



Another EMC resource
from EMC Standards

EMC Design of Switch-Mode Power Converters (1-day course)

Helping you solve your EMC problems

EMC Design of Switch-Mode Power Converters

**including: all isolating and non-isolating AC-DC,
DC-DC, DC-AC and AC-AC converters,
from microwatts to Megawatts**

**including: PWM motor drives for hybrid and electric
vehicles and renewable AC power generators**

A One-day Training Course
by

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Synopsis

Switch-mode power conversion is an extremely noisy technology, and it is very difficult and costly indeed to suppress its emissions for compliance (and happy customers) unless good EMC design techniques are used from the start.

This course covers EMC design techniques to control emissions from all types of switch-mode power converter, at all power levels (from under 1W to over 10MW), from circuit design and PCB layout to packaging and installation, including:

- DC and AC motor drives for hybrid and electric vehicles
- DC and AC motor drives for domestic appliances, commercial and industrial sites, including steppers and servos
- AC power generation from renewable energy sources (e.g. PV, wind, water, tidal, etc.) and batteries.
- Mains powered AC-DC power supplies and isolating DC-DC converters
- Non-isolating DC-DC converters
- Class D audio power amplifiers
- All types of switch-mode conversion, including AC-DC, DC-DC, DC-AC, AC-AC
- EMC design techniques for circuits, PCBs, mechanical packaging, systems and installations, for converters of less than 1W to greater than 10MW

Objectives

To provide practical grounding in the EMC techniques now required for switch-mode and PWM circuits, to help companies quickly improve their commercial and financial performance by:

- Bringing advanced products to market more quickly
- Reducing unit manufacturing costs
- Reducing warranty costs and costs of ownership by improving reliability
- Easily complying with legal EMC requirements
- Reducing financial risks and improving Return On Investment

Who Should Attend

All electronic designers and their managers who are involved with switch-mode and PWM circuits, in all industry areas, including:

Telecommunications (exchanges, networks, etc.)	Radiocommunications (base stations)
Military (sites and vehicles)	Medical and healthcare
Hotels and restaurants	Information Technology (IT)
Infrastructure (water, gas, electricity, telecommunications, internet, etc.)	
Extraction and refining (oil, gas, metals, minerals, mines, refineries, etc.)	
Industrial (plants, instrumentation, control, etc.)	
Entertainment (recording and broadcasting TV/audio studios, theatres, cinema, clubs, etc.)	
Automotive (manufacturing, vehicles, etc.)	
Railway (stations and other fixed sites, vehicles, etc.)	
Marine (harbours, port facilities, docks, container facilities, ships, etc.)	
Aerospace (airports, launch sites, launch vehicles, air/space craft, etc.)	

Prerequisites

Familiarity with circuit (hardware) design, PCBs/PWBs and electronic 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, colour-printed at 6 slides per page. The spaces around the slides usually suffice for taking extra notes.

Copies of the following full-colour textbooks can be provided (at extra cost):

“EMC for Printed Circuit Boards, basic and advanced design and layout techniques”, Edition 2, Nutwood UK December 2010, ISBN 978-0-9555118-5-1.

“EMC Design Techniques for electronic engineers”, Nutwood UK November 2010, ISBN: 978-0-9555118-4-4.

Course Duration

One (1) full day, for example: 9:00am – 5:00pm

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.

Reviews of this course

Delegates have always awarded this course an overall score of more than 80% .

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.

COURSE OUTLINE

- Very brief introduction to EMI and EMC
- Applications of switch-mode power conversion
- EMC design of switchers and choppers
- EMC design of high-frequency isolating transformers
- EMC design of output rectifiers
- Suppressing RF emissions from converter inputs and outputs
- Insulated Neutral, “floating”, mains power systems
- Miscellaneous switcher design issues
- Mains rectifiers – Power Factor Correction (PFC)
– suppressing emissions of mains harmonic currents
- Suppressing emissions of voltage fluctuations and flicker
- Some useful references and further reading

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, 2010
and member of its EMC and Product Safety Engineering Societies since 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

Synchrotrons (inc. the Diamond Light Source, Harwell, Oxfordshire, www.diamond.ac.uk)

Railway and tram systems

Mobile X-ray systems for shipping containers

Large nuclear fusion reactors (specifically ITER, 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.