

# CENTRE FOR POWER ELECTRONICS NEWS

Newsletter Autumn 2018



## Symposium

In November the EPSRC Automotive Challenge Network is holding a Symposium at Austin Court, IET, Birmingham. This two day event will bring together industrialists and academics to explore solutions to the problems faced by the Industrial sector. It will focus on the themes of the Automotive Council Roadmaps and provide plenty of networking opportunities for delegates.

On Day One, our keynote speaker, Chief Scientific Adviser for DfT and Professor of ITS at Newcastle University, Phil Blythe will open the event with his speech on Future Mobility in the UK: Challenges and Opportunities. On Day Two, Neville Jackson from the APC will provide delegates with a Keynote speech on Electrification – A Perspective from the UK Automotive Council .

Six workshops will be run over the course of the two days on the following themes:

- Wide Band Gap Power Devices for Automotive Applications
- Materials for Electrical Machines
- Thermal Management
- Converter in Package/on chip
- Machine Architectures
- Integrated Drives.

[Book your place](#)

## *Inside this issue:*

*Annual Conference Report*

*Business Development*

*Research theme highlights*

*Dates for your diary*



Austin Court, IET, Birmingham

## Annual Conference 2018



The Centre for Power Electronics Annual Conference was hugely popular again this year. Delegates enjoyed keynote speeches by representatives from industry and academia, a poster competition, and the chance to browse an exhibition from leading power electronics companies.

The event also provided attendees with the opportunity to find out more about the research being carried out by CPE's Tranche 2 themes, and the work of the Compound Semiconductor Applications Catapult.

Professor Rik De Doncker from the University of Aachen opened proceedings with his keynote speech entitled "Wide Band Gap Power Electronic DC -DC Converters - a key enabler for modular EV propulsion systems and fast charging urban infrastructure."

Dr Kimimori Hamada from Toyota, Japan gave an interesting presentation in the afternoon, on "The application of SiC on vehicles and its future."

The second day was opened by Professor Xiaoming Yuan from Huazhong University of Science and Technology, China. The theme of his keynote was: "Multi-timescale dynamic issues of power electronised power systems and multi-scale magnitude-phase dynamic theory."

Christina DiMarino from Virginia Tech, USA followed with a talk on "Medium-voltage silicon carbide power MOSFET module packaging: an international collaboration."

Our international speakers also contributed to the debate "How do our panellists see their countries responding to increased demand for power electronics and the transport electrification agenda".

"Once again our Conference was a sell out," said Centre Director, Professor Mark Johnson. "Our international speakers were inspirational and I would like to thank them all for contributing to such a successful event."

Follow this link to the [presentations from the CPE conference](#)

The poster competition was sponsored by PPM Power, and our congratulations go to the winner and runners up:

**1st Prize** – Soroush Faramehr, Swansea University, (Integration of GaN Magnetic Sensors with Inductor for Galvanic Current Monitoring).

**2nd Prize** – Kumaran Nathan, University of Cambridge (A Novel Combined Cuk SEPIC Converter-Based Transformerless Single Phase Solar Inverter).

**3rd Prize** – Yihua Hu, University of Liverpool, (LF-OCT Based Non-Destructive Testing for IGBT Module).



Winner Soroush Faramehr, with Phil Surman representing sponsor, PPM Power

“The conference exceeded my expectation in many aspects and I gained not only the scientific research progress but also the chance to network. The most impressive thing for me was the style of the conference. This event really encouraged all levels of participation, discussion and debate, encompassing the UK, Europe and Asia, academic and industrial. I truly admire the organiser’s courage, honesty and creativity. Many thanks to you and the CPE for your hard work and organising the conference to such a high standard.” *Dr Z Zhou, Loughborough University*

## GDPR - GENERAL DATA PROTECTION REGULATION

The General Data Protection Regulation came into law across the EU in May. Under the new regulations, organisations must keep a record of how and when an individual gives consent to store and use their personal data. With this in mind, the Centre for Power Electronics is asking you to confirm that you still want to receive information from the Centre and will allow us to keep your contact details on our database.

Please follow the link below to confirm that you want to stay in touch with the Centre for Power Electronics.

[Yes I want to continue to receive communications from CPE](#)

If you wish to unsubscribe from our mailing list please follow the link below. Please be aware that if you choose to unsubscribe you will no longer receive any communications from the Centre.

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Presenters from the PCIM tutorial day seminars

The industrial outreach activity of the Centre this quarter kicked off in June with Industry Champion, Geoff Haynes taking part in a tutorial event organised by the University of Cambridge together with Kyutech from Japan and Wolfspeed from the USA. Representatives from the University of Nottingham and Virginia Tech made a joint presentation on a state-of-the-art 10kV fast switching SiC module that is small enough to hold in your hand. There was also a presentation by a team from Imperial College London, showcasing developments made since winning the Future Power Challenge two years ago.

Two of this year's Future Power Challenge winners have also been involved in the Centre's activities.

Zhe Zhang, the winner from the University of Nottingham, is starting to explore his noiseless switch technology further by working with the University of Nottingham spin out company TTPI and other advisors. Runner up, Yichen Cai from the University of Manchester has sparked strong discussion around how best to implement fast switching power transistors in different power level and power density systems that has the potential to become a formative debate within the UK PE community.

"I am sure that this discussion will grow and look forward to it becoming a real subject of engagement between the heterogeneous integration activities of the Centre and the beneficiaries of the PE industrial community," Geoff said.

Business Development Manager, Steve Earl has now left the Centre. Any enquiries regarding future business development activities should be directed to Centre Manager, Helena Cartwright.

Email: [correspondence@powerelectronics.ac.uk](mailto:correspondence@powerelectronics.ac.uk)

## KIT CAR INSPIRES ENGINEERS OF TOMORROW



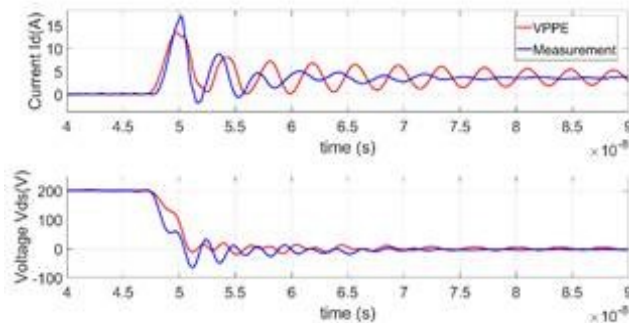
This year saw another successful year for the CPE sponsored Goblin Class electric car competition. Aimed at 10 to 11 year olds, this activity is a great way of encouraging the next generation of engineers.

At the beginning of the year, a core team of enthusiastic children from Abbey Road Primary School, Nottingham, together with researchers from the Centre, successfully built and tested their electric vehicle. The team - together with other children - then designed and manufactured the bodywork. After several testing sessions to hone their driving skills, they attended the Staffordshire Green Goblins race day which was thoroughly enjoyed by all who took part.

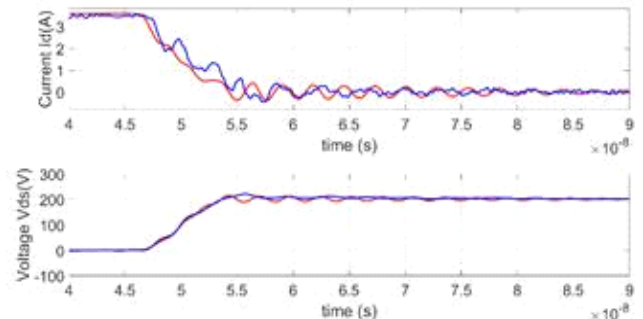
## Multi- Domain Virtual Prototyping Techniques for WBG Power Electronics

PI - Dr Paul Evans University of Nottingham

A GaN HEMT transistor model has been developed and optimised in conjunction with the University of Lille. The HEMT model is now able to predict switching waveforms under a variety of operating conditions and account for dynamic RDS-on effects. When the model is used in the Virtual Prototyping simulation software, it can also account for the effects of circuit layout such as parasitic inductance and capacitance. In October we will begin investigating how the model can be used to predict accurate switching losses under mixed hard- and soft- switching conditions.



Experimental Validation of GaN HEMT Model in Centres Virtual Prototyping software (VPPE) using 200V/3.5A turn-ON switching conditions



Experimental Validation of GaN HEMT Model in Centres Virtual Prototyping software (VPPE) using 200V/3.5A turn-OFF switching conditions

The initial integration of magnetic material loss models under development at the University of Bristol, and electromagnetic modelling techniques developed at the University of Nottingham are now complete. This development will ultimately allow our Virtual Prototyping software to predict losses and temperature profiles in magnetic components, enabling better system-wide efficiency predictions and the application-specific optimisation of magnetic component designs.

## Converter Architecture

PI – Professor Xibo Yuan University of Bristol

In the past quarter, the converter architecture research team has completed three power converter demonstrators, which summarises some of the achievements of the Tranche 1 Converter Theme project.

The three demonstrators are:

- A 120kHz switching frequency and high-density 5kW three-phase DC-AC converter enabled by high junction temperature (180 degree C) operation and using a proposed holistic design optimisation tool.
- An 80kW dual bi-directional interleaved DC/DC converter achieving a high power density of 31.5 kW/L and 15.7 kW/kg with 115kHz switching frequency and 300V-750V voltage conversion ratio enabled by advanced magnetic components and the holistic design optimization tool.
- A Class EF push pull inverter for wireless power transfer achieving 13.56MHz frequency at 500W enabled by advanced circuit topologies, PCB design and thermal management. The converters demonstrated can be used in a wide range of applications such as for aerospace, automotive and renewable energy sectors. State-of-the-art components, converters and applications for wide-bandgap device based power conversion have also been reviewed.

## Heterogeneous Integration



PI - [Professor Lee Empringham](#) University of Nottingham

The Heterogeneous Integration Theme has recently appointed a further researcher, Dr Rasha Saeed. Rasha will work initially on simulating complex 3 dimensional structures for high speed switching cells and integrated inductive structures. Magnetic materials characterisation work continues and significant progress has been made in using gel-casting to create magnetic structures of varying permeability and size to create shapes suitable for integration.

## Reliability Condition Monitoring & Health Management Technologies for WBG Power Modules



PI - [Dr Olayiwola Alatise](#) University of Warwick

The RHM theme is investigating the implementation of condition monitoring on Wide Band Gap devices using innovative gate drive techniques. The theme members have been working on silicon carbide and gallium nitride characterisation for temperature sensitive electrical parameters with Warwick and Bristol respectively billed to present their results at this year's IEEE ECCE 2018 conference. The Warwick team has recently presented its latest findings on SiC MOSFET condition monitoring techniques at this year's European Conference on SiC and Related Materials and has also recently published a journal paper in IEEE Transactions on the topic. Newcastle is currently working on innovative multi-level/current source gate drivers while Nottingham is working on the characterisation of copper interconnects. The RHM theme will be hosting a seminar on the latest findings on condition monitoring of WBG devices in December with the details to be published soon.

## Switch Optimisation



PI – [Dr Peter Gammon](#) University of Warwick


The Switch Optimisation Theme has an ambitious plan to develop silicon carbide IGBTs with voltage ratings up to 15 kV for future grid applications. In the first eight months of the project, the focus has been on the material and the device design.

Unlike in silicon, limited material choices mean that all the IGBT's layers (a P+ emitter, a N buffer and a N- drift region) must all be epitaxially grown on a SiC handle wafer, before that handle wafer is ground away. Within the first months of the project, simulations informed the precise dimensions of the three layers to be grown, initially targeting 10 kV devices, so that they can be compared to state-of-the-art MOSFETs at the same voltage level. A supplier of thick, ultra-high quality silicon carbide has been sourced, and the wafers required to develop both the IGBTs and MOSFETs they will be benchmarked against have been delivered. The material properties of these wafers will be fully characterised shortly before fabrication can begin.

Also in simulation, the final design for the front side of the IGBT and MOSFETs have been finalised including the source and gate regions, as well as the termination structure. A novel P-well has been proposed, which will be discussed at the European SiC conference held in Birmingham in September 2018.

These simulations, now complete, allow the team to form the fabrication masks, which will include eight variants of the IGBTs as well as many test devices. Fabrication will follow for the next six months of the project before initial trials. A second and third iteration of device development will be required in Year 2 to optimise the process and develop devices over a wider voltage range 6.5-25 kV.

## DATES FOR YOUR DIARY

<p><b>14 &amp; 15 November</b></p> 	<p><b>EPSRC Automotive Challenge Network Symposium IET, Austin Court, Birmingham</b></p> <p>This two day event will bring together industrialists and academics to explore solutions to the problems faced by the Industrial sector. It will focus on the themes of the Automotive Council Roadmaps and provide plenty of networking opportunities for delegates.</p> <p><a href="#">Book your place</a></p>
<p><b>November 2018</b></p>	<p><b>Centre for Power Electronics</b></p> <p>Thermal Management Workshop. More details to follow.</p>
<p><b>December 2018</b></p>	<p><b>Centre for Power Electronics</b></p> <p>Reliability and Health Management workshop. More details to follow.</p>

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