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2-Day Essential and Advanced PCB Design and Layout Techniques for SI, PI and EMC 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

PCB Design and Layout Techniques for cost-effective SI, PI and EMC, in 2023

The essential design/layout techniques now generally required for all PCBs, plus advanced techniques for high-speed digital

A two-day Training Course

by

Keith Armstrong
Cherry Clough Consultants Ltd, U.K.

Synopsis

For design engineers and their managers interested in the cost-effective design, layout, manufacturing and assembly practices for printed circuit boards (PCBs) needed in 2023 to help control financial risks.

Every two years, on average, every type of semiconductor that is available on the market goes through a die-shrink, which makes their emissions and immunity worse. This applies to older device types, like 74-series TTL and HCMOS, as well as to the latest microprocessors, FPGAs and memories, so designing with the same old parts does not protect us from this problem.

So PCB design techniques must continually advance for us to design PCBs in a way that doesn't cause Signal Integrity (SI), Power Integrity (PI) or electromagnetic compatibility (EMC) problems.

Special PCB design/layout techniques are generally needed when resonances in PCB structures are excited by the frequencies present in the analogue, digital or power supply current waveforms. Such techniques are becoming increasingly essential for all PCBs that use high-speed processing or data, and are covered in this course.

This course is kept up-to-date as technology advances, so is never the same from one 6 months to the next. It is much more up-to-date than any textbook can ever be.

Objective

After the appropriate choice of semiconductors (or designing your own ASICs), the most cost-effective SI, PI and EMC techniques are those applied at the PCB level.

This course provides a practical grounding in PCB EMC design and layout techniques that have been proven over many years in real life to help companies quickly improve their commercial and financial performance by:

- Bringing products to market more quickly
- Meeting delivery deadlines to help avoid penalty charges
- Improving functional performance
- Reducing overall unit manufacturing costs
- Easily complying with EMC requirements
- Reducing warranty costs and improving customer perception of the brand
- Reducing overall financial risks
- Improving Return On Investment

Who Should Attend

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

Automotive	Medical and healthcare	Consumer
Household (domestic) appliances	Information Technology (IT)	Railway
Industrial instrumentation/control	Marine	Aerospace
Telecommunications	Radiocommunications	Military

Prerequisites

Familiarity with circuit (hardware) design and/or the layout of PCBs.

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 suffice for taking extra notes.

Copies of the textbooks listed on page 6 can be provided at extra cost.

Course Duration

Two (2) days: For example: 9:00am – 5:00pm (other timings may be used)

This is an 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.

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

For over 20 years, delegates world-wide have awarded this course a score of *at least* 80%.

COURSE OUTLINE

DAY 1 Essential PCB design/layout techniques generally required for good SI, PI, and EMC in 2023

- Saving time and money
- Scope and application of these design and layout techniques
- EM Zoning (i.e. circuit segregation)
- Interface analysis, filtering, and suppression
- Planes for 0V(GND) and other power rails (PWR)
- RF-bonding PCB Reference Planes at EM Zone boundaries
- Power supply decoupling
- Switching power converters (inc. AC-DC, DC-DC, DC-AC, AC-AC, etc.)
- Matched transmission line techniques
- Layer stacking and trace routing
- Devices with BGA packages and/or multiple DC power rails
- Some useful references, sources and webinars

DAY 2 Advanced PCB design/layout techniques for good SI, PI and EMC in 2023

- When should we use advanced PCB techniques?
- Future trends and their implications
- Guidelines, approximations, simulations, and virtual design for SI, PI and EMC
- Advanced EM Zoning (segregation) techniques
- Advanced interface filtering and suppression, including using board-level shielding and Metamaterials to 60+ GHz
- Advanced RF-bonding for PCB Reference Planes at EM Zone boundaries
- Advanced PCB planes (and co-locating radio/TV/wireless datacom antennas)
- The totally shielded board assembly
- Damping the resonances in parallel metal structures, including Metamaterial methods e.g. Virtual Ground Fence; EBG (Electromagnetic Band Gap); HIS (High Impedance Surface), Split-Ring Resonators, etc.
- Advanced PCB power supply decoupling
- Buried components (especially buried capacitance decoupling)
- Advanced transmission lines, up to at least 32Gb/s
- Microvia (i.e. high density interconnect, HDI) board techniques
- Future developments, including: a) 3D Moulded PCBs; b) Additive Manufacturing of PCBs; c) Replacing PCBs with ‘SIF’ (Silicon Interconnect Fabric) that use ‘Chiplets’
- Advanced crosstalk
- Some final ‘tips’ and ‘tricks’
- Some useful contacts, sources, references and webinars

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 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 (EurIng), FEANI, Paris, France	1988

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 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
Presented with the IEEE EMC Society's new "Excellence in Continuing EMC Education Award"	2018

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 systems and installations of all types and 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
Railway systems
Mobile X-ray systems for shipping containers
Synchrotrons (e.g. 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 types and sizes
Variable speed AC and DC motor drives, from very small up to 10MW
Automotive engine control units (ECUs) and other electronic subassemblies (ESAs)
Battery chargers, from very small up to MW
Power converters: AC-DC, DC-DC, DC-AC, AC-AC, from very small up to MW
Information technology equipment (ITE) e.g. computers, servers, RAID arrays
Personal Digital Assistants (PDAs) and other hand-held wireless-enabled computing devices
Marine equipment
Subsea oil and gas production equipment
Photocopiers
Digital Signal Processing
Datacommunications devices
Professional audio consoles and other pro 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
Digital microwave radio
Robots
Solar power converters
Military avionics
Military land vehicles
Military submarine variable-speed winch
Medical equipment (various)
Microscope manipulators
Coin mechanisms
Security equipment
Mains-borne communications
Induction heating
Laser welding

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.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' **(also known as 'EMI Stories')**
Nutwood UK, 2007, 500 reports and anecdotes concerning electromagnetic interference (EMI), collected and edited by Keith Armstrong. Read them for free (and at least 300 more 'EMI Stories') at www.emcstandards.co.uk/emi-stories, or buy the book from www.emcstandards.co.uk/books4.

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, 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 and/or www.emcstandards.co.uk for more information.