Another EMC resource
from EMC Standards

How to do EMC Testing to European / IEC Standards (2 Day Course)

Helping you solve your EMC problems

9 Bracken View, Brocton, Stafford ST17 0TF T:+44 (0) 1785 660247 E:info@emcstandards.co.uk

How to do EMC Testing
to European / IEC Standards

A Two-day Training Course

by

EurIng Keith Armstrong
Cherry Clough Consultants, U.K.

Synopsis

Training for EMC test engineers and their managers in testing to European (EN) and IEC standards for emissions and immunity.

Objective

To provide training in how to correctly test products for EMC using European (EN) and IEC standards for emissions and immunity.

Being able to test to these standards will help develop products for the European Union and many other countries at low cost, by avoiding the need to send products overseas for testing.

EN EMC standards are required for compliance with regulatory requirements of the European Union's (EU's) Single Market (i.e. the EMC Directive). IEC EMC standards are employed in the regulatory requirements of many other countries and trading blocs.

The purpose of this course is not to describe exactly how to do each test – this would take far too long, and is best done in a test laboratory using a variety of example EUTs (equipment under test). It is to become familiar with the correct *approach* to EMC testing in general; the correct approaches in applying each test standard; and with the important testing issues that are not covered by the test standards.

Who Should Attend

EMC test engineers, and their managers, who are being asked to test to IEC or EN emissions or immunity standards. The tests that are covered in this course are:

- Conducted emissions
- Radiated emissions
- Mains harmonic emissions
- Emissions of mains voltage fluctuations and flicker
- Conducted immunity, with special attention to bulk current injection (BCI)
- Radiated immunity using an anechoic chamber
- Fast Transient Burst immunity
- Electrostatic discharge (ESD) immunity
- Surge immunity

Training can be provided in many other IEC / EN emissions or immunity test methods, please contact Keith Armstrong to discuss (see below for contact details).

Prerequisites

Familiarity with EMC test instrumentation and testing techniques. Familiarity with ISO 17025 would be a bonus.

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 monochrome at 6 slides per page. The spaces around the slides usually suffice for taking extra notes.

Please note that to actually perform these EMC tests, copies of the relevant IEC or EN test standards are required. This training course cannot convey sufficiently detailed information in the time available to replace the need for having the correct standards to work with.

Course Duration

Two days, for example: 9:00am – 5:00pm each day

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

1 Issues that are common to all IEC/EN emissions tests

What's the problem? — How do emissions arise?
Testers need to know what they are doing, and why
CISPR 16-1 measurement bandwidths — CISPR 16-1 detectors
Other CISPR 16-1 requirements — Inherent noise in the measuring system
Intermodulation in spectrum analysers — Narrowband versus broadband
Measurement uncertainty — Emissions variations in serial manufacture
Finding the maximum emissions — Saving time in emissions testing
References, and further reading

2 Testing conducted emissions

Emissions limits — Using LISNs and ISNs
Obtaining CM and DM data from a LISN — Using a transient limiter
Stray coupling and the importance of the test set-up
Taking test equipment calibration factors into account
Finding the maximum emissions — Verifying the test equipment
The voltage probe — Dealing with ambient noise

3 Testing radiated emissions

Limits — Antennas for measuring radiated emissions
Near and far fields — Suitable sites for emissions measurements
Open Area Test Sites (OATS) — Dealing with ambient noise
Stray coupling and the importance of the test set-up
Taking test equipment calibration factors into account
Finding the maximum emissions – antenna angles and polarisations
Saving time in radiated emissions testing
Daily verification of the test equipment and site

4 Testing emissions of mains harmonics

Sources of mains harmonics, and the problems caused
Easier than RF testing, no requirements for test site
The basic measurement technique
The harmonic analyser — The 230V 'clean' power source
Take care to buy compliant test equipment — Operating the EUT
Applying the limits — Limitations for equipment design
Class D: specifying the power level — Testing three-phase equipment
Standard developments can make test gear unsuitable
EN 61000-3-2 not necessarily same as IEC 61000-3-2
References, and further reading

5 Testing emissions of voltage fluctuations and flicker

Causes of mains voltage fluctuations, flicker, inrush currents

Problems from voltage fluctuations, flicker, inrush currents

The measurement system	The measured parameters
The limits, and how they are applied	Test set-up, and operation of the EUT
The AC source	Combined test instruments

There are no EMC requirements specified for the test site
Standards developments can make test equipment unsuitable

Testing three-phase equipment	References, and further reading

6 Issues that are common to all IEC/EN immunity tests

Testers need to know what they are doing, and why

Measurement uncertainty	Immunity variations in serial manufacture
Finding the worst case immunity	Monitoring the EUT's functional performance
Testing alarms and safety functions	Suitable sites for immunity testing
Test level accuracy	Test as real life (TARL)

References and further reading

7 Testing conducted immunity, especially when using bulk current injection (BCI)

What's the problem?	All conductors are accidental antennas
Where do the threats come from?	How does the interference arise?
Four ways of testing for conducted immunity	The test waveform
The size of the RF power amplifier required	The two BCI test methods

The 'levelling loop' test method and its problems
The 'substitution' test method and its problems
Stray coupling and the importance of the test set-up

Tall EUTs	'Backfire' from the injection clamp
Daily verification of the test set-up	Taking calibration factors into account

Finding the worst case immunity – cycles of operation
Testing telecom and similar equipment with many identical channels

Beware of transient currents	DM testing with BCI

8 Testing radiated immunity using an anechoic chamber

What's the problem?	All conductors are accidental antennas
Where do the threats come from?	How does the interference arise?
Radiated immunity test methods	Free field testing is described here
The test waveform	Rating the RF Power Amplifier (PA)
The levelling-loop method	The substitution method
Anechoic chambers	The test set-up
Preliminary testing	The test procedure
Large EUTs	Testing above 1GHz
Taking calibration factors into account	Beware of transient fields

Finding the worst case immunity – cycles of operation
Daily verification of the test set-up
Different results from different anechoic chambers

9 Testing Fast Transient Burst immunity

What are FTB threats and where do they come from?
What's the problem?
FTB standards
FTB test waveforms
Test generators and coupling devices
Test set-ups
Careful test set-up is required
Test procedure
Taking calibration factors into account
Finding the worst case immunity – cycles of operation
Daily verification of the test set-up
Different results from different test generators

10 Testing electrostatic discharge immunity

Where do the threats come from?
What's the problem?
How does interference arise?
Different human body models
'Mag loop' ESD testing
Test set-ups
Careful test set-up is required
Number of discharges
Selection of test points
Selecting air or contact discharge
Doing contact and air discharge tests
Discharging to VCPs and HCPs
Testing powered and unpowered EUTs
Ungrounded EUTs
Secondary arcing
Verifying the ESD gun
Taking test equipment calibration factors into account
Finding the worst case immunity – cycles of operation
There can be large differences between different models of ESD guns

11 Testing surge immunity

Where do surge threats come from?
What's the problem?
Surge standards
Surge test waveforms
Test generators and CDNs
Testing different kinds of conductors
Test set-ups
Safety issues with earth-lift tests
Careful test set-up is not required
Test procedure
Testing time issues
Taking test equipment calibration factors into account
Finding the worst case immunity – cycles of operation
Daily verification of the test generator and CDN

12 Close-field probe testing techniques that are very useful in all project stages

Proof of design principle
Design, and component selection
Development
Fixing problems during compliance tests
QA of EMC performance in serial manufacture
Checking EMC effects of proposed design changes, component substitutions and software upgrades
Helping ensure EMC of systems and installations
Maintaining EMC despite maintenance, repair, upgrades, modifications, etc.

Course Instructor

EurIng Keith Armstrong C.Eng, FIET, ACGI, MIEEE, BSc(Hons)

Partner and Principal Consultant for Cherry Clough Consultants

www.cherryclough.com, tel/fax: +44 (0)1785 660 247,
email: keith.armstrong@cherryclough.com

EDUCATION/CERTIFICATION

Bachelor of Science (BSc) with Honours, Upper Second Class, Electrical Engineering, Imperial College of Science and Technology, London, U.K. 1972.

Associate of the City and Guilds Institute (ACGI), London, U.K., 1972

Member of the Institution of Electrical Engineers (MIEE) London, U.K. recently renamed as The Institution of Engineering and Technology (IET), since 1977. Appointed Fellow (FIET) in 2010.

Appointed as Chartered Engineer (C.Eng) by the Council of Engineering Institutions, London, U.K., 1977

European Engineer (EurIng) Group 1 awarded by the European Federation of National Engineering Institutions (FEANI), 1988

Member of IEEE (USA) and IEEE EMC Society, MIEEE, 1998

Member of IEEE Product Safety Engineering Society (USA), 2004

PROFESSIONAL ACTIVITIES

President of the EMC Industry Association (www.emcia.org)
2008-date

Chair of IEE's Electromagnetic Compatibility (EMC) Professional Group (E2)
1997-1999

Chair of IET's Working Group on EMC and Functional Safety
1998-date

Member EMC Test Labs Association (EMCTLA) and its Working Group B
2001-date

Member of Technical Panel for IET's EMC Professional Network (PN)	2001-date
Member of Technical Panel for IET's Functional Safety PN	2003-date
UK Expert appointed to the maintenance team (MT15) for IEC 61000-1-2 (EMC & Functional safety)	2003-date
UK Expert appointed to the maintenance team (MT23) for IEC 60601-1-2 (Medical EMC)	2007-date

RECENT RELEVANT EXPERIENCE (1990-PRESENT)

Started Cherry Clough Consultants in 1990, currently one of the two Partners.

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 for Systems and Installations, Tim Williams and Keith Armstrong, Newnes, 2000, ISBN: 0-7506-4167-3, www.bh.com/newnes, RS Components P/No. 377-6463.

EMC for Printed Circuit Boards – Basic and Advanced Design and Layout Techniques,
Keith Armstrong, February 2007. Cost £47 plus p&p.
Perfect bound (with titled spine): ISBN 978-0-9555118-1-3
Spiral bound (lays flat for easy use): ISBN 978-0-9555118-0-6
Full colour graphics throughout. Written in a clear concise no-nonsense style full of practical detail. Order via http://www.emcacademy.org/books.asp

The First 500 'Banana Skins',
Nutwood UK, 2007, 500 reports and anecdotes concerning EMI. Edited by Keith Armstrong.

Very useful for have a laugh at other's mistakes, or frightening yourself with what could go wrong. A useful present for a boss that doesn't believe EMC can cause very real engineering and financial problems. Read it at www.theemcjournal.com, or buy from pam@nutwood.eu.com (approximately £10) or via http://www.emcacademy.org/books.asp.

The IET's new (2008) Guide on EMC for Functional Safety
ISBN 978-0-9555118-2-0, colour graphics throughout, cost £27 plus p&p from www.emcacademy.org/books.asp, or free download from www.theiet.org/factfil;es/emc/index.cfm. Written by an IET Working Group chaired by Keith Armstrong, this book comprehensively describes a practical and cost-effective procedure to help to save lives and reduce injuries where electronics technologies are used in all safety-implicated products, systems and installations.

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)

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.

Member of the editorial advisory board for Compliance Engineering Magazine, 1998 - date.

Member of the editorial board for Interference Technology Magazine, 2007 - date.

Please visit www.cherryclough.com for more information.