POWER ELECTRONICSUK
Underpinning Research

EPSRC
Engineering and Physical Sciences Research Council

CENTRE FOR POWER ELECTRONICS NEWS

Newsletter Autumn 2019

CPE Annual Conference 2019

Our Annual Conference proved as popular as ever this year, with its unique mix of international keynote speakers, updates about the work of the Centre, exhibitors, poster competition and networking barbecue.

Professor Johann W. Kolar, from ETH Zurich, Switzerland opened proceedings with a presentation on Advanced Three-Phase SiC/ GaN PWM Rectifier and Inverter Systems. Professor Leon Tolbert from the University of Tennessee, USA gave a speech on Gate Drive and Protection for SiC Devices. Professor Annette Muetze from Graz University of Technology, Austria was the final international speaker on the first day, with a talk about Innovative Low-Cost Sub-Fractional HP BLDC Claw-Pole Machine Design for Fan Applications.

Professor Mark Johnson gave an overview of the Centre's achievements since its inception in 2013 and the Centre's theme leads ran workshops on different elements of the Centre's work.

On the second day, Professor Frede Blaabjerg from Aalborg University, Denmark gave a keynote speech entitled: Power Electronics Technology - Quo Vadis. Dr Galina Mirzaeva from the University of Newcastle, Australia gave a presentation on High Performance Control of Electronic Converters and Systems. Professor Alex Huang from the University of Texas at Austin, USA presented High Power Density and High Voltage Power Electronics Enabled by Wide Band-Gap Power Devices.

Matt Boyle OBE, interim Challenge Director from Innovate UK gave an update on Driving the Electric Revolution. The event concluded with a debate on achieving competitive advantage in a global market.

Poster Competition sponsored by PPM

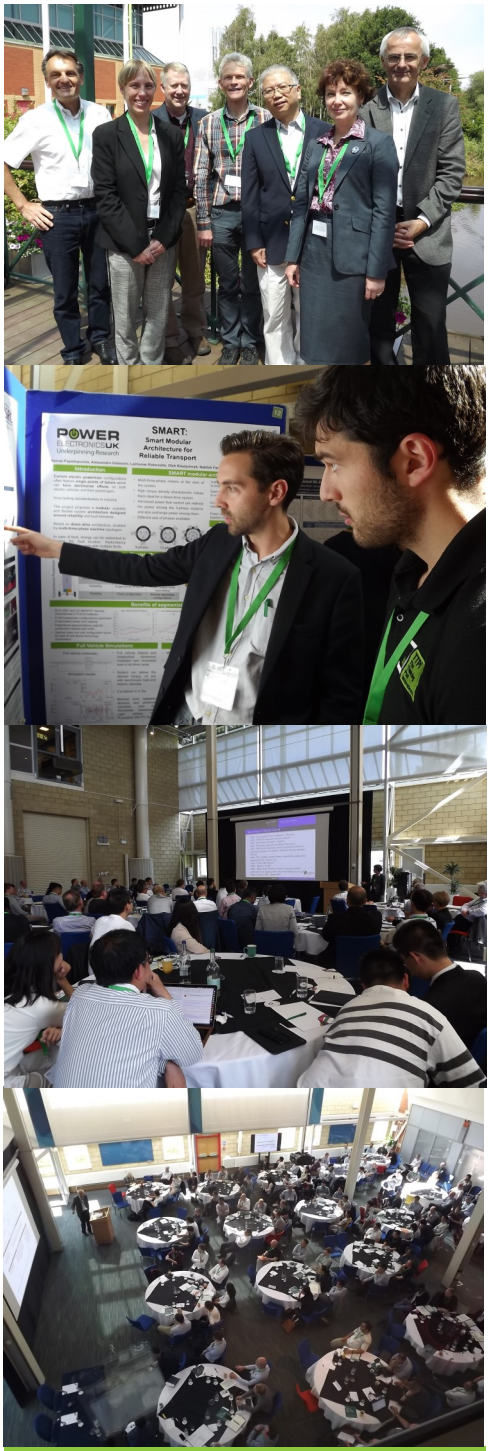
Congratulations to our Poster Competition winners:

1st place - Alejandro Villarruel-Parra, University of Manchester (pictured left with Phil Surman from PPM).

2nd place - Usman Nasir, University of Nottingham.

3rd place - Joan Marc Rodriguez, Imperial College London.

"Thank you so much for organising this amazing conference!"



CPE Annual Conference 2019

EPSRC Centre for Doctoral Training in Power Electronics for Sustainable Electric Propulsion

The universities of Nottingham and Newcastle are working together to deliver an EPSRC Centre for Doctoral Training (CDT) in Power Electronics for Sustainable Electric Propulsion.

This is a collaboration between two of the UK's largest and most forward-thinking research groups. The CDT will train a new generation of power electronics specialists to meet the future demands of society and industry for clean, electric propulsion systems. It will also benefit from the involvement of more than 20 industrial partners.

The new CDT is led by Professor Volker Pickert, an expert in Power Electronics and lead for the Electrical Power research group at Newcastle University.

Find out more about Power Electronics for Sustainable Electric Propulsion CDT

Centre for Doctoral Training to Advance the Deployment of Future Mobility Technologies

The Centre for Doctoral Training to Advance the Deployment of Future Mobility Technologies (CDT FMT) at the University of Warwick invites high-quality applications for 4-year EngD/PhD studentships.

CDT FMT will see the School of Engineering and Warwick Manufacturing Group jointly train cohorts of ten students who will choose research across two streams: Wide Band-gap Power Electronics and Connected and Autonomous Vehicles while working closely with multiple leading companies and organisations.

The programme covers full fees and an enhanced stipend of £19,000 per annum.

Further details and application instructions about CDT-FMT

Future Power Challenge

2019 Winner Andrea Stratta (right) with Phil Surman from PPM (left)

The Challenge was supported by the EPSRC Centre for Power Electronics, and sponsored by the following companies:

EPC, PPM, GaN Systems and P Semi.

The Future Power Challenge 2019 was a competition aimed at PhD researchers working in the field of Power Electronics. It took the form of a poster submission, followed by a Poster and Pitch presentation to our panel of judges. A prize of **£2,000** was awarded to the winner of the Future Power Challenge.

First prize was awarded to Andrea Stratta, University of Nottingham.

Second prize was awarded to Zhiyi Zhao, University of Liverpool.

Third prize was awarded to Nagaditya Poluri, University of Sheffield.

> *"The Future Power Challenge gave me the chance to discuss my work with industrial and academic experts, which means more to me than any possible prize."*
>
> *Andrea Stratta*

Wireless Power Week

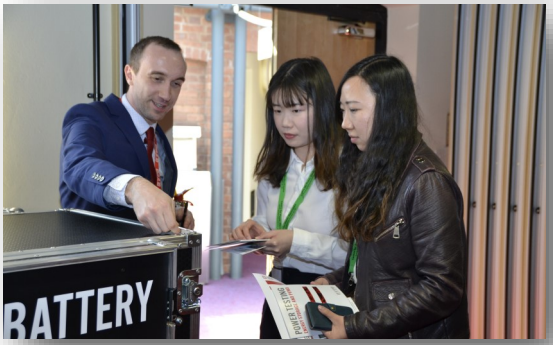
The second Wireless Power Week was held on 17-21 June 2019 at IET's headquarters at Savoy Place, London. The Centre sponsored the welcome reception held on the Roof Terrace with magnificent views across the capital's skyline.

The panel session on Wednesday 19 June was entitled 'The Future of Wide Band-gap Devices in Power Processing and Wireless Power', with contributions from Centre theme leads Professor Xibo Yuan, University of Bristol and Professor Andrew Forsyth, University of Manchester.

Wireless Power Lab from Imperial College London showcased the latest development of their wireless power technology with two main applications: a 100W wide-range wireless power system for autonomous drones, and a 700W wireless charging system for electrical scooters.

Further information about Wireless Power Week

Post Graduate Summer School 2019



Organised by a steering group of Post Graduates, the Summer School provided an opportunity for those researching power electronics in the UK to get together, to develop new skills and browse an exhibition.

The theme this year was the future direction of power electronics and how to prepare for your future career. It included talks by leading industrialists and academics. Speakers included, Professor Bill Drury, Chair of the IET Power Electronics Machines and Drives Network, Professor Peter Malkin, Newcastle University, Jon Regnart, Advanced Propulsion Centre, Dr Saeed Jahdi, University of Bristol and Dr John Bennett, Dyson.

There was an exhibition by leading power electronics companies including CRRC, ETPS and Dynex.

> *"There were very good talks from industry and it was a very informative event for graduates wishing to embark on a career in power electronics."*

Reliability & Health Management Technologies for WBG Power Modules

PI - Professor Olayiwola Alatise University of Warwick

In the Reliability and Health Management theme, we are investigating the use of advanced gate drivers for condition monitoring SiC and GaN power devices. Warwick has developed new techniques for gate oxide condition monitoring based on using body diode voltage characteristics and presented this at the IEEE ISPSD 2019 in Shanghai. Other techniques for gate oxide monitoring that we are currently working on include the use of shoot-through currents which are highly sensitive to threshold voltage. Bristol has developed techniques of junction temperature monitoring in enhancement mode GaN HEMTs. Bristol and Warwick's joint work on dynamic characterization on BTI stressed SiC and GaN power devices will be presented at ESREF 2019 and published in the Microelectronics Reliability Journal. At APEC 2019, Newcastle presented current source gate drive technologies developed for driving SiC power MOSFETs and are developing techniques of junction temperature sensing. Nottingham has made significant inroads in the integration of copper metallisation and wirebonds on SiC technology, which will significantly improve the reliability of the devices under power cycling. Warwick and Aalborg universities will be delivering a joint tutorial at the IEEE EPE 2019 conference on the topic on condition monitoring and reliability in SiC technology.

Switch Optimisation

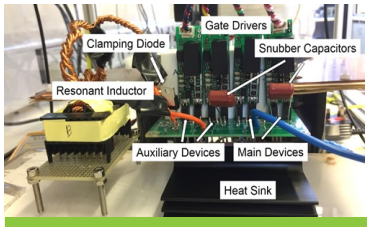
PI – Dr Peter Gammon University of Warwick

The Switch Optimisation theme is continuing in its development of a silicon carbide IGBT and MOSFET, both rated to 10 kV. These are being designed as devices that could impact grid-level power conversion and protection. After the design phase ended in January 2019, the devices are currently being fabricated, with the first results expected in November 2019. A high impact paper on the IGBT design has been published in IEEE Transactions on Electron Devices

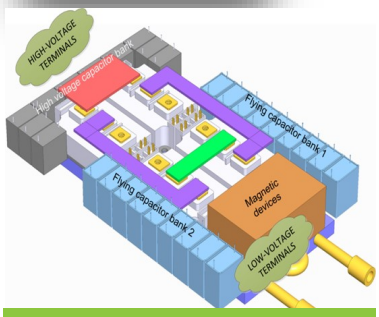
Converter Architectures

PI – Professor Xibo Yuan University of Bristol

In the Converter Architectures theme, we have completed the initial mechanical design of the 1200V dc-bus, 100kW WBG-device-based converter demonstrator. Medium-voltage DC/DC and DC/AC converter topologies have been identified with minimum number of components required, low dv/dt and low current ripple. The magnetic components required are being designed and optimised. Modulation and control strategies aiming to balance dc-link capacitors' voltages and reduce passive components requirement have been developed. Supplying the gate power and signal of high-voltage WBG devices through wireless link is also being explored. Apart from the demonstrator, we have identified the advantages of using SiC devices in soft-switching converters, in comparison to Si IGBTs. Also, shielding techniques have been investigated for wireless power transfer systems.

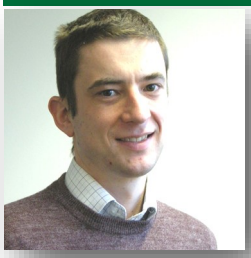


Soft-switched SiC MOSFET converter



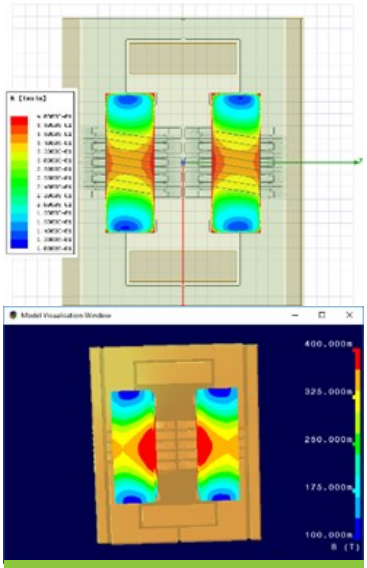
Initial mechanical design of the dc/dc converter as a part of the demonstrator

Multi- Domain Virtual Prototyping Techniques for WBG Power Electronics



PI - Dr Paul Evans University of Nottingham

We have shown that the μPEEC method for simulation can be used for the electromagnetic simulation of the integrated magnetic structures under development in the heterogeneous integration project. Initial investigations demonstrate that we can accelerate these μPEEC models in two ways: elimination of dependent variables and through model order reduction. After an initial model reduction process, the 3D time-domain simulation models can run at a speed of around 18μs per time-step. Current work aims to increase the reduced order model generation process . Work at Bristol has produced a time-domain magnetic loss model using the iGSE method and a three point rain-flow counting algorithm to identify period length and individual cycles of flux waveforms predicted by the μPEEC code. Integration and validation of the two models in ongoing.



Magnetic flux density prediction in an integrated inductor structure:
A comparison between a commercial tool (top) and the reduced order model of the VP tool under development in the project.

In addition, a heatsink model that can account for forced convective heat transfer through channels has been developed using the flow network approach. Extensive validation against commercial CFD has shown how it can also take into account the effect of varying fan speeds. A library of other flow network models has been developed in MATLAB; these cover basic geometrical building blocks that can be used to generate flow network models of arbitrary systems. These are still undergoing testing and when finalised will be converted to a format compatible with the project's VP tool. An initial implementation of a coupled electro-thermal-mechanical model has been implemented in the VP design tool. Once the final problems are resolved, the VP project will link with the centre's reliability project to integrate a damage model to allow wirebond and solder layer lifetime predictions.

Heterogeneous Integration

PI - Professor Lee Empringham University of Nottingham

The Heterogeneous theme has continued to perform research into innovative manufacturing techniques for the integration of both Wide Band-gap semiconductor devices and passive components into power converter structures. Specific effort has focused on high current density inductor manufacture, techniques for EMI shielding and laminated semiconductor device interconnections. High current density (>50A/mm2) inductors with integrated cooling and shielding structures have been demonstrated within a 2MHz, GAN based switching converter. Recently, work on creating electro-plated semiconductor device interconnects utilizing a CO2 laser ablation technique have shown promising results. Work has also started in evaluating a 3D printing methodology for creating high temperature ceramic formers for inductors.

Knowledge Exchange Awards

In June 2019, CPE and the Automotive Challenge Network jointly held a Knowledge Exchange funding call. Applicants were asked to build on the work carried out within CPE/CN funded projects or themes and the following projects were awarded funding:

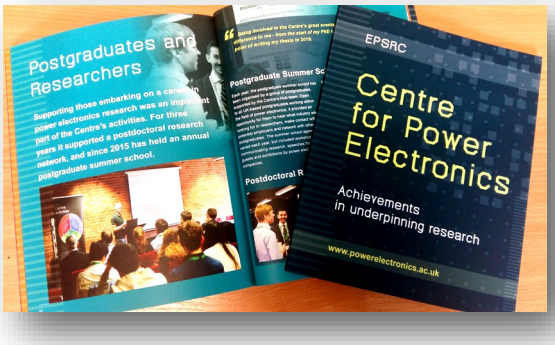
Ultra-Fast Field Stop iGBT/Diode Development led by Professor Layi Alatise, University of Warwick. The goal of this project is to transfer knowledge and secure business engagement with a new device vendor for the UK. This is important for the integration of the supply chain of electric vehicle design and assembly in the UK.

Line-field Optical Coherence Tomography Based Assessment for High Temperature Silicone Gel in Developing SiC Power Module led by Dr Yihua Hu, University of Liverpool. The aim of this project is to develop a line-field optical coherence tomography (LF-OCT) based silicone gel assessment system to help the engineers to assess the impact of silicone gel on bond wires' damping/reliability in high temperature. It will assist engineers in improving the reliability of SiC power modules.

Advancing SiC Schottky Diode Technology for Traction Applications (ASSATTA) led by Dr Peter Gammon, University of Warwick. This project will develop SiC diode technology that will make legacy transport solutions, trains and trams significantly more energy efficient. A transfer of knowledge between academic and industrial partners will enable fundamental research concepts to be tried and tested in a real life traction application, benefitting all partners.

Smart gate driver for HV half-bridges with integrated sensing and protection led by Professor Florin Udrea, University of Cambridge. This project will develop and fabricate a smart gate driver optimised for Dynex's advanced trench IGBTs by integrating the HV lateral technology developed within the previous Centre for Power Electronics projects with driving circuitry and smart sensing and protection functions.

Centre Achievements Brochure



We have produced a brochure outlining the Centre's key achievements and activities since its inception.

If you would like to receive a copy, please email:

correspondence@powerelectronics.ac.uk

CPE staff changes

Centre Manager, **Helena Cartwright** is now on secondment as Senior Business Operations Manager at the Engineering Faculty, University of Nottingham. She is still working for the Centre one day a week, so please be aware that it may take Helena longer than usual to respond to any enquiries.

Communications Officer, **Amanda Miller** left the Centre in August to take up a new role at the University of Nottingham's Business School.

Dates for your diary

9 October 2019	**Tutorial on SiC devices, reliability, converters and applications** Advanced Propulsion Centre (APC), University of Warwick Book your place
12 & 13 November 2019	**APC Power Electronics & Electrical Machines Spokes Symposium** IET Austin Court, Birmingham Book your place

GDPR - GENERAL DATA PROTECTION REGULATION

The General Data Protection Regulation came into law across the EU last year. 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

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