Earthing for EMC
in
Installations

Ian McMichael
Power Quality Solutions

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

1. 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’
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

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”

IEC
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

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
2. EMC

Typical industrial ‘source’ frequencies

- Supply rectifiers and their harmonics
- Switch-mode power converters and their harmonics
- Microprocessor clocks and their harmonics (this example 32MHz)
- Random noise from arcs and sparks

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
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”

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
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

---

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?
3. EMC and Installations

Basics

- Electrical wire has typical inductance of 1μH/m or 6.3Ω/m at 1MHz hence ineffective for voltage reference bonding above 10’s kHz (including yellow/green)
- Conductors make ‘good antennas’ if length >0.1*wavelength or 30/f MHz i.e. 30m at 1MHz
- Cable impedance inductive above few kHz
- Cable impedance has maxima & minima at wavelength/4

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
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

---

3. EMC and Installations

Single-point earthing

---

With permission Cherry Clough Consultants
3. EMC and Installations

Meshed common bonding network

With permission Cherry Clough Consultants

3-D schematic with different EM zones

With permission Cherry Clough Consultants
3. EMC and Installations

EM zones with Bonding Ring Conductors

Send & return paths close together
3. EMC and Installations

Cable classification

<table>
<thead>
<tr>
<th>Class</th>
<th>Signal Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1a</td>
<td>Sensitive analogue signals</td>
</tr>
<tr>
<td>Class 1b</td>
<td>Sensitive digital signals</td>
</tr>
<tr>
<td>Class 2</td>
<td>General analogue &amp; digital signals; filtered power</td>
</tr>
<tr>
<td>Class 3</td>
<td>LV power; ac/dc controls</td>
</tr>
<tr>
<td>Class 4</td>
<td>Interfering signals &amp; power e.g. VSD’s, welders, transmitters</td>
</tr>
<tr>
<td>Class 5</td>
<td>LV air insulated busbars; MV cables and busbars</td>
</tr>
</tbody>
</table>

Cable class spacing – vertical and horizontal

Metal cable tray (for example) – that is part of the CBN

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

Cabinet segregation layout

3. EMC and Installations

Cable shield terminating

Ensure metal-to-metal contact

Ideally: contact over 360°
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

With permission Cherry Clough Consultants

A heavy-gauge wire

Effective only up to about 1kHz

Lightning tape

Corner position in tray is better

Metal tube (stainless or galvanised) is by far the best

Narrow duct

Better with lid

1 = best
7 = worst
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.

- BAD practice: cable cuts/joins PEC without bonding its armour (or heavy braid)
- “U” or “P” clamp from exposed armour (or heavy braid) to the tray
- 360° bonding gland between armour (or heavy braid) and the tray

4. Standards & References

- 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
4. Standards & References

- IEC TR 61000-5-2 Installation and mitigation guidelines ‘Earthing and cabling’
- Cherry Clough Consultants publications see 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

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
Earthing for EMC in Installations

Thank you

Ian McMichael
Power Quality Solutions
Ph: (61) 0411 583 998
ianmcm@pqsolutions.com.au