EMC & Compliance International 2022

Technical Workshops
on the 18th and 19th May

Programme

Day 1 – Wednesday May 18th, 2022

08:30 - 09:00 Registration & Refreshments

09:00 – 10:30 SESSION 1 EMC of traction power converters, battery chargers, and WPT

Chair: Dr. Min Zhang, Principal EMC Consultant, Mach One Design, an Associate of Cherry Clough Consultants Ltd

Session description: Power converters including switched mode power supplies and wireless power transfer modules are often major EMI sources.

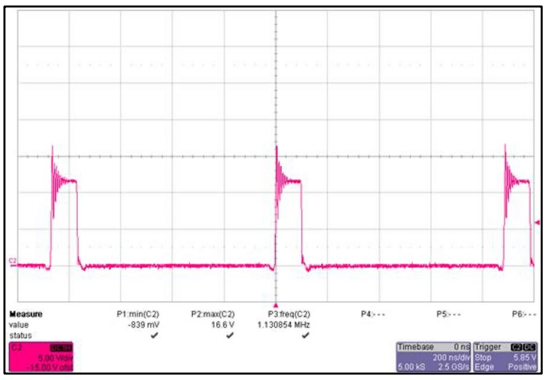
The push for higher efficiency, more compact design leads to high-frequency and faster-switching converters, which inevitably results in more conducted and radiated emissions.

In this session, we look at the challenges and techniques that work on fixing the EMI problems on the source side, which often prove to be the most cost-effective solutions.

09:00 – 09:30 Layout optimisation and package enhancements to minimise switch node ringing and associated radiated EMI in a dc/dc buck converter

Speaker: Dr Jim Perkins, Senior Principal FAE & Senior Member Technical Staff, Texas Instruments Inc.

Synopsis: There are various possible sources of EMI with a dc/dc buck converter, but high frequency ringing on the switch node waveform is one that is commonly encountered.



Remedial steps such snubbers and bootstrap resistors can help reduce the issue but both have significant drawbacks. Far better to avoid generating this ringing waveform in the first place.

This presentation will discuss the causes of switch node ringing and the critical passive component choices and layout optimisation required to minimise or eliminate it.

Ultra-compact portable electronics demand the smallest possible solutions with the highest efficiency to avoid excess heat generation, requiring higher switching frequencies and faster edges. Packaging innovations that help to minimise ringing in these most challenging applications will also be presented.

Bio: Jim is a Senior Member of Technical Staff at Texas Instruments.

He joined TI in 2011 as part of the acquisition of National Semiconductor and has been a field application engineer for over 25 years.

Jim is responsible for supporting the TI analogue and power product portfolio for the personal and portable electronics market.

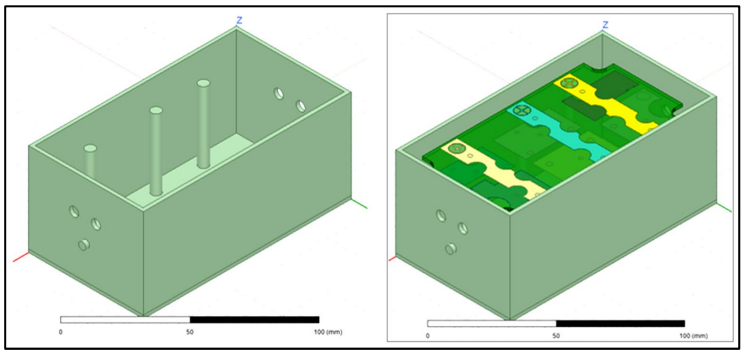
He specialises in power management and dc/dc point of load power conversion, with particular focus on space and cost constrained applications.

Jim graduated from the University of Leeds with a Master of Engineering in electrical and electronic engineering in 1992, and a PhD in InP/InGaAs semiconductor processing in 1996.

09:30 – 10:00 Filter optimisation for high-power converters, using finite element analysis of parasitic effects

Speaker: Dr Graham Roberts, C.Eng, MIET, Turntide Technologies

Synopsis: Filter performance depends not only on component selection, but also PCB layout and enclosure design.



A suspect filter design will be analysed and optimised using a combination of lumped component models and enclosure parasitic effects extracted using finite element analysis.

Bio: Graham graduated from Warwick University in 2006 with a 1st Class Honours Degree in Electronic Engineering, and in 2011 with a PhD in power electronics. He has been a member of the IET since 2006 and is a Chartered Engineer.

After a very brief stint in academia, he worked as a power electronics engineer for General Electric, Dyson, Benchmark Electronics and BorgWarner on power electronics products handling powers of a few watts to several megawatts.

Throughout his career he has been involved in EMC and now works for Turntide Technologies, where he is responsible for design for EMC and EMC test of transport power converters and inverters using the local pre-compliance test facilities.

Simulation has always formed a key part of his work and he has recently been gaining experience using finite element analysis tools with the aim of cutting down prototype iterations and reducing time to market.

09:30 – 10:00 EMC challenges in Wireless Power Transfer (WPT)

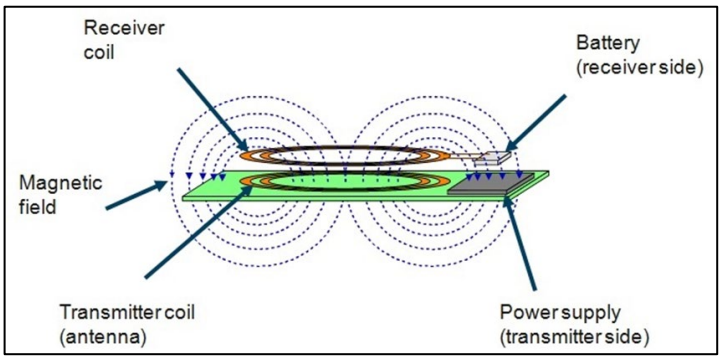
Speaker: Andy Degraeve, Principal EMC consultant, The Limit Line Ltd, an associate of Cherry Clough Consultants

Synopsis: Wireless power transfer has become very popular with products from home appliance robots to electric vehicles.

To deliver the power in the coil, a high-frequency resonant circuit is required.

If not designed right, the leakage field often means strong EMI in the adjacent EM environment.

In this presentation, we will look at the EMC design challenges in Wireless Power Transfer (WPT) technology.



Bio: Andy Degraeve (IEEE Member) was born in Ghent, Belgium, on June 6, 1980. He received the M.S. degree in electronics and computer engineering from the KU Leuven, Technology Campus Ostend, Belgium, in 2014.

In June 2014 he received a nomination for the best master thesis by the ie-net engineering association. From 2014 till 2018, he was a Research Assistant at the KU Leuven Campus Bruges, Research group ReMI, Reliability in Mechatronics & ICT (now called "M-Group" standing for "Mechatronics Group").

His main research interests included electromagnetic compatibility, immunity and functional safety in life or mission critical situations.

In May 2018 he was a Technical Session chair at the joint IEEE EMC and APEMC symposium in Singapore, Singapore. From 2019 till 2020 he was the Technical and Product Manager at Schlegel Electronic Materials, a member of eMei group, in Belgium, with a focus on shielding, absorbing and thermal management materials.

From 2020, he is focussing on EMC education and diagnostics using low-cost test equipment, and joined Cherry Clough Consultants Ltd as an Associate to provide independent expertise in good, cost-effective EMC design, worldwide.

10:30 - 11:00 Refreshments in the Exhibition Hall, and Exhibition Visit

11:00 – 12:30 SESSION 2 Brexit, CE and UKCA Marking

Chair: Paul Duxbury, European Sales Manager, Microwave Vision Group

Speaker: Dai Davis, Partner, Percy Crow Davis & Co.

Synopsis: This 90-minute workshop summarises the consequences of Brexit and the effect on the CE Marking regime, which will now come into effect on 1st January 2023, exactly thirty years after the bulk of the CE Marking regime was first extended to the United Kingdom.

Dai is a lawyer as well as an engineer, so this presentation introduces legal as well as technical aspects of the effect of Brexit.

Dai will look at:

- The structure of the CE Marking legislation
- What are the three Brexit agreements
- The immediate and developing effect of Brexit on EU law
- The differences between CE and UKCA Marking
- Northern Ireland and UKNI Marking

Dai looks at all these questions from a CE Marking perspective, drawing on Machine Safety, Electromagnetic Compatibility, Toy Safety and Medical Device Safety examples throughout.

Bio: Dai Davis, being both a Lawyer and Chartered Engineer is well placed to explore these issues. He holds Master's degrees in both Physics and Computer Science. He is a Chartered Engineer and Member of the Institution of Engineering and Technology.

Dai has for decades consistently been recommended in the Legal 500 and in Chambers Guides to the Legal Profession. Having been national head of Intellectual Property Law and later national head of Information Technology law at Eversheds, Dai is now a partner in his own specialist law practice, Percy Crow Davis & Co.

He has a nationwide legal practice and travels regularly throughout the UK. Dai advises clients on intellectual property in Information Technology products, and all types of computer and technology law issues including such topical matters as Data Protection, Open Source, IT Security and Cloud Computing issues. Dai is a non-executive director of FAST (The Federation Against Software Theft) and a Liveryman of the City of London through the WCIT (Worshipful Company of Information Technologists).

Dai has practised for over three decades in high-tech product safety and product recall, including the law relating to CE Marking.

12:30 – 14:00 Lunch in the Workshop area, refreshments in the Exhibition Hall, and Exhibition Visit

14:00 – 15:30 SESSION 3 Simulation

Chair: Tamara Monti, SIMULIA Solution Consultant, at 3DS.COM/SIMULIA (Dassault Systemes UK Ltd)

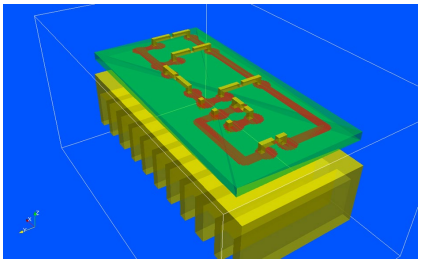
Session description: The modelling of electromagnetic systems has become both feasible and affordable in the last twenty years.

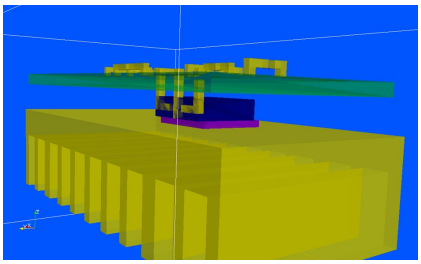
This has been enabled by the increasing availability of powerful computing in addition to a number of software systems which enable, not only the solution of the physics of the interaction of electromagnetic fields with the geometry of concern, but also the modelling of that geometry.

There are still a number of challenges in the use and acceptance of the modelling of electromagnetic interactions, including validation, visualisation and assimilation of results and the modelling of diffusive materials and non-linearities.

14:00 – 14:30 Simulation challenges for conducted emission assessment in the aerospace sector

Speaker: Prof. Dave Thomas, of Nottingham University





Synopsis: : The drive for more environmentally friendly aircraft which are more fuel efficient and quieter has led to the "more electric aircraft" concept.

Electrical systems are being used to replace traditional hydraulic and pneumatic systems. The aircraft frames are being constructed from new lighter composite materials and wiring harnesses are being reduced through the application of wireless technologies.

This has all led to increased reliance on electrical and electronic systems, which must therefore, operate efficiently and reliably within the aircraft environment. It is even more critical to ensure EMC compliance for these new technologies and the simulation challenges associated with this will be discussed in this talk.

Bio: Prof. Dave Thomas is a Professor of Electromagnetics Applications in The George Green Institute for Electromagnetics Research, The University of Nottingham UK.

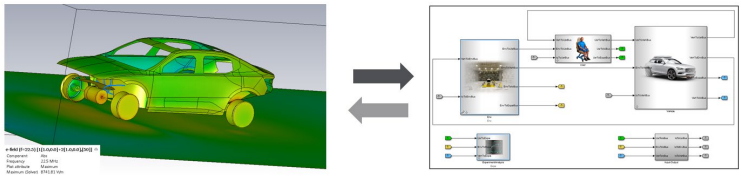
His research interests are in electromagnetic compatibility, electromagnetic simulation, power system transients and power system protection.

He is a member of CIGRE and convenor for Joint Working Group C4.31 "EMC between communication circuits and power systems"; Chair of COST Action IC 1407 "Advanced Characterisation and Classification of Radiated Emissions in Densely Integrated Technologies (ACCREDIT)"; a member of several conference committees inc. the EMC Europe International Steering Committee, and Vice chair of the IEEE Standards committee P2718 Guide for Near Field Characterization of Unintentional Stochastic Radiators

14:00 – 14:30 EMC Simulations on Electrified Vehicles at Volvo Cars

Speaker: Shefeen Maliyakkal, CAE-EMC Engineer, at Volvo Cars

Synopsis: The increased electrification of vehicles in the car industry has made EMC (electromagnetic compatibility) problems more and more difficult to tackle. This is especially due to the high power levels and fast switching frequencies used in modern inverters and DCDC converters. With the ambition to identify and beforehand solve the problems related to electric propulsion in electrified vehicles, Volvo Cars have in recent years put efforts to strategically strengthen the competence within the EMC simulation area.



3D EMC Simulations **0D/1D EMC Simulations**

The main focus is to predict the performance early in the car design, to avoid finding EMC problems later during physical verification. This is indeed a challenging task, especially as we need to understand how all the different electrical components in a modern car are interacting with each other on a complete vehicle level.

It is obvious that the job to perform detailed 3D EMC simulations on all electrical components at the same time would put too high demand on the computing power on today's computers. On the other hand, if we perform only detailed 0D/1D EMC simulations of all electrical components, we will lack the 3D space interaction between the electrical components due to electromagnetic fields propagating via the air, cables and car body.

In order to solve these challenging technical and numerical issues, Volvo Cars have recently initiated a pilot project with the aim to develop a simulation platform on a complete vehicle level, –including not only the mechanical and thermal aspects of electrified cars, but also the electrical performance of individual electrical components.

The simulation platform is available to all development engineers, and the various component owners can contribute to the platform with data and parameters for their respective components. All the components exist in a predefined library which is part of the platform, containing different fidelity levels (0D/1D and 3D). The platform is designed to be modular and flexible, allowing the individual user to combine models of already populated electrical components in any way preferred. With this "super model" the user can enable a study of any parts of the car in various detail levels.

The presentation will highlight some of the main EMC related issues identified in electrified vehicle development at Volvo Cars and share results from the on-going simulation platform development.

Bio: Shefeen Maliyakkal received his Master's in Electrical & Electronics Engineering from National Institute of Technology, Trichy, India (2015).

From 2015 to 2018, he was working for Mercedes Benz R&D as a Simulation Engineer in Bangalore, India. In 2018, he joined Volvo Cars, Gothenburg, Sweden as a CAE-EMC Engineer.

He holds 4 EU patents.

His current work includes signal integrity analysis of wired communication network & EMC simulation of electric powertrain.

14:30 – 15:00 Model validation: less simple than it sounds

This is a pre-recorded video, and Tamara Monti will answer questions afterwards.

Speaker: Dr Alastair R Ruddle PhD BSc (Hons) CEng CPhys MIET MInstP SMIEEE,
Chief Scientist for Vehicle Resilience at HORIBA MIRA Limited

Synopsis: Mathematical modelling and numerical simulation are powerful tools for cost effective analysis and de-risking of designs before committing to practical implementation. Other methods that can be used include experiments on simplified or representative systems. However, models and simulation results are widely regarded with considerable scepticism, and routinely met with demands for "validation" against "real measurements". How best to do this is not always clear, with the result that the IEEE has published a recommended practice to assist with this.

Nonetheless, measurements are often equally questionable as a reliable source of reference data, particularly in relation to EMC, and simulation has an important role in helping to confirm the credibility of measurements. This presentation will consider the features and limitations of measurements and models, identifying some of the practical difficulties and misconceptions that plague the validation of models, and of measurements.

Bio: Dr Alastair R Ruddle PhD BSc (Hons) CEng CPhys MIET MInstP SMIEEE is Chief Scientist for Vehicle Resilience at HORIBA MIRA Limited, working primarily in the areas of electromagnetic and cyber resilience for vehicles and related systems.

Much of his expertise relates to the development of computational electromagnetics to support applications relating to electromagnetic compatibility, electromagnetic metrology, antennas, and human exposure to electromagnetic fields. Other areas of interest include systems engineering, formal specification methods, automotive cyber security and risk analysis.

He has published more than 150 papers in scientific conferences and journals, as well as a number of book chapters, acts as a reviewer for leading international electromagnetics journals and conferences and is also active in standards development in the areas of human exposure to electromagnetic fields and validation for computational electromagnetics. Prior to joining MIRA in 1996, Alastair worked in the defence, rail and power industries.

15:30 – 17:00 Refreshments in the Exhibition Hall, and Exhibition Visit

Please don't forget the evening presentation by the IEEE EMC Society on:

"The nuts and bolts of UKCA and UKNI marking"

organised by their UK & Northern Ireland Chapter
in conjunction with the EMC Test Labs Association (www.emctla.com)

Held from 18:30 – 19:30 in the Workshops area, on the 1st floor of the Grandstand
(above the Exhibition on the Ground Floor),
with free pre-event snacks and drinks available there from 17:00

This event is *free to everyone*, whether they are a member of the IEEE or EMCTLA – *or not.*
Or whether they are registered to attend EMC + Compliance International – *or not.*

Day 2 – Thursday May 19th, 2022

08:30 – 09:00 Registration and refreshments

09:00 – 10:30 SESSION 4 Management of the risks that can be caused by EMI

Chair: Oskari Leppaaho, Doctoral Student - PETER project - Valeo Equipements Electriques Moteurs, France

Session description: With increased digitalization, electronics is used more intensively in equipment that have traditionally been relying in other forms of engineering. Some of these equipment are safety critical.

The presenters of this session highlight recent research results from EU-funded MSCA project PETER. The session gives a wide look at different topics existing in EMI risk management. Pieces from risk management of safety critical systems are spiced up with more traditional obsolescence risk management needed for long lifespan products. These seemingly distant topics have at least one common feature: the EMI risks need to be managed to avoid costly failures!

09:00 – 09:25 EMI risk management for EMC and functional safety in product design – What's the difference?

Speaker: Oskari Leppaaho, Doctoral Student - PETER project - Valeo Equipements Electriques Moteurs, France

Synopsis: In the context of product design, EMI risk management can take two vastly different forms depending on its application. It can simply mean managing the risks related to the electromagnetic compatibility of the product or it can mean managing the safety risk caused by the product, when considering the effect of electromagnetic interference.

This presentation will discuss both viewpoints and provide simple tools and methodologies to get started with risk management, noting that different tools and methods are needed.

It is next to impossible to use the same toolset for risk managing EMC and functional safety considering EMI. However, it will be seen that some generic risk management tools can be shared amongst them.

The EMC side will concentrate on risk prediction with the help of simulation tools taking a simple conducted immunity case with SPICE simulation as an example.

The functional safety side will concentrate on the tools and understanding needed from an EMC engineer to interface with a functional safety team to contribute to the product safety design. Main tool used in there is the goal-structuring notation (GSN).

After the presentation, the participants are expected to have gained basic understanding of the two risk management areas and on the reasons why they need to be treated separately.

Bio: Oskari completed his B.Sc. (2014) and M.Sc. (2015) degrees from Tampere University of Technology (currently Tampere University) in Electrophysics. He also spent an exchange semester in 2013 at FAU Erlangen mainly at Lehrstuhl für Elektromagnetische Felder. He has been a Main Circuit Development Engineer since 2013 at Vacon Oy, Finland, which became part of Danfoss in 2014.

Currently, he is on an extended study leave to embark for a Ph. D. degree. He is doing his current research at Valeo in France with the academic portion at INSA Rennes, France.

He stumbled upon EMC early in his Master's studies, when he was searching for an interesting subject that would combine physics and electronics that were his main interests during Bachelor studies.

During his early career, he contributed to EMC design of Vacon 100 AC Drives and was in charge of the EMC design for some of the models. Later, he got more responsibility outside EMC at Danfoss Drives, moved into the USA for a few years, and participated in various design tasks on a yet-to-be-released product line.

After spending some time in the US, it was time for him to come back to Europe and that is where he found an exciting opportunity to be part of an EU-funded MSCA project PETER.

09:25 – 09:45 Adopting a risk-based EMC approach – Is it necessary? And how can it be done?

Speaker: Lokesh Devaraj, Doctoral Student - PETER project - Horiba Mira Ltd

Synopsis: A risk-based EMC approach for complex systems includes the identification, estimation, and control and/or mitigation of the threat of electromagnetic (EM) disturbances causing system-critical malfunctions (e.g., safety and security) in electrical and electronic (E/E) components.

The recent IEEE standard 1848-2020 provides a set of requirements for the techniques and measures that can be used to reduce the risk of malfunctions due to EMI. However, for mobile systems within a dynamic EM environment, as experienced by road vehicles, estimation of the probability of EM disturbance(s) that can occur in the operational lifetime of a system is a prerequisite for managing or reducing the EM risk to acceptable levels. This presentation will provide a brief summary of the need for the adoption of risk-based approach, and discuss the challenges in quantifying the EMI risk level due to uncertainty of system EM environment.

Further, a new Bayesian multinet (BMN) model and EM environment characterization technique is introduced, to support the probability estimation of EMI causing malfunctions in E/E systems. The proposed BMN model is generic, and hence could enable the adoption of a risk-based EMC approach for critical systems in various domains such as military, automotive, defence, medicine, etc.

Bio: Lokesh Devaraj completed his B.E. (2017) in Electronics and Communication Engineering at Anna University, India and obtained his M.Sc. (2019) in Advanced Optical Technologies at Friedrich–Alexander University Erlangen, Germany.

He is currently an Early Stage Researcher, designated as an automotive electronics research engineer at HORIBA MIRA Ltd., UK.

As a part of the ETN – PETER ESR3, his research topic is on: “Risk – Based Automotive Electromagnetic Engineering Approach aligned with the ISO 26262 Functional Safety Approach”.

His final goal is to develop a risk – based unified approach, which will include areas of functional safety, cyber security and human safety, within the automotive EMC engineering practice, to provide robustness and resilience to future vehicles.

09:45 – 10:05 Incorporation of the electromagnetic environment in the Operational Design Domain

Speaker: Mohammad Tishehzan, PETER Project, University of York

Synopsis: Electromagnetic Interference (EMI) is capable of diminishing the safety margin of a complex system in different ways. While traditionally, the hazards that emerged from EMI has been considered as a functional safety issue (i.e. malfunctions rooted in EMI), the impact of EMI on the Safety of Intended functionality (SOTIF) has not been explored to a similar extend.

The electromagnetic environment could affect the system's perception of the surrounding world by providing insufficient or inadequate input data, which may lead to hazardous behaviour of the system while there is no anticipated EMI originated malfunction. Maintaining the SOTIF of a system requires the specification of the Operational Design Domain (ODD), which includes the conditions that a given system is designed for and allowed to operate in.

Considering the impact of the electromagnetic environment in SOTIF signifies the importance of specifying the electromagnetic environment explicitly in the ODD, which has not been considered in ODD taxonomies such as PAS1883 so far. In this presentation, the contribution of EMI in functional safety and SOTIF will be explained and compared.

Moreover, incorporation of the electromagnetic environment in the ODD, its role during development and operation and the potential approaches and challenges in its specification will be explored.

Bio: Mohammad Tishehzan is an Early Stage Researcher in the EU-funded MSCA PETER Project and PhD student in the department of computer science at the University of York since 2020.

He is carrying out research on "Modelling and Reasoning about EMI Interactions in Autonomous and Complex Vessel". His primary goal is to develop a through-life EMI risk-based modular safety case approach in a form suitable for all of the stakeholders in the marine industry.

He completed his B.Sc. and M.Sc. programs in electrical engineering in 2015 and 2019, respectively, from Shahid Beheshti University and AmirKabir University of technology. He also worked as an EMC test engineer at the EMC type approval laboratory of Amirkabir University for two years before joining the PETER project.

10:05 – 10:30 Obsolescence in EMC Risk Assessment: The Need for ICIM-CPI Models

Speaker: Qazi Mashaal Khan, Doctoral Student – PETER project – Ecole Superieure d'Electronique de l'Ouest (ESEO), France, and Institut National des Sciences Appliquees (INSA), France

Synopsis: In recent years, the ever-changing developments in integrated circuit (IC) technology have increasingly challenged IC developers with confronting electromagnetic compatibility (EMC) problems. Therefore, their specific EMC characteristics and, in particular, their immunity to electromagnetic interference (EMI) are crucial for proper operation over the entire lifetime of a system.

The high-risk factors due to EMC-related reliability can be aging, technological dispersion, and obsolescence.

This presentation will investigate and compare the electric fast transient (EFT) immunity of two-pin compatible, commercially available microcontrollers. The results will show that a more recent IC does not mean a higher EFT immunity, and further EMC analyses are to be performed, mainly when dealing with obsolescence. The non-linear ICIM-CPI (Integrated Circuit Immunity – Conducted Pulse Immunity) model is valuable to help simulate EMC risk

assessment for whole printed circuit boards (PCB). An ICIM-CPI model, designed in Cadence software, will be presented for a custom-designed IC, showing the effect of aging or obsolescence.

This will show the audience how this model can predict the failure of an IC when used in a customer application and under extreme environmental stresses (humidity & temperature).

After the presentation, the audience would have understood IC immunity, aging, obsolescence, and why we need models to overcome EMC issues.

Bio: Qazi Mashaal Khan completed his Bachelor's degree in Electrical Engineering from Fast NUCES Peshawar, Pakistan, in 2016 with Summa Cum Laude. This was followed by a year as a Lab Engineer at his department, where he developed skills for handling instrumentation & measurements.

Afterward, he secured the EU-funded Erasmus + Scholarship for a joint Master's mobility program in 2017. He finished his joint degree in Smart Systems Integration with distinction in 2019. The consortium consisted of Heriot-Watt University (UK), University of South-east Norway (Norway), and Budapest University of technology and economics (Hungary).

For his master thesis, he joined the eesy-IC company (Germany), where he was able to work on Ultra-High speed Analog to Digital Converters and test the transfer speeds using FPGAs.

Qazi is currently an Early Stage Researcher as part of the MSCA ETN PETER project. He is doing his research at the Radio and Hyper-frequency (RF) and the Electromagnetic Compatibility (EMC) group at ESEO, France. INSA Rennes University will provide his Doctoral Degree.

As part of the ETN – PETER ESR 7, he will extend the Integrated Circuit (IC) Immunity and Emission models to incorporate environmental stresses. HALT (Highly accelerated lifetime testing) will be combined with EMC to age an IC in a limited time.

The main objective is an in-depth understanding of aging, thermal stresses, and obsolescence on EMC behavior on many categories of ICs.

His main motive is to work in the automotive sector and accomplish ground-breaking research during PhD in the sensational field of EMC.

10:30 – 11:00 Refreshments in the Exhibition Hall, and Exhibition Visit

11:00 – 12:30 SESSION 5 EMI from a prime contractor's point of view

Chair: Professor Ian MacDiarmid BEng, MSc, MBA, CEng, FIET, Consultant in Applied Electromagnetics, Liverpool University

Session description: The session is less about the equipment design and more about the systems design, development and qualification from the prime contractor's point of view.

Many prime contractors or designers and developers of complex systems do not design and develop the equipment which they integrate into the final system. As such they have to develop specifications which control all the electromagnetic effects with which the equipment has to cope. These include the traditional EMC susceptibility and emission requirements.

In addition, there are a growing number of other electromagnetic effects, including electrostatic charging, induced effects of Lightning, intentional electromagnetic interference etc. Prime contractor organisations also have a responsibility to ensure that systems architecture and installation is designed to ensure that equipment qualification limits are not exceeded.

This session provides an opportunity for speakers to present their approaches to the development of such specifications and systems design, including the responsibility of the prime contractor or integrator to demonstrate the complete system operates safely without electromagnetic incompatibility and without significant disturbance in the presence of an external electromagnetic environment (e.g. High powered radio or radar transmitters or Lightning).

11:00 – 11:30 EMC Integration on Major Rail Projects

Speakers: Dr Dena Servatian and Richard B Williams, of Atkins Rail Ltd

Synopsis: Progressive Electromagnetic Compatibility (EMC) assurance forms a vital part of any overall project life cycle. Documentation may be used to establish a variety of technical requirements, define the legal responsibilities as well as identify general best practices for those involved, thus evidencing that EMC has been considered and implemented where applicable.

When considering the challenges of a complex major railway project, the level of EMC assurance required can increase substantially. Stakeholders, operators, designers and contractors must all be able to clearly understand and execute their duties, from effective coordination during the design and construction phases, right through to maintaining the safe and effective operation of any systems. For complex projects, electrical systems modelling can act as a key element in ensuring the adequacy of EMC controls for the railway; providing designers with a range of design parameters and operational constraints that are necessary to ensure EMC of the final system.

This paper will focus on how EMC is controlled, managed and executed within the context of major rail electrification projects, and highlight how EMC assurance has evolved in line with recent changes to the rail delivery framework process . It defines the various documents and activities which are mandated throughout the project life cycle to achieve EMC assurance under the relevant legislations and standards.

Bio: Dr Dena Servatien is an Electrical Engineer with a background of studying and working on EMC and E&B, railway electrification systems and energy storage systems.

Dena has been qualified for a PhD Degree on a thesis titled "Methods for the Characterisation of Hybrid Energy Storage Systems for Independently Powered Trains" at

the Birmingham Centre for Railway Research and Education, University of Birmingham.

Dena works in Atkins' Electrical Systems team and has three years' experience of EMC, E&B and Traction Power Systems in the UK and Canada rail market, including HS2 Electrification System Modelling Project and Canadian RER Traction Power Modelling Project.

Bio: Richard Bryn Williams is a Senior Electrical Engineer within the Electrical Systems practice of SNC-Lavalin's Atkins UK business. With over ten years' experience of Electromagnetic Compatibility and Earthing and Bonding in railways, Richard has led the design and assurance processes across a variety of diverse projects for a range of clients; both national and international.

His main experience focusses on, line of route systems integration, infrastructure upgrades and depot enhancements. Richard also spent two years based in Maryland, USA, as the Lead EMC Engineer; developing technical assurance and acting as the client representative on the MTA Purple Line Project. Closer to home, he is now supporting the lead E&B Engineer role as part of the HS2 Systems Integration Team.

Prior to joining Atkins, Richard studied at Cardiff School of Engineering, graduating with a BEng in Electrical Engineering and an MSc in Electrical Energy Systems.

11:30 – 12:00 Generic Design Stage EMC Assurance for Nuclear Power Plants

Speakers: Martin Grant, Ian Flintoft, Darren Hayes, Les McCormack, all of Atkins

Synopsis: The management and control of Electromagnetic Interference (EMI) is one of the key safety assessment principles that is relevant to nuclear licenced sites. A robust assurance process should be established at the outset of the Generic Design Assessment (GDA) that can be further developed and followed throughout the project lifecycle.

In an environment as complex and harsh as a nuclear power plant, EMI is a key hazard that must be considered as part of the internal and external hazard assessment process, particularly where it could lead to a radiological release. As well as the impact on safety critical and safety related systems, EMI must also be considered for other systems where there are secondary safety concerns as it could affect the response to other hazards.

This paper explores the Electromagnetic Compatibility (EMC) assurance process during GDA Step 3 and 4 of a new nuclear power station, including the management of functional safety requirements to ensure electromagnetic resilience. It also discusses EMI in the context of the internal and external hazard assessment process for the GDA, with the latter of these also considering the effects of a severe space weather event.

Bio: Martin Grant is a Chartered Engineer with SNC-Lavalin's Atkins business in Glasgow, with over seven years' experience of EMC and Earthing & Bonding assurance to transportation and infrastructure projects in the UK and overseas.

His principal experience is within the UK rail market where he has provided EMC assurance on a vast range of projects, encompassing everything from station upgrades to major national electrification schemes and brand new railways such as Crossrail and HS2.

More recently, Martin has been expanding his knowledge within the nuclear sector and also on the effects of severe space weather events on critical infrastructure. Prior to joining Atkins, Martin studied Physics at the University of Strathclyde

in Glasgow where he received a Master of Physics (MPhys) Degree with specialisation in Complexity Science.

Bio: Dr Ian Flintoft received B.Sc. and Ph.D. degrees in physics from The University of Manchester, Manchester in 1988 and 1994, respectively. He was a Research Scientist with Philips Research Laboratories, Redhill, U.K from 1988 to 1990.

From 1996 to 2017, he was a Research Fellow with the Department of Electronic Engineering, University of York, York, U.K., where he was involved in research on many aspects of applied electromagnetics including electromagnetic compatibility, computational electromagnetics, and antenna design.

He is currently a Principal Engineer with SNC-Lavalin's Atkins Business, York, UK, where he leads electromagnetic compatibility, earthing and bonding and electrical modelling work packages for infrastructure design projects. He has authored over 150 technical papers and articles on electromagnetic engineering topics.

Bio: Darren Hayes is a Chartered Engineer and Atkins Technical Authority for EMC.

After gaining a BEng in Electrical Engineering from Leeds University and an MSc in EMC and RF Communication from the University of York, Darren worked as a Senior Engineer and Laboratory Manager for York EMC Services, providing consultancy for multiple sectors ranging from consumer electronics to power generation.

He joined Bombardier Transportation in 2005, where he worked on the upgrade of the Victoria Line, Sub Surface Lines, the development of Class 378, 379 and other international projects.

Darren is currently a Principal Engineer with SNC-Lavalin's Atkins Business, York, UK, where manages a diverse team working on EMC and HV Earthing and Bonding in both the rail and nuclear sectors.

12:00 – 12:30 EMC requirements for railways, an infrastructure owner's perspective

Speaker: Dr Alex Gavrilakis, BEng (Hons), MSc, PhD, CEng, SMIEEE, MIET, Senior Design Engineer (EMC), Network Rail

Synopsis: This paper discusses the EMC requirements instructed by the main UK infrastructure owner, Network Rail, to the designers and constructors of new railway projects.

It provides guidance on the level of EMC assurance documentation expected from the projects, based on their assigned level of EMC risk.

It also highlights which requirements shall be coordinated with third parties such as local neighbours and train operating companies.

Although this paper focuses on railways, it could inform and/or be adopted by other industries.

Bio: Dr Gavrilakis has been with Network Rail since 2016 as a Senior Design Engineer, specialising on EMC and Earthing and Bonding, based on the London Waterloo station NR offices.

Before joining NR, he spent 2 years with Atkins as a Senior Systems Engineer and from 2004 to 2014 he was an engineer with ERA Technology (now RINA). His research topic during his PhD was the EMC modelling of screened communication cables.

Alex's main current technical focus is on the EMC effects of railways traction power and harmonics on railway systems and third-party interfaces.

He is a member of the IET's professional committees on both Railway and Electromagnetics and has chaired a number of Rail EMC IET events. He is a Chartered Engineer, IET Mentor and a Senior Member of IEEE. He has been the author of Network Rail's Control Period 6 EMC Contractor's Requirements Technical Module, which will be covered within the conference paper.

12:30 – 14:00 Lunch in the Workshop area, refreshments in the Exhibition Hall, and Exhibition visit

14:00 – 15:30 SESSION 6 Military aircraft EMC

Chair: Gavin Barber, Team Leader – E3 Test and Evaluation and EM Security, QinetiQ Ltd, Farnborough, UK

Session description: This session covers some of the challenges associated with applying EMC tests to military aircraft, including the requirements to instrument ordnance during testing, the development of more efficient low frequency clearance techniques and the adoption of test techniques to assess aircraft to the effects of Transmitting Portable Electronic Devices (TPEDs).

14:00 – 14:30 Hazards of Electromagnetic radiation to ordnance, instrumentation developments for High Intensity Radiated Field testing of aircraft

Speaker: Edd Dunkin BEng(Hons) CEng MIET, Principal E3 Trials Engineer, QinetiQ, Air Division, MoD Boscombe Down

Synopsis: A discussion of what an electro explosive device is, what they are used in, how to instrument a typical system for EMC testing, the types of testing that can be carried out with the systems currently on the market, a discussion of the applicable standards and how data can be processed and analysed, concluding with what can go wrong if the test methods are not followed.

The presentation will conclude with a short practical demonstration of an instrumented device being exposed to an RF environment.

Bio: Edd is currently a Principal Engineer in the QinetiQ RF & Signal Processing Group - Air & Space Business, he is the Lead for the Boscombe Down E3 test team and Technical Lead for the Radio Environment Generator (REG) Facility.

He has led aircraft E3 trials for a number of years, including trials for; Electromagnetic Environmental Effects (E3), Electromagnetic Compatibility (EMC), High Intensity Radiated Fields (HIRF) and Armament EMC trials. More recently Edd has taken on test method development for the air and space facilities.

Edd has been involved with military aircraft operations for over 25 years and with E3 trials for over 15 years.

He has worked on a variety of military aircraft both fixed and rotary wing and on trials both in the UK and in the US.

Edd gained his BEng(Hons) in Engineering at Southampton Solent university on a part time basis. He is a Chartered Engineer and is an active member of the Institute of Engineering and Technology (IET).

14:30 – 15:00 The challenges of performing Transmitting Portable Electronic Device (TPED) testing on board Military Aircraft

Speaker: Kieran Mayhew, EMC/HIRF Test Engineer – E3 Test, Evaluation and EM Security, QinetiQ, Farnborough, UK

Synopsis: A discussion of the challenges associated with setting up and applying TPED testing to Military Aircraft, including describing the differences between the ED130A test methods, applying either 'net power' or E-field pre-calibration methods.

In addition, the requirement to perform testing at lower frequencies to simulate HF and VHF radio devices is discussed.

The paper addresses both practical set up and technical challenges applying the test to helicopter aircraft to large transport type aircraft.

Biog: Kieran is an EMC/HIRF Test Engineer in the E3 Test, Evaluation and EM Security team based at QinetiQ Farnborough.

He started at the QinetiQ Apprentice training School completing a 4 year advanced electronics apprenticeship before rolling off into his current position of the last 3 years.

Kieran has been running front line RF chamber testing on many complex customer systems to Def-Stan 59-411, Mil-Std 461 and DO160.

In this time, he has developed methods of streamlining the testing process and modernising legacy techniques.

He has been a key member of the off-site trials team, performing RF surveys and EMC testing at platform level, including HIRF and TPED testing of Aircraft and other military platforms internationally as well as in the UK.

15:00 – 15:30 The Development of the Direct Current Injection (DCI) Method for Military Aircraft Clearance

Speaker: Dr Geoff South, retired, ex BAE Systems

Synopsis: The Direct Current Injection (DCI) method was devised as an economical means of allowing military aircraft clearances to be generated at frequencies up to VHF.

The active use of the technique is, at present, limited in application to lower frequencies in the civil domain, particularly for low level characterisation for lightning and increasingly for HIRF analyses, but at frequencies below first resonance. In such programs, a relatively simple return conductor arrangement can be formed.

This paper will consider the use of the technique at higher frequencies, where the design of the test requires greater effort.

This paper will briefly consider the history of the technique and discuss some of the relevant outcomes of the research projects that have taken place.

The design of the return conductor is a major undertaking as it imposes restrictive limitations on usable frequency range and influences the attachment to the aircraft under test. The paper will discuss computational methods that have been used and give examples of typical designs.

The major aspect of calibration, where the radio frequency power input to the test arrangement is related to the actual clearance, is a fundamental property but has proven to be a serious drawback to its general acceptance.

Possible methods will be discussed, along with representative examples of data obtained. In conclusion, the developments needed for a more general acceptance of the technique will be described.

Biog: Geoff South has been employed by BAE Systems in the EMC discipline for 36 years, joining the company from ERA Technology Ltd. where he was an EMC Research Engineer.

He was sponsored by BAE Systems to study toward a PhD, receiving the award in 1986.

His career has included work on major programs such as Tornado and Typhoon, with the major part as the EMC Technical Authority for Nimrod MRA4.

He has been involved in a number of major research programs, including EU funded ones. BAE Systems continue to research aircraft test methods and have been closely involved with the Direct Current Injection method.

15:30 – 17:00 End of all Workshop sessions, Exhibition closes at 17:00