

ECPE Working Group (WG) 'Power Semiconductor Reliability for Railway Application'

- The ECPE Network European Center for Power Electronics
- ECPE Railway WG Members
- Objectives of the WG



The European ECPE Network



ECPE European Center for Power Electronics

- The Industry-driven Research Network for Power Electronics with about 200 member organisations in Europe
- A strong voice of the Power Electronics community in Europe to the public and to politics!

Main Objectives:

Precompetitive Joint Research in Power Electronic Systems

- ECPE Projects with focus on automotive & industrial power electronic systems as well as renewable energies and electronic power grids
- EC or national funded research projects with partners from the Network

Expert Workshops & Advanced Training

- ECPE Workshops, Tutorials and practical lab courses for engineers in industry
- ECPE online course 'Power Electronics'
- Public Relations & Lobbying for Power Electronics

Directions: - Research Programmes addressing Power Electronics - Young Engineers Needed!

ECPE – the industry-driven Research Network with about 100 Industrial Members



... and > 100 ECPE Competence Centres







ECPE Railway Working Group Member Companies













WG Chairmen (Coordination Team):

- Dr. Bernd Laska (Siemens)
- Eugen Wiesner (Mitsubishi Electric)
- Dr. Oliver Schilling (Infineon Technologies)
- Pascal Mannevy (SNCF)





BOMBARDIER



in cooperation with the European PINTA Project in the Shift2Rail Joint Undertaking











Scope and Overview

Lifetime limits of power semiconductor devices and modules have a significant impact on the overall availability, reliability and repair costs of rolling stock. The European Shift2Rail Joint Undertaking (JU) with its EU-funded Project PINTA dedicated to traction systems intends to significantly improve the reliability of the traction converter. Especially with regard to the introduction of SiC devices into traction converters, reliability shall be one main development target from the very beginning.

The PINTA project partners covering railway operators, system integrators and car builders agreed to focus on power semiconductor reliability which is on the one hand directly linked to the well-known power and thermal cycling loads. Furthermore, recent field-experience shows that loads caused by climatic conditions and harmful gas concentrations of the environment can have as well a significant impact on the lifetime and reliability of the semiconductor devices. Therefore, the PINTA partners have initiated the industrial Working Group on 'Power Semiconductor Reliability for Railway Application' within the European ECPE Network to discuss these topics with the power semiconductor supplier side.





Targets and Approach (I)

- Review current climatic requirements from standards in order to identify the relevant requirements for the power semiconductor modules installed in the electronics compartment. The micro-climate in the converter housing can differ significantly from the external environmental climate. One main target is therefore to prepare a specific technical specification describing the environmental loads for the power semiconductors.
- Validate these values with data from vehicle measurements. The objective is to acquire the relevant requirements for the semiconductor devices for the different installation locations in the train e.g. roof-top, underfloor or in the machine room.
- Micro-climate simulations will enable to analyze the impact of various design aspects of the converter unit. Storage and release of humidity caused by synthetic materials as well as condensation effects on the surfaces will be considered in the microclimate simulation.





Targets and Approach (II)

- The validated climatic requirements shall be used by the semiconductor suppliers as a design and qualification basis. Appropriate tests for the device qualification will be derived from the requirements and the operation conditions on the rolling stock.
- Define appropriate test conditions which requires a detailed knowledge of the semiconductor and housing design as well as the used materials.
- Derive appropriate tests with applicable acceleration factors for the different loads like \geq temperature, humidity and harmful gases.

TAI

Finally, the 'Technical Requirement Specifications' will be published as ECPE Guidelines for the environmental requirements and the applicable test specification.

> Figure: Scope of the requirement specification: Transformation of the external climate into an internal compartment climate.







Power Semiconductor Reliability for Railway Application: impact of warmhumid climate, condensation and chemical substances.

Objectives:

- 1. Environmental requirements for power semiconductors based on field measurements (data collection in PINTA). Mission profiles shall be derived.
- 2. A common understanding about acceleration factors and humidity lifetime model shall be established.
- 3. Agreement on a changed High Voltage H3TRB Tests (HV-H3TRB)

Final deliverable: ECPE Guideline on 'Technical Specifications for Railway Applications: HV-H3TRB tests'

A steady-state temperature, humidity and voltage bias test for the evaluation of the behaviour of non-hermetic power electronic IGBT and SiC MOSFET modules for the use in rolling stock applications agreed by the semiconductor suppliers and converter manufacturers.

The ECPE Guideline will be a publicly accessible document.



Environmental Requirements



Objective:

1. Environmental requirements for power semiconductors based on field measurements (data collection in PINTA). Mission profiles shall be derived.

Topics:

- Use cases with possible condensation events
- A measurement campaign conducted within the PINTA project
 - Which data to collected
 - Sensors, data loggers, position of the sensors, sampling time
 - o Access to train operation data
- Analysis of the existing and (new) measured data





Objective:

- 2. A common understanding about acceleration factors and humidity lifetime model shall be established.
- Models for transfer of humidity into the converter box and then into the semiconductor module
- Models for power module lifetime estimation
- Influence of contaminants: SO₂, NO₂, Cl₂, H₂S (in combination with voltage, humidity -> electrochemical migration + dendrite growth)
 - ECPE Joint Research Programme 2019: Harmful Gas Requirements for Power Electronics, V. Zimmermann, Fraunhofer IISB
 (1) Improvement of the data base for concentrations of gaseous chemicals that trigger corrosive effects,
 - (2) Do standardized environment classifications correspond to real gaseous contaminant concentrations in nature?



HV-H3TRB Tests



Objective:

3. Agreement on (changed) HV-H3TRB tests

To be defined:

- Test voltages, temperature and humidity
- Test duration
- In-test and post-test acceptance criteria
- Number of modules/devices/lots
- Ramp-up, ramp-down and after-test stabilisation procedures
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When completed the guidelines will be available on the ECPE Webpage.