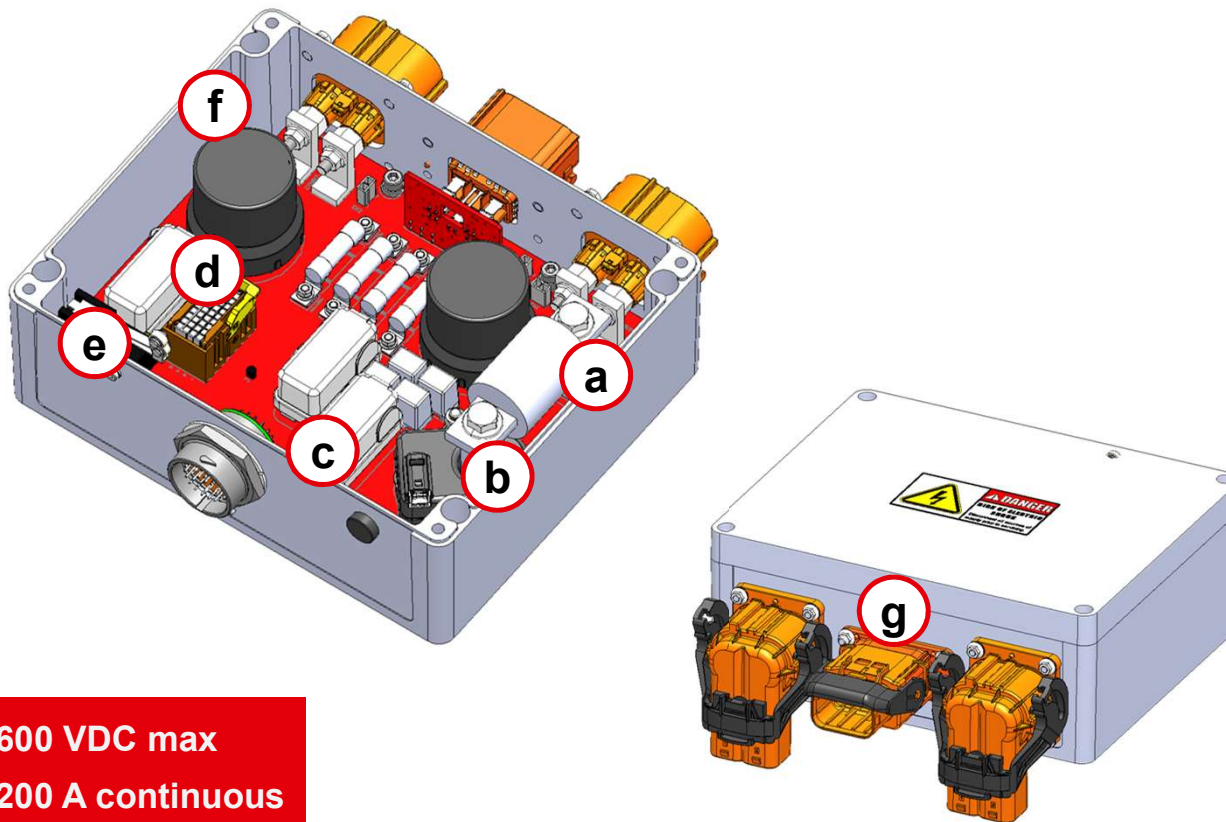
HV PDU 600



High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units

HV PDU 600



- 600 VDC max
- 200 A continuous

400 A fuse

- 400 A 600 VDC fuse integrated

a

Measurement

- Current measurement on CAN
- Temperature measurement

b

Precharge circuit

- Using small contactor & PTC

c

Fuses

- 4 x 8 A to 30 A
- 20,000 A interrupting rate

d

HVIL Loop

- switch for Lid opening detection
- HV-Interlock connectors

e

Contactors integration

- Directly plugged into PCB

f

Plug and Play PDU

- Full connectorised HV + LV

g

High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units

500 A fuse

- 500 A 400 VDC fuse integration
- Dedicated PE design

a

Precharge circuit

- PTC based precharge circuit
- Contactor integration

b

Solid state contactor

- Integration of solid state contactor

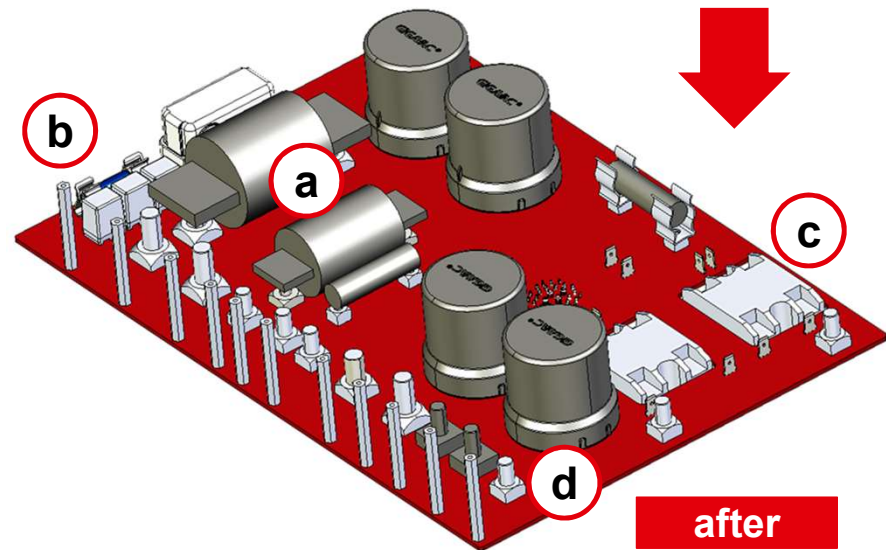
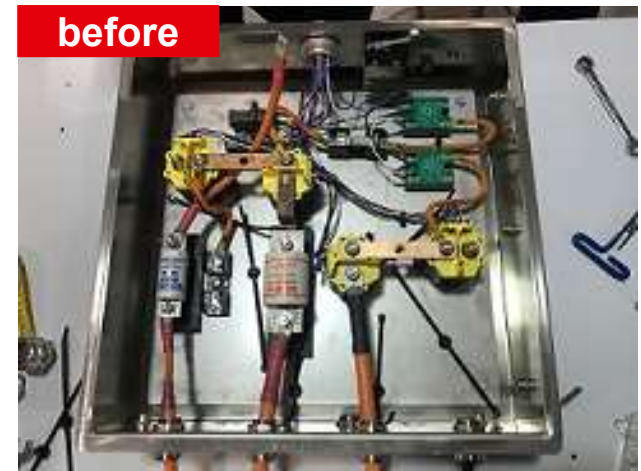
c

Contactor integration

- Directly plugged into PCB
- Busbar press fitted on the back side
- Cost optimisation

d

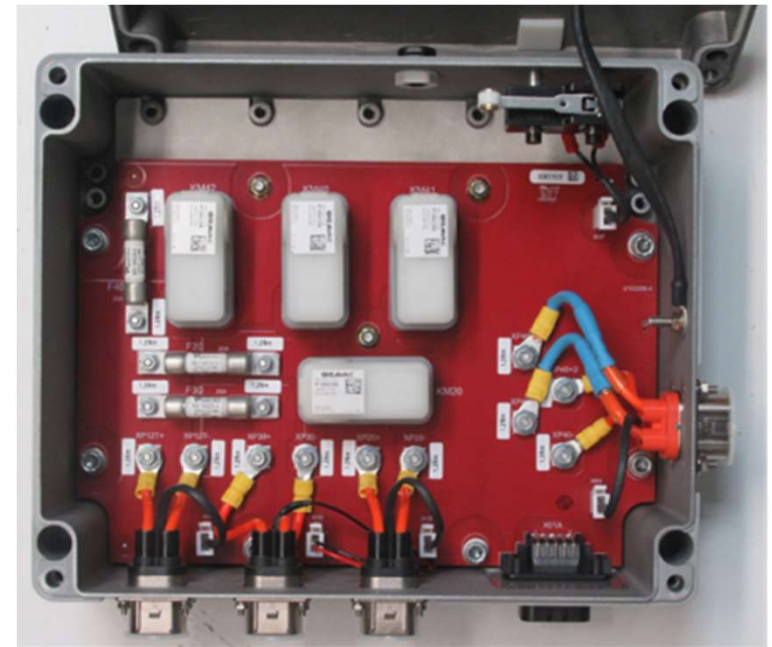
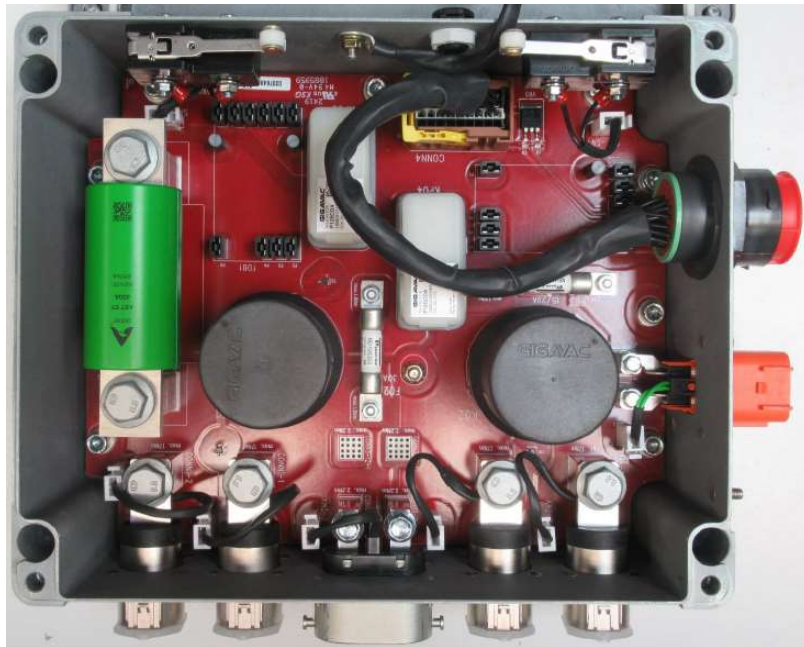
- 400 VDC nominal
- 250 A nominal



High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units

PDU examples



High current, high voltage: PDUs and EMC filters for vehicles

Application of High Voltage Power Distribution Units



Market expectations vs Product advantages

Reliability, quality and safety

- Robust & compact design
- Removal of all intern HV wires
- Multiple in-line and EOL testing

Suitable for mass production

- Established technologies
- Reduced number of assembly steps
- Production lines already available

High flexibility

- PCBs and components within the box can be customized
- Different box sizes possible

Price efficiency

- High components cost removed (bus bars, HV wire harness ...)
- Simplified assembly process
- Smaller assembly

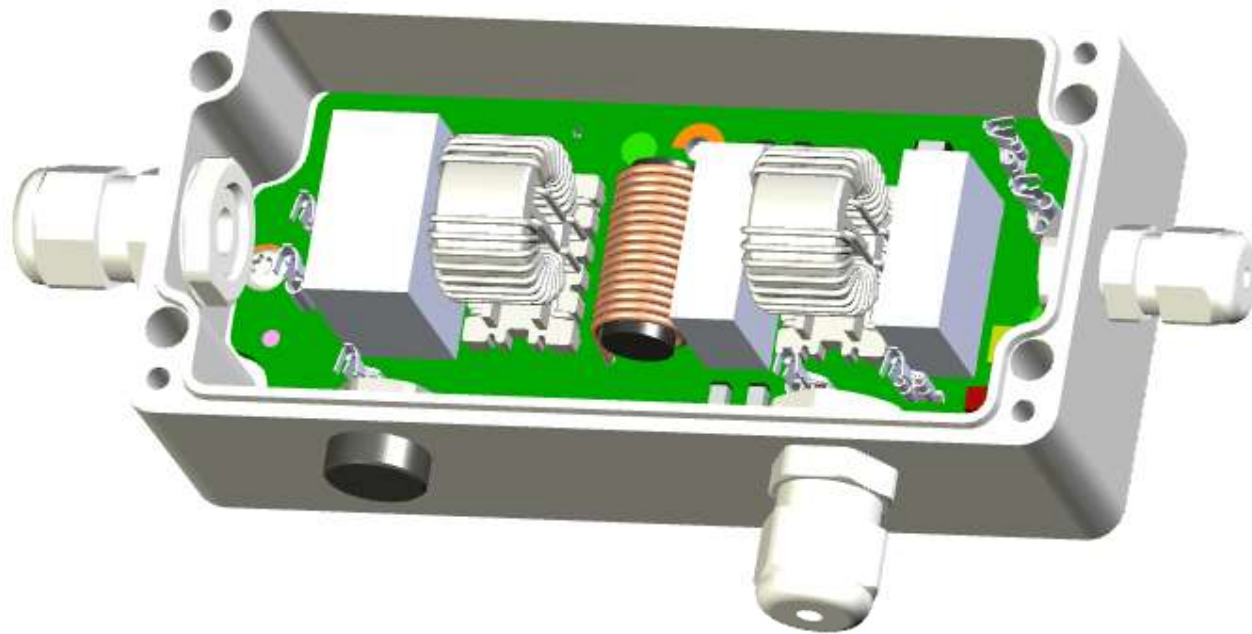
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Filter box example

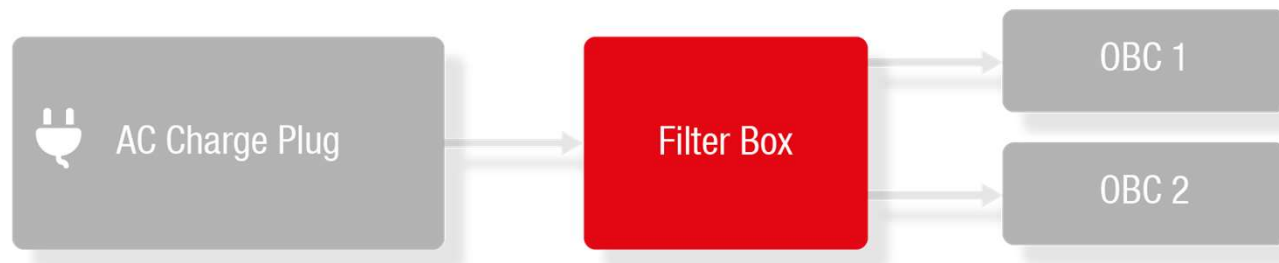
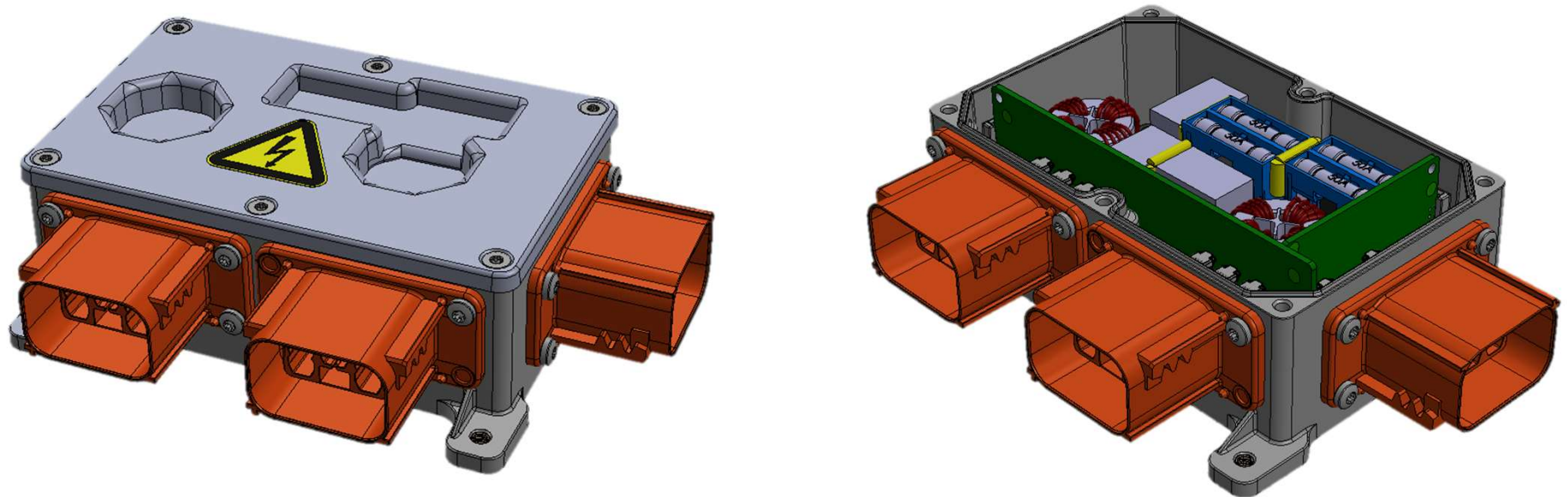
Filter box for 1 On board chargers example



High current, high voltage: PDUs and EMC filters for vehicles

Filter box example

Filter box for 2 On board chargers example



High current, high voltage: PDUs and EMC filters for vehicles

Summary



What did you learn?

- **Different vehicles architectures and size of vehicles lead to different types of PDU.**
- **Press-fit technology allow easy and safe connection to PCB. PDU based on PCB technology are compact and plug & play solutions.**
- **Würth Elektronik ICS is offering its services to help you select and customize our products to your needs. We are always open to develop new things together.**
- **The perfect power distribution is the one that fits your needs. Get in touch with us, we would be happy to discuss that with you!**

Würth Elektronik ICS
Thank you for your attention

