Centre for Power Electronics Annual Conference - 2021

13 - 15 July 2021

Online Conference

POWER ELECTRONICS UK
Underpinning Research

www.powerelectronics.ac.uk

Contents

Welcome from the Conference Chair

It is my great pleasure to welcome you to the online Centre for Power Electronics (CPE) Annual Conference 2021. Across the three afternoons from 13th July to 15th July, we have a varied programme with leading international and UK industrial and academic leaders as plenary speakers, including Professor Hirofumi Akagi from Tokyo Institute of Technology, Professor Tim Green from Imperial College London, Professor Jiabin Wang from the University of Sheffield, Dr Giorgia Longobardi from Cambridge GaN Devices, Mr Simon Price, CEO at Exawatt and Professor Will Drury from UKRI.

This year, to support early career researchers, we have organised an Early Career Researcher Day on the second day of the conference, where career talks will be given by EPSRC, Centre for Doctor Training (CDT), academic and industrial colleagues who will share their experience and suggestions for career development. There will also be 22 early career researchers from institutions across the UK to showcase their work in the form of oral and poster presentations. Later in the day, we have organised 'mentor rooms', where advice can be sought from academic and industrial mentors and there is also an opportunity for networking.

On the first day of the conference, we have organised a panel discussion with the topic on 'The role of wide-bandgap (WBG) devices in the successful rollout of electrification and the UK perspective' with panellists from the Driving the Electric Revolution Challenge, power semiconductor, aerospace, automotive and other industrial sectors, together with academic colleagues. You will also hear an update on the five Tranche 2 research themes during the first and third day of the conference. We are grateful for the support of our Exhibitors, who will present their latest offerings and capabilities at the start of proceedings on the second and third day of the Conference and during a plenary session on Day Two. Our exhibition and networking space will be available throughout the event, providing an ideal forum for discussion of the Centre's work alongside our commercial sponsors.

The Centre brings together the very best research groups in the UK focusing on fundamental power electronics, machines and drives (PEMD) research and their applications, supporting and bringing the community together. It has been a very challenging past year due to the COVID pandemic. Nevertheless, the Centre organised several virtual seminars such as the reliability and gate driving for WBG devices seminar and the high frequency motor drives seminar, to benefit the community. We hope this year's annual conference will help to maintain the PEMD community networking and initiate a journey to norm.

Looking ahead, the Centre will continue to support an integrated UK academic and industrial community by encouraging sustained collaborative working to feed the knowledge pipeline and deliver timely and relevant knowledge exchange and commercialisation. We will continue to support the training of the next generation of innovators and technology leaders and support the development and delivery of government policy through its industrial strategy.

With all above, I sincerely welcome you to the CPE annual conference and please enjoy the event!

Professor Xibo Yuan
University of Bristol
Centre for Power Electronics 2021
Conference Chair

Acknowledgements

The Centre for Power Electronics and IMAPS-UK offer their sincere thanks to all the presenters and exhibitors for their time and we thank them for supporting this event.

Additionally, the Centre for Power Electronics and IMAPS-UK would like to extend its appreciation to the event organising committee and volunteers through their hard-work and determination have made this online conference possible:

- Sarah Rogers – University of Bristol
- Joe Gillet – University of Bristol
- Martin Kubal – University of Bristol
- Martin Wickham - NPL
- Paul Huggett – Knowledge Transfer Network
- Barrie Mecrow – University of Newcastle
- Paul Evans – University of Nottingham
- Lee Empringham – University of Nottingham
- Mark Johnson – University of Nottingham
- Phil Mawby – University of Warwick
- Peter Gammon – University of Warwick
- Layi Alatise – University of Warwick
- Steve Riches – IMAPS-UK

The Centre provides a forum for the UK Power Electronics, Machines and Drives (PEMD) community to share research findings, facilitate knowledge transfer, industrial collaboration and train the next generation of engineers.

The Centre's work includes the following elements:

- Underpinning power electronics research
- Support networks for postgraduates and researchers
- Building the power electronics community in the UK
- Strengthening international links and collaborations
- Knowledge exchange
- Policy influence
- Public engagement activities

Please get in touch if you would like us to share research news, events, funding opportunities and help with events for the PEMD community.

correspondence@powerelectronics.ac.uk

www.powerelectronics.ac.uk

CPE 2021 Online – Conference Agenda

Tuesday 13 July 2021: Day 1

12:00	Enrolment and Introduction to Exhibitors
12:30	Welcome and Introduction to Centre for Power Electronics Annual Conference
12:45	**Keynote Presentation: Research Trends in Modular Multilevel Cascade Converters** Dr. Hirofumi Akagi, Distinguished Professor at the Tokyo Institute of Technology
13:30	**Driving the Electric Revolution – A Collaborative Future for Growth** Professor Will Drury, Challenge Director – Driving the Electric Revolution, UK Research & Innovation
14:00	**EPSRC Tranche 2 Project - Switch Optimisation** Dr Peter Gammon, University of Warwick
14:30	Break
14:40	**EPSRC Tranche 2 Project – Reliability Condition Monitoring and Health Management** Professor Layi Alatise, University of Warwick
15:10	**GaN based high voltage technologies and the advent of Cambridge GaN Devices (CGD)** Dr Giorgia Longobardi, Cambridge GaN Devices Ltd
15:40	Break
15:45	**Panel Discussion: What is the role of Wide Bandgap (WBG) Semiconductors in the successful rollout of electrification and the UK perspective?**
16:30	Close

Wednesday 14 July 2021: Day 2

12:00	Enrolment and Exhibitor Presentations
13:00	Welcome and Outline of Conference Day 2
13:10	**Challenges and solutions of running a national electricity system with a high penetration of inverter-interfaced resource** Professor Tim Green, Imperial College
13:40	**Plenary Industrial Presentations from CPE Exhibitors**
14:15	Break
14:20	**EPSRC Support for Early Career Researchers** Ben Alexander, EPSRC
14:40	**Careers Talks and Panel Discussion**
15:15	**Early Career Researchers Presentations**
16:15	Exhibitors, **Posters** and **Mentor Rooms**
17:15	Awarding of Prizes to Early Career Researchers and Close

Thursday 15 July 2021: Day 3

12:00	Enrolment and Exhibitor Presentations
13:00	Welcome and Outline of Conference Day 3
13:10	**The impact of fast-switching converters on machine insulation and reliability** Professor Jiabin Wang, University of Sheffield
13:40	**EPSRC Tranche 2 Project – Virtual Prototyping** Dr Paul Evans, University of Nottingham
14:10	Break
14:20	**EPSRC Tranche 2 Project – Heterogeneous Integration** Professor Lee Empringham, University of Nottingham
14:50	**EPSRC Tranche 2 Project – Converter Architectures** Professor Xibo Yuan, University of Bristol
15:20	**Market analysis for SiC devices, modules and systems, UK SiC supply chain** ***Simon Price, Exa-watt***
16:00	**Closing Remarks and the Future of the Centre**

CPE 2021 Online Exhibition

CPE 2021 is pleased to have the support of:

Exhibitors

- Cupio Ltd
- Driving the Electric Revolution – Industrialisation Centres
- Heraeus Electronics
- Inseto Ltd
- IPTest Ltd
- Rohde & Schwarz
- Zeiss Microscopy

Exhibitors

Cupio Ltd: Cupio supplies and supports inspection from the Nordson Test and Inspection Group which includes systems for X-Ray of solder die attach both in-line and stand alone and optical systems for the measurement of die bonds, bond attach, underfill and contamination. Cupio also provides failure analysis and inspection services at our facility in Basingstoke.

Contact Details:
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Exhibitors

Driving the Electric Revolution – Industrialisation Centres:
The Driving the Electric Revolution Industrialisation Centres (DER-IC) is a UK-wide project to accelerate delivery of Power Electronics, Machines and Drives (PEMD) solutions for the global market.
The centres form a network of PEMD expertise across the UK, connecting industry with researchers to develop and scale up PEMD technologies and manufacturing processes.
DER-IC was set up by UK Research and Innovation in 2020 as part of the Driving the Electric Revolution Challenge.
The centres support companies with open access to over £300m of PEMD equipment for developing, testing and manufacturing products. In addition, they've invested £28M in new state-of-the-art open-access equipment to help grow the UK supply chain and fill gaps in the UK's current capability.

DER-IC supports a variety of industry sectors from rail, truck and bus, off-road, industry, aerospace, micro-mobility, robotics, energy, marine and automotive.
The four centres are based in the North East, South West and Wales, Midlands and Scotland and have various specialist capabilities.

Find out what we can do for you.

Contact Details:
Email Jon King on j.king.7@warwick.ac.uk or call 07802 476479
Website: https://www.der-ic.org.uk/
Twitter: https://twitter.com/DER_IC_UK
LinkedIn: https://www.linkedin.com/company/driving-the-electric-revolution-industrialisation-centres/

Driving the Electric Revolution
Industrialisation Centres

Accelerating Power Electronics, Machines and Drives supply chain capability and growth

North East | South West & Wales | Midlands | Scotland

der-ic.org.uk

UK Research and Innovation

Exhibitors

Heraeus Electronics – a Global Business Unit of the Heraeus Group – is one of the leading manufacturers of materials for the assembly and packaging of devices in the electronics industry.
The company develops sophisticated materials solutions for consumer electronics and computing, automotive, LED, power electronics and communications.
Core competences include bonding wires, assembly materials, thick film pastes as well as substrates, and their integration into perfectly matched systems.
The innovative product portfolio, the application knowhow and expertise in matching materials are qualifying Heraeus Electronics to support customers in a unique way. Heraeus Electronics does not only have the knowhow to integrate materials in a system, but also has a deep understanding of optimizing materials and material combinations and the possibility to test them under real conditions.
This leads to higher speed, lower costs and – above all – to better devices.

Contact details/web links:

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https://www.linkedin.com/company/heraeuselectronics

Exhibitors

Inseto provides manufacturing equipment, plus assembly materials and adhesives for microelectronic research & production.
Products include: vacuum reflow systems, plasma cleaners/etchers, probers, dicing & scribing systems, die sort and bonders, wire bonders, pull/shear test equipment, in addition to complementary machine consumables and materials.

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Contact: Eamonn Redmond
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Exhibitors

ipTEST Ltd: designs and manufactures a range of high volume production testers for all types of discrete power semiconductors for both back end and wafer applications. We are an engineering-based organisation located in Surrey, UK and focus on developing solutions for testing challenging new technologies such as GaN and SiC as well as for the latest generation of mosfets, IGBT's, diodes, SCR's and bipolars. We invest heavily in R&D and have a dedicated custom engineering team to design unique test systems for custom applications.

Our first Mostrak tester was introduced in 1987 and was the world's first indexed parallel test system, offering production throughput increases between 2 and 4 times the output of competitive systems for wafer and back-end. Our latest Mostrak-2 (M2) system provides comprehensive testing for power MOSFETs, in parallel at the fastest possible throughput rates, using test-type specific resources. M2 has multiple test generators that can be used to perform static parameter tests, transient thermal tests, avalanche energy tests and dynamic switching tests. The module small footprint system gets the tester as close as possible to the handler interface so it can operate at the highest possible speeds and UPH.

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power semiconductor testers

Exhibitors

Rohde and Schwarz:
Test and measurement solutions for power electronics design
The demand for energy and power is rising. Among the causes are the rapid growth in renewables, electrification of transportation and industrial automation as well as the increasing storage, transmission and availability of data. Consequently, power electronics have become a key differentiator in electronic systems and services.

Engineers working in the fields of embedded power, power conversion and motor drive electronics often face contradictory design challenges. These include reliability and power efficiency, reduced size and weight, as well as compliance related matters. Rohde & Schwarz offers test and measurement solutions that will help you overcome these challenges meet your design goals and be faster to the market.

For more detailed information download our Solution Flyer:

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Exhibitors

Carl Zeiss Microscopy

ZEISS has the most comprehensive portfolio of light, X-ray, electron beam and ion beam imaging technologies in the industry and is a leading solution provider to the global semiconductor community. Solutions span semiconductor manufacturing from wafer fab through packaging and assembly. ZEISS materials characterization and non-destructive failure analysis solutions deliver actionable information to both wafer fab and packaging/assembly processes to meet the semiconductor industry's challenges for next-generation devices.

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Day 1: Keynote Presentation

Research Trends in Modular Multilevel Cascade Converters
Dr. Hirofumi Akagi, Distinguished Professor at the Tokyo Institute of Technology

Since 2003, the presenter has been conducting comprehensive research on the so-called “modular multilevel cascade converters” in a broad sense. He focuses on the multilevel converters and its applications, providing his own thoughts and/or prospects.

First of all, he will start with the following two different downscaled prototypes designed, built, and tested by his research team, showing their experimental waveforms: A modular multilevel SSBC (single-star bridge-cell) converter was applied as a STATCOM for reactive-power control in industrial and utility power systems. Two multilevel DSCC (double-star chopper-cell) converters were applied as an HVDC back-to-back (BTB) system intended for asynchronous intertie between two power systems with the same line frequency and for frequency change between those with different line frequencies.

Finally, he will turn on tomorrow’s ac-link multi-drive system combing the common line-side modular multilevel DSBC (double-star bridge-cell) converter with multiple motor-side ones. This “versatile” system can drive multiple medium-voltage motors with different power, voltage, and/or frequency ratings. Each motor is characterized by being isolated galvanically from the other motors and the ac mains. The waveforms obtained from circuit simulation confirm that “decoupled control” is achieved among a line-side DSBC converter and two motor-side DSBC converter.

Professor Hirofumi Akagi received his Ph. D. degree in electrical engineering from the Tokyo Institute of Technology, Tokyo, Japan, in 1979. Since 2000, he has been Professor, currently Distinguished Professor, at the Tokyo Institute of Technology. Prior to it, he was Professor at Okayama University, Okayama, Japan, from 1991 to 1999, and Assistant and then Associate Professor at Nagaoka University of Technology, Nagaoka, Japan from April 1979 to 1991.

His research interests include power conversion systems and their applications to industry, transportation, and utility. He has authored and co-authored some 140 IEEE Transactions papers, and three invited papers in the Proceedings of the IEEE.

Dr. Akagi was elevated to the grade of IEEE Fellow in 1996. He has received six IEEE Transactions Prize Paper Awards, and 16 IEEE Industry Applications Society Committee Prize Paper Awards. He is the recipient of the 2001 IEEE Power Electronics Society William E. Newell Award, the 2004 IEEE Industry Applications Society Outstanding Achievement Award, the 2008 IEEE Richard Harold Kaufmann Award, the 2012 IEEE Power & Energy Society Nari Hingorani Custom Power Award, the 2018 IEEE Medal in Power Engineering, and the 2020 EPE Gaston Maggetto Medal.

Dr. Akagi served as the President of the IEEE Power Electronics Society from 2007 to 2008 for two years, and the IEEE Division II Director from 2015 to 2016 for two years.

Day 1: Driving the Electric Revolution

Presentation 2 – Driving the Electric Revolution – A Collaborative Future for Growth

Professor Will Drury, Challenge Director – Driving the Electric Revolution, UK Research & Innovation

Driving the Electric Revolution is working to deliver ecosystems between organisations within the UK. Through collaborative funding this is growing and thus delivering impact to the UK in PEMD supply chains. I will address the importance of collaboration between organisations from academia, RTO and industry. I will also discuss the activities ongoing through Driving the Electric Revolution and how the community and continue to engage and benefit from the opportunities and investments made to date.

Professor Will Drury (MEng PhD CEng FIET SMIEEE) is Challenge Director for the £80 million Driving the Electric Revolution Challenge. He leads the strategy and delivery of the Challenge alongside ensuring the investments made have maximum impact on the UK's Power Electronics, Machines and Drives industry. Driving the Electric Revolution is part of the Industrial Strategy Challenge Fund (ISCF) from UK Research & Innovation (UKRI).

Will joined UKRI from engineering and environmental consultancy Ricardo where he was Global Technical Expert – Power Electronics and Head of Electronics & Electric Machine Products. Before this he led and worked in the engineering delivery team for electric drives at Ricardo having previously worked at a start-up company in the renewable energy sector. At Ricardo Will led strategy in PEMD component development and approaches to engineering solutions for clients. He worked with a globally distributed team with technical centers in China, USA, Europe and the UK and a truly global footprint of clients from Chennai to Cambridge and Shanghai to Santa Clara.

Will is a Visiting Professor at the University of Strathclyde within the Electronics & Electric Engineering Department. Will achieved his PhD from the University of Bristol in Electrical Engineering, is a Chartered Engineer, Fellow of the IET and a Senior Member of the IEEE. He sits on the IET Transport Sector Executive, previously holding the position of deputy-chair.

Day 1: EPSRC Tranche 2 Project Outcomes

Presentation 3 – Ultra High Voltage Power Electronics, Realising the Full Potential of SiC Devices Rated at 10 kV+

Dr Peter Gammon, University of Warwick, Arne Benjamin Renz, Marina Antoniou, Tianxiang Dai, Guy Baker, Richard McMahon, Vishal Shah, Phil Mawby, University of Warwick.

Neophytos Lophitis, University of Nottingham.

Tanya Trajkovic, Amit Tiwari, Florin Udrea, University of Cambridge.

Jesus Urresti, Anthony O'Neill, Nick Wright, Newcastle University.

Samuel Perkins, Coventry University.

The evidence is before us of SiC power devices reaching their potential in the 600-1700 V class, as they are used to deliver lighter, smaller and more efficient power conversion solutions. Their exponential rise in uptake in recent years is driven by staggering demand from the automotive, solar and industrial machines sectors. Yet the Switch Optimisation Theme of the EPSRC Centre for Power Electronics has, for the last 3 years, sought to realise the full potential of SiC, beyond this narrow voltage range. With applications that include traction and HVDC converters, there is potential demand for devices that can extend beyond the upper limit of existing Si devices, while offering similar boosts in efficiency and a reduction in system size and complexity. The consortium has therefore been at the forefront of the design and development of SiC UHV devices, developing SiC MOSFETs and IGBTs rated to 10 kV, a voltage that may come to be the transition between these unipolar and bipolar technologies. In this presentation, we will dive further into the motivation for UHV devices, chart the progress of their development over the project, and show in public for the first time the initial characteristics of these unique devices.

Dr Peter M Gammon is a Reader at the School of Engineering, in the University of Warwick. He leads a 6-strong team of post-doctoral researchers and PhD students in the development of SiC power electronic devices. His research interests include ultra-high voltage power devices, power electronics for space, and electrical characterisation techniques. He has been Principal Investigator on 5 major research projects and has published 2 patents and over 40 journal papers related to SiC device development. He is a Senior Member of the IEEE, a Member of the IET, and a Senior Fellow of the Higher Education Academy (SFHEA).

WARWICK
THE UNIVERSITY OF WARWICK

Presentation 4 – Reliability, Condition Monitoring and Health Management
Professor Layi Alatise, University of Warwick

This presentation highlights the research achievements of the reliability and condition monitoring theme of the Centre of Power Electronics. Wide bandgap devices are increasingly penetrating the power electronics market; hence, their reliability and condition monitoring is increasingly becoming more important. The reliability and health management theme has focused on advanced reliability analysis, condition monitoring and gate driving of the latest generations of WBG devices including SiC MOSFETs and GaN devices. The theme, comprised of the University of Warwick, Bristol, Nottingham and Newcastle University tackled the question of reliability at the device level, gate drive system level as well as interconnects and packaging. Novel techniques for assessing gate dielectric reliability in SiC and GaN devices were explored along with the application of advanced gate drivers for assessing junction temperature as well as the latest developments on integrating copper interconnects with SiC devices. We showed the importance of threshold voltage shift and its impact on the use of temperature sensitive electrical parameters in WBG devices as well as demonstrating how programmable gate drivers and high speed current sensors can be used for condition monitoring of fast switching GaN devices. We considered the latest generation SiC and GaN devices including Cascode devices and normally OFF current and voltage driven GaN HEMTs. The use of current source gate drivers and their comparison to voltage source gate drivers in the control of SiC power devices was explored as well as the integration and performance of copper interconnects for improved thermo-mechanical reliability of SiC modules.

Professor Layi Alatise is a Professor of Electrical Engineering and Royal Society Industry Fellow in Power Electronics. His research interests are mainly in power semiconductor devices and their applications. He has been at the University of Warwick for over 10 years and worked at NXP Semiconductors UK Ltd as a Semiconductor Device Engineer for 3 years before joining Warwick. While at NXP, he designed transistors for automotive applications and switch mode power supplies. Before then, he worked at ATMEL North Tyneside as a CMOS device engineer. He completed his BEng in Electrical Engineering in 2005 and PhD in Semiconductor physics in 2008 both at Newcastle University, Newcastle upon Tyne. He is currently an Associate editor of the IEEE Journal of Emerging and Selected Topics in Power Electronics, a Fellow of the IET, a Chattered Engineer, Senior member of the IEEE and has published over 100 journal and conference papers.

WARWICK
THE UNIVERSITY OF WARWICK

Day 1: Invited Speaker

Presentation 5 – GaN based high voltage technologies and the advent of Cambridge GaN Devices (CGD)

Dr Giorgia Longobardi, Cambridge GaN Devices

GaN has being considered the most efficient material to be used in power devices for applications rated at 650V. Such applications include the rich fields of power supplies, data servers, LED drives and automotive chargers and inverters. Still, GaN has to overcome reliability problems such as dynamic Ron and ease of use. The fragility of the gate remains an open issue to overcome.

This presentation will give an overview of GaN based technologies, the main applications and their market share. Finally it will show the solution that Cambridge GaN devices, a spin-off from the University of Cambridge, has developed to deliver to market an efficient and easy to use solution.

This solution is based on a smart IC, called ICeGaN™, monolithically integrated alongside the HEMT device.

The first results from CGD technology demonstrated within the GaNext project will be also shown.

Prospective applications of CGD technology will be discussed in the wider context of creating zero carbon opportunities.

Dr Giorgia Longobardi is founder and CEO of Cambridge GaN Devices Ltd (CGD), a start-up developing highly efficient power electronics that can offer major energy savings in applications ranging from power supplies for consumer electronics to LED drives, data centres and wireless chargers.

Giorgia graduated from University of Naples Federico II in 2010 with a Master degree with honours in electronics engineering. In 2014, she completed her PhD at University of Cambridge in collaboration with industrial partners and continued her research sponsored by an EPSRC follow on impact acceleration fund. She was awarded a prestigious Junior Research Fellowship (JRF) at Gonville & Caius College Cambridge and spun her company out of the engineering department at Cambridge University after winning the first prize of Cambridge Enterprise business plan competition.

After spending a year in Japan in 2018 sponsored by a JSPS fellowship, Giorgia focused on leading her company that now employs 22 people. She has so far raised more than £9M in private investment and £1M in public funds and her drive for innovation has led to several high-impact patents. She has established and led partnerships with numerous academic and industrial players worldwide. She is the recipient of several awards among which the Royal academy of Engineering Engineers Trust Young Engineer of the Year in 2019 and Cofinitive #21 to watch in 2021.

Cambridge GaN Devices has been selected in June 2021 as the winner of the deep tech investment of the year award by UKBBA association.

CGD
CAMBRIDGE GAN DEVICES

Day 1: Panel Discussion

What is the role of Wide Bandgap (WBG) Semiconductors in the successful rollout of electrification and the UK perspective?

Chaired by Professor Phil Mawby, University of Warwick

The growth in application of wide bandgap semiconductors is creating many opportunities for the power electronics, machines and drives community. Although there is a drive towards adoption, many challenges remain in establishing a sustainable and profitable supply chain and fostering a world class research environment in the UK. This panel session has been organised to gain the opinion of several of the leading lights in academia and industry on the major issues facing adopters and considering possible solutions to bring the potential opportunities to fruition.

Panellists:
Dr Giorgia Longobardi – Cambridge GaN Devices
Professor Will Drury – Challenge Director, Driving the Electric Revolution
Adam Dawson – Exawatt
Craig Fisher – Maxpower
Steve Lambert – McLaren Applied
Giovanni Raimondi – Safran
Professor Chris Bailey – University of Greenwich
Professor Mark Johnson – University of Nottingham

CPE 2021 Exhibitor Presentations
Wednesday 14 July 2021

12:00 – 12:15:

High Reliable Packaging Material Solutions for E-mobility Applications by Habib Mustain, Heraeus Electronics

12:15 – 12:30:

Inseto

12:30 – 12:45:

Testing today's high spend power discrete semiconductors by Robert Pullman, IPTest Ltd

12:45 – 13:00:

Cupio Ltd

Copies of presentations will be made available on line on the IMAPS-UK website during and after the event.

Day 2: Invited Speakers

Presentation 6 – Grid with Inverter Interfaced Resources

Professor Tim Green, Imperial College London

The replacement of electro-mechanical machines by inverter-based resources (IBR) is fundamentally changing the dynamics and stability properties of grids. A review will be made of the needs a grid system has in order that it is stable and secure. The needs in terms of voltage strength, frequency regulation and synchronisation will be discussed in term of how they are met by synchronous machines, grid-following converters and grid-forming converters. A case will be made that there is advantage in not all resources being obliged to provide all system services and that new services can replace some traditional services. Thus, strictly following a virtual synchronous machine (VSM) approach may not yield the best solution.

Approaches to ensuring system-wide dynamic stability will also be explored noting that IBR have overlapping sets of dynamics but with details often hidden in black-box models. A method for identifying root-causes of poorly damped modes in black-box models will be illustrated. This analytical grey-box method avoids exhaustive transient simulation. A toolbox for compiling models of composite grids with IBR and synchronous machines will be introduced. The talk will conclude with some thoughts on modelling and analysis challenges that remain for IBR dominated grids.

Professor Tim Green received a B.Sc.(Eng) from Imperial College London, UK in 1986 and a Ph.D. from Heriot-Watt University, Edinburgh, UK in 1990. He is a Professor of Electrical Power Engineering at Imperial College London, and Co-Director of the Energy Futures Lab with a role of fostering interdisciplinary energy research across the university. His research uses the flexibility of power electronics to enable electricity networks to operate with very high fractions of low carbon technologies. In HVDC, he has contributed converter designs that strike improved trade-offs between power losses, physical size and fault handling. In distribution systems, he has pioneered the use of soft open points. He has made important contribution to the study of stability of grid-connected inverters. Prof. Green is a Chartered Engineering in the UK, a Fellow of the Royal Academy of Engineering and a Fellow of IEEE.

Imperial College London

Day 2: Support for Early Career Researchers

Presentation 7 – The Engineering and Physical Sciences Research Council: Opportunities for Early Career Engineers

Dr Benjamin Alexander, Portfolio Manager – Engineering, EPRSC

This presentation will focus on the opportunities within the Engineering theme at the Engineering and Physical Sciences Research Council (EPSRC) for Early Career Researchers, namely our New Investigator Award Scheme and our Early Career Forum. We will provide an overview of UK Research and Innovation (UKRI) and EPSRC, followed by a more detailed look at the aforementioned schemes and opportunities, including an overview of our Peer Review processes.

Dr Benjamin Alexander is a Portfolio Manager at the Engineering and Physical Sciences Research Council (EPSRC) responsible for the Electrical Motors and Drives Research Area within the Engineering Theme.

Ben has a background in Chemistry, having previously worked in both industry and academia, as well as working within a research office of a University, before joining EPSRC.

Ben has extended responsibilities and interests within his role which include Equality, Diversity and Inclusion, as well as Public Engagement in Engineering and Science.

UKRI Engineering and Physical Sciences Research Council

Day 2: Early Career Researchers Panel Discussion

What are the options available for starting and pursuing a career in power electronics, machines and drives?

Chaired by Dr Paul Evans, University of Nottingham

Starting a new career in a particular subject area can be a daunting prospect. This panel session gives attendees the opportunity to hear first-hand from several people who have established their careers in the field of power electronics, machines and drives and engineering and to ask questions on how to approach and develop their skills to make a valuable contribution to the sector.

Panellists:

Maisie England – Joint Head of Theme for Engineering, EPSRC, UKRI
Tim Green – Imperial College London
Richard Gibson – Nidec Control Techniques
Volker Pickert – Newcastle University Sustainable Electric Propulsion CDT
Marina Antoniou - University of Warwick, Royal Society Research Fellowship Holder

Day 2: Mentor Rooms

This session from 16:15 to 17:15 on Wednesday 14 July gives attendees the opportunity to discuss their career development path and options with the following people who have been involved in the development of power electronics, machines and drives in separate breakout rooms.

Mentors:

Bill Drury – University of Bristol
Phil Mellor – University of Bristol
Andrew Forsyth – University of Manchester
Chris Bailey – University of Greenwich
Merlyne de Souza – University of Sheffield
Michael Mawby - Lyra Electronics

CPE 2021 Exhibitor Presentations
Thursday 15 July 2021

12:00 – 12:15:

Driving the Electric Revolution – Industrialisation Centres

12:15 – 12:30:

Rohde and Schwarz

12:30 – 12:45:

Zeiss Microscopy

12:45 – 13:00:

Die top system (DTS) interconnect with pre-sintered silicon nitride AMB substrate for Power Module Applications by Habib Mustain, Heraeus Electronics

Copies of presentations will be made available on line on the IMAPS-UK website during and after the event.

Day 3: Invited Speaker

Presentation 8 - The impact of fast-switching converters on machine insulation and reliability

Professor Jiabin Wang, University of Sheffield

Power electronic converter-fed machines and drives are increasingly being used in a variety of applications ranging from electrification of transport and renewable energy generations to industrial automation and household appliances. Converters or inverters operating in pulse width modulation (PWM) provide effective and efficient control of energy conversion and machine operation. However, the PWM voltage pulses at a high frequency and high voltage slew rate (dv/dt) can result in excessive voltage at the machine terminal and non-uniform voltage distribution within the winding. These voltage transients are expected to significantly reduce the lifetime of the insulation of the connected machine/generator owing to increased voltage overshoot, increased voltage across turns, phases and phase-to-ground, and higher frequencies.

In this talk, the effects of impulse and high frequency PWM voltages produced by fast-switching power electronic converters on voltage distributions in machine winding and insulation systems are analyses and characterised. In particular, a low frequency oscillation mode associated common mode impedance of machines, which is discovered recently, will be presented and its implication on inverter operation discussed. Lifetime test results under partial discharges caused by high voltage slew rate will also be highlighted.

Professor Jiabin Wang graduated with a BEng in 1982 and MSc in 1996 from Jiangsu University in China, and a PhD in 1996 from the University of East London, UK, respectively, all in electrical engineering.

I am currently a professor in electrical engineering at the University of Sheffield. My research encompasses novel rotary and linear electrical machines and drives, advanced control techniques for electrical drives, electrical power-trains and 'more-electric' technologies for electric and hybrid vehicles, and aircraft. Currently, my research focuses on high integrity, fault tolerant and high efficiency electric drives and associated condition monitoring techniques for applications in aerospace, automotive and renewable energy systems. I am currently PI and coordinating £1.2M EPSRC funded project, EP/S00081X/1 on "Insulation degradation and lifetime of inverter-fed machines with fast switching (high dv/dt) converters".

The University Of Sheffield.

Day 3: EPSRC Tranche 2 Project Outcomes

Presentation 9 – Highlights from the Centre for Power Electronics Virtual Prototyping Project

Dr Paul Evans, Dr Valon Blakaj, Bawar Jalal, Xinning Gao - University of Nottingham, Dr Nick Simpson, Dr Andrew Hopkins, Dr Kevin Kails, Dr Lihong Xie, Prof Xibo Yuan - University of Bristol, Dr Tim Tilford, Prof Chris Bailey – University of Greenwich

The Virtual Prototyping Theme is working to develop the tools that power electronic system designers need to be able to design optimal wide band-gap systems, right-first-time, on a computer using virtual prototyping techniques. The presentation will describe key achievements of the project including:

- Time domain techniques for accelerated 3D thermal and electromagnetic modelling of power electronic systems that are capable of running in real-time. An augmented reality application is used to demonstrate the speed and efficiency of the techniques.
- Time-domain loss models for magnetic materials, and averaged material models for winding loss estimation, that can couple with the accelerated 3D electro-thermal models.
- A coupled flow-network, CFD simulation approach for fast thermal boundary condition estimation
- Details of the software tool developed as a project demonstrator.

Dr Paul Evans received the MEng degree in Electrical and Electronic Engineering, and the PhD degree in Electrical engineering from the University of Nottingham, UK, in 2007, and 2011 respectively. In 2010 he became a Research Fellow, was appointed Assistant Professor in 2013 and then Associate Professor in 2019 at the same institution. His expertise lies in the application of accelerated computational modelling techniques to the simulation of power electronic systems and his work on extraction of compact thermal models was awarded the IEEE Transactions on Power Electronics second prize paper in 2013. He currently leads the Virtual Prototyping work in the EPSRC Centre for Power Electronics.

Presentation 10 – Heterogeneous Integration

Professor Lee Empringham, Rasha Saeed, Stewart Marchant, Andrea Stratta**, University of Nottingham**

Heterogeneous Integration is the combination of dis-similar materials and components to create multi-featured, functional power electronic blocks or systems. The main aim is to develop design and manufacturing methodologies to enable the integration of power devices, interconnect, passive components, EMI reducing structures and thermal management techniques in a single manufacturing process and to facilitate the adoption of Wide Bandgap semiconductors. This presentation will outline the aims of the EPSRC Centre for Power Electronics theme on Heterogeneous Integration in order to exploit the advantages of WBG devices and will give an update on the concepts and methodologies which have been worked on to date.

Professor Lee Empringham is a professor of power conversions technologies within the Department of Electrical and Electronic Engineering at the University of Nottingham. He is the deputy director of the Advanced Propulsion Centre thematic spoke on Power Electronics. His research interests include high power density power conversion techniques and topologies and currently leads the EPSRC Centre for Power electronics research theme into Heterogeneous Integration.

Presentation 11 – Converter Architectures

Professor Xibo Yuan, University of Bristol,
Professor Andrew Forsyth, University of Manchester,
Professor Paul Mitcheson and Dr David Yates, Imperial College London

This presentation will provide an update on the Converter Architecture project, which investigates optimal converter architectures, advanced passive components, control techniques and holistic optimisation to realise the full potential of wide band-gap (WBG) devices in achieving higher efficiency, high power density with extended voltage, frequency and power handling capability. We will show several converter prototypes that have been built with WBG devices and demonstrate how the adoption of WBG devices can benefit the system performance in terms of power density, operating frequency and temperature improvement with benchmarking results. Technical highlights such as novel design of magnetic components with hybrid windings, new multilevel converter topologies with novel redundant level modulation, highly efficient wireless power transfer technologies and applications, and a holistic design optimisation tool will be presented. Through this project, a demonstrator rated at 100kW and 1.2kV dc-bus with WBG device based dc/dc and dc/ac converter has been built, with the gate drivers powered through wireless power transfer. This demonstrator can emulate scenarios with energy storage at one end and medium voltage motor drive at the other end, which will also be shown during the presentation.

Professor Xibo Yuan is a Professor in Advanced Energy Conversion at the University of Bristol, Bristol, U.K. He also holds the Royal Academy of Engineering/Safran Chair in Advanced Aircraft Power Generation Systems. He is an executive committee member of the UK National Centre for Power Electronics and the IET Power Electronics, Machines and Drives (PEMD) network. His research interests include power electronics and motor drives, wind power generation, multilevel converters, application of wide-bandgap devices and more electric aircraft technologies. He has been working on the application of wide-bandgap (SiC, GaN) devices in the past 15 years and leads several research projects in this area. Professor Yuan is an Associate Editor of IEEE Transactions on Industry Applications and IEEE Journal of Emerging and Selected Topics in Power Electronics. He is a Fellow of IET and received The Isao Takahashi Power Electronics Award in 2018.

University of BRISTOL

Day 3: Invited Speaker

Presentation 12 - The market opportunity for SiC in the UK EV supply chain

Simon Price, Exa-Watt Ltd

This presentation examines the opportunity for silicon carbide (SiC) power semiconductors in the UK electric vehicle (EV) market and considers the implications for transportation, energy and industrial applications more broadly. With a combination of superior power conversion efficiency and power density, SiC-based traction inverters offer a compelling case for widespread use in EV powertrains. SiC devices and modules are costly to manufacture, relative to the incumbent silicon-based technologies, but a compelling case for SiC can be made at the vehicle level, where significant net savings can be achieved by reducing battery pack size, taking advantage of the "fuel economy" benefits accruing to SiC. We will discuss improvements in SiC device manufacturing cost and performance, and will examine the impact of these improvements in the context of the growing EV market, as SiC usage migrates from high-performance vehicles such as those manufactured by Tesla, to widespread use in mainstream EVs. Finally, we will outline the potential impact of, and opportunity for, SiC in the UK EV market, as costs fall, performance continues to improve and the automotive industry electrifies.

Simon Price is CEO of Exawatt, a provider of strategic consulting, technology analysis and cost forecasting to manufacturers in the power electronics, EV, lithium-ion battery and solar PV industries.

Prior to founding Exawatt in 2015, Simon 2010 co-founded PV Tech Group, which provided factory design and integration services to solar PV companies. In 2008, he was part of the founding team of a startup technology company dedicated to improving the efficiency of crystalline solar cells.

Previously, as a consultant in the interactive entertainment industry, Simon provided services to software publishers and hardware manufacturers, including Microsoft, Sony, Intel and Nokia. An electrical engineer by first degree, Simon began his career as a business and technology journalist, focusing on disruptive technologies.

Simon has an MSc in Science Communication from Imperial College London, and a BEng in Electrical and Electronic Engineering from the University of Newcastle upon Tyne, UK.

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Early Career Researcher Oral Presentations

Presentation 1 - Mitigation of the Terminal Overvoltage in SiC-Based Motor Drives with Slew Rate Profiling

Wenzhi Zhou, Mohamed S. Diab and Xibo Yuan, University of Bristol

Wide bandgap (WBG) power semiconductor devices, such as silicon carbide (SiC) MOSFETs, take electronic performance to the next level, leading to transformative advances in motor drives. However, the high voltage slew rate (dv/dt) of the switching transitions results in excessive overvoltage at motor terminals, due to the reflected wave phenomenon (RWP), which stands behind the premature failure of motor winding insulation while raises electromagnetic interference (EMI) problems. This presentation will showcase a voltage slew rate profiling approach to mitigate the motor overvoltage in SiC-based cable-fed drives. The proposed approach optimizes the rise/fall time of the output voltage according to the cable length, without altering the switching speed of the SiC devices. Since increasing the switching rise/fall times using conventional approaches, such as increasing the gate resistance, results in an increased switching power loss, the proposed profiling approach is implemented using a soft-switching inverter. The optimum rise/fall time that can significantly mitigate the overvoltage is derived using frequency and time domain analysis. The auxiliary resonant commutated pole inverter (ARCPI) is adopted as a soft-switching inverter to experimentally verify the proposed slew rate profiling approach for the overvoltage mitigation. The analysis and experimental results show that the motor overvoltage is fully mitigated when the output voltage rise/fall time is set as the cable anti-resonance period. Further, the slew-rate profiling approach along with the ARCPI reduce the switching loss and improve the EMI performance at high frequency region, compared with the conventional hard-switching converter.

Wenzhi Zhou received the B.S. degree from Dalian Jiaotong University, Dalian, China, and the M.Sc. degree from Zhejiang University, Hangzhou, China, in 2013 and 2016, respectively, both in electrical engineering. He is current working toward the Ph.D. degree with the Electrical Energy Management Group, Department of Electrical and Electronic Engineering, University of Bristol, Bristol, U.K.
His research interests include wide-bandgap device applications, soft-switching, partial discharge and motor drives.

University of BRISTOL

Presentation 2 - Control and Power Sharing Strategy of Dual Three-Phase Permanent Magnet Synchronous Motor for Fuel Cell and Battery Trains

Nursaid Polater, Tamer Kamel and Pietro Tricoli, University of Birmingham

Dual three phase permanent magnet synchronous machines (DTPMSM) are gaining attraction nowadays due to their remarkable superiorities such as reliability, decreasing of harmonic distortion and total losses, having higher power density and tolerance against fault. Therefore, the aim of the research is examining speed-current control methods, identifying optimal power sharing strategy for fuel cell(FC)/battery trains, and to be sure to have reliable propulsion system. In accordance with these purposes, following methodologies are able to give desired results. It is known that T-NPC converters offer fault tolerance in case of any both source and windings failure by deactivating the corresponding source/windings and allow the operation of the system to continue. After utilisation of DTPMSM with TNPC and implementation of virtual field weakening (VFW) which enables to compensate any FC voltage drop, reliability of traction system increases as well as fixed DC/DC boost converters are able to be removed from power conditioning unit. By doing so, volume of the converter will reduce, and overall efficiency of the power-conditioning unit will increase thanks to lower conversion step. In the light of the aim, this study includes benchmarking on sorts of six-phase PMSM, mathematical analysis of DTPMSM, power sharing scheme, VFW as well as simulation results.

Nursaid Polater (PhD student) was born in Van, Turkey in 1991. He received the B.Sc. degree in electrical engineering from Yildiz Technical University, Turkey, in 2014 and M.Sc. degree in electrical engineering for renewable and sustainable energy from University of Nottingham, UK, in 2017. He is currently a PhD student at Department of Electronic, Electrical and Computer Engineering, University of Birmingham, Birmingham, U.K. He is also a member of Birmingham Centre for Railway Research and Education (BCRRE). His research interests include electric machines, drives and power electronics, multi-phase permanent magnet synchronous motors, the modelling and control of fuel cell/battery hybrid traction systems for electric vehicles.

UNIVERSITY OF BIRMINGHAM

Early Career Researcher Oral Presentations

Presentation 3 - A Wirelessly Synchronized Bidirectional HF-IPT System for Ultra-Low Coupling Applications

Nunzio Pucci, Juan M. Arteaga, Christopher H. Kwan, David C. Yates, Paul D. Mitcheson, Wireless Power Laboratory, Imperial College London

This work presents a high-frequency inductive power transfer system (HF-IPT) with bidirectional capability. A synchronization technique viable for a wide range of couplings is employed to obtain frequency matching of the transceivers. This is achieved through a reference high-frequency tone (433.92 MHz) that is stepped down to 13.56 MHz on each of the two transceivers. The optimal phase is obtained by tracking and maximizing the power throughput of the synchronizing transceiver. This allows operation at unity power factor (no reflected reactances) at a phase of ±90° between transceivers. The setup consists of two back-to-back class EF coil drivers, whose input voltages are obtained through a source-sink configuration of an electronic load operating in constant-voltage mode in parallel with a DC power supply. Experimental results prove successful synchronization of the transceivers. For a coupling as low as 1.6%, 4 W are transferred with an efficiency of 30% in either direction. For such low couplings, the required optimal load for a typical passive rectifier would be incredibly small, resulting in significantly higher losses. This proves a successful application of class EF transceivers paired with the aforementioned synchronization technique for ultra-low coupling applications.

Nunzio Pucci received the M.Eng. degree in electrical and electronic engineering in 2019 from Imperial College London, London, U.K., where he is currently working toward the Ph.D. degree. His research interests include power electronics, resonant converters, wireless power transfer, custom instrumentation, and machine learning.

Wireless Power Lab

Imperial College London

Presentation 4 - Characterization and Analytical Calculation of Core Loss with High-frequency Rectangular Voltage in Power Converters

Dr Jun Wang and Professor Xibo Yuan, University of Bristol

Accurate estimation of the high-frequency power losses of magnetic components, the core loss in particular, has been a challenge for pulse width modulated (PWM) power electronics converters. While the conventional approaches based on Steinmetz Equation lose the accuracy in PWM excitations, the empirical “loss map” approach has been considered as the most accurate practical method to estimate the core loss. This work covers both the experimental characterization of core loss with rectangular voltage to generate a “loss map” and the analytical models to retrieve the inductor operating space, which together form a convenient “datasheet + calculation” process. The characterization is conducted with a novel testing circuit/procedure called “Triple Pulse Test (TPT)”, which enables high-power (e.g. hundreds of volts and amps) in-situ testing with arbitrary rectangular voltage and dc-biased current on a magnetic component. The analytical models derive the operating space of an inductor from the operation and modulation principles of a PWM converter. Ultimately, the manufacturers can conduct the characterization and distribute the loss maps as datasheets to the end-users, which can then enable the engineers to apply the analytical models to rapidly estimate the accurate core loss in the design stage of a power converter.

Dr Jun Wang received the B.S. degree from Sichuan University, China, the MSc degree from the University of Nottingham, UK, both in Electrical Engineering, in 2014, and the Ph.D. degree in Power Electronics from University of Bristol, UK, in 2019. He is currently a Senior Research Associate with the Electrical Energy Management Group (EEMG) at the University of Bristol. His research interests include PWM power converters, multilevel DC/AC converter topologies, power loss modelling of power devices and magnetic components, design optimization and application of wide-bandgap power devices.

University of BRISTOL

Early Career Researcher Oral Presentations

Presentation 5 - Presentation of 4H-SiC n-GTO Simulation

Qinze Cao and Dr Peter Gammon, University of Warwick and Neo Lophitis, University of Nottingham

The presentation will start with an introduction to the need for new UHV (≥10kV) SiC bipolar power devices for HVDC applications. The SiC n-GTO and its general working principles will then be introduced, and the state-of-the-art SiC GTOs briefly reviewed. A novel 15 kV SiC GTO design that is being developed in Nottingham and Warwick Universities will then be presented, which includes a novel base region, designed to optimise both the static and transient performance. The comparison between this novel design and a conventional GTO, will be investigated via simulations in a switching circuit, leading to the advantages and limitation of using this base design.

Qinze Cao obtained his BEng degree in electrical and electronic engineering in University of Warwick. He is currently a first PhD student in Power Semiconductors in School of Engineering, University of Warwick. His work focuses on the design and fabrication of Silicon Carbide power semiconductor devices. The project that he is doing now is fabricating 4H-SiC n-GTO with new base design and lifetime enhancement.

WARWICK
THE UNIVERSITY OF WARWICK

Presentation 6 - Optimal co-design of semiconductors and passive devices

Andrea Stratta, PEMD Group, University of Nottingham

Traditionally, power electronic converters design is approached subdividing it in different steps, where in each step the single components are designed and optimized independently from the others. This might clearly overlook the effect that the design choices of a single sub-system has on other sub-systems, leading to sub-optimal solutions. In this research activity, an automated design approach is proposed with the aim of maximising power density whilst minimising total losses. As a vessel to investigate the presented optimization workflow, the magnetically coupled interleaved H-bridge topology is chosen as an emblematic example of multi-variable design problem. The first step of this approach consists of developing loss models of each converter component, which takes into account components physical dimensions, the temperature dependence and the circuit parasitics. In the second step, these models are used within a nested optimization procedure in order to estimate the losses for multiple points of load. With the aim of validating both design approach and optimization results, different optimal solutions have been deeply analysed with commercial suit, prototyped and tested. The experimental setup includes a Gallium Nitride (GaN) based H-bridge and three custom inductors of different power density manufactured using NiCuZn ferrite bars and U-shape windings technique. The experimental results endorse the adopted design approach confirming the optimality/validity of the manufactured solutions.

Andrea Stratta received the B.Eng. degree in energy engineering and M.Eng. degree in electrical engineering from the University of Pisa, Pisa, Italy, in 2014 and 2017, respectively. In 2017, he spent six months with the German Corporate Research Center of ABB AG, Ladenburg, Germany, where he was involved in design of electromagnetic components for EV battery chargers. He is currently working toward the Ph.D. degree at the Power Electronics, Machines and Control Group, The University of Nottingham, Nottingham, U.K. His research interests include soft magnetic materials, electromagnetic components integration, and high power density energy conversion **techniques.**

The University of
Nottingham

Early Career Researcher Oral Presentations

Presentation 7 - Current Sharing with Dual Phase-Shift Control for IPOP of Modular CLLC Dual Active Bridge DC-DC Converters

Ibrahim Alhurayyis, Ahmad Elkhateb, Mohamed Elgenedy and Timothy Littler, Queens University Belfast

Medium Voltage DC (MVDC) distribution networks shape modern distribution power systems' futures since they provide a co-infrastructure tied to different AC and DC networks' voltage levels and enable easy connection for large-scale renewable energy sources. Concerning the integration of MVDC to LVDC systems, the input-parallel output-parallel (IPOP) arrangement is preferable for high-power applications under medium-frequency isolation. IPOP system based on CLLC resonant dual active bridge (DAB) converters operating under dual-phase shift modulation is a promising topology achieving both zero-voltage switching (ZVS) and zero-current switching (ZCS). That results in high efficiency and high-power density. Besides, the CLLC DAB can reduce the number of magnetic components and the size of the medium-frequency transformer magnetizing inductance. However, one of the most significant challenges in using IPOP configuration is sharing the current between all modules. With a proper control scheme, both input current sharing (ICS) and output current sharing (OCS) between the modules can be achieved. Different control strategies have been discussed, but some can increase the magnetic component or even complicate it. Therefore, this work proposes a current sharing control strategy. The feasibility of the proposed control strategy for CLLC DAB modules has been verified initially using Matlab/Simulink.

Ibrahim Alhurayyis received the BS. degree in electrical engineering from Jouf University, Skaka, Saudi Arabia, and the MSc. degree from the Department of Electrical Engineering, University of South Florida, Tampa, FL, USA, in 2011 and 2016 respectively. Currently, he is pursuing his PhD degree at Queen's University, Belfast, UK. His current research interests include DC-DC converters, DC grids, and renewable energy systems.

QUEEN'S UNIVERSITY BELFAST

Presentation 8 - A Non-Galvanic SiC MOSFET Condition Monitoring Technique for High Frequency Applications

Javad Naghibi, Kamyar Mehran, Queen Mary University London and Professor Martin P. Foster, University of Sheffield

The feature of low conduction loss in high frequency applications has paved the way for achieving high density power electronic systems using power modules with Silicon Carbide and Gallium Nitride chip materials. Characterising and assuring high reliability performance, however, is a main prerequisite to enable this technology to be widely used in the next generation applications like electric vehicles. Considering the performance characteristics of WBG power modules, a novel condition monitoring technique based on the magnetic profile of the power module is proposed in this research work. Non-galvanic sensing and high bandwidth capabilities of the proposed magnetic field-based condition monitoring approach enable this technique to be used in high frequency and high power applications. Tunnel magneto-resistance (TMR) magnetic sensors, as the new technology of magnetic field sensing, are employed in order to enable the developed condition monitoring system to be used in high frequency applications efficiently. As a result, the onset of any degradation process including wire bond lift-off, solder delamination, and solder cracking can be detected and monitored. This can be a major step towards characterising and monitoring the failure onset of the Wide bandgap power modules.

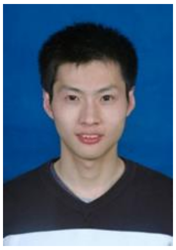
Javad Naghibi received the B.Sc. degree in electrical engineering from Amirkabir University of Technology, Tehran, Iran, in 2015 and the M.Sc. degree in electrical engineering from Sharif University of Technology, Tehran, Iran, in 2017. He is currently pursuing the Ph.D. degree in electronic engineering with the Queen Mary University of London, where he is the Supervisor of the Real-Time Power and Control Systems (RPCS) Laboratory. He has conducted a number of industrial projects on the implementation of high voltage power electronics while he was working as a Power Electronics Design Engineer at Sharif University Research and Innovation Center. His current research interests include wide bandgap technology, reliability in power electronics systems, condition monitoring techniques, and high voltage power electronics.

Early Career Researcher Poster Presentations

Poster 1 - Common-Mode Current Reduction at DC and AC Sides in Inverter Systems by Passive Cancellation

Xie Lihong and Xibo Yuan. Department of Electrical and Electronic Engineering, University of Bristol

For reducing the CM current at both sides in inverter systems with silicon-carbide devices, a passive cancellation method will be introduced, which is realised by inserting two CM transformers (CMT) into the input and output side of the inverter. The selection of the turns ratio for two CMTs and the influence of their parasitics will be analysed regarding the noise cancellation performance. This method could reduce the CM current at both sides simultaneously regardless of the CM impedance at both sides. The experimental results show that the proposed method achieves 40 dB reduction at both sides in a single-phase inverter.



Lihong Xie works as a Research Associate in the Electrical Energy Management Group (EEMG) at the University of Bristol as part of its work with the EPSRC Centre for Power Electronics. His current research interests include transformer modelling, conducted EMI and virtual prototyping of power converters.

University of BRISTOL

Poster 2 - Analytical Modelling and Optimisation of an Exciterless Synchronous Generator Using Wireless Power Transfer

Daniel Fallows and Dr Michael Galea, University of Nottingham and Dr Stefano Nuzzo, University of Modena and Reggio, Italy)

This poster presentation showcases work carried out to develop a fast analytical model that allows for optimisation of an air-cored inductive wireless power transfer (WPT) system, designed to supply the field current of a 72.5kVA wound-field synchronous generator. By integrating the WPT system with existing components of the machine, primarily the cooling fan, it is possible to achieve a significant improvement in power density, when compared to the use of the classical AC exciter. An additional advantage over previous exciterless work is the freedom maintained within the main machine design, allowing for low-cost implementation across a product range.

Daniel Fallows completed his M.Eng. degree in Electrical and Electronic Engineering at the University of Nottingham, UK, in 2015. He is currently working towards a Ph.D. degree with the PEMC Group at the University of Nottingham, UK. His employment experience includes working at Cummins Generator Technologies where he was involved with engineering software development and synchronous machine analysis. Currently he is a teaching assistant with the Department of Electrical and Electronic Engineering at the University of Nottingham, UK.
His fields of interest include synchronous generator excitation systems, including their modelling and optimization, along with inductive wireless power transfer.

University of Nottingham
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Early Career Researcher Poster Presentations

Poster 3 - Flexible Medium Voltage DC Electric Railway Systems

Sina Sharifi, Dr. Pietro Tricoli, Prof. Clive Roberts, University of Birmingham

In this research, medium voltage DC (MVDC) railway electrification system with 25 kV DC overhead lines has been introduced. This electrification system has a wide range of advantages over traditional AC and DC electrification systems.
Modular multilevel converter with full-bridge submodules has been identified as a promising solution for AC-DC converter of the MVDC traction power substation (TPS). The TPS and its converter have been simulated in Matlab/Simulink.
In this poster presentation, the performance of MVDC TPS is analysed. For instance, the operation of DC short circuit current controller, harmonic emissions by the TPS converter, and the converter efficiency curve are investigated.

Sina Sharifi (PhD student) was born in Mashhad, Iran in 1994. He received the B.Sc. and M.Sc. degrees in electrical engineering - power from Ferdowsi University of Mashhad, Iran, in 2016 and 2019, respectively. He is currently a PhD student at Department of Electronic, Electrical and Systems Engineering, University of Birmingham, Birmingham, U.K. He is also a member of Birmingham Centre for Railway Research and Education (BCRRE).
His research interests include railway electrification systems, power electronics, renewable energy resources, smart grids and microgrids.

BCRRE

UNIVERSITY OF BIRMINGHAM

Poster 4 - Redundant Level Modulation for Capacitor Voltage Balancing in Multilevel Converters

Dr Jun Wang and Professor Xibo Yuan, University of Bristol

Multilevel converter topologies have been an active research area for decades, while the voltage balancing is still a challenge for many of these topologies nowadays, e.g. four-level neutral point clamped (NPC) converter, which significantly hurdles their practical implementation. This work showcases a novel Redundant Level Modulation (RLM) that has successfully solved this problem in several challenging topologies to enable them to function in various applications without any limitations. The proposed RLM utilizes additional voltage levels in one switching cycle to gain extra control of capacitor voltages without distorting the output, which is easy to implement with regular level-shifted carriers and free from PI controllers.

Jun Wang received the B.S. degree from Sichuan University, China, the MSc degree from the University of Nottingham, UK, both in Electrical Engineering, in 2014, and the Ph.D. degree in Power Electronics from University of Bristol, UK, in 2019. He is currently a Senior Research Associate with the Electrical Energy Management Group (EEMG) at the University of Bristol. His research interests include PWM power converters, multilevel DC/AC converter topologies, power loss modelling of power devices and magnetic components, design optimization and application of wide-bandgap power devices.

University of BRISTOL

Early Career Researcher Poster Presentations

Poster 5 - Research Advancements in the Torque Ripple Minimization for the Permanent Magnet Synchronous Motors

Muhammad Saad Rafaq, Thomas Steffen and Will Midgley, Loughborough University

Flux harmonics, current harmonics, parameter variations, measurement error, and cogging torques are the major sources of the torque ripples in the permanent magnet synchronous motor (PMSM). Motor design-based solutions and control design-based solutions are generally employed for the torque ripple minimization (TRM) of the PMSM. Considering the advantage of the control-based TRM solutions being applied to the existing motors in the industry, this presentation overviews the recent advancements and open research issues in the control-design based TRM techniques for the PMSM drives. Different analytical and advanced control methods are used to optimize the current harmonics for TRM techniques.

Muhammad Saad Rafaq received the B.S. degree in electrical engineering from the University of Engineering and Technology, Taxila, Pakistan, in 2011, and the Ph.D. degree from the Division of Electronics & Electrical Engineering, Dongguk University, Seoul, Korea, in 2019.
From 2012 to 2013, he was a Laboratory Engineer with the University of Gujrat, Gujrat, Pakistan. From 2019 to 2020, he worked as a Research Professor with the Korea University, Seoul, South Korea. Since 2020, he is working as a Research Associate with the Loughborough University, UK. His research interests include distributed generation systems, control of power converters, electric vehicles, DSP-based electric machine drives, parameter identification, diagnostics, and monitoring of the electrical machines.

Loughborough University

Poster 6 - Interconnection Design of a DC-DC Mini-Grid for Developing Remote Regions.

Joan Marc Rodriguez-Bernuz and Adrià Junyent-Ferré, Department of Electrical and Electronic Engineering, Imperial College London

Off-grid microgrids and solar home systems have become an enabler for the electrification of rural areas in developing countries. However, the future integration of these systems into full-scale grids, and even the coordination of individual autonomous low power systems, presents multiple complex technical challenges. Under the RENGA project (EP/R030235/1) and supported by the RCUK's GCRF, we have investigated how small-scale DC microgrids could be interconnected to build up mini-grids as a step towards the bottom-up development of larger grids. Under this scope, our work has focused on the power electronic technology and the system operation to achieve these goals.

Joan-Marc Rodriguez-Bernuz obtained his Bachelor and Master degrees in Energy Engineering from the Barcelona College of Industrial Engineering in 2013 and 2015 respectively. He obtained his PhD degree in Electrical Eng. from Imperial College London in 2019. Since then, he joined the Control and Power research group at Imperial College as a research associate. His research is on the control of power converters for renewable energy technologies, microgrids and HVDC power transmission with focus on applied predictive controllers.

Imperial College London

Early Career Researcher Poster Presentations

Poster 7 - What if you can’t afford a Tesla? A novel energy model for long distance travel by light battery vehicle.

Fred Spaven, Dr Yuanchang Liu and Dr Mehdi Baghdadi, University College London

One in five motorists worldwide depend on motorcycles for all of their transport needs. Long-distance capability is the key to wide acceptance of electric vehicles; unfortunately these cheap, lightweight vehicles are some of the hardest to electrify, unable to depend on the heavy and expensive batteries at the heart of modern electric cars. Without tackling this subtle problem of light vehicle electrification, transport decarbonisation lies beyond our reach. This research shows how a battery motorcycle can not only keep up with a Tesla, but can do so at lower cost, with lower emissions and without depending on complex

Fred Spaven is a second-year PhD student studying long-distance electric motorcycle travel and electric motor design in the Electric Propulsion Group at UCL.

Poster 8 - A Multi-Active Bridge-based Automotive Inverter

Ferdinand Grimm and Mehdi Baghdadi , University College London

This poster presents a novel modular multilevel inverter for automotive drivetrain applications. The inverter consists of a module balancing circuit and a tap selector that chooses the correct output voltage. The module balancing circuit is based on a multi-active bridge with a series-magnetical and series-electrical connection. The tap selector is composed of several switches which are capable of synthesizing the desired output voltage. To increase the efficiency, a special gate driver is constructed for the magnetics circuit that achieves zero voltage switching. A 400V prototype was constructed and characterized in the UCL electric propulsion lab achieving 99% efficiency.

Ferdinand Grimm obtained the MSc. Degree in Mechanical and Electrical Engineering from the Technical University of Munich. During his studies, he focused on modern methods of signal processing and control theory. While completing his degrees he worked on several projects in the fields of localization, direction of arrival estimation, renewable energies, and model order reduction. He joined UCL in February 2019 to pursue a Ph.D. within the electric propulsion group.

Poster 9 - Optimal Design Solution for Planar Magnetics

Pouya Kolahian and Mehdi Baghdadi, University College London

There is an enormous range of winding methods and geometries available, which makes optimising planar windings a rather complicated procedure. There are several physical constraints, such as efficiency, power density, and size constraints. It takes complex decisions even to produce a simple planar winding. There are numerous crucial decisions to make, including the winding shape, the outer and inner dimensions, the number of turns, the spacing between conductors, the number of layers, and the conductor thickness. Following is a list of the methods used to optimize planar magnetics: Interleaving, Shifting, Track Width Reduction, having Hollow effect, and litzing.

Pouya Kolahian received his B.Sc. in power electrical engineering from University of Tabriz, Tabriz, Iran, in 2014 and his M.Sc. in power electrical engineering from Shahid Beheshti University, Tehran, Iran, in 2017. He is currently working toward the Ph.D. degree in power electronics engineering in Electric Propulsion at the Department of Mechanical Engineering at University College London (UCL). He is working on ultra-efficient and dimensionally compact power converters specially for electric vehicles. His research interests include power electronic converters analysis and design, DC-DC converters, high step-up power conversion, soft-switching, electric drives, and renewable energies.

Early Career Researcher Poster Presentations

Poster 10 - Control Methods for Higher-Order Compensation Schemes in Wireless Power Transfer Systems for Electric Vehicle Battery Charging

Iman Okasili, Ahmad Elkhateb and Timothy Littler, Queens University Belfast

Compensation schemes play a vital role in wireless power transfer as they allow for better efficiency. Compensation was first used to achieve resonant operation ensuring better power quality, this was achieved with four basic topologies: Series-Series (SS), Series-Parallel (SP), Parallel-Series (PS) and Parallel-Parallel (PP). For electric vehicle (EV) battery charging a constant voltage (CV) or constant current (CC) operation is desirable. It was found that each scheme had its unique properties with some offering load-independent operation. Further compensation schemes were developed to achieve CV/CC on the primary or secondary side that was not affected by a change in mutual inductance. This presentation will focus on control methods for LCL and LCC compensation schemes that make use of their unique properties to achieve a constant power to the charging battery of an EV.

Iman Okasili is a PhD student at Queens University Belfast (QUB) focusing on Wireless Power Transfer Systems for Electric Vehicle Battery Charging. Iman completed his master's in Electrical and Electronic Engineering at QUB in 2020, focusing on power electronics and energy. In his spare time, he enjoys exercise and training Muay Thai at the university club, he is also a hobbyist and a maker who enjoys designing small scale engineering projects.

QUEEN'S UNIVERSITY BELFAST

Poster 11 - A concept of quasi-three-phase dual active bridge converter

Olutayo Omotoso, Oleh Kiselychnyk, Richard McMahon, Pete James, University of Warwick

To contribute to meeting the government's target of ensuring that the electric cars outnumber the diesel-powered cars on the UK road by 2030, a concept of "Quasi-three-phase dual active bridge converter" is presented. This concept aims to increase the converter efficiency, reduce its volume and cost. The converter is modelled in MATLAB/Simulink™. The simulation result of this concept shows reduced ripple translating to about 51% reduction in the output filter capacitor volume when compared to the single-phase equivalent. This work is in progress and will be validated experimentally in due course.

Omotoso Olutayo Olusogo was born in Ekiti State, Nigeria. He graduated as the overall best student in MSc Electrical Power — with distinction from Newcastle University UK in 2019. He received a BSc degree in Electrical and Electronic Engineering with First Class honours at Olabisi Onabanjo University, (Nigeria) in 2017. He is currently a Doctoral Student at the Centre for Doctoral Training (CDT): To advance the deployment of Future Mobility Technology (FMT), University of Warwick under the sponsorship of Lyra Electronics Ltd, UK.

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Early Career Researcher Poster Presentations

Poster 12 - Characterisation of Unclamped Inductive Switching in SiC Cascode JFETs

Nereus Agbo, J. Ortiz-Gonzalez, R. Wu and O Alatise, University of Warwick

The poster presentation will detail comparison between Avalanche ruggedness in SiC cascode JFETs and SiC MOSFETs. This is a good robustness metric to measures how well a power device can sustain power shocks from anomalous operation. The Avalanche ruggedness characterisation was performed using unclamped inductive switching (UIS). SiC cascode JFETs when compared to SiC MOSFETs display improved performance in various metrics (e.g., switching rates, switching energies, specific ON-state resistance, and avalanche ruggedness). To determine, how both technologies compare in terms of reliability, it is important to compare UIS performance. Peculiarities were also noticed in cascode JFETs during UIS and these are explained using Finite element (FE) simulations.

Nereus Sunday Agbo received an M.Sc. degree in control systems from Coventry University, Coventry, U.K., in 2018. He is currently pursuing a Ph.D. degree at The University of Warwick, UK., with the Power Electronics Applications and Technology in Energy Research (PEATER) group. His current research interests include device modelling of wide-bandgap power devices to investigate failure mechanisms, mainly SiC power devices.

WARWICK
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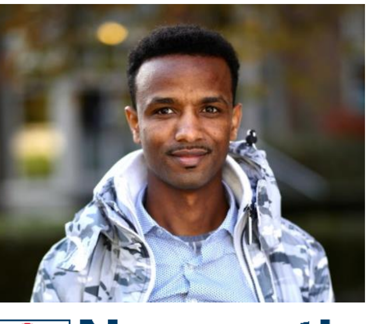
Poster 13 - Silicon Carbide Based Switched Reluctance Motor Drive for Automotive Application

Yohannes E Tecklehaimanot, Newcastle University

Generally, the poster illustrates the advantage of Silicon Carbide (SiC) in motor drives in general and in switched reluctance motor (SRM) drive particularly. The poster incorporates the project's aim and objective and addresses the drawback of SRM technology.

The poster also introduces different power converter topology and describes the benefit of SiC device as an alternative to silicon device. It will also include simulation of Si IGBT and SiC MOSFET based converter to collaborate the difference between the two components and emphasizes the superiority of the SiC device.

Yohannes E Tecklehaimanot is one of the students in cohort 1 - CDT on Sustainable electric propulsion based at Newcastle University. I am working on SiC based Switched reluctance motor drive for Automotive application.



Newcastle University

Early Career Researcher Poster Presentations

Poster 14 - Comparison of a Flux Reversal and Vernier Hybrid Machine for a Hinged Wave Energy Converter

Lewis Chambers and Nick Baker, Newcastle University

In the UK, wave energy converters are on the rise in the renewable power sector, but operation and maintenance in the marine environment bears a high cost. For wave energy to become economical, it is essential to adopt directly driven generators for mechanical simplicity.

The Vernier Hybrid and Flux Reversal Machines are simple, robust, and modular. However, little work has been done in making a direct performance comparison between the two.

This poster seeks to compare the two through the lens of a case study, with a particular focus on cogging torque and the mechanisms of torque production.

Lewis Chambers is currently a PhD candidate in the Electrical Power Group at Newcastle University. He is researching structural optimisation and integrated design of direct drive wave energy converters.

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How would you rate the venue?

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Content:	Excellent: ☐	Very Good: ☐	Good: ☐	Fair: ☐	Poor: ☐
Relevance:	Excellent: ☐	Very Good: ☐	Good: ☐	Fair: ☐	Poor: ☐
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Other……………………………………………………………

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