



Another EMC resource
from EMC Standards

The Physical Basis of EM Engineering to help achieve
good, cost-effective SI, PI, and EMC - Half-Day course

Helping you solve your EMC problems

The Physical Basis of EM Engineering to help achieve good, cost-effective SI, PI, and EMC

**Understanding and visualising the physics of Signal
Integrity (SI), Power Integrity (PI) and Electromagnetic
Compatibility (EMC) *without maths***

**Supporting all our courses on
Good, Cost-Effective, SI, PI, and EMC Design**

A half-day Training Course

by Keith Armstrong

Keith was the first recipient of the IEEE EMC Society's new
"Excellence in Continuing EMC Education Award", in 2018

Presented for "Continuous education in EMC, signal integrity and power integrity
from a practically based point of view"

Synopsis

Low-frequency Signal Integrity (SI), Power Integrity (PI) and Electromagnetic Compatibility (EMC) issues are easy to understand using normal circuit design techniques when strays/parasitics are included.

So, this module focuses on those strays/parasitics, and on the SI, PI and EMC issues that most engineers find difficult because of the apparently weird things that can happen at frequencies above a few MHz.

Using only a little very simple maths, it helps engineers and their managers to understand, and visualize, the physics of SI, PI, EMI and EMC. It supports all our courses on Good, Cost-Effective, SI, PI and EMC Design.

Objective

To help all engineers and their managers to understand, and visualize, the physics of SI, PI, EMI and EMC, supporting all our courses on Good, Cost-Effective, SI, PI and EMC Design by providing the background for why those courses work so well in practice.

Who Should Attend

All electronic, mechanical, and PCB designers and their managers, in all industry / application areas, including:

Automotive	Medical and healthcare	Consumer
Information Technology (IT)	Industrial instrumentation or control	Railway
Aerospace	Household (domestic) appliances	Military
Radiocommunications	Scientific instrumentation	Telecommunications

Prerequisites

Some familiarity with the design, assembly and testing of electrical and/or electronic products or equipment. Plain English is used, with a small amount of very easy mathematics.

Course Methodology

This course is presented classroom style using a PowerPoint slideshow containing practical illustrations of the techniques to aid understanding.

Each attendee will be presented with a colour-PDF copy of the PowerPoint slides used during the training, for viewing on a display screen or colour-printing. Printed/bound versions can also be provided, by agreement, at extra cost.

Course Duration

Half a day, for example: 9:00am – 1:00pm, or 1:00pm – 5:00pm, allowing for breaks and lunches. In countries where English is not the first language, a longer duration may be preferred.

Venue and Date

To be decided.

The course could be provided as a public course, or as an in-house course. As an in-house course, it has the added value of allowing confidential discussions on how best to apply the material to particular projects or products.

Reviews of this course

For the past 20 years, delegates have always awarded this course – which is always kept up-to-date – an overall score of at least 80%.

COURSE OUTLINE

1. Electromagnetic fields, waves, & importance of the return current path
2. Field theory, permittivity, permeability, wave impedance and velocity
3. Near-field and Far-field
4. Three types of analysis (includes Skin Effect)
5. Waveforms, spectra, and 'accidental antennas'
6. Three parts to every EMC issue, and four types of EM coupling
7. Differential mode (DM) and common mode (CM)
8. The SI, PI, and EMC benefits of metal planes
9. An overview of RF emissions, to help when things get too complicated
10. External connections to 'earth', 'ground', 'chassis', etc.
11. Non-linearity, demodulation and intermodulation
12. Three interference mechanisms
13. An overview of RF immunity, to help when things get too complicated
14. 'Internal EMC' and its relationship to crosstalk, SI and PI
15. Improving profitability while reducing financial risks
16. Introduction to EM Engineering
17. Controlling return currents with metal planes
18. EM Zoning: guidelines based on the wavelength, l , at f_{MAX} ; plus the use of Reference Planes and RF References, RF_{REFS}
19. Some useful references and equations

Course Instructor

Academic Qualifications

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

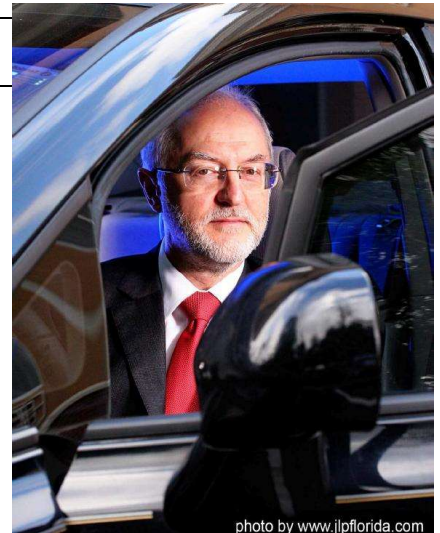
Professional Qualifications

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

Presented with the IEEE EMC Society's new "Excellence in Continuing EMC Education Award" 2018

Professional Activities

Chair of IEE/IET's Working Group on EMC and Functional Safety 1997-date
Chair of IEEE EMC Soc. Special Committee on Risk Management of EMC 2012-2016
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
Editorial board member, Inside Functional Safety magazine 2010-date
Editorial Advisory board member, Interference Technology magazine 2007-date
Editorial Advisory board member, In Compliance magazine 2005-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) 2010-2012
Chair of IEE's EMC Professional Group (E2) 1997-1999



RECENT RELEVANT EXPERIENCE (1990-PRESENT)

Started Cherry Clough Consultants in 1990, Director of the Limited Company since 2010.

External lecturer, Sensors and Electronic Instrumentation MSc course, University of Manchester, teaching an IET-accredited module on practical EMC design techniques, 2002/3 – 2007/8.

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 (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 Design Techniques for electronic engineers

Nutwood UK November 2010, ISBN: 978-0-9555118-4-4, full colour graphics throughout.

Order from www.emcstandards.co.uk/books4. Covers all electronic applications, with a very practical approach to good design practices that will save time and cost, reduce time-to-market, and reduce warranty costs and financial risks.

(Chapter 2 of this book is the complete text of "The Physical Basis of EMC" (below), so don't buy both!)

The Physical Basis of EMC

Nutwood UK October 2010, ISBN: 978-0-9555118-3-7, full colour graphics throughout.

Order from www.emcstandards.co.uk/books4. Provides an understanding of electromagnetic phenomena, in a way that can be easily understood by practising electronic engineers.

(Chapter 2 in "EMC Design Techniques for electronic engineers" is the same text, so don't buy both!)

EMC for Printed Circuit Boards – Basic and Advanced Design and Layout Techniques

Nutwood UK December 2010, ISBN 978-0-9555118-5-1, full colour graphics throughout. (2nd Edition, identical to 1st Edition except for format.) From www.emcstandards.co.uk/books4.

Practical good-practice EMC design techniques for printed circuit board (PCB) design and layout, for designers of electronic circuits and PCB designers themselves. All application areas are covered, from household appliances, commercial and industrial equipment, through automotive to aerospace and military. This book is used by some University courses.

The First 500 'Banana Skins' (also known as 'EMI Stories')

Nutwood UK, 2007, 500 reports and anecdotes concerning electromagnetic interference (EMI), collected and edited by Keith Armstrong. Read them for free (and at least 300 more 'EMI Stories') at

www.emcstandards.co.uk/emi-stories, or buy the book from www.emcstandards.co.uk/books4.

EMC for Systems and Installations

By Tim Williams and Keith Armstrong, Newnes, 2000, ISBN: 0-7506-4167-3, www.bh.com/newnes, RS Components part number: 377-6463, also available from www.emcstandards.co.uk/books4.

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 (now available from www.emcstandards.co.uk):

- "EMC design of Switching Power Converters" (14 parts, 2011-2013)
- "Designing for EMC" (6 parts 2006-8)
- "Advanced PCB Design for EMC" (8 parts, 2004-5)
- "EMC Testing" (7 parts, 2001-2)
- "EMC for Systems and Installations" (6 parts, 2000)

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 another 5 booklets on EMC issues in systems and installations, for example: Power Quality, Good EMC Engineering Practices, Variable-Speed Drives, etc. They can all be downloaded for free from www.emcstandards.co.uk.

Please visit www.cherryclough.com and/or www.emcstandards.co.uk for more information.