



# Earthing for EMC in Installations

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## Earthing for EMC in Installations

- Introduction
- Electromagnetic Compatibility or EMC
- EMC and installations
- Standards and References
- Concluding comments

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## 1. Introduction

### 'Wiring Rules' examples

- ❑ NFPA 70 National Electrical Code – “practical safeguarding of persons and property from hazards arising from the use of electricity”
- ❑ AS/NZS 3000 Electrical Installations -  
“requirements that are intended to protect people, livestock and property from electric shock, fire and physical injury hazards”
- ❑ Specific industry requirements e.g. underground mines, oil & gas, transport, military

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## 1. Introduction

- ❑ Why are any additional earthing requirements needed?
  - Electronic equipment has signals/noise from DC to at least 10's MHz
  - Disturbances may have MHz frequencies
  - Wiring Rules primarily focused on 50/60Hz
- ❑ Objective is to manage the broad range of frequencies of the installation so that it will 'operate as intended'

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## 1. Introduction

- Earthing system is required for:
  - Personnel safety
  - Lightning
  - Installation protection
  - EMC
  
- Design constraints:
  - Lightning & safety – earth electrode design
  - Safety & installation – conductor sizing
  - EMC – earthing network layout

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## 2. EMC

**Electromagnetic Compatibility or EMC** is defined as

“the ability of an equipment or system to function satisfactorily in its electromagnetic (EM) environment without introducing intolerable electromagnetic disturbances to anything in that environment”

**EM Environment** is “the totality of EM phenomena existing at a given location”

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## 2. EMC

### **Electromagnetic Environment**

- Every electrical or electronic device creates an EM environment as electrons move to make the device operate
- Any frequency between 0Hz and many GHz
- Natural phenomena e.g. lightning
- Electrostatic discharges etc

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## 2. EMC

### **Emissions and Immunity**

- Any EM emission can potentially impact another device in the environment – fatally or cause a malfunction
- Source equipment – limit emissions
  - E.g. power lines, electronic circuits, motors, transmitters etc
- Victim equipment – improve immunity
  - E.g. electronic circuits, receivers etc

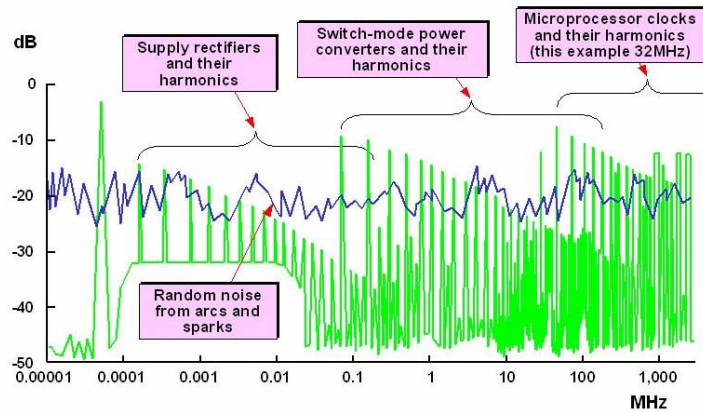
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## 2. EMC

### Typical industrial 'source' frequencies



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## 2. EMC

### Disturbance Path

- Source and victim equipment can be coupled by
  - Electric current or voltage
  - Electric field
  - Magnetic field
  - Electromagnetic field
  - Coupling can be conducted or radiated
  - Usually a complex combination of the above
  
- Difficult to identify and may be impossible

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## 2. EMC

### Achieving EMC

- Remove coupling by rule or regulation
- Reduce emissions from the source
- Improve immunity of the victim by filtering, shielding, relocation etc
- Combination to ensure that the installation will “operate as intended”

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## 3. EMC and Installations

### Basics

- All modern electronics involve a wide band of frequencies
- All conductors have significant impedance at frequencies above several kHz – skin effect
- All conductors – wires, cables, metalwork – make good ‘accidental antennas’ and **emit** EM energy into the environment

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### 3. EMC and Installations

#### Basics

- All conductors – wires, cables, metalwork – make good ‘accidental antennas’ and **receive** EM energy from the environment
  
- All conductive structures ‘earth systems’ become ineffective at some frequency based on their dimensions and construction

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### 3. EMC and Installations

#### Basics

Two earthing system considerations:

- How to reduce the impedance over the frequency range of interest?
  
- How to minimise the ‘accidental antenna’ effects over the frequency range of interest?

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### 3. EMC and Installations

#### Basics

- Electrical wire has typical inductance of  $1\mu\text{H}/\text{m}$  or  $6.3\Omega/\text{m}$  at 1MHz  
hence ineffective for voltage reference bonding above 10's kHz (including yellow/green)
- Conductors make 'good antennas' if length  $>0.1 \times \text{wavelength}$  or  $30/f_{\text{MHz}}$  i.e. 30m at 1MHz
- Cable impedance inductive above few kHz
- Cable impedance has maxima & minima at  $\text{wavelength}/4$

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### 3. EMC and Installations

#### Installation Guidelines

- Use a meshed earthing network or common bonding network (CBN) – no single point earthing
- EM zones with Bonding Ring Conductor (BRC)
- Route send & return conductors together
- Segregation of 'clean' & 'dirty' power supplies & associated equipment
- Classify and segregate cables

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### 3. EMC and Installations

#### Installation Guidelines cont.

- Equipment segregation within cabinets
- Use RF bonding techniques
- Use Parallel Earth Conductor (PEC)
- Earth loops are beneficial with maximum dimensions based on frequency of interest
- Bond shielded/screened cables at both ends unless supplier specifically says otherwise

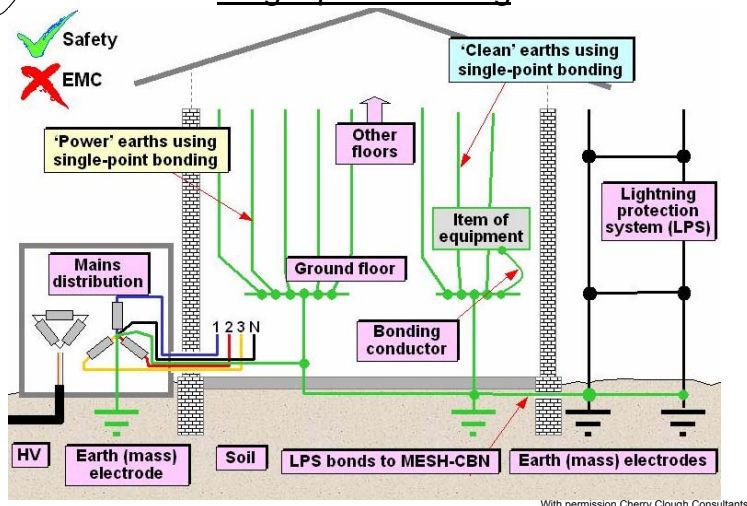
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### 3. EMC and Installations

#### Single-point earthing



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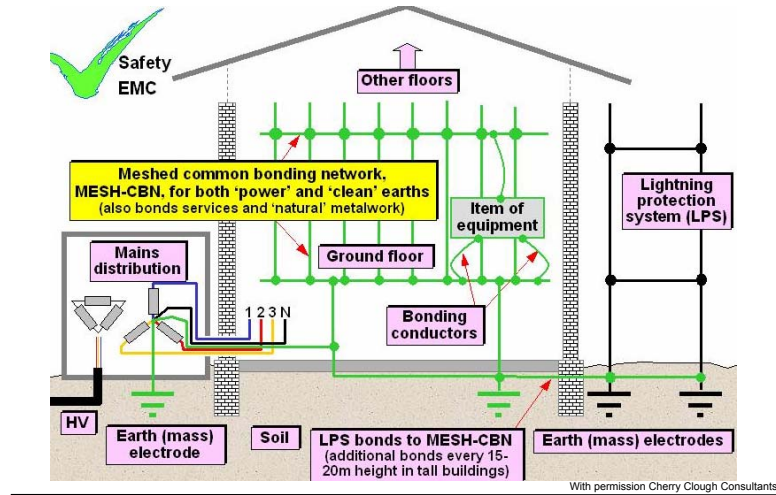
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### 3. EMC and Installations

#### Meshed common bonding network



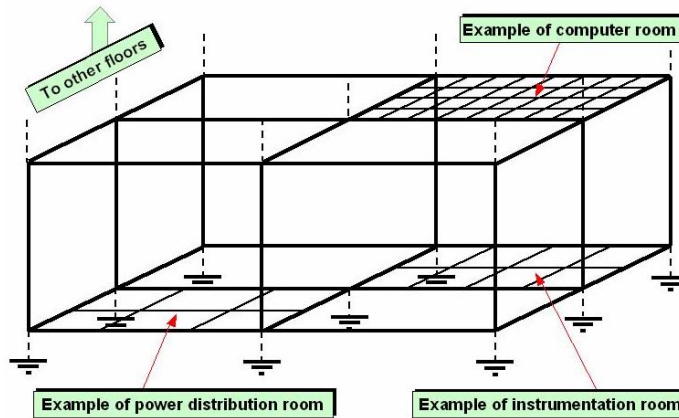
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### 3. EMC and Installations

#### 3-D schematic with different EM zones



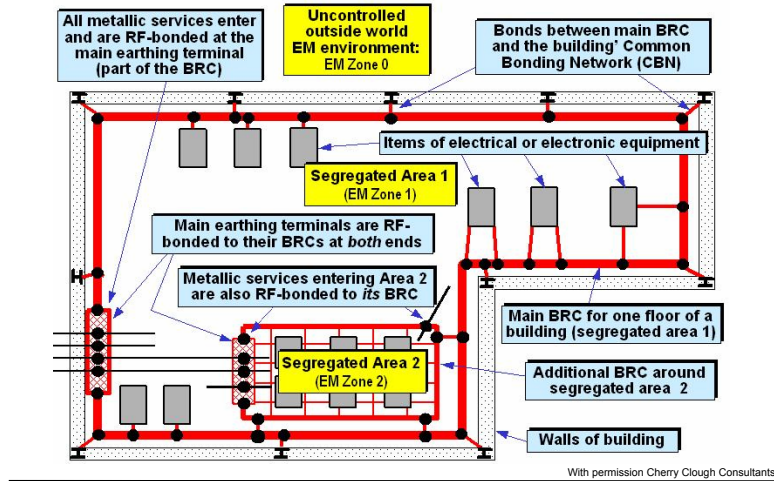
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### 3. EMC and Installations

#### EM zones with Bonding Ring Conductors



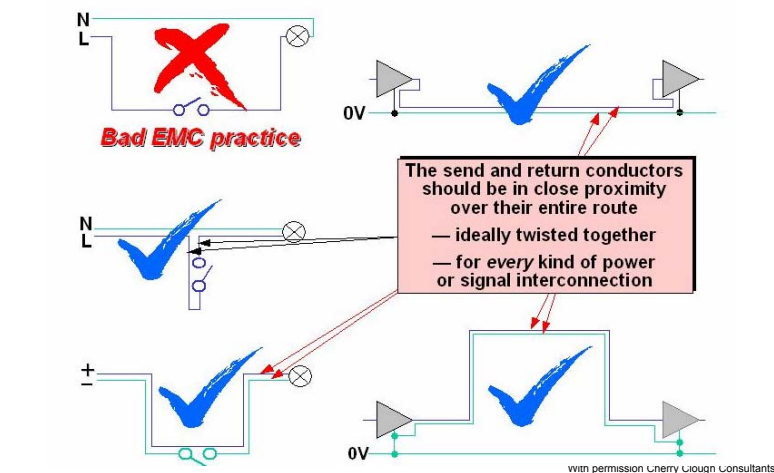
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### 3. EMC and Installations

#### Send & return paths close together



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### 3. EMC and Installations

#### Cable classification

Class	Signal Type
Class 1a	Sensitive analogue signals
Class 1b	Sensitive digital signals
Class 2	General analogue & digital signals; filtered power
Class 3	LV power; ac/dc controls
Class 4	Interfering signals & power e.g. VSD's, welders, transmitters
Class 5	LV air insulated busbars; MV cables and busbars

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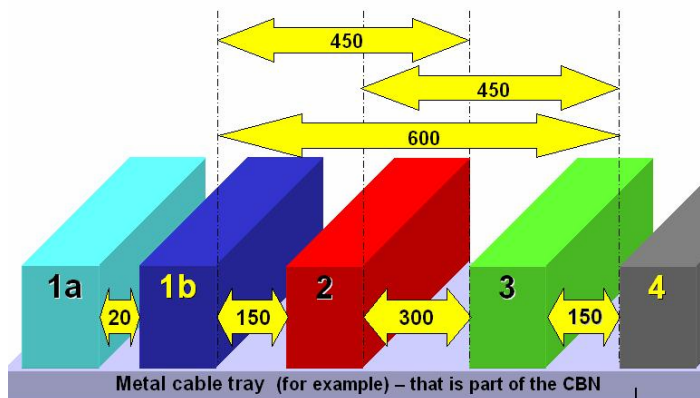
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### 3. EMC and Installations

#### Cable class spacing – vertical and horizontal



These are for cables run close to a single metal tray for up to 30 metres. For longer runs multiply by: length (metres) ÷ 30



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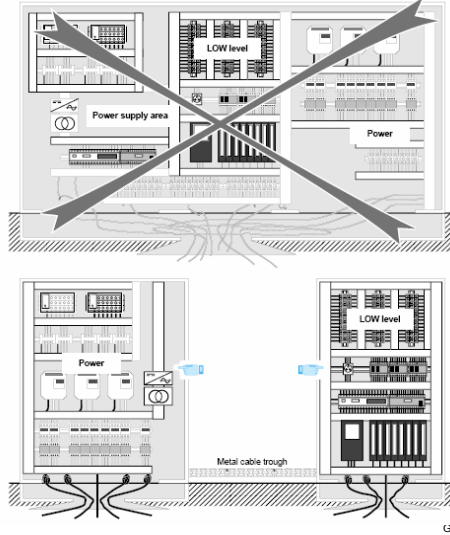
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### 3. EMC and Installations

#### Cabinet segregation layout



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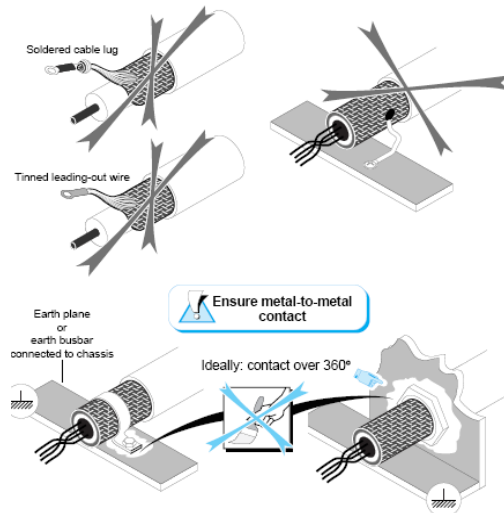
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### 3. EMC and Installations

#### Cable shield terminating



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### 3. EMC and Installations

#### Parallel Earth Conductor (PEC)

- Route cables along elements of Mesh-CBN to minimise 'accidental antenna' effects
- Elements of Mesh-CBN can also act as PEC's diverting power frequency currents away from cable shields
- Cables must run very close to their PEC's
- Braided/armoured cables must be bonded when leaving/entering PEC
- Bond PEC to Mesh-CBN wherever possible

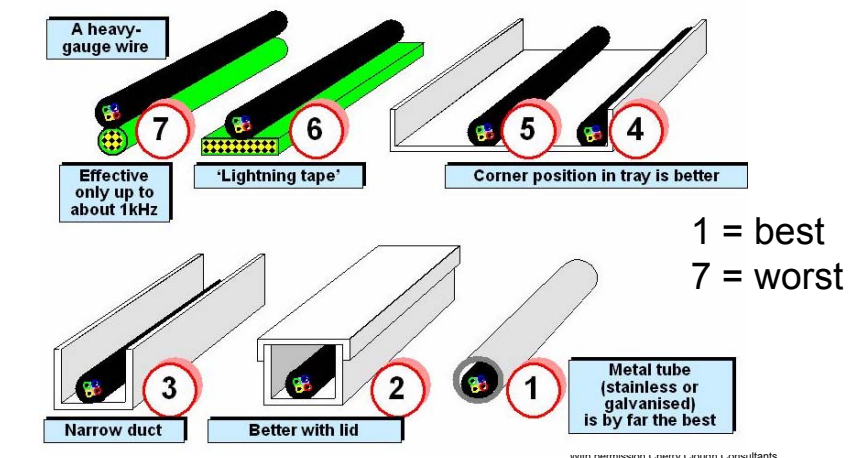
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### 3. EMC and Installations

#### Parallel Earth Conductor



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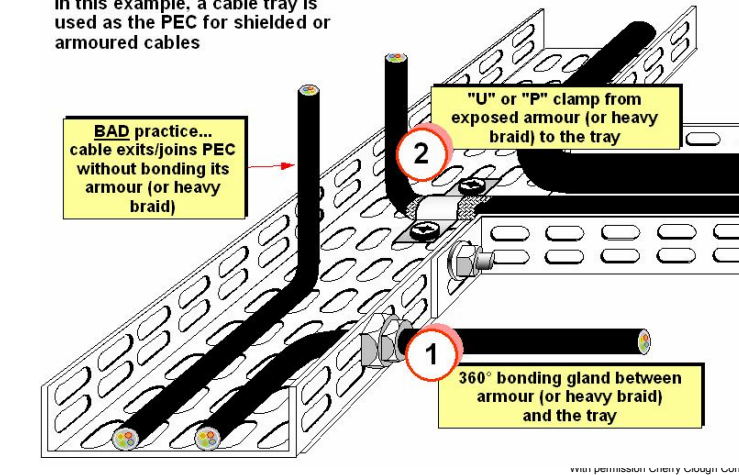
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### 3. EMC and Installations

#### Armoured/braided cable joining/leaving tray PEC

In this example, a cable tray is used as the PEC for shielded or armoured cables



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### 4. Standards & References

- IEC Technical Report 61000-5-2 'Earthing and cabling'
- No equivalent AS/NZS standard
- Aust/NZ has some limits on EMC emissions e.g. "C-tick" but no EMC immunity requirements
- EU and UK have both EMC emissions and immunity requirements
- EU and UK now have a strong focus on 'functional safety' i.e. risk of EM interference degrading the safety performance of systems of equipment

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## 4. Standards & References

- IEC TR 61000-5-2 Installation and mitigation guidelines 'Earthing and cabling'
- Cherry Clough Consultants publications see [www.cherryclough.com](http://www.cherryclough.com) for many references
- EMC Practical Installation Guide, Groupe Schneider
- EMC Compliant Installation for PDS, Technical Guide No 3, ABB
- IEEE 1100 Powering and Grounding Electronic Equipment
- CIGRE Guide 124 EMC in power plants and substations

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## Earthing for EMC in Installations

### Concluding comments

- EMC requirements should be considered at the design stage of installation projects
- Most engineers, systems integrators, contractors believe that good EMC installation practices are achieved by using 'Wiring Rules'
- Focus of majority of EMC standards is at the boundary with an external environment
- EMC installation integrity to be retained during maintenance and upgrade works

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## *Earthing for EMC in Installations*

Thank you



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