the emc journal

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Destined for Afghanistan

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Call it what you like...
it still interferes with the Radio Spectrum

See Page 5

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What's In This Issue

emc the journal — www.theemcjournal.com

emcia Electromagnetic Compatibility Industry Association — www.emcia.org

EMC UK 2009 — www.emcuk.co.uk

emc ACADEMY EMC Training for Industry by Industry — www.emcacademy.org

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PLT PLC BPL

Power Line Telecommunications **Power Line Communications** **Broadband over Power Lines**

Call it what you like...it still interferes with the Radio Spectrum

It may provide a cheap method of watching TV over Broadband and connecting other digital equipment but is has some very serious interference pitfalls. Despite these shortcomings, the EU (apparently supported by the UK Government) have treated with contempt legitimate complaints from some very respected organisations NATO, BBC, ERA Technology & York University plus many in Europe, these along with others being highlighted in other articles in this issue.

Why is this? It was recognised from the outset that PLT had inherent technical problems with respect to interference but such was the onslaught (lobbying) of the commercial interests that it was agreed Regulations would be overridden (ignored) in the interest of Broadband commercial success.

Will the misguided politicians and bureaucrats never learn. Is it not that very same attitude that has devastated our rainforests. Cheap fuel, gas guzzling cars and over burning of coal in power stations, that has resulted in unacceptable levels of pollution. All largely in the interests of commercial success and allowed to run amok by those self same bureaucrats. Who now desperately try to make themselves look good by solving the problem.

And they wonder why we do not trust them.

The EMC Journal, over the years has run some notable articles on the pitfalls of the technology, including "PLT and broadcasting - can they co-exist?" by Jonathan Stott, November 2004; "Headroom for PLT: is it necessary?" by Richard Marshall, March 2009; "Why broadband PLT is bad for EMC" by Tim Williams, January 2009 & "RF Emissions of Powerline Ethernet adaptors" by Tim Williams, May 2009.

This special PLT/PLC/BPL issue features yet more excellent articles written by highly respected, world class, *very concerned, EMC experts.*

The Journal is also supporting the cause of both **RSGB*** and **UKQRM****. Both have devoted considerable time and energy in an attempt to make the bureaucrats see sense, who by and large have listened... but not acted. Just loads of futile time wasting gobbledegook (political speak).

Together we are raising the bar. We want them not just to listen but to act. Now... not wait ten years.

We are not suggesting that PLT be banned, far from it, we are simply asking that some of the monies, time and effort wasted on lobbying and Government protecting its position be spent on solving the serious interference problem caused by PLT.

Surely it is not beyond the bounds of Government to encourage and provide the necessary support that will facilitate engineering expertise to solve the problem.

Interestingly, Lord Carter, the first Minister for Communications, Technology and Broadcasting, highlights in his report on Digital Britain many aspirations and pledges as to how Britain is to become the leading major economy on all things Digital. Although it has been noticed PLT is not mentioned once, which considering the acclaimed influence it will have on Broadband is somewhat surprising. Now Lord Carter given is experience should know more than most the importance of the Radio Spectrum within the success of the economy.

Alas, Lord Carter is now to leave the Government, What effect his departure has on Digital Britain remains to be seen... the campaign for genuine "*legally compliant*" PLT will continue.

Editor

** RSGB www.rsgb.org.uk. Be sure to visit their stand at EMCUK 2009 so as not to miss the PLT Inference demonstration.*

** * UKQRM www.mikeand sniffy.co.uk/UKQRM/, an excellent web site full of useful PLT information. Make sure to sign the Downing Street petition.* *See page 10.*

PLT Articles in this Issue:

Check out the PLT Database of information and documents from around the world.
www.theemcjournal.com/plt

Don't miss Banana Skins in this Issue it's all about Interference page 15.

Reg 765 is coming. Are you ready for it. See page 6.

News and Information

What does EU Regulation 765/08 on Accreditation and Market Surveillance do?

Accreditation -The Regulation establishes a European-wide legal framework for the organisation and operation of accreditation, thus enhancing confidence in conformity assessment by strengthening the role of accreditation for activities such as calibration, testing, certification and inspection bodies.

Market Surveillance -It reinforces Market Surveillance structures to protect citizens from unsafe products and level the playing field for compliant businesses, by removing those products from the market and taking action against fraudulent manufacture.

EU Regulation 765/08 was adopted by the EU Parliament and the Council of the European Union on 9 July 2008.

The EU Regulation is directly applicable from 1 January 2010.

To find out more just search for EU Reg. 765 on Google it will take you to the BIS web page. Quicker than providing the very long URL

New Standard for designing more substainable Electrotechnical Products

BSI has just published a new standard establishing the necessary procedures for designing more sustainable electrotechnical products.

Environmentally conscious design (ECD) aims to reduce the impact a product or component has on the environment, from design through manufacture and use to disposal.

BS EN 62430:2009 Environmentally conscious design for electrical and electronic products specifies requirements and procedures to integrate environmental aspects into the design and development processes of electrical and electronic products. It provides a set of requirements for the process of ECD reflecting the contents of IEC Guide 114 and ISO/TR 14062.

ECD can help designers and manufacturers meet customer and legislative demands for greater sustainability in electrotechnical products. The use of BS EN 62430 as a base reference is encouraged in order to ensure consistency throughout the sector.

The standard is intended for use by all those who design or develop electrical and electronic products, including all parties in the supply chain.

BS EN 62430 is applicable to all types of electrotechnical products, new as well as modified. This includes combinations of products, and the materials and components of which they are composed.

For more information, visit:
www.bsigroup.com/bsen62430

Replaced or Withdrawn Publications available shortly from IEC webstore

As from early August 2009, it will be possible to order more than 8,000 replaced or withdrawn IEC Publications directly from the IEC Webstore - **http://webstore.iec.ch/**

In fact, these publications have always been available but only via the IEC Central Office Customer Service Centre, and not through the new user-friendly Webstore.

To avoid any confusion with current editions these publications will show up in the search results in a dedicated section "Replaced / Withdrawn standard" and will carry a reference number starting with "P-". They will also display a watermark clearly indicating that they are obsolete.

Users may need to purchase obsolete publications for many reasons, such as legacy and legal purposes and comparisons with the current edition.

Thanks to years of in-depth research, the IEC Central Office has been able to build an extensive electronic library of nearly all IEC Publications issued since the IEC's creation more than 100 years ago

Front Cover

Hero circle, QinetiQ, page 9
Circle top, Rohde & Schwarz, page 29
Circle middle, Schaffner, page 29
Circle bottom,, see page 28

Secretariat for EMCIA

emcia
Electromagnetic Compatibility Industry Association

The Trade Association for the EMC Industry.
Web: www.emcia.org

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Aircraft Electromagnetic Certification Workshop 17-20 November 2009

The QinetiQ Electromagnetic and Environmental Services (EMES) Group is very pleased to announce that the Aircraft Electromagnetic Certification Workshop (AECW) 2009 will be held at QinetiQ, Cody Technology Park, Farnborough, Hampshire, GU14 0LX from the 17th to 20th November 2009. Acting on extremely positive feedback from the previous courses, the workshop is now conducted over four days to allow more time for interactive sessions and tutorials.

Prof. Nigel Carter will once again be our lead trainer for the workshop and brings over 40 years of aircraft electromagnetic certification experience. Prof. Carter will be accompanied by other key speakers from the CAA, QinetiQ and BAE Systems. As always live demonstrations of test techniques and actual examples will be provided.

If you are interested in the stringent electromagnetic certification requirements for modern aircraft and avionics systems, including EM immunity requirements (such as High Intensity Radiated Fields (HIRF)) and test techniques then this workshop is for you. The workshop content has been modified this year to serve a growing interest in military aircraft certification requirements and includes interactive sessions to develop the delegate's understanding in the material presented. Presentations on the UK's centre of excellence for military aircraft release located at Boscombe Down, a tour of the UK's largest reverberation chamber and full workshop notes will be included within the delegate fee. For further details or to register your interest in attending AECW 2009 please e-mail: **nbevan@qinetiq.com** or call the EMES business group on **+44 (0) 1252 394236.**

AECW 2009 is Technically co-sponsored by the Institution of Engineering and Technology (IET).
www.qinetiq.com

T-Mobile selects Rohde & Schwarz as its exclusive supplier of network optimization test and measurement equipment

Mobile communications operator T-Mobile International has chosen the Rohde & Schwarz group as the exclusive supplier of its standard drive test systems. The contract includes the delivery of R&S ROMES software and associated mobile radio scanners to five European countries. T-Mobile International will use the drive test systems from Rohde & Schwarz to test the transmission quality of channels in its mobile radio networks. This will enable the network operator to ensure interference-free mobile communications coverage.

The drive test systems' performance and cost effectiveness made T-Mobile International decide in favor of Rohde & Schwarz. The company's T&M solution is the fastest on the market and can simultaneously analyze the quality of both GSM and UMTS radio channels. This is a key advantage for T-Mobile International because the drive test systems can handle all of the standards relevant to its networks.

T-Mobile International provides wireless telephony, messaging and data services to 128 million customers. "Our service teams are constantly doing field work to make sure that we provide optimal network coverage, voice quality and data transmission. They rely on Rohde & Schwarz drive test systems, which have proven to be excellent solutions," said Kai Schatton, Vice President Radio Networks Automation & Quality at T-Mobile International.

Significantly lower acquisition and operational costs compared with other solutions also helped persuade T-Mobile International to partner with Rohde & Schwarz. In addition, the systems provide a high level of investment protection: "Rohde & Schwarz is the leading supplier in drive testing. This will enable us to offer T-Mobile International a long-term, future-safe solution," said Hubert Meichelböck, Head of the Systems and Projects Subdivision at Rohde & Schwarz.
www.rohde-schwarz.com
www.telekom.com

Link Microtek moves to new premises to bring all operations under one roof

Link Microtek, the manufacturer and supplier of RF and microwave components, subsystems and instrumentation, has successfully completed its move into new premises in the centre of Basingstoke.

For the first time since it was established in 1995, the company now has all its operations – including the design and manufacturing activities of its Engineering Division – under one roof. **www.linkmicrotek.com**

Jim Maginn named President of AR RF/Microwave Instrumentation

AR RF/Microwave Instrumentation has announced the appointment of Jim Maginn as President, effective immediately.

Maginn, who joined AR in 1992 as Engineering Manager, has held the position of Senior VP/Chief Executive Officer since 2006.

His extensive career began in 1975 with the Department of Defense, where he was employed as a radar systems engineer at the Naval Air Development Center. From there, he moved on to defense-related engineering management positions with several leading companies before joining AR.

Mr. Maginn holds a Bachelor's degree in Electrical Engineering from Villanova University and a Masters in Industrial Engineering from Texas A&M.

125 Years of the IEEE

This year marks the 125th anniversary of the IEEE, in recognition of this and the anniversary theme of 'Engineering the Future', the UKRI Chapter of the EMC Society organised a special event on "Developments in EMC, and EMC in the Future" which was held at The de Havilland Aircraft Heritage Centre near St Albans, Hertfordshire, on 8th July. The museum is home to several Mosquito aircraft (one of which provided the backdrop to the meeting) as well as many other de Havilland aircraft including Vampire, Comet, Tiger Moth, Chipmonk, Sea Vixen and part of a Horsa - the World War II wooden troop-carrying glider.

With presentations from Steve Hayes (TRaC EMC & Safety), Jim Wood (EMC Compliance), David Ward (MIRA), Stephen Colclough (Samsung) and Richard Turner (Mott MacDonald), we considered recent developments and issues which are currently and will be impacting EMC in five different areas; commercial aerospace, military, automotive, commercial and railway. While each has its own unique challenges, the general trends towards technology convergence, introduction of new technology and proliferation of wireless technologies was a common theme. This was shown quite clearly by Stephen Colclough with the example of a mobile phone - no longer is it just a phone, but it is also a PDA, MP3 player, camera, GPS, Bluetooth and WLAN device. To tie in with the 125th anniversary theme of 'Engineering the Future', the meeting concluded with an interesting and thought provoking talk from Tim Williams (Elmac Services), in which by looking at the three main areas of design, testing and standardisation he discussed "EMC - the Next 15 Years".

The IEEE traces its history back to New York City on the 13th May 1884 when a small

group of engineers met to form the American Institute of Electrical Engineers, AIEE. Following the development of radio in the early years of the 20th century, a new organisation modelled on the AIEE but focused on radio and later increasingly on electronics, the Institute of Radio Engineers (IRE) was founded in 1912.

Both organisations served their members and professions by organising technical conferences, publishing journals and standards and, by encouraging the training and development of student engineers. Throughout the 1920's and 30's, electrical technologies were being increasingly applied as part of complex and geographically dispersed systems such as power grids and radio networks. With the advent of World War II, many governments started to organise their scientists and engineers, setting them to work on devising new technologies to help the war effort. This not only contributed to rapid development in areas such as radar, computing and weaponry, but produced major advances in technologies from electronics to signal processing that would have broad implications for the succeeding years.

For many years, the membership of the IRE had lagged behind the AIEE but, though the late 1940's and early 50's, the competition between the two organisations for members heated up. In 1947, the AIEE had almost 35,000 members, compared to 21,000 in the IRE. However, fuelled by the increasing interest in and development of electronics, the IRE grew faster and by 1956 both had about 50,000 members. The IRE eventually surpassed the AIEE, becoming the larger organisation in 1957.

As the differences between the two organisations became more blurred, their boards explored ways of working together which, in 1962 led to them agreeing to merge. More than 60% of eligible members voted, with 87% of them supporting the merger. As such, on the 1st January 1963, the IEEE, or Institute of Electrical and Electronic Engineers was born with 150,000 members, 140,000 of whom were in the United States.

Today, the IEEE is a truly global organisation with more than 375,000 members, 43% of whom live in 159 countries outside of the United States. There are 38 societies (of which the EMC Society is one) with more than 1,750 chapters around the world. The IEEE publishes a total of 144 journals, transactions and magazines, sponsors 850 conferences a year and, the IEEE Xplore(r) digital library now contains nearly 2 million items.

The information on the history on the IEEE for this article was taken from a presentation prepared by the IEEE History Centre entitled "The History of IEEE and Electro-technologies" and an article by Anna Bogdanowicz, "Looking Back 125 Years", published in the June 2009 issue of 'The Institute'.

For more information on the UKRI Chapter of the IEEE EMC Society & to be updated on future events, please contact the Chapter Chairman, Paul Duxbury, **paul.duxbury@ieee.org**.

Annual TILE!™ Users Group Meeting Announced

ETS-Lindgren has announced that it will again sponsor the annual meeting of the TILE! Users Group (TUG). The meeting will be held on Wednesday, August 19 in conjunction with the 2009 IEEE International Symposium on Electromagnetic Compatibility (EMC) in Austin, Texas. TILE! users and those interested in learning more about this popular EMC lab management software are invited to register to attend the meeting at TUG Meeting Registration. Users can also log in at this site to read or post information related to TILE! software.

After acquiring the TILE! software product, ETS-Lindgren sponsored last year's TUG meeting to show its support for existing and new TILE! customers, as well as announce plans for continued product development and improvement. "The feedback from users at the first meeting was invaluable," said Roger Hatch, ETS-Lindgren Director, Service Operations and manager of TILE! product service. He added, "We learned what features of the product users like best and what features needed improvement. Most importantly, we realized how enthusiastic TILE! users are about the product and how they appreciate its ability to integrate their lab instrumentation and perform complex test routines, without having to become programmers. TILE!'s simple drag-and-drop interface makes their job easy; it's gratifying to know we've achieved one of our key goals with this product."

Further information about TILE! software and support is available at:
www.ets-lindgren.com/tile

emcia Member

Modified Boeing Chinook Mk3 successfully completes First Test Flight

A UK Chinook Mk3 helicopter successfully completed its first test flight on 6 June at MOD Boscombe Down during the flight testing and evaluation phase of the Mk3 reversion programme.

A Boeing-led team in conjunction with key suppliers QinetiQ and GE Aviation Systems Ltd, and in close collaboration with the Royal Air Force (RAF), is reverting eight Mk3s for compatibility with the RAF fleet of 40 Mk2 Chinooks. Once all aspects of the modification and test programme are completed, the eight converted helicopters, which are scheduled for delivery from late 2009 through 2010, will join the rest of the RAF Chinook fleet at RAF Odiham in Hampshire.

"Significantly increasing the heavy-lift capability of the RAF, the additional eight Chinook Mk3 helicopters will help support demanding operational needs in Afghanistan," said Commander Joint Helicopter Command Rear Admiral Tony Johnstone-Burt.

"This programme, which is a team effort empowered by the RAF and key suppliers

QinetiQ and GE Aviation Systems, is a wonderful example of working together to achieve an expanded mission-ready fleet," said Jim O'Neill, Vice President of Integrated Logistics for Boeing Global Services and Support. "Getting these aircraft into service will help save lives and support essential missions."

A Chinook helicopter can carry up to 55 troops or 10 tons of freight and be used in a variety of operational roles, including troop transportation and casualty evacuation. They are highly capable and versatile helicopters that cope well with many diverse environments, including the harsh conditions in Afghanistan.

www.qinetiq.com

AR Releases Orange Book of Knowledge 3rd Edition

Several years ago AR compiled a book of articles, application notes and other information that's important to everyone involved in the EMC, Wireless, and Communication industries. That book, known as The Orange Book of Knowledge, quickly became a significant industry resource tool; and AR has now released the 3rd Edition.

As new products, new solutions, and new innovations are created, The Orange Book of Knowledge must naturally expand to reflect new learning. The new edition includes new application notes on topics ranging from "Custom Pulses Made Easy" to a reference guide for coaxial connectors and cables. The book represents the cumulative knowledge of all AR companies, making it perhaps the most comprehensive resource in the industry.

Everyone involved in EMC testing or wireless communications should have The Orange Book of Knowledge on their desk. To get your free copy, just contact an AR sales associate today.

www.ar-worldwide.com

UKQRM UKQRM UKQRM UKQRM UKQRM

We believe that PLT in its current form (using an already occupied part of the spectrum) is flawed and should never have come to market.

Tests have been conducted and shown that the PLTs do not comply with the regulations and clear evidence shows they do not and can not comply with the Essential Requirements.

UKQRM was formed by Mike Trodd in July 2008 after his neighbours installed BT Vision with Comtrend power line adaptors. It is now a team effort run by an advisory group of 16 members drawn from a wide variety of fields, representing the short wave radio listeners and shortwave radio users.

UKQRM speaks for its 520+ members and the 3433 people (to date) who have put their signature to the UK Government e-petition.

Please sign our petition.

Go to: http://www.mikeandsniffy.co.uk/UKQRM/ and click on the link:

Urgently sign up to the new petition (UK only) and help us build on the last. Ends 24/10/2009 (off site page)

Or go direct to the Number10 petition website:

http://petitions.number10.gov.uk/SaveShortwave2/

Number10.gov.uk

The official site of the Prime Minister's Office

We the undersigned petition the Prime Minister to require the relevant regulatory authority namely Ofcom to take active and speedy measures to test samples of all makes and types of PLT device and to remove from the UK market all those devices where the sample is found to be non compliant with the requirements of the Electromagnetic Compatibility Regulations 2006. And to take all practicable and necessary steps to prevent anyone placing non compliant PLT devices on the UK market now and in the future. The Department for Business Enterprise and Regulatory Reform and Ofcom are familiar with these devices they being widely distributed by a national communications supplier, various high street stores and on the Internet. These devices are used to transfer electronic data via domestic electrical household wiring and the techniques involved in typical use result in harmful interference to short wave radio reception.

EMC UK 2009

Exhibitors

Agilent Technologies UK Ltd
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AQL-EMC Ltd
AR Europe
BAE SYSTEMS (Rochester)
BAE SYSTEMS (Warton)
BalSeal Engineering
Border Precision Ltd
Cobham Microwave
CST - Computer Simulation Technology
Dowding & Mills (UK) Ltd
Electronic Test & Calibration Ltd
Electronics KTN
EMC Hire Ltd
EMC Industry Association
EMC Partner UK Ltd
ETS-Lindgren Ltd
FEKO - by EM Software & Systems GmbH
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The IET
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Pulse Power & Measurement Ltd
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Fully contracted as of 21.7.2009... more to come.

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EMC UK 2009

The Racecourse, Newbury
13/14th October 2009

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Training Sessions

The Racecourse, Newbury 13/14 October 2009

Who should attend:
Design engineers of electronic products in all sectors (consumer, medical, industrial, military, transport, telecom) who have to meet high frequency EMC compliance requirements.

Benefits:
Delegates will hear from two of the most respected lecturers in the business. After attending this course, delegates will be able to review their designs with confidence in all aspects – mechanical drawings, PCB layouts and circuit schematics – for adherence to principles of minimum disturbance emissions and maximum interference immunity.

Fee:
£135 plus VAT including lunch, full copy of proceedings and attendance certificate. Why pay more.

Running in parallel will also be the IET Technical Conference Programme. All delegates to those sessions will be allowed FREE entry to the Training Sessions and will also receive the proceedings.

Book Online Now!

www.emcuk.co.uk

Tuesday 13th October 2009

Electronic Fundamentals for Good EMC

Presenters:
Keith Armstrong, Cherry Clough Consultants
&
Tim Williams, Elmac Services

09.10 - 10.30	Shielding Theory; Effect of apertures and seams; The slot-in-a-box model; Conductive gaskets; Conductive coatings; Using the shield as ground; Cable layout and large enclosures
10.30 - 11.10	Coffee and Visit to Exhibition Stands
11.10 - 12.30	EMC Techniques for PCB Layout Saving time and money; Segregation; Interface analysis, filtering, and suppression 0V and power planes; Power supply decoupling; Transmission line techniques; Layer stacking; Some useful references
12.30 - 14.00	Lunch and Visit to Exhibitions Stands
14.00 - 15.20	EMC in Circuit Design and in the selection of Active Components Digital design for EMC; Analogue (not RF) design for EMC; Switch-mode design for EMC; Communication design for EMC; Optoisolator design for EMC; Checking device EMC characteristics; Some useful references
15.20 - 16.00	Tea and visit to Exhibition Stands
16.00 - 17.20	Filtering and Cabling Filter configuration; Components: capacitors and ferrites; I/O and mains filtering; Mode of propagation; Unscreened cables: using twisted pair; Screened cables - screen operation, transfer impedance & the effect of the connector; Transducer and communi-cations interfaces

Wednesday 14th October 2009

Basics of Emissions and Immunity Testing

Presenter:
Keith Armstrong
Cherry Clough Consultants

Synopsis
There are certain issues common to all emissions and immunity tests, that the test standards may not make very clear. If they are not understood, significant differences between test laboratories can result.

This morning's session describes these issues, and is intended for those new to commercial EMC testing.

09.10 - 10.30	Making Emissions Measurements
10.30 - 11.10	Coffee and Visit to Exhibition Stands
11.10 - 12.30	Making Immunity Measurements
12.30 - 14.00	Lunch and Visit to Exhibitions Stands

Immunity requirements related to design choices

Presenter:
Tim Williams
Elmac Services

Synopsis:
Immunity test requirements are standardized for many products, either under the EMC Directive or through product specifications, and even without standardized requirements, good EMC immunity is the hallmark of a well-designed product. Since immunity can only be verified through testing, a test plan should be drawn up at the start of each design; but how do circuit, PCB and mechanical design choices relate to this test plan?

This afternoon's session is aimed at electronic product design and development engineers, who need to be able to implement a design in the knowledge that, when it comes to the immunity tests, they have anticipted and allowed for the electromagnetic stresses that their product will undergo.

14.00 - 15.20	RF Immunity Immunity of analogue circuits, cable coupling at low frequencies; high-Z and low-Z common mode filtering; required common mode rejection; effect of circuit and cable resonances; radiated coupling to structures; layout, circuit bandwidth, shielding if necessary; RF immunity of digital circuits.
15.20 - 16.00	Tea and visit to Exhibition Stands
16.00 - 17.20	Transient and LF Immunity Immunity of digital circuits; ESD effects on edge-triggered signals; layout, filtering and decoupling; enclosure design to control ESD strikes; ESD protection of interfaces; integration with RF filtering; capacitive filtering for EFT/B; effectiveness of the ground reference for EFT/B; HF filtering of power supplies; surge protection of power supply and interfaces, integration with RF filtering; LF immunity: AC supplies - dips, interrupts, inrush current; DC supplies: same, plus overvoltage and reverse polarity protection.

Technical Sessions

The Racecourse, Newbury 13/14 October 2009

About the Technical Conference Sessions
The conference programme will address key issues facing the EMC world in EMC regulations and the automotive, military and civil aviation sectors.

By attending the conference sessions you will:
- Understand how to put an end to the radiated emissions test lottery
- Gather information on the development of a near field immunity test method to counter the risk of electromagnetic interference from cellular phones
- Understand what the EU Regulation on Accreditation and Market Surveillance (RAMS) will mean for you
- Explore the essential requirements to ensure CE marking and how to achieve compliance within Europe while understanding what challenges can occur

Programme

Tuesday, 13 October 2009

08:30 Registration and refreshments

09:30 Opening Remarks from the Chairman
Ayhan Gunsaya, EMC Technical Specialist, Ford Motor Company

EMC in the Automotive Sector

09:35 Keynote Address:
Functional Safety in Modern Vehicles
Keith Armstrong, Cherry Clough Consultants

10:30 Putting an End to the Radiated Emissions Test Lottery and Exploring New Automotive Chamber Validation Methods
Dr Luke Turnbull, EMC Technical Manager, TRW Conekt

11:10 Refreshments and Exhibition

11:50 Analysis of Electromagnetic Threats from Cellular Phones: Development of a Near Field Immunity Test Method
Ayhan Gunsaya, EMC Technical Specialist, Ford Motor Company

12:30 Lunch and Exhibition

14:00 EMC Standards Gap Analysis in Practice
Peter Dorey, Senior Consultant, TUV Product Service

14:40 The Challenges of Enforcing the UK's EMC Regulations
Dave Holland, Trading Standards Service, Cardiff County Council

15:20 Refreshments and Exhibition

15:50 The New Market Surveillance Directive and its Implications
Richard Lawson, Deputy Director, Technical Regulation, BERR

16:30 Chairman's Closing Remarks

16:40 Close of Day One

Wednesday, 14 October 2009

08:30 Refreshments

09:30 Opening Remarks from the Chairman
Ian MacDiarmid, Head of Electronics, BAE Systems

Defence and Civil Aviation

09:35 Keynote Address:
A New Approach to EMC in Defence
Ian MacDiarmid, Head of Electronics, BAE Systems

10:30 Meeting CE Marking Requirements in a Military Environment
Steve Hayes, Managing Director, TRaC EMC and Safety Ltd

11:10 Refreshments

11:50 CE-Marking Military Equipment - the Devil's Advocate View
Tim Haynes, Electromagnetic Engineering Specialist, SELEX Sensors and Airborne Systems

12:30 Lunch and Exhibition

14:00 EMC Standards: Keeping Abreast of the Changes
Nick Wainwright, Operations Director, York EMC Services

14:40 The Intentional Electromagnetic Interference (IEMI) Conundrum
Richard Hoad, Principal Consultant, Electromagnetic and Environmental Services (EMES), QinetiQ

15:20 Panel Discussion: Spectrum Commercialisation – What Effects can Industry Expect?

Moderator: Simon Middleton, TUV Products and Services

16:15 Closing Remarks and Close of Conference

Book Online visit www.emcuk.co.uk/conference

Experiment Demonstrations

The Racecourse, Newbury 13/14 October 2009

Organised by the UKRI Chapter, the Experiment Demonstration session will be held in the Marquee Annex on the Ground Floor.

Free to All

Experiment Demonstrations and Computer Solution Demonstrations

The practical hardware presentations are intended to demonstrate EMC concepts and principles, phenomena, effects, and measurement methods. The computer solutions presentations are intended to illustrate EMC modelling approaches and simulation methods through a series of interactive computer demonstrations. The presentations are table-top informal practical demonstrations that are similar to poster sessions, they are presented simultaneously and repeated continuously. This year's agenda will include new demonstrations plus some popular ones from previous years.

Agenda

Session time: 09:30 - 16:00. There will be different demonstrations each day and content will include:

Tuesday 13th October 2009

A double theme demonstration…
Stuart Charles, E-Mead. Consulting Ltd
(i) MathCAD 14 simulation of time domain and frequency domain voltage and current on a high speed clock line as a function of pulse rise time, series termination impedance and other line parameters.

(ii) Inductance experiment demonstrating how current flows down the circuit of least inductance, not least resistance.

Static electricity and Real ESD sources.
Jeremy Smallwood, Electrostatic Solutions.
Dr Jeremy Smallwood demonstrates how static electricity gives rise to ESD from people and objects in the real world, and shows some of the waveforms and characteristics of the ESD from these sources.

Analyzing current paths and magnetic fields.
Roy Ediss, Ediss Electric.
The demonstration reviews a sensing method and then focuses on its application using various probes and a range of test pieces, in order to identify associated current paths and magnetic field properties. Current paths and field effects will be shown on PCB track arrangements, a "real" circuit, a coaxial transmission line, twisted pair transmission line, a crosstalk demonstrator PCB, etc.

Ground currents in RF circuits.
John Kitchen, S J Technologie
A computer simulation demonstrating ground return current distribution.

PCB Filter Demonstrations.
Glen Wallis, Wurth Electronics.
A signal is fed through a reference line and then through various filter circuits on a SMD test board to show how the different filter topologies clean-up the signal and can be used to achieve different levels of attenuation. These can be seen in real-time on an impedance analyzer.

Video presentations of:
EMC Aspects of Magnetic Field Coupling of Current Loops. *Jasper Goedbloed.*
ESD and EMI in Printed Wiring Boards". *Douglas Smith.*
Effects of Pulse Rise/Fall Time on Signal Spectra". *Clayton Paul.*

Wednesday 14th October 2009

Effects of currents on the screens of cables.
John Woodgate, J M Woodgate and Associates.
Under what circumstances can a current in the screen of a screened cable cause a disturbance in the signal circuit? The demonstration will show effects and, equally significant, the absence of effects.

Shielding and EMP Analysis of an Enclosure.
Paul Duxbury, CST-UK.
The measurement or calculation of shielding effectiveness is often thought of as being relatively simple. However, there are many aspects which need to be taken into account, including the source and method of measurement of the field. The demonstration will also show how the material properties of the enclosure can have a significant impact on the shielding and therefore the coupling to an internal coaxial cable when the enclosure is exposed to an EMP pulse.

Presented in morning until 12:30. **Coupling and screening between wires.** ***Tim Williams, Elmac Services.***
Using a spectrum analyser and tracking generator, the contrast between electric and magnetic field coupling in the RF range between a pair of parallel wires is shown; the different effects of a screening plate between the wires are explored, including the effect of the quality of the screen ground connection.

Presented in the afternoon from 13:00. E**SD immunity of an analogue and a digital circuit to ESD.** ***Roy Ediss, Ediss Electric.***
Immunity of analogue and digital circuits to a close proximity indirect air electrostatic discharge is demonstrated. It will be shown how digital circuits that are not immune to electromagnetic fields will lock-up and stop working but analogue circuits can recover.

Analysing the use & performance of clip on ferrites.
Glen Wallis, Wurth Electronics.
A live practical demonstration.

A double theme demonstration… ***David Welsh, York EMC Services.***
Longitudinal voltage, transverse voltage and balance.
Demonstration of cable effects.
Shielding Effectiveness measurement demonstration.
The demo will show the difference in shielding performance with gasketed/non-gasketed joints, holes and slots, penetration/non-penetration with cables.

Video presentations of:
EMC Aspects of Magnetic Field Coupling of Current Loops. *Jasper Goedbloed.*
ESD and EMI in Printed Wiring Boards". *Douglas Smith.*
Effects of Pulse Rise/Fall Time on Signal Spectra". *Clayton Paul.*

Banana Skins...

Editor's note: The volume of potential Banana Skins that I receive is much greater than can possibly be published in the Journal, and no doubt are just the tip of the EMI iceberg. Keep them coming! But please don't be disappointed if your contribution doesn't appear for a while, or at all.

538 **Interference: Reports from the Field**

This Banana Skin Item is a compendium very kindly sent in by Pete Alsop, a Senior Field Engineer working for Ofcom (www.ofcom.org.uk). Ofcom has the responsibility for radio, TV, radiocommunications and tele-communications (including the Internet) in the UK, and part of that is ensuring that these services do not suffer from interference, so they employ 35 field engineers whose job it is to investigate complaints and deal with them. Causing the interference to cease is a matter of pride to them, and they deal with most complaints successfully.

If you think you might have an interference problem with your telephone (landline or cell), your radio or TV reception, or your internet service, click on "How to complain" on the above website, or go direct to http://www.ofcom.org.uk/complain/.

I had asked Pete what technologies gave him and his fellow field engineers most interference complaints over the years. I was not concerned with co-channel or adjacent-channel interference, or illegal transmitters, all of which Ofcom's field engineers also have to deal with, and his reply (on 30 June 2009) is below.

Here is a general breakdown of types of proven causes of interference for the period January 2007 to May 2009:

Lighting Systems	252
Thermostats	223
Aerial Amplifiers	197
Power supplies (switch-mode)	82
Digital Receivers	49
IT equipment	33
Motor Systems	29
Ignition Systems	24
ISM Equipment	5
Welding Equipment	1

You can see from above, that the two major causes of interference, and several others, are wide band interferers, where obviously some kind of arcing is taking place. The cause of the arcing is obvious enough in a thermostat, and explains why we find that complaints of interference increase during the winter months – more people are using their central heating, and so are passing currents through the contacts of the thermostats on their boilers and in their rooms!

PLT is a new technology that Ofcom are also receiving complaints about, and solving, but it is felt that it is too early to include it on the above list of interference from established technologies. The latest Ofcom update on PLT is at: www.ofcom.org.uk/radiocomms/ifi/enforcement/plt.

I once had to deal with a complaint of radio interference that turned out to be caused by a low-power nightlight that used a low-energy fluorescent tube. At certain times, it would apparently start to arc inside, causing the problem. Filament lightbulbs will also often maintain a small arc inside (usually before they fail) that can generate a surprising amount of radio noise.

Aerial amplifiers have become less of a problem more recently, as Digital Terrestrial Television broadcasts using OFDM techniques can cope well with a single carrier interferer. Cheap unfiltered aerial amplifiers are also prone to creating intermodulation products (overloaded by strong RF signals nearby) which go on to interfere with the required TV channel, and that's why they are high on the list.

Generally speaking, our work results from devices that have been incorrectly installed and/or have developed a fault of some description, not as a result of being poorly designed with regards to EMC.

Occasionally we do have issues with equipment radiating energy on or very close to the emissions limit in an EN standard. For example, recently I received a complaint from an airport that used 125MHz for AM voice communications, complaining of a permanent interfering signal at a particular location. The source was traced to a nearby building which had recently installed a new CAT 5 cabled IP CCTV security system, where its external video cameras were radiating 125MHz from clock circuits within the control switch, which was located deep in the centre of the building. The cameras where changed for others, and this stopped the interference. But it was not really the cameras' fault – they weren't generating the interference themselves, simply allowing it to pass through.

Here are some examples and experiences that my colleagues and I have had over the years.

- Light sensors found radiating in the TV band causing patterning to one UHF channel. The light sensors where submitted for testing under the relevant EMC Directive-listed standards, which showed that they failed to satisfy both the radiated emission *and* interference power limits.

The devices contained an emission source having a 10 MHz bandwidth with the maximum emission occurring at the top of the band at 157 MHz. The disturbance power emission (EN 55014) limit was exceeded at 157 MHz by 37.8 dB. Radiated emissions exceeded the limit (EN 55022 Class B) at 157 MHz by 31.4 dB and exceeded the limit at 314 MHz and 471 MHz by 23.8 dB and 8.7 dB respectively.

The manufacturer claimed compliance with EN 55014, but this standard applies specifically to household appliances, electric tools and similar apparatus. This standard only tests up to 300 MHz, so does not encompass the TV band in which its 471 MHz (the third harmonic of 157MHz) emissions spectrum lies. Tests were made using EN 55022 (information technology equipment) which is the basic measurement standard applicable to residential, domestic and light industrial applications, which covers up to 1000 MHz and so covers all of the UHF television bands. This standard was considered to be more applicable to light sensor devices.

- Complaints were received from numerous residents unable to start their vehicles due to spurious carrier blocking

the RF receivers on the key fob car alarm/ management systems.

The signal was traced to a child's life size motorbike with a built in video game operating on the 433 MHz licensed exempt band. The residents couldn't believe it until we de- activated the gaming unit on the bike adjacent to the affected vehicles and the problem cleared. The RF unit had developed a fault and was returned to the manufacturer by its owner.

• In the 1970s I was still dismantling old sewing machines and vacuum cleaners to fit suppression capacitors. Central heating interference was solved by trying suppressors first and only condemning the worn-out thermostat if all else failed to stop the interference. There was still VHF monochrome television susceptible to all forms of electrical interference and herringbone patterning from transmitter harmonics and local oscillators in other receivers. Valve oscillators ran at higher power levels than today's semiconductors and shielding had to be restricted to allow for their cooling.

• 4 watt AM CB Radio appeared in the late 1970s and early 1980s, revealing terrible EMC design weakness in every type of electronic appliance, including telephones. In the worst cases, the breakthrough would continue with the affected TV set or HiFi amplifier switched off and unplugged. The audio output transistors or ICs would act as 'crystal set detectors' and produce sufficient energy to drive the loudspeaker audibly *without any additional power*.

• Microwave ovens appeared in the 1980s, revealing EMC weakness in nearby TV tuners, which accepted the low levels of 2.4GHz from the ovens. On certain channels, a harmonic of the TV local oscillator would fall at the I.F. frequency away from the microwave oscillation, resulting in a distinctive pattern on the TV screen whenever the cooker was in use.

• Vehicle ignition suppression has improved but some misguided car enthusiasts still compromise the vehicle's EMC performance by replacing carbon plug leads with copper, resulting in TV interference where reception is weak. A few white analogue dots can be ignored but DTTV is far less forgiving with pixilation and sound loss causing greater annoyance.

• Manufacturers of electric motors and thermostats gradually incorporated RF components into the design, but occasionally the suppression fails, or a fault generates excessive interference.

• TV aerial amplifier design used to be straightforward and cheap – high gain, no shielding, no filtering and wide bandwidth. Amplifier specifications are now far more important – with cellphones below 1GHz, Airwave communications (e.g. TETRA), Amateur, CB and PMR on many other frequencies. Dynamic range is also more critical with five analogue channels and six weaker DTTV multiplexes having to be amplified without excessive intermodulation. Also, when a mast head amplifier develops a fault, it easily becomes an oscillator and causes nearby interference.

• Rear-of-set TV amplifiers continue to create problems. A favourite is the unused amplifier which remains powered. The owner, not fully understanding it finds a loose coax flex and plugs it neatly into a spare socket. It looks tidy but an oscillator has now been created causing interference to nearby TV or radio.

• Low-power radio devices operating in the license-exempt 433MHz band are used for a wide variety of purposes, but inevitably a small number develop a fault and transmit constantly causing interference.

For example, cordless doorbells operate around 433 MHz, as do car remote door locks. A manufacturer designed a doorbell push with a grey rubber button surrounded by a white plastic housing, but if its button is pressed slightly off-centre it gets trapped under the plastic surround – causing the doorbell to transmit permanently. A nearby car's door lock receiver cannot receive the brief signal from the key fob (being swamped by the continuous noise from the door bell) so the car stays locked.

• Although ADSL broadband causes little radio interference, plug-top switch-mode power supply units that power their wireless routers only have a manufacturer's expected MTBF of 3 to 4 years when run 24/7 as many people do. One PSU fault which occurs generates high levels of wideband buzzing across MF and HF radio frequencies. Ironically the noise is easily induced into unshielded telephone wiring, considerably slowing ADSL speed for the owner of the faulty unit and also neighbours nearby.

• I guess interference affecting TV reception has changed with the uptake of DTV. What used to be a tolerable interference problem, e.g. an occasional one second burst from an arcing boiler thermostat affecting analogue TV has now become more of a problem. The one second burst now appears as a total loss of reception for a longer period of time, due to the processing time of the digital receiver.

• One that I have quoted as an example of the 'never discount anything' principle, involved domestic TV interference that went in bursts. Each burst lasted 2 - 3 minutes at a time and the first one would be around 7.30pm. This was followed by another at around 8.00pm with a third shortly afterwards. It would then be quiet all evening until around 11.00pm where there would be two further bursts.

The source was traced to a house on the opposite side of the road occupied by a family with three youngish children. The source was found to be a battery operated toothbrush and the bursts coincided with bedtime for the children followed by bedtime for the parents!

You wouldn't think that something running off a single 1.5V battery could have caused interference that was strong enough to affect a television the best part of 100m away – but these toothbrushes did!

• Electric fences have caused a few problems particularly if they are poorly maintained. DIY repairs to the long wire result in arching and play havoc with DTTV reception, whereas previously – with analogue TVs – only a faint horizontal line may have been seen.

Banana Skins

Banana Skins are kindly compiled for us by Keith Armstrong.

If you have any interesting contributions that you would like included please send them, together with the source of the information to:
keith.armstrong@cherryclough.com

John Woodgate's Column

Alternative test methods

The discord over the relative status of alternative test methods in EMC standards continues unabated. The problem stems form a provision in IEC and CENELEC rules that requires one method to be nominated *in the standard* as the 'referee' or 'reference' method, which seems to stem from the US FCC rules. What it does is in fact to fatally undermine the status of any/all other methods, because if the reference method were used, the result might be sufficiently different to change PASS to FAIL. This problem can be overcome, without changing the rules, by specifying in each case that the method originally chosen by the manufacturer to demonstrate conformity shall be the reference method.

There is a further question; what is an 'alternative test method'? Well, if a single standard says 'Use method a or method b…', then they are clearly (?) alternative. But are measurements on an open-air site, measurements in an anechoic room and measurements in a GTEM cell 'alternative'? If so, which is to be the reference method, and what was the point of developing the other methods at all?

In the face of these arguments, the support for reference methods seems increasingly difficult to understand.

Access denied

Most standards bodies treat their documents as if they were state secrets, and they may even think that they are. In fact, they seem to be more securely held than many British state secrets have proved to be!

On the other hand, US law requires the Audio Engineering Society to conduct its standards-making under public scrutiny, and only final publications are available only by purchase. Yet the system hasn't ground to a halt or been taken over by lobbyists or cranks.

This obsession with secrecy extends to be applied to the people who actually do the standards-making work, and it can seriously affect their efficiency, because they have access only to the documents in their particular committee. They can only see another document, such as for checking cross-references or compatibility, by asking, in each individual case, the national or international committee secretary for a copy of the document. Even if they own a published standard, it is a protected PDF, from which text cannot be copied for inclusion in a standard under development or a working document, or printed. A special request has to be made for a copyable or editable document, and that may take many days to become available. There can even be a case where the committee secretary is not sure that a copy can be provided, because of the Byzantine nature of some of the internal rules.

In the Lyon den

CISPR and IEC TC77 and their sub-committees and Working Groups will meet in Lyon, France in September. Here is a synopsis of the main subjects that will be discussed.

TC77 Electromagnetic compatibility

Items for consideration include:

- Edition 2 of IEC TS 61000-1-2;
- Maintenance of IEC 61000-4-1;
- Measurement uncertainty (with CISPR);
- Reports from sub-committees A, B and C;
- Exchange of information with ACEC;
- 'Independent test methods' - this is a new term: perhaps it will make the discussions even more complicated;
- Co-ordination with CENELEC TC210;

SC77A Low frequency phenomena

Items for consideration include:

- Status of IEC TS 61000-3-4 (proposed for withdrawal but to be reconsidered);
- Reports from Working Groups;
- Compatibility level for the fifth harmonic - should it be increased?
- Standards for dispersed generation;

SC77B High frequency phenomena

Items for consideration are mainly reports for maintenance teams for the sections of IEC 61000-4. These Basic standards (methods of measurement) were originally expected to be quite stable, but the reverse is the case for many of them.

SC77C High power transient phenomena

This sub-committee deals with high-energy EMC phenomena, which are of limited interest except to large network operators, and it is to be hoped that that will remain so.

CISPR International special committee on radio interference

Items for consideration include:

- CISPR organization: CISPR operates under a different Constitution than the rest of the IEC and unnecessary differences should be eliminated;
- Review of the sub-committees activities, especially CISPR/B.

CISPR/A Radio-interference measurements and statistical methods: the agenda is not available at the time of writing.

CISPR/B Interference relating to industrial, scientific and medical radio-frequency apparatus, to other (heavy) industrial equipment, to overhead power lines, to high voltage equipment and to electric traction

Items for consideration include:

- further consideration of the maintenance of CISPR 11, which has proved difficult;
- maintenance of CISPR 18 series - four sections on EMC issues with power networks, which do not seem to be used very widely;

CISPR/D Electromagnetic disturbances related to electric/electronic equipment on vehicles and internal combustion engine powered devices

Items for consideration include EMC issues related to electric vehicles.

CISPR/F Interference relating to household appliances tools, lighting equipment and similar apparatus

Items for consideration include:

- Maintenance of CISPR 14-1 and 14-2;
- Maintenance of CISPR 15;
- Maintenance of CISPR 30.

CISPR/H Limits for the protection of radio services

Items for consideration include:

- Maintenance of Generic emission standards IEC 61000-6-3 and -4;
- Revision of CISPR 31 (Database on characteristics of radio services);
- PLT 'mains decoupling factor'.

CISPR/I Electromagnetic compatibility of information technology equipment, multimedia equipment and receivers

Items for consideration include:

- Maintenance of CISPR 22 and 24;
- Progress on CISPR 32 and 35 (the new multimedia emission and immunity standards: most significant!);
- PLT

This represents nine days work for a large number of people from all over the world. Traditionally, progress in CISPR has been deliberate; it may be that the new officers will be able to increase the pace, without loss of integrity of the standards and without indulging in change for change's sake.

If anyone wants to know more about any of the above subjects, please contact the email address below.

The IDEA project

If you search for that with Google, you get an article about identifying individual farm animals, which is not the IDEA I have in mind. That is a project to collect data on the mains harmonic and interharmonic emissions from a wide range of products all over the world, when operating on non-ideal mains supplies, with finite impedance and pre-existing voltage distortion.

The project includes instructions for making a simple voltage and current sampling device, which, with associated (free) software and a free audio analysis application such as Audacity (http://audacity.sourceforge.net/) allows accurate and useful measurement of the emissions and analysis in considerable detail. Details of the project can be obtained through the email address below - there is too much to publish here.

If you join the project, you are invited to share your test results with other members, so as to create a knowledge-base on the subject.

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The EMCIA's position on PLT

By EurIng Keith Armstrong, C.Eng, MIET, MIEEE, www.cherryclough.com

Last year, the EMC Industries Association (www.emcia.org) chose me as their President, a decision that they have not yet come to regret (but its still early days). If you haven't heard of the EMCIA, it's probably because it has been run for the benefit of its members and has kept a low profile as far as the rest of the world is concerned.

But recently, the EMCIA has decided that there are various issues in EMC that are not being correctly addressed, and that it ought to try to play a part in getting them resolved, for the benefit of all. The first issue they have decided to address is the situation surrounding PLT (powerline technology), also known as broadband-over-powerline (BPL) or powerline communications (PLC).

If in your house you use an Ethernet adaptor that communicates by using the mains power cables in the wall, instead of a dedicated Ethernet cable, you are using PLT.

Some background: the Single European Market, with its CE Marking directives for products, was created for two reasons:

i) To achieve the economies of scale that had been observed to work so well in Japan and Northern America, by converting the differing import regulations of the various European nations into a single set, so that a single product design could be tested for compliance and sold to all of them.

ii) To keep cheap rubbish out (more accurately: protect responsible manufacturers from non-compliant products that could increase safety risks beyond those generally considered tolerable by Europeans, or damage the very important radio spectrum).

Well, item i) has been achieved, but not ii). Enforcement of regulations has an associated cost, and most European Union (EU) Member States apparently decided that they would enjoy the economic benefits of membership whilst saving money by not doing very much enforcement.

This is the governmental equivalent of being a teenager (who can confusingly now be 30 or more years of age) who prefers to live with his/her parents because of the financial benefits, but who doesn't actually want to help with the housework.

As many of us know from personal experience, such situations usually do not last for ever, and so it has proved for the EU. Discovering in 2005 that between 30 and 50% of products actually supplied in the EU did not comply with EU Directives they are supposed to [1], worried the European Commission (EC) greatly, because societal studies show that when such 'free loading' exceeds 15% they risk the collapse of the society itself.

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This has resulted in the first change to the CE marking approach in the EU, since its inception – EU Regulation 765, 2008 on Accreditation and Market Surveillance. From the 1st January 2010, "Reg 765" will require Member States to perform at least a specified minimum of effort in enforcing EU Directives in their countries, and they will have to provide figures to show that they are, in fact, doing their bit.

So it's very ironic, that whilst one part of the EC was busy being worried about the lack of product compliance, another part of it (DG Enterprise) was busy adding to the problem by encouraging the use of PLT – a technology that comes nowhere near complying with the EMC standards notified under the EMC Directive, which are intended to protect the radio spectrum from intolerable interference.

The original justification given by DG Enterprise for permitting the use of PLT, was that it provided competition for delivering broadband Internet services, especially to remote places where running additional cables would be very costly.

Since the mains cables already exist, why not use them to carry the data? Well, the reason, well established by numerous investigations and field trials, is that the mains cables make very good antennas for the MHz frequencies needed to

communicate the data, and since the data has to be sent over them at a very high level because of all the noise on the mains, PLT ends up broadcasting its signals all over the short-wave radio communication bands (known as the HF spectrum or HF bands).

This is known as 'Access PLT', but it has not been a commercial success and since other technologies are now a better bet for the future it is unlikely to ever take off. But PLT is also used for distributing high-rate data inside the home, where it has recently found a niche for distributing HDTV from room to room, or replacing Wi-Fi for people whose walls and floors attenuate 2.45GHz too much.

Whereas Access PLT had *some* political justification – however misguided this might appear to those who were concerned to protect the HF spectrum – there is *no political justification* for in-house PLT (unless you believe there is a political reason to turn people into couch potatoes), and yet DG Enterprise continues to support it.

Lay waste to the HF spectrum, causing untold difficulties and increased costs for the BBC, NATO, MOD, etc., spoil a natural resource that has huge safety benefits during large-scale disasters as well as providing an alternative broadcast medium for those who can't or won't use internet access, not to mention damaging the hobbies of many Radio Amateurs – all so that people don't have to string extra wires around in their homes? It hardly seems an equitable bargain.

You will find a wealth of technical detail about PLT and the test standards in Tim Williams' excellent analyses in Issues 80 and 82 (January and May 2009) of the EMC Journal, plus Richard Marshall's article in Issue 81 (March 2009) – and also in the articles by those same two independent EMC experts in this Issue.

There is also a wealth of historical documents on PLT posted on the EMC Journal's website at **www.theemcjournal.com/plt.** I recommend you read the correspondence between ADDX and DG Enterprise – for myself, I have never read such well-written technically-competent questions, and I never even *imagined* ever reading such arrogant, weasel-worded, patronising replies, which failed to address any of the questions and were devoid of any meaningful technical content.

All this excellent material leaves me free to discuss the EMCIA's concerns about PLT in this brief article using a general, more hand-wavy approach, as follows.

A) PLT is an extremely noisy technology

The mains noise emissions from a single Ethernet-over-Powerline product, widely sold throughout the EU, is conservatively equivalent to that of *at least* 1,000 products that only just meet the limits in their relevant harmonised emissions standards.

This is like having the total mains noise emissions of all the houses in a small village injected into the mains distribution at one point in a house! And of course this could conceivably happen in every house or apartment in a town, or even in a large city.

I have seen a technical argument that seems quite reasonable, that estimates the figure to be more like *100,000* products that just about meet their emissions limits, on the basis that the PLT device blankets the major portion of the HF spectrum and is always on – equivalent to plugging in the mains noise of all the households in a *small town* – at just one point in each house.

B) Many warnings have been given about PLT

Several theoretical investigations by leading organisations (York University, ERA Technology, NATO, BBC, RSGB, Netherlands Broadcasting Authority, etc.) over recent years have all shown that PLT technology must be expected to cause a significant increase in the background noise levels in the HF (short-wave) bands worldwide, if deployed Europe-wide.

Some of the research indicated that an Access PLT system covering the whole of Greater London would significantly raise the noise floor in the HF bands as far away as Plymouth, while others claimed it would be detected as far away as Moscow.

They also showed that near to a PLT product, HF reception could be rendered impossible for a radius of several hundred metres.

Field tests in Japan found that these predictions are not unreasonable, and that a single PLT system could also interfere with Radio Astronomy in the HF bands at distances of up to 219km, and its harmonics could interfere at UHF at up to 12km.

The HF bands are used for vital communications with impacts for safety, national security and defence, and proved invaluable in coping with both 9/11 in New York and the Boxing Day tsunami, when the 'normal' telecommunications and radiocommunications (including cellphones and the emergency services' own systems) all failed. So the raising of the noise floor in the HF bands can have very serious safety consequences.

C) An example of one PLT vendor's claims of EMC compliance.

Recent correspondence on the subject of one particular product has revealed the claims made for compliance with the EMC Directive by the product's manufacturer, when challenged. EMC enforcement agents throughout the EU seem content to accept these claims, despite them being erroneous in <u>every</u> respect.

Claim 1: Our product conforms to the EMC Regulations as amended, and the Product has been tested by an accredited independent Test House. The tests carried out simulated the conditions in which the Product is likely to be used.

Rebuttal 1: Their Declaration of Conformity referred to CISPR/I/89/CD as the test standard used by the test house. But this is not a harmonised standard, so cannot be used to provide a presumption of conformity to the EMC Directive.

Worse, it is just a committee draft which was widely criticised and subsequently (and acrimoniously) withdrawn from IEC website. It is a totally discredited document.

The actual emissions when measured are at least 30dB above the maximum limits set by the relevant harmonised standard. A level that – when measured in all of the EMC test houses that

anyone in the EMCIA has ever visited – would unquestionably result in a 'failure to comply' report.

Claim 2: Customers and enforcement agencies have also looked at our product and have had it tested for EMC regulations compliance.

Rebuttal 2: From our contacts throughout Europe, we understand this claim to be untrue, or – at the very least – intentionally misleading. Yes, they may have "looked at our product" – but they have certainly not formally endorsed its compliance with the EMC standards.

Claim 3: Our product design has a 'notching out' feature that can be used to block out the frequency that is the cause of problem in 'short wave' region of the electromagnetic spectrum.

Rebuttal 3: They can only block their emissions over a part of the spectrum – since some of the spectrum must remain unblocked to allow data to be communicated. Emissions in those unblocked parts of the spectrum still contravene the essential requirements of the EMC directive.

Also, recent analysis has shown that, in real life, 'notching' (e.g. to protect Digital Radio Mondiale) will have limited effectiveness, maybe none, due to intermodulation in the rectifiers that are certain to be connected to the mains supply.

Claim 5: We have sold about 75,000 products, but enforcement officials in the UK have only received 81 complaints, only 3 of which have not been resolved.

Rebuttal 5: There are several excellent reasons why the number of complaints (whether resolved or not) cannot provide any real understanding of the potential of any product to cause unacceptable interference. See Richard Marshalls article elsewhere in this Issue. What other product of similar sales volume would be regarded as satisfactory if it had received "only" 81 complaints?

D) Other manufacturers are likely to copy PLT emissions

Because certain vendors are (so far) being allowed to get away with selling Ethernet-over-Powerline PLT products that do not comply with the relevant harmonised emissions standards, using laughably incorrect compliance justifications such as those given above, many manufacturers of other classes of product will probably become interested in copying their emission levels.

By doing so, they can remove costly and large components from their product's mains filters. High-volume manufacturers could save millions of GB Pounds each year, a persuasive argument at any time, but especially so in today's difficult economic climate.

Of course, having such products on the market would quickly make noise levels on the mains supply network very much higher than they are at present, making it likely that PLT products would no longer work as well.

More importantly – this would add to the damage that the PLT products are doing to the HF spectrum – on which many specialist users (including UK Coastguard, Defence and National Security) rely, and would have significant safety implications.

DG Enterprise has recently started to claim that because there has been a low level of complaints of interference due to PLT products, this shows that they actually comply with the Essential Requirements of the EMC Directive (but see Rebuttal 5 above).

Although such statements are logically and technically incorrect [2], since they are being made by the people who have overall responsibility for the EMC Directive - manufacturers will be able to copy such statements in their EMC Technical Documentation and use them as justification for their non-PLT products having similar extremely high levels of conducted mains emissions.

The result would be that the value of the HF bands will be compromised forever, and for no good reason – PLT products would no longer be reliable, so very few people would use them anymore.

[1] Ivan Hendrikx, "The Future of Market Surveillance for Technical Products in Europe", Conformity, April 1, 2007 (but not a joke!), www.conformity.com/PDFs/0704/0704_F01.pdf

[2] Keith Armstrong, "Absence of proof is not proof of absence", EMC Journal, Issue 78, September 2008, www.theemcjournal.com

PLT

BT Vision; the radio interference iceberg

By Richard Marshall MA, CEng. FIEE, FInstP, FIET, Richard Marshall Limited

Overview

Some people say that interference to radio services from power-line telecommunications cannot be a serious problem because relatively few complaints have been documented.

This article examines this proposition, asking – and answering - the question "how many victims are close enough to a culprit for interference to be expected?"

This examination has been made possible by the marketing in the UK of BT Vision. This is a consumer service which includes as part of its package Power Line Adaptors (PLAs) that use the technology PLT (Power Line Telecommunications, also known in other countries as PLC or BPL) to communicate between the telephone line interface and the user's TV. This technology [Ref. 1] generates conducted interference upon domestic mains wiring at a power level a thousand times that which would be reasonable for any other domestic appliance, and does so twenty-four hours a day, seven days a week, simultaneously across almost the whole of the short-wave radio spectrum.

We will show that, despite the quite large numbers of both culprit BT Vision installations and victim radio users, geographical separation and the motivation and mechanics of the complaint process have so-far limited the registration of complaints.

However, complaints are proliferating with enhanced victim awareness, and this trend will accelerate with increased market-penetration of culprit and me-to products.

The balance between innovation in business and environmental loss to the wider community can only be managed successfully by conformance to a consistent set of EMC Standards, and it is important that all attempts to destroy this consistency should be resisted.

Introduction

Norms for interference emission for domestic appliances and IT products, as exemplified by refs. 2 and 3, are based upon a conceptual "protection distance" of 10 metres. By this is meant that product emission is allowed up to a level that should not interfere seriously with the reception 10 metres away – that is, on an adjoining property - of a radio transmission whose strength puts it within its "service area" as defined by the International Telecommunications Union [ref. 4]. There are many uncertainties in real-life situations, but the practical experience of Administrations and Radio Users over the last eighty years has confirmed that this protection distance sets a sensible statistical compromise between the cost of appropriate design of domestic products and the cost of transmission power for the delivery of radio services.

Broadband PLT technology, by virtue of the wider spread of its thousand-fold excess interference emission power, predicates a protection distance that is larger by the square root of a thousand. Accordingly, radio receivers may expect trouble if they are located anywhere within 310 metres of a culprit, rather than just within 10 metres.

It is important to distinguish between the various flavours of PLT. Low-speed communication for metering and control of the mains network was standardised many years ago [Ref. 5]. It is widely used and being kept in technically-competent hands has caused few problems. Broadband PLT uses higher powers over a much wider and higher-frequency band and has been let loose onto the consumer market. The broadband power-line adapter used for BT Vision is supplied by Comtrend and uses the DS2 chipset. Uniquely, this chipset radiates prolifically even when no data is being transmitted: The rival "Homeplug" hardware emits only occasional "ticks" when in the standby state.

In more technical detail, this Comtrend device emits from its mains terminals an interference signal that is about 30dB greater than the customary Class B conducted limit [Refs.2 and 3] for mains terminals over the range 2 to 26.6MHz, except that some (but not all) amateur bands are "notched" down to that limit. (It has been noted that these notched bands, and other parts of the wider spectrum, can never-the-less experience interference when PLT emissions are frequency-shifted by inter-modulation that is caused by rectifiers elsewhere in the supply network, or by adventitious "rusty rectifiers" such as iron guttering and clothes lines.) In the scaling calculation above we have used a "far field" calculation and absorbed the inherent errors [ref. 6] of such an approximation into the general statistical uncertainties of EMC prediction.

So a large number of devices have been placed on the market that can be shown by quite simple mathematics to have the potential to cause interference to short-wave users within a radius of a few hundred metres. They have provided a unique opportunity to check interference theory against practice - and it will be shown below that the agreement is good.

First we estimate how often culprit and victim will be sufficiently close to each other for BT Vision to be a problem.

How many potential victims are there?

There are "professional" victims in aviation, shipping, military, security and emergency services as well as devices for the disabled, but these do not yet appear in Ofcom statistics.

There are 65,000 Amateur Transmitting licences issued in the UK. Some amateurs hold two licences, some are interested only in vhf and microwaves, some are quite dormant. We can

estimate that 20,000 are active within the HF band that is open to interference from PLT.

There must be 200,000 short-wave listeners with varying degrees of interest. Some 22,000 of these are committed enough to buy the specialist magazines "Radio User" and "Practical Wireless". Some were born outside the UK and to these people the link with their homeland may be regarded as a basic human right.

All the above are potential victims, but if they do suffer interference they will only appear in complaint statistics if they can cross two barriers;

* The first problem for all the above would be recognising the source of interference. The noise PLT makes is rather featureless (but listen to the examples that may be found by searching for "radio interference" on Youtube.co.uk), and the straightforward technique of switching off each possible source in turn is not usually practicable. However such identification is easier for the more-technical Amateurs than for the broadcast listeners. This is probably why about two-thirds of the complaints in Ofcom's statistics are from Amateurs despite the much larger population of broadcast listeners. Maybe one half of the 20,000 Amateurs and one-fortieth of the 200,000 Listeners would be able to recognise the source of any problem - that is 15,000 in all.

* Next the victim must be sufficiently motivated to do something. We British are lethargic and not natural whingers. To whom should one complain? BT may have supplied the offending item but the victim is not usually BT's customer and so there is no straightforward way to contact them. Trading Standards pass the issue to Ofcom, whose website page http://www.ofcom.org.uk/complain/inter/radio/293505/?itemid=300133 is very helpful but does mention the possibility of a £50 charge.

If we reckon that only 20% of potential victims cross these two hurdles then in the UK there are 3,000 people who, if they were exposed to interference from PLT, would complain. *Out of a total population of 60 million some 220,000 people - 1 in 270 - might suffer the problem, but of these only 3,000 - 1 in 20,000 – would make an official complaint that would appear in the statistics.*

How likely is it that there is a potential victim within range of a BT Vision Culprit?

National statistics provide the following population and land area figures from which an average distance between people can be calculated. There is of course a very wide variation in people/km^2 between different regions;

Region	Population	Area km^2	people/km^2	average distance between individuals
Whole UK	60,000,000	242,000	248	64 metres
Greater London	7,513,000	1,579	4,758	14.5 metres

The above analysis is quite robust because of the square-rooting that is inherent in the calculation of average distance.

Since both the above protection distance calculation and an informal analysis of reported complainants shows that victims are typically up to 150 metres from BT Vision users, we may conclude that, on average in the UK, *whenever a BT Vision customer has a near-neighbour who is a short wave user, actual interference will result.*

Arguably such a customer will have 4 to 20 near-neighbours. We will assume 10 as a round-figure average.

How many Culprits are there?

BT have formally stated [Ref. 7] that *"The take-up of BT Vision accelerated during the year. By the end of March 2009 we had 423,000 customers"* Sources within BT, acknowledging that some sales are not currently installed and others have had the Comtrend PLT components replaced by a wired connection, accept that there are probably 300,000 active installations using PLT.

Complaint Prediction

Above, we postulate that there are now 300,000 culprits, each of whom has 10 near-neighbours, there being a 1 in 20,000 chance of each such neighbour having a life style that leads to their suffering interference , recognising it and doing something about it. This ought to produce 300,000 x 10 /20,000 = 150 complaints.

At the time of writing, Ofcom has reported a total of 143 complaints. There is of course a strong element of chance in this close agreement. However, *the point is that the logged complaints represent a near 100% complaint rate from relevant neighbours, and is held at what some may consider a manageable level only by the sparse distribution of the victims and by the difficulties of identifying the culprit and recording a complaint.*

The future

Service Engineers for electrical and electronic products generally expect a "bathtub" complaint profile, with most failures due to workmanship or component failure at the beginning of life, a trouble-free middle age, and gradually increasing failures due to wear-out as the end of life nears. In contrast, interference complaints result from *design* failure, and so are equally likely at any time in the working life: They will happen when an affected radio user recognises the problem.

The overall rate of complaint should be largely dependent upon the total field population *times* user awareness of the problem. The effect of user awareness can be clearly seen in the Ofcom statistics plotted in the chart together with the BT Vision population figures.

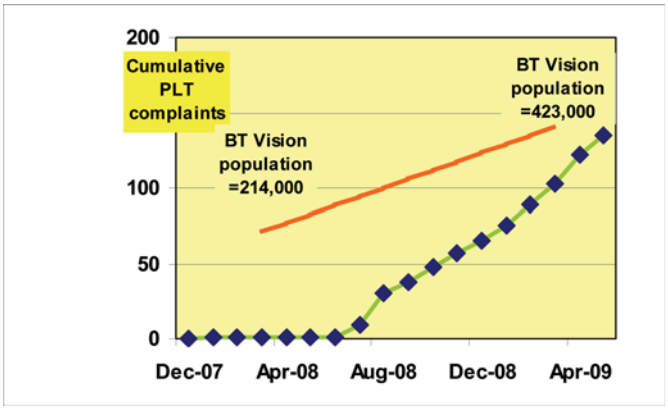

Chart: This shows the growth of complaints (Courtesy Ofcom) and the related subscriber numbers for BT Vision [Refs. 7 and 8]

Despite the field population of 214,000 units at 31st March 2008 [Ref. 8] virtually *no* complaints were logged before August 2008, at which time the activities of the UKQRM group, the various postings on Youtube and reports in the press of a question at BT's AGM raised awareness of the problem and of how to deal with it.

There remains considerable scope for increased user awareness to push up the complaint rate. An increase by a factor of 220,000/3,000 = 73 is conceivable.

Dan Marks, CEO of BT Vision until June 2009, has stated [Ref. 9] that BT's objective is 3 million subscribers by 2010. That 7-fold increase on the March 2009 claim would, at the present level of public awareness, lead to a complaint rate of about 100 per month. However, one article in the *Daily Mail* could increase awareness sufficiently to overwhelm the resources of Ofcom and BT. How many complaints are needed to make the authorities, the marketeers, and the product designers to go back to basics?

The declared UK and EC policy of "facilitating deployment of PLC, whilst retaining a regulatory influence on any undesirable side effects" [Ref. 10] clearly cannot work given the limited efficiency of a complaints-driven process that is without focus or motivation. A complaints-driven process is equivalent to shutting the stable door once the horse has bolted.

Furthermore, the time delay inherent in such a process is incompatible with twenty-first century design and marketing time-scales. We have to implement a better process for managing the electromagnetic environment.

Postscript

In addition to the local problems discussed above, there is a long-distance-interference problem due to ionospheric reflection carrying PLT interference around the globe. This causes a general increase in the HF noise floor, to which the logical counter-response will be the environmentally undesirable use of higher radio transmitter powers. This will become a serious issue if PLT is widely deployed since it renders impossible the avoidance of interference by the separation of culprit and victim. This "Cumulative Interference" is an inevitable result of the laws of physics, and was demonstrated in practice for analogue cordless phones many years ago. It is intended to return to this problem in a future issue of *The EMC Journal*.

The writer acknowledges the contribution of Robert Barden to the brainstorming of the structure of some of the calculations in this article.

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[1] *"RF Emissions of Powerline Ethernet Adaptors"* by Tim Williams, The EMC Journal, May 2009, Issue 82 pp 15-18.
[2] *"Electromagnetic Compatibility – Requirements for household appliances, electric tools and similar apparatus. Part 1: Emission"* CISPR14-1
[3] *"Information Technology Equipment – Radio disturbance characteristics"* CISPR22
[4] *"Radio-Frequency Protection Ratios in LF, MF and HF Broadcasting"* ITU-R Recommendation BS.560-4
[5] *"Signalling on low-voltage electrical installations in the frequency range 3KHz to 148.5kHz"* EN50065-1
[6] *"Distortion of the Interference field near cables carrying PLC signals"* by R.C.Marshall. IET 7th International Conference on Computation in Electromagnetics, Brighton, UK, 7th-10th April 2008.
[7] BT's Annual Report for 2009, p. 13
[8] BT's Annual Report for 2008, p. 18
[9] *"Frustrated Marks quits BT Vision"* Daily Telegraph, 10th June 2009, p.B1
[10] UK position paper for the EC Joint Workshop on PLC, Brussels, 16th October 2003.

After the EMC Directive

By Tim Williams, Elmac Services

Does the EC think that standards are a waste of time? It has always been legally permissible to comply with New Approach Directives without actually testing to their listed harmonised standards, the aim being that whatever other approach is used should meet the Essential Requirements of the Directive. But what we are seeing now in the case of Power Line Communications (PLC, occasionally Power Line Telecommunications, PLT) is a situation in which manufacturers of such products are complaining about their inability to meet these standards, twisting out of doing so by using rejected draft documents as if they were legitimate, and doing this apparently with the full support and encouragement of the European Commission.

In the past year, complaints about interference from PLC products, and particularly about in-house Ethernet-to-Powerline adaptors that are on all the time, have been fired at the European Commission and at enforcement authorities from all directions. The response, when it comes, has been to shrug off the complaints as if they are irrelevant. A widely-circulated letter to an MEP from the Vice-President of the EC [1] says

> *"Power line adapters" are covered by Directive 2004/108/EC on "electromagnetic compatibility" (EMC), which provides Member States (in the case of the UK OFCOM) with ample provisions to correct situations of interference. The relatively few problems that occurred can be handled within its context. PLC technology does not interfere into military services since they typically do not operate in areas where there is a risk of interference. Emergency services now use advanced digital radio technologies to communicate. Shortwave broadcast reception has further been substituted by internet radio."*

This article will look at some aspects of the response and draw some conclusions for European regulation – conclusions which may surprise some people.

The Discussion Document

The European Commission's EMC Working Party last met at the end of June 2009, and PLC was one of the topics on the agenda. The Commission had circulated a "Discussion Document On The PLC Standardisation State Of Affairs" [2] in May, for the EMCWP to consider. In it, it was suggested that as of October 2009, manufacturers of PLC products will not be able to use EN 55022:2006 or any other harmonised standard for demonstrating compliance. This was taken to be because of a new testing flowchart which appears in this edition and which, it was felt, forced a PLC manufacturer to apply a conducted emission test which the PLC industry claims it didn't have to do under the previous 1998 edition; and October 2009 is the date from which the 1998 edition is superseded, as published in the *Official Journal of the EU*. The document includes what sounds like a sob story for PLC:

> *Any market surveillance check of PLC products conducted after October 2009 with the EN 55022:2006 test methods will show test results substantially above the limits of Table 1 & 2. As a result, PLC manufacturers have the impression that, even if their technical file is convincing, they run a serious risk of a sales ban by market surveillance authorities.*

The Commission had clearly been briefed in this regard by PLC manufacturers, not for the first or only time. A written question to the Commission in April [3], over the signatures of a number of MEPs, started by saying

> *Recent amendments to European standard EN55022 throw into jeopardy the future of powerline communications (PLC) technologies by imposing artificially low electromagnetic emissions limits that will make it impossible to place PLC equipment on the EU market from October 2009.*

Consequently, the Discussion Document for the EMCWP proposed one of two "solutions", either:

> *- to postpone the date of withdrawal of EN 55022:1998 which is the only standard with which PLT/PLC are able to comply. The new date could be discussed with CENELEC and industry so as to give reasonable time before the mandate deliverables can be referenced in the OJEU. However, for PLC/PLT equipment, which would continue to use the 1998 version, this solution postpones the benefits of all the other non controversial improvements which have been integrated in the 2006 version.*

> *- to render inapplicable to PLT/PLC the branch "mains" in the 2006 version (Article 6.4.b "publish with restrictions"). Thus, PLC/PLT technologies would still benefit from the non controversial improvements in the 2006 version.*

But it is *not true* to say that such technologies could comply with earlier versions of the standard, i.e. CISPR 22: 1998 or its EN equivalent. The later 2006 edition has, in the flowchart in Annex C, explicitly referred to the "mains type" as a potential type of telecommunications port which must be tested according to the established limits for mains terminals. This aspect of the flowchart has been maintained by CISPR/I in the face of pressure from the PLC industry for it to be modified; moreover, it has been maintained into the replacement for CISPR 22, the draft CISPR 32. This shows that CISPR/I regard it as imperative that the established limits should be applied *whatever the*

notional function of the mains connection. The CISPR/I approach has a solid technical foundation, which is operative regardless of the type of equipment which is connected to the mains.

CISPR emissions standards exist to protect the radio spectrum. The radio spectrum is a valuable and irreplaceable natural resource, like air and water, but its true value is only really appreciated when it is no longer available. These emissions standards, their test methods and limits, are based on a rigorous, well documented approach* and many decades of experience in real-world prevention of radio interference.

The third edition of CISPR 22, published as EN 55022:1998, was drafted before the question was raised of whether a PLC mains connection should be treated as a telecommunications port. It has no Annex C flowchart (although, in their discussion document, the Commission don't seem to know this) and does not explicitly state that a telecommunications port could be a "mains" type. However, it applies, without qualification, limits for conducted disturbance at the mains terminals. Nothing in the standard would disapply this to a PLC modem. These are exactly the same limits as are referred to in the Commission's document as "too low to be complied with by today's PLC technologies". Therefore there is no difference as far as the mains terminals are concerned between EN 55022:1998 and EN 55022:2006. Any manufacturer whose equipment breaches the limits for mains terminal disturbance voltage in tables 1 or 2 of EN 55022:1998 and yet who has declared unqualified compliance to that standard, has done so incorrectly.

Consequently, there is no change in status when EN 55022:1998 is withdrawn in October 2009. So the "two solutions" proposed in the discussion document are illusory. The first would not change the situation that a PLT modem which cannot comply with the mains terminal disturbance limits, cannot comply with the EMC Directive through the harmonised standards route. The second clearly sets the Commission at odds with CISPR/I.

The implication of the Commission's two suggested solutions is that they regard the approach taken by CISPR/I as inconsistent with the purpose of the EMC Directive, and are looking for ways to circumvent it. This has serious consequences for the application of harmonised standards, which are largely based on CISPR requirements.

In the event, the outcome of the Working Party meeting was inconclusive; the point regarding the lack of difference between EN 55022:1998 and :2006 was made clear to the Commission, who nevertheless "reserved their position". It is obvious that the Commission had been incorrectly briefed by the PLC lobby (and had accepted that briefing), who for some reason think that they can "get away with" inadequate compliance to EN 55022:1998. What is that reason?

* Interested parties may care to look at CISPR 16-4-4, "Statistics of complaints and a model for the calculation of limits for the protection of radio services"; of relevance to this argument, it contains, in its new Annex A, values of the classical CISPR mains decoupling factor which were determined by measurements in real LV AC mains grids in the 1960s. It is deemed that these mains decoupling factors are still valid and representative.

The advice to Notified Bodies

A previous article [4] has pointed out that the actual levels that one particular device puts on the mains supply are 30dB over the limit, over 75% of the conducted emissions frequency range. That device is said to use CISPR/I/89/CD, a withdrawn draft from 2003, in order to "tweak" CISPR 22 to allow compliance, and [4] discusses why this is not acceptable. But another source has suggested using a rejected CISPR document to allow a PLT device to claim compliance. This is ECANB (Group Of Notified Bodies Under The EMC Directive) TGN17 Version 1.0: April 2008, "Technical Guidance Note TGN on Assessment of Powerline Telecommunications (PLT) Equipment" [5]. It says

> *CISPR/I/257CD "CISPR 22 Limits and method of measurement of broadband telecommunication equipment over power lines" replaces the older CISPR/I/89CD. Thus it may be the basis for assessment by Notified Bodies until an amended CISPR 22 comes into force.*
>
> …
>
> *Notified Bodies when being consulted to provide an opinion on PLT conformity assessment should base their opinion on the following:*
>
> *a) Measurement of PLT emission should be done according to CISPR I 257CD (depending on the outcome of the voting this clause may need to be revised).*
>
> *b) Additional mitigation measures can be recommended to be implemented as described in CISPR/I/258DC* [which refers to notching and power management].

CISPR/I/257/CD having been swiftly rejected, TGN17 has now (a year later) been revised. For over a year Notified Bodies, and by extension manufacturers wishing to perform their own assessment, had an official imprimatur – ECANB is recognised as a source of guidance by the EC – for using a failed method. But the revised TGN is hardly any different; it merely repeats most of the relevant parts of CISPR/I/257/CD in its own text, and adds a description of mitigation techniques which is derived from (but not the same as) CISPR/I/258/CD. This in itself introduces problems, partly because the TGN now clearly diverges from the present thinking in the CISPR working group, and partly because some of the techniques are either patented or not yet commercially available. The guidance in the new TGN now reads

> *Notified Bodies when being consulted to provide an opinion on PLT conformity assessment are strongly encouraged to base their opinion on the following:*
>
> *a) Measurement of PLT emissions have to be done according to what it is described in clause 2 of this TGN.*
>
> *b) Additional mitigation measures have to be implemented according to what it is described in clause 3 of this TGN*

Note the difference between "strongly encouraged" and "should". In neither case is the word "shall" used. Even so, the

ECANB view is clearly at odds with the approach taken by CISPR.

The EMC assessment

At this point it would be as well to remind ourselves of the wording of the second edition EMC Directive 2004/108/EC. Annex II.1 says

> *The manufacturer shall perform an electromagnetic compatibility assessment of the apparatus, on the basis of the relevant phenomena, with a view to meeting the protection requirements set out in Annex I, point 1. The correct application of all the relevant harmonised standards whose references have been published in the Official Journal of the European Union* ***shall be equivalent to*** *the carrying out of the electromagnetic compatibility assessment.*

Point 3 says

> *In accordance with the provisions set out in Annex IV, the manufacturer shall draw up technical documentation providing evidence of the conformity of the apparatus with the essential requirements of this Directive.*

And Annex IV.1 says

> *The technical documentation must enable the conformity of the apparatus with the essential requirements to be assessed. It must cover the design and manufacture of the apparatus, in particular:*
>
> *— a general description of the apparatus;*
>
> *— evidence of compliance with the harmonised standards, if any, applied in full or in part;*
>
> *— where the manufacturer* ***has not applied harmonised standards, or has applied them only in part****, a description and explanation of the steps taken to meet the essential requirements of the Directive, including a description of the electromagnetic compatibility assessment set out in Annex II, point 1, results of design calculations made, examinations carried out, test reports, etc.;*
>
> *— a statement from the notified body, when the procedure referred to in Annex III has been followed.*
>
> (My emphasis)

From these points, we can understand that while a manufacturer *could* apply harmonised standards in full, *he doesn't have to*. If he doesn't, then he has to document how he thinks he's met the essential requirements in such a way that the conformity can be assessed; but the Directive doesn't say who is to do the assessing, except that the documentation must be held "at the disposal of the competent authorities". Reference to CISPR/I/257/CD, and even to CISPR/I/89/CD, would almost certainly be accepted by anyone who is not familiar with the detailed technical arguments that have gone into their rejection.

Now, this has always been the case since 2004/108/EC was published; there is nothing new in it. But various correspondence with Trading Standards and Ofcom (the competent authority in the UK) as well as statements from the EC themselves have all indicated repeatedly that these authorities believe that PLT modems, which clearly don't meet the limits in the harmonised standards, nevertheless have been legally placed on the market. This, even though there is plenty of evidence that these units are not designed such that "the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended" (the EMC Directive's first essential requirement). To quote a senior EC official, "Why make legal products illegal?" This leads us to reinforce a very significant conclusion (and I apologise for the triple negative):

Non-compliance with a harmonised standard's limits does not mean non-compliance with the EMC Directive.

This is dire news for CISPR and for the effort to protect the radio spectrum through the application of standards. It is clear that, as ITE, PLT modems should fall under CISPR 22; and that if their emissions are above the well-established limits for mains conducted disturbance, they cannot comply with CISPR 22; and therefore, there is no justification for them to be placed on the market, end of story. There are plenty of precedents to show that non-compliance with applicable standards mean effectively that a technology is outlawed. There is no reason for PLT modems to be treated as a special case, despite the lobbying by their supporters, nor should there be. They are used in the same electromagnetic environment as other products, all of which are subject to the same regulatory environment. But we now have clear evidence that the body responsible for the regulations agrees with the view, put forward in [3] quoted above, that the limits in the standards are "artificially low". The consequent conclusion must be that they are artificially low for all products.

If the standards can be discarded in such a cavalier fashion, why does anyone bother to work for their development, and why does anyone bother to observe their limits, or even test for them? And what price the EMC Directive itself? If anyone thought the Directive was about protecting the radio spectrum, think again. If spectrum protection collides with commercial protection, the spectrum loses.

References

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[2] *Discussion Document On The PLC Standardisation State Of Affairs*, European Commission Enterprise And Industry Directorate-General, Brussels, 19 May 2009

[3] WRITTEN QUESTION by Alejo Vidal-Quadras (PPE-DE), Fiona Hall (ALDE), Satu Hassi (Verts/ALE), Pilar del Castillo Vera (PPE-DE) and Erika Mann (PSE) to the Commission, 2nd April 2009; see **http://tinyurl.com/mvc2th**

[4] *RF Emissions of Powerline Ethernet adaptors*, Tim Williams, EMC Journal no 82 May 2009, pp 15-18, **www.theemcjournal.com**

[5] *Technical Guidance Note TGN on Assessment of Powerline Telecommunications (PLT) Equipment*, ECANB TGN17; Version 1.0, April 2008; Version 2.0, July 2009; available from **http://circa.europa.eu/Public/irc/enterprise/emccbnb/library**

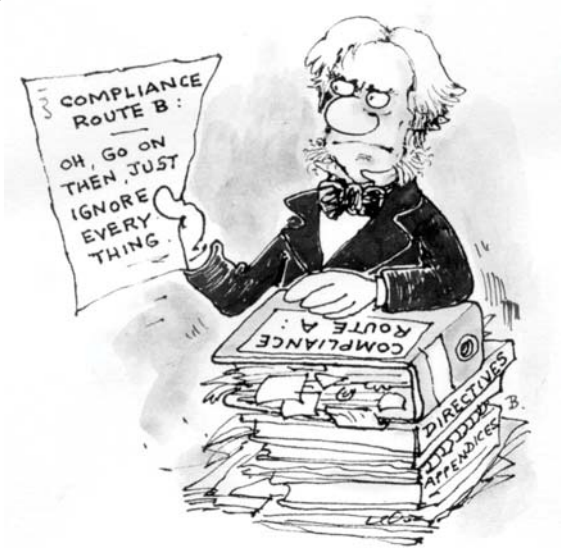
PLT

The *new* route to compliance with the EMC Directive

By "Faraday"

DG Enterprise have given the green light to a new route to complying with the EMC Directive, which they claim is fully in accordance with 2004/108/EC – and don't we EMC experts now all look stupid for not having seen it before!

So far, DG Enterprise have only encouraged its use on PLT products (see other articles in this Issue of the Journal). But I'm sure that – in the spirit of achieving a 'level playing field' for all economic operators in the EU (a fundamental principle in the very creation of the Single European Market) – they will be more than happy to see it used more widely.



There are just a few easy steps in this newly created compliance route:

a) Ignore any/all warnings about your technology's likely bad EMC, no matter who they are from; and – whatever you do – avoid designing in EMC countermeasures, they're far too costly! Customers prefer low cost products.

b) Ignore all emissions limits in the harmonised standards listed under the EMC Directive. In the same spirit, why not ignore all the immunity standards too!

c) Don't bother to write a Technical Documentation File that details why your product conforms to the EMC Directive's Essential Requirements. EMC enforcers won't ask to see it, and if they do will be easily satisfied by half a page of meaningless waffle as long as it sounds vaguely plausible to someone who is not an EMC expert. It might also help to declare conformity to a non-existent EMC standard or withdrawn draft.

d) Sell the product and wait to see if there are "too many" complaints to the authorities that cannot be individually "resolved" on a "case-by-case basis".

   (Note that "too many" and "resolved" are flexible terms, and the period over which any decision must be made is not stated, so there is plenty of room for manoeuvre.)

e) Sell a great many products in the EU, at least a quarter of a million. This new route to compliance makes this easier, because of the substantial cost savings of omitting filtering and shielding, and because time-to-market will be made quicker by not having to bother with passing any EMC tests.

   Then, even if the outcome of d) is unfavourable, your products will be permitted to stay on the market regardless of the interference it causes, because it is "too late to do anything about them now".

I can't see why we haven't all been following this route all along! It's so obvious, now that the PLT manufacturers have shown us how to do it.

Your good friend, Michael.

Some quotes by Michael Faraday

I am busy just now again on Electro-Magnetism and think I have got hold of a good thing but can't say; it may be a weed instead of a fish that after all my labour I may at last pull up.

I could trust a fact and always cross-question an assertion.

With respect to Committees as would perceive I am very jealous of their formation. I mean working committees. I think business is always better done by few than by many. I think also the working few ought not to be embaras[s]ed by the idle many and further I think the idle many ought not to be honoured by association with: the working few.

What a weak, credulous, incredulous, unbelieving, superstitious, bold, frightened, what a ridiculous world ours is, as far as concerns the mind of man. How full of inconsistencies, contradictions and absurdities it is. I declare that taking the average of many minds that have recently come before me... I should prefer the obedience, affections and instinct of a dog before it.

Why, sir, there is every probability that you will soon be able to tax it!
Said to William Gladstone, the Chancellor of the Exchequer, when he asked about the practical worth of electricity.

PRODUCT GALLERY

R&S FSV signal and spectrum analyzer now up to 40 GHz

Rohde & Schwarz has enhanced its R&S FSV signal and spectrum analyzer family to handle measurements up to 40 GHz. Manufacturers of satellite, radar or military communications systems operating in this frequency range can now benefit from the R&S FSV's unique measurement speed, high sensitivity and convenient touch-screen user interface. New options for noise figure and phase noise measurements are available for characterizing components such as amplifiers and oscillators. For scalar network analysis, the R&S FSV provides an internal tracking generator up to 7 GHz. Microwave generators can be connected to attain frequencies up to 40 GHz.

Like all members of the signal and spectrum analyzer family launched in 2008, the **R&S FSV40** features outstanding sensitivity, dynamic range and measurement speed. The low inherent noise of –139 dBm (1 Hz) at 40 GHz combined with a +18 dBm third-order intercept (TOI) allows measurement of spurious emissions without inherent distortions at high

sensitivity even at high signal levels. The R&S FSV40 offers exceptional speed: It measures a 1 GHz span at 1 kHz resolution bandwidth in 2.5 s – compared with the 1000 s required by the preceding generation in this class. Measurement speed with remote control is also impressive – 1000 measurements/s – which means the R&S FSV40 ensures high throughput in production. The convenient touch screen and the on-screen keyboard make manual alignments easier.

Rohde & Schwarz is offering the **R&S FSV-K30** option for noise figure and gain measurements on receiver frontends, amplifier components and system modules. Adding this option makes an additional noise figure test assembly unnecessary. The **R&S FSV-K40** option measures single sideband phase noise on oscillators. This means that a single instrument – the R&S FSV – can determine the key parameters of an oscillator: output power, frequency and frequency stability.

Together, the **R&S FSV-B9** and -**B10** options transform the R&S FSV into a scalar network analyzer. The internal R&S FSV-B9 tracking generator covers the range from 100 kHz to 7 GHz. For higher frequencies, the analyzer uses external signal generators as tracking generators that are connected via the R&S FSV-B10 option in order to measure two-port devices. This option also makes it easy to perform measurements on frequency-converting DUTs as well as measurements on frequency dividers and multipliers.

The new R&S FSV40 , which covers up to 40 GHz, as well as the options for noise figure measurements (R&S FSV-K30), phase noise measurements (R&S FSV-K40), tracking generator (R&S FSV-B9) and external generator control (R&S FSV-B10) are now available from Rohde & Schwarz.

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The Digital Solution for excellent Power Quality

Schaffner have increased their range of power quality solutions for industrial power systems. Following the success of their ECOsine™ passive harmonic filters launched in 2008, Schaffner has now introduced a digital solution for the efficient reduction of system perturbations - the ECOsine™ Active. Latest generation electronics enables an intelligent and adaptive compensation of harmonic currents with a response time of less than 300 microseconds. ECOsine™ Active takes Schaffner's range of harmonics mitigation products to new levels of performance.

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Delta Electronics Extends Industrial EMI Filter Line with 6 New Series

Delta Electronics, amongst the world's leading providers of EMI filters and known for high quality EMI filter products, announced today the launch of 6 new EMI filter series. Delta developed the new filter series to optimally cover the EMI filter requirements of today's industrial markets.

All filters are 3-phase filters having either 3- or 4-wire connection, and ratings up to 180 Amp and 680 VAC are now available. The mounting style, dimensions, and performance of the filters are in accordance with industry standards, enabling direct exchangeability. To enhance safety, the filters are equipped with touch safe terminal blocks connectors. High attenuation characteristics over a broad frequency spectrum make these series suitable for a wide variety of industrial applications. Low-leakage current versions are available, and all filters have obtained UL approval.

With many years of in-depth manufacturing expertise, Delta Electronics can develop custom-made versions upon request. An experienced staff is at the customers' disposal at Delta's EMC competence center in Soest, Germany. Here all tools and equipment are available to conduct EMC testing on customer equipment. Delta can also provide on-site testing using mobile test equipment.

The new filter series are produced at Delta Electronics' plant in Thailand, where single- and 3-phase EMI-filters are also produced for well-known multinational OEMs. This factory holds all the necessary quality certificates such as ISO9000:2000, TS16949, and ISO14001, and it has received countless supplier recognition awards from world-class electronic equipment manufacturers.

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cschade@delta-europe.com
www.delta-europe.com

Transformer for energy saving electronic devices

In today's world and for the future environmentally friendly technologies is a necessity! Consumer and manufacturers have turned their attention towards energy saving electronic devices.

Various semiconductor manufacturers already offer simple ICs with which competitive SMPS can be designed. **Würth Elektronik** has developed two transformer series, which are designed and manufactured to the requirements of the leading semiconductor manufacturers STMicroelectronics and Power Integrations. The offline transformer WE- UNIT has an input voltage of 85 – 265 V_{AC} and an isolation voltage of 4 kV_{AC}. The transformers are especially designed for universal input as well as for offline-switch mode power supply.

An additional requirement to decrease the energy consumption will be released by the law. One of these requirements results in the

disappearance of the linear regulators in the near future. They will be replaced by SMPS.

The aim of manufacturing SMPS' is the development of power supply for the worldwide universal input. The advantages are obvious: Efficiencies of 80% and more, less weight and smaller size than linear regulators as well as a low stand by-power consumption.

All products are available ex stock. Samples are free of charge.

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PRODUCT GALLERY

AWR announces AWR Connected™ for Rohde & Schwarz

AWR, the innovation leader in high-frequency electronic design automation (EDA), today announced AWR Connected for **Rohde & Schwarz**, which integrates the capabilities of R&S® WinIQSIM2 simulation software from the leading test and measurement manufacturer within its Visual System Simulator (VSS) system analysis software. The complete range of digitally-modulated signals generated by R&S WinIQSIM2, along with those already present within VSS, ensure that the same real-world test signals can be used throughout the design cycle.

The integration of R&S WinIQSIM2 gives VSS access to today's modern communication signals (including those for 3GPP LTE, 3GPP FDD/HSPA/HSPA+, and WiMAX). Having such accurate representation of signals in the VSS simulation environment ensures engineers are simulating their designs with the same signal as the device will encounter in service.

For cross-domain simulations, hardware components can easily be integrated into any simulation. The signals generated by the instrument are sent back into VSS so the device under test can be optimized in VSS to meet the performance goals of specific wireless network standards. The solution works with the Rohde & Schwarz high-performance vector signal generators such as the R&S® SMU200A, which offers outstanding RF and baseband performance and also provide signal processing capabilities such as real-time fading required for Multiple Input Multiple Output (MIMO) measurements.

R&S WinIQSim2 joins the AWR Connected product portfolio, which includes LTE-specific Rohde & Schwarz measurement solutions within VSS. Together with AWR's Test Wave solution for linking measurement hardware and software, these tools provide the industry's most complete solution for evaluating communication systems and subsystems using both basic RF signals and standards-compliant waveforms.

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www.awrcorp.com

CST Announces Substantial Advances in Frequency Domain Solver Technology

Computer Simulation Technology (CST) has announced that the CST MICROWAVE STUDIO® frequency domain solver will feature 3rd order and mixed elements with the 2010 release.

Design engineers and researchers working on electrically small or resonant structures value the frequency domain solver of CST MICROWAVE STUDIO® as a well integrated alternative to the market leading time domain solver, and for cross verification purposes. The range of possible applications and users has now been enlarged.

With the introduction of the True Geometry Adaptation, a technique which improves the geometrical representation of a structure during the mesh adaptation process, in version 2009, CST reinforced its claim to technological leadership through a distinct and significant development. This technique overcomes an inherent accuracy problem of traditional FEM codes which refine the mesh but not the segmented geometry.

Version 2010 will feature 3rd order elements alongside the already available 1st and 2nd order elements. These will enable electrically larger problems to be solved as the spatial sampling of the wave can be reduced and therefore the memory efficiency in homogenous regions increased. In addition the combination of all three types of elements allows the efficient tackling of simulation models which feature a combination of electrically small, detail rich portions as well as larger homogenous areas, thus extending the range of applicability for the frequency domain solver and addressing an extended customer base.

"*We are committed to supplying our customers with cutting edge simulation technology, allowing them to select the numerical method which is most appropriate for their current task,*" commented Dr. Peter Thoma, Managing Director, R&D, CST. "*This FEM implementation with 3rd order and mixed elements represents a major technological step in our frequency domain technology, opening the way to an even more diverse customer base.*"

True Geometry Adaptation is available with CST STUDIO SUITE™ 2009, and 3rd order elements with version 2010.

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The Extraordinary Life of Prisoners of War

Imperial War Museum North, Special Exhibitions Gallery
23 May 2009 – 3 January 2010. FREE. www.iwm.org.uk/north

In the year which sees the 70th anniversary of the outbreak of the Second World War, Imperial War Museum North in Manchester presents the first major exhibition ever held by the Imperial War Museum dedicated to the experiences of prisoners of war (POWs) during the conflict.

The exhibition reveals the experiences of British and Commonwealth prisoners and civilian internees in Europe and the Far East and also features stories of Italian and German prisoners in the UK and their relations with their captors.

More prisoners were taken during the Second World War than in any other conflict. Millions of soldiers, sailors and airmen found themselves behind barbed wire. What happened to them depended on when and where they were captured - and sometimes their nationality or race. Many of us know something about prisoners of war through films which romanticise daring escapes. But there is another story. It is one of extremes - from courage, comradeship and compassion, to hunger, boredom, deprivation, cruelty and neglect.

In this total war, civilians including women and children were also interned, simply because of their nationality. Either they were people caught in enemy territory when war broke out, or they had escaped persecution and were rounded up and interned by the very countries in which they had sought refuge.

This unique exhibition will look in detail at what was needed to survive in an often harsh environment. Using an engaging mix of objects, art, documents, photographs, film and sound from Imperial War Museum s unrivalled collections, Captured will reveal incredible personal stories during periods of captivity that in many cases lasted for several years.

Visitors can uncover the truth behind stories that have since become legends such as The Great Escape, The Colditz Story and The Bridge On The River Kwai and find out what everyday life was really like as a POW, from experiences of capture, food, welfare, work, recreation and illicit activities to liberation. This exhibition looks at the real experiences of prisoners of war and civilian internees during the Second World War, and at the impact and legacy still affecting former prisoners and their families today.

New ESD Standard and Influence on Test Equipment Requirements

By Nicholas Wright, EMC Partner AG

Abstract

The IEC61000-4 series of standards form a basic framework for the immunity and emissions testing of electrical and electronic equipment. They are the basis for EN standards used to test CE compliance of electrical and electronic products sold within the European Union. After a period of relative stability, changes are being introduced, designed to improve reliable application of the basic standards and ensure that the same results are obtained no matter where the tests are performed. Many changes relate to the calibration procedures for the test equipment. The surge standard, IEC61000-4-5, was revised at Edition 2 to amend impulse performance when applied through Coupling Decoupling Networks (CDNs) of varying current ratings. The Electric Fast Transient (EFT) standard, IEC61000-4-4, is also currently being studied with a view to changing the calibration requirements when used with CDNs and the Electrostatic Discharge (ESD) standard, IEC61000-4-2, is spearheading the application of measurement uncertainties and reviewing failure criteria.

While these changes do not directly influence the test procedure or methodology, the test equipment used is being subjected to much tighter scrutiny. ESD phenomenon is possibly the most complex EMC event to characterise or model. The IEC has accumulated experience over many years with ESD and is now updating the standard to reflect current technology. In the process of these changes, one aim is to improve the reliability of ESD tests. A result of these improvements is an increase in generator calibration and test time.

Introduction

For the uninitiated, ElecroStatic Discharge (ESD) is a phenomenon as old as history itself. Particularly in cold dry climates, ESD events are extremely common. Who has not experienced a "shock" when getting out of a car in winter? Although unpleasant, ESD is not dangerous to humans as the energy content is very low. Figure 1 puts ESD in perspective in relation to other Electro-Magnetic (EM) events.

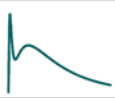
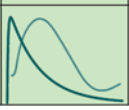
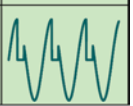
CHARACTERISTICS	STATIC DISCHARGE	SWITCHING OPERATIONS	LIGHTNING	POWER TRIP
PHENOMENON	ESD	EFT/BURST	SURGE	DIPS
VOLTAGE U	Up to 15 kV	Up to 4 kV	Up to 6 kV	Mains
ENERGY AT MAXIMUM VOLTAGE	Below 10mJ	300mJ	300J	N/A
REPETITION RATE	Single impulse	Multiple pulses in kHz range	Ca. 1 per minute	Related to power frequency
APPLICATION (EUT)	Metal parts which can be touched by persons	Power, signal measuring & data lines	Power, signal measuring & data lines	Anything connected to AC or DC supplies
UPPER FREQUENCY LIMIT	Ca. 4GHz	Ca. 100MHz	Ca. 350kHz	Ca. 100kHz
WAVEFORM				

Figure 1: Transient Overview

International Standard for ESD

IEC61000-4-2 [1] relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges. The standard defines the following:

- ranges of test levels
- different environmental installation conditions
- establishes test procedures.

The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. This standard has been used for many years and is an evolution of the IEC801-2 dating from 1991 [2]. In light of modern measurement methods and experience gained over the last 30 years, changes have been proposed and will be adopted during 2009.

Reasons for Revision of IEC 61000-4-2

Today, using the equipment available and the current test standard, it has been found that any EUT could either pass or fail based on which type of simulator is used. Also new high speed technology is in use which operates into the GHz range. The Maintenance Team responsible for ESD standards (MT12) have issued a Committee Draft (CD) [3] proposing the following changes:

- Calibration and verification of measurement equipment to be more clearly defined
- Standard current waveform defined as a mathematical equation
- Measurement uncertainty defined for different parameters
- No tests at lower level for contact discharge

The "good old days"

Before everything got high-tech, ESD was a simple affair. Anything resembling the specified waveform that "magically" (and unexpectedly) appeared on the analogue oscilloscopes at the time, was acceptable and nobody could do anything to prove the contrary.

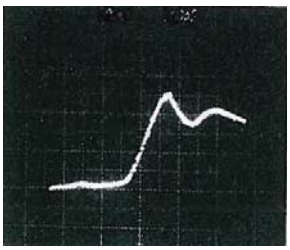


Figure 2: Analogue ESD measurement

But, technology moves on and with the advent of digital oscilloscopes, bandwidths increased and oops! Suddenly our ESD doesn't look so good anymore. Taking these advances into account and the view that ESD test results appeared to vary between locations led the standards organization to investigate further.

Round Robin Test Waveform

Various "remedies" were proposed to improve the situation. One such was an attempt to modify the waveform tolerances, controlling the waveform to within much tighter limits and eliminating high frequency ringing.

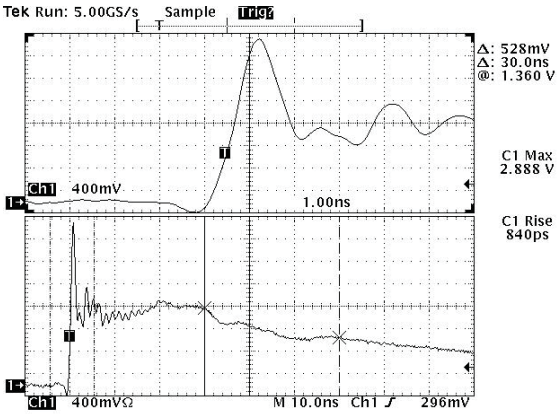


Figure 3: Existing Simulator

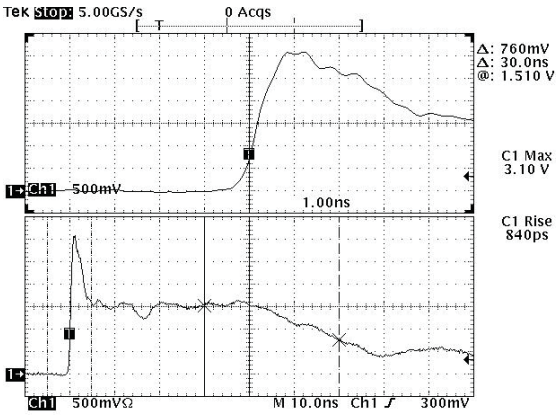


Figure 4: Modified Simulator

Additionally, a series of round-robin tests on six EUTs was conducted at different international locations using both the existing and modified simulators.

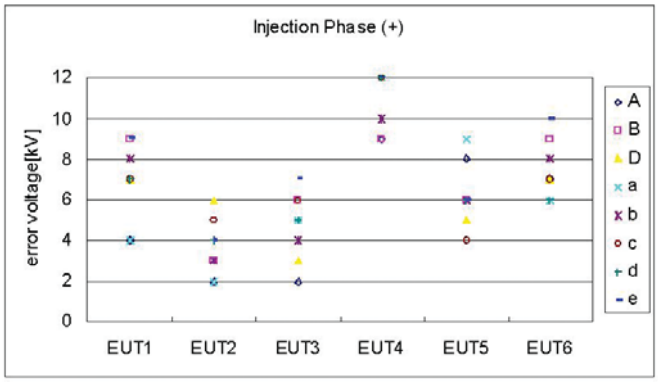


Figure 5: Round Robin Results

The problem is no correlation could be found. To start with, the EUTs did not exhibit failures when subjected to the standard ESD test levels. Some EUTs had to be modified to even show a failure. Huge variations were observed as a result of changing the ESD simulator model. However, the modified simulators did not give an improved variation in results compared with the non-modified generators. Significantly, no direct correlation was found between current, fields or frequency related parameters and EUT failure level. As the final "nail in the coffin", test result variations were observed between ESD simulators from the same manufacturer!

Variation in test results and escalation strategy

As no definitive source could be identified to explain the differences, a new approach had to be adopted for the whole test process. This involves the following steps

1. Verify the test setup; examine all the details, including the position of each cable and the condition of the EUT (e.g., covers, doors).

2. Verify the test procedure, including the EUT operation mode, position and location of auxiliary equipment, operator position, software state, application of discharges to the EUT.

3. Verify the test generator; is it operating correctly? When was it calibrated last? Is it operating within specifications? Are test result differences due to the use of different generators?

Variation in Test Results due to the ESD simulator

If test results are varying because of the ESD simulator, apply the following procedure

1. If differences in test results are caused by the use of different ESD generators, then the results with any generator that meets the requirements of 6.1 [from IEC 61000-4-2 Ed2]can be used for determining compliance with this standard.

2. Note: In terms of compliance with the standard, it is sufficient to consider only the results given by the ESD generator which is less aggressive to the EUT. In terms of EUT quality/reliability and customer satisfaction, it may be advisable to ensure the EUT exhibits error-free performance with the ESD generator which is more aggressive to the EUT.

Escalation Strategy

As a further verification of test results, it was decided that an escalation strategy should be employed.

1. If more than 1 error occurs in the first 50 discharges applied to a test point, the EUT fails the test at that test point and test level.

2. If 1 error occurs in the first 50 discharges applied to a test point, a second test is run at that test point applying 100 new discharges. If no error occurs in this set of 100 discharges, the EUT passes the test at that test point. If more than one error occurs in this set of 100 discharges, the EUT fails the test. If exactly 1 error occurs in this set of 100 discharges, a third test is performed.

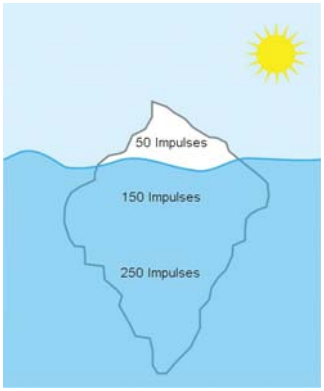


Figure 6: Hidden "detail"

3. The third test is a repetition of point 2. If no error occurs in this set of 100 discharges, the EUT passes the test at that test point. If 1 or more errors occur in this set of 100 discharges, the EUT fails the test.

Immediate Effects

These measures are intended to increase the reliability and repeatability of test results, making them independent of the ESD simulator model. The immediate effect for EVERYBODY is a dramatic increase in test time. Test laboratories, who charge by the hour, will be delighted by this.

Proposed New Target

As part of the new calibration procedure, an updated target has been proposed. In the late 1980's, the existing "Pelligrini" target [2] represented the height of technology with a bandwidth of approximately 1GHz. This was perfectly matched to the oscilloscopes of the time.

Figure 7: Existing IEC 61000-4-2 Ed 1 "Pelligrini Target" approx. >1Ghz

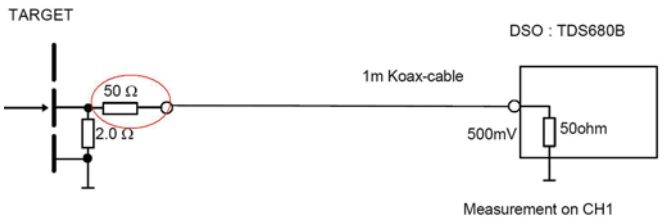


Figure 8: Existing Target

With increasing bandwidth, measurement discrepancies started to creep in so it became evident a matched, higher bandwidth, measurement chain was necessary. The result is a revised target with 4GHz bandwidth [4]. From the schematic diagram, Z_{SYS} = V50 / I_{SYS} and therefore $I_{ESD} = V_{ESD} / Z_{SYS}$ Zsys must be used to calculate the ESD current. U_2 is a factor 2 higher because of the missing 50 ohm. Because of the high bandwidth and very tight tolerances on variation across the frequency range, any discontinuity will have a significant effect on frequency response. It is therefore important to employ good RF engineering practice and calibrate the target together with any cables and connectors necessary for the ESD calibration.

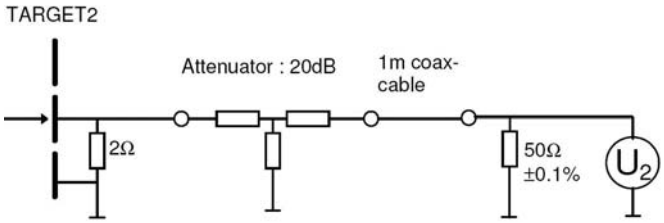


Figure 9: New Target

Figure 10 New 4Ghz ESD Target

New Target Calibration requirements

For the first time in an ESD standard, the calibration target is carefully defined.

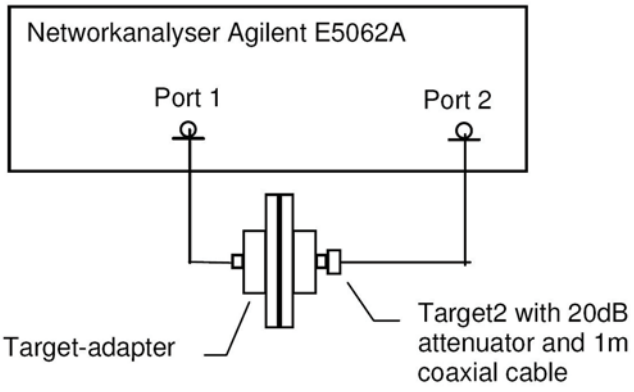


Figure 11: Target Calibration

As with any high frequency calibration measurement, the actual test equipment can be a significant factor and must be carefully considered. The standard doesn't specify the exact measurement equipment, but a network analyser capable of measuring S-Parameters is practically indispensable. The other problem is how to make a connection to the target that does not introduce electrical discontinuities. A conical adaptor is shown but other shapes are also acceptable.

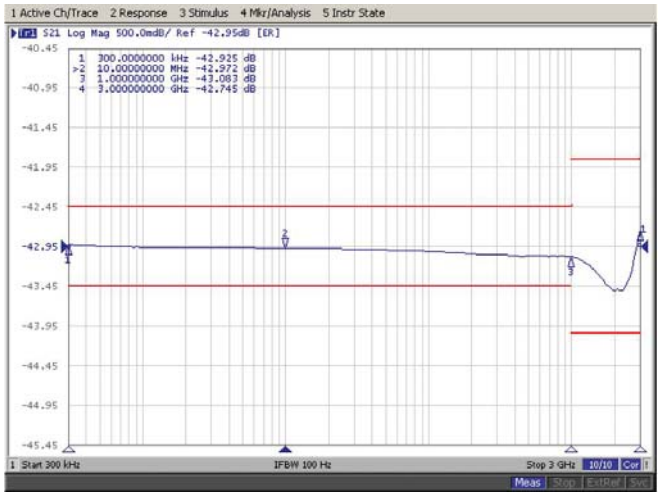


Figure 12: Frequency Response of New Target

New Calibration Procedure

A new calibration procedure for ESD simulators is designed to remove the "one shot wonder" approach by specifying the exact number of discharges and levels to be verified. This approach, like the new test procedure, will increase the time necessary to calibrate ESD simulators. 5 (discharges) x 2 (each polarity) x 4 test levels = 40 impulses minimum. This simple change will mean more time in the calibration laboratory and therefore calibration costs for ESD simulators will increase.

Table B.1 – Contact discharge calibration procedure

Step	Explanation
Discharge the ESD generator at each test level as defined in Table 1 five times for both polarities, store each result.	The specifications shall be met for all 5 discharges.
Measure I_p, I_{30}, I_{60}, t_r on each waveform.	The parameters shall be checked at each test level
Current at 30 ns Check if I_{30} is 2 A ± 30 %	The parameters shall be checked at each test level[a]
Current at 60 ns Check if I_{60} is 1 A ± 30 %	The parameters shall be checked at each test level[a]
Peak current Check if I_p is 3,75 A ± 15 %	The parameters shall be checked at each test level[a]
Rise time Check if t_r is 0,8 ns ± 25 %	The parameters shall be checked at each test level
[a] The value of the current given in this table corresponds to a voltage of 1 kV. This measured value changes proportionally to the generator voltage.	

Figure 13: Simulator Calibration Procedure

No change here!

ESD simulators shall meet the requirements given in paragraph 6.1, of IEC61000-4-2 Ed2, when evaluated according to the procedures in Annex B of the standard. Therefore, neither the diagram in Figure 14, nor the element values are specified in detail. The intent is not to define a generator in terms of the component values, rather the calibration waveshape. Because of this, there should be no problem with existing ESD simulators complying with the edition 2 requirements.

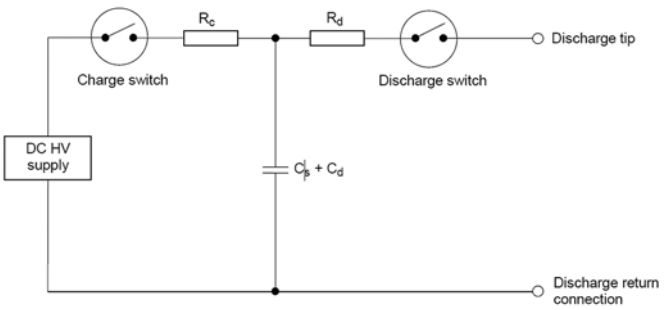


Figure 14: ESD Simulator Schematic

Exploration of EUT using 20Hz discharge repetition.

Note 1 indicates that the voltage should be measured at the point of discharge. This has been a controversial point for many years. The only way to be absolutely certain the voltage is as specified (assuming the ESD indication is ignored) is by use of an external measurement device. Note 2 is specifically intended for finding weak spots in the EUT. Because of the electro-mechanical switches used in ESD simulators, the 20 Hz test is best performed in air discharge mode. Such a high repetition reduces the life span of the high voltage relay.

Table 2 – General specifications

Parameters	Values
Output voltage, contact discharge mode (see NOTE 1)	At least 1 kV to 8 kV, nominal
Output voltage, air discharge mode (see NOTE 1)	At least 2 kV to 15 kV, nominal (see NOTE 3)
Tolerance of output voltage	±5 %
Polarity of output voltage	Positive and negative
Holding time	≥5 s
Discharge mode of operation	Single discharges (see NOTE 2)
NOTE 1 Open circuit voltage measured at the discharge electrode of the ESD generator. NOTE 2 The generator should be able to generate at a repetition rate of at least 20 discharges per second for exploratory purposes. NOTE 3 It is not necessary to use a generator with 15 kV air discharge capability if the maximum test voltage to be used is lower.	

Figure 15: ESD Simulator Performance

References

[1] International Electrotechnical Commission, "Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test", IEC61000-4-2 Ed 1, 1995

[2] International Electrotechnical Commission, "Electromagnetic compatibility for industrial process measurement and control equipment – Part 4-2: Electrostatic discharge requirements", IEC801-2, 1991

[3] International Electrotechnical Commission, "Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test", IEC61000-4-2 Ed 2, 2008

[4] EMC PARTNER, "ESD-TARGET2 for calibration of the ESD discharge current waveform, target type SMD as proposed for gun comparison.", 2008

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Did you miss the PLT articles, see page 5

Circuit Modelling for EMC

By Ian Darney, B.Sc. MIET, EMC Consultant, Defence Support (International) Ltd

The article 'Everything you always wanted to know about SPICE' in the May 2009 issue was a very welcome inclusion in the pages of the EMC journal. Colin Warwick has focussed on the analytical approach to the task of designing electronic equipment.

SPICE software provides an essential computational tool, in that it enables the functional behaviour of the system to be simulated, long before the final product is built and tested. In detailing the mathematical formulae on which SPICE software is based, Colin Warwick has revealed information that no supplier of such software is ever likely to divulge. Such information allows engineers to make better use of the options available.

However, the final paragraph reads: 'SPICE has its limitations. If there is a changing magnetic flux through a given mesh, Faraday's law of magnetic induction . . . affects the branch equations and breaks KVL by making the electric field non-conservative and the voltage undefined. At that point you need to switch to an EM solver . . .'

This is rather discouraging, in that it implies that the analysis of electromagnetic interference necessarily involves a good working knowledge of the mathematics underlying Electromagnetic Field Theory. Few electronic equipment designers have that ability.

On the other hand, it is reasonable to assume that every circuit design engineer is completely familiar with Circuit Theory. Such knowledge allows SPICE software to be used with complete confidence, and for the results of any computations to be error-free.

Even so, the entire article is very thought-provoking. The point is made that the average number of branches per node is only three or four. However, this is not true of the datum node; the one to which the voltage at every other node is referred. In a complex circuit there could be thousands of branches connected to the datum node.

If an attempt were made to draw a physical diagram which represented every node with a single point, then the result would be similar to that of a bicycle wheel, with the spokes representing circuit branches, and the hub representing the datum node. Such a diagram cannot possible represent the actual assembly.

It could be reasoned that the datum node represents the voltage on a ground plane. That is, the ground plane can be represented by an equipotential surface. This is a useful engineering ploy, since it enables the functional behaviour of the system to be analysed, uncluttered by relatively minor complications.

The concept of the 'equipotential ground plane' is not supported by any derivation in electromagnetic theory. Sectional views of an 'equipotential surface' are used in the 'method of images', but these surfaces are non-conducting. Moreover, the use of a sectional view of magnetic field distribution disguises the fact that there is a voltage drop along the surface in a direction orthogonal to that section.

Consideration of Faraday's Law of magnetic induction leads to the conclusion that if a transient current flows in a conductor, then a voltage is induced along the length of that conductor. Since the ground plane is certain to carry transient currents, it follows that there must be transient voltages between different points on the plane. If different points on a surface are at different voltages, then that surface cannot possibly be equipotential.

Further consideration reveals that the concept of the 'equipotential conductor' is also true of the way Circuit Theory is treated in most textbooks. If the terminals of any two components are joined by a length of conductor, then it is assumed that the junction can be represented by a single node. It does not matter how long the conductor is.

Since the primary cause of intra-system interference is coupling between conductors of the interconnecting cables, and since the conductors themselves behave as unintentional aerials, it can be reasoned that Circuit Theory has been developed on the assumption that there is no such thing as electromagnetic interference.

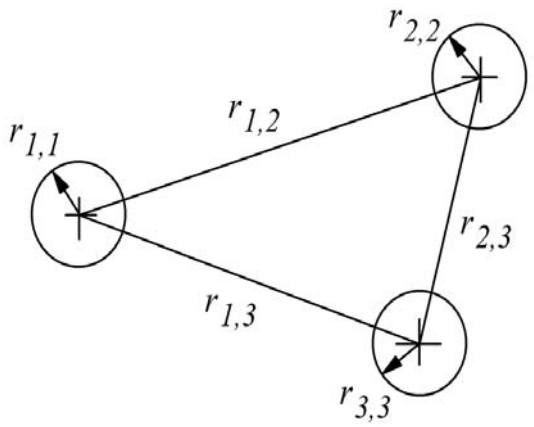

Figure 1: Cross section of conductor assembly

However, it can also be noted that every conductor possesses the properties of inductance, capacitance, and resistance; and that these properties are those which Circuit Theory has been designed to handle. So the interconnections themselves can be represented by circuit models.

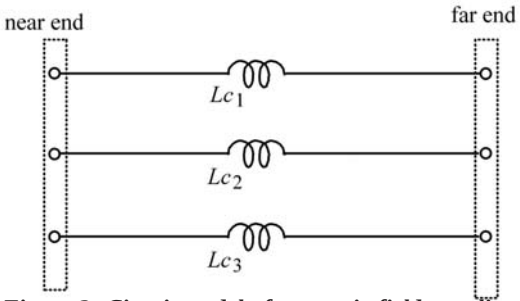

Figure 2: Circuit model of magnetic field coupling

Since such a simulation involves a culprit loop and a victim loop, then a minimum of three conductors are involved. So any circuit model which simulates interference coupling must contain at least three conductors. The need for such a model brings to mind the existence of textbooks which derive formulae for the inductance and capacitance of three-phase power lines. **Figure 1** illustrates a section of a three-conductor assembly.

Magnetic field coupling can be modelled by the circuit diagram of **figure 2**.

The relationships between spatial dimensions and electrical parameters are [1]:-

$$Lc_1 = \frac{\mu_0 \cdot \mu_0 \cdot l}{2 \cdot \pi} \cdot \ln\left(\frac{r_{1,2} \cdot r_{1,3}}{r_{1,1} \cdot r_{2,3}}\right) \quad (1)$$

$$Lc_2 = \frac{\mu_0 \cdot \mu_0 \cdot l}{2 \cdot \pi} \cdot \ln\left(\frac{r_{1,2} \cdot r_{2,3}}{r_{2,2} \cdot r_{1,3}}\right) \quad (2)$$

$$Lc_3 = \frac{\mu_0 \cdot \mu_0 \cdot l}{2 \cdot \pi} \cdot \ln\left(\frac{r_{1,3} \cdot r_{2,3}}{r_{3,3} \cdot r_{1,2}}\right) \quad (3)$$

where l is the length of the assembly, μ_0 is the permeability, and is the relative permeability.

Examination of these equations reveals that the value of each inductance is a function of the spatial dimensions of all three conductors. If conductor 2 and 3 move closer together, then the value of Lc_1 changes. This highlights the fact that Lc_1 is not a unique property of conductor 1. The same reasoning applies to conductors 2 and 3.

However, if the section is fixed (as would be the case in any equipment-under-review) then the electrical parameters, Lc_1, Lc_2, and Lc_3 of any particular cable can be treated as unique properties of the related conductors.

Such a correlation identifies the most significant benefit of circuit modelling; it simplifies the relationships dramatically.

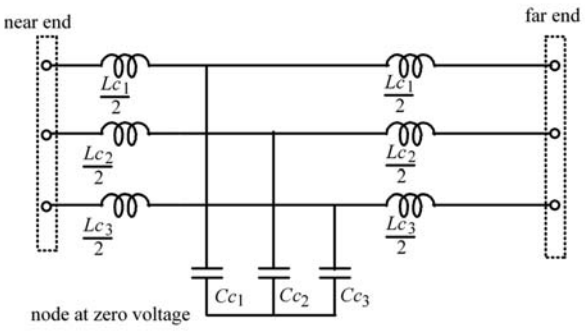

Figure 3: Extending the model to include electric field coupling

Electromagnetic theory teaches us that the voltage of any conductor is a function of the current in every other conductor, as well as the current it actually carries. Circuit Theory is based on the assumption that the voltage across any branch is dependent solely on the current in that branch and the impedance of that branch. It is completely independent of currents in other branches. With Circuit Theory, the mathematics of time-dependent, three-dimensional, electromagnetic Field Theory is eliminated.

Developing the model to include electric field effects leads to **figure 3**. Each capacitor is related to the associated inductor by:-

$$Cc_i = \frac{\mu_0 \cdot \mu_r \cdot \varepsilon_0 \cdot \varepsilon_r \cdot l^2}{Lc_i} \quad (4)$$

where the subscript *i* is an integer used to identify the conductor, is the permittivity, and is the average value of the relative permittivity.

It is necessary to create nodes at the mid-points of the inductors to allow capacitors to be included. A noteworthy feature of this model is the existence of a node at zero voltage at the junction of the three capacitors.

Thus far, a model has been developed to simulate the reactive components of a three-phase power line.

The diagram of **figure 1** illustrates a simple configuration in which the three conductors are circular in section and similar in diameter. Since it is possible to derive values for the circuit parameters of any cross-section of three conductors [2] then the model of **figure 3** can be applied to any configuration where two conductors are routed along the structure.

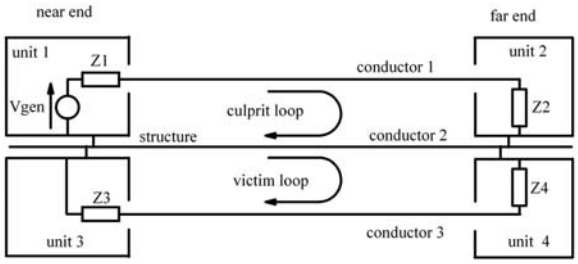

Figure 4: Assembly under review

The assembly of **figure 4** represents a conducting structure on which four electronics units are mounted. Each equipment unit is shielded by an outer conducting surface, and signals within each unit are processed with respect to that surface. It is assumed that unit 1 transmits a high-powered signal to unit 2, whilst unit 3 transmits a low-powered signal to unit 4.

The level of interference to which the low-powered signal is subjected can be assessed by using the circuit model of **figure 5**.

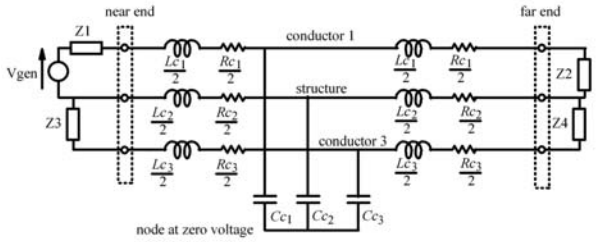

Figure 5: Circuit model of assembly under review

This model includes resistors Rc_1, Rc_2 and Rc_3 to represent the series resistances of the conductors, while *Z*1, *Z*2, *Z*3 and *Z*4 represent the impedances at the interfaces of the relevant units. Component values for the conductors can be derived from measurements of the spatial parameters. Alternatively, a set of electrical measurements could be used.

The value of *Vgen* can be set to represent the worst-case output of unit 1, and circuit analysis can be used to determine the interference voltage appearing across *Z*3 or *Z*4. Such an analysis is well within the capability of any SPICE software package presently on the market.

When the interference level is known, a comparison can be made with the minimum amplitude of the intended signal. If the filters in equipment unit 4 can handle this level of interference with a defined safety margin, then a judgement can be made that the design is adequate. If not, modifications can be carried out.

The next step in the development process is to separate the two loops so that each can be independently assessed.

The top section of **figure 6** illustrates the action of the culprit loop. The signal generator creates a current in the loop formed by conductor 1 and the structure. This current creates a voltage *Vthreat* along the length of the structure, and the amplitude of this voltage can be calculated.

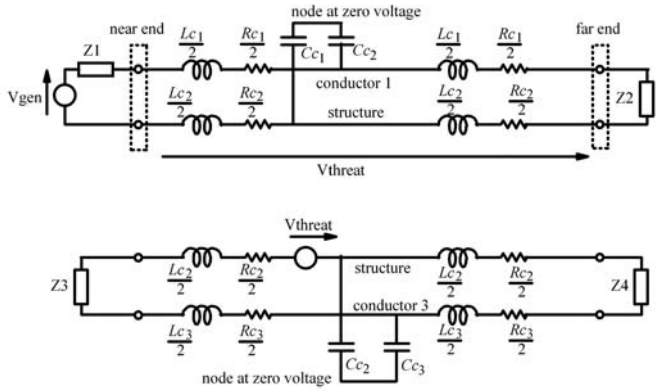

Figure 6: Separating the culprit and victim loops

The bottom section of the figure illustrates the action of the victim loop. It is assumed that a voltage source of amplitude *Vthreat* exists in series with the structure, and that this voltage creates unwanted current in the loop formed by conductor 3 and the structure. This interference current flows in units 3 and 4 of the equipment under review. The circuit model can simulate the response of this sub-section of the system.

Having established a method of assessing the emission characteristics of the culprit loop separately from the susceptibility of the victim loop, the way is now open for more complex circuits to be analysed.

If it is decided that the intra-system interference present in the configuration of **figure 4** is unacceptable, then it becomes necessary to modify the system. Probably the most cost-effective method of minimising the unwanted coupling would be to provide a return conductor for both signals.

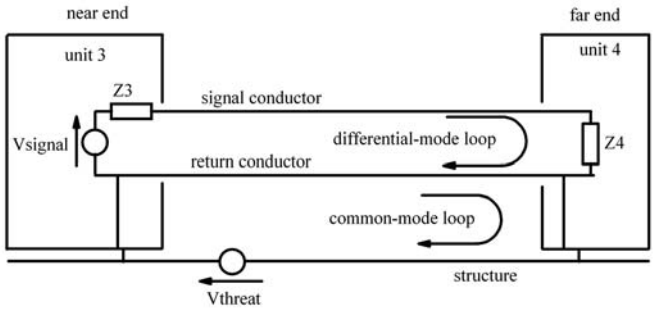

Figure 7: Susceptibility assessment

Figure 7 illustrates the new configuration of the victim loop. Any current created by the generator *Vthreat* will flow in the common-mode loop. This will create a voltage along the length of the return conductor, and this voltage will create an unwanted current *Idiff* in the differential-mode loop. Since the three-conductor model is perfectly capable of simulating this configuration, the response of the new configuration to any signal generated by *Vthreat* can be predicted.

If *Vthreat* is defined in terms of an amplitude/frequency characteristic, and the resultant current in the differential-mode loop is determined, then the resultant graph would depict the susceptibility characteristic of the new configuration-under-review. It is possible to define this characteristic as the transfer admittance *Ysusc*, where

$$Ysusc = \frac{Idiff}{Vthreat} \quad (5)$$

The emission characteristics of the configuration of **figure 7** can be determined by the same circuit model. In this case, it would be assumed that *Vthreat* is replaced by a short-circuit. The transfer admittance for circuit emission would be:

$$Yemission = \frac{Icommon\text{-}mode}{Vsignal} \quad (6)$$

Conclusion

It has been shown that circuit modelling techniques can be used to analyse the conducted emission and the conducted susceptibility of any circuit link in the system-under-review. There is no need to invoke the complex mathematics of EM field modelling.

A pessimist would identify shortfalls, snags, and problems associated with the approach described here. An optimist can visualise endless possibilities.

References

[1] Higher Electrical Engineering. J. Shepherd, A. H. Morton, & L. F. Spence. Pitman 1985.
Chapter 7 'Electric and Magnetic Field Theory'

[2] www.designemc.info > Contents > Chapter 3: 'Other Cross-Sections'

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Designing I/Os so they will not suffer from 'ground loop' currents in cable screens (shields)

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In the previous Issue of the EMC Journal [1] I wrote about the various ways of terminating cable screens (shields). I made the point that bonding a cable's screen at *both* ends was generally recommended for new designs, and 360° bonding – sometimes called circumferential or peripheral bonding – at *both* ends will generally achieve the best EMC possible from the type of cable used, at the lowest cost.

Unfortunately, legacy design and construction considerations can make it undesirable to directly bond the screen at both ends, so the article went into the various alternatives available, describing their pros and cons.

I happened to mention once or twice in [1] that it would have been so much better if all electronic engineers had taken the trouble to design their products and equipment correctly. Their customers would then have found it much easier to interconnect equipment in systems and installations of any size, while using direct screen bonds at both ends to maximise EMC whilst keeping costs low.

> When I mention 'EMC' I am referring to the whole business of controlling electromagnetic interactions both inside and outside products, to help ensure that products will be quick and easy to design and market; will function excellently in real life (keeping customers happy) and will earn good profits for their manufacturers [2].
>
> All electrical power and signals, whether their energy is communicated by conductors or waves in the air, are electromagnetic, so "EMC engineering" has a huge scope, and a huge relevance to every kind of electrical and electronic design.
>
> But when I am referring to the *very tiny* subset of EMC that is concerned with compliance with standards, directives, import regulations, etc., I use appropriate terminology to indicate the restricted scope.

Traditionally, many electronic engineers failed to design their input and output circuits (I/Os) for the earth (ground) potential equalising currents that inevitably flow in cable screens when they are connected at both ends to different items of equipment that receive their power from different parts of a building, vehicle or site.

These screen currents have been demonised for the last 50 years at least, by some electronic engineers – and (apparently) by <u>all</u> electrical contractors and installers – as "earth loops", "ground loops", "hum loops" and other less well-known jargon terms. So how do we design input and output circuits so that they are not significantly affected by screen currents? It's easy:

Do not allow 'ground loop' currents to cause significant 'ground noise' voltages to arise in a circuit's 0V reference.

The earth/ground potential difference that appears on a cable connected to a separate item of equipment appears as a common-mode (CM) noise voltage. This is easily dealt with by using a circuit that provides adequate CM rejection (CMR).

The best input or output circuits for CMR use differential (balanced) signalling techniques, typically using twisted-pair conductors with an overall screen. In such cables, capacitive coupling between the screen and the internal conductors is never perfectly balanced, so a differential-mode (DM) noise appears, especially when input impedances are lower.

If this DM noise lies within the bandwidth of the wanted signal it cannot be removed by filtering or phase-sensitive detection. In this situation it is important to use cables that have adequate capacitive balance for the signal-to-noise ratio (SNR) required given the earth/ground potential differences that might occur in real-life.

When a screened (shielded) cable is used with its screen directly bonded at both ends, the earth/ground potential between the items of equipment drives an equalising current in the screen. The amplitude of this current is set by the potential difference divided by the impedance of the screen and its bonds.

The screen current couples with the internal conductors like a very well-matched 1:1 transformer, and so *reduces* the CM voltage seen by the input or output [3]. So, for this contributor to the noise, all that is required is for the I/O to have sufficient CMR.

> I am assuming here that the cable screen is of a type that provides a useful amount of radio frequency (RF) screening (shielding), and so completely surrounds the inner conductors. If a screen was sufficiently 'unbalanced' with respect to its inner conductors, it is possible that a current in it could induce some differential-mode (DM) noise between two or more conductors, but such a construction would be ineffective for RF and so bonding it at both ends would provide few/no RF benefits.
>
> Since bonding at both ends to achieve EMC benefits over all frequencies is the purpose of this discussion, such cable types are not considered here.

Since screen currents act to reduce the CM voltage, why have the 'ground loops' caused by bonding screens at both ends become so demonised? As I said earlier, it is all because of <u>bad electronic design</u>.

I say this not because of some academic theory or benchtop experiment, but because over 28 years ago *I was that bad designer.*

The very high-performance circuits (when measured on the test bench, according to the specification I had been given) I designed were very difficult indeed to use in systems and installations. But since everyone else in my limited experience at that time designed circuits with the same problem, it took me a while to realise there had to be a better way, and what it was.

It turns out that this better way helps achieve low-cost regulatory EMC compliance; improves functional performance, and saves a great deal of time and effort in system integration and installation (see [2] for more on this).

The bad design practices that my colleagues and I were guilty of all those years ago, (and some designers still use) were:

a) using traces on our printed circuit boards for our 0V reference, and

b) connecting the screens of our input and output cables to those traces.

We did this because that was how we got the best functional performance on our test benches, and because "everyone knew" that this was correct design.

The design 'trick' we were missing, was to reduce the amount of 'ground noise' voltage arising in our circuit 0V reference structures, due to the low-frequency screen currents that inevitably flowed through them.

As already mentioned above: digital and analogue I/Os can easily be designed to have adequate CMR, using transformers and other circuit techniques and differential ('balanced') signalling techniques that use two conductors driven in antiphase.

Single-ended communications should never be used between items of equipment that can have significant earth/ground potential differences, except for:

i. RF, where inputs and outputs are automatically tuned to pass the wanted frequencies and reject 'earth/ground loop' noise

ii. Digital signals where the 'noise margin' is adequate to cope with the noise

iii. Fixed-frequency instrumentation using phase-sensitive detection, where the frequency of operation can be set to avoid the major noise frequencies

Nevertheless, some designers have used single-ended communications with weak signals that cannot be filtered to remove 'ground loop' noise, such as video over 75Ω coaxial cable. The resulting 'hum bar' problems with video spawned a whole industry dedicated to mitigating its problems [4]. Even with such thoughtless (but low BOM cost! [2]) system design, we can still improve the noise performance of our products by taking care to ensure that the cable screen currents do not interfere with our circuits.

Traditionally, the spectrum of the earth/ground potential was dominated by the mains power distribution (50, 60 or 400Hz) and its harmonics extending to 2kHz, and possibly even to 10kHz. In telco (and now 'blade server') rooms powered from 48Vdc, the CM voltage can include appreciable levels at 0Hz.

The increasing use of variable-speed AC motor drives is now adding noise at the motor drive frequencies (say 0.1 to 120Hz) and their harmonics (say up to 12kHz) plus switching noise from their pulse-width-modulation (PWM), generally between 1 and 250kHz, plus *its* harmonics.

Because of the non-linearity of mains rectifiers, all these frequencies intermodulate madly to produce a veritable forest of spikes in the noise spectrum, from almost DC to radio frequencies.

> This type of noise is bound to increase in all installations, as variable-speed motor drives are employed in all domestic appliances, HVAC and industrial machines, to help reduce electricity consumption, reduce CO_2 emissions and save the planet from overheating.

Cable-screen bonding for EMC ensures that – above some frequency – the external interfering currents are forced by the skin effect to flow on the outside surface of the screen, while the stray CM emissions from the twisted-pair (or the return current in a coax), flows – by the same mechanism – on the inside surface of the screen.

Section 2.6.2 and Figure 2P in [5], reproduced below as Figure 1, describe how this keeps the noisy external currents out of the sensitive circuits.

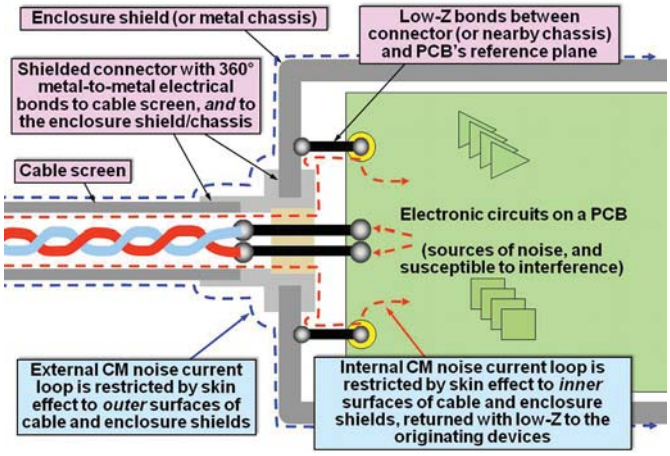

Figure 1: Cable screen bonding for good EMC at RF

Figure 2 shows a graph of skin depth versus frequency for three common metals, and [6] will also be useful.

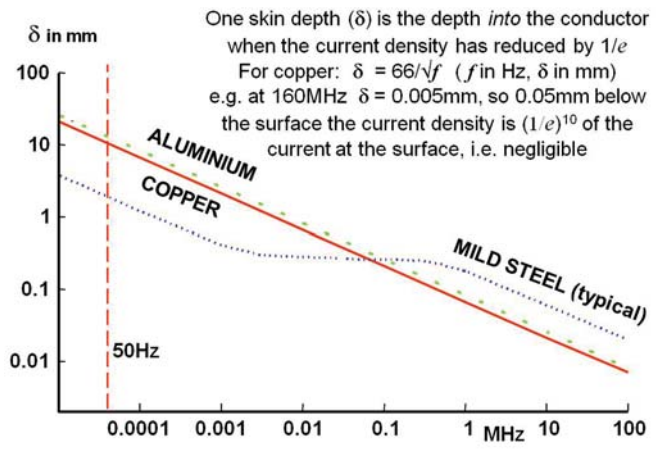

Figure 2: Skin depth versus frequency

When the thickness of the screen material for skin depth is insufficient to maintain an adequate separation of surface currents – which might be because the metal is very thin (e.g. metallised foil), or because the frequency is low – the screen current flows throughout the thickness of the shield, and we cannot them from flowing *inside* our product.

At such (low) frequencies, the prevention of excessive 'ground loop' noise depends entirely on providing very low impedances for the loop currents to flow in, to minimise the 'ground noise' voltages that inevitably appear as they flow in our circuit's 0V reference structure.

To be able to use simple examples, let's consider just low frequencies, say up to 1kHz, and assume that all that matters is resistance. (At higher frequencies inductance becomes the dominant contributor to the impedance, but the same analysis applies and the techniques described below become even more effective.)

It used to be traditional to carry the cable screen through the shell of a connector on one of the pins, and connect it to a 0V trace on the PCB, as shown in Figure 3 for an audio product. Many of the standard pin designations for traditional connectors specify one of the pins for the shield, but as Figure 2Y of [5] shows, the resulting 'pigtail' screen connection does immense harm to the screen's RF attenuation.

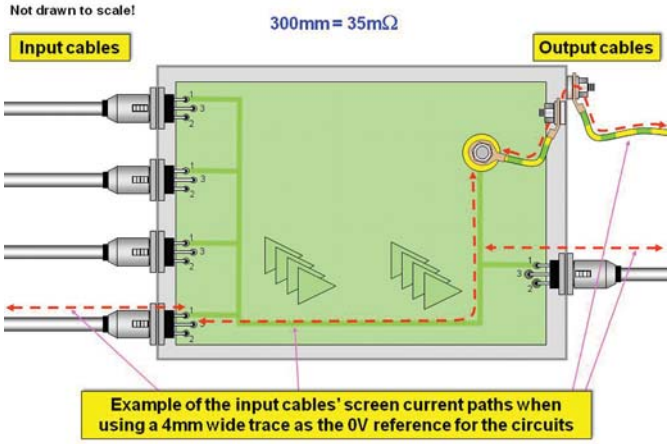

Figure 3: Example of traditional design

Figure 3 shows an analogue 'pro-audio' product, because I had to use something as an example, and professional audio SNR specifications are very high. I could just have easily used an instrumentation, or even a digital example.

If we assume that the 0V trace is 300mm long and 4mm wide, and is made of 1oz copper, its end-to-end resistance will be about 35mΩ. Let's also assume that one of the cable screens is carrying 100mArms of 50Hz 'earth/ground loop' current. 100mA in 35mΩ creates 3.5mV of voltage difference along the 300mm 0V trace, which is used as the reference voltage for the signals in all of the circuits.

If all of this noise voltage appeared in a 10Vrms output signal – as it easily could with such a design – it would cause the signal-to-noise ratio (SNR) to degrade to 69dB (equivalent to a digital resolution of about 11.5 bits).

Now consider the same product with a single PCB over the entire product, with a solid copper 0V plane made from 1oz copper, as shown in Figure 4.

[7] tells us that the resistance between two 4mm diameter plane bonds 300mm apart is about 0.8mΩ. The 100mA screen current now causes a voltage drop of 80μV, which if it all appeared in a 10Vrms output signal would give an SNR of 102dB, equivalent to a digital resolution of about 17 bits. This is 33dB better than when using a 4mm 0V trace, with very little additional BOM cost and a much shorter design cycle.

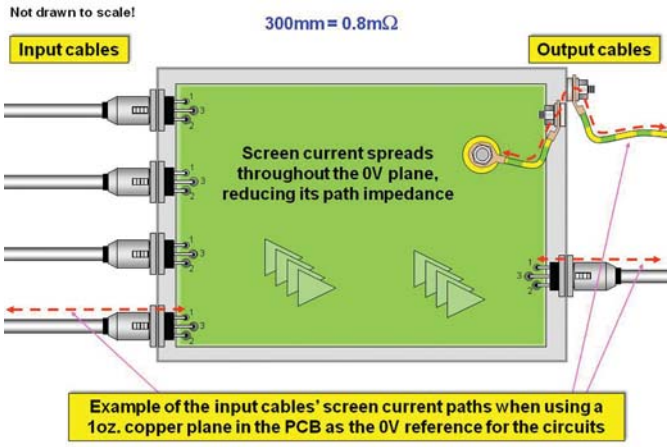

Figure 4: Using a 0V plane instead of a trace

If we now bond the solid copper 0V plane from Figure 4 to the metal chassis of the product, as shown in Figure 5, the resistance of the chassis appears in parallel with that of the plane. If we assume that the chassis is a single plate of 2mm thick aluminium, [7] tells us that between two 4mm diameter bonding points 300mm apart, the resistance is 22μΩ. With the chassis and the 0V plane effectively connected in parallel, the 100mA screen current now causes a voltage drop of about 2.2μV, which if it all appeared in a 10Vrms output signal would have an SNR of 133dB, equivalent to a digital resolution of about 22 bits. This is 31dB better than the 0V plane alone, and 64dB better (more than 1000 times) than when using a 4mm 0V trace, again with very little additional cost.

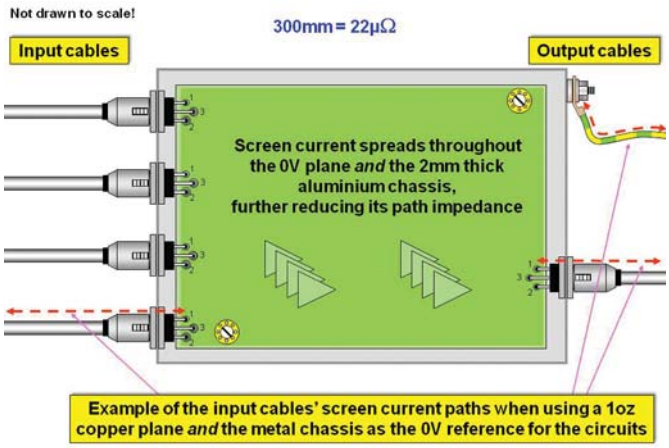

Figure 5: Using a 0V plane bonded to the chassis at two points

Figure 6 shows the same design as Figure 5, but this time with multipoint 0V plane to chassis bonding. We can safely assume that this will improve the SNR by a further 6-10dB at 50Hz. Increasing the chassis to 4mm thick aluminium would gain another 6dB.

If you are wondering about the graphical image I have used for the plane-to-chassis bonds in Figures 5 and 6, see Chapter 3 of [8], especially its Figure 3B.

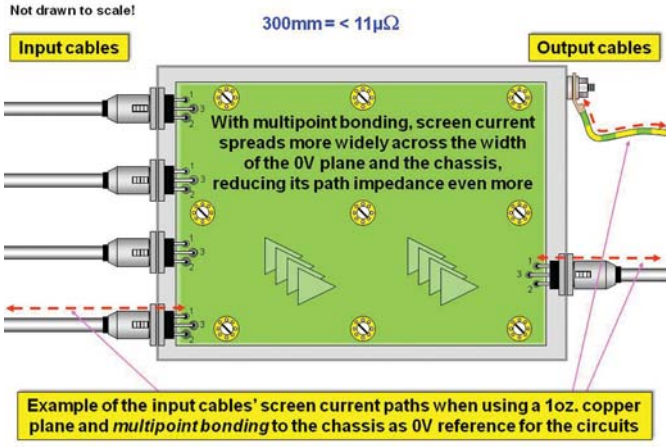

Figure 6: Using a 0V plane multi-point bonded to the chassis

In the above, admittedly rather crude analysis, I simply assumed that the 50Hz 'ground noise' voltage that was developed along the 300mm of 0V current trace on the PCB appeared in the output of a 10Vrms (full scale) signal. But the noise is developed along the length of its 0V current path, so has the characteristics of mV/metre, or μV/mm.

Wherever a circuit uses differential signalling, 'ground noise' in the 0V reference structure appears as CM noise and is attenuated more the higher the CMR. But when using single-ended signalling, it appears as a DM noise *directly in series with the signal*. Understanding that the ground noise appears as μV/mm helps when deciding where to place components and route traces, so that as little of it as possible gets amplified. Of course, reducing the impedance of the 0V reference structure in a circuit is not only very good for reducing the noise contributions of cable screen currents, it is also good for reducing the noise contributions from *any* source within the product, leading directly to better signal integrity, SNR, crosstalk, etc.

As I learned in the years up to 1981, very careful design of 0V traces, using 'single-point grounding' techniques, can achieve good control of 50Hz 'ground noise', and crosstalk even up to 20kHz. Some of the artwork for my PCBs were amazing, almost works of art (even if I do say so myself!), and they took a long time to get just right.

But during 1981 I learned that wherever there is modulated RF noise, for instance from a microprocessor or switch-mode power converter anywhere in the product, or entering on cables from outside – the only low-cost technique that can be relied upon to work well for both SNR and crosstalk whilst *reducing* time-to-market, is to use a solid 0V plane layer over the whole PCB. Ideally multi-point bonded to a thick metal chassis. My boards now had four layers, rather than two, and were much quicker to lay out.

Finally, 100mArms is rather a lot of earth/ground potential equalising current, but might not be that unusual for a long cable with a braid shield in a large installation that had been constructed along 'single-point earthing' rules, when it was the only cable screen bonded at both ends.

But with a meshed earthing structure (MESH-CBN) as recommended by [11], the earth/ground potential differences would be 10 to 100 times smaller – so the effect on SNR of 'ground noise' caused by low-frequency screen currents flowing inside products would be 20-40dB less.

Where there are many cable screens in a system or installation – the more of them that are bonded at both ends, the lower will be the currents flowing in the screens of each one and the less the effect of screen currents on SNR.

Since the source impedance for the earth/ground potential difference is not zero, encouraging currents to flow in cable screens, and mesh-bonding the earthing structure (all recommended by [11]), will significantly reduce the DM noise caused by capacitive imbalance in differential cables. [3] includes some calculations along these lines, for different values of resistance in building earth structures.

Designing products so that screen currents do not upset circuits or worsen SNR is a powerful, easy and low-cost technique that makes systems integration and installation quick and easy. It also improves their functional performance and reliability, and helps considerably with achieving EMC compliance for products and fixed installations, now the law throughout the EU.

References

[1] Keith Armstrong, "*Terminating Cable Screens (shields)*", The EMC Journal, Issue 82, May 2009, pages 19 – 23, www.theemcjournal.com

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[3] Tony Waldron and Keith Armstrong "*Bonding Cable Shields at Both Ends to Reduce Noise*", EMC + Compliance Journal, pages 14-27, May 2002, www.compliance-club.com
[4] For example, visit: www.21best.com/21_best/electronic/security/video/filters/for_sale_.html#HBPremium
[5] Keith Armstrong, "*Design Techniques for EMC, Part 2 – Cables and Connectors*", www.compliance-club.com/KeithArmstrong.aspx. You will have to register, but it only takes a few seconds and access is immediate.
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[9] Keith Armstrong, "*Design Techniques for EMC, Part 4 – Shielding*", www.compliance-club.com/KeithArmstrong.aspx. You will have to register, but it only takes a few seconds and access is immediate.
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[11] BS IEC 61000-5-2:1997, "*Electromagnetic Compatibility (EMC) – Part 5: Installation and Mitigation Guidelines - Section 2: Earthing and cabling*"

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Newsletter

The Institution of ***Engineering and Technology***
Electromagnetics Network

EMCUK – Technical Conference sessions announced

Since the last issue we've been working hard on pulling together the programme for the conference sessions we're organising for EMCUK in October. The focus of the conference is around EMC regulations and EMC in the automotive, military and civil aviation sectors.

The Keynote speakers are Keith Armstrong from Cherry Clough Consultants and Ian MacDiarmid, Head of Electronics at BAE Systems. Other highlights include Dr Luke Turnbull, TRW Conekt and Nick Wainwright from York EMC Services.

By attending the conference sessions you will:

- Understand how to put an end to the radiated emissions test lottery
- Gather information on the development of a near field immunity test method to counter the risk of electromagnetic interference from cellular phones
- Understand what the EU Regulation on Accreditation and Market Surveillance (RAMS) will mean for you
- Explore the essential requirements to ensure CE marking and how to achieve compliance within Europe while understanding what challenges can occur.

Registration for the conference is now open at **http://www.theiet.org/events/2009/emcuk.cfm.**

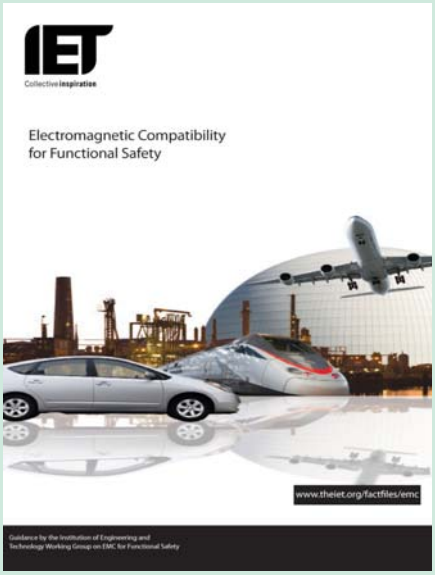
The IET Electromagnetics Network will have a stand at the EMCUK exhibition so if you're planning to attend the event, come by and say hello.

Is conventional EMC testing inadequate for functional safety?

On 22nd September the IET is holding an afternoon discussion meeting called *EMC for Functional Safety: Your questions answered.*

Over past decades the disciplines of EMC engineering and functional safety engineering have developed separately and so often EMC testing, no matter how high the test levels are cranked up, is inadequate where functional safety risks need to be controlled.. Many engineers and project managers are unaware of the functional safety risks (and corresponding financial risks) they are running by relying solely on EMC testing.

Current Conventional EMC tests may; ignore foreseeable faults and misuse to check safety is maintained, overlook real-life environments with more than one EMI threat, fail to take account of the impact of the physical environment or, disregard the possibilities and consequences of emergent behaviour.



The IET's 2008 Guide on EMC for Functional Safety

For the first time ever, a practical guide is available for managers and engineers - the IET's 2008 Guide on "EMC for Functional Safety" is derived from IEC/TS 61000-1-2, Ed.2 2008, the IEC's basic standard on EMC for Functional Safety. Printed copies can be obtained from the EMC Academy website - **www.emcacademy.org/books.asp**

Join us at 1.30pm on 22nd September at Austin Court, Birmingham for a brief introduction to the guide and to discuss it with fellow EMC and functional safety engineers.

The IET Austin Court, Birmingham

This event is free to attend and open to IET members and non members alike but to avoid disappointment make sure you register. Full details and further information can be found by visiting the website: **www.theiet.org/events/2009/emcfunctionalsafety.cfm**

Extreme Electromagnetics case studies

In 2010 we are planning a lecture on an extreme electromagnetics theme. In advance of this we are building a collection of resources for the website and we're looking for case studies. If you are engineering for environments in either the extremely low or high electromagnetic spectrum and would like to discuss the challenges, we'd love to hear from you.

Contact your Community Development Manager, Victoria Snelling, on **01438 765601** or **vsnelling@theiet.org**.

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