Another EMC resource
from EMC Standards

Good EMC Engineering practices for electrical cabinets systems and installations

Helping you solve your EMC problems

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Good EMC engineering practices for cabinets, systems and installations

– Avoiding the electromagnetic interactions that cause delays and increase costs

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Change Record: v2.8 July 2018 – v3.3 Feb. 2019

- All URL hyperlinks activated
- New Slide 3 added "Good EM Engineering" and subsequent slides renumbered accordingly
- Two new sections added to Contents List:
  Section 6: "High Power Electromagnetics, HPEM, inc. IEMI, EMP, NEMP, HEMP" slides 316-320;
  Section 7: "Special EMC issues for rail and light rail systems" slides 321-335, and
  "Some useful references" and the appendix on "Close-field probing" renamed as Sections 8 and 9 respectively with new slide numbers
- Old slide 8, now slide 9: updated
- Improved slides: old 33 now 34; old 40 now 41; old 49 now 50; old 66 now 67; old 67 now 68; old 94 now 95; old 107 now 108; old 116 now 117; old 129 now 130; old 153 now 154; old 165 now 166; old 166 now 167; old 183 now 184; old 185 now 186
- Old slide 201, replaced by new slides 202-205 (on threadlocking techniques) and subsequent slides renumbered accordingly
- Old slides 212-224 now slides 216-237 (on gaskets – military and hi-rel gasketing added) and subsequent slides renumbered accordingly
- Old slides 284-289 now slides 297-304 (on corrosion, two new slides added) and subsequent slides renumbered accordingly
- Useful References section updated
- Old slides 343-344 replaced by one slide 377
- Two new slides 378-379 added, on de-risking a mechanical design using close-field probing

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Change Record: v3.3 Feb 2019 – v3.4 March 2019

- Slides 32 and 36 are new in this version 3.4. Other slides have been renumbered as appropriate.
- The block of text at the foot of slide 46 (which was slide 43 in v3.3) has been completely replaced with better guidance.
- Slide 87 (was slide 84 in v3.3) has its last line of text improved.
- Slides 94 and 95 are new in this version 3.4. They are photographs illustrating seam welds and spot welds. Other slides have been renumbered as appropriate.
- Slide 97 (was 92 in v3.3) has been improved by using formulas based on λ, instead of being based on f_{MAX}
- Slide 100 (was 95 in v3.3) has been improved by using formulas based on λ, instead of being based on f_{MAX}
- Slides 107 and 108 (were 102 and 103 in v3.3) colour of wire insulation has changed from green/yellow stripe to pink (because green/yellow stripe is not a requirement for internal bonding conductors)
- Slide 108 (was 103 in v3.3) has a new text block added on protective (safety) bonding.
- Slide 133 (was 128 in v3.3) title has been improved
- Slide 140 (was 135 in v3.3) text has been improved
- Slides 172 and 173 (were 166 and 167 in v3.3) improved by using formulas based on λ, instead of based on f_{MAX}
- Slides 189 and 191 (were 184 and 1186 in v3.3) improved by using formulas based on λ, instead of based on f_{MAX}
- Slide 208 (was 203 in v3.3) text has been improved
- Slide references in slide 228 (was 223 in v3.3) have been corrected
- Slide 268 (was 263 in v3.3) has been improved by using formulas based on λ, instead of being based on f_{MAX}

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Good Electromagnetic (EM) Engineering…

- is cost-effective SI, PI and EMC engineering: well-proven to save time & money in all lifecycle stages, helping to increase profits & reduce financial risks…
- for PCBs, modules, sub-assemblies, devices, products, equipment, vehicles, sub-systems, systems, installations, etc., etc.; of <u>any</u> size, in <u>all</u> applications

see Module 1 especially 1.15 (also in Webinar 1c) and 1.16 (also in Webinar 1d)

- <u>This</u> Module contains many EM Engineering guidelines that should *also* be used as an initial design checklist: *any that <u>can't</u> or <u>won't</u> be followed identify a project risk!*

see Module 1, section 1.16 (also in Webinar 1d)

- to adapt any λ-based design guidelines to different EMC standards, *see Module 1, section 1.18* *(also in Webinar 1d)*

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Contents (1)

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1. Introduction
- EMC Directive (2014/30/EU)
- Lightning protection for electronics (BS EN 62305)
- IEE Wiring Regulations (BS7671)
- Overview of the overall EMC control procedure

2. Good EMC practices for general use
- Buying electronic equipment
- Power distribution systems and power quality for EMC
- Galvanic isolation for EMC
- Reducing the accidental-RF-antenna efficiency of cables
- Segregation (zoning) of sites, equipment, and cables
- Using a bonding ring conductor (BRC)
- Cable routing, and correct shield termination at *both ends*
- Galvanic isolators and PECs
- Creating an RF Reference
- RF-bonding techniques for metalwork and cable shields

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Contents (2)

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3. EM Mitigation Techniques
- EM Zoning
- Safety earthing/grounding for safety and EMC
- Mesh-bonding of Common Bonding Networks (MESH-CBNs) – and of Insulated Bonding Networks (MESH-IBNs)
- Damping the CM loop
- What to do if you can't use mesh-bonding
- Filtering power and signals for cabinets and EM Zones
- Shielding for cabinets and EM Zones
- Surge and Lightning protection

4 Preventing corrosion

5 Maintaining good EMC over the operational lifecycle

6 High Power Electromagnetics, HPEM, inc. IEMI, EMP, NEMP, HEMP

7 Special EMC issues for rail and light rail systems

8 Some useful references

9 *Bonus material: Close-field probing*

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Introduction

- This module is based on many years of solving EMC problems in a wide range of electrical / electronic assemblies, systems, and installations
  - to improve functionality and reliability (and also to meet EMC standards)
  - the methods described generally correspond with BS IEC 61000-5-2:1997 and BS IEC TR 61000-5-6
- This presentation uses examples based on industrial applications…
  - but these techniques can easily be extended to cover any electrical / electronic applications

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The new EMC Directive 2014/30/EU

- This requires all '*fixed installations*' to employ '*good engineering practices having regard to the state of the art*'…
- And also requires a '*Responsible Person*' to document the *good engineering practices*
  - and keep the records ready for inspection, for as long as the fixed installation is in operation
    - please note that the phrase: "*good engineering practices*" actually means: "good EMC engineering practices"

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Lightning protection for electronics

- The UK's venerable lighting protection standard BS 6651 is now obsolete…
  - superseded by BS EN 62305
- BS EN 62305 requires the potential for lightning damage to electronic equipment/systems to be taken into account in all lightning risk assessments
  - it was optional under BS6651 Appendix C…
    - and rarely done…
  - the EMC requirements are covered by BS EN 62305-4

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IET Wiring Regulations (BS7671)

- Amendment 1 (2011) to the 17th Edition of the IET Wiring Regulations (BS7671, 2008) contains…
  - in Chapter 33: requirements to assess the electromagnetic compatibility of any equipment…
    - as regards other equipment, or the impairment of the AC mains supply…
    - and for compliance with the EMC Directive…
  - in Chapter 44: detailed design requirements for protection against voltage disturbances and electromagnetic disturbances
- The 18th Edition did not change any of this, but did reduce its overlap with BS EN 62305

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But neither 2014/30/EU nor BS EN 62305-4 nor Amd1 to the 17th Edition… describe how to actually *do* the EMC engineering, in practice

- But if you don't design and construct EMC engineering correctly – it won't work…
  - and many of the practical EMC techniques that are required, are not yet commonly used in electrical installations
- So this course module is about… how to *do* practical EMC engineering, in real life

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Up-to-date good EMC engineering practices…

- are outlined in the following slides, and some are uniquely identified (e.g. METHOD "A")
- Quality-controlled Procedures and Work Instructions should define these practices and how they are to be used…
  - designers should identify the appropriate EMC practices wherever they are needed on their drawings…
  - assemblers should follow the appropriate Work Instruction for each practice identified on a drawing
- Organisations should develop the good EMC practices most suited to their own activities…
  - many have used this course material as a starting point

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Using these guidelines as a checklist during design, commissioning, or fault-finding

- **Where a guideline can be followed, *it should be*…**
  - **to help control financial risks and achieve the lowest overall cost for a project**
- **Trying to reduce costs by cutting corners generally ends up costing more *overall*…**
  - **as well as risking penalty charges or liability lawsuits that can *easily* run into £millions (I have many case studies!)**
- **But where a guideline can't be followed…**
  - **something else will generally have to be done to achieve the same benefits for EMC…**
    - **if you have got away with it so far, the increased risk may well get you one day**

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Good EMC engineering practices for general use

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Buying electronic equipment: CE + CE ≠ CE !

- **Equipment supplied to professional integrators (not available to end-users) doesn't have to comply with the EMC Directive, but may be CE marked for other Directives**
- **Around 30% of CE-marked equipment sold in the EU doesn't *comply with all relevant Directives*…**
  - **so could be unsafe, never mind not being EMC compliant**
- **So, don't rely on the CE mark !**
  Always check evidence of suitable EM performance (e.g. test certificates, test reports, third-party approvals)…
  - **I also recommend checking EMC of electronic equipment at Goods-In, e.g. using close-field probing *(see Appendix)***

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Buying electronic equipment: CE + CE ≠ CE ! (2)

- **Only buy equipment with *proven* EMC performance for their intended operational EM environment…**
  - **after checking that their EMC installation and use instructions are sensible, reasonable and affordable…**
  - **then follow the sensible instructions faithfully, and use good EMC practices everywhere else…**
    - **I recommend quick-checks on EMC of equipment *actually supplied*, using low-cost spectrum analyser & probes**
- **Because emissions build up, the EMC specs for the purchased equipment may need to be tougher than the specs for the finished cabinet, system or installation…**
  - **can use the 'RSS Spreadsheet' technique for guidance (free download from www.emcstandards.co.uk)**

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Following the manufacturer's sensible EMC instructions

- The manufacturers of the electronic units *should* have determined their EMC compliance…
  - and will have assumed they are assembled/installed in a particular way (grounding, cable routes, cable screens, etc.)
  - since 2006 it has been a legal requirement under the EMC Directive to provide assembly/installation instructions for EMC compliance…
  - if the manufacturers' instructions agree with EMC good practices (e.g. as described in this course) follow them exactly, or you will ruin their equipment's EMC…
    - if they do not agree, check why this is (there may be special reasons why they are OK anyway)

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Following manufacturer's sensible instructions (2)

- Proven good EMC practices and codes of practice exist for electrical design and assembly…
  - e.g. IEC 61000-5-2 and -6, NAVAIR 1115, Def Stan 59-41 Part 7, Def Stan 59-411 Part 5, etc…
  - these may differ from traditional commercial and industrial practices (e.g. single-point earthing; terminating only one end of cable shields – both being generally bad for EMC)…
- So check manufacturers' EMC instructions against the most relevant guides or codes…
  - watching out for vagueness (e.g. "use shielded cable"), and mere repetition of traditional assembly methods

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All the necessary EMC details must be clearly shown on the assembly drawings…

- using quality-controlled methods…
- and including any special instructions extracted from manufacturers' manuals (where necessary)…
- so that assembly personnel know exactly what to do in every case