Another EMC resource
from EMC Standards

Two day course for cost-effective EMC design for electronic products in 2023

Helping you solve your EMC problems

1 Brassey Road, Old Potts Way, Shrewsbury, SY3 7FA T:+44 (0) 1785 660 247 E:info@emcstandards.co.uk

Proven Cost-Effective Electronic Design Techniques for good SI, PI and EMC – in 2023

Please note: this course does not cover Printed Circuit Board (PCB) design/layout for EMC.
We offer a separate one-day Basic course, and a two-day Basic + Advanced course, on PCB EMC.

A Two-Day Training Course

by

Keith Armstrong
Cherry Clough Consultants Ltd, U.K.

Synopsis

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

This course *does not cover* low-frequency emissions and power quality issues for AC-DC power converters, because many manufacturers purchase them as discrete units already compliant with the relevant standards. Other course modules are available to customise this course.

Longer versions are available, up to five days, which can go into more depth and/or cover more topics (including low-frequency emissions and power quality issues for AC-DC power converters), and which can cover basic PCB EMC techniques, or basic + advanced PCB design techniques.

Objective

The aim of the course is to help companies quickly improve their commercial and financial performance by using design techniques that have been proven in real-life for many years to:

- Bring advanced products to market more quickly
- Reduce unit manufacturing costs
- Reduce warranty costs and costs of ownership by improving reliability
- Easily comply with legal EMC requirements
- Reduce financial risks and improve Return On Investment

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 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 (vehicles and infrastructures)
- Consumer electronics
- Information Technology (IT)
- Process control
- Railway (vehicles and infrastructures)
- Marine (vehicles and infrastructures)
- Aerospace (vehicles and infrastructures)
- Power generation and distribution
- Medical & healthcare
- Household (domestic) appliances
- Industrial instrumentation or control
- Entertainment, inc. TV and radio broadcasting
- Telecommunications
- Radiocommunications
- Military, security, and defence
- Datacommunications

Prerequisites

Familiarity with circuit (hardware) and mechanical 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 relevant textbooks (see page 9) can be provided, at extra cost.

Course Duration

Two (2) full days, each 9:00am – 5:00pm (for example, other timings 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.

It can be delivered in person, or on-line (up to a maximum of 1,000 attendees).

COURSE OUTLINE

Day 1

A. EMC and Interconnections 2hrs

1 Accidental antenna behaviour of all conductors
2 Using fibre-optics, and other alternatives to conductors
3 The “RF Reference”
4 Cable classification and segregation
5 Good practices for shielded and unshielded interconnections: DM & CM paths
6 Shielding techniques for cables
7 Terminating cable shields
8 Interconnecting shielded enclosures
9 Dealing with ‘ground loops’
10 Transmission-line interconnections
11 Some useful references

B. Filtering for EMC 2hrs

1 Filtering is not ‘black magic’
2 How filters work
3 The advantages of soft ferrites
4 CM filtering
5 Specifying filters
6 Real-life problems with resonances, inductors, and capacitors
7 Earth leakage currents and safety
8 Filter construction, mounting, and cabling
9 The synergy of filtering and shielding
10 Some useful references

C. Shielding 2hrs

1 Economic issues for shielding
2 Shielding with metal plates (image planes)
3 How shielded enclosures work
4 DC and low frequency shielding
5 The problems caused by apertures
6 The problems caused by box resonances
7 The problems caused by conductor penetrations
8 Shields in the near field of a source
9 RF-bonding with multiple metal bonds or conductive gaskets
10 Waveguides-below-cutoff
11 Shielding of displays
12 Shielding of ventilation
13 Shielding of plastic enclosures
14 Preventing corrosion at shielding joints
15 D-I-Y testing SE before hardware or software is ready
16 Some free SE calculators and useful references

Day 2

D. Circuit design for EMC 2hrs

Digital circuits

1 Rise/fall times and emissions spectra
2 Numerous digital circuit design techniques
3 Watchdogs and brownout monitors
4 Data scrambling and spread-spectrum clocking

Analogue circuits

5 Linearity, bandwidth and stability of feedback circuits
6 Numerous analogue circuit design techniques, using hysteresis in comparators

Switching power converters

7 “EMC benign” and spread-spectrum techniques
8 Reducing dV/dt and dI/dt with snubbers
9 Heatsinks
10 Use SiC Schottky or soft-switching rectifiers, SiC or GaN switching devices
11 The isolating transformer’s interwinding capacitance
12 Don’t over-use galvanic isolation!

Communications circuits

13 Better alternatives to copper cabling
14 How to use copper cabling
15 Common-mode noise reduction techniques
16 Optoisolators and optocouplers
17 Gigabit laser diodes
18 Terminating transmission lines
19 Some useful references

E. Component selection for EMC 1hr

1 Active devices
2 Passive components
3 Problems with second sources, counterfeits, and controlling purchasing
4 Some useful references

F. Suppressing electrostatic discharge (ESD) 1.5hrs

1 ESD threats
2 Insulation techniques
3 Shielding techniques
4 Suppressing signal, data and power connector pins and conductors
5 PCB layout for ESD suppressors
6 Earth lift problems in systems
7 Protecting control, data and signals from errors
8 Some useful references, including “software techniques for ESD suppression”

G. Suppressing surges/transients on AC, DC power supplies, signals & data

2hrs

1	What transients are, and how they cause damage
2	Using galvanic isolation
3	Using filters
4	Using surge protection components (SPCs) – types
5	Rating SPCs
6	Protecting and maintaining SPCs
7	Lead inductance and “let-through” voltage
8	Avoiding the effects of SPC capacitance on signals
9	Types of surge protection devices (SPDs)
10	Electronic transient protection for DC power supplies
11	“Earth/ground lift” problems in systems
12	Data needs error correction
13	Dealing with long-duration overvoltages
14	Some useful references

A more detailed course contents list is available upon request.

Note 1: Modules recommended as additions or replacements for the above standard course:

- **Getting Started with EM Engineering, List of Resources** 0.5 hr
- **Cost-effective uses for near-field probing, and RF current monitoring in every project stage, for emissions, immunity, and more!** 2 hrs
- **Introduction to EMC and EMI** 2 hrs
- **The Physical Basis of EMI and EMC** (Maxwell’s without maths!) Half-day
- **EMC Awareness – the Myths and the Realities** 2 hrs
- **EMC design of heatsinks** 1.5hrs
- **Analogue design techniques for SNR and EMI immunity** Half-day
- **Switch-mode power conversion** Full-day
- **Good EMC practices for cabinets, systems and installations** 1.5 days

Many more modules are available – if you don’t see what you want, please ask!

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, and member of its EMC and Product Safety Engineering Societies since	2010 1998
IEEE EMC Society's 'Excellence in Continuing EMC Education Award'	2018
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
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
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
Chair of IET Standards Code of Practice on 'Electromagnetic Resilience'	2015-2016
Chair IEEE Standards P1848: 'Techniques & measures to manage functional safety and other risks with regard to electromagnetic disturbances'	2016-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.
Started EMgineering Ltd (owns www.emcstandards.co.uk) and appointed Director, October 2017.

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. Good signal integrity, power integrity, and EMC can be achieved quickly and cost-effectively, without risking over-engineering, by a well-proven set of design techniques.
- Assessment of electromagnetic environments
- Control plans, test plans, etc., for effective management of EMC and safety in projects of all sizes. De-risking projects as regards EMI and EMC issues.
- Company procedures for EMC and safety, for financial benefits and 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, other compliance documentation
- Assessment of EMC Directive Technical Construction Files for a number of EMC Competent / Notified Bodies
- Education and training for designers and managers on cost-effective EMC and Safety techniques; and on "Functional Safety Risk Management of EMI"
- 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, including:
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
Railway and tram systems	Mobile X-ray systems for shipping containers

Synchrotrons (inc. the Diamond Light Source, Harwell, Oxfordshire, www.diamond.ac.uk)
Fusion reactors, Tokamaks, (e.g. the ITER project in southern France, www.iter.org/)

Products and items of equipment:
Industrial instrumentation, control, and machinery of all sizes, including:
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
Cellphones, Personal Digital Assistants (PDAs), pagers and similar hand-held wireless 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	Very large video displays e.g. for Sports Stadiums
Lifts (elevators)	Domestic (household) appliances
Gambling machines	Gas boilers
Electricity meters, inc. 'smart' meters	Electrical power generators (small scale)
Building electrical services equipment	Subsea oil and gas production equipment
Robots	Solar power converters (grid-connected, bidirectional)
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
Military land vehicles	Wheeled robots for search/rescue and bomb disposal

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.

Started in analogue design in 1968; added 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'
Nutwood UK 2007, 500 reports and anecdotes concerning electromagnetic interference (EMI), collected and edited by Keith Armstrong. Buy from www.emcstandards.co.uk/books4. Now published as 'EMI Stories' at www.emcstandards.co.uk/emi-stories, where there are currently 873 of them.

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, Asia-Pacific EMC, Euro-EMC, and 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 or www.emcstandards.co.uk for more information.