



Another EMC resource  
from EMC Standards

## EMC Design Techniques for Low-Frequency Analogue Circuits (0.5-day course)

*Helping you solve your EMC problems*

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# EMC Design Techniques for Low-Frequency Analogue Circuits

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## A Half-day Training Course

*by*

Eurlng Keith Armstrong  
Cherry Clough Consultants, U.K.

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

Training for engineers and managers in the use of good EMC design and manufacturing practices for low-frequency analogue circuits; suitable for use in modern products and equipment.

### Objective

To provide practical grounding in the EMC techniques required for low-frequency analogue 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 low-frequency analogue circuits, for instance in measurement; instrumentation; control; audio and video; professional audio & video; analogue telephony; etc., in all industry areas, including:

Automotive	Medical & healthcare	Consumer
Railway	Information Technology (IT)	Marine
Aerospace	Industrial instrumentation or control	Military
Telecommunications	Radiocommunications	Broadcasting
Professional Audio/Video		

### Prerequisites

Familiarity with low-frequency analogue 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, printed at 6 slides per page. The spaces around the slides usually suffice for taking extra notes.

Copies of the textbook “*EMC for Printed Circuit Boards, basic and advanced design and layout techniques*”, Armstrong/Nutwood January 2007, ISBN: 978-0-95555118-0-6 (spiral bound to lie flat when open) or 978-0-95555118-1-3 (perfect bound), can be provided at extra cost.

### Course Duration

Half (½) day, for example: 9:00am – 12:30 pm; or 1:30pm – 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.

### 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

### DAY 1 (half day)

- 1 The EMC immunity problems of low-frequency analogue circuits
- 2 Saving costs
- 3 How does the interference get in?  
(direct interference, demodulation and intermodulation)
- 4 Some general and system issues
- 5 Filtering at the input
- 6 Filtering balanced inputs when using transformers or 'electronic balancing'  
with one, two or three opamps
- 7 Improving power supply rejection at RF
- 8 Improving linearity, bandwidth, stability in feedback circuits
- 9 A quick and easy way to allow for parameter variations
- 10 Filtering at the output
- 11 Shielding circuits and their cables
- 12 Bench testing techniques
- 13 Hysteresis is needed for comparators
- 14 Some useful references

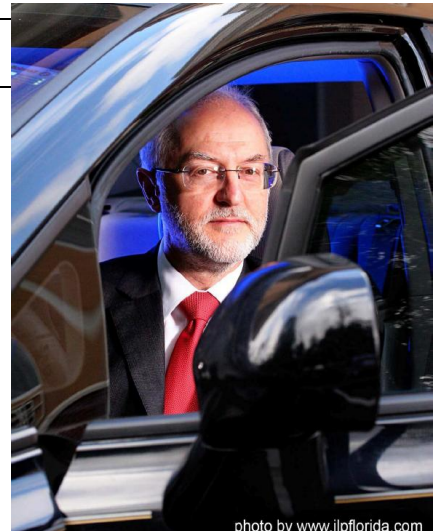
## Course Instructor

### Academic Qualifications

BSc (Elec.Eng), Upper 2<sup>nd</sup> 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.emcacademy.org/books.asp](http://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 buy 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](http://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 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.emcacademy.org/books.asp](http://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](http://www.theemcjournal.com), or buy from [www.emcacademy.org/books.asp](http://www.emcacademy.org/books.asp). More 'Banana Skins' are published 6 times a year in 'The EMC Journal', available free at [www.theemcjournal.com](http://www.theemcjournal.com) or [www.compliance-club.com](http://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](http://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 (now available from [www.emcstandards.co.uk](http://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](http://www.emcstandards.co.uk).

Please visit [www.cherryclough.com](http://www.cherryclough.com) and/or [www.emcstandards.co.uk](http://www.emcstandards.co.uk) for more information.