Sensata
Technologies

EVS35
OSL2022

Touch Hazards at 800+ V

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About Sensata

Global industrial technology company

with 100+ years of experience in mission-critical design and innovation of sensor-rich solutions that create insights for our customers

Market leader

in various diversified end-markets including automotive, aircraft, industrial, military, heavy vehicle, off-road, HVAC, and marine

BY THE NUMBERS

$3.8B
2021 revenue

21,000+
employees

13 countries
with Sensata sites

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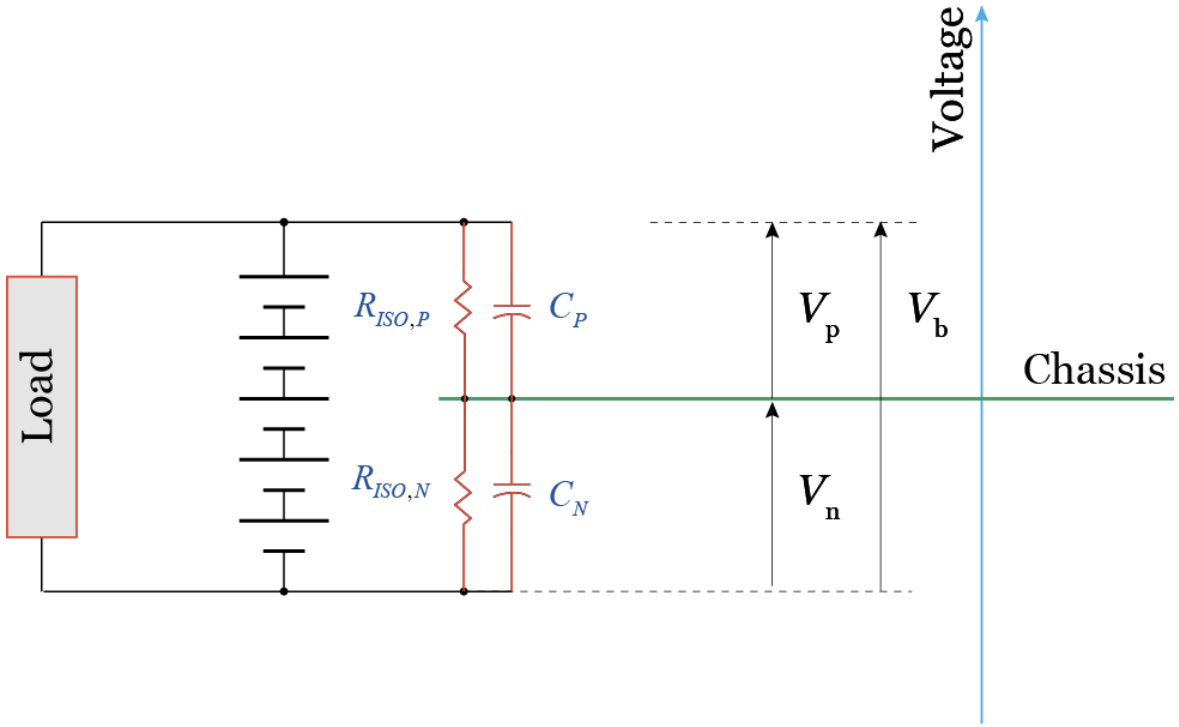
Beyond cell safety

- **Battery Hazards**

  - Pack safety goes beyond cell and BMS safety
  - High voltage packs are susceptible to hazards inherent to any ungrounded IT power system

The IT power system

- Potential Hazards



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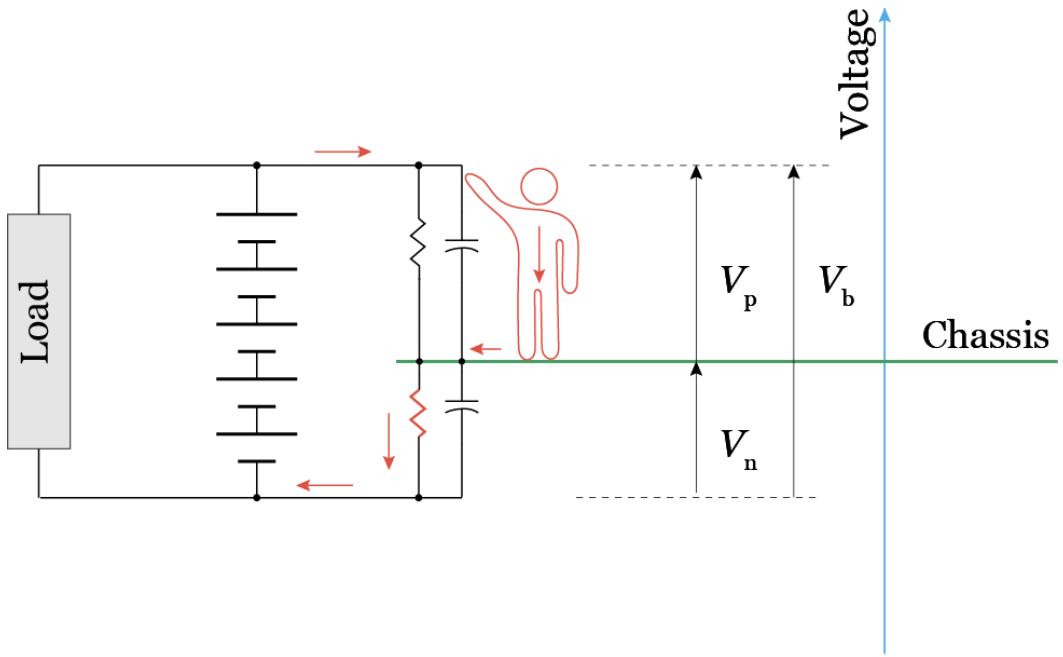
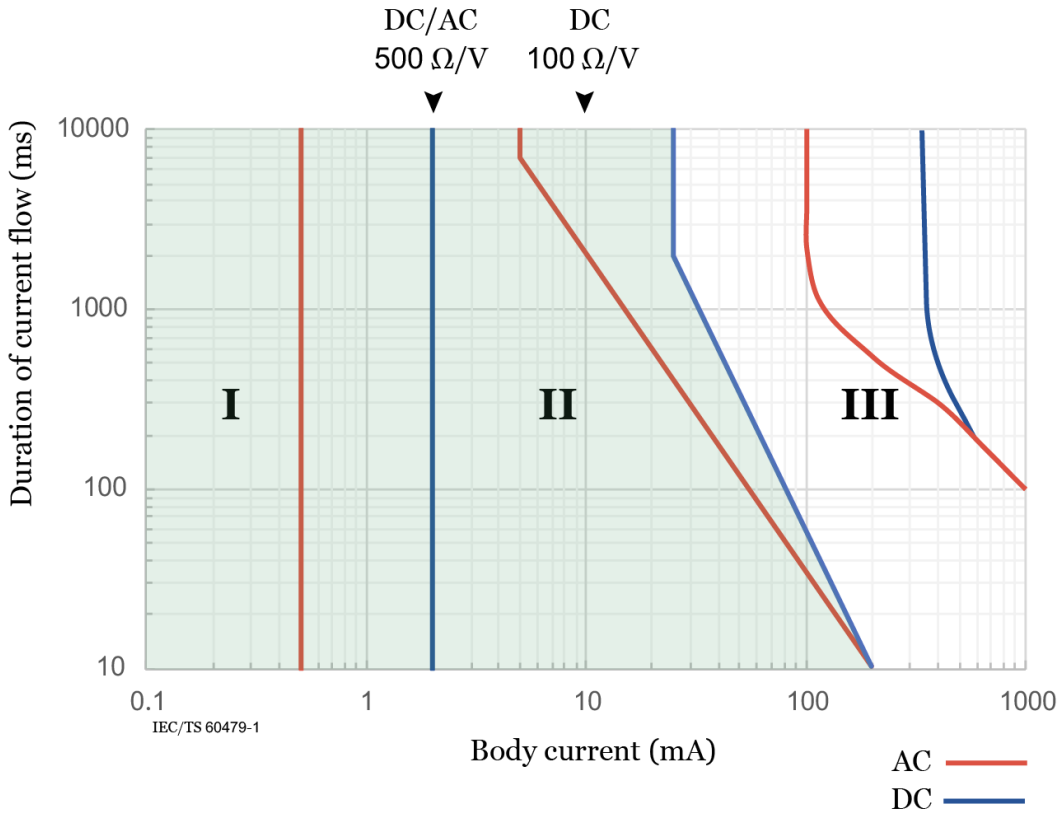
Isolation resistance fault

- Touch Current

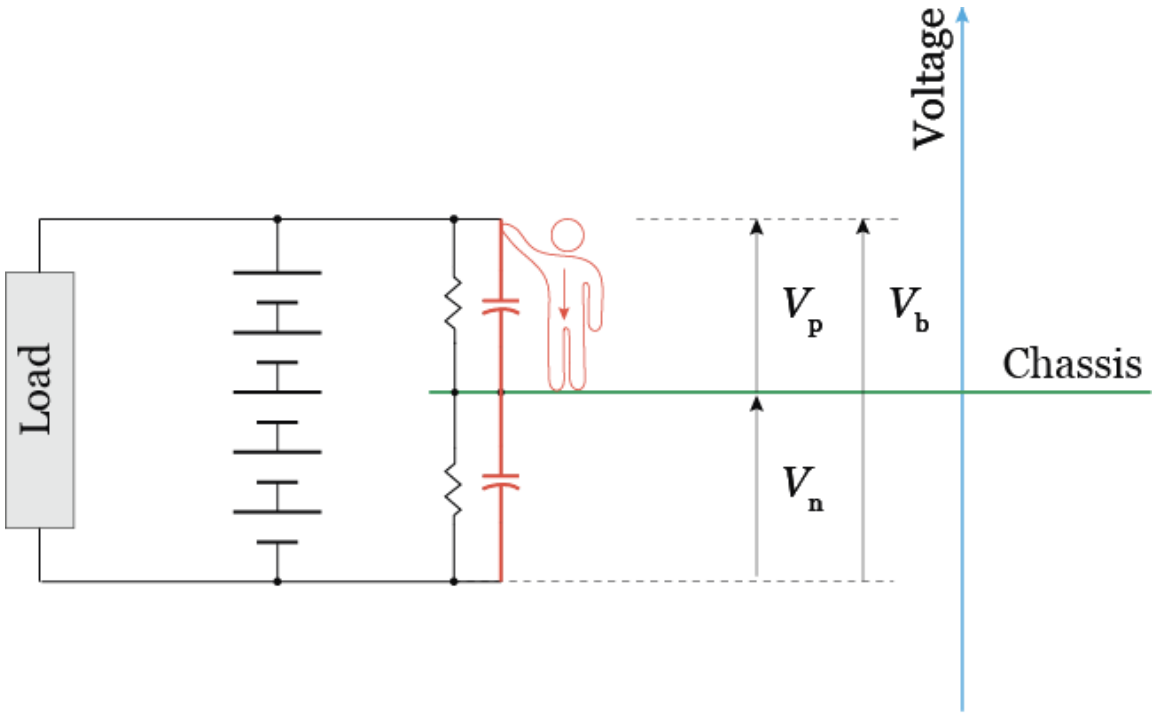




IEC, I. 2017. 60479-1: 2017 Effects of current on human beings and livestock part 1. (2017).

Capacitive faults

- Touch Energy

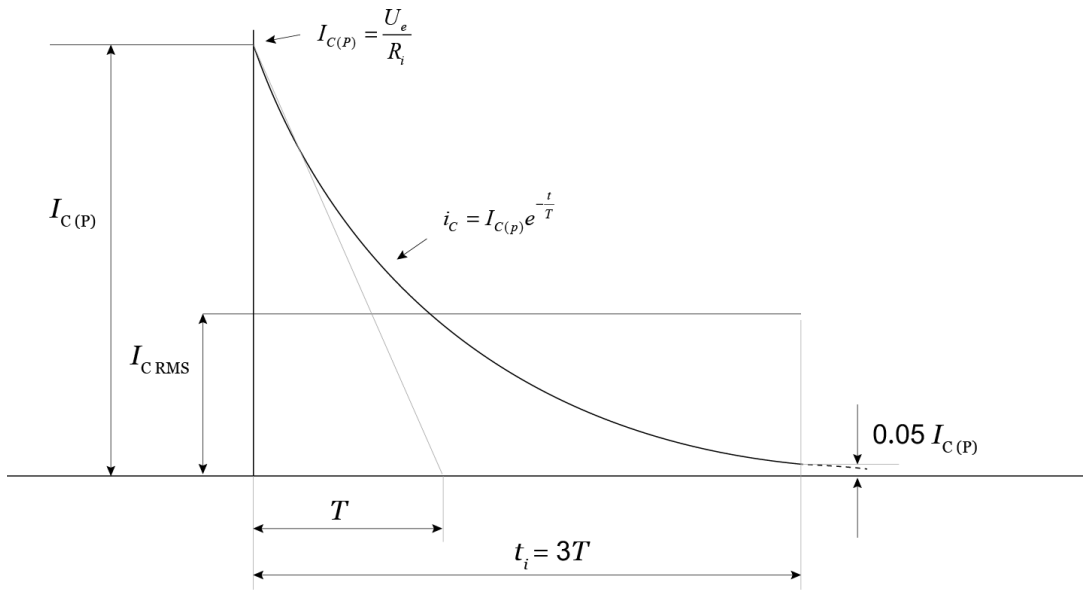


$$E_{MAX} = 0.5 \cdot C_{TOTAL} \cdot U_{MAX}^2$$

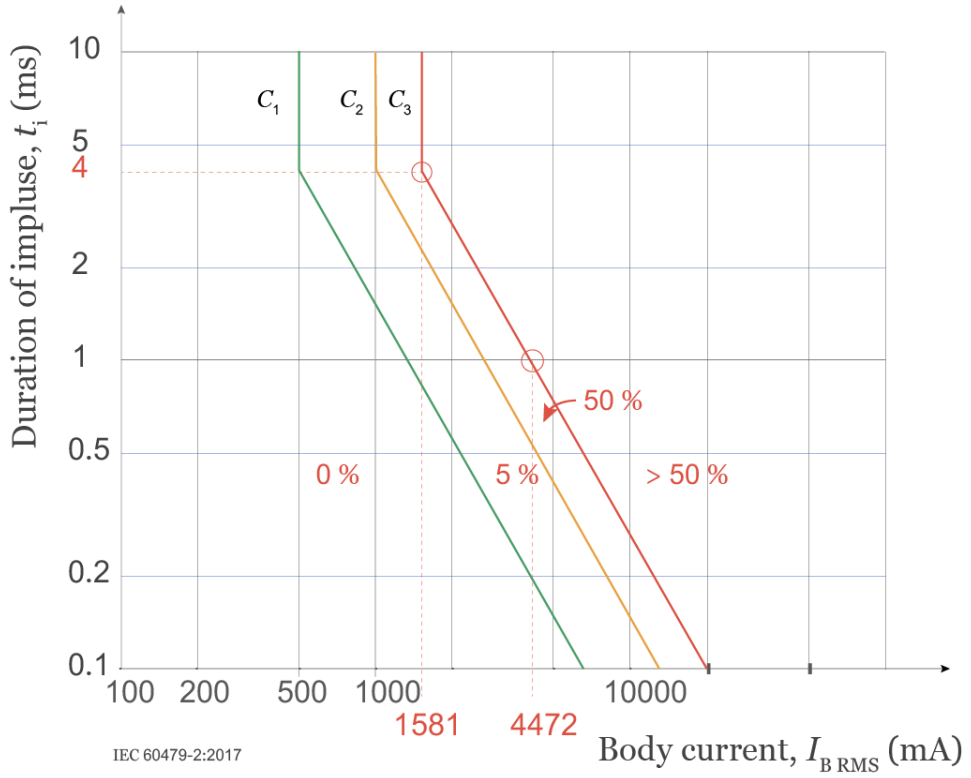
$$C_{TOTAL} = C_P + C_N$$

$$U_{MAX} = \max\left\{|V_P|, |V_N|\right\}$$

Human body tolerance to Touch Energy



IEC 60479-2:2017



IEC, I. 2017. 60479-2: 2017 Effects of current on human beings and livestock part 2. (2017)

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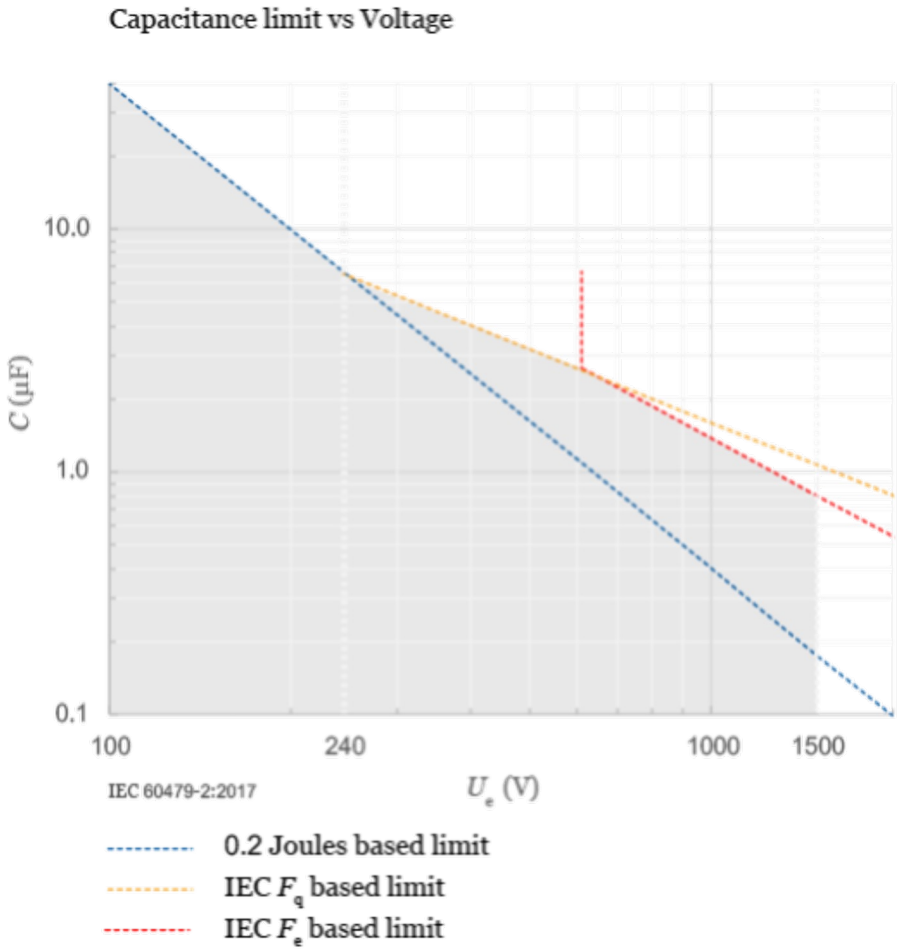
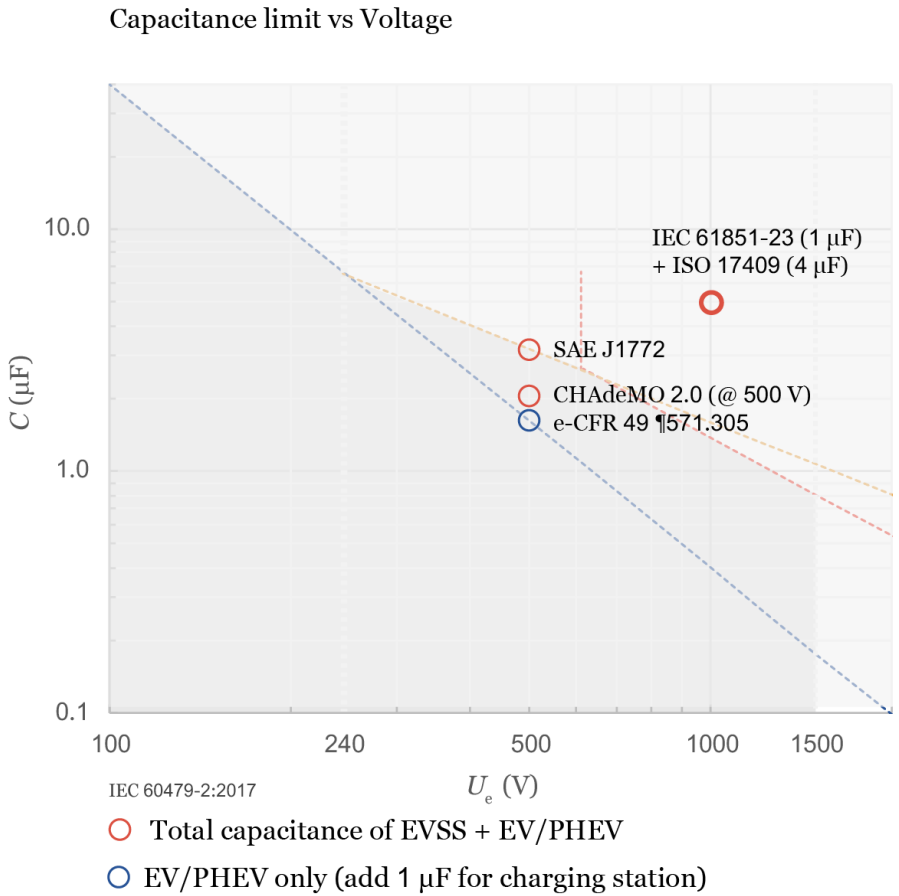
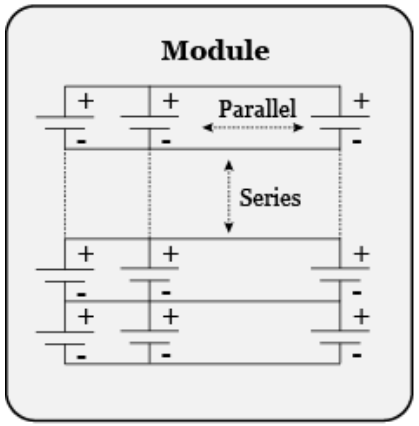
Capacitance limits

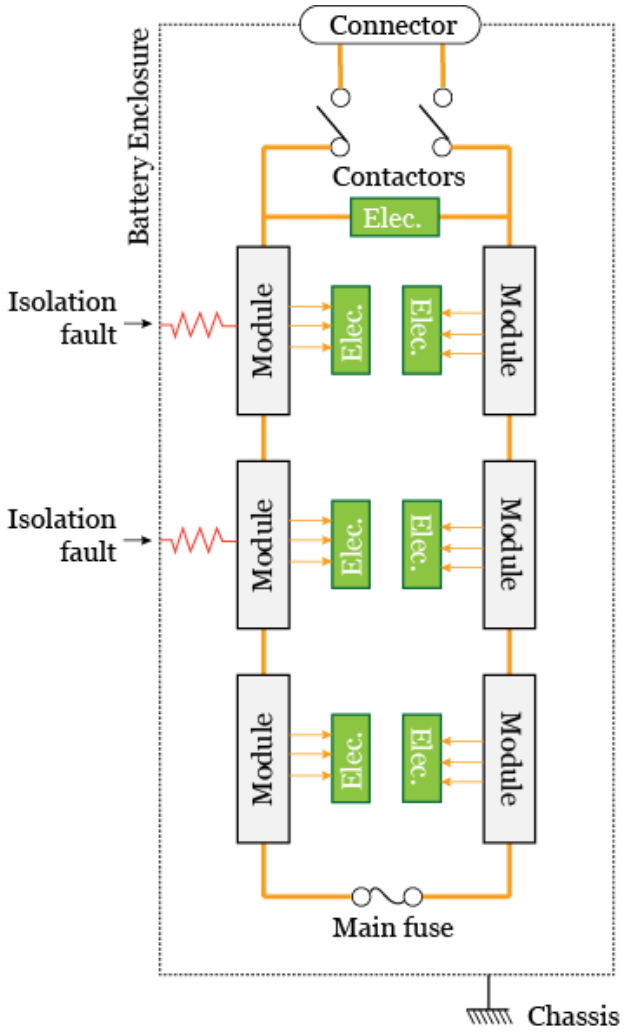




Where can they occur

- Inside the battery





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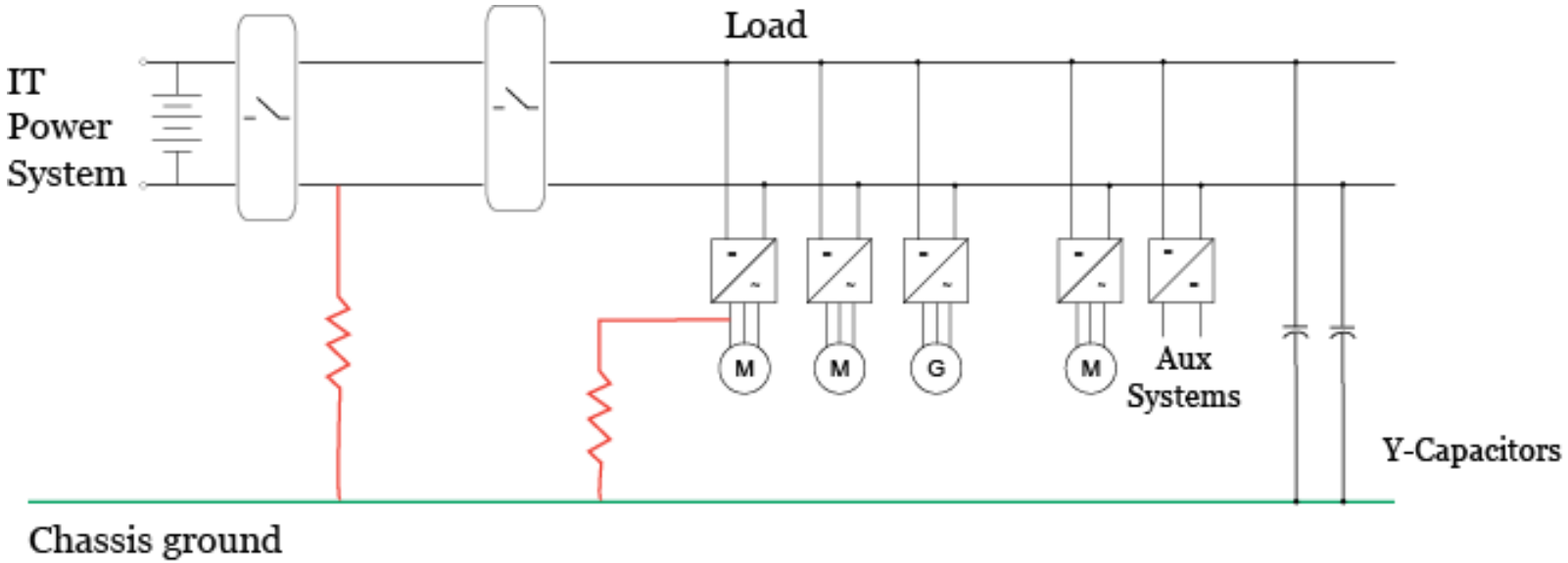
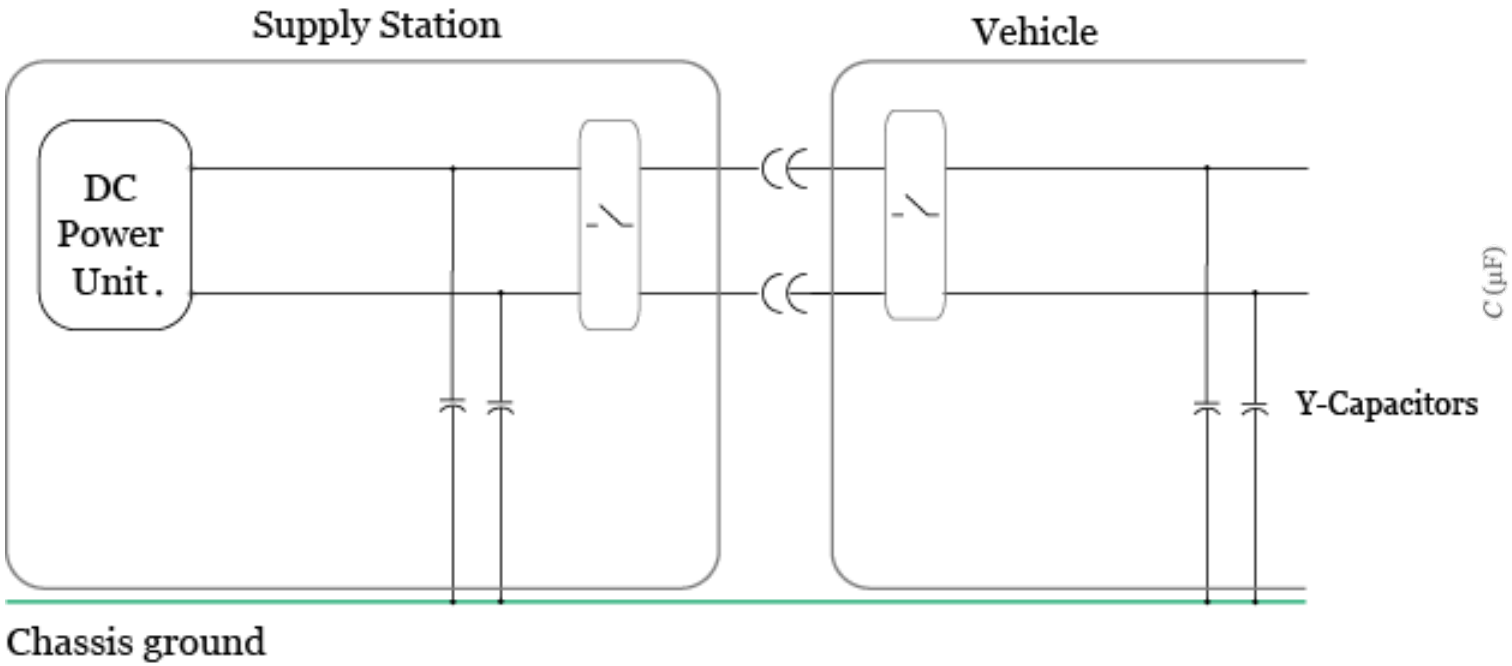
EV

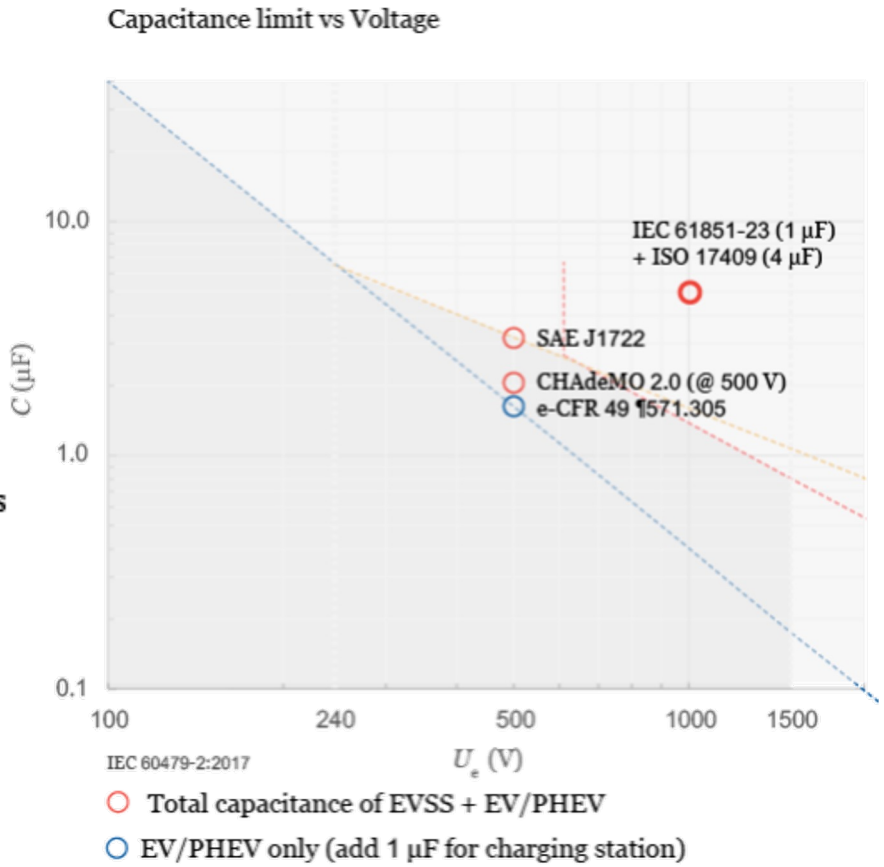
- Inside the EV



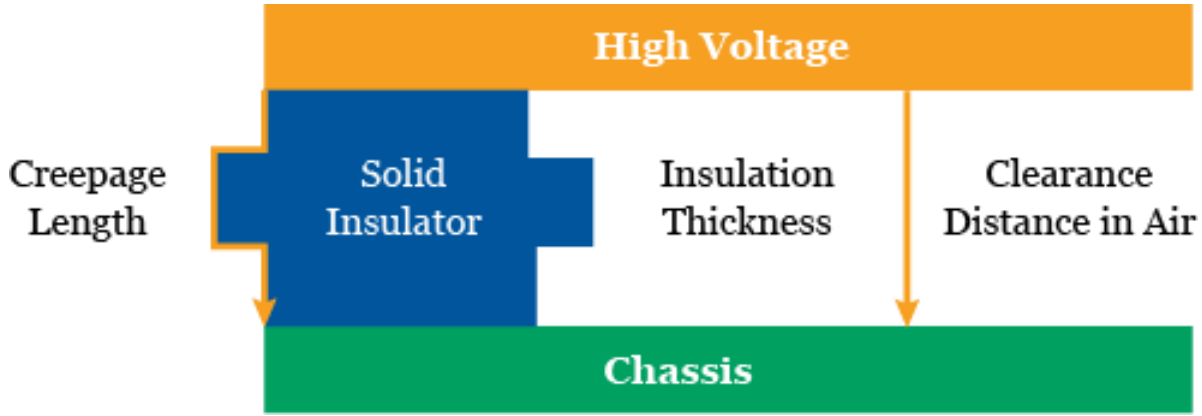
EVSS

- Combination of EV and Charging Station

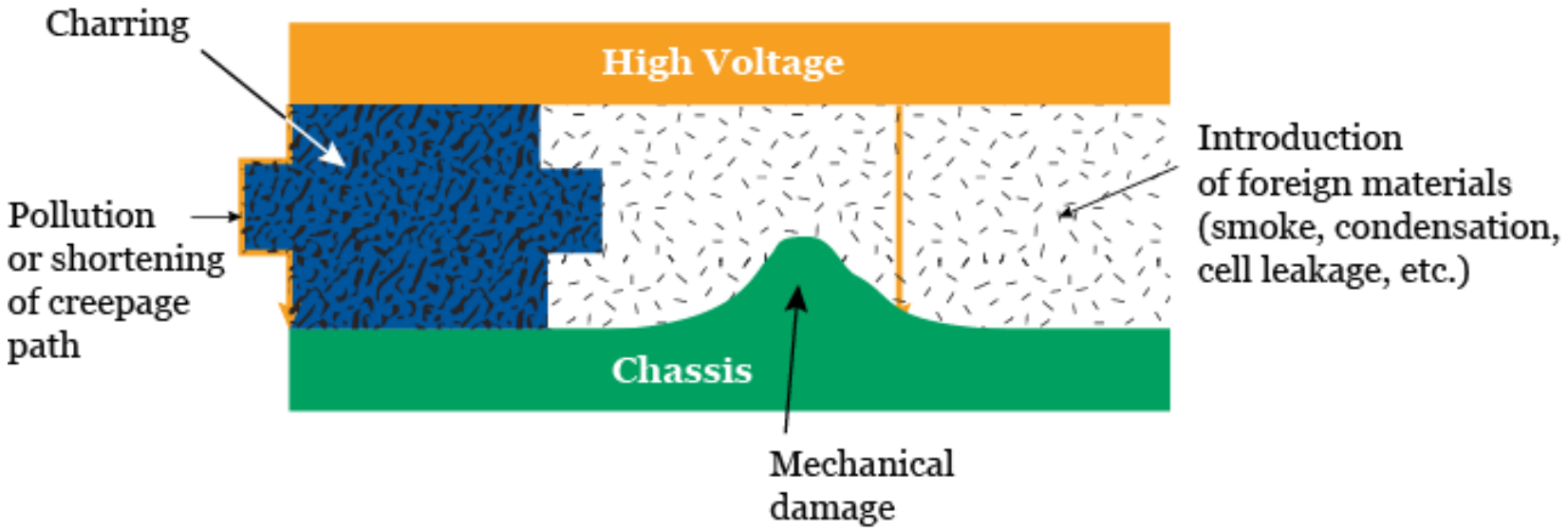




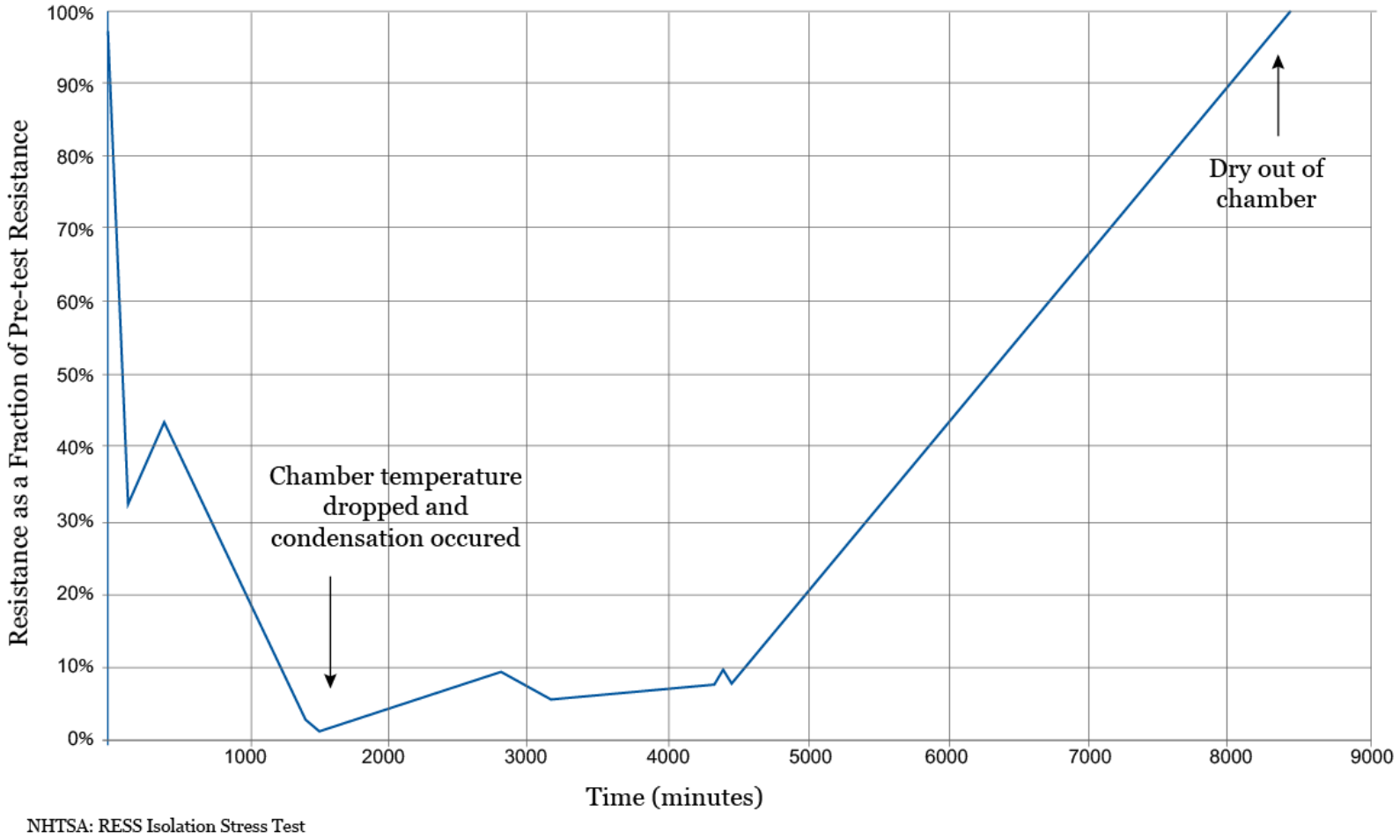
How can it happen



How can it happen

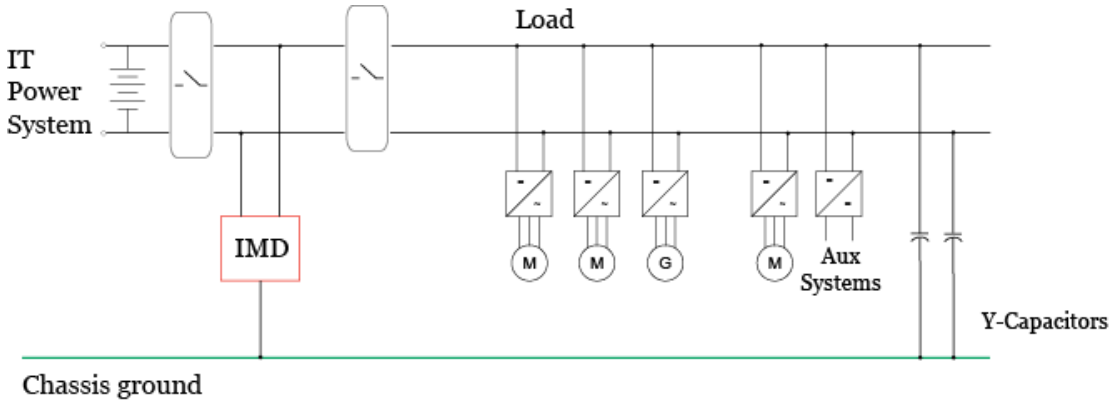


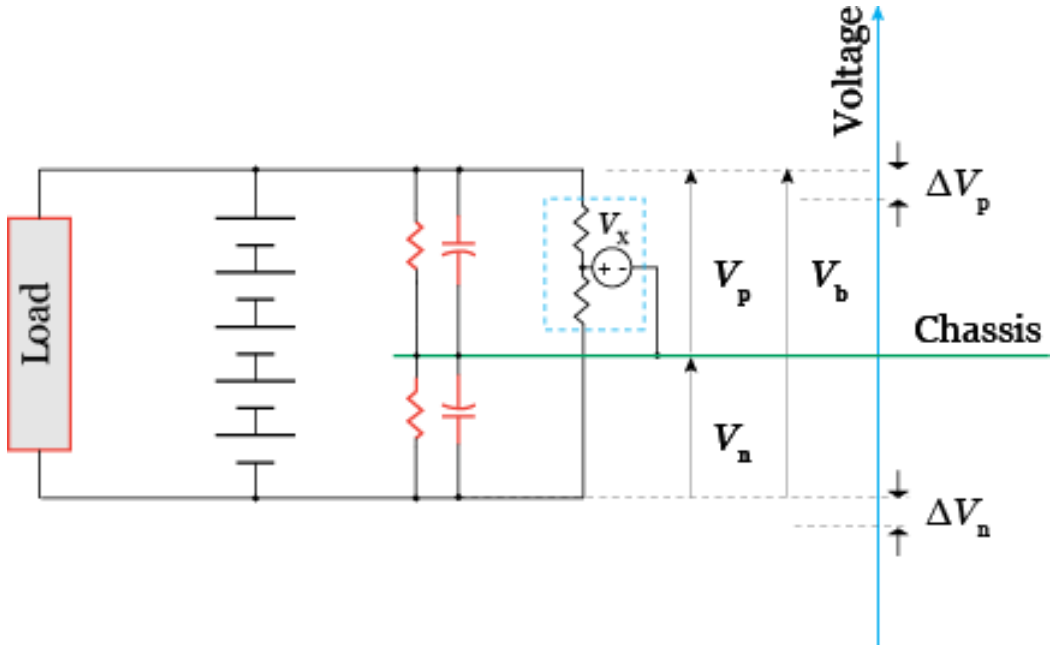
Effect of condensation



NHTSA: RESS Isolation Stress Test

Insulation Monitoring Device (IMD)



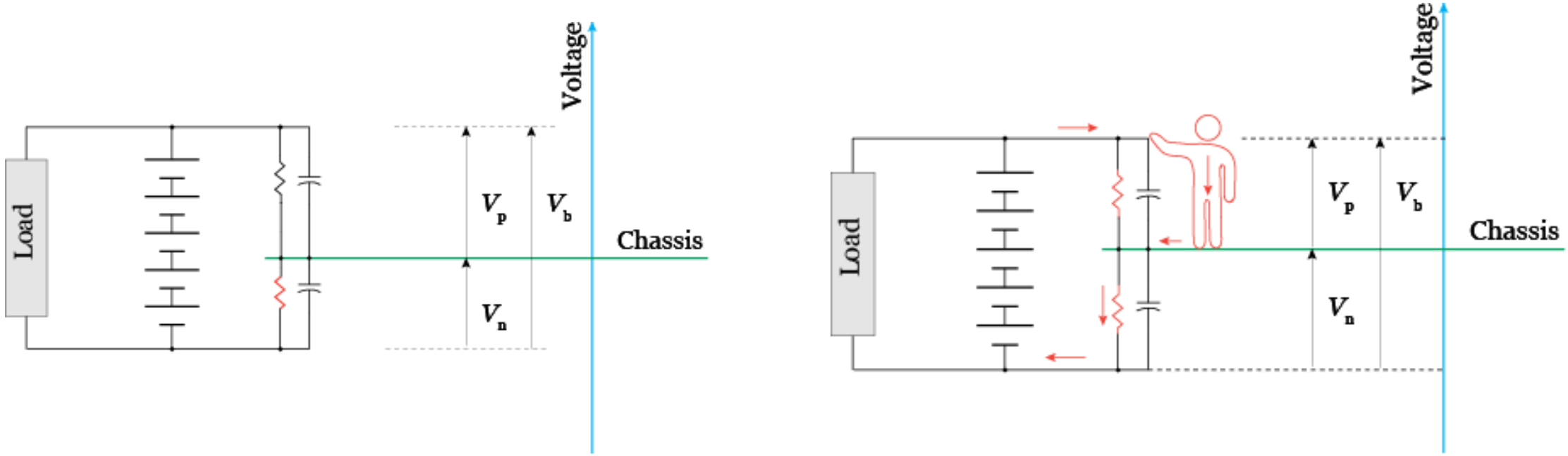


Mandatory in EVs, EVSSs. Battery packs?

Monitoring methods

- Voltage method

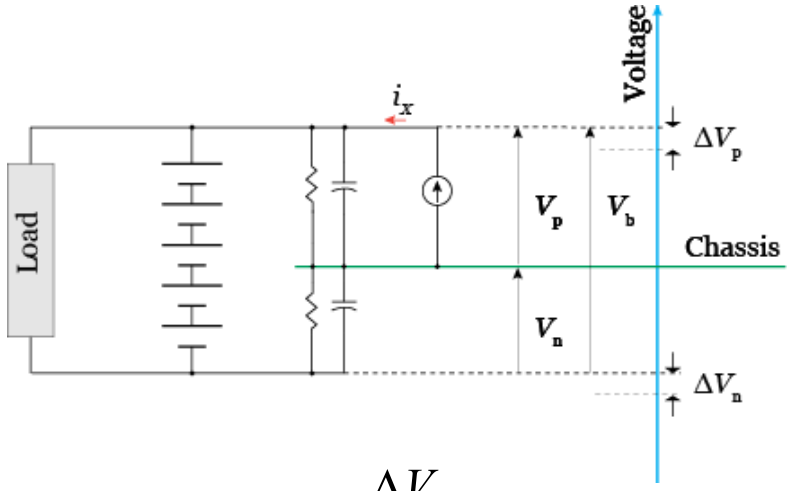
Detect by monitoring Voltage



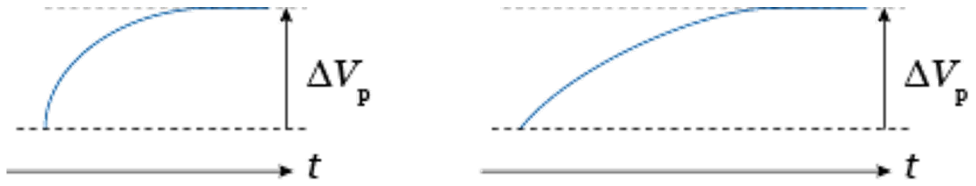
Fails to detect symmetrical faults, requires prior estimates & steady state voltage

Signal injection

Inject a known current and monitor the Voltage change



$$R_{ISO,//} = \frac{\Delta V}{i_X}$$



- Detects parallel combination of resistances
  - Will cause fault alerts
- Requires steady state
  - Will give erroneous results if voltage changes
  - Slow – detection time depends on capacitance
- Susceptible to noise

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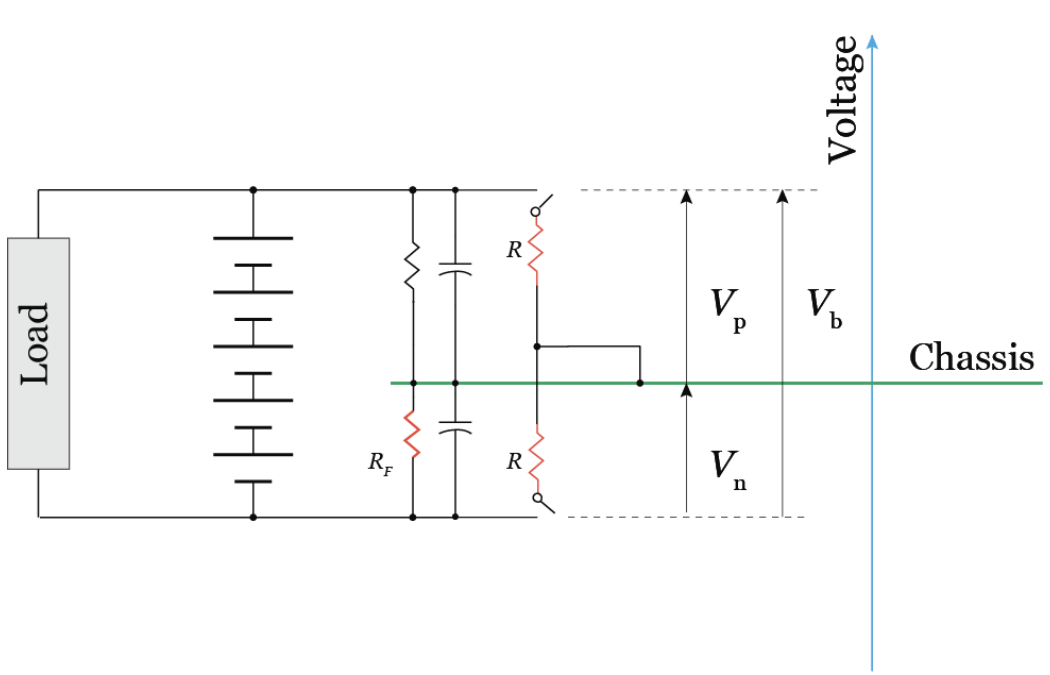
Resistor switching



STEP 1: Measure V_P and V_N and determine the lower of the two.

STEP 2: Connect a known resistance R_0 in parallel to the isolation resistance of the higher voltage ($V_P > V_N$) and measure again the new voltage values V_P' and V_N'

$$R_F = R \frac{V_P - V_P'}{V_P'} \left[1 + \frac{V_N}{V_P} \right]$$

Method and formula valid in steady state.

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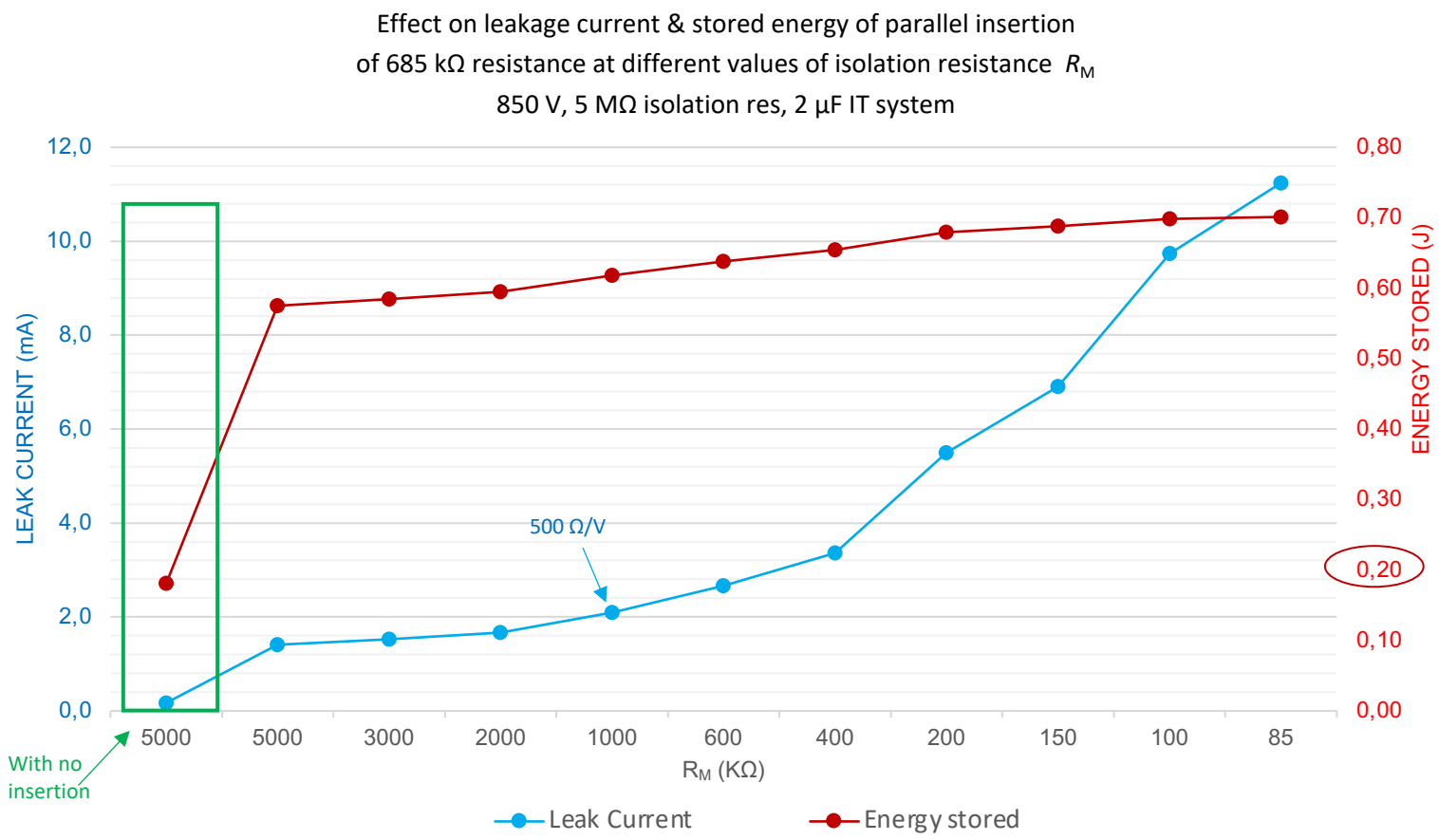
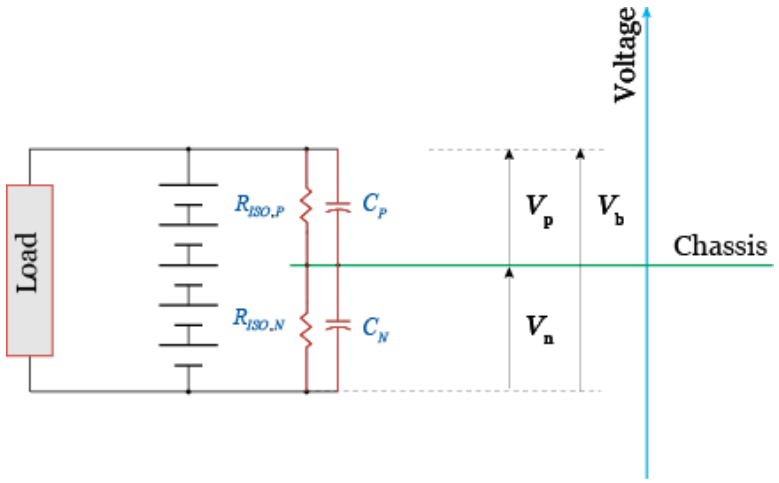
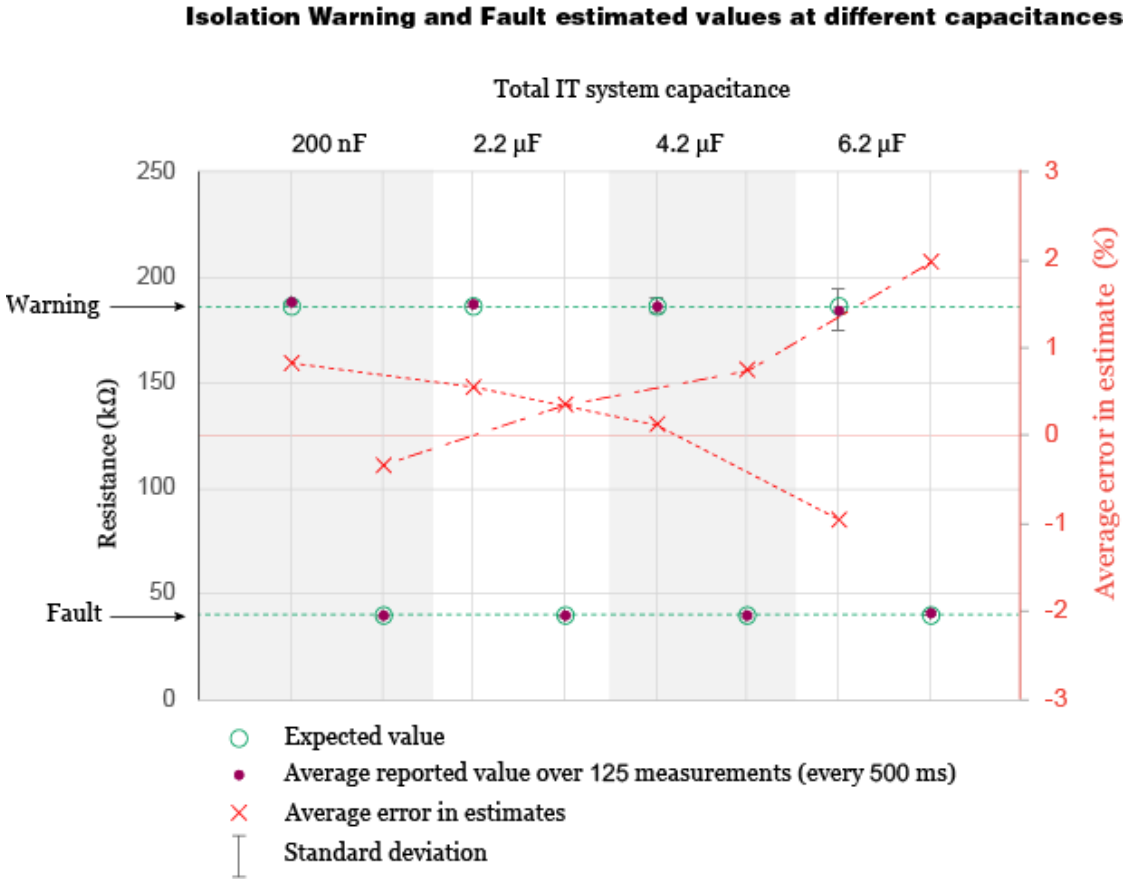
Effect on stored energy



Detect both ISO resistances and capacitances

Solve the system





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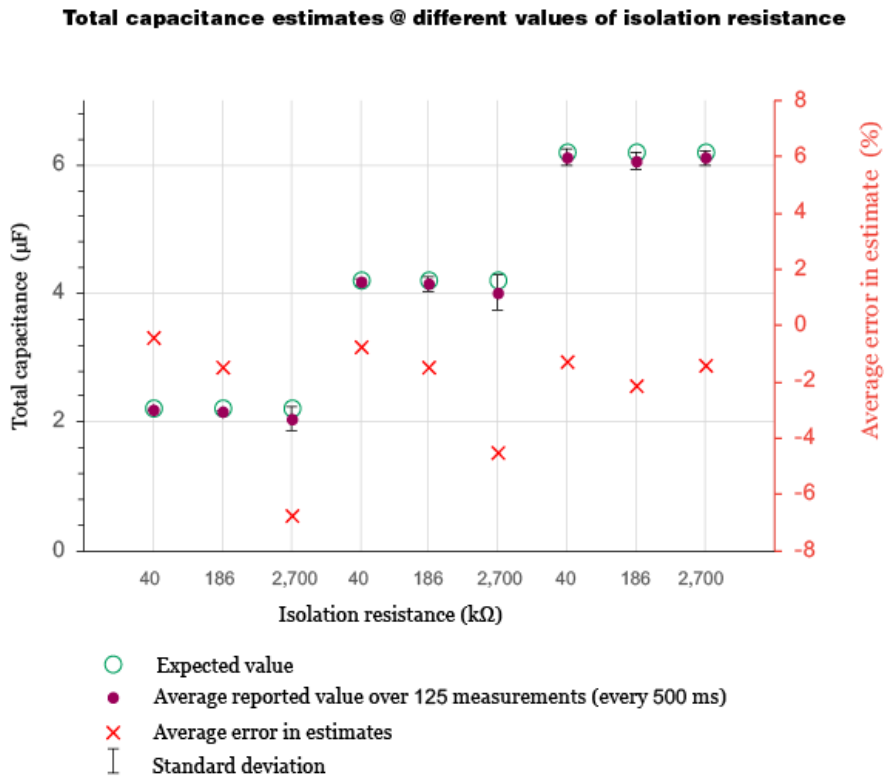
Capacitance detection



IMD Essentials

- Ability to detect isolation faults in any part of the IT power system (motor, inside the battery, etc.)
- Being able to discriminate $R_{ISO,+}$ and $R_{ISO,-}$
- Ability to detect total Y-capacitance
- Able to work under any load variations
- High speed in determining isolation status
- Self-checking
- Developed with safety device standards (SEooC)

Thank You

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