



Another EMC resource
from EMC Standards

EMC design of products & equipment (Pro-Audio,
3-day course)

Helping you solve your EMC problems

Practical EMC Techniques for the Cost-Effective Design of Electronic Products and Equipment

– including: ‘Advanced PCB design and layout’

A Three-day Training Course

by

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Synopsis

Training for electronic, mechanical and PCB/PWB design engineers, and their managers, in the use of good EMC design and manufacturing practices for modern products and equipment.

The good EMC practices taught here are the result of over 40 years of experience worldwide in almost all applications and industries where electronics are used, and rely on basic physical principles to achieve good Signal Integrity (SI), good Power Integrity (PI) as well as good EMC.

For these reasons, applying the course material in full has been proven many times in real-life to:

- a. Reduce development time for hardware and software
- b. Improve functional specifications (S/N ratio, Noise Margin, Open Eye Area, etc.)
- c. Reduce time-to-market (now the most important factor for financial success, says KPMG)
- d. Reduce rework in serial production
- e. Reduce overall cost-of manufacture in serial production
- f. Reduce warranty repair rates
- g. Reduce a project's financial risks

The financial payback time for these courses, when what they teach is fully adopted, can be a matter of months. The first project to employ them properly will usually pay back the overall cost of the training (including the reduced productivity of the attendees while they are on the course) very many times over.

Objective

The aim of the course is to help companies quickly improve their commercial and financial performance by using well-proven practical design techniques that deal with SI, PI and EMC all at once, which can be put into practice immediately to provide immediate benefits.

This course is highly recommended for those involved in any aspect of the design or testing of electrical/electronic products.

It is based upon the EMC course module that Keith taught in the late 1990s to post-graduate students as part of the IET-accredited Sensors and Electronic Instrumentation M.Sc. course at the University of Manchester (formerly UMIST, University of Manchester Institute of Science and Technology), UK.

Who Should Attend

All electronic designers and their managers, in all industry areas, including:

Automotive	Medical & healthcare
Consumer	Household (domestic) appliances
Information Technology (IT)	Industrial instrumentation or control
Railway	Marine
Aerospace	Military
Professional audio, video, lighting	Broadcasting
Telecommunications	Radiocommunications

Prerequisites

Familiarity with circuit (hardware) design, PCBs/PWBs and electronic and mechanical assembly and interconnection techniques.

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.

Case studies that are relevant to the trainees will be included verbally.

Each attendee will be presented with a bound copy of the PowerPoint slides used during the training, printed at 6 slides per page. The spaces around the slides usually suffice for taking extra notes.

Copies of the following textbooks can be provided at 50% of their normal cost:

'EMC Design Techniques for electronic engineers', Keith Armstrong, Nutwood UK Nov. 2010, ISBN: 978-0-9555118-4-4, full colour graphics. Only from www.emcacademy.org/books.asp

'EMC for Printed Circuit Boards – Basic and Advanced Design and Layout Techniques, Edition 2', Keith Armstrong, Nutwood UK December 2010, ISBN 978-0-9555118-5-1, full colour graphics throughout. Only from www.emcacademy.org/books.asp

Course Duration

Three full days, e.g. 9:00am – 5:00pm (other start/finish times can be used)

This is a very intensive course with a very large amount of practical detail. If presented as an in-house course it can be very usefully combined with individual consultancy for each engineer or manager, to help him or her apply the material to his or her current projects.

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

Delegates have always awarded our EMC and safety courses an overall score of 80% or more.

COURSE OUTLINE

DAY 1

Overview of pro-audio EMC tests for emissions and immunity	1.5 hrs
Cables and connectors	1.5
EMC shielding	1.5
Circuit design for EMC (digital, analogue, switch-mode and comm's)	1.5

DAY 2

Choice of PCB components for EMC	1.0
EMC filtering	1.0
Suppressing electrostatic discharge (ESD)	1.0
Good EMC practices in the design and assembly of electrical/electronic equipment (using the example of an industrial control panel)	3.0
Buying electrical/electronic units	
Following the manufacturer's sensible EMC instructions	
Following good EMC practices	
Route send/return current paths together	
Creating an RF Reference and routing conductors close to it	
RF bonding techniques for metalwork	
Don't confuse the reference plane with safety earthing	
RF bonding techniques for units and PCBs	
RF bonding techniques for cable screens	
Choosing and using filters	
Enclosure shielding and how not to ruin it	
Choosing and using EMC gaskets	
Preventing galvanic corrosion	
Cable classes, segregation, and routing	
Segregation of units	
Maintaining EMC in repair, maintenance, and upgrading	
Information in user manuals	
Some very useful references	

DAY 3

The EMC techniques now generally required for all PCBs	Full day
Saving time and money	
Segregation	
Interface analysis, filtering and suppression	
0V and power planes	
PCB-chassis bonding	
Power supply decoupling	
Transmission line techniques	
Layer stacking	
Some useful contacts, sources, references	

Advanced PCB

- When do we need to use advanced PCB techniques?
- Silicon trends and their implications
- Rules of thumb, approximations, simulations
- Virtual design for SI and EMC
- Advanced segregation
- PCB-level shielding at GHz
- Advanced interface filtering and suppression
- Advanced PCB-chassis bonding
- Advanced planes
- The totally shielded PCB assembly
- Advanced decoupling
- Buried capacitance
- Advanced transmission lines
- Differential transmission lines up to 10Gb/s
- Advanced layer stacking
- Microvia (hi-density interconnect) PCB technology
- Electronic band-gap techniques
- Some final tricks
- Some useful contacts, sources, references

A more detailed course contents list is available upon request.

NOTE: To fit the half-day 'Advanced PCB' and 'electrical/electronic equipment' modules into this 3-day course, very little time has been allowed for discussions and case studies, and the following course modules have been removed.

- The Physical Basis of EMC (i.e. why these good design practices work so well)

- Introduction to EMC

- Approaches for regulatory compliance; high reliability or functional safety
 - What interference can occur, and how it affects hardware and software
 - Saving time and money with good EMC techniques
 - EMC specification and standards

- Suppressing surges

- Suppressing electromechanical devices (switches, relays, commutators, sliprings, etc.)

- Suppressing emissions of harmonics, voltage fluctuations and flicker

- Techniques for dealing with poor mains power quality

- Heatsink design for EMC

To allow time for discussions and case studies (often the most useful part of the course, but best if they follow after all the course's modules) and/or reinstate some/all of them would require a four-day course at least.

The following additional modules are often requested, and can be included if the duration of the course is increased to 4 or more days:

- Integrating wireless datacommunications

- Close-field probing techniques which are very valuable for every project stage

- Demonstration of shielding and filtering design issues, which also shows how very easy and helpful it is to use close-field probing.

BENEFITS OF ADDING A HALF-DAY ON 'CASE STUDIES'

Many of our European training customers require at least a half-day's 'case study' session at the end of each training course, during which attendees describe an EMC problem they have had, are having, or expect to have with their designs, and the whole group discusses it in the light of what they have learned on the course. The Instructor supervises the discussion and only gets involved when something has been misunderstood or some useful approach omitted.

Although we try hard to make our course material as practical as possible for the active design engineer, of necessity the explanations and graphics are generic so they can be widely used. These case study sessions help to cement the understanding of good EMC engineering practices gained during the course in the minds of the attendees as regards the sub-assemblies, modules, products, equipment, systems or installations they are working on. The result is a faster take-up of these techniques leading to much quicker and larger financial benefits for the company.

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 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 (EurIng), FEANI, Paris, France	1988



Professional Activities

Chair of IET's Working Group on EMC and Functional Safety	1997-date
Chair of IEEE EMC Soc. Special Committee on Risk Management of EMC	2012-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
Editorial Advisor, 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)	2010-2012
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 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 Design Techniques for electronic engineers

Nutwood UK November 2010, ISBN: 978-0-9555118-4-4, full colour graphics throughout. Order from www.emcacademy.org/books.asp. 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 purchase both!)

The Physical Basis of EMC

Nutwood UK October 2010, ISBN: 978-0-9555118-3-7, full colour graphics throughout. Order from www.emcacademy.org/books.asp. Provides an understanding of electromagnetic phenomena, in a way that can be easily understood by practising electronic engineers. (Chapter 2 of my book "EMC Design Techniques for electronic engineers" (above) is the complete text of this book, so don't purchase both of them!)

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.emcacademy.org/books.asp 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'

Nutwood UK, 2007, 500 reports and anecdotes concerning electromagnetic interference (EMI), collected and edited by Keith Armstrong. Read it at www.theemcjournal.com, or buy from www.emcacademy.org/books.asp. More 'Banana Skins' are published 6 times a year in 'The EMC Journal', available free at www.theemcjournal.com or www.compliance-club.com

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

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)
- "EMC Design of Switched-Mode and PWM Power Converters (AC/DC, DC/DC, DC/AC, AC/AC, mW to MW) (14 parts, 2011-2013)

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.

Please visit www.cherryclough.com for more information.