



Another EMC resource
from EMC Standards

EMC for Mechanical Designers

Helping you solve your EMC problems

EMC for Mechanical Designers

'Generic' Agenda

Modified to suit specific customer requirements

All course modules are relevant for designers and their managers.

Please choose the modules you want to fill the time you want, assuming 6 module-hours to the full working day (to allow some time for discussions)

- A** Demonstration of emissions and close-field probing 1.5 hrs
- Showing (amongst other things) how close-field probing can help with designing/developing the EMC aspects of a mechanical construction, e.g. the shielding effectiveness of the enclosure and screened cables, and the effectiveness of filters and their mountings.
- B** EMC and interconnections for mechanical designers 1.5 hrs
- Antenna effects of conductors
 - Use fibre optics or alternatives, instead of conductors
 - The "RF Reference"
 - Cable classification and segregation
 - Good practices for both shielded and unshielded interconnections: controlling the DM & CM return paths
 - Shielding techniques for cables
 - Terminating cable shields
 - Interconnecting shielded enclosures
 - Ground loops
 - Transmission-line interconnection
- C** EMC filtering for mechanical designers $\frac{3}{4}$ hr
- Filtering is not 'black magic'
 - How filters work
 - Filter construction, mounting, and cabling
 - The synergy of filtering and shielding

D **EMC shielding for mechanical designers** Short: 1.5 hrs
Long: 2.5hrs

- Economic issues for shielding
- Shielding with metal plates (image planes)
- How shielded enclosures work
- Low frequency shielding
- The problems caused by apertures
- The problems caused by box resonances
- The problems caused by conductor penetrations
- Shields in the near field of a source
- EMC gasketing
- Waveguides-below-cutoff
- Shielding of displays
- Shielding of ventilation
- Shielding of plastic enclosures
- Preventing corrosion at shielding joints
- Some free shielding calculators and useful references

E **Heatsinks and EMC for mechanical designers** 1¼ hr

- Importance of controlling stray heatsink currents
- Ceramic and plastic heatsinks have no stray currents
- Returning stray heatsink currents to their sources
- Using the PCB's Reference Plane as a heatsink
- Practical RF-bonding issues
- Heat sink RF resonances
- Resonance effects of heat sink shapes, fins, pins, and the locations of the semiconductors
- Heat pipes
- Some other techniques that could be useful
- Low-inductance bonding to control resonances to GHz
- Combining shielding with heatsinking

F **Good EMC engineering practices in the design and construction of electrical and electronic cabinets, for mechanical designers** 3 hrs

1. Good EMC practices for general use
 - Buying electrical/electronic units, following the manufacturer's sensible EMC instructions, and using good EMC engineering practices
 - Reducing the accidental RF-antenna efficiency of cables
 - Cable classification
 - Segregation (zoning) of equipment and cables
2. EM Mitigation Techniques
 - EM Zoning
 - Creating an "RF Reference"
 - Routing cables close to the RF Reference

- Don't confuse the RF Reference with safety earthing
 - RF bonding techniques for metalwork
 - RF bonding techniques for cable screens (shields)
 - Filtering techniques
 - Shielding techniques
3. Preventing corrosion
 4. Maintaining EMC during maintenance, upgrades repair and refurbishment
 - Providing EMC installation information in user manuals
 5. Easy, low-cost EMC checking

F Good EMC engineering practices for systems and installations, for mechanical designers 3 hrs

1. Introduction
 - EMC Directive
 - Lightning protection for electronics
 - IEE Wiring Regulations (BS7671)
 - Overview of the overall EMC control procedure
2. Good EMC practices for general use
 - Power distribution systems and power quality for EMC
 - Galvanic isolation for EMC
 - Reducing the RF-antenna efficiency of cables
 - Segregation (zoning) of apparatus and their supplies
 - Using a bonding ring conductor (BRC)
 - Cable classification, segregation and routing
3. EM Mitigation Techniques
 - EM Zoning
 - Safety earthing/grounding for safety and EMC
 - Mesh-bonding, and creating an RF Reference
 - What to do if you can't use mesh-bonding
 - Direct and indirect RF-bonding practices
 - Terminating cable shields at both ends is best for EMC
 - Parallel earth conductors (PECs)
 - Selecting and installing mains filters
 - Cable shielding
 - Shielding for EM Zones
 - Surge and Lightning protection
- 4 Preventing corrosion
- 5 Maintaining EM performance over the operational lifecycle



G Close-field probing techniques to find EMC problems with enclosures and assemblies before electronics are available
3 hrs

H 'Show and Tell' ad hoc half-day problems solving session
3 hrs

Attendees bring examples to discuss, which could be associated with old, current or future projects, or generic issues associated with certain technologies, applications or products. Examples can be described by, for example:

- going out into the manufacturing or testing facility to look at the example, and/or
- bringing actual hardware to the courseroom (I have sometimes had quite large machines wheeled in), and/or
- drawings, test results, other documents or simulations projected onto the screen, and/or
- oral presentations, usually accompanied by ad-hoc sketches on the whiteboard and a lot of hand-waving.

This session can be run as *ad hoc* EMC design consultancy, but if used at the end of a training course I usually encourage group discussion and try to avoid stepping in unless something significant is being overlooked or misunderstood.

Presented by: Keith Armstrong Eurlng (Gp1), C.Eng, FIET, Senior MIEEEE, ACGI

Course Instructor

Academic Qualifications

BSc (Elec.Eng), Upper 2nd Class with Honours, Imperial College of Science & Technology, London, UK, 1972

Professional Qualifications

Fellow IET (Institution of Engineering and Technology, formerly the Institution of Electrical Engineers, IEE), London, UK (Member since 1977)	2010
Senior Member IEEE (Institute of Electrical and Electronic Engineers Inc.) USA, member of its EMC, Product Safety Engineering Societies since 1998	2010
Associate of the City and Guilds Institute, London, UK	1972
UK Chartered Engineer, Engineering Council, London, UK	1978
Group 1 European Engineer (Eurlng), FEANI, Paris, France	1988



Professional Activities

Chair of IET's Working Group on EMC and Functional Safety	1997-date
Reviewer, IEEE Transactions on Electromagnetic Compatibility	2007-date
UK expert appointed (by invitation) to IEC maintenance team MT23 for IEC 60601-1-2 (Medical Equipment/Systems EMC)	2006-date
UK expert appointed (by invitation) to IEC maintenance team MT15 for IEC 61000-1-2 (EMC & Functional Safety)	2003-date
UK expert appointed to IEC 61000-6-7 (EMC & Functional Safety, Generic)	2010-date
Member EMC Industries Association (EMCIA)	2003-date
Member EMC Test Labs Association (EMCTLA) and its Working Group B	2001-date
Technical Panel, IET Functional Safety Professional Network	2003-date
Technical Panel, IET EMC Professional Network	2001-date
Editor, Inside Functional Safety magazine	2010-date
Editorial Advisory board member, Interference Technology magazine	2007-date
Editorial Advisory board member, Compliance Engineering magazine	1998-date
EMCIA representative to BSI GEL 210/12 EMC committee	2009-date
President of the EMC Industries Association (EMCIA)	2008-2010
Vice-President of the EMC Industries Association (EMCIA)	2010-date
Chair of IEE's EMC Professional Group (E2)	1997-1999



RECENT RELEVANT EXPERIENCE (1990-PRESENT)

Started Cherry Clough Consultants in 1990, currently one of the two Partners.

External lecturer for the Sensors and Electronic Instrumentation MSc course at the University of Manchester, teaching an IET-accredited module on practical EMC design techniques.

The services that Keith provides for Cherry Clough Consultants include:

- Product, system, and installation EMC and safety good practices for reliability and cost-effective regulatory compliance
- Assessment of electromagnetic environments
- Control plans, test plans, etc., for effective management of EMC and safety in projects of all sizes
- Company procedures for EMC and safety, for financial benefits and/or regulatory compliance
- Production / QA procedures for maintaining regulatory compliance in volume manufacture and custom engineering

- Testing and remedial work to meet EMC and safety standards
- Creation of EMC Directive Technical Construction Files and other compliance documentation
- Assessment of EMC Directive Technical Construction Files for a number of EMC Competent Bodies
- Education and training for designers and managers on cost-effective EMC and Safety techniques; and on “EMC for Functional Safety, high-reliability and legal metrology”
- Education and training for executives in EU compliance; liability; financial benefits of using good EMC techniques; and related marketing issues

The above services have been applied in the following areas (so far) – please note this is not a complete listing:

Systems and installations:

Machinery and manufacturing/process plant of all sizes

Robotics

Air traffic control towers

Computer and telecommunication rooms

Administration centres

Financial dealer rooms

Professional audio systems and installations (e.g. theatres, opera houses, recording studios)

Steel rolling mills

Hospitals

Hotels

Chemical and pharmaceutical processing plant

Nuclear processing plant

Bottling and canning lines

Road tunnel lighting schemes

Broadband-Over-Power-Line (BPL) systems

Synchrotrons (e.g. the Diamond Light Source, Harwell, Oxfordshire)

Railway systems

Mobile X-ray systems for shipping containers

Products and items of equipment:

Industrial instrumentation, control, and machinery of all sizes

Variable speed AC and DC motor drives from very small to 10MW

Automotive engine control units (ECUs) and other electronic subassemblies (ESAs)

Information technology equipment (ITE) e.g. computers, servers, RAID arrays

Personal Digital Assistants (PDAs) and other hand-held wireless-enabled computing devices

Marine equipment

Computers

Photocopiers

Digital Signal Processing

Datacommunications devices

Professional audio consoles and other equipment

Professional video projectors

Lighting

Telephones and telecommunications

Consumer electronics (TV, Hi-Fi, etc.)

Radiocommunications, cellphones and pagers

Lifts (elevators)

Domestic (household) appliances

Gambling machines

Gas boilers

Electricity meters

Electrical power generators (small scale)

Building electrical services equipment

Subsea oil and gas production equipment

Robots

Solar power converters

Military avionics

Medical equipment (various)

Microscope manipulators

Coin mechanisms

Security equipment

Mains-borne communications

Induction heating

Laser welding

Digital microwave radio

Variable-speed winch for a military submarine

PREVIOUS PROFESSIONAL EXPERIENCE (1982-1990)

Keith was mostly involved with the design and development of state-of-the-art capital equipment during the period 1968 to 1990. He has wide experience in electronic product design and project management in the UK, South Africa and France, after finishing graduate apprenticeship with Thorn Automation in 1973.

Technically, he started in analogue design in 1968; adding digital control of analogue circuits in 1978, and A/D and D/A conversion in 1980. Project and departmental management experience was gained from 1983 onwards, including teams of more than 20 engineers and scientists (this was for the Microwave division of Marconi Instruments Ltd, Stevenage, UK, 1983-1988).



BOOKS, PUBLICATIONS and PAPERS

EMC for Systems and Installations, Tim Williams and Keith Armstrong, Newnes, 2000, ISBN: 0-7506-4167-3, www.bh.com/newnes, RS Components P/No. 377-6463.

EMC for Printed Circuit Boards – Basic and Advanced Design and Layout Techniques, Keith Armstrong, February 2007. Cost £47 plus p&p.

Perfect bound (with titled spine): ISBN 978-0-9555118-1-3

Spiral bound (lays flat for easy use): ISBN 978-0-9555118-0-6

Full colour graphics throughout. Written in a clear concise no-nonsense style full of practical detail. Order via <http://www.emcacademy.org/books.asp>

The First 500 'Banana Skins',

Nutwood UK, 2007, 500 reports and anecdotes concerning EMI. Edited by Keith Armstrong.

Very useful for have a laugh at other's mistakes, or frightening yourself with what could go wrong. A useful present for a boss that doesn't believe EMC can cause very real engineering and financial problems. Read it at www.theemcjournal.com, or buy (approximately £10) from www.emcacademy.org/books.asp.

The IET's new (2008) Guide on EMC for Functional Safety

ISBN 978-0-9555118-2-0, colour graphics throughout, cost £27 plus p&p from www.emcacademy.org/books.asp, or free download from www.theiet.org/factfil/es/emc/index.cfm. Written by an IET Working Group chaired by Keith Armstrong, this book comprehensively describes a practical and cost-effective procedure to help to save lives and reduce injuries where electronics technologies are used in all safety-implicated products, systems and installations.

Keith has written and presented a great many papers for a wide range of symposia, conferences, colloquia, and seminars worldwide, including ERA, IEE, IET, IEEE EMC Society and IEEE Product Safety Engineering Society events. Too many to list here, please ask for further details.

He has also published a great many articles on EMC for publication in professional journals and trade magazines worldwide, including the following five annual series for the EMC Compliance Journal (visit http://www.compliance-club.com/keith_armstrong.asp):

- "Designing for EMC" (6 parts 2006-8, updating the 1999 series)
- "EMC for Systems and Installations" (6 parts, 2000)
- "EMC Testing" (7 parts, 2001-2)
- "Advanced PCB Design for EMC" (8 parts, 2004-5)

Keith has written 17 informative booklets on electromagnetic phenomena, what they are, what causes them, how they cause interference, and how to test for them using IEC and EN standard methods, plus 5 booklets (so far) on EMC issues in Installations, for example: Power Quality, Good EMC Engineering Practices, Variable-Speed Drives, etc. They can all be downloaded for free from www.reo.co.uk/knowledgebase.

Member of the editorial advisory board for Compliance Engineering Magazine, 1998 - date.

Member of the editorial board for Interference Technology Magazine, 2007 - date.

Please visit www.cherryclough.com for more information.