EMC AWARE

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See REO On Stand 34

EMC & Compliance International Exhibition 2022

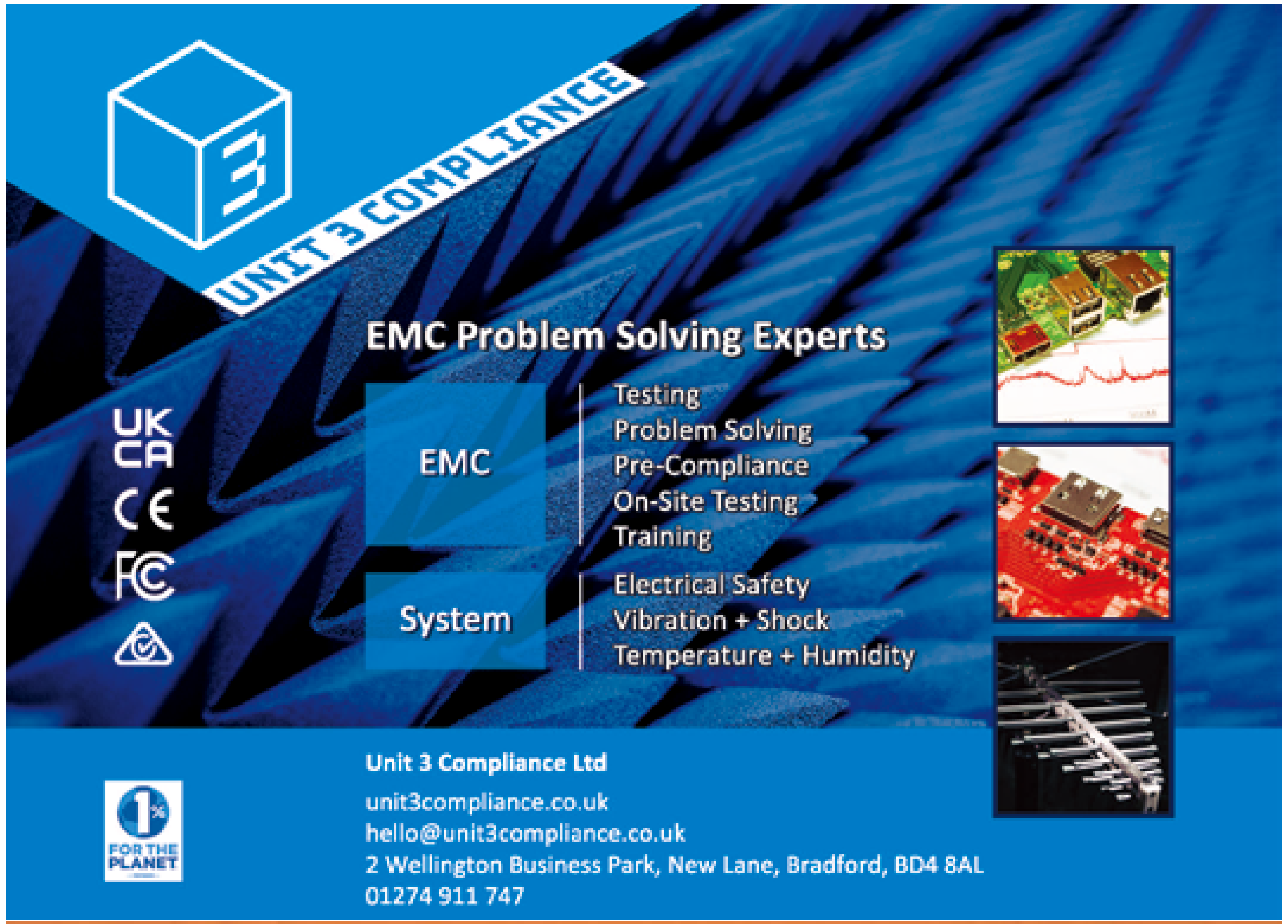
- Latest Generation N CNW Choke And Filter Series.
- Greater Effectiveness Combined With Reduced Weight
- The New Edgewise Winding Series Also Boasts Superior Cooling

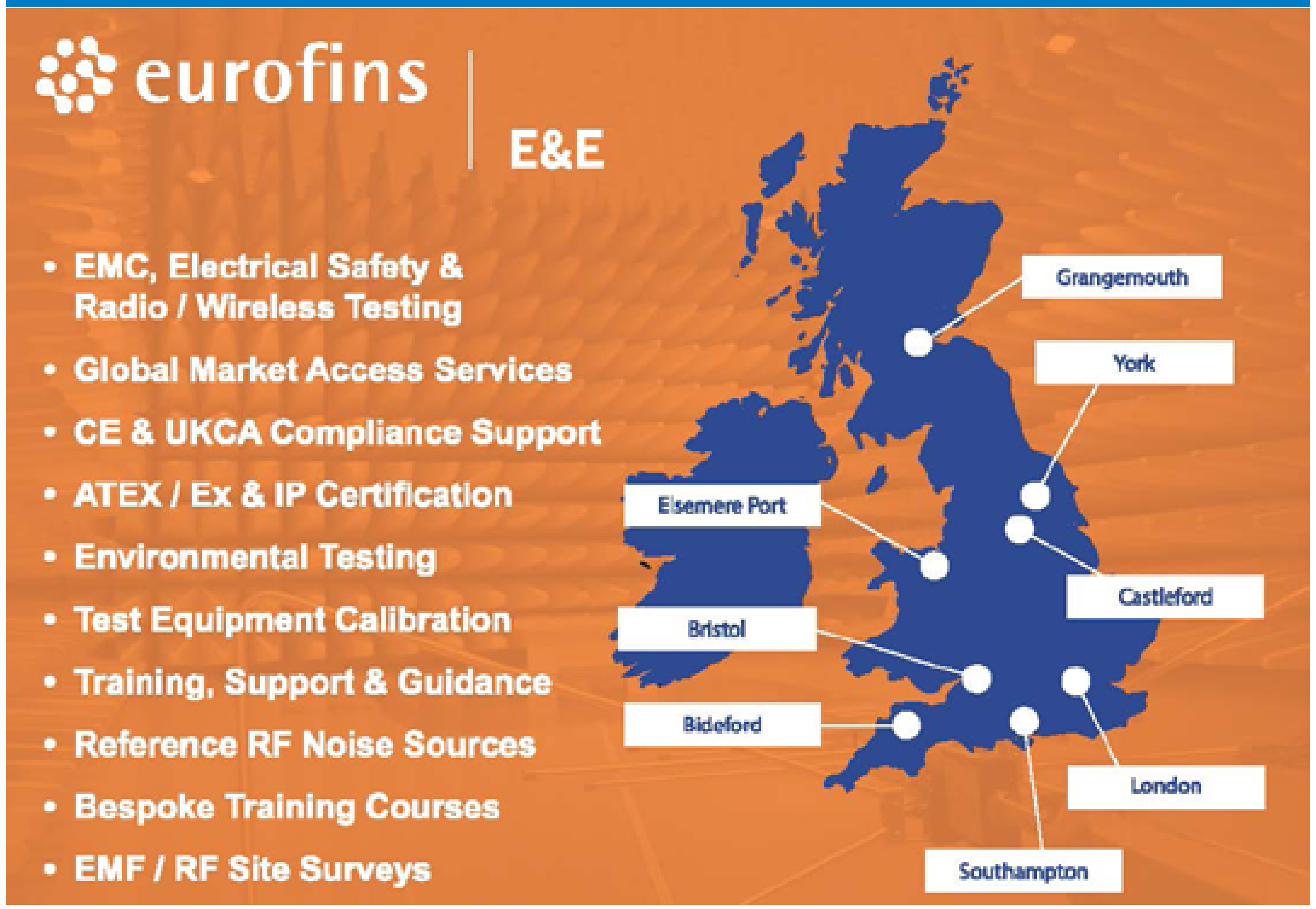
Official Exhibition Magazine

Twex - FREE 10 Mininutes With An Expert

Getting The Financial Resources We Need

Insertion Loss And Filter Performance





Issue 1 | May 2022

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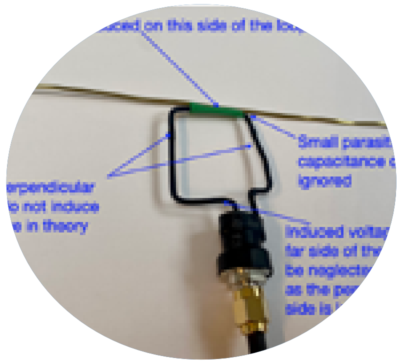


MESSAGE FROM THE EDITOR

Dear Readers,

I am most pleased to welcome you to our new magazine - EMC Aware.

We have created this magazine to provide a means and space to communicate knowledge, dialogue and collaboration between researchers and designers, engineers, managers and business owners, training and service providers and equipment suppliers. The idea behind this magazine was to present EMC to all, and make available the knowledge, technology and test equipment that could be utilised to effect compliant products.

EMC Technology is relevant to all industries. It can affect every piece of Electronic & Electrical Equipment. When improperly considered, it will seriously affect the design cycle, delay the production process and time to market. In short, it can cost money and reduce profits.

In the technology world of emails and social media, electronic based publications provide access to each other and to developments in our respective fields giving a near first hand perspective in on-going knowledge creation.

Our magazine is independent of corporate demands and the overlay of profit. We invite you to share in this creative process together.

We are extremely pleased that our inaugural journal offering an index and map to the EMC show will also cover topics such as A Capacitively Coupled Pin Injection Method, Insertion Loss And Filter Performance, Getting The Financial Resources We Need.

We cover topics on Test methods, component applications, proven rules and management methods. The contributors are practising EMC engineers who get involved in the practical "hands on" methods and are experts in their own areas sharing their experiences with you.

Additionally, as part of the EMC C&I show, you can also choose which expert might be able to help you sort out your technical issue.
We will be inspired by your issues and difficulties in your niche areas.

As an EMC test equipment provider or Training organisation, you could also help in informing our readership in how to solve their EMC compliance issues. Perhaps you have specific equipment or techniques and material that you can contribute here.

We are delighted that you are joining us as readers and hope you will also join us as contributors

The team here at EMC Aware hope that you will find this opportunity beneficial. Please send your feedback to alanw.emc-eandt@outlook.com

Stay safe and take care.

Chris Nicholas
EMC Aware Editor

Welcome To The UK's Only Independent EMC Show

The UK's only independent EMC show, EMC & CI is hosting an event which will take place at Newbury Racecourse 18th & 19th May 2022.
2021's 'virtual' event attracted several guest speakers who provided keynote presentations on the following:

- **Antennas, and Real-Time Spectrum Analyser Measurements.**
- **Simulation**
- **RED (the Radio Equipment Directive)**
- **High Power EMC**
- **Brexit, CE and UKCA Marking**
- **Transport, Systems and Installations**

For 2022 and in conjunction with the free exhibition and TWEX event, there is also a full programme of EMC Technical Sessions available to delegates, about the following:-

- **Management of the risks that can be caused by EMI**
- **EMC of traction power converters, battery chargers (vehicles,**
- **grid storage, etc.), and WPT**
- **Brexit**
- **Simulation**
- **EMI from a prime contractor's point of view, e.g. for public utilities**

In addition the EMC Training Workshops will be provided over the 2 days and are presented by world renowned EMC Expert Keith Armstrong and his team of associates at Cherry Clough Consultantants.

General Infomation

EMC Technology is relevant to ALL industries, it can affect every piece of Electronic & Electrical Equipment, and it can seriously affect the design cycle, delay production and time to market. In short, it can cost money and reduce profits.

A visit to the EMC & Compliance International exhibition is **FREE**.

Join us at the EMC & Compliance International exhibition in 2022 and keep up to date with new EMC directives, components, test techniques, test equipment and latest EMC Modelling software.

The exhibition will feature **over 30 companies** with experts on their stands that can give you the free advice you need.

There is also an **EMC Training & EMC & Compliance Workshops.**

Refreshments

Beverages, light snacks and lunches are served on the exhibition floor.

Toilets

Toilets are located on each floor of the stands

Information Point

Information can be found at the Berkshire Stand Reception (ground floor).

Taxis

The taxi drop off and pick up point is located outside the East Entrance.

Challenge 25

If you appear to our staff to be under age of 25 you will be challenged – to avoid this please take valid ID (valid passport, photo driving licence or PASS card)

First Aid

The First Aid Centre is located next to the East Entrance in the Grandstand Enclosure. If you require urgent first aid please contact your nearest steward.

How to Find Us

The Grandstand, Newbury Racecourse, Newbury, Berkshire, RG14 7NZ.

Access to Newbury Racecourse

From M4 – Junction 13
Exit the M4 at Junction 13 and join the A34 for Newbury. Follow the signs for Newbury, joining the A339. Go straight on at the Vodafone roundabout and first set of traffic lights.

For Car Park 2 – Sat navs use postcode RG14 7PN (over new bridge)
Keep in one of the two lanes to the left hand side and, at the large roundabout (Robin Hood pub) roundabout, take the second exit onto the A4 (London Road). Continue on the A4 for approximately 1.5 miles then turn right onto the B4321 (Hambridge Road). At the mini roundabout go straight on over the new bridge, then turn right at the roundabout on the other side, following the road past the Nuffield Health Centre.

By Train
Newbury Racecourse has its own station, one stop from Newbury Station, with direct connections to London Paddington and the West.

From M3 – Junction 9
Exit the M3 at Junction 9 (signed to the Midlands, Newbury and A34). Join the A34 heading North, leave the A34 at the exit sign posted Newbury B4640. Follow the B4640 towards Newbury and go through Newtown, to the roundabout with the A339 Basingstoke Road by the Swan Inn. Turn left onto the dual carriageway (passing St. Gabriel's School on the right). Go straight on at the roundabout at the top of the hill.

For Car Park 2 – Sat navs use postcode RG14 7PN (over new bridge)
Continue on the A339 and go straight on at the Burger King roundabout, and straight on to the next large roundabout. At the Robin Hood roundabout take the fourth exit onto the A4 (London Road). Continue on the A4 for approximately 1.5 miles then turn right onto the B4321 (Hambridge Road). At the mini roundabout go straight on over the new bridge, then turn right at the roundabout on the other side, following the road past the Nuffield Health Centre.

There is ample free parking, but at owners' risk

Accommodation

0.1 miles from Newbury Racecourse

The Lodge, Newbury

Racecourse, Newbury, Berkshire,
RG14 7NZ (For sat nav use
postcode
RG14 5AW)

Tel: +44 (0) 1635 39673

www.thelodgenewbury.co.uk

0.9 miles from Newbury Racecourse

Premier Inn, Newbury Centre
(London Road)

Park Way, Newbury, Berkshire.
RG14 1EE

Tel: +44 (0) 1635 888719

www.premierinn.com

5.3 miles from Newbury Racecourse

Hilton, Newbury Centre

Pinchington Lane, Newbury,
Berkshire, RG14 7HL

Tel: +44 (0) 1635 247010

www.hilton.com

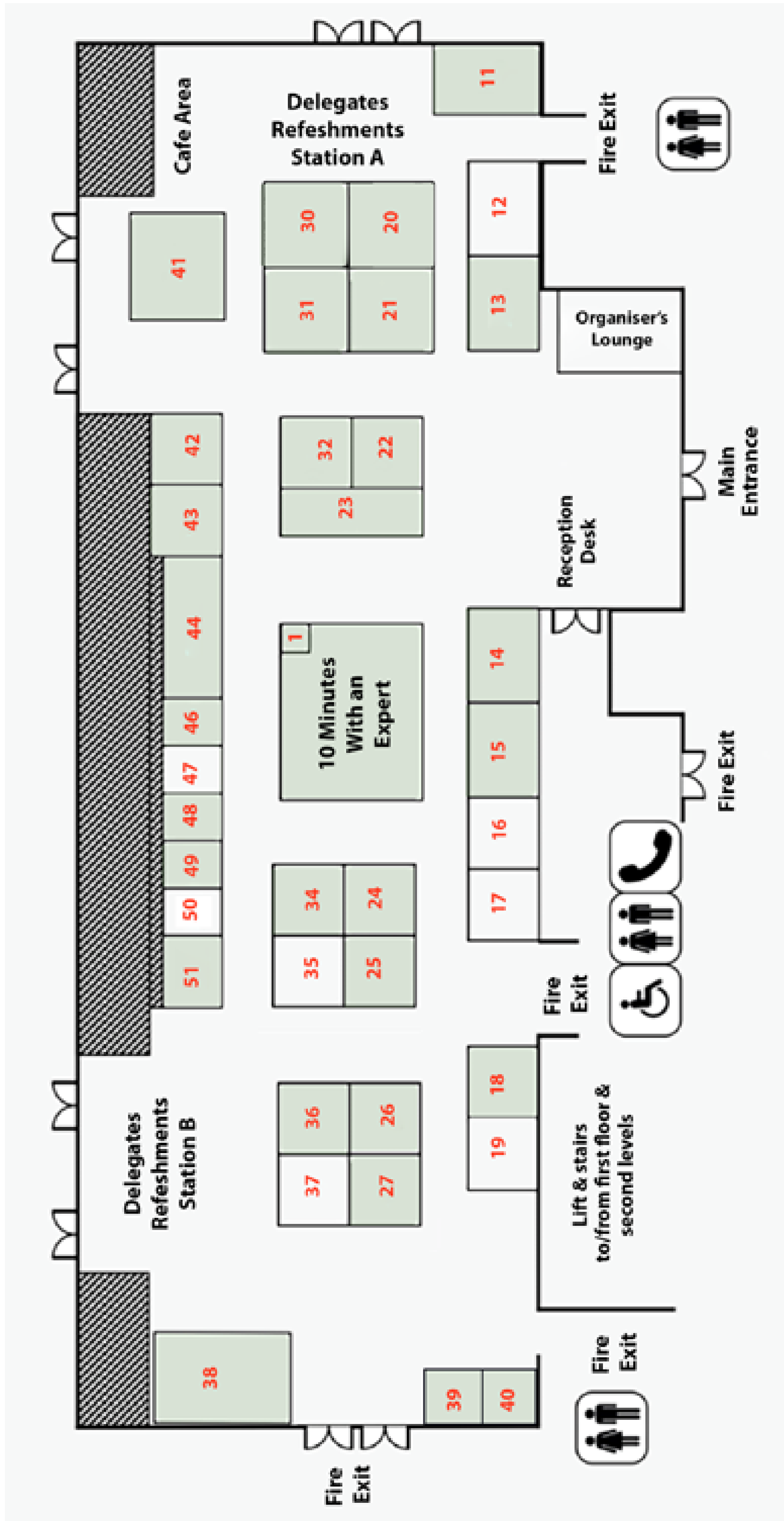
Exhibitors List 2022

Exhibitor	Stand
Advanced Test Equipment Rentals	27
Astute Global	42
Castle Microwave	26
Cherry Clough Consultants	43
Electromagnetic Testing Services Ltd	49
Element Materials Technology	32
EMC Hire Ltd	25
EMC Partner UK Ltd	31
Eurofins E & E	36
Geometric Manufacturing Ltd	18
Hitek Electronic Materials Ltd	41
Kemtron Ltd	14
Keysight Technology UK Ltd	20
Kiwa Electrical Compliance	44
Lambda Photometrics Ltd	13
Laplace Instruments Ltd	24
Link Microtek	39
MCS Test Equipment	21
MDL Technologies Ltd	30
Microwave Vision Group	22
NSI-MI UK Ltd	15
NTD Shielding Services	11
Oxley Group	46
REO (UK) Ltd	34
SGS United Kingdom Ltd	48
Stone Junction	40
Telonic Instruments Ltd	23
TWEX	1
Unit 3 Compliance Ltd	51
Wurth Electronics (UK) Ltd	38

*Subject To Change

Exhibitors Stands

Green stands indicate exhibitors, listed on page 10, Use the list of exhibitors to find who you are looking for.



Event Programmes

Technical Workshops

This event will be photographed & recorded, please let us know if you do not wish to be recorded.

Technical Workshops	Speakers	Time
Day 1 - Wednesday 18th May 2022		
EMC Of Traction Power Converters, Battery Chargers, And Wireless Power Transfer (WPT)	*Chair* ***Dr. Min Zhang***	**Session 1 9:00 - 10:30**
Layout optimisation and package enhancements to minimise switch node ringing and associated radiated EMI in a dc/dc buck converter	*Speaker 1* ***Dr Jim Perkins*** ***9:00 – 9:30***	
Filter optimisation for high-power converters, using finite element analysis of parasitic effects	*Speaker 2* ***Dr Graham Roberts*** ***9:30 – 10:00***	
EMC challenges in Wireless Power Transfer (WPT)	*Speaker 3* ***Andy Degraeve*** ***9:30 – 10:00***	
Brexit, CE And UKCA Marking	*Chair* ***Paul Duxbury***	**Session 2 11:00 - 12:30**
	Speaker 1 ***Dai Davis***	
Simulation	*Chair* ***Tamara Monti***	**Session 3 14:00 - 15:30**
Simulation challenges for conducted emission assessment in the aerospace sector	*Speaker 1* ***Prof Dave Thomas*** ***14:00 – 14:30***	
EMC Simulations on Electrified Vehicles at Volvo Cars	*Speaker 2* ***Shefeen Maliyakkal*** ***14:00 – 14:30***	
Model validation: less simple than it sounds	*Speaker 3* ***Dr Alastair R Ruddle*** ***14:30 – 15:00***	
"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)* ***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.*	**IEEE EMC Society** ***18:30 – 19:30*** ***free*** *pre-event snacks and drinks available there from 17:00*	***18:30 – 19:30*** *Workshops area, on the 1st floor of the Grandstand* *(above the Exhibition on the Ground Floor)*

Technical Workshops

This event will be photographed & recorded, please let us know if you do not wish to be recorded.

Day 2 - Thursday 19th May 2022		
Management Of The Risks That Can Be Caused By EMI	*Chair* ***Oskari Leppaaho***	**Session 4 9:00 - 10:30**
EMI risk management for EMC and functional safety in product design - What's the difference?	*Speaker 1* ***Oskari Leppaaho*** ***9:00 – 9:25***	
Adopting a risk-based EMC approach - Is it necessary, and how can it be done?	*Speaker 2* ***Lokesh Devaraj*** ***9:25 – 9:45***	
Incorporation of the electromagnetic environment in the Operational Design Domain	*Speaker 3* ***Mohammad Tishehzan*** ***9:45 – 10:05***	
Obsolescence in EMC Risk Assessment: The Need for ICIM-CPI Models	*Speaker 4* ***Qazi Mashaal Khan*** ***10:05 – 10:30***	
EMI From A Prime Contractor's Point Of View	*Chair* ***Professor Ian MacDiarmid***	**Session 5 11:00 - 12:30**
EMC Integration on Major Rail Projects	*Speaker 1* ***Dr Dena Servatian*** ***Richard B Williams*** ***11:00 – 11:30***	
Generic Design Stage EMC Assurance for Nuclear Power Plants	*Speaker 2* ***Martin Grant*** ***Ian Flintoft*** ***Darren Hayes*** ***Les McCormack*** ***11:30 – 12:00***	
EMC requirements for railways, an infrastructure owner's perspective	*Speaker 3* ***Dr Alex Gavrilakis*** ***12:00 – 12:30***	
Military Aircraft EMC	*Chair* ***Gavin Barber***	**Session 6 14:00 - 15:30**
Hazards of Electromagnetic radiation to ordnance, instrumentation developments for High Intensity Radiated Field (HIRF) testing of aircraft	*Speaker 1* ***Edd Dunkin*** ***14:00 – 14:30***	
The challenges of performing Transmitting Portable Electronic Device (TPED) testing on board Military Aircraft	*Speaker 2* ***Kieran Mayhew*** ***14:30 – 15:00***	
The Development of the Direct Current Injection (DCI) Method for Military Aircraft Clearance	*Speaker 3* ***Dr Geoff South*** ***15:00 – 15:30***	

Training Workshops

This event will be photographed & recorded, please let us know if you do not wish to be recorded.

Training Workshops	Speakers	Time
Day 1 - Wednesday 18th May 2022		
Designing Interconnections for EMC (cables and connectors)	Session 1 ***Keith Armstrong***	*09:00 -10:30*
Suppressing Electrostatic Discharge (ESD)	Session 2 ***Keith Armstrong***	*11:00 - 12:30*
Suppressing surges/transients on AC or DC power, signals or data	Session 3 ***Keith Armstrong***	*14:00 - 16:00*
Day 2 - Thursday 19th May 2022		
Basic EMC For The Manager	Session 1 ***Chris Nicholas***	*09:00 - 09:40*
EMC design for Switched Mode Power Supply Techniques that will give you an EMC pass first time	Session 2 ***Min Zhang***	*09:40 - 10:30*
How to calibrate and use a Network Analyser, including revealing the hidden characteristics of components	Session 3 ***Chris Nicholas***	*11:00 - 11:45*
Accidental Antennas - the No. 1 Radiated noise source	Session 4 ***Min Zhang***	*11:45 - 12:30*
Teaching EMC using an EMC demonstration unit	Session 5 ***Andy Degraeve***	*14:00 - 15:30*
So you think you know how to design a good filter?	Session 6 ***Min Zhang***	*15:30 - 16:00*

TWEX

TWEX Timetable

Please turn up for the sessions you want, and wait for your TWEXpert to become free

TWEXpert	Wednesday 18th Session 1 09:00 – 10:30	Wednesday 18th Session 2 11:00 – 12:30	Wednesday 18th Session 3 14:00 – 15:30	Thursday 19th Session 1 09:00 – 10:30	Thursday 19th Session 2 11:00 – 12:30	Thursday 19th Session 3 14:00 – 15:30
Michael Derby	-	-	-	✓	-	✓
Ian MacDiarmid	✓	-	✓	✓	-	-
Geraldine Salt	-	✓	✓	-	-	-
James Pawson	✓	✓	-	✓	✓	-
Neil Bonter	-	✓	-	-	✓	✓
Charlie Blackham	-	✓	-	-	✓	✓
Andy Degraeve	-	-	✓	-	✓	-
Jeremy Smallwood	-	-	-	✓	-	✓
Min Zhang	-	-	✓	-	-	-

Note 1: a ✓ in a cell in the above table means the named expert will be available in the TWEX table area in the Exhibition Hall during the session indicated.
Note 2: - in a cell in the above table means that the named expert will not be available during that session.

Guest Speakers

Andy Degraeve

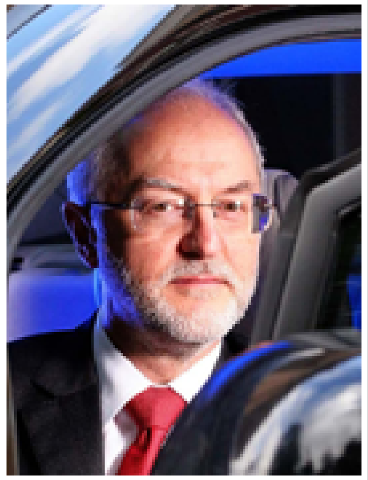
Andy Degraeve (IEEE Member) was born in Ghent, Belgium, on June 6, 1980. He received the M.S. degree in electronics and computer engineering from the KU Leuven, Technology Campus Ostend, Belgium, in 2014.

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.

Keith Armstrong



Keith graduated in 1972 from Imperial College, London, UK, with an Honours Degree in Electrical Engineering.

He has been a member of the IEE/IET since 1977 and of the IEEE since 1997, and was appointed both Fellow of the IET and Senior Member of the IEEE in 2010.

After working for others for 18 years, in 1990 Keith started Cherry Clough Consultants to help companies reduce project costs and timescales, and also reduce warranty costs and other financial risks, through the use of well-proven signal integrity, power integrity and EMC engineering design and manufacturing techniques. So far he has had over 900 satisfied customers, in almost all types of applications, all over the world.

In 2018 he was first person to receive the new IEEE award: "Excellence in Continuing EMC Engineering Education, for continuing education in EMC, signal integrity, and power integrity from a practically based point of view".

Keith chaired the team that produced the IET's "2017 Code of Practice on Electromagnetic Resilience in Support of Functional Safety"; and the team that produced IEEE Std 1848:2020 "Techniques and Measures to Manage Functional Safety and Other Risks with Regard to Electromagnetic Disturbances".

Dr Graham Roberts

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.

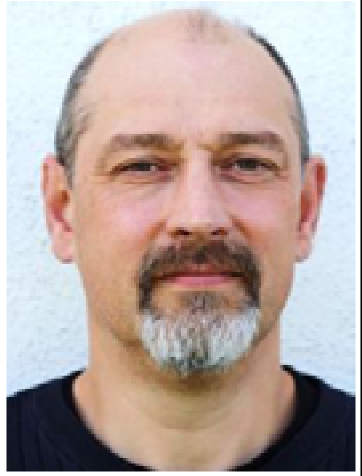
Gavin Barber

Gavin is the Team Leader for the E3 Test and Evaluation and EM Security team based at QinetiQ Ltd, Farnborough. Gavin heads up a team of engineers developing test methods, providing consultancy for internal and external customers and a test team providing both equipment level EMC testing and mobile HIRF testing both in the UK and Overseas. His specific areas of interest include, research and development of equipment level and whole platform EM test techniques, High Intensity Radiated Field (HIRF) and Product/Equipment EMC design techniques and qualification.

Gavin was instrumental in the development of whole aircraft Direct Current Injection (DCI) techniques and worked on reverberation chamber methods in conjunction with the Naval Surface Warfare Center (NSWC). Gavin spent four years within a commercial IT company gaining valuable experience in the areas of EMC design from board to chassis level and in the routes to worldwide commercial product compliance. Gavin has experience of design and verification techniques across a broad spectrum of EM disciplines and has been an active participant in many Military and Commercial aircraft HIRF measurement programmes. Gavin is a member of the Institute of Engineers and Technologists (IET).

Gavin has presented many technical papers at EMC seminars and conferences both in the UK and oversees, including IEEE and IET sponsored events.

Dr Jim Perkins



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.

Paul Duxbury

Paul has over 25 years of experience in EMC and antenna measurements, covering both practical measurements as well as simulation and modelling.

After gaining his BEng(Hons) in Electrical and Electronic Engineering from the University of Hertfordshire in 1995, which included a year working in the RF Free Field group at the National Physical Laboratory in the UK, Paul got his grounding in EMC test and measurement while at BSI Testing and then IFR (formerly Marconi Instruments). This was followed by time with Flomerics and CST, working on electromagnetic simulation and modelling for EMC and antenna applications, with a particular emphasis on EMC applications. Paul joined MVG Industries UK (formally Rainford EMC Systems) in 2012 and within MVG (the Microwave Vision Group) has responsibility for EMC and Anechoic Chamber sales across Europe, and also for antenna measurement systems in the UK.

Paul is a member of the IET (where he currently serves on the Electromagnetics Technical Network) and also the IEEE (where he is currently chair of the UK and Ireland chapter of the EMC Society).Paul has over 25 years of experience in EMC and antenna measurements, covering both practical measurements as well as simulation and modelling. After gaining his BEng(Hons) in Electrical and Electronic Engineering from the University of Hertfordshire in 1995, which included a year working in the RF Free Field group at the National Physical Laboratory in the UK, Paul got his grounding in EMC test and measurement while at BSI Testing and then IFR (formally Marconi Instruments). This was followed by time with Flomerics and CST, working on electromagnetic simulation and modelling for EMC and antenna applications, with a particular emphasis on EMC applications.

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Guest Speakers

Professor Dave Thomas

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

Dai Davis

Dai Davis, being both a Lawyer and Chartered Engineer is well placed to explore these issues. He holds Masters 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 two decades in high-tech product safety and product recall, including the law relating to CE Marking.

Martin Grant

Martin Grant is an Engineer in Atkins' Electrical Systems team with over five years' experience of EMC, predominantly in the UK rail market. As well as producing the necessary assurance documentation for projects and working with the design disciplines to ensure EMC requirements are met, Martin has been heavily involved in undertaking calculations and modelling where specific EMC issues have been identified. This has varied from Mathcad-based calculations through to utilising Atkins' Multi-Train Simulator (MTS), a multi-conductor modelling package developed in a Knowledge Transfer Partnership with the University of Birmingham.

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.

Lokesh Devaraj

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.

Mohammad Tishehzan

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.

Edd Dunkin

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).

Professor Ian MacDiarmid

Ian started his professional industrial career in the field of Applied Electromagnetics following jobs in telecoms, missile engineering and academia. He quickly became a nationally known and later an internationally known expert in the field of Applied Electromagnetics and was responsible for initiating some and driving forward many developments which placed BAE Systems and the UK at the forefront of the field, of Applied Electromagnetics in aviation.

Following a Company sponsored, part-time, MBA programme in my mid-forties, he was offered a range of opportunities which involved the formulation and implementation of strategy on a range of issues. These opportunities usually involved establishing the agreement of Directors.

More recently he was invited to serve as a founding member on a Technology Board created and chaired by the then, Managing Director of BAE Systems (excluding the US business).

Dr Alastair R Ruddle

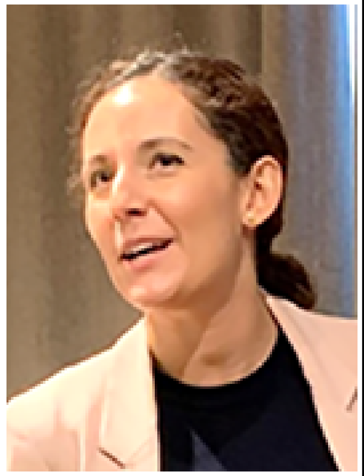
Alastair R Ruddle PhD BSc (Hons) CEng CPhys MIET MInstP SMIEEE, is Chief Scientist for Vehicle Resilience at HORIBA MIRA Limited, working primarily in the areas of electromagnetic and cyber resilience for vehicles and related systems.

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.

Tamara Monti

Tamara Monti is a Solution Consultant for the electromagnetic simulation tools of Dassault Systemes. She earned a master's degree in electronics engineering and a PhD degree in Electromagnetics.
She has been visiting researchers at the Trieste Synchrotron, at Temple University of Philadelphia and at the University of Maryland at College Park working on microwave nanotechnology. She has held a postdoctoral position at the University of Nottingham from 2014 to 2017, before joining CST and focusing on computational electromagnetics.



Oskari Leppaaho

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.

Qazi Mashaal Khan

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.

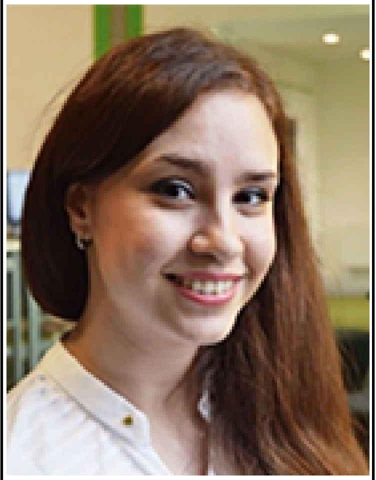
Kieran Mayhew

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.

Dr Dena Servatian



Dr Dena Servatian is an Electrical Engineer with a background of studying and working on power systems, energy storage systems and transportation (rail). Dena has received 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 as an Engineer and has got two-year experience of EMC in the UK rail market, including one year experience of working on HS2 Project. While working at Atkins, Dena has provided inter-practice coordination for the development and documentation of EMC interface design and implementation strategies.

Dr Alex Gavrilakis

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.

Guest Speakers

Shefeen Maliyakkal

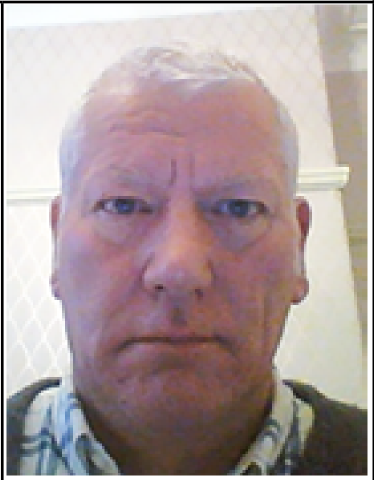
Shefeen Maliyakkal received his Master's in Electrical & Electronics Engineering from National Institute of Technology, Trichy, India (2015).
From 2015 to 2018, he was working for Mercedes Benz R&D as a Simulation Engineer in Bangalore, India. In 2018, he joined Volvo Cars, Gothenburg, Sweden as a CAE-EMC Engineer.

He holds 4 EU patents. His current work includes signal integrity analysis of wired communication network & EMC simulation of electric powertrain.

Dr Geoff South

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.



Richard B Williams

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.

Chris Nicholas

Chris, a graduate of Salford University, has over 35 years experience in the RF design of military, aerospace, automotive, commercial and retail electronics working for companies involved in equipment design and EMC compliance.
He started his career in Racal in the early 80's, learning the basics of RF engineering and EMC/EMI.

When automotive electronics first got started, Chris joined the Ford Motor Co. (Dunton, Essex, UK) and was instrumental in setting up their RF and EMC laboratory facilities. He became experienced in high volume design and manufacture, and was awarded a Patent for antenna diversity.

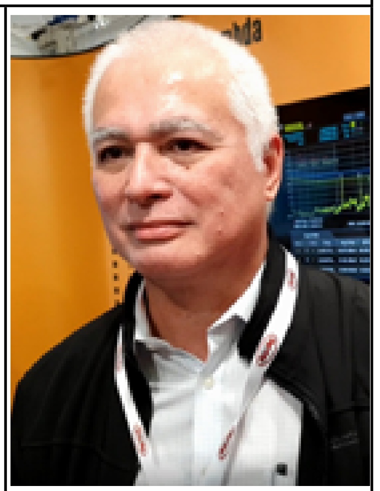
In 2000, working for EADS ASTRIUM he developed a 100W low-band microwave power amplifier for a Galileo satellite launched by ESA.

Until recently, at Lockheed Martin UK, he set up and managed the Military EMC pre-compliance facility used by their design teams.

Chris likes to consider different approaches to difficult problems, and pass on knowledge to younger engineers. He has a passion for good pragmatic engineering design practice and implementing low noise signatures.

Chris passed the radio amateur's examination in 1976 but spends most of the time on the bench tinkering with low noise electronics.

Presently he is running his own EMC consultancy business.



Dr Min Zhang

Dr. Min Zhang received his PhD within Newcastle University's Electrical & Electronics Engineering department in 2013.

His research was in novel power
switching schemes to reduce EMI emissions, and his research papers have received many citations.

Since then, he has worked as an EMC specialist on milestone projects with Dyson Technology, UK.

With a proven track record designing state-of-the art electronics and electric machines with minimal EMC issues, Min then established the EMC capability for the Dyson Electric Vehicle project.

Following the closure of that project, he started Mach One Design, and became associated with Cherry Clough Consultants Ltd, to provide independent expertise in good, cost-effective EMC design, worldwide.

Min's in-depth knowledge in power electronics, digital electronics, electronic machines and product design is sure to benefit your product's design, helping you win the race against time and cost.

Ian Flintoft

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.

Darren Hayes

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.

Les McCormack

Les McCormack is an experienced Project Director, Chartered Engineer and a Fellow of the IET. He leads a diverse team of electrical specialists within Atkins' Transportation business providing expertise in EMC, AC & DC distribution design, electrical systems integration, earthing & bonding and traction power system modelling. Les specialises in Electro-Magnetic Compatibility (EMC) and electrical systems integration and has over 25 years' experience of working on projects both in the UK and overseas.

He is a member of the CER Train Detection Working Group and a former member of the RSSB Energy Standards Committee, DfT Space Weather Working Group and the European Union Railway Agency Train Detection Working Group.

Exhibitors 2022

The exhibition has been re-launched as EMC & Compliance International and returns to Newbury Racecourse in 2022 as an independent event and through our link with EMC Standards will have a more global promotion activity.

Exhibitor	Contact Details		Stand
Advanced Test Equipment Rentals	**Website:**	www.atecorp.com	27
Advanced Test Equipment Corporation (ATEC) is the rental, sales and service leader of test and measurement equipment, offering thousands of choices for rent or purchase, and equipment calibration. Providing the latest technology and legacy equipment from common everyday use, to unique and industry specific, ATEC fulfills all customer equipment needs. The automotive, aerospace, defense, communications, EMC, consumer electronics and a variety of other industries rely on ATEC's extensive inventory of new and used equipment to meet test standard requirements. Also offers calibration services for customers' equipment. As an A2LA ISO 17025 accredited for calibration company, ATEC holds the largest scope of accreditation in the industry.	**Phone:**	01905369258	
	Email:	rentals@atecorp.com	
	Address:	10401 Roselle Street San Diego, CA USA 92121	
Astute Global	**Website:**	www.astutegroup.com	42
Astute's growth spans 30+ years with offices across five continents. We're one of the world's most knowledgeable, quality-driven experts in franchised electronics distribution, global procurement, and supply-chain management. Our E-Design team provide component engineering support across our franchises, modifying & adapting for your projects, and supporting you throughout the design cycle with experienced technical advisers. We work in partnership with your design teams to help you introduce new technology to your projects – speeding up your innovation cycles and development times. Astute can engineer components to suit your needs, supported all the way directly by the manufacturer. Come and speak to us at the show where we will be showcasing Quell's EESeal, (retrofit EMI filters) and several of our other franchise offerings.	**Phone:**	01438 909 909	
	Email:	lee.widdowson@astutegroup.com	
	Address:	Astute House, Rutherford Close, Stevenage, SG1 2EF	
Castle Microwave	**Website:**	www.castlemicrowave.com	26
Founded in 1981 Castle Microwave is one of the UK's foremost suppliers of high technology and leading-edge RF and Microwave products with an extensive remit and expertise covering components and subsystems used in today's state-of-the-art Military, Space, Telecoms, Smart Energy and Test & Measurement markets.	**Phone:**	01635 271300	
	Email:	sales@castlemicrowave.com	
	Address:	5 The Pentangle, Park Street, Newbury, Berkshire RG14 1EA	

Cherry Clough Consultants	**Website:**	www.cherryclough.com www.emcstandards.co.uk	43
Worldwide design consultancy and training in all aspects of electromagnetic engineering, from DC to 50GHz, including: EMC, EMI, RFI, TVI, Interference, electrical noise, etc., as regards mechanical, PCB, hardware, software, testing, verification, validation, and regulatory compliance. Also, consultancy and training in techniques and measures to manage the functional safety and other risks that can be caused by EMI. Plus general good design for safety compliance. All the above for modules, sub-systems, products, equipment, systems and installations of any size and complexity, in any/all applications, including medical, automotive, industrial, military, etc., that use electronics. Established for 32 years with nearly 1,000 very satisfied customers, so far.	**Phone:**	01785 660247	
	Email:	keith.armstrong@cherryclough.com	
	Address:	9 Bracken View, Brocton, Stafford ST17 0TF	
Electromagnetic Testing Services Ltd	**Website:**	www.etsemc.co.uk	49
ETS is an independent UKAS accredited, award-winning company providing EMC testing, certification, consultancy and troubleshooting of EMC problems covering most product groups. Our Test Facility is fully equipped with the latest state of the art testing and measurement equipment providing an efficient and fully automated testing service, covering EMC and EMF testing. At ETS we pride ourselves on our remedial investigation and problem-solving capabilities. In the event of non-compliance we have the knowledge, expertise and purpose designed tools to evaluate problems and identify short and long-term solutions with competitive costs. ETS is UKAS accredited to carry out antenna calibration 20 MHz to 18 GHz. In addition to antenna calibration, we calibrate RF Cables, Pre-amplifiers, and attenuators. ETS also provides an offsite mobile testing unit, which is used in many sectors, ranging from railway to fully integrated installations in domestic and industrial environments.	**Phone:**	01371 856061	
	Email:	info@etsemc.co.uk	
	Address:	Pratts Fields, Lubberhedges Lane, Stebbing, Essex CM6 3BT	
Element Materials Technology	**Website:**	www.element.com	32
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	Email:	david.west@element.com	
	Address:	100 Frobisher Business Park, Leigh Sinton Road, Malvern, WR14 1BX	
EMC Hire Ltd	**Website:**	www.emchire.co.uk	25
EMC Hire Ltd is the UK's largest hire company providing RF and EMC specialist test equipment, and consultancy services. Unlike other rental companies, we focus solely on sourcing RF and EMC equipment. This enables us to provide an extensive range to support a wide variety of EMC and RF testing requirements, whether this be in accordance with standards, approvals, or EMC-related research. EMC Hire's portfolio of test equipment ranges from signal generators, antennas, receivers (DC- 40GHz), transient equipment, ESD and test systems. Same day dispatch options are available for time sensitive projects, and we also provide global shipment from our operations in the UK.	**Phone:**	01462 817111	
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EMC Partner UK Ltd

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Email:	eeinfouk@eurofins.com
Address:	HQ, Unit 1 Arabesque House, Monks Cross Drive, Huntington, York, YO32 9GW

We are Eurofins E&E UK, a provider of world-class testing, inspection, approval and certification services for manufacturers, product designers, importers and retailers of electrical and electronic products. Whether you are designing a single product for the UK market or a range of products for multiple global markets, we can provide support, guidance and product testing services to help get your product to market on time and within budget. Our core services cover EMC, Radio/Wireless Testing & Product Certification, Product Safety, Global Market Access, Hazardous Area Testing, Certification and Approval, Environmental Testing, Compliance Guidance and Support, Training, Testing Equipment Calibration and Reference Noise Sources. Eurofins E&E UK consists of Eurofins E&E ETC, Eurofins E&E Hursley, Eurofins York and Eurofins E&E CML and Eurofins E&E London. With our extensive scope of accreditation, experience and expertise, we can help you deliver compliant, safe and efficient products now and in the future.

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Address:	15 Wentworth Road, South Park Industrial Estate, Scunthorpe, North Lincolnshire DN17 2AX

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Kemtron Ltd, the UK's largest manufacturer of materials for EMC/RFI shielding and environmental sealing. Our fully equipped factory in Braintree, Essex has the flexibility to produce short run and prototype solutions as well as standard products in volume. Kemtron will have on show the latest range of materials including conductive elastomers, oriented wires in silicone, woven wire in silicone, conductive caulks, knitted wire mesh, aluminium honeycomb vent panels, conductive adhesives, shielded windows amongst others. Kemtron has provided a specialist service in EMC solutions for over 30 years and has developed unparalleled experience and expertise in design, manufacture and support.

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Keysight Technologies is the world's leading electronic measurement company, transforming today's measurement experience through innovations in wireless, modular, and software solutions. With its Hewlett-Packard and Agilent legacy, Keysight delivers solutions in wireless communications, aerospace and defense and semiconductor markets with world-class platforms, software and consistent measurement science. The company's nearly 12,600 employees serve customers in more than 100 countries.

Kiwa Electrical Compliance

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Email:	uk.service@kiwa.com
Address:	Kiwa House, Malvern View Business Park, Stella Way, Bishops Cleeve, Cheltenham GL52 7DQ

Kiwa Electrical Compliance (KEC) is a UKAS-accredited testing laboratory (no .2667) for EMC and Electrical Safety in Blackwood, Gwent. Part of the global Kiwa organisation, renowned for its TIC services.

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We are known for our reliable, prompt and professional service in achieving CE/UKCA/UKNI marking for a range of products.
We are joined on Stand 44 by RN Electronics, who became part of the Kiwa family earlier this year. We look forward to welcoming you.

Lambda Photometrics Ltd

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Phone:	+44(0)1582 764334
Email:	contact@lambdaphoto.co.uk
Address:	Lambda Photometrics Ltd Lambda House, Batford Mill Harpenden, Hertfordshire AL5 5BZ, United Kingdom

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Link Microtek is a manufacturer and distributor of RF & microwave components, instruments & systems. We manufacture a range of waveguide products including rotary joints.
We are the UK's leading supplier of EMF safety instrumentation and services and we'll have on display much of the range of products from Narda Safety Test Solutions: measurement equipment covering the range DC to 100 GHz plus area and personal monitors. We also have the Narda SignalShark handheld Real-Time Spectrum Analyser (RTSA) used for detecting, locating and classifying RF signals & interference.
Also on display will be our range of components and amplifiers including class leading high power solid state solutions from Exodus: 10 kHz to 40 GHz, various rack mount models for EMC applications with output power of 1kW or more.

MCS Test Equipment (Test Equity)

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Email:	uksales@testequity.com
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Based in St Asaph, North Wales, TestEquity (Formerly MCS Test) is an authorised distributor focused on providing the largest and highest quality selection of test solutions, electronic production supplies and tool kits from its leading manufacturer partners supporting the aerospace, defence, automotive, electronics, education, and medical industries.

MDL Technologies Ltd

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Phone:	+44 (0)1462 431981
Email:	epadgham@mdltechnologies.co.uk
Address:	Unit 11, Devonshire Business Centre, Works Road, Letchworth, Herts, SG6 1GJ

MDL Technologies has been providing electronic test solutions to the EMC, RF and Electrical Safety markets, for well over a decade.
Working with leading manufacturers such as ASYSOL, BOLAB, BONN ELEKTRONIK, CHROMA ATE INC., EMSCAN, DETECTUS, ETS-LINDGREN, HAEFELY, HIOKI, PMM NARDA, ROHDE & SCHWARZ, TEKTRONIX, TYPHOON HIL, TOELLNER. Services: system integration, consultancy, project management, facility design, installation/testing/commissioning, calibration, technical support.
We are very much looking forward to finally meeting colleagues and customers, existing and new, face to face once again, after an enforced hiatus.
So whether interested in test equipment, or turnkey test facilities, commercial or Military/Avionics Standards, from Amplifiers to X,Y,X Positioners, from a few V/m to many hundred, from a few micro-volts/m to many kilo-Volts, and a few amps/watts to many kA/kW, "DC to Daylight", we look forward to meeting you and discussing your requirements at the EMC & COMPLIANCE INTERNATIONAL Show 2022: Stand 30. www.linkedin.com/company/mdltechnologies

Microwave Vision Group

Website:	www.mvg-world.com
	22
Phone:	01942 296190
Email:	paul.duxbury@mvg-uk.com
Address	Unit 400 Haydock Lane Haydock WA11 9TH

The Microwave Vision Group (MVG), formed by the coming together of 4 industry leaders; SATIMO, Orbit/FR, AEMI and REMC, is a world leading supplier of cutting-edge technologies and solutions for EMC, RF, uWave and Antenna testing applications. We design, manufacture, supply and install shielded, semi and fully anechoic chambers for our clients across the globe. Our EMC solutions include pre-compliant chambers, as well as CISPR16 compliant 3m, 5m and 10m chambers, chambers for MIL STD and Automotive applications, and EMP protection, plus a wide range of different absorber materials, antennas, and other accessories. Our antenna measurement solutions include the StarLab and SG near field systems, along with Planar, Cylindrical, and Spherical near field systems, Far Field and Compact Antenna Test Ranges. With highly skilled teams across the world, and over 400 dedicated employees, MVG proudly serves, and is trusted by, the major electronics, telecoms, automotive, defence and aerospace companies around the world.

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	15
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Address:	Unit 51 Harley Road Sheffield S11 9SE UK

NSI-MI UK provides test equipment, consultancy and support services to the UK and European Electronics Industry in the areas of EMC, RF & microwave, shielding, anechoic material and general antenna measurements.

NTD Shielding Services

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NTD is a UK based world leading manufacturer and supplier of high-performance EMC chambers, EMI chambers, Antenna chambers, RF chambers, Faraday cages, 5G solutions and EMC test and measurement equipment.

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Website:	www.oxleygroup.com
	46
Phone:	01229 582621
Email:	m.johnson@oxleygroup.com
Address:	Priory Park Ulverston Cumbria LA12 9QG

Oxley offers a comprehensive range of EMI suppression products, including filters (discrete and multiline), ceramic planar capacitor arrays, arrays of discrete filters, filtered connectors and custom filter modules. The company offers a wide range of standard & advanced packages including TVS (Transient Voltage Suppression). Oxley products are high quality, robust and reliable solutions, designed to meet tough military and aerospace specifications, as well as less demanding industrial applications.

Products are developed in-house using sophisticated design, manufacture and assembly techniques, the facilities include an in-house ceramic production capability for discoidal, tubular and multiway capacitors. Manufacture is supported on site by CNC machining, electro-plating, a prototype model shop, tool room and dedicated test area. All products are rigorously tested with network analysers and high voltage test facilities on site. With eighty years' experience in designing and manufacturing the latest solutions, Oxley are the right people to talk to - whatever your EMI requirements.

REO (UK) Ltd

Website:	www.reo.co.uk	34
Phone:	01588 673411	
Email:	main@reo.co.uk	
Address:	Units 2-4 Callow Hill Road Craven Arms Business Park Craven Arms Shropshire SY7 8NT	

REO is an original manufacturer of high quality power equipment, including electronic controllers, components and electrical regulators. REO was founded in 1925 and manufactures a range of products used in medium-voltage power systems (up to 3000A) across a number of markets.

We have a wealth of experience in the manufacture of wound components onto cylindrical and toroidal cores. We are also conversant with the latest electrical standards and the use of modern production methods. We have a wide range of products ex-stock but also have the capability to offer product modifications or even bespoke design to ensure that REO solutions match your needs.

Working with you to develop innovative, energy efficient and EMC compliant solutions for your electrical power control and power quality problems. Providing technical expertise to deliver an enhanced return on investment through lower energy consumption, superior process efficiency and increased product life.

RN Electronics Ltd

Website:	www.rnelectronics.com	44
Phone:	+44 (0)1277 352219	
Email:	enquiries@rnelectronics.com	
Address:	Arnolds Court, Arnolds Farm Lane, Brentwood, Essex, CM13 1UT	

RN Electronics Ltd has joined Kiwa Ltd, part of the international testing, inspection and certification company Kiwa Group. Kiwa is known for its technical rigour, reliability and industry knowledge; RN Electronics' reputation, quality of service and market position is an excellent fit. RN Electronics specialise in the testing of wireless electronic devices to ensure they meet the relevant EMC and Radio standards, and comply with the Radio Equipment Directive (RED), before being placed on sale in the EU / UK. Our experienced engineers work with customers to identify and resolve any issues identified by testing.

Were also an FCC Conformity Assessment Body for the USA, as listed by ISED for Canada and accredited for testing for Australia and New Zealand. Our certification service can support the worldwide approval of your electronic devices. RN Electronics is a leading test laboratory in the UK testing electronic products for a number of industries.

SGS United Kingdom Ltd

Website:	www.sgs.co.uk	48
Phone:	0151 350 6666	
Address:	Inward Way Rossmore Business Park Ellesmere Port, Cheshire CH65 3EN	

SGS is the world's leading inspection, verification, testing and certification company. We are recognised as the global benchmark for quality and integrity. With more than 94,000 employees, we operate a network of more than 2,600 offices and laboratories around the world.

Our core services can be divided into four categories:
Inspection: our comprehensive range of world-leading inspection and verification services, such as checking the condition and weight of traded goods at transshipment, help you to control quantity and quality, and meet all relevant regulatory requirements across different regions and markets
Testing: our global network of testing facilities, staffed by knowledgeable and experienced personnel, enable you to reduce risks, shorten time to market and test the quality, safety and performance of your products against relevant health, safety and regulatory standards.

Stone Junction

Website:	www.wechangeminds.com	40
Phone:	+44 (0) 1785 225416	
Email:	sayhello@stonejunction.co.uk	
Address:	1 St Mary's Place, St Mary's Grove, Stafford Staffordshire ST16 2AR	

Stone Junction is a technical PR and digital marketing agency, delivering international PR results, strategic consultation and global storytelling for clients around the world.

We are Joined-Up-Content specialists. We generate content that works in every single part of your marketing strategy. Content that makes your business easy to find, easy to trust and easy to choose.

Are you a STEM company looking for expert PR and digital marketing? Or maybe you are currently working with multiple agencies for various different services?

Work with Stone Junction, an agency that streamlines all of your PR and digital marketing needs under one roof. We create content that speaks to the media, whilst handling all aspects of your digital marketing strategy.

PUT SIMPLY, WE CHANGE MINDS.

Telonic Instruments Ltd

Website:	www.telonic.co.uk	23
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Email:	info@telonic.co.uk	
Address:	Unit 5, The Business Centre, Molly Millar's Lane, Wokingham, Berkshire RG41 2QZ	

Telonic Instruments Ltd an ISO9001:2015 registered company which specialises in Test Instruments and Programmable AC and DC Power Supplies from industry leading manufacturers including Kikusui, Delta Elektronika, Lab-Power, ETL Pruftechnik, Rigol, Siglent, Brymen, Danisense, Tekbox, Graphtec, Sensepeek, Microtest, and Micsig. Telonic has been supporting the electronics, automotive, aerospace, education, manufacturing, research and development sectors with sales, service, calibration and hire in the UK for over 50 years.

TWEX

Website:	www.emcandci.com/twex1	1

TWEX – Ten minutes With an EXpert - Get your free 10-minute consultation! TWEX is a completely new type of activity at exhibitions and conferences, and this is its first outing!

A wide variety of experts (we call them TWEXperts) will be offering their advice for free, for no longer than 10 minutes at a time, during the EMC & Compliance International event at Newbury Racecourse, 18th and 19th May 2022, www.emcandci.com.

To help you decide whom best to see, please see the 'TWEXperts Bios'To see when each 'Twexpert' will be available please see the 'TWEXpert Timetable

Unit 3 Compliance Ltd

Website:	www.unit3compliance.co.uk	51
Phone:	01274 911 747	
Email:	hello@unit3compliance.co.uk	
Address:	2, Wellington Business Park New Lane, Bradford West Yorkshire, UK BD4 8AL	

Consultants solve EMC problems. Laboratories provide test services. What happens when you have both? You get us. Great advice and quality testing at the same time. Unit 3 Compliance is a test laboratory and consultancy specialising in EMC testing, problem solving, pre-compliance and design analysis.
We solve EMC problems quicker, cheaper, and more effectively than anyone else we know.

Our combination of product design experience, EMC skills, and full test laboratory lets us iterate rapidly from theory > experiment > new theory > new experiment. Experience has taught us which investigation paths are likely "dead ends" helping us get your product under the limit line even faster.
Our services don't just stop at the EMC test report. From initial design review, product specification, through pre-compliance, to final compliance testing and ongoing design change support. We also offer testing for Electrical Safety, vibration & shock, and temperature & humidity.

Wurth Electronics (UK) Ltd

Website:	www.we-online.com	38
Phone:	+44 161 872 0431	
Email:	eiSos-uk@we-online.com	
Address:	8 The Vic, MediaCityUK, M503SP, Manchester	

The Würth Elektronik group of companies, with headquarters in Niedernhall (Hohenlohe), Germany, has about 8,300 employees worldwide and generated global sales of € 848 million in 2018 (prel.). With 16 production locations worldwide, Würth Elektronik is one of the most successful companies of the Würth Group.

Würth Elektronik operates internationally with its three company areas in various markets: Electronic & Electromechanical Components / Headquarters: Waldenburg Würth Elektronik eiSos is one of Europe's biggest manufacturer of electronic & electromechanical components. Together with Wurth Electronics Midcom, Würth Elektronik iBE, Erwin Büchele and Würth Elektronik Stelvio Kontek, Würth Elektronik eiSos ensures a high availability on all markets. More than 700 sales representatives worldwide make up a direct sales network that is unique in this industry: Local Design in support, all catalogue products in stock and samples free of charge is the promise to our customers. Würth Elektronik operates production plants in Europe, America and Asia. More than you expect!

Circuit Boards / Headquarters: Niedernhall One of the leading producers of printed circuit boards in Germany, Würth Elektronik CBT has specialized in prototypes and in small and medium-sized orders. Electronics developers can find here all the prevalent and many innovative circuit board technologies and system solutions, all from a single source. Last but not least, they can also speak here with expert specialists.

"Ten minutes With an EXpert"

Get your **FREE** 10-minute consultation!

TWEX is a completely new type of activity at exhibitions and conferences, and this is its first outing!

A wide variety of experts (we call them TWEXperts) will be offering their advice for free, for no longer than 10 minutes at a time, during the EMC & Compliance International event at Newbury Racecourse, 18th and 19th May 2022.

Ian MacDiarmid

Visiting Professor in Applied Electromagnetics at University of Liverpool, 35 years in aerospace electromagnetic engineering. The final twelve years as Head of Electromagnetics at BAE Systems

- Electromagnetic Hazards (e.g. HIRF, EMC, EMP, DEW) design, development, verification, qualification
- Installed antenna performance – design, development, verification, qualification

Geraldine Salt

BSI Standards Development Manager for EMC, Energy, Oil, Gas,

- The standards-making process
- How to participate in International and European standards bodies
- How to join a BSI Committee
- Demonstration of BSI standards development portal
- BS Online
- Ecommittees

Andy Degraeve

Cherry Clough Consultants Ltd

- Quick and Easy EMC Education using low-cost test equipment
- Quick and Easy EMC Diagnostics using low-cost test equipment

TWEX Speakers

Charlie Blackham

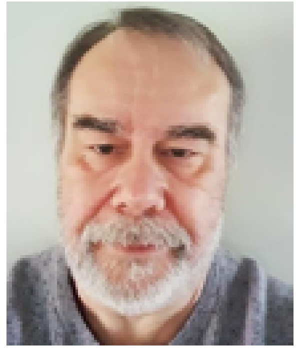
Sulis Consultants Ltd

- Radio Equipment Directive compliance – self declaration or using Notified Body
- EMC Directive compliance
- LVD compliance
- CE marking Technical Files
- RoHS Directive compliance
- FCC/IC/EU radio testing
- Radio modules and integrating radios into non-radio products
- Efficient EMC test planning
- Do I need to use an accredited test lab?

Michael Derby

Technical Director at Element Materials, Connected Technology

- RED (Radio Equipment Directive) compliance
- RED EU Type Examination Certificates
- FCC USA Radio Certifications
- ISED Canada Radio Certifications
- FCC and ISED Electronics compliance (sDoC)
- Test Planning and Test Reduction
- Test Standards, Test Labs, Measurements
- Radio Module approvals
- Installing Radio Modules
- Combining radio and non-radio equipment
- Surfing, Karate, Mexican food, beach life



Neil Bonter

CE & FCC Compliance Consultant (TCFs), Member of the REDCA

- RED (Radio Equipment Directive) compliance (EU)
- EMC Directive compliance (EU)
- Machinery Directive compliance (EU)
- LVD & Electrical Safety
- Electromagnetic Exposure Safety
- Technical file construction
- RISK assessment
- On-site EMC Testing

James Pawson

EMC Problem Solver, Unit 3 Compliance

- EMC problem solving
- Design for EMC
- EMC Pre-Compliance Testing
- CE marking
- Reducing costs of EMC testing

Jeremy Smallwood

Electrostatic Solutions Ltd

- Static electricity and electrostatic discharges (ESD)
- Real world ESD: What they're like and how they happen
- Electrostatics and ESD standards

Dr Min Zhang

Mach One Design EMC Consultancy

- PhD received within Newcastle University's Electrical & Electronics Engineering department in 2013.
- EMC specialist on milestone projects with Dyson Technology, UK.
- EMC capability for the Dyson Electric Vehicle project.
- Mach One Design with Cherry Clough Consultants Ltd

TWEX

TWEX Biographies

Michael Derby

Technical Director at Element Materials, Connected Technology

Michael Derby is a Technical Director at Element Materials in their Connected Technologies group, supporting manufacturers and colleagues in the test and approval of radio enabled equipment. He has more than 30 years' experience in the industry, with testing and approvals roles, including EMC, Radio performance, and RF Exposure SAR. He also provides training and technical support to the industry through advisory projects and seminar courses. Within Element, Michael is a Certification Body for the USA and Canada; an EU Notified Body for the RED and a UK Approved Body for the RER.

Michael has been with Element since September 2020.

Michael is an active member of the REDCA (RED Compliance Association) and TCB Council; acting as the liaison between the two organisations and author of many technical guidance documents within the industry.

Michael is the technical secretary of the EMC Test Lab Association.
His past experience includes product development, testing and certification for manufacturers and test laboratories. He provides worldwide services to customers and colleagues from his office in the Hampshire area of the UK.

Ian MacDiarmid

Visiting Professor in Applied Electromagnetics at University of Liverpool, 35 years in aerospace electromagnetic engineering. The final twelve years as Head of Electromagnetics at BAE Systems

Ian worked at BAE Systems from April 1978, starting as an EMC Test Engineer, then becoming the Company Specialist in EMC in 1980. As the subject broadened to include Low Observability, Installed antenna performance and EW installed systems, Ian became a Company Consultant in Electromagnetics, ultimately becoming Head of Electromagnetics in 2002.

In 2007 Ian was appointed as a Company Engineering Fellow. Ian retired from BAE Systems, reluctantly, due to ill health, in September 2013.

Ian has been actively involved with the IET for many years, including Chairman of three specialist groups over the years and continues to be a member of the TPN, also a regional PRA, Registration Assessor and Fellow Assessor and interviewer and referee for two journals.

Geraldine Salt

BSI Standards Development Manager: EMC, Energy, Oil, Gas,

Geraldine is a Standards Development Manager at the British Standards Institution (BSI). Part of her role involves managing a number of national committees which are responsible for UK input to ISO/IEC Standards and CEN/CENELEC ENs.

The committees which she manages are mainly in the electrotechnical area and cover subjects including:
• Electromagnetic Compatibility (EMC)
• Safety of household and similar electrical appliances
• Equipment and systems incorporating lasers and LEDs
• Electrotechnical technical policy

Geraldine has previously been Secretary to the international committee responsible for standards on Lighting and the European Committee responsible for standards on Automatic Controls for Household Use.

She is also Committee Manager to the BSI Committee responsible for industrial valves, steam traps, actuators and safety devices against excessive pressure.

James Pawson

EMC Problem Solver, Unit 3 Compliance

Unit 3 Compliance is a West Yorkshire test lab and consultancy specialising in EMC testing, troubleshooting/problem solving, pre-compliance and product design support.

James has 10+ years experience in EMC design, testing, fault finding and problem diagnosis and in running an EMC test laboratory. He finds his wide ranging electronics and product design background invaluable in coming up with innovative solutions to all manner of EMC problems.

His career has spanned several different disciplines including industrial LCD monitor design, SMPS design, microcontroller coding, environmental testing, thermal design and simulation, high speed digital design/test and project management.

Outside of work James is a keen board gamer, cyclist, runner and mountaineer and can often be found on the local hills, occasionally muddy.

TWEX Biographies

Andy Degraeve

Cherry Clough Consultants Ltd

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, Andy is focussing on EMC education and diagnostics using low-cost test equipment,
and joined Cherry Clough Consultants Ltd to provide independent expertise in good, costeffective EMC design, worldwide.

Charlie Blackham

Sulis Consultants Ltd

Charlie Blackham is the founder and Director of Sulis Consultants. He specialises in helping companies meet CE marking and other Product Approvals requirements worldwide from their offices in north-eastHampshire.

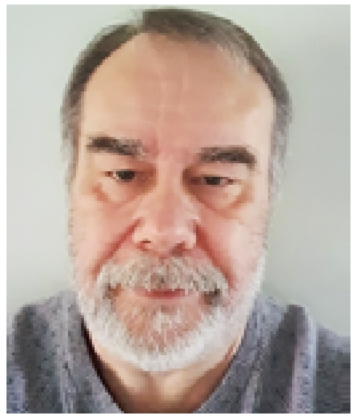
Charlie can perform or arrange test plans, testing and certification using his own expertise and a team of compliance partners. Charlie regularly performs the compliance testing and technical reviews, in addition to the compliance consultancy. He is an active member of the REDCA (RED Compliance Association) and a UKAS accredited RED Notified Body Technical Expert.

His past experience includes compliance management for product manufacturers and technical reviews for a certification body and Notified Body for the RED and EMCD.

Charlie is a graduate in Electrical and Electronic Engineering, a Chartered Engineer and member of the IET.

Neil Bonter

CE & FCC Compliance Consultant (TCFs), Member of the REDCA



Neil Bonter has been an independent consultant running his own business for the past 12 years. Specialising in the Radio Equipment Directive, EMC and Safety for CE compliance with testing, documentation and assisting customers with their compliance. Many clients now require more extensive support into other world markets and TCFs assists with compliance into many other countries such as North America, Australia and many Asian countries.

For many years the manager of the regulatory and Notified Body department at RFI and a long-standing member of the REDCA and supporter of SRCG. A wealth of experience has been gained from more than 40 years in the electronics industry, commercial control systems, military fire control and domestic sound and vision.

Jeremy Smallwood

Electrostatic Solutions Ltd

Jeremy designed electronic instruments before completing his PhD in electrostatic discharge ignition studies.

In 1998 he formed Electrostatic Solutions Ltd, providing electrostatics consultancy, training and R&D services.

He works with British and IEC standards and was awarded the 2010 ESD Association Industry Pioneer Award and 2017 International Fellow Award at Electrostatics 2017.

Dr Min Zhang

Chief EMC Consultant at Mach One Design EMC Consultancy

Dr. Min Zhang received his PhD within Newcastle University's Electrical & Electronics Engineering department in 2013.

His research was in novel power switching schemes to reduce EMI emissions, and his research papers have received many citations.

Since then, he has worked as an EMC specialist on milestone projects with Dyson Technology, UK.

With a proven track record designing state-of-the art electronics and electric machines with minimal EMC issues, Min then established the EMC capability for the Dyson Electric Vehicle project.

Following the closure of that project, he started Mach One Design, and became associated with Cherry Clough Consultants Ltd, to provide independent expertise in good, cost-effective EMC design, worldwide.

Min's in-depth knowledge in power electronics, digital electronics, electronic machines and product design is sure to benefit your product's design, helping you win the race against time and cost.

Getting the Financial Resources We Need

How to Get the Financial Resources We Need

A problem faced by all engineers and engineering managers is persuading our managers that we need a new item of test equipment, or need to add something to a product that is not in its technical specification (for example to reduce financial risks such as high levels of warranty returns), or whatever.

Our managers need us to provide justifications that use financial language – often so that they can then use the same arguments to persuade the bean counters (otherwise known as accountants) that run all engineering companies. But we have to be the ones that do it!

The Heart of the Challenge

Make no mistake, modern electronics and other engineering is all about the money, and if we want our companies to be successful we must learn to communicate in money terms.

The Secret to Getting What You Want

Every engineer needs to be able to describe their company investment needs in terms that their Financial Director can understand, as this often the person who runs the whole company but usually knows almost nothing at all about what it actually does or how it does it!

Since I learned how to justify expenditure on engineering over 30 years ago, I have not had a single capital application, design change request or request for additional personnel turned down, ever.

Read my step by step method to help you effectively communicate engineering needs to managers, at 'Getting what you want' . It will help your company be successful, and may also help you get raises and promotions!

The person who runs the whole company but usually knows almost nothing at all about what it actually does or how it does it!

Your proposal must have an attention grabbing Executive Summary followed by detailed and thorough appendices.

The Executive Summary must contain...

a) The financial benefits to your company

b) The timescale over which the benefits will be realized (a simple graph is often best)

c) The probability of success (don't be shy, even a 50% chance of success is a very good bet for a gambler)

d) The total value of the investment required to achieve the above

e) The timescale over which the investment will be required (e.g. a simple graph)

f) Briefly say what the investment will be used for, using commonplace words (no jargon, technical terms or standards numbers)

In all the above, be direct and straightforward.

Don't try to achieve the Nobel Prize for Literature, just get your basic message across without ambiguity.

Once you have their attention, they can read all the details, and caveats, in the carefully argued appendix (10-point Arial, single line spacing, 6-point paragraph spacing, for example).

It is generally best to have an appendix with two sections:

- The first section amplifies the five basic items in the Executive Summary, using about one page each, so each of these is itself likely to be a summary. Avoid technical language as far as possible, because your manager is likely to read this section – if your Executive Summary crossed his or her noise threshold and got him interested.

- Your detailed calculations, using all the technical information you need. Your manager will almost certainly do no more than skim this to see how much effort you put into your proposal. But if you don't get them interested in the first 10 seconds or so, the appendices and all the work that went into them will be wasted.

Since I learned how to justify expenditure on engineering over 30 years ago, I have not had a single capital application, design change request or request for additional personnel turned down, ever.

The Magic Loop Techniques Of Using Magnetic Field Loops

Theory

The simplest form of a transformer is a pair of wires placed in close proximity. When a changing current I1 goes through conductor 1, there is voltage induced on conductor 2 (assuming conductor 2 is open circuit). The induced voltage is defined as

V2 = M dI1/dt,

where M is the mutual inductance between the two conductors.

Therefore, a square magnetic field loop shown in Figure 2 is ideal to measure the induced voltage on one side of the loop, which is proportional to the rate of change of flux generated by rapidly changing current in the wire under test. Such a loop is called magnetic field loop, or “H-field loop”. But it is more accurate to be called a “dΦ/dt” loop.

It is important to emphasize here that the output of the square magnetic field loop is a voltage measurement (assuming the other end of the coaxial cable is connected to either a spectrum analyzer or an oscilloscope with a 50-ohm impedance).

Since the mutual inductance M is less than the inductance of either

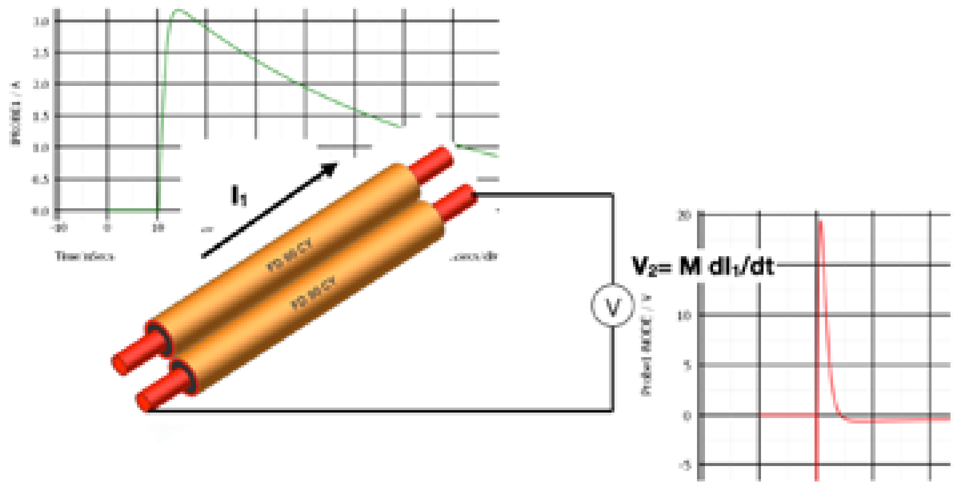


Figure 1 Two conductors as a 1:1 transformer

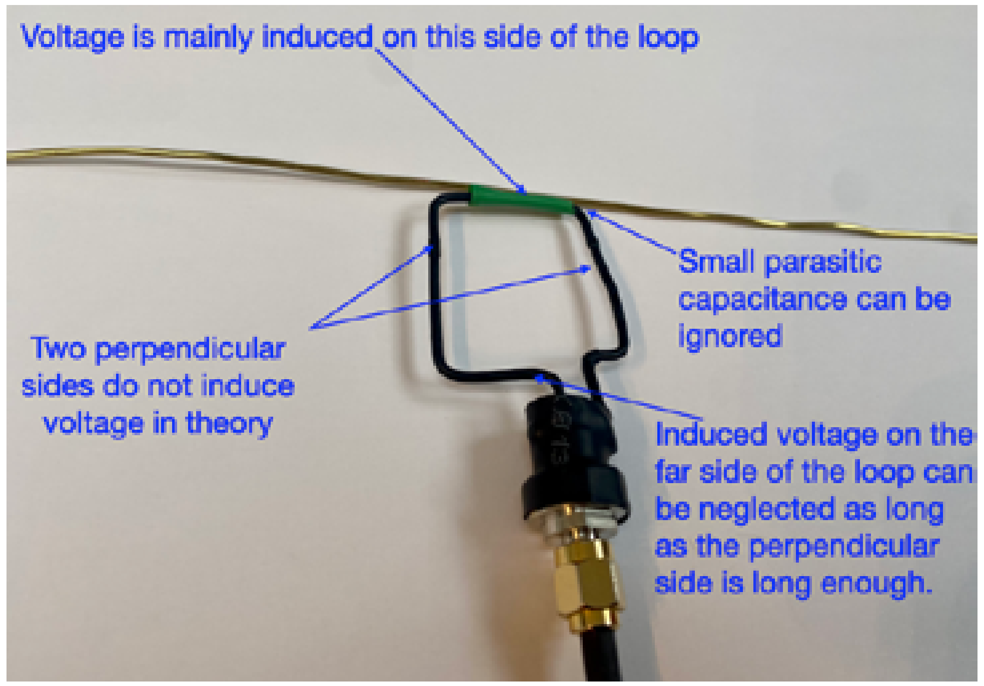


Figure 2 An unshielded square magnetic field loop placed alongside a wire

conductor, the output of a magnetic field loop is a lower bound for the voltage per unit length across the inductance of a current carrying conductor [1].

Note, a few assumptions are needed to make the sense of a magnetic field loop.

1. The circumference of the loop is significantly less than ½ wavelength at the frequency of interest. This is because the loop could self-resonate. For instance, for a 8 cm long loop, the self-resonant frequency is about 2GHz. This means the loop can be useful up to at least 1 GHz.
2. The opposite side of the loop is far enough away so the induced voltage on the far/opposite side of the loop is neglected (see Figure 2).
3. The perpendicular sides of the loop do not induce voltages (see Figure 2).
4. The parasitic capacitance between the magnetic field loop and the wire is ignored.

According to [1], a magnetic field loop can be modelled as shown in Figure 3. In this case, a 8 cm magnetic field loop is simulated (with circa 2 cm long conductors on each side). The 10 nH inductance value is the mutual inductance M. The 70 nH is the self-inductance of the loop. The 50 ohm impedance (of either a spectrum analyzer, or an oscilloscope with 50 ohm impedance) forms an L-C filter with the inductance of the loop. This causes the cut-off frequency shown in the frequency response.

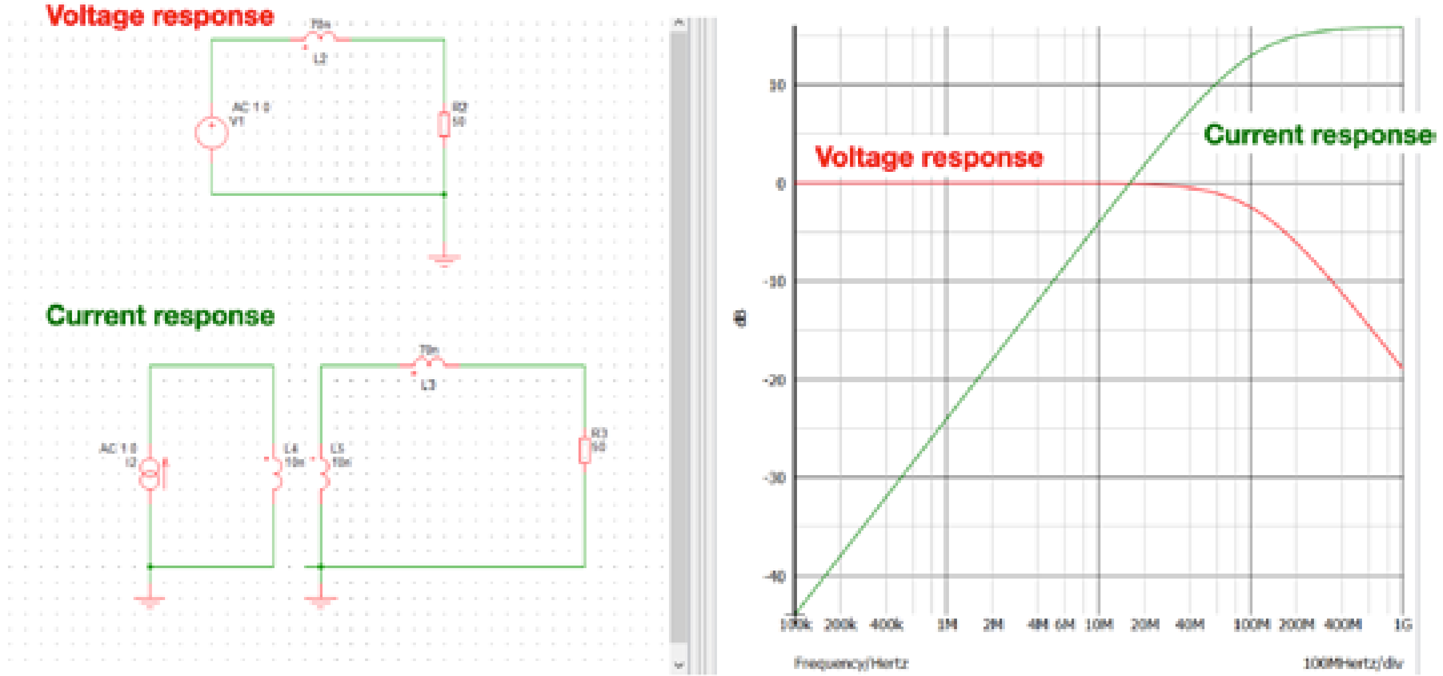


Figure 3 Voltage and current responses of a magnetic field loop

As it can be seen, the voltage response of a magnetic field loop is flat until the cut-off frequency (in this case, around 100 MHz). Above this frequency, the sensitivity of the loop starts to drop at a rate of -20dB/dec. This means the loop is useful for voltage measurement till at least 100 MHz.

The current response of the magnetic field loop (shown in green in Figure 3) means that a magnetic field loop can be used to measure (or to put it more precisely, estimate) high frequency current (whose frequency contents extend beyond the cut off frequency of the magnetic field loop). However, in general, this is not a preferred approach. This is because the mutual and self inductance of a loop is difficult to quantify (really depends on the loop construction and how one places the loop on the PCB, or next to a wire). Thus, the transfer impedance (the ratio between measured voltage to the current) of a magnetic field loop is almost impossible to calculate.

The Magic Loop Techniques Of Using Magnetic Field Loops

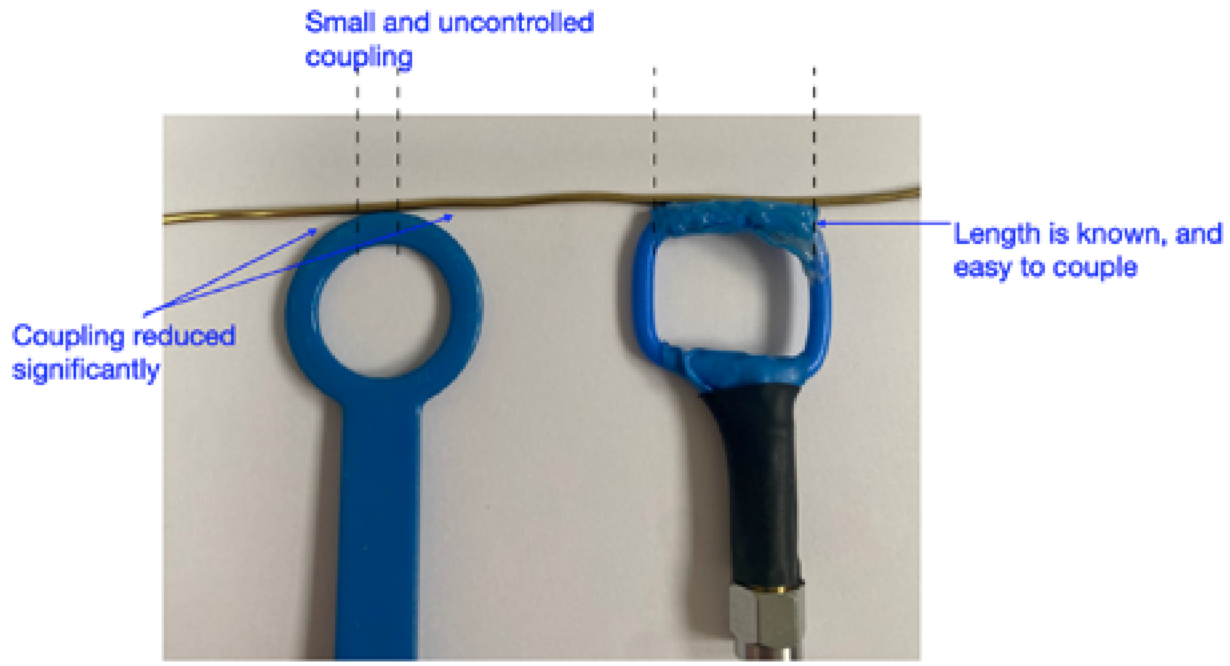


Figure 4 Square shaped vs round shaped magnetic field loop

Types and Constructions

Round shape or square shape?

The shapes of a magnetic field loop don't matter that much. However, it is highly recommended that square shaped magnetic field loops should be used for EMC troubleshooting purposes. The reason is simple, as demonstrated in Figure 4, square shaped magnetic field loops have the advantages of being easy to couple to the subject under test. The mutual inductance of a square shaped loop is also relatively easier to quantify compared with that of a round shaped loop.

Shielded or unshielded?

The debate of shielded or unshielded magnetic field loops can be found in [2]. According to [2], unshielded loops work well as the shielded types in most applications. They are widely used for noise injection purposes during the pre-compliance immunity test.

Construction of a simple unshielded magnetic field loop and instructions of making

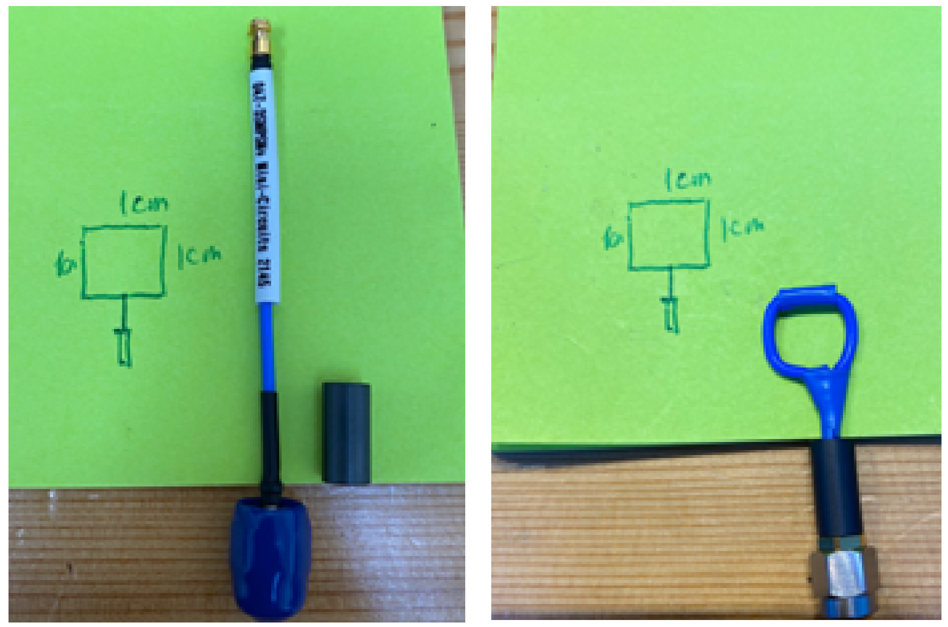


Figure 5 Using a mini-circuits hand-flex coaxial cable to make a 4 cm shielded magnetic field loop

shielded types can be found in [2]. Compared with unshielded loops, making a shielded loop takes much longer time and cost more. The trick of making shielded magnetic field loops depend on the semi-rigid coaxial cable. The best cables for making shielded magnetic field loops are

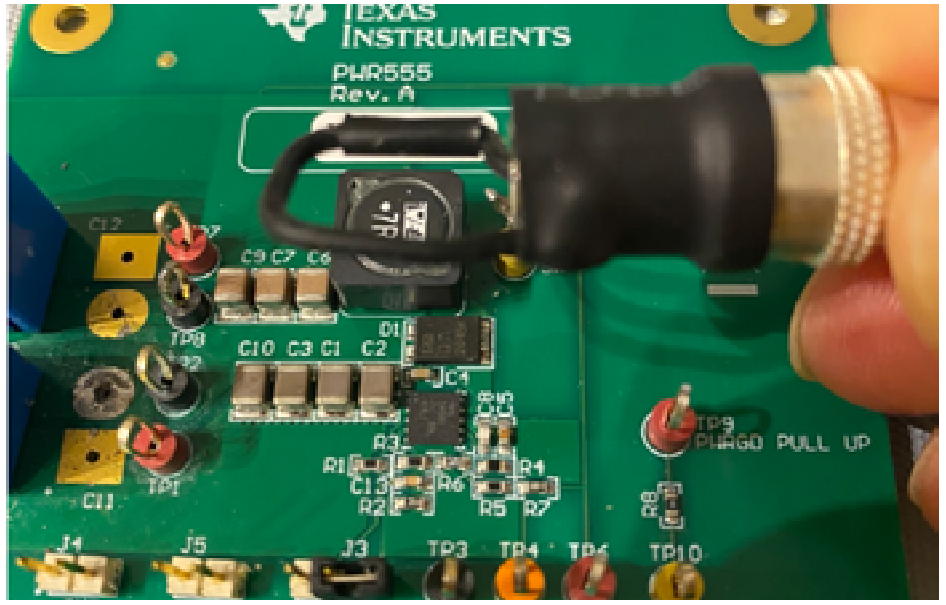
1. Mini-circuits Hand-flex Interconnect, 0.086'' centre diameter coaxial cables for making a 8 cm magnetic field loop.
2. Mini-circuits Hand-flex Interconnect, 0.047'' centre diameter coaxial cable for making a 4 cm magnetic field loop. A larger diameter such as the 0.086'' cable cannot be bent to form a small loop such as the 4 cm loop.

Measurement

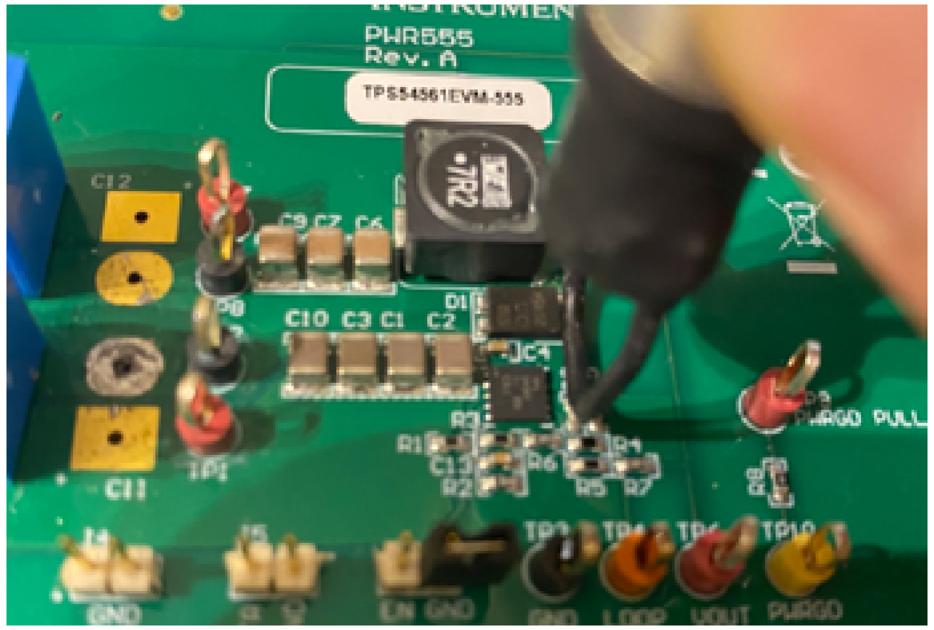
Positioning

There are two ways of positioning a magnetic field loop over a PCB. When positioned horizontally to the PCB (shown in Figure 6 (a)), a magnetic field loop picks up the changing magnetic field using the whole loop area. This is what the EMC engineers called "sniffing". The purpose is to identify the "hot" area (maximum changing magnetic field area) on the PCB. The magnetic field loop can be connected either to a spectrum analyzer or an oscilloscope with 50 ohm impedance. The "hot" area is identified when the results on the scope/spectrum analyzer shows maximum values during the "sniffing" exercise.

When positioned perpendicularly to the PCB (shown in Figure 6 (b)), a magnetic field loop is used to measure the induced voltage on a particular trace/ track on the PCB. The reason that the loop needs to be placed perpendicularly is to minimize the induced voltage on the side wires of the loop. In this case, the magnetic field loop should be connected to a high bandwidth oscilloscope as the measurement is in the time domain.



(a)



(b)

Figure 6 Positioning of a magnetic field loop over a PCB (a) horizontal position to "sniff" (b) perpendicular position to measure induced voltage on a trace

Demonstrations

For a typical buck converter, the current waveforms of the switch side and the load side are shown in Figure 7. Both the switch node and the "hot loop" area are shown. A Texas Instrument buck EVM board is used for demonstration purposes. Moving a magnetic field loop horizontally over the PCB, one can easily identify the "hot loop" area. In Figure 8, the induced peak to peak voltage reached 300 mV for a small magnetic field loop, indicating a sharp rise time during the hard switching events. If one were to integrate the result, a current waveform similar to that is shown in Figure 7 (the MOSFET current waveform) can be arrived at. Remember, the magnetic field loop outputs a voltage reading (V=Mdi/dt). To get the current waveform, one need to do an integration.

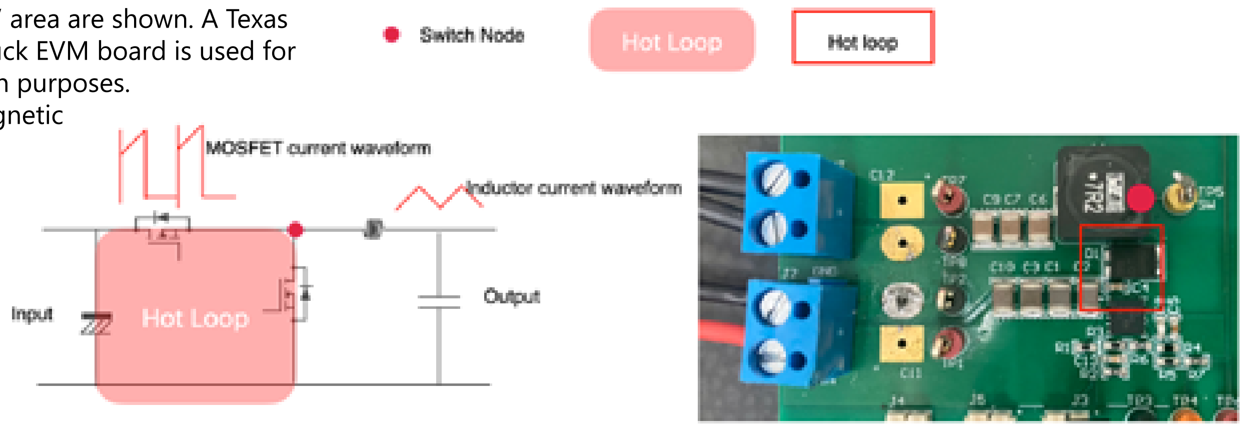
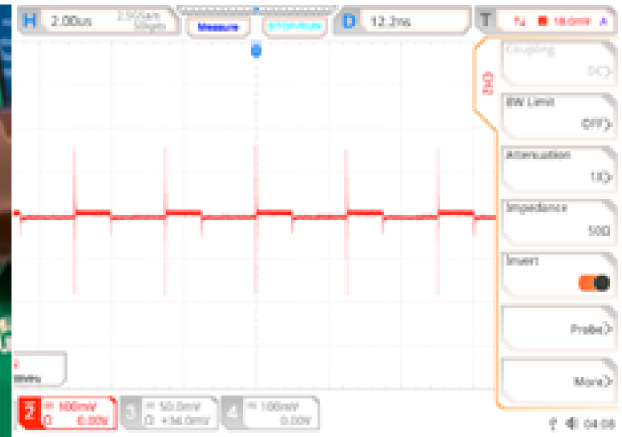


Figure 7 The "hot loop" area in a buck converter

(a) A magnetic field loop is placed over the "hot loop" area



(b) Results shown in the oscilloscope

Figure 8 Placing a magnetic field loop horizontally over the PCB and move along the loop until the maximum induced voltage is seen in the oscilloscope

I=1/M·∫Vdt

Similarly, when placing the loop over the inductor, a smooth voltage waveform is seen as shown in Figure 9. Using the integration function in the oscilloscope, one can calculate the inductor current waveform (shown in green triangular waveform in Figure 9).

After the "hot loop" area is identified, the next step is to place the magnetic field loop perpendicularly to the PCB and move it slowly across the suspicious area. Note down areas where large voltage spikes are seen during the exercise. Because the area on the PCB is rather small, a smaller size shielded loop is used instead. A few areas on the PCB were probed, all showed similar induced voltage level as shown in Figure 10.

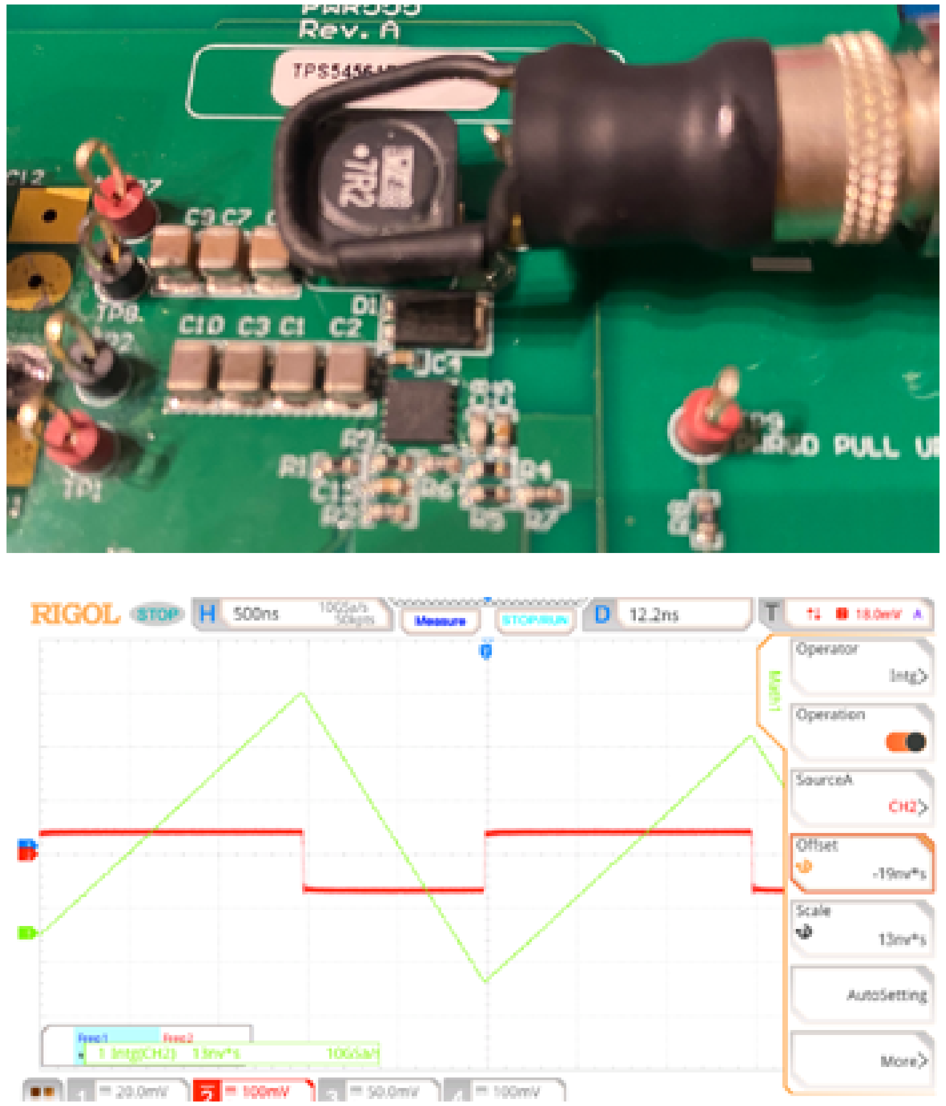


Figure 9 Placing the loop over the inductor gives the induced voltage caused by current going through the inductor. The integration of the waveform gives the inductor current waveform

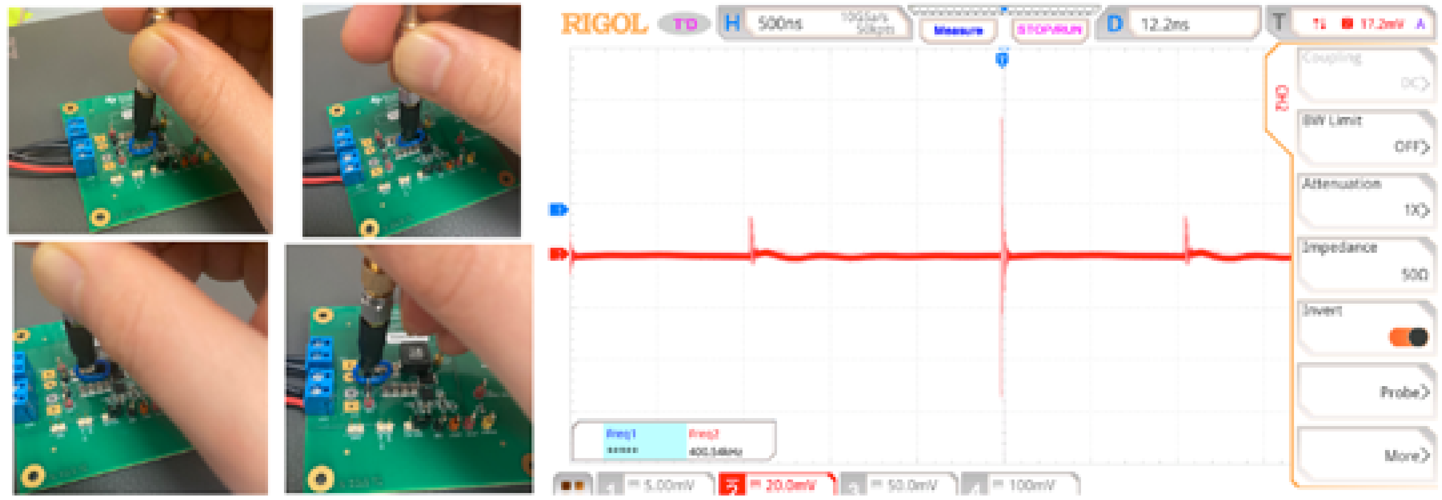


Figure 10 Use a smaller size loop and place it perpendicularly on the PCB, traces/tracks where large di/dt can thus be measured, the result is shown here.

Can we predict the EMI results based on this technique?

This is basically asking if there is any correlation between the near-field measurement and far field measurement result. And the answer is no. Any attempt to use the near field measurement to predict far field performance would lead to either under-estimation or over-estimation. Thus the proposed technique in this article is most suited for a few scenarios listed below:

» If a product/system is known to have failed EMC test, using a magnetic field loop can quickly help locate the noise source and propagation mechanism.

» If a probe is well calibrated, then using the loop might give you a Pass/Fail indication.

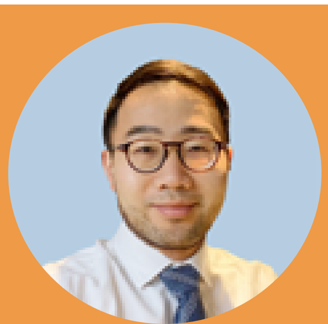
But how to calibrate a homemade magnetic field loop? Since each loop is made differently in size. For shielded magnetic field loops, the diameter of the coaxial also plays a role in affecting the mutual inductance. Many factors could affect the reading of a magnetic field loop. Therefore, the loop method result should only be treated as a qualitative indicator.

One method the author often uses is to test the loop on a known product. For instance, both the conducted and radiated emission test results of the EVM board in this study were known to the author. Therefore, for products that need to pass the automotive EMI test standards such as those defined in CISPR 25, any induced voltage over 100 mV on a small magnetic field loop certainly will raise a red flag. If the product is a home appliance product, then even 200mV induced on the same loop will most likely be okay.

References

[1] D. C. Smith, *High Frequency Measurements and Noise in Electronic Circuits*, New York: Van Nostrand Reinhold, 1993.

[2] Doug Smith, Arturo Mediano, "Shielded vs unshielded square magnetic field loops for EMI/ESD Design and Troubleshooting," *InCompliance Magazine*, vol. July, no. July, 2014.



Dr. Min Zhang,
Mach One Design Ltd

Dr. Min Zhang received his PhD within Newcastle University's Electrical & Electronics Engineering department in 2013. His research was in novel power switching schemes to reduce EMI emissions, and his research papers have received many citations.

Since then, he started Mach One Design, and became associated with Cherry Clough Consultants Ltd, to provide independent expertise in good, cost-effective EMC design, worldwide.

Min's in-depth knowledge in power electronics, digital electronics, electronic machines and product design is sure to benefit your product's design, helping you win the race against time and cost.

A Capacitively Coupled Pin Injection Method

For EMC testing in the automotive, military and aerospace sectors, a Bulk Current Injection (BCI) test is widely used as an immunity test method.

This test requires a high-power amplifier (often at least 80 Watt unsaturated output power), together with a BCI injection probe, to achieve a reasonably high interference level on the device under test (DUT). . The BCI injection probe and monitor probe are shown in Figure 1.

In this example, an automotive remote controller unit has experienced immunity issues during the BCI test in an accredited testing laboratory. The Local Interconnect Network (LIN) of the module lost communication in the frequency range between 5 and 15 MHz. The BCI test results are shown in Figure 2.

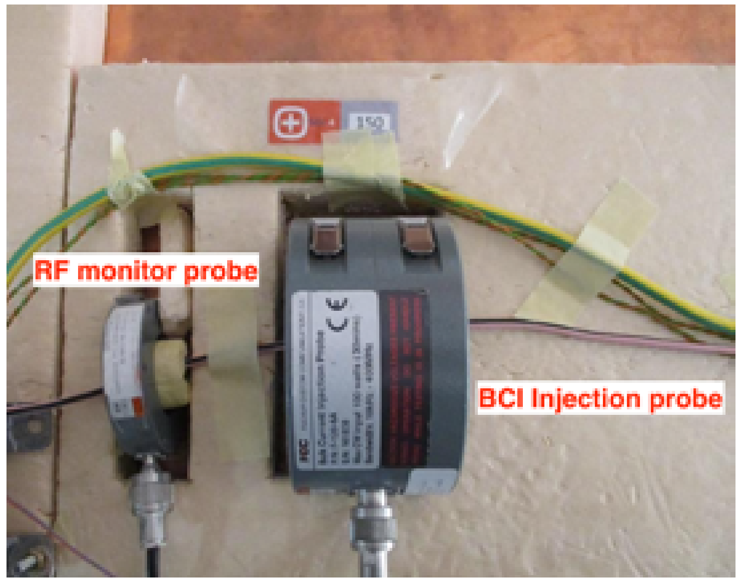


Figure 1 BCI injection probe and RF monitor probe set-up for BCI test.

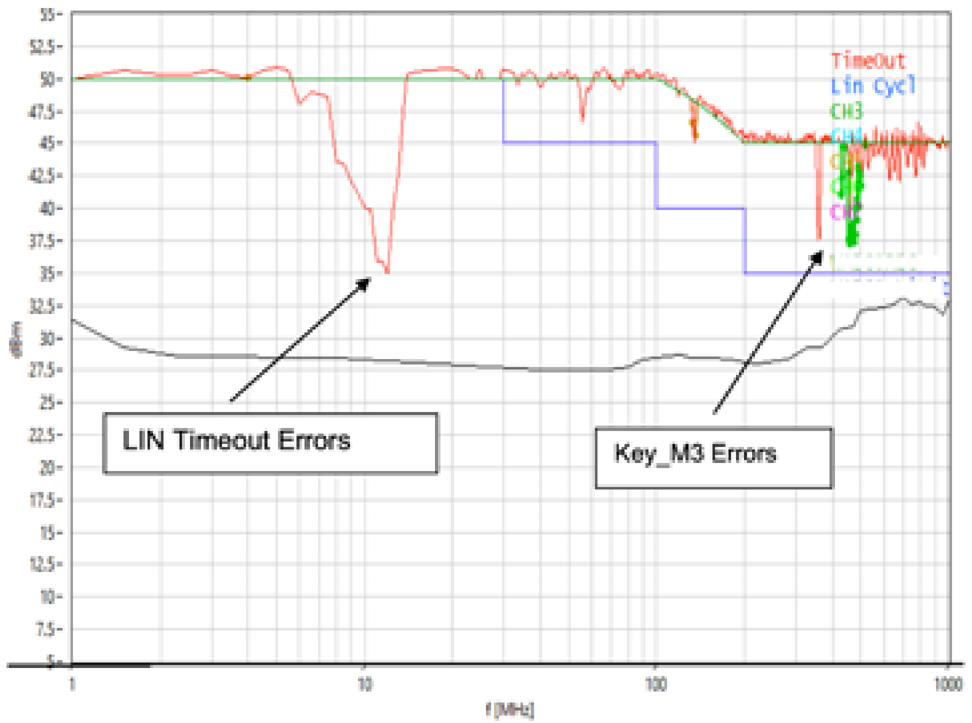


Figure 2 LIN communication errors from 5 MHz to 15 MHz during BCI test

Commonly Used Pre-Compliance Immunity Test Techniques

As always, to fix an EMI issue, the same failure mode needs to be reproduced in a precompliance EMC test set-up. For pre-compliance EMC tests, unless the specific BCI test equipment is available, to reproduce the same failure mode often requires a different setup. In this article, a capacitively coupled pin injection method as an alternative is presented.

The Following Test Set-Ups Are The Most Commonly Used In Pre-Compliance Emc Immunity Tests:

1. **A Workbench Bci Test Using An Rf Monitor Current Probe As An Injection Probe.**
2. **A Coupling And Decoupling Network (Cdn) Method.**
3. **A Transverse Electro-Magnetic Cell (Tem Cell) Method.**
4. **A Capacitively Coupled Pin Injection Method.**
5. **Other Methods Such As Chattering Relay**

It is often down to an EMC engineer's personal preference to select a test method that is best suited for pre-compliance EMC test. For instance, a Fischer current monitor probe F-33-1 is often seen being used as an injection probe for pre-compliance BCI test. The test setup was documented in detail and it was mentioned that in order to achieve a higher level of RF interference, one would need to put some ferrite chokes on the other side of the probe to reflect more energy to the DUT.

While this method might work to some extent, it is generally not a good practice to use an RF monitor probe to inject noise, unless you know the specified maximum RF power that you can feed into the probe. Besides, most of the RF monitor probes are designed to receive rather than emit RF signals. BCI injection probes typically have a very large cross section toroid to increase the saturation levels (see Figure 1).

Today, using a CDN is the recommended choice for immunity test. As one can see from Table 1 (Table E.1 from), compared with a BCI test, a CDN requires a much smaller power level to achieve a higher coupling factor. Using a TEM cell for immunity test is also gaining popularity, studies have shown that there is a strong correlation between the TEM cell and BCI test results.

Table 1

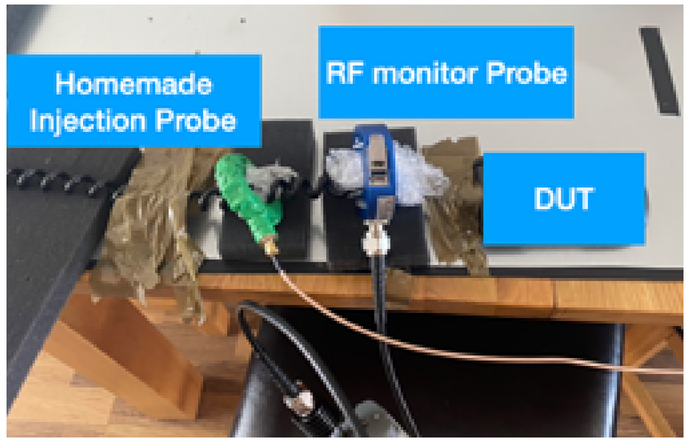
Table E.1 – Required power amplifier output power to obtain a test level of 10 V

Injection device	Minimum coupling factor ± 1,5 dB dB	Required power at output of PA W
CDN	0	7
Current clamp winding (ratio 5:1)	−14	176
EM clamp	−6	28

NOTE The coupling factor is defined in 3.6. It can be measured by using the output level setting circuit (see Figure 9c)). The coupling factor is the ratio between the output voltage U_{mr} obtained when using a coupling and decoupling device in series with a 150 Ω to 50 Ω adapter and the output voltage when using two 150 Ω to 50 Ω adapters in series.

In the following example, a suitable pre-compliance immunity test needs to be selected. Before the capacitively coupled pin injection technique was introduced, a work bench BCI injection and a TEM Cell immunity test were applied. Test set-ups for both are shown in Figure 3. In both cases, the power amplifier used is Tekbox TBMDA4. which can produce up to 37 dBm output power (5Watt power over a 50 Ω load) from 100 kHz to 50 MHz. Neither of these methods could re-produce the failure modes as seen in the actual BCI test.

Alternative Method 1 - Workbench BCI



Alternative Method 2 - TEM CELL

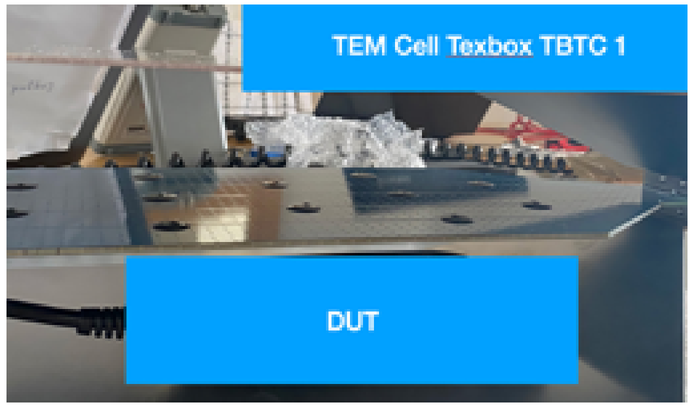
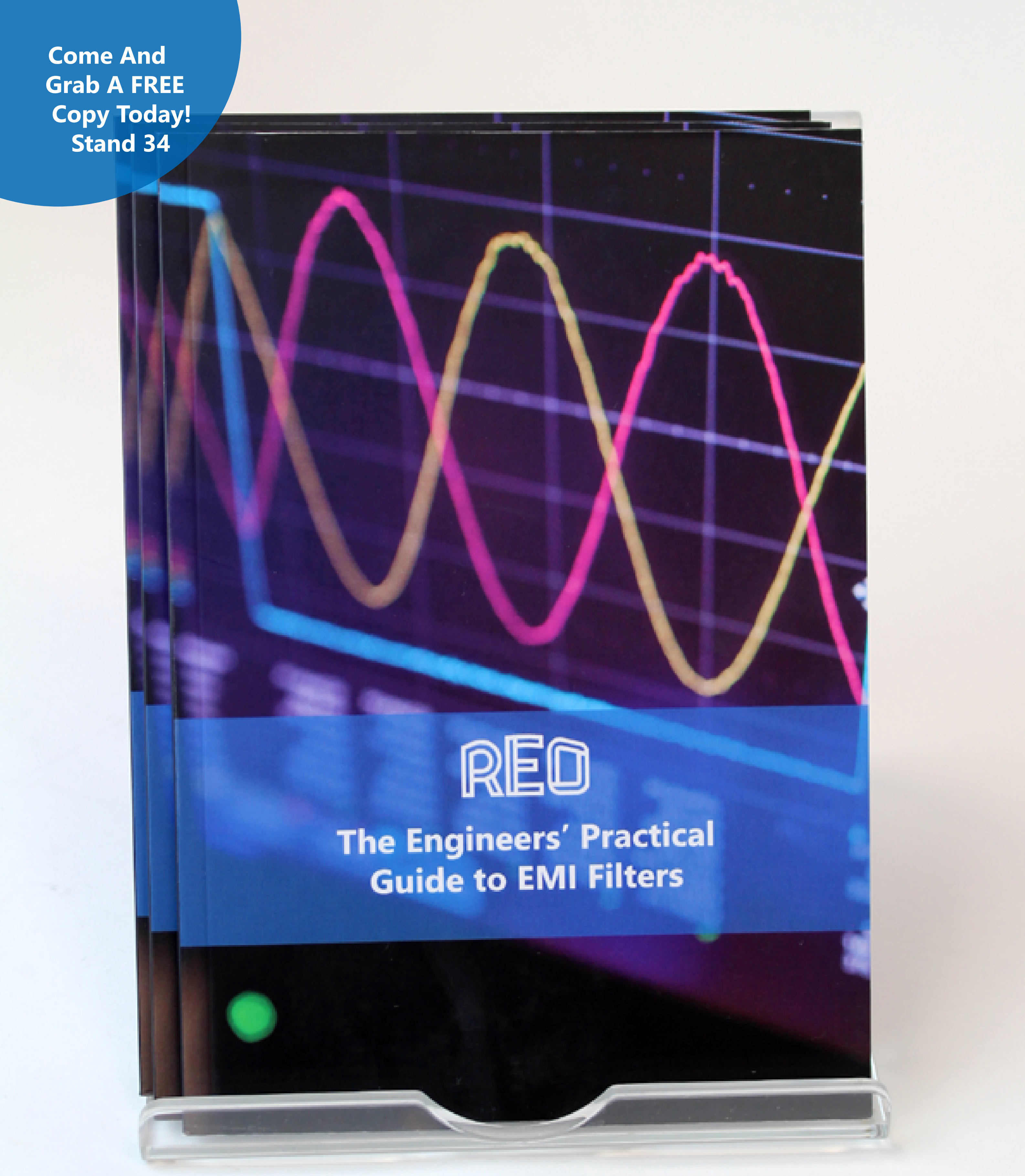


Figure 3 Two alternative immunity test set-ups

The reasons for failing to reproduce the failure mode using the workbench BCI test set-up could be that the core of the home-made injection probe was saturated during the test, or simply, the power level was not large enough. Adding multiple ferrite cores on the other side of the current injection probe proved to have little impact during the test.

The open TEM Cell (Tekbox TBTC1) used during the test could potentially achieve a field strength of 300V/m, a strong field exposure for the DUT. Immunity testing of a device in a TEM cell requires testing of at least three orthogonal DUT positions. The direction of the electrical field is orthogonal to the septum. A typical mechanism of immunity issues are PCB traces acting as antennae and coupling RF into semicoductor junctions, where the RF is rectified, resulting in bias voltages or offsets which then cause malfunction of circuitry. As PCBs typically have traces routed in two main directions, orthogonally with respect to each other, it is the best practice to test the DUT with the PCB plane orthogonal to the septum and then rotate it 90 degree, but still orthogonal with respect to the septum. Two positions of the DUT were tested in this case, the failure mode was not reproduced.



REO UK Celebrating EMC & Compliance International 2022 Event, With Their 18th Book, The Engineers' Practical Guide To EMI Filters.

Insertion Loss and Filter Performance

Filters are almost always a part of electronics design. Design engineers design a filter to achieve certain attenuation in specified frequency range. There are many types of filters, such as high pass, low pass or bandwidth. Popular filter configurations include L-C, C-L-C (π) or L-C-L (T). It is safe to say that when it comes to filter design, the discussion of the subject could easily become a very thick book.

In this article, we only want to discuss one fundamental subject, which is the performance of a filter. The performance of a filter is measured in terms of attenuation, or insertion loss, both of which use the units of dB.

Theory

The best place to start this discussion is CISPR 17, which defines the technical terms of a filter. It also presents detailed explanation of how to measure the insertion loss of a filter.

A filter often provides attenuation to noise in both differential mode and common mode. At low frequency range (often between a few kHz and 1 MHz), noise is predominantly differential mode. When the frequency goes up, common mode noise becomes more dominant.

Take a 50Ω/50Ω (source impedance/load impedance) system for instance, CISPR 17 defines two tests to measure the filter performance, which are symmetrical (differential mode) and asymmetrical (common mode). The test set-ups are shown in Figure 1. The signal generator (G) performs a signal sweep between defined frequency range and the voltage over the load (Z2) is measured.

Note that in both cases Z0 and Z2 are 50 Ω. In [1], the author(s) question the 50Ω/50Ω test set-up, arguing that worst-case test set-ups, such as 0.1Ω/100Ω and 100Ω/0.1Ω give better filter performance analysis. It is a valid point, since in reality, a 50Ω/50Ω system barely exists.

Regardless of the test set-up, the insertion loss is defined

$$\text{Insertion loss} = 20\log(V20/V2),$$

Where V20 is the voltage over Z2 before the filter is inserted, V2 is the voltage measurement after the filter is inserted. Test set-ups are shown in Figure 2.

Practical

While the theory sounds easy and straight forward.
In order to get a feel of what insertion loss of a filter is all about, here we present a practical example to demonstrate.
The filter we demonstrate is an off-the-shelf Schaffner part FN 670-3Amp. The filter and its electric schematics are shown in Figure 3.

According to the supplier datasheet, the filter performance is shown in Figure 4. As it can be seen, four test set-up results are presented to give the best filter analysis. It should be noted that for set-up C and D, the insertion loss is only performed between 10kHz

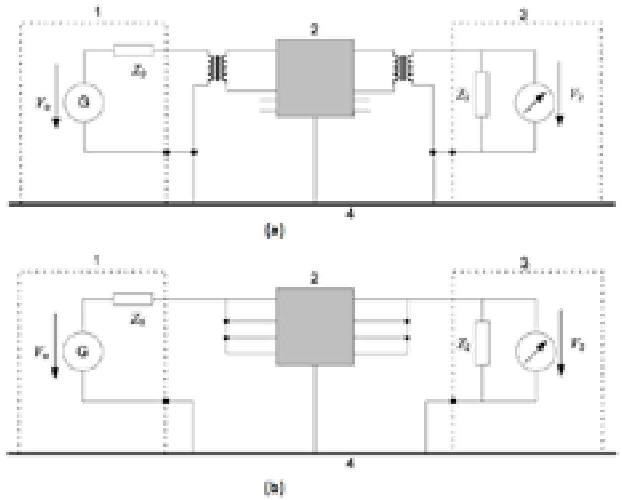


Figure 1 Test set-up for insertion loss, CISPR 17 (a) symmetrical (b) asymmetrical

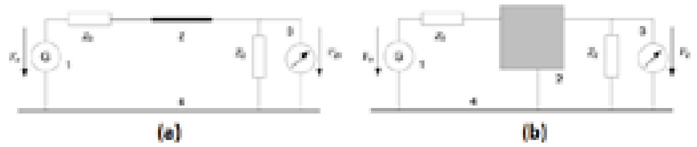


Figure 2 Test circuits for insertion loss measurement, CISRP 17 (a) reference, (b) filter

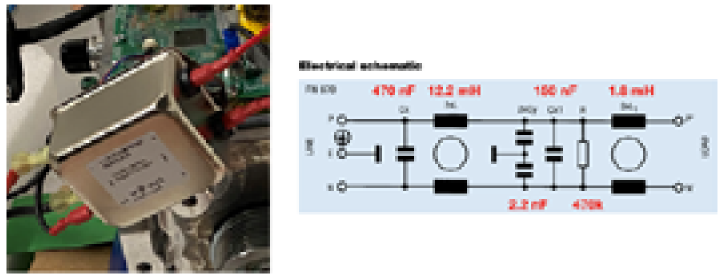


Figure 3 A Schaffner FN 670-3 Amp Filter

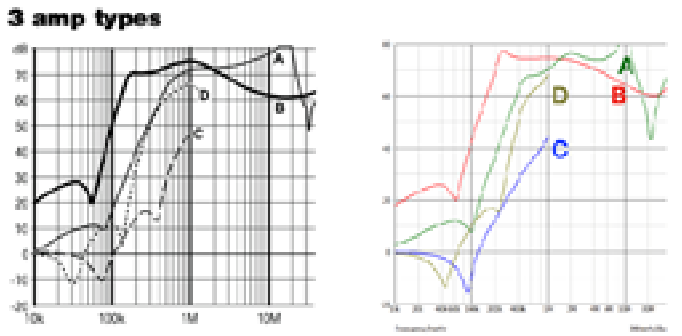


Figure 7 Simulation results match the datasheet test results almost perfectly

and 1 MHz. As we mentioned earlier, this is because when frequency goes beyond 1 MHz, common mode noise starts dominating, therefore the measurement results for the symmetrical mode beyond 1 MHz can over predict the filter performance.

A SPICE based simulation model is then modelled to demonstrate the insertion loss. The filter needs to be carefully built with the consideration of parasitic

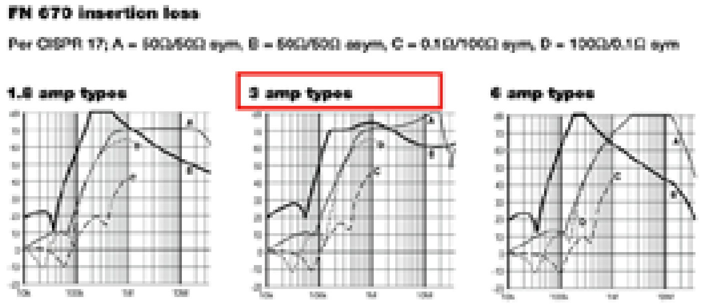


Figure 4 Insertion loss of the filter

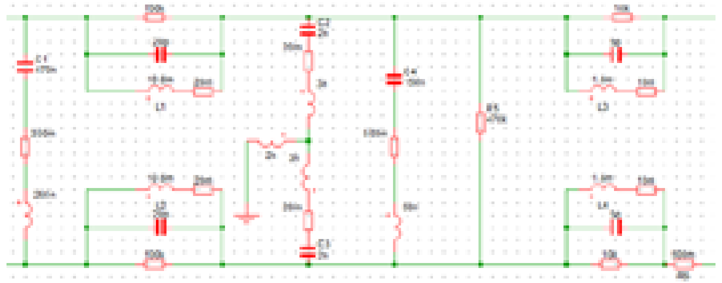


Figure 5 Simulation model of the Schaffner filter

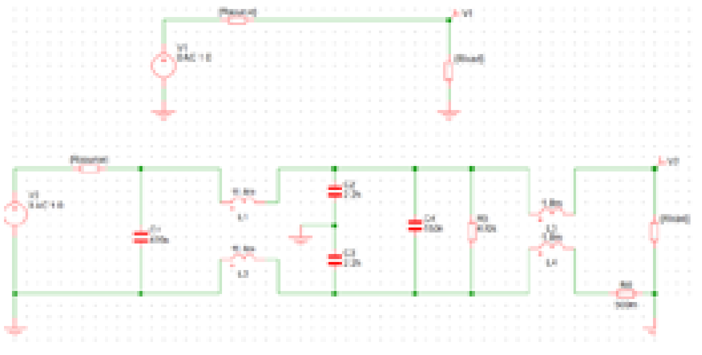


Figure 6 Simplified filter model for symmetrical (differential mode) analysis

parameters, since above 500kHz, parasitic parameters of the passive components in the filter start taking effect. The simulation model is shown in Figure 5. For details of the simulation model and how to tune the parasitic parameters, refer to.

The filter insertion loss analysis can be easily performed using the SPICE based AC analysis tool. The simulation model is shown in Figure 6. Selected frequency sweep can be completed within seconds, and the insertion loss is plotted either using the simulation probe tool or simply using the equation of 20log(mag(V1/V2)). Figure 7 shows the simulated results compared with the datasheet measurement results. As it can be seen, a high level of matching is achieved.

Conclusion

In this article, the basics of filter insertion loss and measurement set-ups are introduced. Simulation model is presented to demonstrate the filter performance. The simulated insertion loss of the filter matches the test results very well.