High precision current, voltage, and insulation measurement with CAN bus interface for battery management systems

(M.Sc.) Felix Lebeau

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ENERGY STORAGE

Structure

- Current Measurement
  - Application
  - Future Requirements
- Voltage Measurement
  - Application
- Isolation Measurement
  - Theory
  - Application

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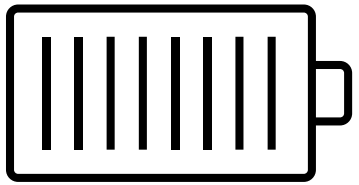
Current Measurement

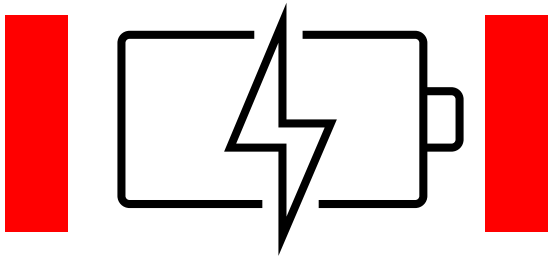
Current Measurement

Application Requirements

Charge / Discharge

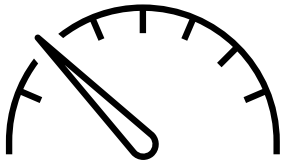


Detect Overstress



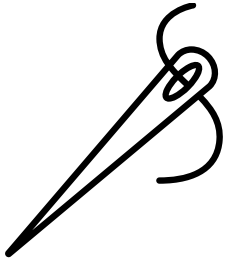
Sensor Requirement

Range

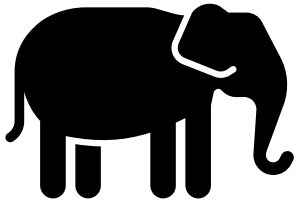


Speed

Accuracy



Robustness



Diagnostic

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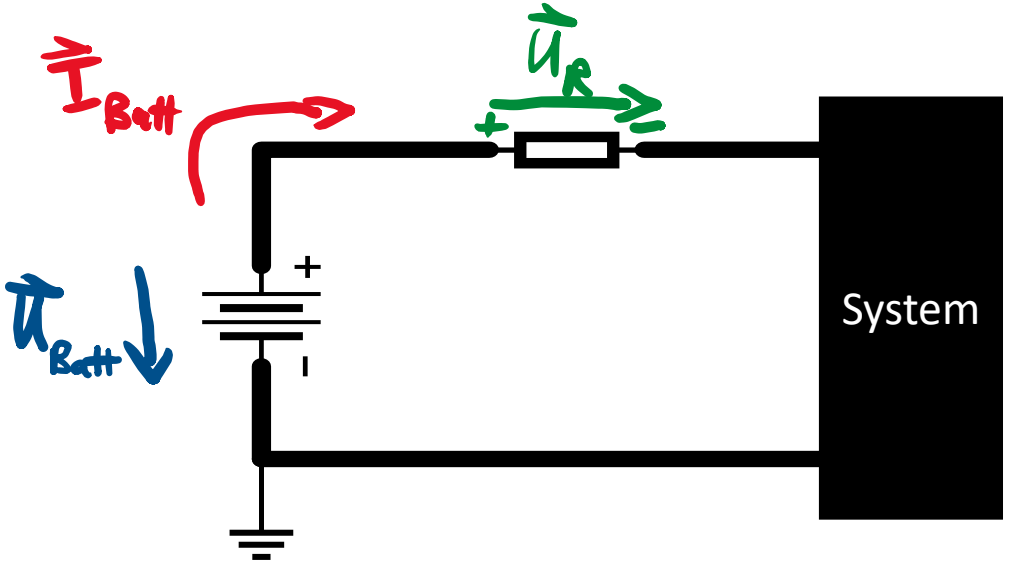
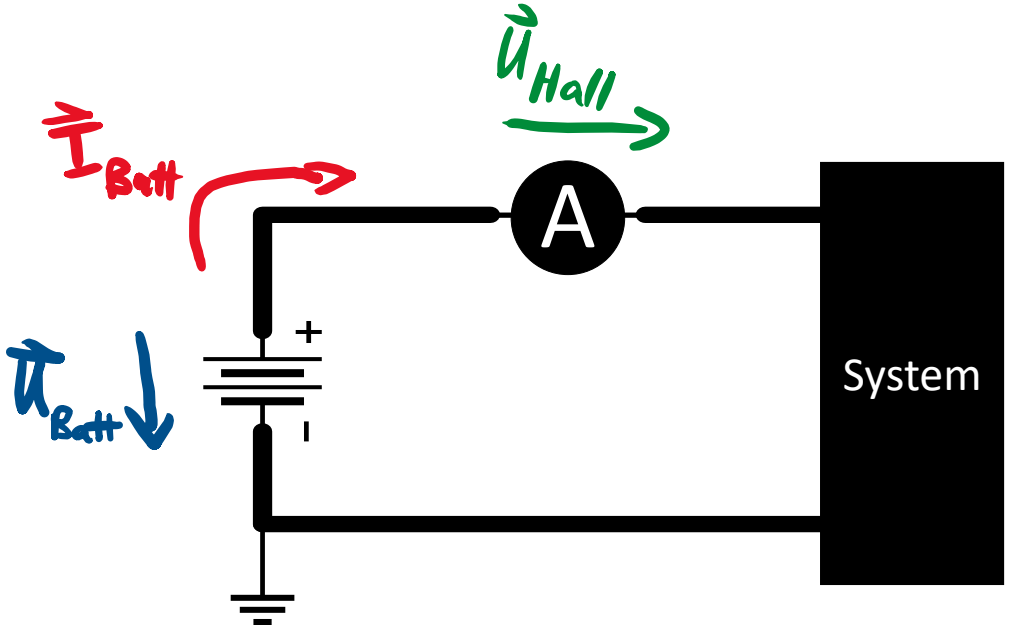
Current Measurement

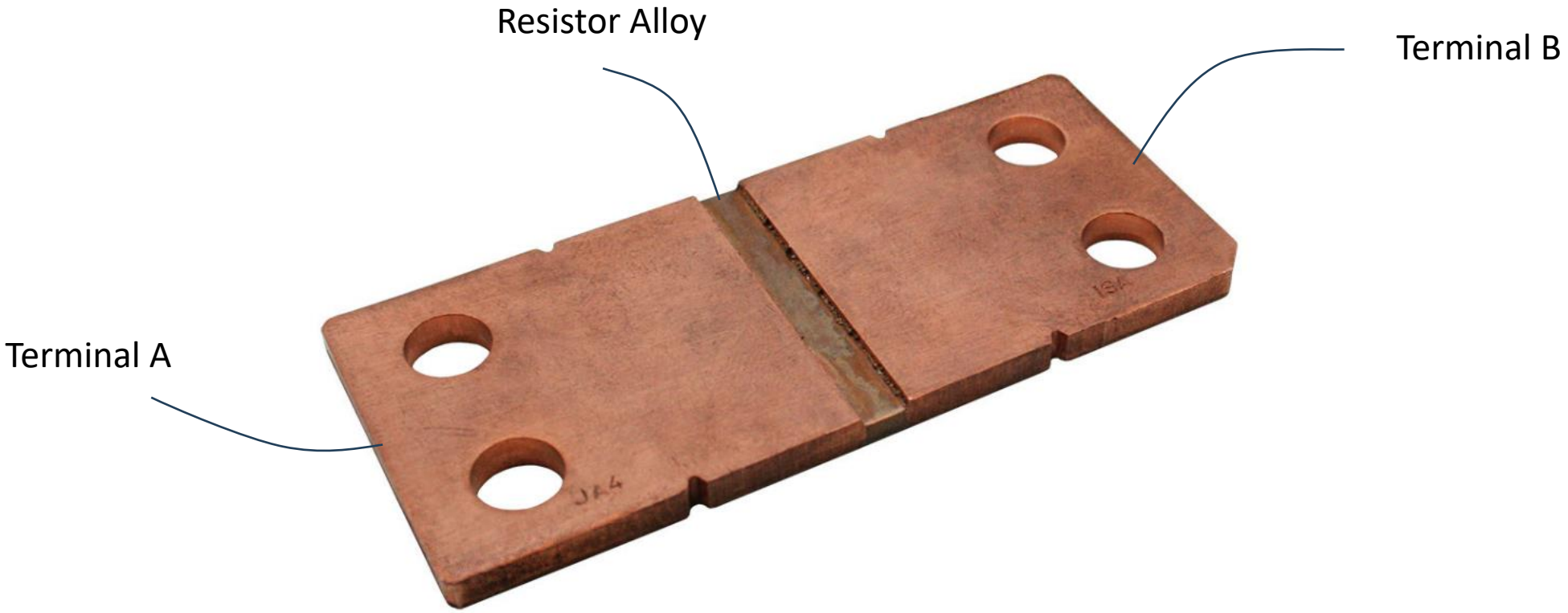
Measurement Principles





Current Measurement

Challenges Shunt Measurement



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Current Measurement

Challenges Shunt Measurement

- Total tolerance over Lifetime
  - Initial Tolerance
  - Temperature coefficient
  - Environmental Influences

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Current Measurement

Initial Tolerance

- Nominal Values used 5 µΩ – 50 µΩ
- R-Value Tolerances through stamping process (low resistance)

A. Mechanical Trimming of resistance

B. Calibration with known current at System Level

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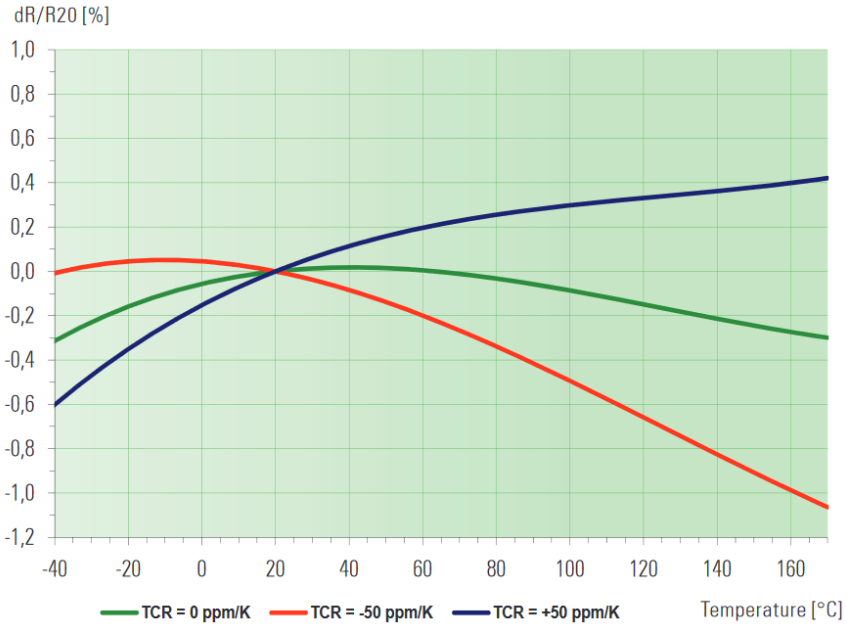
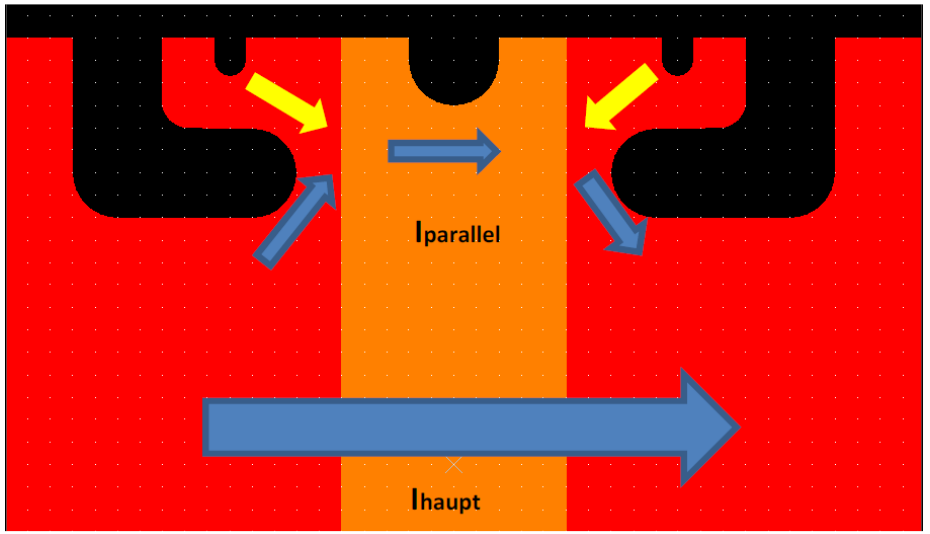
Current Measurement

Temperature Coefficient





- Resistance TCR
- TCR spreading

- Temperature correction on System level
- *Current Shadow* Design

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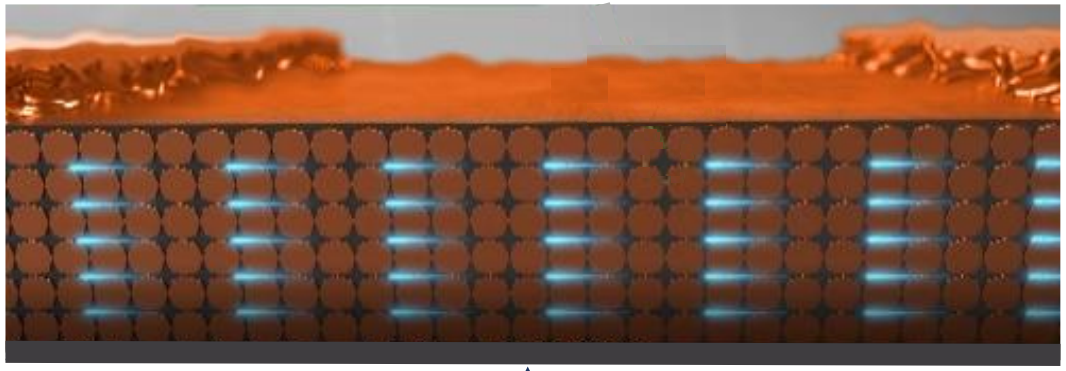
Current Measurement

Environmental Influences



Material Aging Process

- Aging
- Oxidation of resistance alloy
- Mechanical forces

- Artificial Aging
- Coating
- Housing

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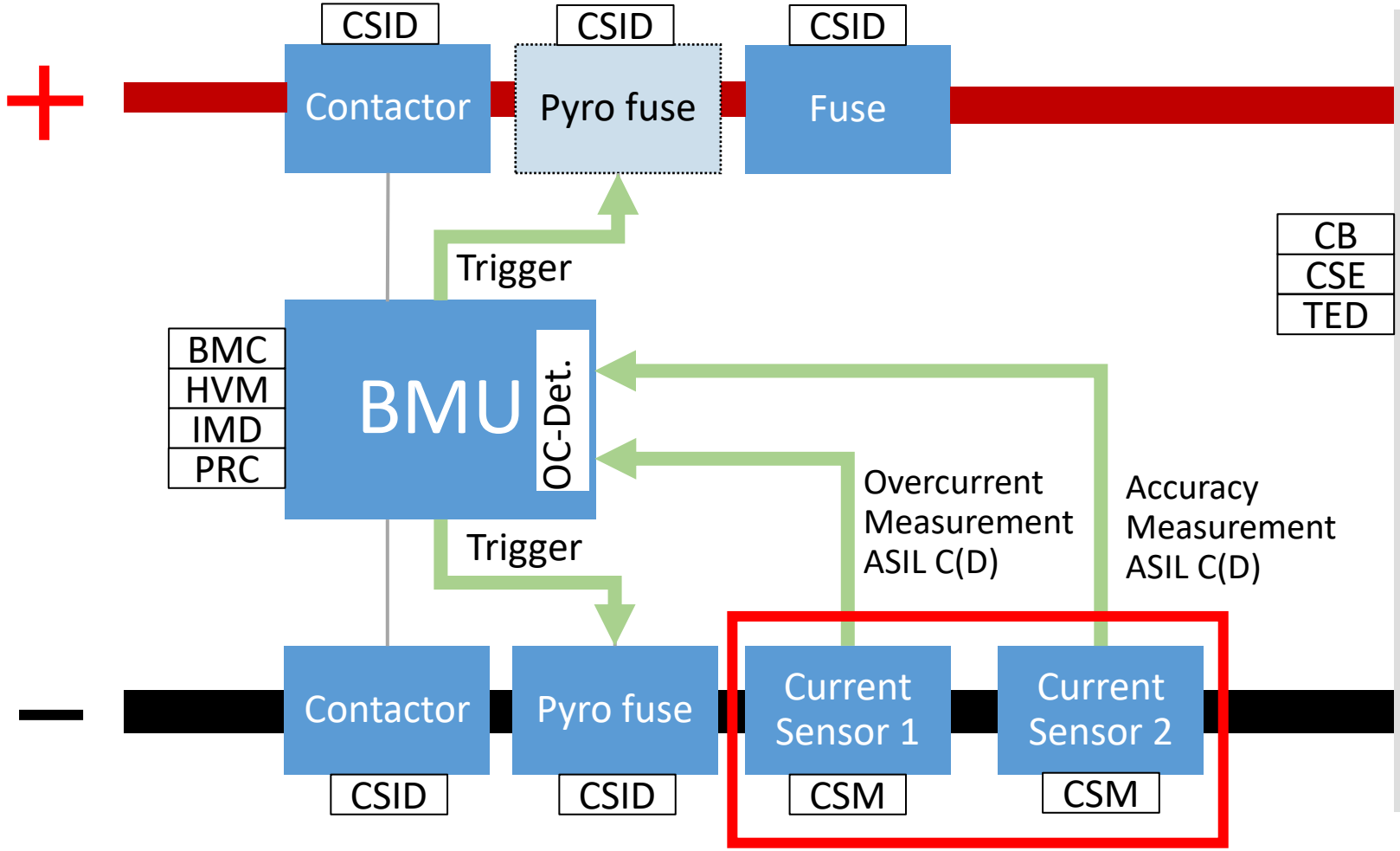
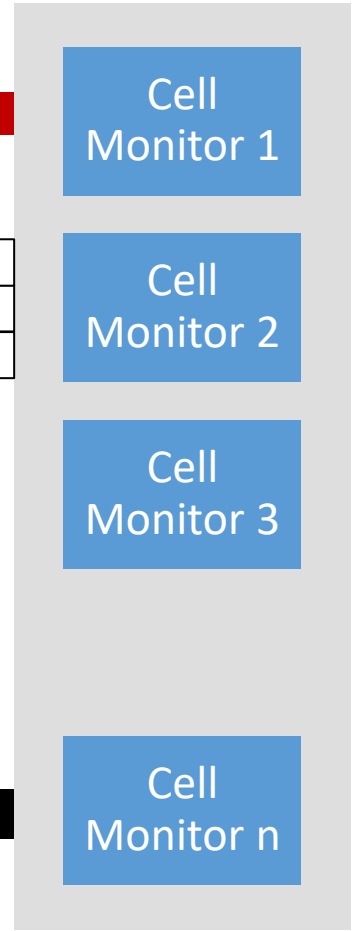
Current Measurement



System Integration



CSM	Current Sense Module
HVM	High Voltage monitoring
CSE	Cell supervising electronics
CSID	Current trig. short circuit interruption device
BMC	Battery management controller
CB	Cell balancing
DIL	Decentral interlock
TED	Thermal event detection
TMP	Busbar temperature
IMD	Isolation measurement device
PRC	Pre-Charging

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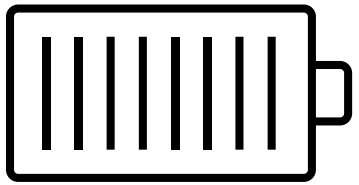
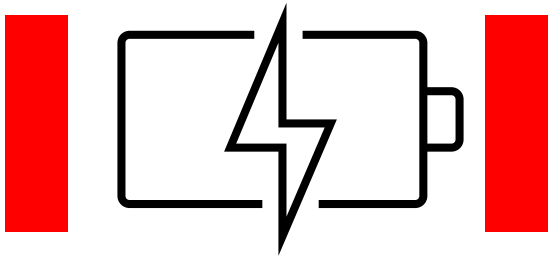
Current Measurement

Future Requirements

FASTER Charge / Discharge



FASTER Detect Overstress



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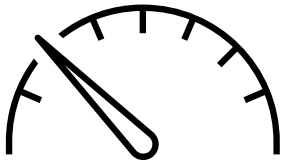
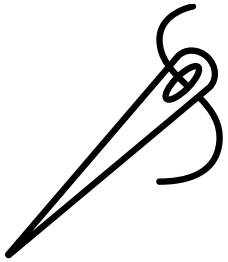


Speed

Accuracy



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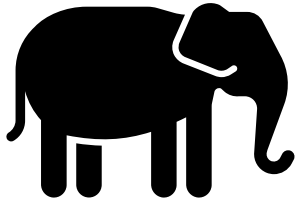

Diagnostic

Reaction

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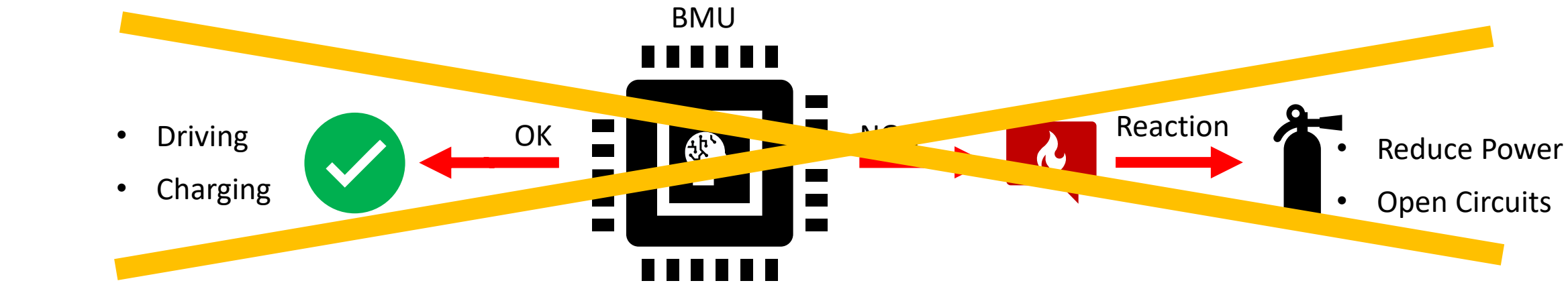
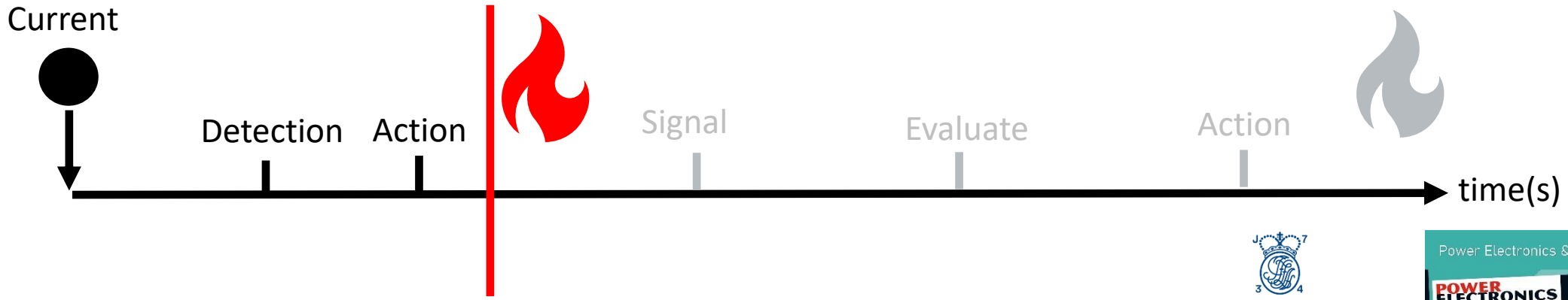
Current Measurement

Application Requirements





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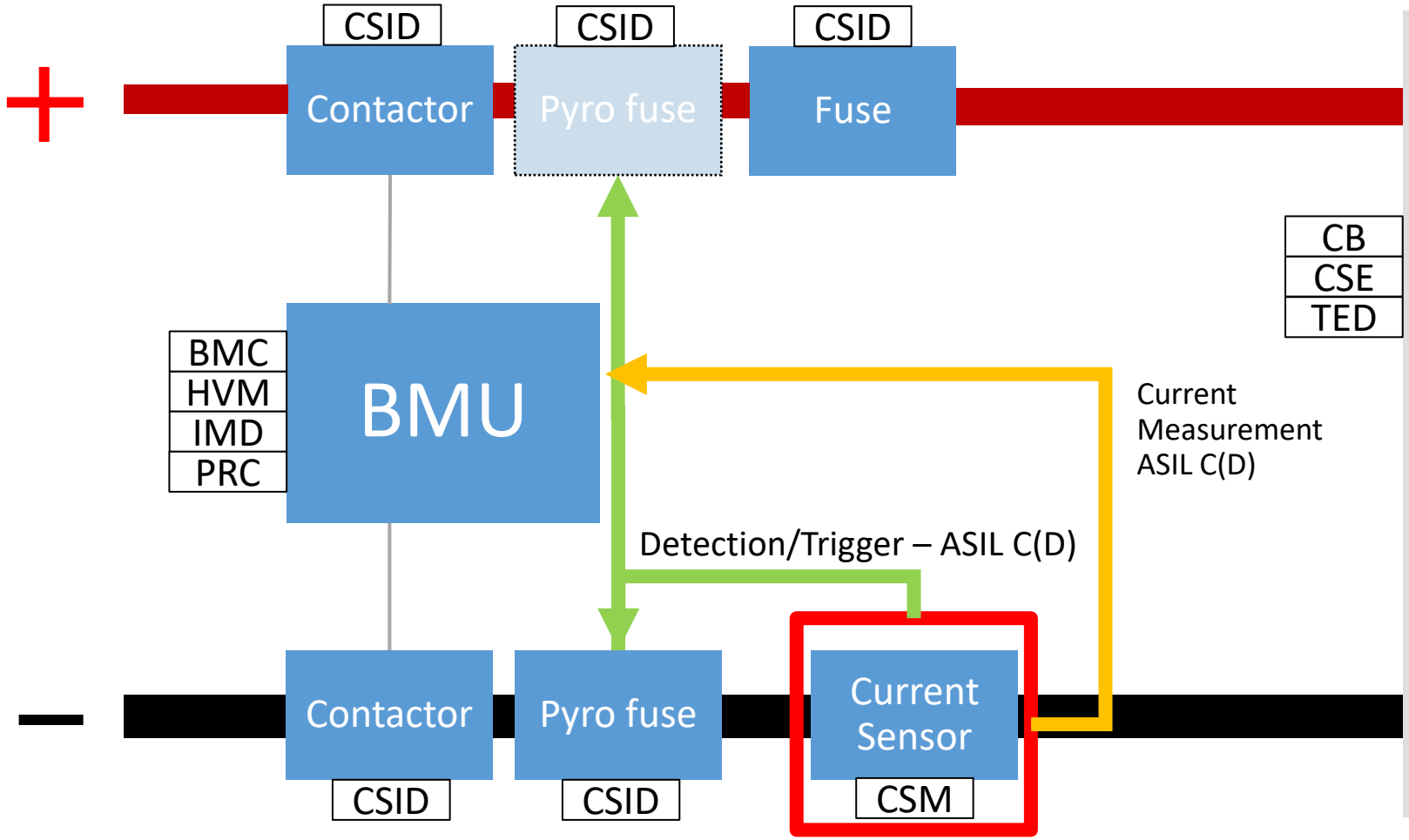
Current Measurement

System Integration



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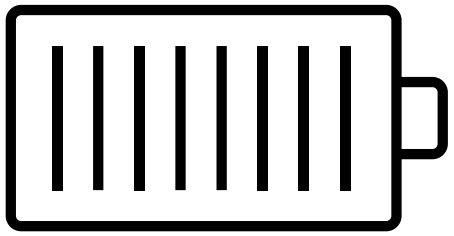
Voltage Measurement

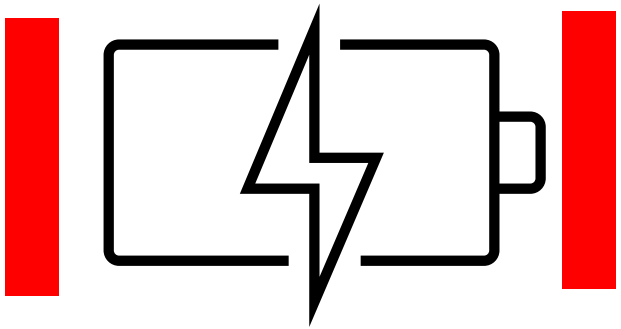
Voltage Measurement

Application Requirements

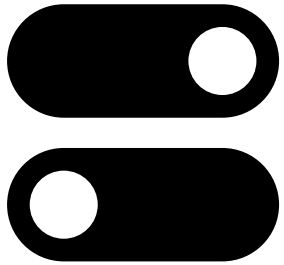
Charge / Discharge



Detect Overstress



Contactor Detection



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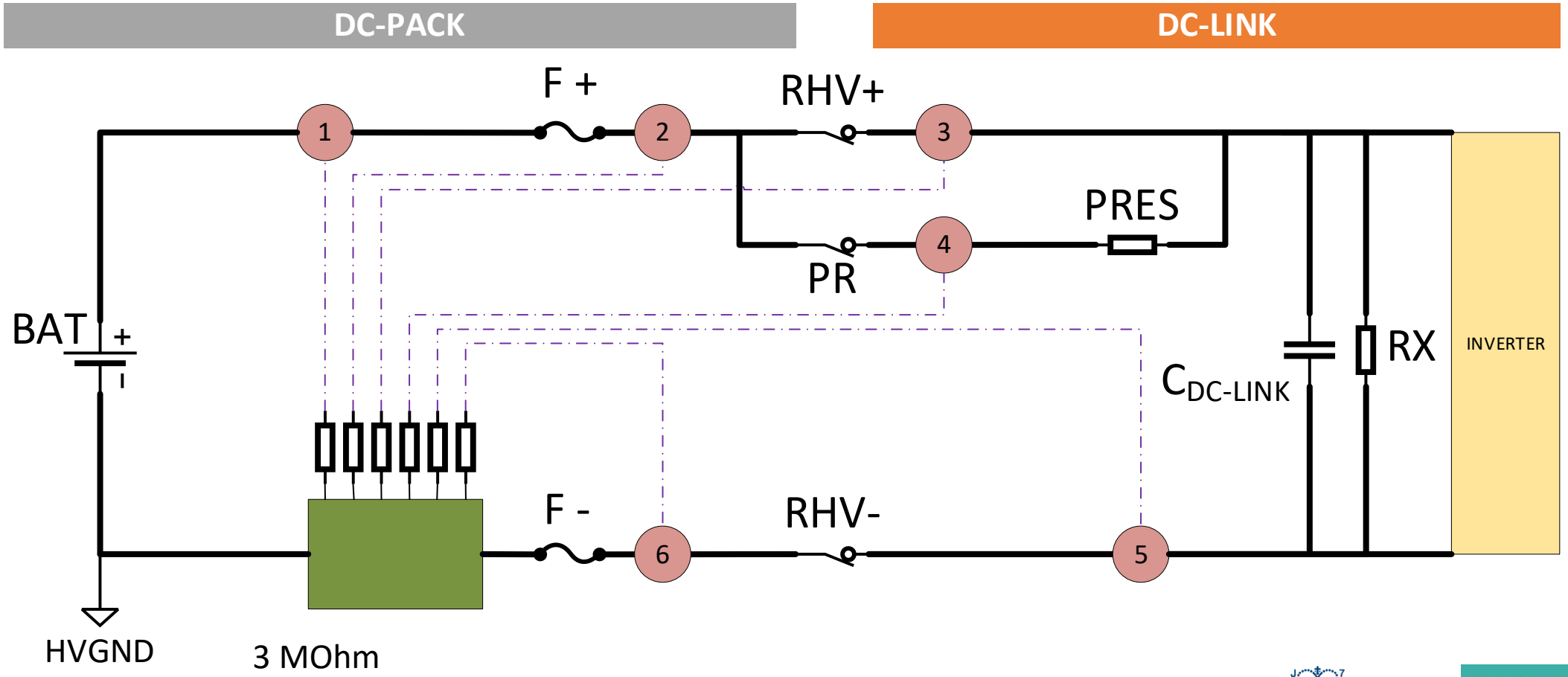
Voltage Measurement

Application Schematic



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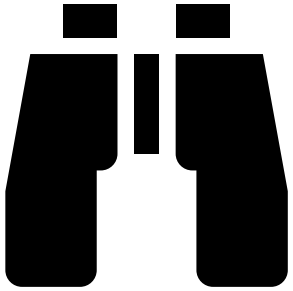
Insulation Monitoring

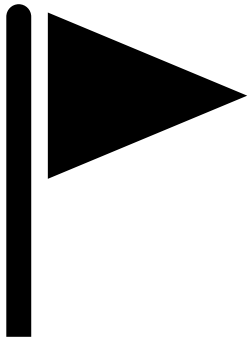
Insulation Monitoring

Application Requirements

LV-HV Resistance Monitoring



Reliable Signalisation



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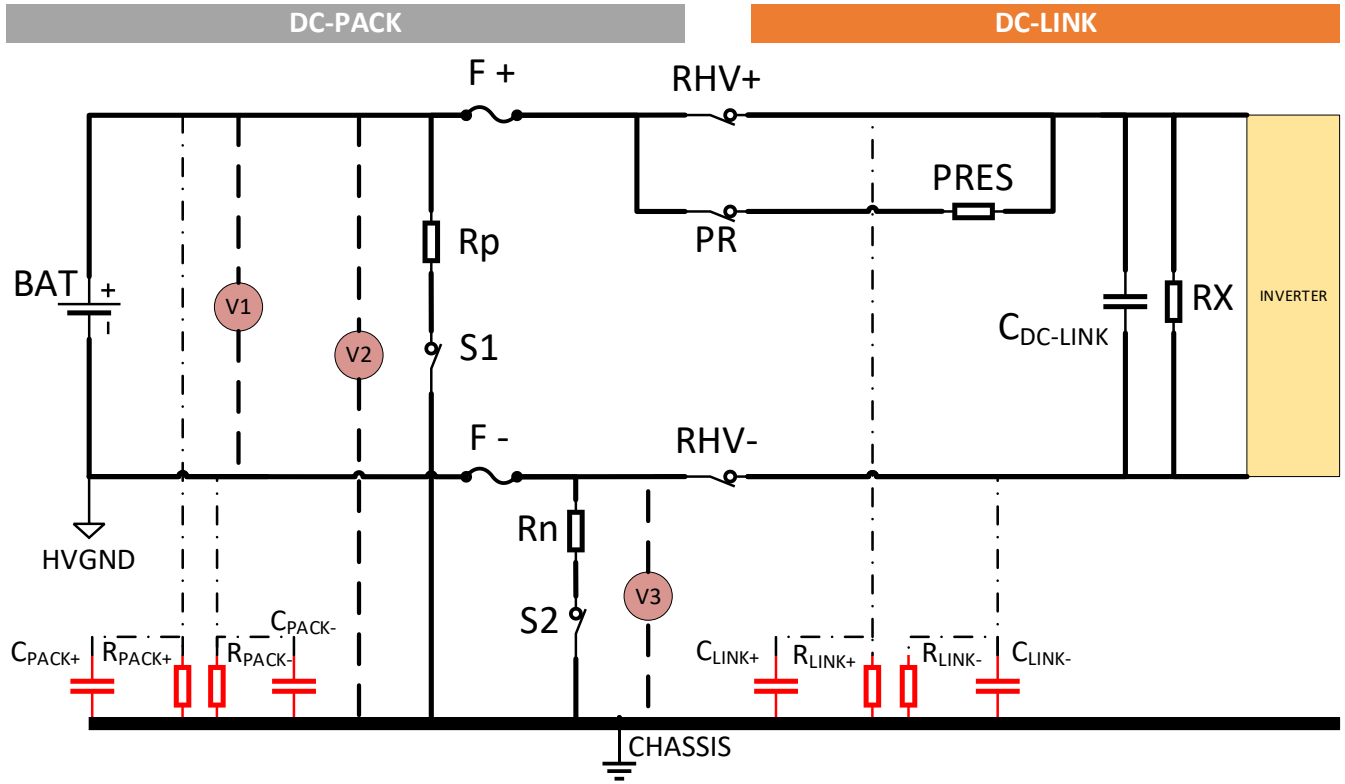
Insulation Monitoring

Measurement Principles

Passive 3 Voltmeter Method



Advantages

- Accurate (under stable conditions)
- Symmetrical errors are also recognized
- Errors on HV+ or HV – can be separated be determined

Disadvantages

- High tolerances in unstable conditions
- Voltage-dependent tolerances
- No monitoring at 0V
- High number of switching cycles for switches S1 and S2

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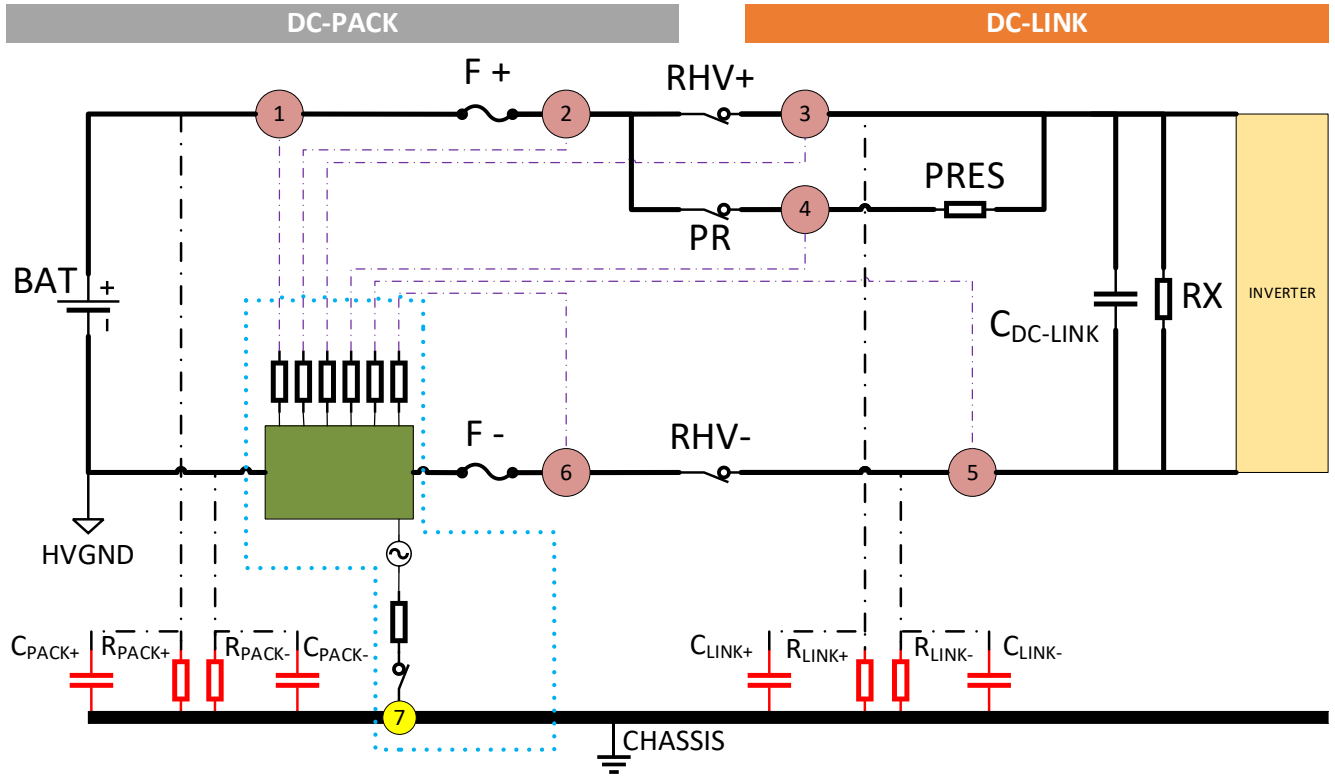
Insulation Monitoring

Measurement Principles

Active Method + Pack and Link Measurement



Advantages

- Precision
- Symmetrical faults are detected
- Robust against noise and voltage drop
- No voltage required on the HV network
- Measurement of Pack and Link side while contactors are opened

Disadvantages

- Longer measurement times as with passive 3VM method

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