



# The European Power Electronics Network ■

- Joint Research
- Advanced Training
- Public Relations





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## ECPE European Center for Power Electronics

- the Industry-driven Research Network for Power Electronics with about 240 member organisations in Europe
- a strong voice of the Power Electronics community in Europe to the public and to politics!

### 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

#### Directions:

- Promoting Research Programmes addressing Power Electronics
- Young Engineers Needed!

### ECCE Europe Conference

- Annual Power Electronics conference in Europe
- Jointly organised with IEEE PELS



# ECPE – the industry-driven Research Network with 123 Industrial Members (incl. 46 SMEs)





# ECPE – the industry-driven Research Network with 118 Competence Centres





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## ECPE Board of Directors



President  
**Prof. Dr. Leo Lorenz**

President of ECPE e.V.



Vice President  
**Matthias Hammerl**

Senior Expert High-Power Electronics  
Vitesco Technologies GmbH



Vice President  
**Philippe Loizelet**

Schneider Electric



Treasurer  
**Peter Beckedahl**

Vice President Product Development  
Modules  
SEMIKRON International GmbH



Secretary  
**Dr. Stefan Weber**

Vice President  
Development & Application  
Magnetics Business Group  
TDK Electronics AG



Member of the Board  
**Dr. Francisco Canales**

Corporate Research Fellow  
ABB Switzerland Ltd.



Member of the Board  
**Dr. Peter Friedrichs**

Senior Director SiC  
Infineon Technologies AG



Member of the Board  
**Prof. Dr. Rolf Hellinger**

Vice President for Technology & Pre-  
development Power Electronics  
Siemens AG



Member of the Board  
**Dr. Torsten Leifert**

Electronic Engineering  
Volkswagen AG



Member of the Board  
**Regina Roos**

Senior Business Development Lead  
Europe  
Typhoon HIL GmbH



Member of the Board  
**Dr. Peter Steimer**

Power Grid Research Fellow  
Hitachi Energy



Member of the Board  
**Orhan Toker**

Vice President Sales & Marketing  
Plexim GmbH



## ECPE HQ Office Team



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Events & Secretary  
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**Margit Thureau**

Finance & Controlling  
Tel.: +49 (0)911/810288-20

ECPE Office Team: technical staff (engineers) and administrative staff incl. event organisation  
(incl. 3 employees for the Bavarian Cluster project)



# Content

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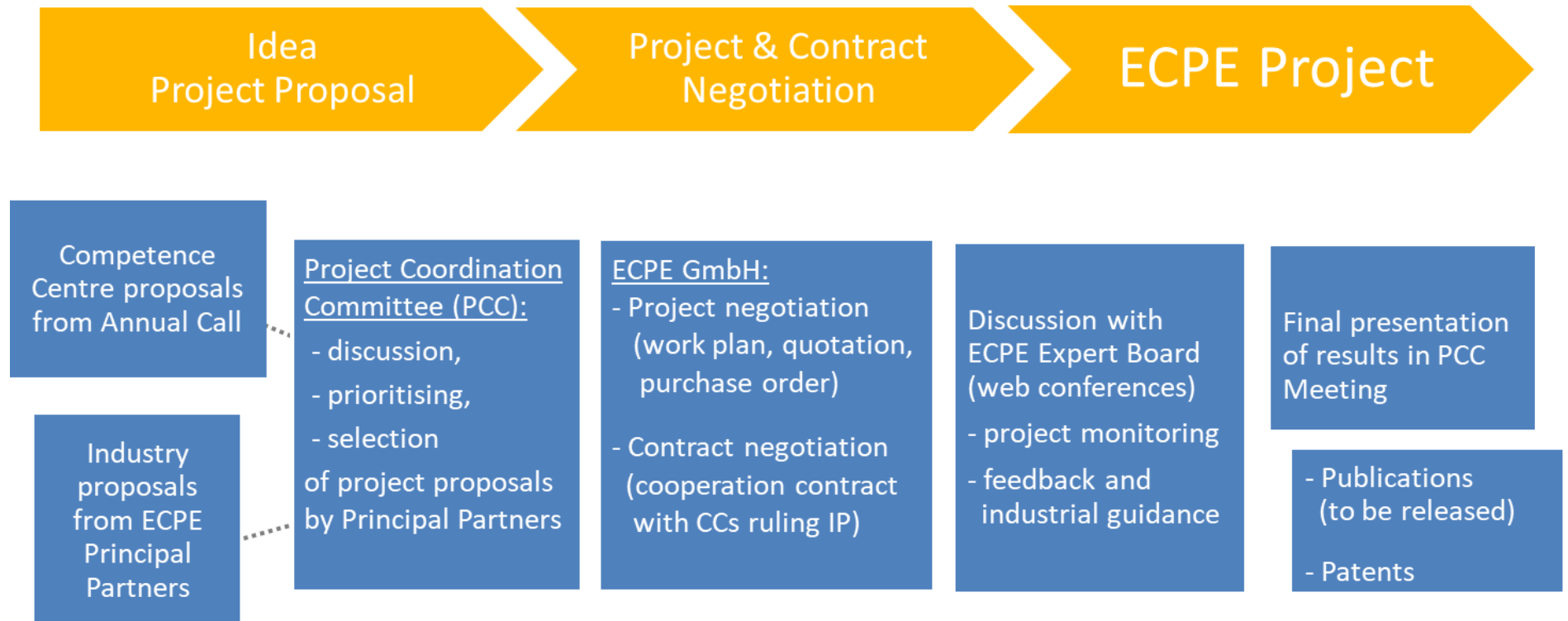
- [The ECPE Network](#)
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# ECPE Joint Research Programme

## Procedure from the Project Idea to the Final Demonstrator and Report

- Joint Research Programme for ECPE Member companies and Competence Centres
- ECPE Principal Partners pay an annual fee of 40.000,- € into the research fund
- Industry-financed R&D contracts with ECPE Competence Centres (CCs)





# ECPE Joint Research Programme

## Annual Call for Proposals for Competence Centres

### Scope of the Call and Thematic Areas:

- Passive Components - Improved Materials and Reliability
- High Performance Substrates, Packaging and Interconnection Technologies for High Power/High Temperature Applications
- Topologies and Technologies for Fast Switching (Ultra-Low Impedance/Inductance)
- High Power Density System Integration
- Reliability and Robustness of Power Electronics (Components)
- Condition and Health Monitoring
- Smart Power Electronics Systems and Artificial Intelligence
- Gate Drivers and Advanced Gate Control
- Energy Efficient Systems
- Power Electronics for Smart Grids incl. Renewables and eMobility
- Next Generation of Power Electronics Packaging and Partitioning

Multi-disciplinary topics should be addressed preferably in a joint project proposal of two or more ECPE Competence Centres.



#### ECPE Joint Research Programme

In the frame of the ECPE Joint Research Programme, pre-competitive research projects are jointly funded by the ECPE Partner companies. ECPE GmbH (limited company) manages the research fund and concludes the research contracts with the ECPE Competence Centres performing the research work. The selection of topics/projects is done by the ECPE Principal Partners in the Project Coordination Committee (PCC). The ECPE Partners are providing industrial guidance and technical feedback by the PCC and specific Expert Boards in the thematic areas.

#### Call for Proposals 2025.1

##### Scope of the Call and Thematic Areas:

- High Power Density System Integration
- Medium Voltage Power Electronics - Power Semiconductors and Modules, Topologies, Converters and Systems/Applications
- Reliability and Robustness
- Condition and Health Monitoring
- Passive Components – Improved Performance
- High Performance Packaging and Interconnection Technologies
- Topologies and Technologies for Fast Switching (Ultra-Low Impedance/Inductance)
- Smart Power Electronics Systems and Artificial Intelligence
- Gate Drivers and Advanced Gate Control
- Highly Efficient and Sustainable Power Electronics
- Power Electronics for Smart Grids incl. Renewables and eMobility

Multi-disciplinary topics should be addressed preferably in a joint project proposal of two or more ECPE Competence Centres.

##### Application and selection procedure:

1. The ECPE Competence Centre submits a short project description (max. 3 pages incl. definition of objectives, work packages, time and cost plan) by e-mail to ECPE GmbH<sup>1)</sup>. Each project proposal has to be supported by at least one ECPE Principal Partner<sup>2)</sup> who will present the project during the PCC selection procedure.

##### Submission Deadline: 24 January 2025

2. The first stage selection is conducted by the ECPE Principal Partners via e-mail voting. The Competence Centres receive the results within one month.
3. The second stage selection is conducted at the ECPE PCC Spring Meeting in March. A recorded power point presentation of the project proposal prepared by the Competence Centre is shown and the project is presented by the supporting Principal Partner. After a discussion, the ECPE Principal Partners decide on the proposals and prioritise them by voting.
4. Contracting and project start: The selected projects are initiated according to the available budget. The Competence Centres prepare the offer by considering the feedback received from the selection procedure. The project starts after the contract is signed.

##### General Conditions:

ECPE GmbH will engage in a Cooperation Contract with the Competence Centre for the ECPE Project. As ECPE GmbH has to provide project results and Intellectual Property Rights (IP) to the funding Partners, ECPE GmbH claims exclusive rights to project results and IP from the Competence Centres.

Contact: ECPE GmbH, Nuremberg  
Thomas Harder

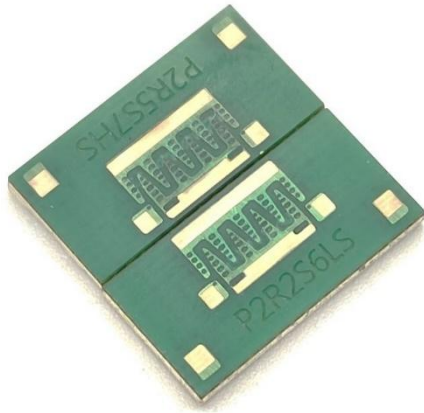
Tel. +49 (911) 8102880, [thomas.harder@ecpe.org](mailto:thomas.harder@ecpe.org)

<sup>1)</sup> For questions contact Gudrun Felix Tel. +49 (911) 810288-15, [gudrun.felix@ecpe.org](mailto:gudrun.felix@ecpe.org)

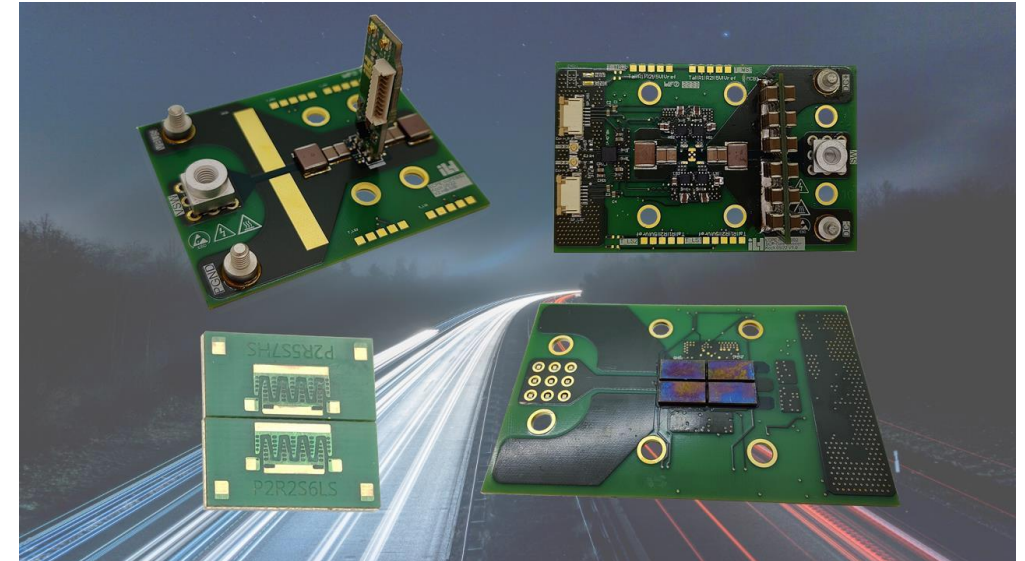
<sup>2)</sup> A list of ECPE Principal Partners is enclosed to this call.

### ECPE Project: Mild Hybrid msPEBB with Integrated Sensor Systems

- Overall concept and innovations
- Semiconductor packaging
- Modelling and thermal simulation
- Resistive temperature sensor integrated in to GaN prepackage
- Overcurrent detection with integrated pick-up coil



GaN single chip package HS and LS with integrated resistive temperature sensor



Different msPEBB views:

Top left: msPEBB 2nd generation with external half-bridge daughter gate-drive board

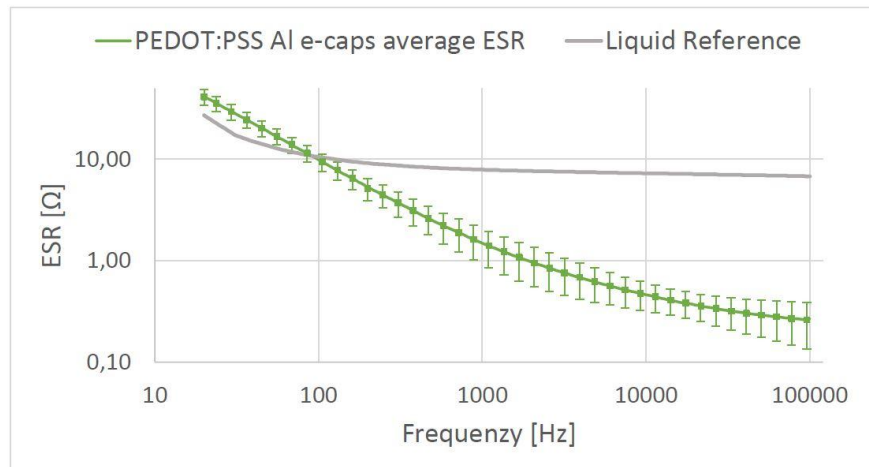
Top right: top view of the 2nd generation msPEBB

Bottom right: bottom view of the 2nd generation msPEBB with single chip package

Bottom left: GaN single chip package HS and LS with integrated resistive temperature sensor

### ECPE Project: Development of new high-performance aluminium electrolytic capacitor for automotive use

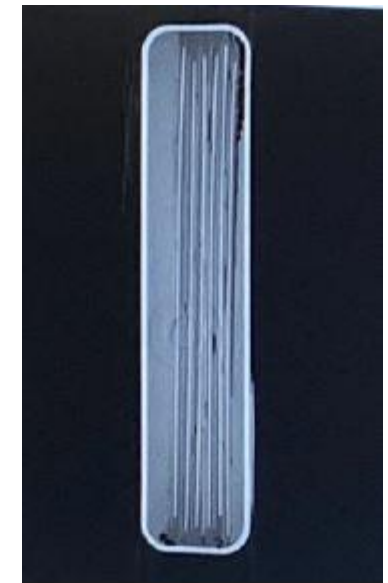
- Using conducting polymer (PEDOT) as electrolyte
- Significant reduction in ESR
- Working voltages up to 450 V proven
- Ripple current up to 20 A possible w/o cooling



ESR of PEDOT:PSS Al e-cap stacks and a liquid reference stack from 20Hz to 100kHz.



Left: Canned capacitor with 32  $\mu$ F



Right: Top view of encapsulated cap with XRT

### ECPE Project: M-Shunt II

- Low inductive measurement system based on PCB technology
- Temperature compensation by use of Manganin
- Skin effect compensation for fast switching applications by design

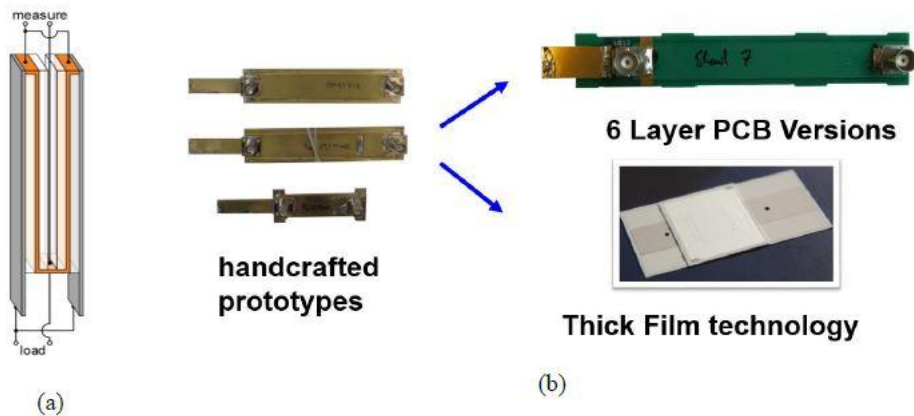


Figure 1: (a) Structure of the M-shunt, and (b) various M-shunt structures implemented in different technologies.

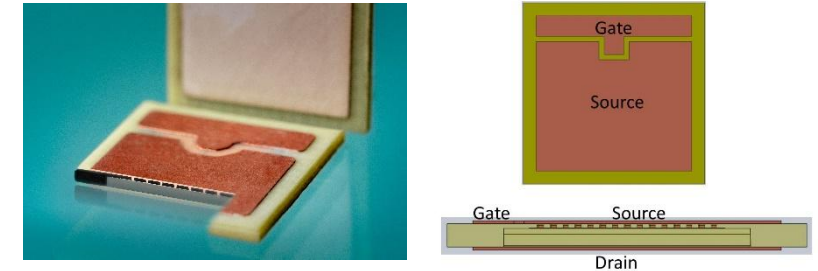
Parameter	Unit	Value	Comment	Reference ** T&M SSDN-0025
Resistance	[mOhm]	24		25
Max. continuous power dissipation	[W]	5	Vertical mounting, free convection: $T_{max} = 125^{\circ}\text{C}$ ; $T_{amb} = 25^{\circ}\text{C}$ $R_{th} = 20 \text{ K/W}$	2
Max. Energy input	[J]	120	$\Delta T = 50 \text{ K}$ with $C = 2,4 \text{ J/K}$	28
Bandpass frequency	[MHz]	42*	Based on first order model, not experimentally verified $f_0 = \frac{R}{2\pi L}$ with $L = 91\text{pH}$ from Q3D simulation	12
Insertion Inductance	[pH]	724*	Simulated with Q3D at 100 MHz	

\* Value based on simplified model excluding effect of connectors and parasitic capacitances

\*\* For comparison the datasheet specifications of a commercially available Coaxial shunt are listed

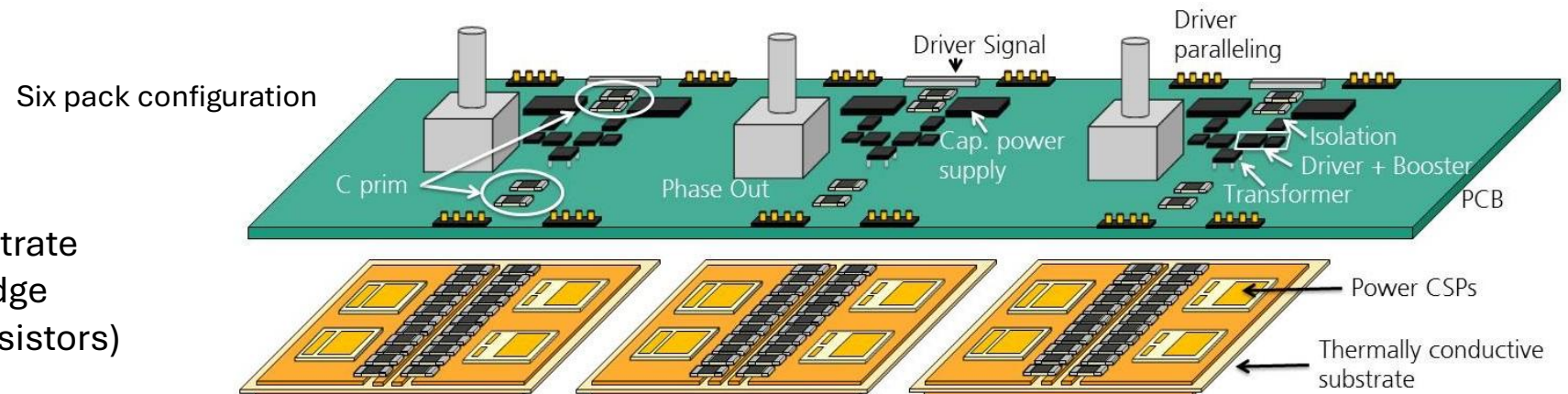
### 1. SiC-MOSFET packaged as Power-CSP

- Power-CSP are manufactured using PCB technologies. The chips are sintered to copper foil on the one side and contacted with  $\mu$ -vias on the other one.  
=> robust pre-package easy to handle in further assembly processes



### 2. Two substrate approach: one for thermal and insulation, one for interconnection

- the thermally conductive substrate carries Power-CSPs in half bridge configuration (and damping resistors)
- the electrical board includes the bus bar, driver assembly, current measurement and the AC terminals



by  
Prof. E. Hoene



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## ECPE Workshops for Expert Discussion

### Range of recent topics:

- ECPE SiC & GaN User Forum  
Potential of Wide Bandgap Semiconductors in PE Applications
- High PE for a Successful Energy Transition towards 100% RE
- Power Electronics Developments for Data Centres
- Power Electronics Reliability in Outdoor Grid-Connected Systems
- Design, Technology, Simulation & Application Aspects of Magnetic Components in PE
- Embedding and Advanced Integration Technologies in Power Electronics
- Low Voltage DC Grids for Industry and Office
- Capacitors in Power Electronics
- RT-HIL Testing of Power Electronics Converter and Drives Systems
- Condition & Health Monitoring in Power Electronics
- Sustainable Energy Supply to Reach Net-Zero CO2 Emissions by 2050
- Sinter Technology in Power Electronics
- Materials Innovations for Advanced Power Packaging  
– Substrate, Interconnection and Encapsulation
- Eco-Design Approaches of Power Electronics
- Medium Voltage Power Electronics



free download of presentations  
for ECPE member companies on  
[www.ecpe.org/membersarea](http://www.ecpe.org/membersarea)

- **2 days and about 20 speakers**
- **70 – 80 % industry participation**
- **3 seats free of charge for members**

All up-to-date topics, programmes and registration: [www.ecpe.org/events](http://www.ecpe.org/events)

### Range of recent topics:

- Corrosion in Power Electronics
- Digital Control | Modelling and Feedback Design in State-Space
- EMC in Power Electronics
- EMC Optimised Design (Parasitics in Power Electronics)
- GaN-based Power Electronics
- Gate Drivers and Control Circuitry for IGBTs and MOSFETs
- Introduction in Power Electronics
- Insulation Polymers for PE: Failure Mechanisms, Preventive Measures, Testing Strategies
- Isolation Coordination
- Model Predictive Control for Power Electronics, Drives and Power Grid Applications
- Passives in PE: Magnetic Component Design and Simulation
- Power Circuits for Clean Switching and Low Losses
- Power Electronics Packaging
- Power Semiconductor Devices & Technologies
- Reliability of Power Electronics - Part I & II
- Testing and Electrical Characterization of Power Semiconductor Devices
- Testing Automotive Power Modules acc. to the ECPE Guideline AQG 324
- Thermal Engineering of Power Electronic Systems - Part I & II
- Use and Assessment of Power Device Models in PE Simulation
- Wide Bandgap User Training - GaN-based PE (Part 1) | - SiC-based PE (Part 2)



free download of presentations  
for ECPE member companies on  
[www.ecpe.org/membersarea](http://www.ecpe.org/membersarea)

All up-to-date topics, programmes and registration: [www.ecpe.org/events](http://www.ecpe.org/events)

- **Classroom atmosphere**
- **Reduced fee for members and CCs**
- **1 seat free of charge for members in online tutorials**

ECPE tutorials are dedicated to young engineers or those new in the field of power electronics. They usually get in contact with ECPE tutorials because they are told by their colleagues or company.

Use the ECPE Tutorial Programme to bring your team forward, too!

download on  
[www.ecpe.org/events](http://www.ecpe.org/events)

Have a look on the ECPE Tutorial Brochure and learn more about:

- Target groups
- Contents
- Related topics
- Team of speakers



[www.ecpe.org/onlinecourse](http://www.ecpe.org/onlinecourse)

## eLearning Tool

for ECPE Industrial Members  
and Competence Centres  
(free of charge)

### ECPE Online Course

The **ECPE Online Course on Power Electronics** is built up in cooperation with Prof. J.W. Kolar and Dr. U. Drogenik from Swiss Federal Institute of Technology (ETH) Zurich, Power Electronic Systems Laboratory. The Course comprises interactive and animated Java applets as well as a script on fundamentals and theory of power electronics. The Course on electronic power conversion is basically structured in DC-DC, AC-DC, DC-AC and AC-AC power conversion and also some new modules in the range of EMC.

Feedback from the users of the Online Course is welcomed. Please send your comments to [info@ecpe.org](mailto:info@ecpe.org).

The Online Course has been developed under license of ETH Zurich, Power Electronic Systems Laboratory.

Limitations of Liability and Disclaimer of Warranties

- **DC/DC**
  - [Spectrum / Filtering of Square Wave](#)
  - [Efficiency and Losses](#)
  - [Control of Switching Behavior \(MOSFET\)](#)
  - [Passive Components / Filter Circuits](#)
  - [Thermal Design](#)
  - [LC Resonant Circuit State-Plane Trajectory \(uZi-Diagram\)](#)
  - [u1 Constant / Load Variable](#)
  - [u1 Variable / u2 Controlled](#)
  - [Dynamic Behavior](#)
  - [Boost Converter - u1 Variable / u2 Controlled](#)
  - [Boost Converter - Root Locus Diagram, RHP-Zero](#)

#### DC-DC Converter - Influence of inductive coupling to filter performance

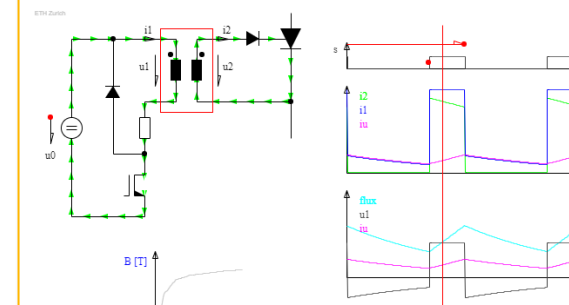
Filters in  $\pi$  topology are very sensitive to magnetic coupling. As the difference in interference levels between the input and output capacitor of the filter is very high, very low coupling between the magnetic stray fields of both is sufficient to severely influence the filter performance. If the filter for example provides 60 dB damping between input and output side than the current on input side is 1000 times higher since at the output. In this case 1% coupling between the input and output capacitor are enough to reduce the filter equals a ten times higher noise at the filter output.

is have to be taken. The layout of the current path for high med for low stray inductance. This is mainly done by his is not perfectly possible there will be remain stray fields s themselves. Therefore these capacitors should be placed in orthogonal orientation to each other.

ut capacitor are coupled. The coupling factor can be 00%. The influence to the noise spectra can be observed in is case there is no stray capacitance at the output side mon mode noise produced, because this coupling between er differential mode noise can not have any influence to

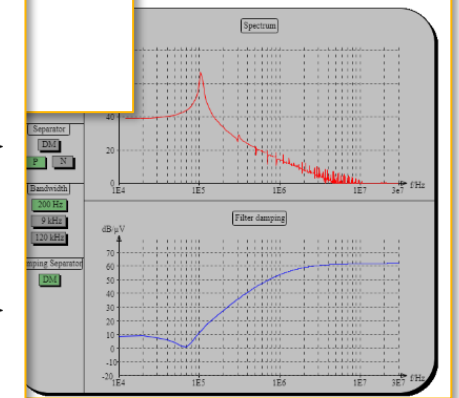
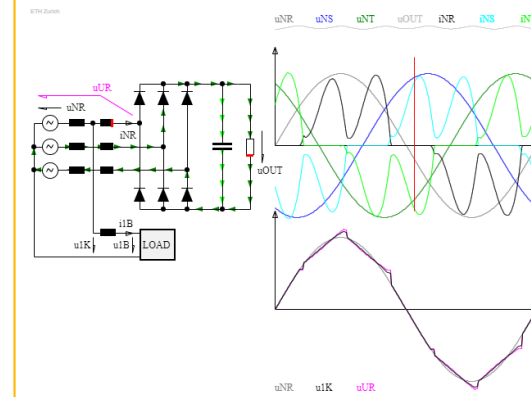
### Magnetizing Current

Overview



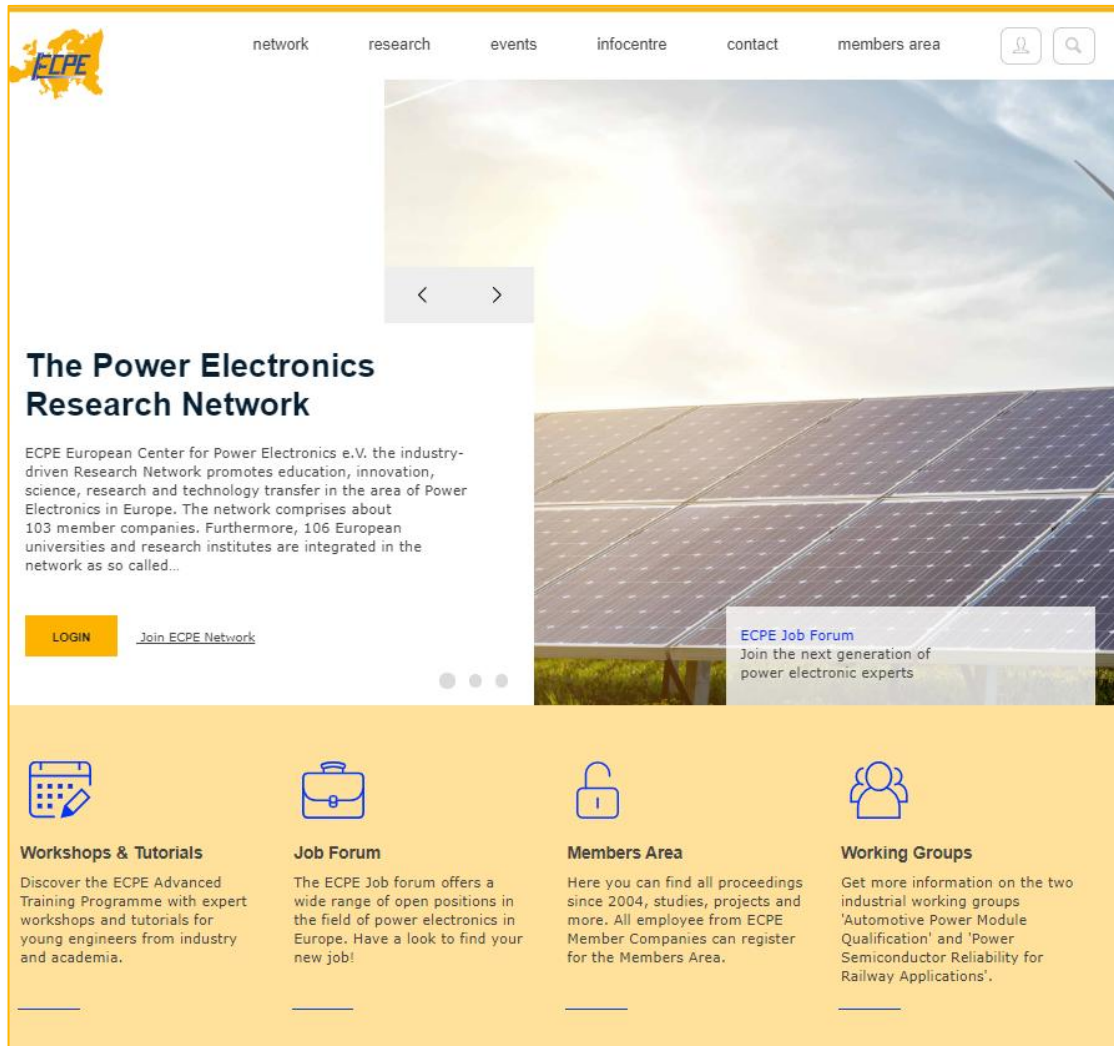
### Commutation

Overview





## ECPE Website



[www.ecpe.org](http://www.ecpe.org)

- ECPE Calendar of Events
- List of PE Conferences and Events
- Cluster Calendar of Events with workshops and tutorials in German language
- ECPE Network News
- Job Forum with open positions
- ECPE Working Groups
- List of European Research Calls
- ECPE Roadmaps and Strategy Papers
- ECPE Members Area – access for all employees of ECPE Member Companies and Competence Centres



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## ECPE Joint Stand at PCIM Europe

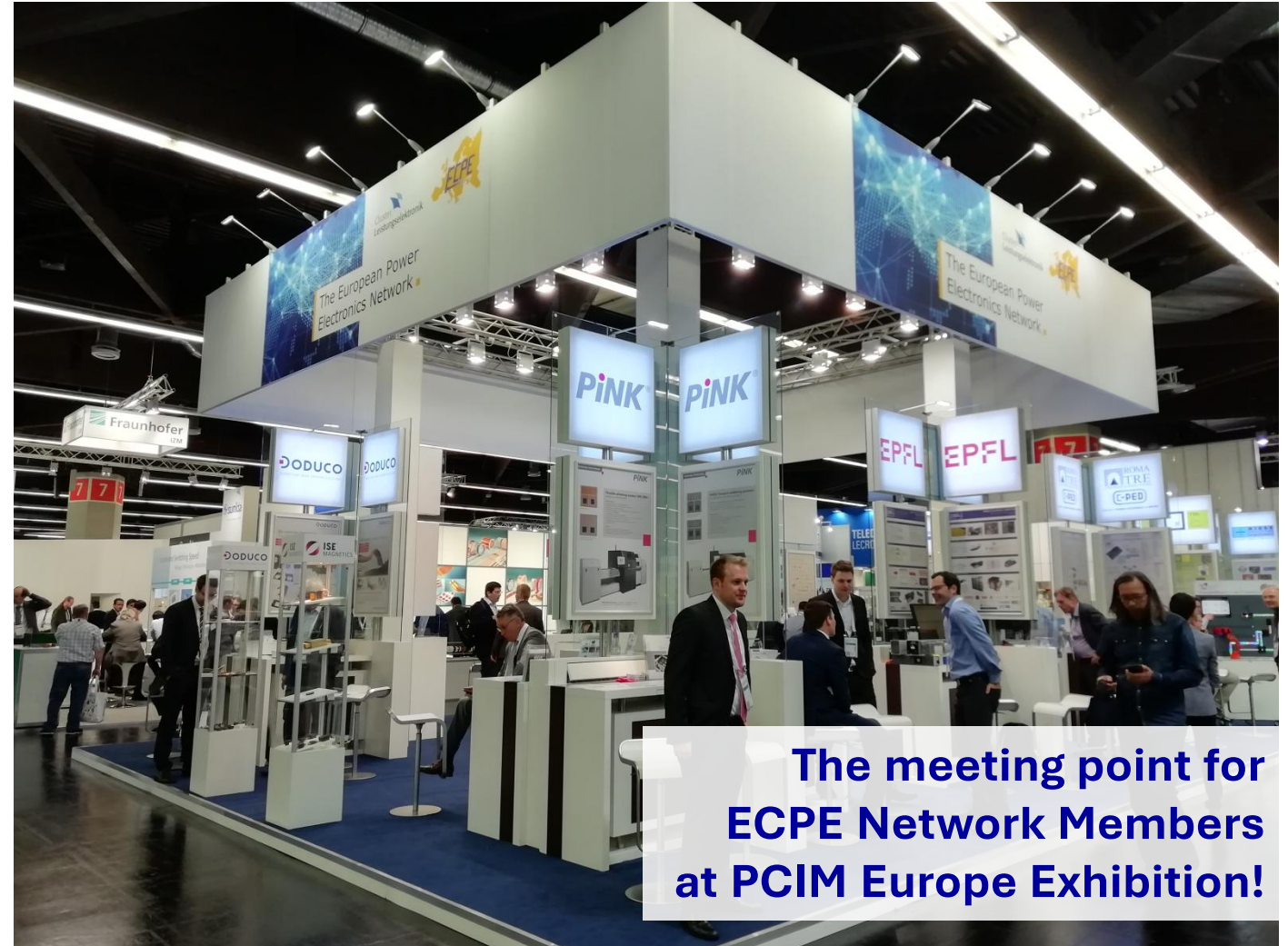
More information and application  
[www.ecpe.org/pcim](http://www.ecpe.org/pcim)

**pcim**  
EUROPE

International Exhibition and Conference  
for Power Electronics, Intelligent Motion,  
Renewable Energy and Energy Management

PCIM Europe is the world's leading exhibition and conference for power electronics, intelligent motion, renewable energy and energy management. Since 2004 ECPE gives companies and institutes the opportunity to present their innovations at the ECPE Joint Stand.

**6 – 8 May 2025 | Nuremberg, Germany**



**The meeting point for  
ECPE Network Members  
at PCIM Europe Exhibition!**



## ECPE Programme 'Young Engineers Needed'

### ECPE Students Day at PCIM Europe Exhibition

On 3<sup>rd</sup> day  
of PCIM Europe

One part of the ECPE public relations and lobbying activities is to future young engineers in the field of power electronics. The ECPE Students Day at PCIM gives the possibility to visit the exhibition and ECPE Member Companies.





## ECPE Programme 'Young Engineers Needed' European PhD School in Gaeta (Italy)

The European PhD School on 'Power Electronics, Electrical Machines, Energy Control and Power Systems' is jointly organized by University of Cassino and ECPE in cooperation with IEEE PELS. It's an unique event in Europe for young power electronics engineers from academia to exchange experience and technical information about their PhD projects. Moreover, ECPE sponsors the European PhD School Poster Award.

At the **ECPE Industry Day for Recruitment** participating companies get in contact with about 100 PhD students from all over Europe.

[www.ecpe.org/phdschool](http://www.ecpe.org/phdschool)



**26 – 30 May 2025**

Gaeta Castle, Italy

For further information  
please contact

[christian.manneschmidt@ecpe.org](mailto:christian.manneschmidt@ecpe.org)





## ECPE Programme ‘Young Engineers Needed’ Job Forum on [www.ecpe.org](http://www.ecpe.org)






In the Job Forum on [www.ecpe.org](http://www.ecpe.org) network members have the possibility to publish open positions in the field of power electronics free of charge. In addition, there is a separate rubric for student positions for practical trainings, master thesis or working students.

During PCIM Europe the ECPE job forum gets analog with the ECPE Job Board.

[www.ecpe.org/jobs](http://www.ecpe.org/jobs)

Publishing open positions  
is free for ECPE Member  
Companies and  
Competence Centres.



	<b>Researcher in the field of Power Electronics – Magnetic components (m/f/d)</b> Mitsubishi Electric R&D Centre Europe Rennes, France 05-09-2023
	<b>Technician for Power Electronics</b> Chemnitz Power Labs Chemnitz, Germany 08-08-2023
	<b>Field Application Engineer (m/f/d)</b> Opal-RT Nuremberg, Germany 01-08-2023
	<b>Research Engineer in Detection, Diagnosis and Prognosis of Electric Arcs (m/f/d)</b> Safran Tech Toulouse, France 10-07-2023
	<b>(Senior) Power Electronics Research Engineer (m/f/d)</b> Huawei Nürnberg, Germany 30-06-2023



# European Power Electronics Conferences

ECPE supports conferences and further events with focus in power electronics. Upcoming events and open call for papers are published on the ECPE website.

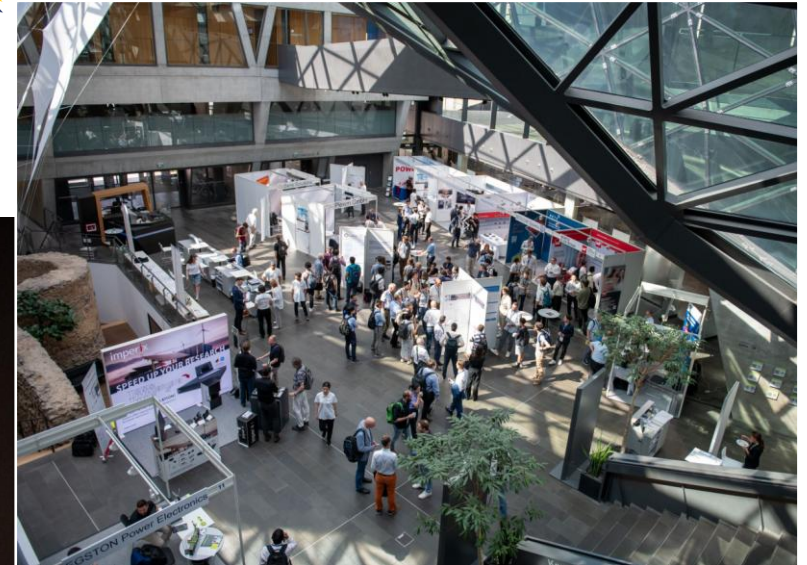
[www.ecpe.org/conferences](http://www.ecpe.org/conferences)





# First ECCE Europe Conference 2024 in Darmstadt, Germany

Jointly organised by ECPE and IEEE PELS





# ECCE Europe Conference 2025 in Birmingham, UK

Jointly organised by ECPE and IEEE PELS

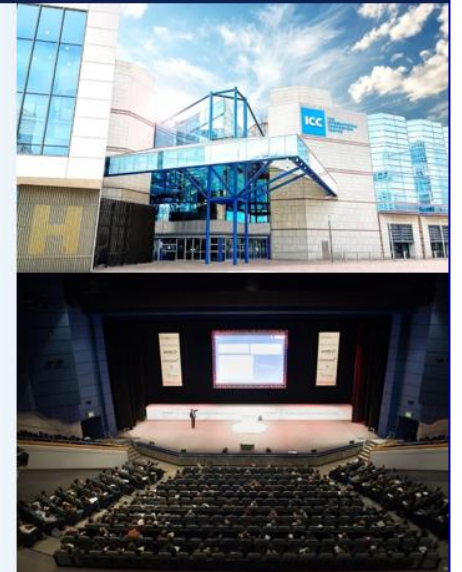


## See you next year in Birmingham!

Join us in Birmingham, UK, located in the region which is known as the birthplace of the Industrial Revolution and the perfect location to explore the latest advancements in power electronics.

Don't miss this opportunity to connect with industry and academic experts, share knowledge, and experience the future of power electronics!

The Call-for-Papers is available at the conference website. All papers presented at the conference will be included in the IEEE Xplore Digital Library.



[www.ecce-europe.org/2025](http://www.ecce-europe.org/2025)



### General chairs:

**Volker Pickert**  
Newcastle University

**Pat Wheeler**  
University of Nottingham



## ECCE Young Engineer Award

ECPE Young Engineer Award is dedicated to outstanding contributions of engineers under 30 presented at ECCE Europe & CIPS Conferences.



CIPS 2024  
12 - 14 March 2024 in Düsseldorf (D)

### ECPE Young Engineer Award

to

Sibasish Laha

for the outstanding presented paper  
at the CIPS 2024 - 13<sup>th</sup> International Conference on  
Integrated Power Electronics Systems  
entitled

*Milliseconds Power Cycling (PCmsec) driving bipolar  
degradation in Silicon Carbide Power Devices*

Düsseldorf / Germany, 14 March 2024



# Semikron Danfoss Innovation and Young Engineer Awards

organized by ECPE

The **Semikron Danfoss Innovation Award** and the **Semikron Danfoss Young Engineer Award** is given for outstanding innovations in projects, prototypes, services or novel concepts in the field of power electronics in Europe, combined with notable societal benefits in form of supporting environmental protection and sustainability by improving energy efficiency and conservation of resources. Both prizes have been initiated in 2012 by the SEMIKRON Foundation. Semikron Danfoss is awarding the prizes in cooperation with the **European ECPE Network**.

- **Winner of the Semikron Danfoss Innovation Award 2025**

This year the jury has decided to give the SEMIKRON Innovation Award to a research team from *Leibniz University Hannover, Germany* comprising *Niklas Himker, Georg Lindemann, Viktor Willich and Axel Mertens* for their joint work on an 'Self-Sensing Control of Permanent Magnet Synchronous Machines: Enabling Widespread Use in Commercial Applications'.

- **Winner of the Semikron Danfoss Young Engineer Award 2025**

The SEMIKRON Young Engineer Award 2025 goes to *Xufu Ren* from *University of Cambridge, United Kingdom* for his work on 'Highly Efficient and Compact 4: 1 Bus Converter for Next-generation AI Computing'.





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- [ECPE Working Groups](#)
  - Automotive Power Module Qualification Guideline (AQG 324)
  - Power Semiconductor Reliability for Railway Application
- [ECPE Programmes](#)



## ECPE Working Group

### Automotive Power Module Qualification (AQG 324)

WG Chairman: Dr. Martin Rittner (Robert Bosch)

Vice Chairmen: Dr. Markus Thoben (Fachhochschule Dortmund)

Peter Dietrich (Richardson RFPD Germany)

Frank Heidemann (SET Smart Embedded Technologies)

WG Members: > 30 industrial members including OEMs, tier 1 suppliers, power semiconductor and module manufacturer, test equipment supplier

[www.ecpe.org/AQG324](http://www.ecpe.org/AQG324)  
with download area





# ECPE Guideline

## Automotive Qualification Guideline (AQG 324)



AQG 324



### ECPE Guideline AQG 324

Qualification of Power Modules for Use in Power Electronics  
Converter Units in Motor Vehicles

with new annex  
for SiC-based power modules  
(and for GaN)

Release no.: 03.1/2021

Release date: 31.05.2021

Contact: ECPE European Center for Power Electronics e.V.  
Dipl.-Phys. Thomas Harder  
Landgrabenstrasse 94  
90443 Nuremberg, Germany  
Email [thomas.harder@ecpe.org](mailto:thomas.harder@ecpe.org)  
Phone (+49) 911 8102 880

- ECPE Working Group started mid of 2017
- based on the former German LV324 'Qualification of Power Electr. Modules for Use in Motor Vehicle Components - General Requirements, Test Conditions and Tests'
- ECPE Guideline is a public document available on the ECPE website
- owned by ECPE

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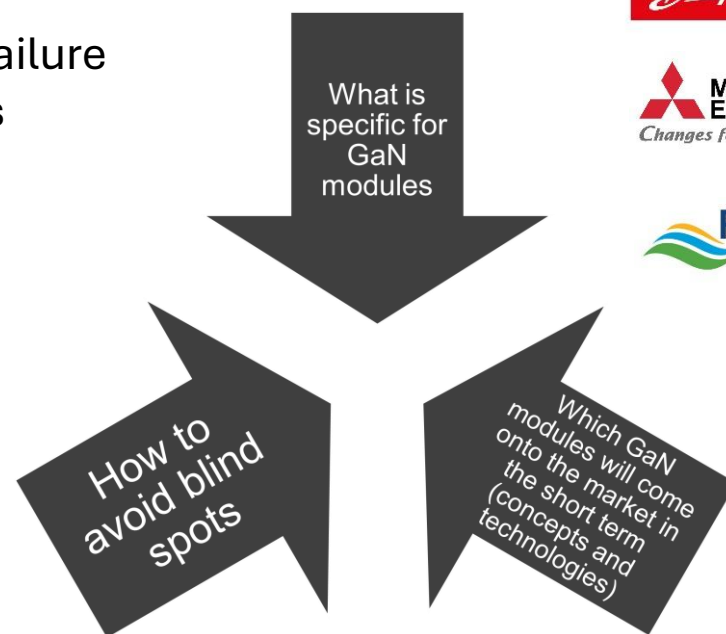
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Chair: Peter Dietrichs (Richardson RFPD)

Vice Chair: Stefan Schmitt, Semikron Danfoss

## Objectives

- Evaluate existing test procedures from AQG 324 on their applicability for GaN
- Identify and handle different failure modes for different GaN types
- Define new test procedures if necessary



GaN Task Force  
started in March 2022



## Task-Force ‘GaN Power Modules’ within the ECPE Working Group AQG 324

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### Main topics of the Task Force

#### **Special characteristics of GaN**

- Ringing
- Parameter variation
- HV GaN multi-level topology
- Multi-chip design module (e.g. cascode type)
- Missing avalanche capability

#### **Assure valid test setup**

- Module concepts
- Paralleling chips
- Physics-of-failure
- Gate concepts

#### **Appropriate qualification**

- TSEP considerations PCT
- Thermal characterization
- Failure characteristics and criterion in GaN and multi-chip modules



# ECPE Working Group

## Power Semiconductor Reliability for Railway Application

WG Chairman (Coordination Team):

Michel Piton (Alstom)

Werner Kauffeld (Deutsche Bahn)

Dr. Oliver Schilling (Infineon Technologies)

WG Member Companies:

Dr. Nils Soltau (Mitsubishi Electric)

Oskar Schuster (Siemens)

Power Semic.: Rolling Stock/  
Converter: Infrastructure:

ABB

Hitachi Energy

Infineon

MITSUBISHI  
ELECTRIC  
Changes for the Better

Fuji Electric

DYNEX  
Power through Innovation

ALSTOM

CAF  
Power &  
Automation

SIEMENS

DB

SNCF



[www.ecpe.org/railway-reliability](http://www.ecpe.org/railway-reliability)  
with download area

In cooperation with the  
European projects PINTA  
(Shift2Rail Joint Undertaking)  
and Rail4Earth (Flagship  
project)



PINTA

Europe's Rail

MinebeaMitsumi (Pending)  
Passion to Create Value through Difference



# ECPE Guideline

## PSRRA 01 - Railway Applications HV-H3TRB tests for Power Semiconductor

ECPE Guideline

PSRRA 01

Release 04.07/2024



ECPE Guideline PSRRA 01

Railway Applications  
HV-H3TRB tests for Power Semiconductor

Release no.: 04.07/2024  
Release date: 01.07.2024  
Contact: ECPE European Center for Power Electronics e.V.  
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Ostendstrasse 181  
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Email [chris.gould@ecpe.org](mailto:chris.gould@ecpe.org)  
Phone (+49) 911 8102 880

ECPE Working Group  
Power Semiconductor Reliability for Railway Application - PSRRA

Power Semiconductor Reliability for Railway Application:  
Impact of **warm-humid 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)

A steady-state temperature, humidity and voltage bias test for the evaluation of the behavior 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 is a publicly accessible document.

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# ECPE Guideline

## PSRRA 02 - Railway Applications HTC-CRB (Humidity Temperature Cycling – Cold Reverse Bias) test for Power Semiconductor

Power Semiconductor Reliability for Railway Application:  
Impact of warm-humid 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 Humidity Temperature Cycling – Cold Reverse Bias (HTC-CRB) test.

This document describes a Humidity Temperature Cycling – Cold Reverse Bias (HTC-CRB) test for the evaluation of the behaviour of non-hermetically sealed power electronic IGBT and SiC MOSFET modules for the use in rolling stock applications, as agreed by the semiconductor suppliers and converter manufacturers. The ECPE Guideline is a publicly accessible document.

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ECPE Guideline

PSRRA 02

Release 01.07/2024



### ECPE Guideline PSRRA 02

#### Railway Applications

#### HTC-CRB (Humidity Temperature Cycling – Cold Reverse Bias) test for Power Semiconductor

Release no.: 01.07/2024

Release date: 01.07.2024

Contact: ECPE European Center for Power Electronics e.V.  
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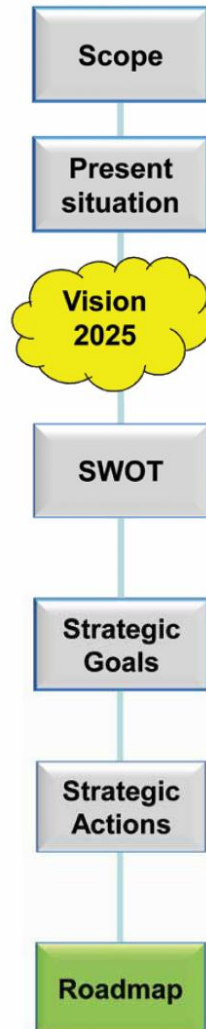
ECPE Working Group  
Power Semiconductor Reliability for Railway Application - PSRRA



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  - ECPE Roadmap 'WBG Lead Applications for SiC & GaN'
  - International Cooperations (with Japan, US, Africa)
  - Design Automation in Power Electronics
  - ECPE Position Papers



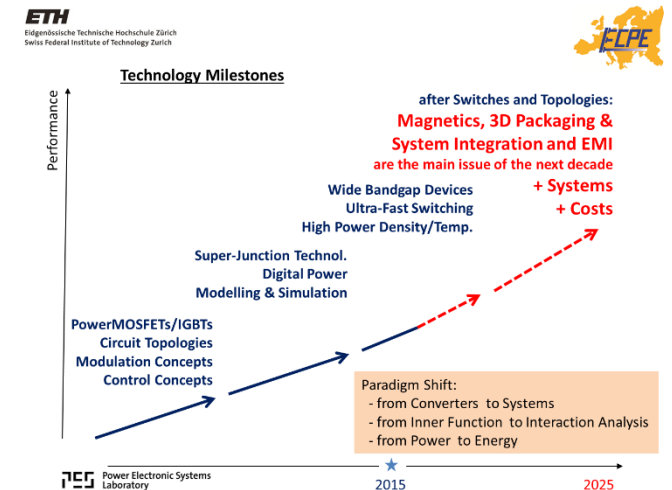
Research and Technology Roadmaps are an important strategic tool to identify and guide a mainstream for medium to long term research. The 'Power Electronics 2025' Roadmaps will be the key element of the ECPE Strategic Research Agenda.

### 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)

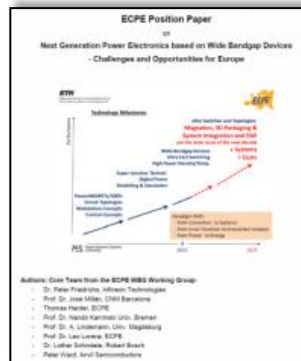
Structure: three application-related roadmapping teams

- Power Supplies (low power)
- Automotive & Aircraft (medium power)
- Electronic Power Grids (high power)



- The target applications for WBG power devices include both mobile (automotive, railway) as well as stationary systems like photovoltaic, industry drives and grid-related applications.
- For these applications the main drivers for the use of wide bandgap devices were evaluated e.g. the increase of power density regarding volume and weight reduction, the higher efficiency regarding the reduction of dynamic or static losses, the higher reliability, ruggedness and temperature capability as well as the easier controllability.
- In the next step the degree of market readiness and penetration was evaluated: demonstrator according to industry standards (D), first product available (F), significant market share (S) and predominant market share (P).

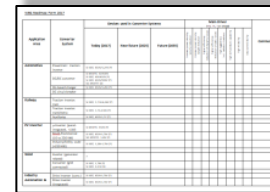
WBG Position Paper



Roadmap Workshop



Roadmap Survey



Technology	Application	Timeline
SiC MOSFET	Automotive On-Board Charger	2018-2020
SiC MOSFET	Automotive Traction Inverter	2020-2025
SiC MOSFET	Industrial Motor Drive	2020-2025
SiC MOSFET	Power Supply	2018-2020
SiC MOSFET	Power Amplifier	2020-2025
SiC MOSFET	Power Diode	2018-2020
SiC MOSFET	Power Transistor	2020-2025
SiC MOSFET	Power Diode	2018-2020
SiC MOSFET	Power Transistor	2020-2025

Roadmap Conclave



Roadmap validation with application experts

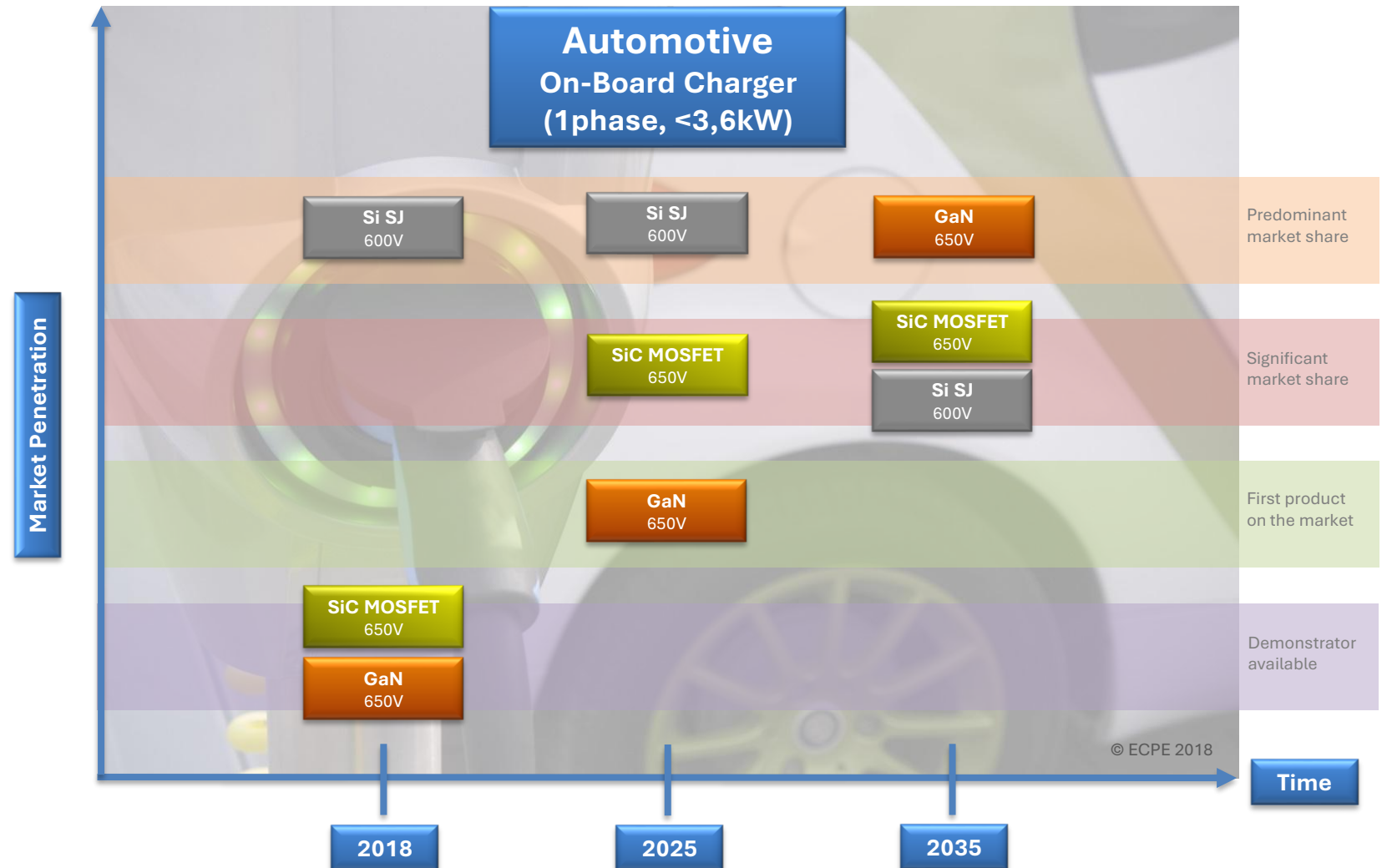


2016

2017


2018

### Example from Automotive





# International Cooperation with Japan (NPERC-J) and USA (CPES)



ECPE European Center for Power Electronics e.V.

**ECPE Workshop  
Power Electronics  
Research & Technology  
Roadmaps**

8 September 2007  
"Odd Fellow Palais"  
Copenhagen, Denmark

in cooperation with

<b>CPES</b> Center for Power Electronics Systems (USA)	<b>AIST PERC</b> Power Electronics Research Center (Japan)
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at Joint Roadmap Meeting in Japan January 2008

at 10 Years ECPE Anniversary in Nuremberg, on 17 April 2013



**European Sustainable Energy Cluster partnership for Africa (ESECA)** of 5 European clusters (ACE, MEDEE, LE2C, MetalIndustry4 and ECPE/Cluster Power Electronics) from **Spain, France, Italy, and Germany**. Together, we gather around **550 organizations and 290 SMEs**.

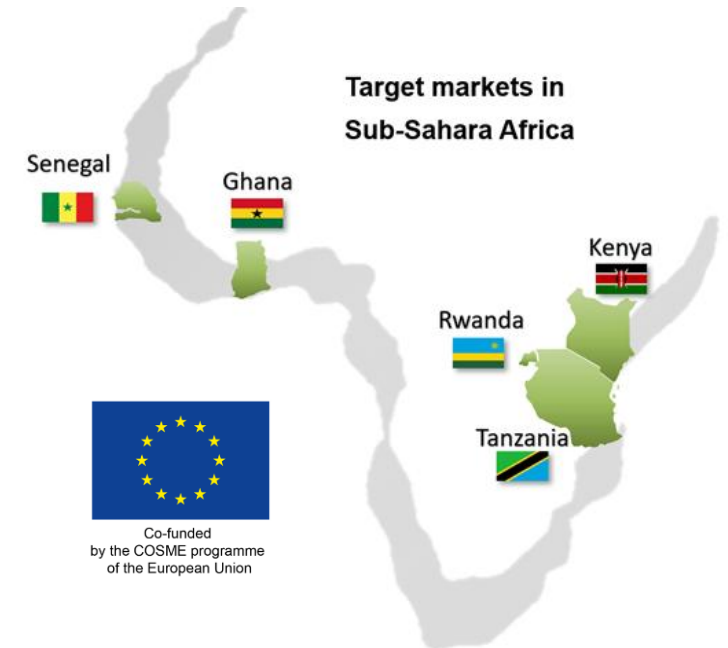
## Goal:

Intensify business network collaboration among European companies (mostly SMEs) and African stakeholders in the renewable energy and smart grids sectors.

## Benefits for ECPE members:

- Market reports available
- Networking events
- Business missions to target markets

ESECA project is funded by the European Commission (2021-2024) to support European companies from the sustainable energy sector in sub-Saharan African markets.



More information on  
Bavarian cluster webpage  
[www.clusterle.de/ESECA](http://www.clusterle.de/ESECA)

Programme

Expert Discussion

### Sustainability in Power Electronics (Carbon Footprint, Life Cycle Assessment, Circular Economy)

Date 12.07.2023, 9h – 16:00h

Location ETH Zürich, Gästehaus Villa Hatt  
Freudenbergstrasse 112, 8044 Zürich

Organizers Johann W. Kolar, Jonas Huber, ETH Zürich  
Gudrun Feix, Thomas Harder, ECPE

Sustainability is one of the key words of our times. It is commonly accepted that power electronics helps to convert our world into a greener version of itself, be it in renewable energy utilization, in electric vehicles or in more efficient variable speed drives. However, this perspective considers only one part of a converter's life cycle, i.e., the realized energy or CO<sub>2</sub> emission savings during its useful life, but not the environmental burden (climate impact / CO<sub>2eq</sub> emissions, water usage, release of toxic substances, etc.) which accrued during manufacturing nor the disposal at the converter's end-of-life.

Therefore, in this expert discussion, we would like to shed light on the environmental footprint of power electronic systems over their entire life cycle, which is commonly achieved by means of life cycle assessments (LCA). A first focus will be on sharing knowledge and experiences regarding LCAs in general, the specific challenges like data availability for LCAs of power electronic, and the implications for future concepts, materials to be used, and design for repair, reuse, recyclability, and reliability. Furthermore, we would like to give an overview of current and possibly upcoming legal questions related to the EU Green Deal.



A second focus targets the inclusion of LCA-related performance indicators early in the design and optimization process of power electronic converters to establish a quantitative understanding of design trade-offs and parameter sensitivities, i.e., an extension of commonly employed efficiency-vs.-power-density Pareto analysis by including further dimensions such as the embodied energy or lifetime CO<sub>2eq</sub> emissions.

The expected results of the expert discussion are a common understanding of the necessary steps towards a comprehensive characterization of power electronic systems concerning sustainability aspects:

- Establish a general understanding of LCAs of complete converter systems, including parameters, data sources, and requirements from the legal/standardization side.
- Identification of main cause-effect-chains, i.e. available degrees of freedom in a converter design and/or utilization of the design space diversity to modify the overall climate impact (LCA outcome), and suitable performance indices: e.g., trade-off between increased realization effort for higher efficiency and loss savings in operation or a larger cooling system and thus extended lifetime, etc.

ECPE e.V. organised in July 2023 an expert discussion on the topic “Sustainable Power Electronics” following a network discussion in September 2022. First outcome was a ECPE e.V. study and a white paper, both published for ECPE Members in September 2023.



European Center for Power Electronics study:

**Circular economy potential analysis for power electronics for battery-driven vehicles: case study on-board charger**



White Paper and Study available for members on  
[www.ecpe.org/membersarea](http://www.ecpe.org/membersarea)



ECPE Position Paper

The All-Electric Society - Enabled by Power Electronics



Available for download on  
[www.ecpe.org/AllElectricSociety](http://www.ecpe.org/AllElectricSociety)

Due to the current transformations in energy and transport, power electronics is gaining further importance as a key technology for energy efficiency and sustainability. Based on the The 2022 published ECPE Position Paper ‘The All-Electric Society - Enabled by Power Electronics’ is based on the position paper from 2007 ‘Energy Efficiency - The Role of Power Electronics’.

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# ECPE Position Paper

## What Drives Power Electronics in the New Decade

ECPE e.V./25.03.2020



### ECPE Position Paper

#### What Drives Power Electronics in the New Decade

- Global megatrends in society and their mutual impact with Power Electronics



#### 1. Main power electronics drivers in the last two decades

The starting situation coming from the 20<sup>th</sup> century was that power electronics was a very traditional topic in electrical engineering with key application areas in industry drives and railway traction in the medium to high power world, as well as in various kinds of power supplies.

Power electronics was existing in a niche without major public awareness outside the closed community of power electronics experts. Public research programmes hardly addressed power electronics topics directly.

This situation has changed when it became obvious that power electronics is a key technology for increased energy efficiency along the full chain from generation, transmission & distribution up to the use of electric energy. Furthermore, it is an enabler for the grid integration of renewable energy sources e.g. from photovoltaics and wind power. E-mobility has been boosting this development as power electronics is a key technology for e-mobility on the vehicle side as well as on the grid side. As a consequence of this change, power electronics has moved out of the niche into the focus of public awareness, regarding public funding programmes for research & innovation in Europe and also regarding its attractiveness for students.

Now the question is what will drive power electronics in the new decade up to 2030 and beyond? The approach used in this ECPE Position Paper is to derive such drivers from global megatrends in society.



This and further papers are available for download on  
[www.ecpe.org/research/roadmaps-strategy-papers](http://www.ecpe.org/research/roadmaps-strategy-papers)



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[www.ecpe.org](http://www.ecpe.org)