[Document reference]

NEW WORK ITEM PROPOSAL

Proposer Mart Coenen	Date of proposal
TC/SC	Secretariat
Date of circulation	Closing date for voting

A proposal for a new work item within the scope of an existing technical committee or subcommittee shall be submitted to the Central Office. The proposal will be distributed to the P-members of the technical committee or subcommittee for voting on the introduction of it into the work programme, and to the O-members for information. The proposer may be a National Committee of the IEC, the secretariat itself, another technical committee or subcommittee, an organization in liaison, the Standardization Management Board or one of the advisory committees, or the General Secretary. Guidelines for proposing and justifying a new work item are given in ISO/IEC Directives, Part 1, Annex C (see extract overleaf). **This form is not to be used for amendments or revisions to existing publications.**

The proposal (to be completed by the proposer)

Title of proposal
In-situ EMC testing of Physically Large Systems/ Installations

☐ Standard ☒ Technical Report

Scope (as defined in ISO/IEC Directives, Part 2, 6.2.1)
Physically large systems and installations cannot be easily tested in-situ with minimum interaction with the other equipment within that environment when using basic EMC test methods. Additional requirements, other than avoid interference to and disturbance from formal broadcast and communication signals, need to be verified to assure reliable operation of physically large systems and installations after installation.

Purpose and justification, including the market relevance, whether it is a proposed horizontal standard (Guide 108)[1] and relationship to Safety (Guide 104), EMC (Guide 107), Environmental aspects (Guide 109) and Quality assurance (Guide 102). (attach a separate page as annex, if necessary)
In-situ EMC testing has been considered a responsibility of the end-user as long as formal broadcast and communication signals remain unaffected to residential users. From industry, references are required to set references in case of dispute

Target date	for first CD July 2009	for IS/ TS July 2012
Estimated number of meetings 8	Frequency of meetings: 2 per year	Date and place of first meeting: ....
Proposed working methods	☒ E-mail	☐ Collaboration tools

Relevant documents to be considered
IEC CISPR 11, IEC 61000-4-3, IEC 61000-4-6, IEC 61000-4-4, IEC 61000-4-8, IEC 61000-4-16

Relationship of project to activities of other international bodies
IEC CISPR B, IEC TC77A/B

Liaison organizations	**Need for coordination within ISO or IEC**

Preparatory work
Ensure that all copyright issues are identified. Check one of the two following boxes

☒ A draft is attached for comment* ☐ An outline is attached

* Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

We nominate a project leader as follows in accordance with ISO/IEC Directives, Part 1, 2.3.4 (name, address, fax and e-mail): Mart Coenen, EMCMCC bv, Sedanlaan 13a, Eindhoven, the Netherlands, +31-402927481, mart.coenen@emcmcc.nl

1) Other TC/SCs are requested to indicate their interest, if any, in this NP to the TC/SC secretary

Concerns known patented items (see ISO/IEC Directives, Part 2)	**Name and/or signature of the proposer**
☐ Yes. If yes, provide full information as an annex ☒ no	Mart Coenen

Comments and recommendations from the TC/SC officers

1) Work allocation
☐ Project team ☐ New working group ☐ Existing working group no:

2) Draft suitable for direct submission as
☐ CD ☐ CDV/ DTS

3) General quality of the draft (conformity to ISO/IEC Directives, Part 2)
☐ Little redrafting needed ☐ Substantial redrafting needed ☐ no draft (outline only)

4) Relationship with other activities
In IEC

In other organizations

5) Proposed horizontal standard
☐ [1)]

Remarks from the TC/SC officers

[1)] Other TC/SCs are requested to indicate their interest, if any, in this NP to the TC/SC secretary.

Approval criteria:

- Approval of the work item by a simple majority of the P-members voting;
- At least 4 P-members in the case of a committee with 16 or fewer P-members, or at least 5 P-members in the case of committees with more than 17 P-members, have nominated or confirmed the name of an expert and approved the new work item proposal.

Elements to be clarified when proposing a new work item

Title

Indicate the subject matter of the proposed new standard or technical specification.

Indicate whether it is intended to prepare a standardor a technical specification.

Scope

Give a clear indication of the coverage of the proposed new work item and, if necessary for clarity, exclusions.

Indicate whether the subject proposed relates to one or more of the fields of safety, EMC, the environment or quality assurance.

Purpose and justification

Give details based on a critical study of the following elements wherever practicable.

a) The specific aims and reason for the standardization activity, with particular emphasis on the aspects of standardization to be covered, the problems it is expected to solve or the difficulties it is intended to overcome.

b) The main interests that might benefit from or be affected by the activity, such as industry, consumers, trade, governments, distributors.

c) Feasibility of the activity: Are there factors that could hinder the successful establishment or general application of the standard?

d) Timeliness of the standard to be produced: Is the technology reasonably stabilized? If not, how much time is likely to be available before advances in technology may render the proposed standard outdated? Is the proposed standard required as a basis for the future development of the technology in question?

e) Urgency of the activity, considering the needs of the market (industry, consumers, trade, governments etc.) as well as other fields or organizations. Indicate target date and, when a series of standards is proposed, suggest priorities.

f) The benefits to be gained by the implementation of the proposed standard; alternatively, the loss or disadvantage(s) if no standard is established within a reasonable time. Data such as product volume of value of trade should be included and quantified.

g) If the standardization activity is, or is likely to be, the subject of regulations or to require the harmonization of existing regulations, this should be indicated.

If a series of new work items is proposed, the purpose and justification of which is common, a common proposal may be drafted including all elements to be clarified and enumerating the titles and scopes of each individual item.

Relevant documents

List any known relevant documents (such as standards and regulations), regardless of their source. When the proposer considers that an existing well-established document may be acceptable as a standard (with or without amendments), indicate this with appropriate justification and attach a copy to the proposal.

Cooperation and liaison

List relevant organizations or bodies with which cooperation and liaison should exist.

Preparatory work

Indicate the name of the project leader nominated by the proposer.

In-situ EMC testing of Physically Large Systems/ Installations

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organisation for standardisation comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardisation in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organisations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organisation for Standardisation (ISO) in accordance with conditions determined by agreement between the two organisations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

   The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 6xxxx has been prepared by WG: Electromagnetic Compatibility (EMC), of subcommittee:

This publication has been drafted in accordance with the ISO/IEC Directives, IEC Guide 107.

Annexes A and B are for information only.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date[2)] indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

2) The National Committees are requested to note that for this publication the maintenance result date is ….

Introduction

Since the introduction of the generic emission and immunity standards for testing electric and electronic products in a laboratory environment, the issue on how to test a physically large system (PLS) and installations (PLi) in-situ remained unsolved. Also the requirements as indicated in the IEC 61000-6-x, generic emission and immunity, apply to stand-alone products rather than systems and installations and cannot be used unambiguously.

As a result, various ambiguous approaches, often derived from the basic standards, are in use with all their advantages and disadvantages. One on the highest restriction is that other equipment next or even adjacent to the one being testing should not influence the test results with more than ± 3 dB by choosing a test method with sufficient directivity and/or by near-field coupling rather than plane wave excitation. Another restriction with RF immunity testing is that wireless radio and other communication services may not be disturbed by applying a disturbance signal with sufficient source strength over the whole frequency range of interest.

Last but not least, the interaction between (sub-) systems at close range i.e. separation will be quite different from the interaction with wireless radio and other communication services at orders of wavelength distance from the system. Local H-fields emitted by a switching power supply, deflection system, linear motors, sensors, etc. may cause significant interaction at low frequencies but will seldom exceed the RF emission limits as posed by the generic emission standards for testing electric and electronic products in a laboratory environment.

It is intended, together with the surface current methods proposed in this Technical Specification, that commercially available probes, networks, antenna, etc. are used. Furthermore, in case the applicable test methods do not apply to the system/ installation concerned, these tests can be skipped and the rationale thereto shall be recorded in the test report. However due to the introduction of wireless services and faster microcontrollers applications, the frequency band of interrogation needs to be extended to demonstrate functional system compatibility.

In-situ EMC testing of Physically Large Systems/ Installations

1 Objective

The objective of this technical report (TR) is to define unified measurement procedures which enable EMC qualification of multi-object physically large systems (PLS) and installations (PLi) in-situ. The test methods provided are intended for close proximity evaluation (≤ 1 meter) of the electrical and electronic objects in the frequency range DC to 40 GHz (when applicable) to reduce i.e. eliminate the contribution of other objects and installations to the results obtained.

With radiated RF emission measurements, measurement distances of 10 or 30 meter cannot be achieved in-situ without any influence of reflective structures nearby. Basic conductive RF emission measurements are often not suited as these are intrusive with the installation involved. Nearby measurement results are fully determined by the antennae used.

Though many immunity test methods have been defined for laboratory testing; IEC 61000-4-x, most of these test methods are not suited for in-situ evaluation due to the difficult access of all installed cables concerned and the measurement distances required.

As a result of the different test methods and measurement procedures chosen, no one-on-one correlation can be expected between the in-situ test results and those obtained in a laboratory environment. It is intended by this TR that the ambiguity of measurement results will diminish.

2 References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050(131):2002, *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory*

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 61000-3-2, Ed 3.0: *Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3: 2005, *Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC 61000-3-4: *Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A*

IEC 61000-4-x: 2006, *Electromagnetic compatibility (EMC) - Part 4-1: Testing and measurement techniques - Overview of IEC 61000-4 series (+ reference to other parts)*

IEC 61000-5-x: *Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 1: General considerations (+ reference to other parts)*

IEC 61000-6-x: 2007, *Electromagnetic compatibility (EMC). Generic standards, Emission and Immunity for residential, commercial, light-industrial and industrial environments*

IEC CISPR 11; 2008, *Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement*

3 Definitions

For the purpose of this document, the definitions in IEC 62132-1, IEC 60050(131) and IEC 60050(161), as well as the following, apply.

3.1 Directional antennae

A **directional antenna** or **beam antenna** is an antenna which radiates greater power in one or more directions allowing for increased performance on transmit and receive and reduced interference from unwanted sources.

3.2 ERP; Effective Radiated Power

ERP is not equivalent to the total power that is radiated, but is a quantity that takes into consideration transmitter power and antenna directivity (in the main direction of propagation).

3.3 Ground Reference plane (GRP)

A conductive metal plane which is extended to a minimum of 0,2 meter each side from the projected geometry of the product being tested. The GRP may also applies as RF reference for probes and/or networks applied on cables.

3.4 Hall sensors

A Hall effect sensor is a transducer that gives a output voltage perpendicular to a static magnetic field and which varies its output voltage in response to changes in magnetic field.

3.5 Multi-object system

A multi-object system is a system that comprises multiple sub-systems which are physically separated and as such not treatable as a single system

3.6 Physically large system (PLS) or installation (PLi)

With physically large systems or physically large installations a system is meant which comprises multiple sub-systems and which is more than 2 m^3 in volume or physically distributed with and end-to end distance of 6 meter or more.

3.7 Rogowski coil

A Rogowski current probe is suitable for detecting large currents from AC lines. A Rogowski coil has an integration circuit and typically detects current in a pre-determined intermediate frequency band.

4 General

With physically large installations or systems, it is assumed that such a PLS/ PLi can be extended over tens of meters and more and/or distributed over several floors in a building. With these installations or systems, the electrical and electronic parts are commonly confined in 19-inch (sub-) racks are where the electric/electronic hart of the system may occupy several cubic meters of volume with multiple cables in-between for power, signaling and control.

As the cables are passive, their contribution to the interaction to the EM environment is limited to providing an RF coupling path whereas the electrical and electronic parts are driving these cables w.r.t. unintended RF emission and while picking up RF energy out of the EM environment in which the physically large installations or systems is installed.

The cable contribution to the interaction with the EM environment is limited and dominantly applicable in the frequency ranges where the frequency i.e. wavelength of the signal considered is large compared to the physical size of the electrical and electronic parts involved.

Aside the cable contributions to the EM interaction, also direct RF emission may stem from leaking transformers, deflection coils, linear motors, measurement sensor systems, actuators, solenoids, etc. which can locally dominated the overall EM interaction. Additionally, at high frequencies where sizes of the electrical and electronic parts become a quarter of a wavelength or larger of the frequency involved, the direct emission from these electrical and electronic parts will become dominant over the cable contributions.

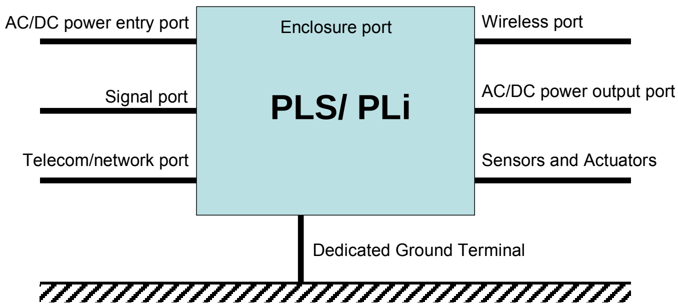

Figure 1 – Definition of ports with a PLS/ PLi

5 Test definition

As specified in the scope, the frequency range of application is from DC to 40 GHz. This broad frequency range needs to be sub-divided into smaller bands for which dedicated test methods shall be used.

RF emission and immunity levels will be indicated in informative annexes and will only be given for guidance. To ensure compatibility between the systems and installations considered i.e. suited for integration, the RF emission levels need to be at least twice less as the minimum immunity level of the adjacent system at the closest (allowed) distance of installation.

5.1 RF emission

Table 1 - RF emission frequency ranges

Frequency	Applicable to port	Measured quantity	Procedure clause
DC – 50 (60) Hz	AC-power entry and outputs	Residual currents, H-fields	6.1.1.1 6.1.1.2
50 (60) Hz – 150 kHz	AC-power entry and outputs Enclosure	Conducted emission; power, I/O, control H-fields	6.1.2.1 6.1.2.2
150 kHz – 30 MHz	All cable interfaces	Conducted emission; mains, I/O, control,	6.1.3.1

	Enclosure	surface currents, H-fields	6.1.3.2 6.1.3.3
30 MHz – 1 GHz	All cable interfaces up to 230 MHz Enclosure	Conducted emission, Surface currents, radiated fields	6.1.4.1 6.1.4.2 6.1.4.3
1 – 6 GHz	Enclosure	ERP	6.1.5
6 – 18 GHz	Enclosure	ERP	6.1.5
18 – 40 GHz	Enclosure	ERP	6.1.5

NOTE: Though it is theoretically incorrect to express equivalent radiated emission by just measuring common-mode currents and surface currents from in a non-defined impedance network i.e. circuit topology, it is assumed that certain nominal common-mode impedances are achieved.

5.2 RF immunity

Table 2 - RF immunity frequency ranges

Frequency	Applicable to port	Measured quantity	Procedure clause
DC – 50 (60) Hz	Enclosure	H-field	6.2.1
50 (60) Hz – 150 kHz	AC-power entry and outputs Enclosure	Conducted immunity; mains, I/O, control H-fields	6.2.2.1 6.2.2.2
150 kHz – 30 MHz	All cable interfaces Enclosure	Conducted immunity; mains, I/O, control, Surface currents, H-fields	6.2.3.1 6.2.3.2 6.2.3.3
30 MHz – 1 GHz	All cable interfaces up to 230 MHz Enclosure	Conducted immunity, Surface currents RF fields	6.2.4.1 6.2.4.2 6.2.4.3
1 – 6 GHz	Enclosure	ERP	6.2.5
6 – 18 GHz	Enclosure	ERP	6.2.5
18 – 40 GHz	Enclosure	ERP	6.2.5

NOTE: In order not to violate any RF radiation requirements, the local transmitted ERP, exposed to the PLS/PLi under test at frequencies above 150 kHz shall be restricted to 5 Watt forward power maximum. Due to reflections, the measured power, expressed in H-field, induced currents, etc. will typically indicate less as in-situ field impedance and termination impedances are less well-defined.

6 Test methods

The test methods used are subdivided in frequency ranges as indicated in clause 5. With each frequency range the measurants to be quantified are given. Various test methods may apply in parallel for the frequency ranges concerned.

6.1 RF emission

When possible, the RF emission measurements shall be taken with the equipment turned on and active in its normal mode of operation and with the entire system shut-off to enable background noise measurements. Critical frequencies observed while the PLS/ PLi was switched off, shall be noted in the test report and disregarding with the evaluation of the test results.

6.1.1 DC - 50 (60) Hz

In this frequency range two critical phenomena may occur: residual current on the mains and static magnetic or very low frequency magnetic fields.

6.1.1.1 Disturbance current measurements

Residual DC and ELF currents in power supply systems are typically caused by single-sided rectification or by asymmetric controlled thyristor/ IGBT bridges. These DC/ ELF currents in the mains power supply network may cause saturation in mains transformers or even inversely affect residual current circuit breakers (safety). The generation of DC residual current onto the mains distribution network is therefore prohibited.

Sub-harmonic mains frequency signals can be expected from mains cycle controlled heating systems, typically down to one-tent or one-sixteenth of the mains frequency (10 (new) or 16 (old) mains frequency periodic controls). Non-correlated mains power frequency effects may occur as a result of thermal sensed switching (bi-metal).

The preferred test method is to use a current probe which is suited from DC to a few kHz with sufficient current handling capabilities. This current probe e.g. with a Hall sensor, shall be used with an oscilloscope with mathematical operation capabilities like averaging and FFT.

6.1.1.2 Near-magnetic field measurements

With high power DC supplies e.g. for electrolytic processes, near to high output current DC supplies or at close proximity of power transformers and MV or HV power cables, high levels of static magnetic fields can be expected which may cause static deflection on CRT or magnetic sensors or may cause saturation of materials like transformer cores, mains filters, etc.

Strong low frequency magnetic fields may be caused by saturated transformer core material and cable routing. Transformer core material is typically used in EMI filters, power conversion or sensor applications. Due to the low frequencies involved, down to DC, these magnetic fields can best be measured by using Hall sensors.

6.1.2 50 (60) Hz – 150 kHz

In this frequency range, different tests apply for measuring disturbance signals on all mains, signal, I/O and communication cables and H-fields.

6.1.2.1 Disturbance current measurements

It is assumed that functional signals; e.g. single phase, neutral, phase and protective earth are tested as one common cable. Similar, the 5 wires from a three-phase power system; R, S, T, neutral and PE, are routed as one cable or at close proximity to one another to minimize the H-field emission from such cable interfaces. Although, according Kirchhoff's law assumes that the total sum of currents at the cable cross-section will always be “zero”, a fraction of the “main(s)” current might be flowing through unintended system cables, frames, permanent PE connections, etc. This fraction of current can be easily measured by using a common-mode current probe e.g. based on a Rogowski coil on the various cables and wires in the system.

NOTE In high power installation with MV or HV supply, the power cables will be routed separately typically overhead over a longer distance to an outdoor power infra-structure. In this case, the currents shall be measured individually and than summed mathematically in the measurement system used.

These LF common-mode current measurements shall preferably be measured in the time domain on all individual conductive cables and wires connected between the (sub-) system tested and the rest of the system/ installation including all dedicated ground terminal connections, connections to cable conduits, etc. A Rogowski coil based current probe is the most suited for these individual wire measurements which can be taken simultaneously.

When various cables are defined to be routed as one cable trunk, in one cable harness or in a defined cable conduit according the manufacturer’s installation instructions, then those cable trunks, harnesses and conduits shall be treated as a single (multi-wire) cable. In this case, a common-mode current probe e.g. with Hall sensor can be used.

NOTE: At these frequency of interest, it will be difficult to separate the ambient signals from the PLS/PLI induced signals. In case the PLS/PLI is turned off, no phase or neutral currents can flow as the load impedances will be switched off as well. Only the PE connection will remain.

6.1.2.2 Near-magnetic field measurements

To gather local H-field information, it is preferred to use a small 36 turn magnetic loop antenna and to carry out partial emission tests at 0,07 ± 0,01 meter distance, only perpendicular to the surface of the PLS/ PLi, when possible synchronized to a reference signal. Typically, these H-field measurements shall be taken on a grid; 0,5 ± 0,1 meter spacing perpendicular to the surface of the system. H-fields measurements can be carried out in the time or frequency domain. In the frequency domain, a scalar H-field intensity value is recorded as function of frequency over a fixed bandwidth whereas the signals gathered in the time domain can be synchronized, decomposed and integrated over the surface grid scanned.

NOTE: Dedicated H-field areas like inductive card reader scan areas shall be noted but further ignored from these H-field measurements when it has been demonstrated to be compliant with the applicable product standards. Compliance to the relevant ETSI or IEEE standards shall be noted in the test report

Large distributed H-field sources like contact-less power transfer system used with all kind of transport systems shall be measured at that distance where other adjacent equipment might be installed. Due to the orientation of these contact-less power transfer conductors, the H-field will dominate in a single direction unless large metal objects/ electrically conductive constructions are installed near to those power conductors. For this reason, the H_x, H_y and H_z -field components as function of frequency or time shall be recorded at various places i.e. at different contact-less power transfer sub-system topologies, e.g. a bend, a split, a feeding point, a crossing, etc. along the contact-less power transport system at a maximum distance equal to the adjacent equipment surface distance specified.

NOTE: In addition to those system integration requirements, legally enforced EMF requirements apply for those areas when people can be exposed to these, possible hazardous, LF magnetic fields.

6.1.3 150 kHz – 30 MHz

6.1.3.1 Conducted emission; mains, I/O, control

Conducted RF emissions on mains cables are preferably measured by using the artificial mains network (AMN) or Line Impedance Stabilizing Network (LISN) on the number of phases available plus neutral or by using a 150 Ω AC voltage probe (in combination with a power frequency filter network), as defined in IEC CISPR 16.

As an alternative, also the interference voltage on the mains lines can be measured by using the capacitive coupling probe which initially has been developed for measurements of interference voltages on telecom lines. 0,3 to 0,5 meter of conductive foil shall be wrapped around the individual mains wires and then measured against a PE grounded GRP underneath at 0,01 meter distance. The interference voltage between the foil(s) and the GRP underneath shall then be measured through a high input impedance converter, typically with 50 Ω output impedance.

As mains cables with fixed installations are not easy accessible, the common-mode current on the mains cable(s) shall be measured. With single phase, neutral, phase and protective earth shall be tested as one common cable. With 3 phase equipment, the common-mode current shall be measured on all 5 wires: R, S, T, neutral and protective earth.

When considering common-mode current rather than asymmetric (lines-to-PE) voltage, a common-mode impedance of 150 Ω (= 44 dBΩ) is theoretically assumed. With RF emission standards like IEC CISPR 22, the common-mode emission requirement is xx dBμV in the frequency range 150 kHz to 500 kHz. This would yield a common-mode current of (xx-44) dBμA to achieve compliance in this example. The main constraint for the current probe used shall be that it is suited for the cable cross-section diameter as the mains supply current will be compensated for and no saturation is expected.

For those ports/ cables which are easy accessible, it is still preferred that coupling/decoupling networks (CDNs) or an EM-clamp (IEC 61000-4-6) shall be used rather than a current probe as the common-mode impedance is then unambiguously defined by the networks/clamp used.

The same current probe can be used for measuring the common-mode currents on all other cables attached; I/O, control, etc. when measuring these cables, the same common-mode current requirements shall be applied as with the conducted emission measurements on the mains cable.

When various cables are defined to be routed as one cable trunk, in one cable harness or in a defined cable conduit according the manufacturer's installation instructions, then those cable trunks, harnesses and conduits shall be treated as a single (multi-wire) cable.

All the cables measured shall individually satisfy the RF emission requirements as specified.

6.1.3.2 Surface currents

In addition to common-mode currents on cable testing, also the surface currents over large metal objects; machines, 19 inch racks, cable conduits, etc. shall be measured. With this measurement, the induced voltages on surface current sense wires need to be measured. The surface current sense wires shall be insulated and shall be kept close to the metal surface to be measured to represent a transmission line with a characteristic impedance of about 50 Ω. The conductive wire needs to be terminated to the metal object to be measured by means of a 50 Ω terminating resistor on the far-end. The near-end of the surface current sense wires need to be terminated by 50 Ω, being the input impedance of the RF spectrum analyzer or EMI receiver. At this near-end, the local reference for termination is against the local metal surface of the object being tested.

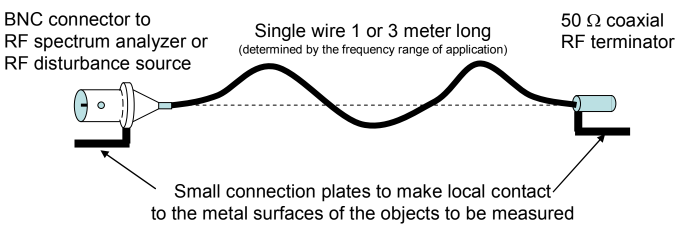

Figure 2 – Surface current sense wire

With this test set-up, surface current sense wires of maximum 3 meter length shall be placed in various orientations over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

NOTE: With real installations all metal accessible objects will be grounded for electrical safety reasons to a common protective earth terminal typically at the bottom of the rack in which the main(s) power supply cable enters.

As it is assumed that the metal structure is large, the excitation voltage and its source impedance are expected to be low. In this case, the measurement impedance is irrelevant and the port excitation voltage limits apply over the 50 Ω measurement impedance rather than the 150 Ω used with the common-mode voltage measurements. Additionally, the use of 50 Ω at both ends of the “micro strip” transmission line will show minimal resonances due to the small discontinuities caused by the test structure itself.

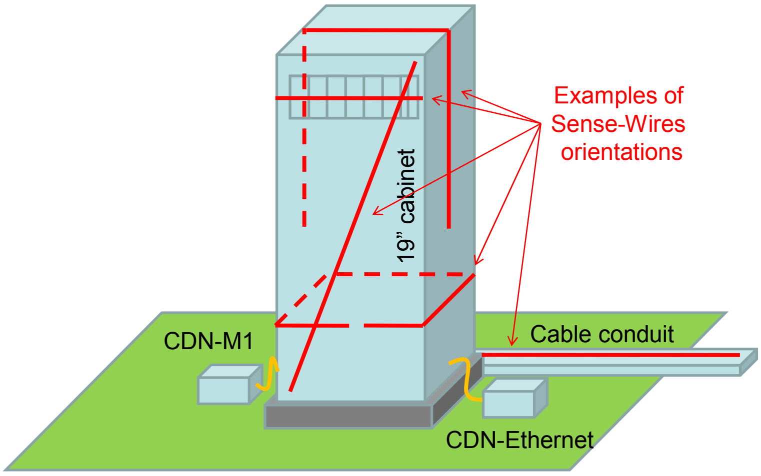

Figure 3 – Example of the surface current sense wire application combined with CDNs

6.1.3.3 H-fields

Similar the magnetic field measurement method depicted in clause 6.1.2.2, the local magnetic field perpendicular to the surface shall be measured in two orthogonal orientations with small magnetic loop antenna or a surface current probe. The larger the probe, the larger the area of H-field or surface current integration will be. However, the maximum loop size will be restricted by the wavelength of the upper frequency concerned. The effective loop circumference shall remain less than $\lambda/20$ (≈ equal phase along the path of integration).

When the large machine or installation does not carry any source of H-field emission in this frequency range, these measurements along the surface of the machine is considered to be covered by the surface current measurements as defined in clause 6.1.3.2.

6.1.4 30 MHz – 1 GHz

In this frequency range, the equivalent RF emission can again be measured by conductive measurements, surface current measurements or by using nearby directive antenna at a distance of 1 meter from the surface of the object being tested.

6.1.4.1 Conducted emission

The RF emission measurement equal to the method described in clause 6.1.3.1 can be used. The frequency of application when using CDNs, EM-clamps and current probes is restricted to about 230 MHz. Above this frequency; it is recommended to use the surface current or radiated field measurement method.

In addition to the conducted RF emission measurements on the cables, also the RF voltage occurring between the chassis of the PLS/ PLi and a metal reference plate in front of or insulated underneath the PLS/ PLi shall be measured across a 50 Ω or 150 Ω load impedance while all other connections are in position When a dedicated PE terminal plus earth wire is connected to the PLS/ PLi at this location, this wire shall be replaced by an earth ground choke of 50 μH and sufficient current rating (in parallel to the 50 Ω input impedance) or a CDN-M1 shall be used, see figure 3.

6.1.4.2 Surface currents

The test method is identical to the one described in clause 6.1.3.2. However, with this set-up in this frequency range of interest, surface current sense wires of maximum 1 meter length are recommended and these shall be routed in various orientations tight over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

6.1.4.3 Radiated fields

Directional antennae, like log-per or horn antennae, shall be used at close distance; 1 meter, to the PLS/ PLi at the higher frequencies; > 300 MHz. These antennae shall be oriented with their main receiving lob pointing perpendicular to the surface of the PLS/ PLi. The opening angle of the main lob is expected between 40 to 65 degrees.

Due to the smaller opening angle of directive antenna, the RF emission shall be measured by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to store the max-hold reading of the RF emission level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height. In case the PLS/ PLi is extended in height, the 1 meter scanning height interval shall be extended proportionally.

NOTE: No (active) antennae with a dipole antenna structures shall be used as directivity is lacking and ambient signals are received proportionally.

6.1.5 1 GHz – 40 GHz

Above 1 GHz, all RF emission properties shall be measured by using small directional horn antennae at close distance to the PLS/ PLi with their main receiving lob pointing perpendicular to the surface of the PLS/ PLi.

Due to the smaller opening angle of these horn antenna, the RF emission shall be measured by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to store the max-hold reading of the RF emission level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

6.2 RF immunity

The RF immunity needs to be verified according to the measurement methods defined below. Here, a distinct must be made between nearby RF threats and those resulting from intended RF radiators like broadcast stations but also industrial heating and other sources where RF energy is generated for functional purposes.

With near field coupling it is expected that two or more pieces of equipment are installed aside or on top of one another at close distance e.g. in a 19 inch rack or racks adjacent to one another.

When it is defined or allowed that other systems or installations may be installed next to or even be incorporated in the same installation environment, then high levels of immunity are necessary, unless otherwise specified in the installation manual.

6.2.1 DC - 50 (60) Hz

With high power DC supplies e.g. for electrolisation processes, near to high output current DC supplies, at close proximity of power transformers and MV or HV power cables, high levels of static or LF magnetic fields can be expected which may cause static or LF deflection on CRT or magnetic sensors or may even cause saturation of materials like transformer cores, mains filters, etc.

Static or low frequency magnetic fields can be easily generated by using multi-turn loops. However, the size of the loop shall be determined by the size of the interference source to be expected in real installation conditions but shall be less or equal to 3 by 3 meter. This loop shall be oriented perpendicular to the metal surface at 0,5 ± 0,1 meter distance from the metal surface of the PLS/ PLi to avoid an inductive short-circuit of the field generating loop.

When local H-field sources are expected, a local H-field can be generated by using a standard 10-turn loop antenna, 0,13 meter ± 5 mm diameter. This loop antenna shall be oriented perpendicular to the metal surface at 0,07 ± 0,01 meter distance from the metal surface of the PLS/ PLi

6.2.2 50 (60) Hz – 150 kHz

In this frequency range of interest most mains frequency related harmonic disturbances can be expected as well as emission from switched mode power supplies, electronic luminaries, pulse width modulation (PWM) motor controls, mains communication signals, etc.

6.2.2.1 Conducted immunity; mains, I/O, control

Part of the emission sources mentioned penetrates into other system or installation via mains, I/O, communication or control signals. In this frequency range, these disturbance signals are more difficult to superimpose on the functional signal without disturbing the functional signal itself. As functional signals may occur asymmetric or differentially, the injection of the disturbance signal should have directivity, by common-mode coupling/decoupling networks, this to avoid that other system or installations to become unintentionally affected.

The coupling/decoupling networks as (<u>not</u>) defined in the IEC basic immunity standards can't be used. The proposed coupling method is to inject the disturbance signal of interest between the chassis/PE terminals of the various sub-systems concerned. For this purpose high power audio amplifiers with sufficient power bandwidth an be used. The current injected shall be sensed and when adapted to the requirements specified.

6.2.2.2 H-fields

In the frequency range 50 to 150 kHz a distinct shall be made between local point sources and sources further away. Nearby H-field sources shall be represented by using a small 10-turn loop with 0,13 meter ± 5 mm diameter. This loop shall be positioned on a 0,5 ± 0,1 meter grid all along the surface area of the PLS/ PLi where adjacent equipment can be expected in real installation conditions.

In all other cases, a large square loop antenna of 3 by 3 meter maximum shall be used with 3 windings. This large loop shall be positioned at 0,5 ± 0,1 meter distance from the surface of the PLS/ PLi. In this case it is assumed that a typical (concrete) floor will be reinforced by a steel grid which will reduce any H-field penetrating from the bottom side. The large loop antenna shall not be magnetically short-circuited by a conductive metal sheet e.g. the walls of a Faraday cage.

6.2.3 150 kHz – 30 MHz

The test set-ups provided in this frequency range are adopted from the RF emission tests. The main differences will be the power handing capabilities of the networks, current injection networks, clamps used.

6.2.3.1 Conducted immunity; mains, I/O, control

Conducted RF immunity on mains cables is preferably tested by injecting a common-mode current on all 5 wires: R, S, T, neutral and protective earth, simultaneously. When considering common-mode current rather than an asymmetric RF voltage, a common-mode impedance of 150 Ω (= 44 dBΩ) is theoretically assumed. With RF immunity standards like IEC CISPR 24, the common-mode immunity requirement is 10 V_{EMF} or 20 dBV_{EMF} in the frequency range 150 kHz to 30 MHz. This would be equivalent to an injected common-mode current of (xx – 44) dBA to achieve compliance in this example. The main constraints for the current injection probe used are that it is suitable for the cable cross-section diameter as the mains frequency supply current will be compensated for and that no RF saturation will be reached.

For those ports/ cables which are easy accessible, it is still preferred that CDNs or EM-clamps (IEC 61000-4-6) are used rather than current injection probes as the real common-mode impedance remains ambiguously and directivity is provided.

The same current injection probe can be used for injecting the common-mode currents on all other cables attached; I/O, control, etc. When injecting on these cables, the same common-mode current requirements shall be applied as with the conducted mains immunity measurements.

When various cables are defined to be routed as one cable trunk, in one cable harness or in a defined cable conduit according the manufacturer's installation instructions, then those cable trunks, harnesses and conduits shall be treated as a single (multi-wire) cable.

All the cables tested shall individually satisfy the RF immunity requirements as specified.

6.2.3.2 Surface current

In addition to common-mode current injection on all cables connected, also the surface current over large metal objects; machines, 19 inch racks, cable conduits, etc. shall be injected. With this measurement, a surface current will be induced by surface current sense wires. The surface current sense wires shall be insulated and shall be kept close to the metal surface to be injected to represent a transmission line with a characteristic impedance of about 50 Ω. The surface current sense wires need to be terminated to the metal object to be injected by means of a 50 Ω terminating resistor at the far-end. The other side of the conductive wire needs to be connected to an RF disturbance generator with 50 Ω output impedance. At this near-end, the port reference for termination is against the local metal surface of the system/ installation to be tested.

With this set-up, a conductive wire of 3 meter maximum length shall be placed in various orientations over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

NOTE: With real installations all metal accessible objects will be grounded for electrical safety reasons to a common protective earth terminal typically at the bottom of the rack in which the power supply cable enters. As such, no AC coupling in the RF path will be necessary as all metal accessible parts of the PLS/ PLi will be electrically safe.

As it is assume that the metal structure is large, the induced current will be determined by the disturbance source output impedance as the metal surface impedance is expected to be low. As the surface impedance is irrelevant, the RF excitation voltage (forward power) limits the injected current applied from the 50 Ω disturbance source impedance. Additionally, the use of

50 Ω at both ends of the “micro strip” transmission line will reduce resonances caused be this test set-up itself.

6.2.3.3 H-fields

In this frequency range, it is typically sufficient to apply the two conductive tests defined in 6.2.3.1 and 6.2.3.2. In rare occasions, H-fields may be applied to represent a specific point source. For this purpose, a 10-turn loop can be used without resonance up till 10 MHz as defined in 6.2.2.2. For the frequency range 10 to 30 MHz, no commercial loops are available for H-field immunity testing. Above 10 MHz, local threats can be expected e.g. from RFID readers.

When the object to be tested is small e.g. a sensor belong to a PLS/ PLi, this sensor can be tested by using Helmholtz coils. Here too, for commercially available Helmholtz coils the upper frequency is restricted to about 10 MHz.

6.2.4 30 MHz – 1 GHz

Similar to the RF emission testing, the three methods can be applied for which the first two are RF power efficient as low RF losses occur between the RF disturbance source and the PLS/ PLi under test.

6.2.4.1 Conducted immunity

The RF immunity measurement is equal to the method described in clause 6.2.3.1. The frequency of application is restricted to about 230 MHz. Above this frequency; it is recommended to use the surface current or radiated field measurement method.

In addition to the conducted RF immunity measurements on the cables, also the RF voltage occurring between the chassis of the PLS/ PLi and a metal reference plate in front of or underneath the PLS/ PLi shall be injected from a 50 Ω RF disturbance source generator impedance while all other connections are in position When a dedicated PE terminal plus earth wire is connected to the PLS/ PLi at this injection location, this wire shall be replaced by an earth ground choke of 50 μH with sufficient current rating.

6.2.4.2 Surface currents

The test method is identical to the one described in clause 6.2.3.2. However, with a set-up in this frequency range of interest, the conductive wire of 1 meter maximum length shall be routed in various orientations tight over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

6.2.4.3 RF fields

Directional antennae, like log-per or horn antenna shall be used at close distance; 1 meter to the PLS/ PLi at the higher frequencies; > 300 MHz. These antennae shall be oriented with their main transmitting lob pointing perpendicular to the surface of the PLS/ PLi. The opening angle of the main lob is expected between 40 to 65 degrees.

Due to the smaller opening angle of directive antenna, the RF field shall be exposed to the PLS/ PLi by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to set the forward power of the RF disturbance generator to a fixed level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

6.2.5 1 GHz – 40 GHz

Above 1 GHz, all RF field shall be exposed to the PLS/ PLi by small directional horn antennae at close distance to the PLS/ PLi with their main transmitting lob pointing at the PLS/ PLi.

Due to the smaller opening angle of these horn antennae, the RF field shall be exposed to the PLS/ PLi by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to set the forward power of the RF disturbance generator to a fixed level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

6.3 Calibration methods

For most of the probes, sensors, CDNs, clamps and antennae defined, the calibration information as provided by the manufacturer shall be used.

6.3.1 LF loop antennae

With small loop antenna; diameter 0,125 m, the H-field can be assumed homogeneous over the surface area of the loop. Simple mathematical expressions can be used to obtain the loop voltage as function of H-field strength and frequency.

When using large loop antenna e.g. 3 x 3 meter, the induced voltage as indicated above can be calculated but it will be quite unlikely that the H-fields stemming from the PLS/ PLi will be homogeneous over the whole loop area.

When generating H-fields with small loop antennae, again, the H-field strength at a 0,07 meter in front of the loop can be calculated as function of the current applied through the loop and will be frequency independent.

When large loop antenna are used, the H-field strength between the center of the antenna and near to the ribs of the square loop, although 0,5 meter away will differ with a factor over 2. The H-field at the center of the loop at 0,5 meter distance shall be measured with a magnetic field probe or a small multi-turn loop antenna. Due to the large loop area, the loop impedance will increase substantially with frequency such that the H-field shall be recorded by the current applied as function of frequency.

6.3.2 Surface current sense wire

The calibration of the transfer function of the surface current sense wire is straight forward. When the insulated wire diameter in combination with its dielectric insulation material is chosen to satisfy the 50 Ω transmission line impedance, no further calibration will be required.

- When across a narrow gap/ slit a voltage occurs with low equivalent source impedance, then ½ the voltage (-6 dB) will be measured at the near-end of the surface current sense wire, when the termination impedances at both ends are equal. The variances in the readings will be determined by:
    - Variation of the height of the surface current sense wire over the metal surface of the PLS/ PLi to be tested is expected to be “null”, thus 50 Ω.
    - The termination resistance at the far-end. Typically a VSWR < 1,1 up to several GHz
    - The input impedance towards the spectrum analyzer or EMI receiver as seen at the near-end of the surface current sense wire. With proper coaxial cable and 20 dB input attenuation, the VSWR < 1,1 up to several GHz.
- When an RF disturbance signal is injected into the surface current sense wire, the whole loaded transmission line will respond as 50 Ω to the output of the disturbance source:

- o Variation of the height of the surface current sense wire over the metal surface of the PLS/ PLi to be tested is expected to be "null", thus 50 Ω.
- o The power termination resistance at the far-end. Typically a VSWR < 1,1 up to several GHz
- o The output impedance from the RF power amplifier as seen at the near-end of the surface current sense wire. With proper coaxial cable and 6 dB attenuator in-between, the VSWR < 1,5 up to several GHz.

With an open RF disturbance signal; V_{EMF}, of 10 Volt, a surface current of 100 mA will result.

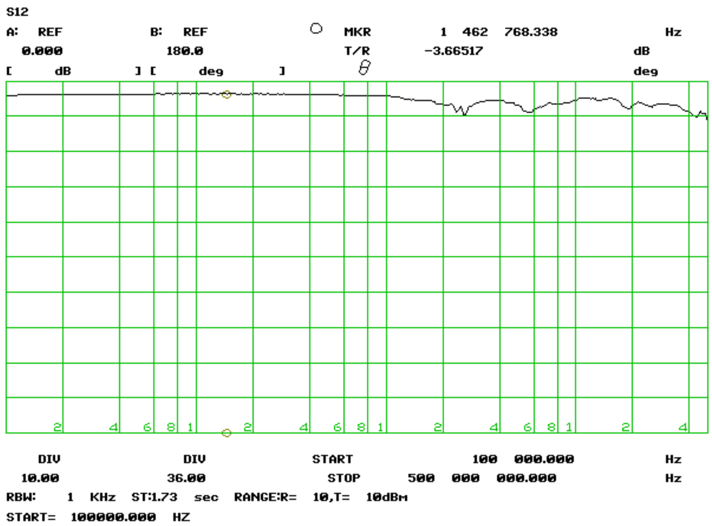

Figure 4 – Typical transfer function of the surface current sense wire over a slit

6.3.3 Directional antennae

Regarding the receiving properties of directional antenna, the free-space antenna factor as supplied by the manufacturer shall be used. Care shall be taken w.r.t. the (50 Ω) loading of the antenna as the antenna impedance will be affected by the metal surface of the PLS/ PLi at 1 meter distance, this to assure reproducibility.

For the calibration of the EM-field in front of the antenna, a 3-axis E-field sensor shall be placed in front of the antenna. The RF disturbance source shall be set in a non-modulated, CW mode of operation. The necessary forward power to achieve e.g. 10 V/m (rms of all E-field components) in free-space conditions at 1 meter distance along the center axis of the antenna shall be recorded and used during the RF immunity tests without taking into account the reflected E-field by the metal surface of the PLS/ PLi.

NOTE: Compensation for the reflected E-fields should not be done as it will lead to serious under and over testing!

7 Test procedure

7.1 RF emission

When possible, the RF emission measurements shall be taken with the equipment turned on and active in its normal mode of operation and with the entire system shut-off to enable back-ground noise measurements. Critical frequencies observed while the PLS/ PLi was switched off, shall be noted in the test report and disregarding during the evaluation of the test results.

The tentative RF emission requirements are given in the informative annex A. The final requirements agreed upon shall be negotiated between the end-user and the manufacturer.

7.1.1 DC – 50 (60) Hz

In this frequency range no bandwidth requirements apply other than those stated in the following clauses.

7.1.1.1 Disturbance current measurements

DC current shall be measured on all AC mains supply cables, on each of the phase conductors individually, by means of a suitable current probe and an oscilloscope. The measured DC level (= average current) shall be less than 1 ‰ (-60 dB) of the nominal phase current over 10 (16) mains frequency periods for a PLS/ PLi in a steady-state mode of operation.

Sub-harmonic mains frequency signals can be expected from mains cycle controlled heating systems, typically down to one-tent or one-sixteenth of the mains frequency (10 (new) or 16 (old) mains frequency periodic controls). Non-correlated mains power control may occur as a result of thermal sensed switching (e.g. bi-metal). When switching occurs in an interval ≥ 200 ms, these shall be ignored (or tolerated with a margin of 30 dB; equal to IEC 55014) .

The mains frequency disturbance current measurement shall be measured with a suitable current probe and an oscilloscope with FFT (Fast Fourier Transform) capabilities. According to the requirements, an interval of 10 (16) periods shall be recorded and an FFT with a rectangular window shall be applied when full mains periods are taken (often not exactly 50 (60) Hertz). As alternative, one or more additional mains cycle; at least half a mains cycle at the beginning and half a cycle at the end of the recording period shall be added and a Hamming (or better) filter window shall be used before the FFT analysis is performed. A minor offset in mains frequency from 50 (60) Hertz can then be disregarded.

7.1.1.2 Near-magnetic field measurements

Strong extreme low frequency (ELF) magnetic fields may be caused by open inductors, open transformers, by transformers with saturated core material or by separated mains distribution conductors. Transformer core material is typically used in EMI filters, power conversion or sensor applications.

Due to the low frequencies involved, down to DC, these magnetic fields can best be measured by using Hall sensor or, when AC, a multi-turn loop antenna based measurement equipment. The H-field measurements, H_x, H_y and H_z -field components, are taken at a sensor heart to surface distance of 0,1 ± 0,03 meter on a grid spacing at 0,5 ± 0,1 meter distance all along the surface of the system. In case H_{total} (“DC” – 50 (60) Hertz bandwidth) is less than the emission requirement applicable, the individual magnetic field component values shall be ignored.

7.1.2 50 (60) Hz – 150 kHz

According to the requirements of IEC CISPR 16, an equivalent measurement bandwidth of 200 Hz shall be used for frequencies beyond 10 kHz. In-between 50 Hz to 10 kHz a bandwidth of 10 Hz or less is recommended. When FFT operations are used, it will be typically less than 1 Hz.

7.1.2.1 Disturbance current measurements

Mains power supply signals; e.g. the 5 wires from a three-phase power system; R, S, T, neutral and PE, are typically routed as one cable or routed at close proximity to minimize the H-field emission from such cable interfaces. Although, according Kirchhoff’s law assumes that the total sum of currents in a node will always be “zero”, a fraction of the “main” current might be flowing through unintended system cables, frames, permanent PE connections, etc. This fraction of current can easily be measured by using a common-mode current probe. A current probe based on a Rogowski coil on the various cables and wires connected to the system is recommended when measuring individual wire as no saturation will occur.

NOTE: In high power installation with MV or HV supply, the power cables will be routed separately typically overhead over a longer distance to an outdoor power infra structure. In this case, the currents shall be measured individually and than summed mathematically in the measurement system used.

With these common-mode current measurements, these shall be preferably measured in the time domain on all individual conductive cables and wires connected between the (sub-) system tested and the rest of the system/ installation including all dedicated ground terminal connections, connections to cable conduits, etc. to obtain and maintain the phase relation between the conductors concerned.

When various cables are defined to be routed as one cable trunk, in one cable harness or in a defined cable conduit according the manufacturer's installation instructions, then those cable trunks, harnesses and conduits shall be treated as a single (multi-wire) cable. For this kind of applications, a Rogowski current probe can be snapped around the cable conduit in which the cables are fitted.

7.1.2.2 Near-magnetic field measurements

To gather H-field information, it is preferred to use a small 36 turn magnetic loop antenna; 0,13 meter ± 5 mm diameter and to carry out partial emission tests at 0,07 ± 0,01 meter distance, only perpendicular to the surface of the PLS/ PLi, when possible synchronized to a reference i.e. trigger signal. Typically, these H-field measurements are taken on a grid; 0,5 ± 0,1 meter spacing along the surface of the PLS/ PLi. H-fields measurements can be carried out in the time or frequency domain. In the frequency domain, a scalar H-field intensity value is typically recorded as function of frequency over a fixed bandwidth whereas the signals gathered in the time domain can be synchronized, decomposed and mathematically integrated over the surface grid scanned.

NOTE: Dedicated H-field areas like inductive card reader scan areas shall be noted but furthermore ignored from these H-field measurements when it has been demonstrated to be compliant with the applicable product standards. This condition shall be stated in the test report.

Large distributed H-field sources like contact-less power transfer system used with all kind of transport systems shall be measured at a distance where other equipment might be installed. Due to the orientation of these contact-less power conductors, the H-field will dominate in a single direction unless large metal objects/ electrically conductive constructions are installed near to those power conductors. For this reason, the H_x, H_y and H_z-field components as function of frequency or time shall be recorded at various places (at different topology conditions, e.g. a bend, a split, a feeding point, a crossing, etc.) along the transport system at the least adjacent equipment surface distance to be specified.

NOTE: In addition to those system integration requirements, legally enforced EMF requirements apply for those areas when people can be exposed to these, possible hazardous, magnetic fields.

7.1.3 150 kHz – 30 MHz

According to the requirements of IEC CISPR 16-1, an equivalent measurement bandwidth of 9 (10) kHz shall be used.

7.1.3.1 Conducted emission; mains, I/O, control

Conducted RF emissions on mains cables are preferably measured by using the artificial mains network (AMN) or Line Impedance Stabilizing Network (LISN) on the number of phases available plus neutral or by using a 150 Ω AC voltage probe (in combination with a power frequency filter network), as defined in IEC CISPR 16-1.

As an alternative, also the interference voltage on the mains lines can be measured by using the capacitive coupling probe which initially has been developed for measurements of interference voltages on telecom lines. 0,3 to 0,5 meter of conductive foil shall be wrapped around the individual mains wires and then measured against a PE grounded GRP underneath at 0,01 meter distance. The interference voltage between the foil(s) and the GRP underneath shall then be measured through a high input impedance converter, typically with 50 Ω output impedance.

As mains cables with fixed installations are not easy accessible, the common-mode current on the mains cable(s) shall be measured as alternative. With single phase equipment, neutral, phase and protective earth (PE) shall be threaded as one common mains cable. With 3-phase equipment, the common-mode current shall be measured on all 5 wires: R, S, T, neutral and PE together. When the PLS/ PLi is provided with dedicated earth terminal (fixed installation), this connection shall be measured separately.

When considering a common-mode current rather than asymmetric (line-to-PE) voltage, a common-mode impedance of 150 Ω (= 44 dBΩ) is theoretically assumed. With RF emission standards like IEC CISPR 22, the common-mode emission requirement is xx dBμV in the frequency range 150 kHz to 500 kHz (up to 30 MHz). This would yield a common-mode current of (xx – 44) dBμA to achieve compliance in this example. The main constraint for the current probe used is that it is suitable for the cable cross-section diameter as the mains frequency supply currents will be compensated for and no saturation due to mains frequency currents is to be expected.

The same current probe can be used for measuring the common-mode currents on all other cables attached; I/O, control, etc. When measuring these cables, the same common-mode current requirements shall be applied as with the conducted mains measurements, corrected for by the assumed common-mode impedance of 150 Ω (= 44 dBΩ).

When various cables are defined to be routed as one cable trunk, in one cable harness or in a defined cable conduit according the manufacturer’s installation instructions, then those cable trunks, harnesses and conduits shall be treated as a single (multi-wire) cable.

For those ports/ cables which are easy accessible, it is still preferred that coupling/decoupling networks (CDNs) or an EM-clamp (IEC 61000-4-6) shall be used rather than a current probe as the common-mode impedance is unambiguously defined by the networks used.

All cables measured shall individually satisfy the RF emission requirements as specified.

7.1.3.2 Surface currents

In addition to measuring the common-mode currents on all cables, also the surface currents over large metal objects; machines, 19 inch racks, cable conduits, etc. shall be measured. The induced voltage on a surface current sense wire needs to be measured. The surface current sense wire itself shall be insulated and shall be kept close to the metal surface of the object to be measured to represent a transmission line with a characteristic impedance of about 50 Ω towards that surface. The surface current sense wire needs to be terminated to the metal object to be measured by means of a 50 Ω coaxial terminating resistor on the far-end. The near-end of the surface current sense wire needs to be terminated by 50 Ω, being the coaxial input impedance of the RF spectrum analyzer or EMI receiver. At the near-end, the local reference for termination is another local metal surface of the installation to be tested.

With this set-up, the surface current sense wire of maximum 3 meter length shall be placed in various orientations over the metal surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions or on the exterior of cable conduits, etc. which are expected to make electrical contact to one another.

NOTE: With real installations all metal accessible objects will be grounded for electrical safety reasons to a common protective earth terminal typically at the bottom of the rack in which the power supply cable enters.

As it is assumed that the metal structure is large, the excitation voltage and its source impedance is expected to be low. In this case, the measurement impedance is irrelevant and the port excitation voltage limits apply over the 50 Ω measurement impedance rather than the 150 Ω used with the common-mode voltage measurements. Additionally, the use of 50 Ω termination at both ends of the "micro strip" transmission line will show minimal resonances caused be this surface current sense wire structure itself.

NOTE: For test relevance's sake, at least 8 wire orientations on a PLS/ PLi shall be performed. As the surface current sense wires are also suited for RF immunity testing, these wires shall remain installed but single side terminated throughout the test.

7.1.3.3 H-fields

Similar to the magnetic near-field measurement method depicted in clause 7.1.2.2, the local magnetic field perpendicular to the surface shall be measured in two orthogonal orientations with small magnetic loop antenna or a surface current probe. The larger the probe, the larger the area of field i.e. surface current integration will be. However, the maximum loop size will be restricted by the wavelength of the upper frequency concerned.

When large machines or installations do not carry any source of H-field emission in this frequency range, these measurements along the surface of the machine shall considered to be covered by the surface current measurements as defined in clause 7.1.3.2.

7.1.4 30 MHz – 1 GHz

According to the requirements of IEC CISPR 16-1, an equivalent measurement bandwidth of 120 kHz shall be used.

7.1.4.1 Conducted emission

The RF emission measurement equal to the common-mode emission method described in clause 7.1.3.1 can be used. The frequency of application is restricted to about 230 MHz. Above this frequency; it is recommended to use the radiated field or surface current measurement methods.

In addition to the conducted RF emission measurements on the cables, also the RF voltage occurring between the chassis of the PLS/ PLi and a metal reference plate in front of or insulated and underneath the PLS/ PLi shall be measured across a 50 Ω load impedance while all other cable connections are in position. When a dedicated PE terminal plus earth wire is connected to the PLS/ PLi at this location, this wire shall be replaced by an earth ground choke of 50 μH with sufficient current rating. As an alternative an CDN-M1 can be used.

7.1.4.2 Surface currents

The test method is identical to the one described in clause 7.1.3.2. However, with this set-up, in this frequency range of interest, the surface current sense wire of maximum 1 meter length shall be routed in various orientations tight over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

7.1.4.3 Radiated fields

Directional antennae, like log-per or broadband horn antennae shall be used at 1 ± 0,1 meter distance from the surface of the PLS/ PLi. These antennae shall be positioned with their main receiving lob pointing perpendicular to the surface of the PLS/ PLi. The opening angle of the main lob from the antennae is expected between 40 to 65 degrees.

Due to the smaller opening angle of directive antenna, the RF emission shall be performed by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi in both polarization orientations. It is recommended to store the max-hold reading of the RF emission level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

The radiated fields shall be measured at the location of the electronics; racks, cabinets, etc. No further measurements shall be carried out beyond 1 ± 0,1 meter aside the surface of the cabinets with electronics.

NOTE: No (active) antennae with a dipole antenna structure shall be used as directivity is lacking and ambient signals are received proportionally.

7.1.5 1 – 40 GHz

According to the requirements of IEC CISPR 16-1, an equivalent measurement bandwidth of 120 kHz shall be used.

Above 1 GHz, all RF emission properties shall be measured by using small directional broadband horn antennae at close distance to the PLS/ PLi with their main receiving lob pointing perpendicular to the surface of the PLS/ PLi.

Due to the smaller opening angle of these horn antennae, the RF emission shall be measured by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to store the max-hold reading of the RF emission level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

No radiated fields shall be measured at the locations where no electronics are involved; cable conduits, metal structure as radiation will occur quite close to its source only. No further measurements shall be carried out beyond 0,5 ± 0,1 meter aside the surface of the cabinets with electronics.

Intended antenna e.g. for wireless communication, which are (type) approved for their function, shall be ignored with these measurements. Their position, orientation and ERP as well as the wireless standard to which they are assumed to be compliant, shall be stated in the test report.

7.2 RF immunity

The response of the PLS/ PLi is fully dependent on the functionality of the system being tested. The responses of the PLS/ PLi may vary in a change of supply current, change of output voltage, change of speed, change of sensor reading or any other response parameter that can be instantaneously be observed during the RF immunity test. It is preferred, for the sake of reporting to have a closed-loop measurement set-up in which the RF disturbance frequency is recorded against the response parameter, when possible with the information about the RF disturbance source position at which this response has occurred.

NOTE: The parameter affected may differ by the RF disturbance frequency and test method applied.

To speed up the RF immunity measurements, the test shall be performed at the maximum disturbance level applicable and the response is recorded unless the PLS/ PLi is incapable to handle these disturbances applied. After each individual test, the parameter responses shall be compared to the functional requirements applicable to the system. The rationale for these functional requirements and the allowed deviations thereof and the test result shall be noted in the test report.

The increment of the RF disturbance source carrier frequency shall be 4 % for all frequencies above 10 kHz (~ 60 steps/ decade). Dedicated frequencies may be added when RF emission information of other systems and installations is gathered to which the PLS/ PLi will be installed.

NOTE: The latency of the response shall be considered with the dwell time, frequency step time used with the RF immunity test. A step size of 4% is sufficient as the unintended resonances within systems seldom occur with a quality; bandwidth over resonance frequency, over 100.

Below 30 MHz, the RF disturbance signal shall be amplitude modulation, 80% in depth by a 1 kHz sinusoidal signal. Above 30 MHz, the RF signal shall be on-/off-keyed (at least 30-to-1 signal ratio; 30 dB) by an RF disturbance source with sufficient power capabilities to generate 10 $Volt_{emf}$ (across 50 Ω) or 10 Volt/meter at 1 meter distance; when directional antennae are used. For this purpose it is considered to use a CW RF signal source e.g. the RF tracking generator of a spectrum analyzer of which the output signal is modulated by means of a PIN-diode before it is amplified to the required signal level. The amplitude modulation frequency shall be chosen unequal to 1000 Hz and fully asynchronous to any signal occurring with the PLS/ PLi being tested.

Typical RF immunity requirements are given in Annex B.

7.2.1 DC – 50 (60) Hz

With high-power DC supplies e.g. for electrolytic processes or near to high output current DC supplies or at close proximity of power transformers and MV or HV power cables, high levels of static and low frequency magnetic fields can be expected which may cause static deflection on CRT or magnetic sensors or may cause saturation of materials like transformer cores, mains filters, etc.

Static or low frequency magnetic fields can be easily generated by using multi-turn loops. However, the size of the transmitting loop shall be determined by the size of the interference source to be expected but shall be less or equal to 3 x 3 meter. This loop shall be oriented perpendicular to the metal surface but at 0,5 meter distance from the metal surface of the PLS/ PLi to avoid an inductive short-circuit of the field generating loop.

Typically, these H-fields are generated on a grid; loop size ± 0,1 meter spacing along the surface of the PLS/ PLi.

7.2.2 50 (60) Hz – 150 kHz

In this frequency range of interest most mains frequency related harmonic disturbances can be expected as well as the fundamental emission from switched mode power supplies, electronic luminaries, pulse width modulation motor controls, mains communication signals, etc.

7.2.2.1 Conducted immunity; mains, I/O, control

Part of the emission sources mentioned penetrates the other system or installation via mains and other I/O, communication or control signals. These disturbance signals are more difficult to superimpose on the functional signal without disturbing the functional signal. As functional signals may occur asymmetric or even differentially, the disturbance signal should find directivity via common-mode coupling/decoupling networks to avoid other system or installations to become affected.

The coupling/decoupling networks as (not) defined in the IEC basic immunity standards can't be used. The proposed coupling method is to inject the disturbance signal of interest between the chassis/ PE terminals of the various sub-systems concerned.

7.2.2.2 H-fields

In the frequency range 50 to 150 kHz a distinct shall be made between local point sources and sources further away. Nearby H-field sources shall be represented by using a small 10-turn loop with 0,13 meter diameter. This loop shall be positioned on a 0,5 meter grid all along the surface area of the PLS/ PLi where adjacent equipment can be expected in real installation conditions.

In all other cases, a large loop antenna of 3 x 3 meter shall be used with 3 windings. This large loop shall be positioned at 0,5 meter distance from the surface of the PLS/ PLi. In this case it is assumed that a typical (concrete) floor will be enforced by a steel grid which will reduce any H-field penetrating from the bottom side. The large loop shall not be short-circuited by a conductive metal sheet e.g. the walls of a Faraday cage. Typically, these H-fields are generated on a grid; loop size ± 0,1 meter spacing along the surface of the PLS/ PLi.

7.2.3 150 kHz – 30 MHz

The test methods provided in this frequency range are adopted from the RF emission tests. The main differences will be the power handing capabilities of the networks and current injection networks, clamps used.

7.2.3.1 Conducted immunity; mains, I/O, control

Conducted RF immunity on mains cables is preferably measured by injecting common-mode current on all 5 wires: R, S, T, neutral and protective earth. When considering common-mode current rather than asymmetric voltage, a common-mode impedance of 150 Ω (= 44 dBΩ) is theoretically assumed. With RF immunity standards like IEC CISPR 24, the common-mode immunity requirement is xx dBV_{emf} in the frequency range 150 kHz to 30 MHz. This would be equivalent to a common-mode current of xx - 44 dBμA to achieve compliance in this example. The main constraint for the current injection probe used shall be that it is capable to handle the RF power and suitable for the cable cross-section diameter as the mains frequency supply current will be compensated for and no saturation is expected.

For those ports/ cables which are easy accessible, it is still preferred that CDNs or an EM-clamp (IEC 61000-4-6) shall be used rather than a current probe as the common-mode impedance is then unambiguously defined by the network used. In this case, the test set-up as defined in IEC 61000-4-6 shall be addressed.

The same current injection probe can be used for injecting the common-mode currents on all cables attached; I/O, control, etc. when injection on these cables, the same common-mode current requirements shall be applied as with the conducted mains immunity measurements.

When various cables are defined to be routed as one cable trunk, in one cable harness or in a defined cable conduit according the manufacturer’s installation instructions, then those cable trunks, harnesses and conduits shall be treated as a single (multi-wire) cable.

All cables stressed shall individually satisfy the RF immunity requirements as specified.

7.2.3.2 Surface current

In addition to common-mode current injection on the cables connected, also the surface current over large metal objects; machines, 19 inch racks, cable conduits, etc. shall be injected. With this measurement, a current will be induced by a single conductive wire. The conductive wire shall be insulated and shall be kept close to the metal surface to be injected to represent a transmission line with a characteristic impedance of about 50 Ω towards the surface of the metal object. The conductive wire needs to be terminated to the metal object to be injected by means of a 50 Ω terminating resistor on one side. The other side of the conductive wire needs to be sourced by 50 Ω, being the output impedance of the RF disturbance generator. At this end, the local reference for termination is again the local metal surface of the installation to be tested.

With this set-up, the conductive wire of maximum 3 meter length shall be placed in various orientations over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

NOTE: With real installations all metal accessible objects will be grounded for electrical safety reasons to a common protective earth terminal typically at the bottom of the rack in which the power supply cable enters.

As it is assume that the metal structure is large, the induced current will be determined by the disturbance source output impedance as the metal surface impedance is expected to be low. In this case, the surface impedance is irrelevant and the excitation voltage limits the current applied from the 50 Ω disturbance source impedance. Additionally, the use of 50 Ω at both ends of the “micro strip” transmission line will show minimal resonances caused be this test structure itself.

NOTE: For test relevance’s sake, at least 8 wire orientations on a PLS/ PLi shall be performed. As the surface current injection wires are also suited for RF emission testing, these wires shall remain installed but single side terminated throughout the test.

7.2.3.3 H-fields

In this frequency range, it is typically sufficient to apply the two conductive tests defined in 6.2.3.1 and 6.2.3.2. In rare occasions, H-fields may be applied to represent a specific source. In this case, the 10-turn loop can be used without resonance up till 10 MHz as defined in 6.2.2.2. For the frequency range 10 to 30 MHz, no commercial loops are available for H-field immunity testing.

When the object to be tested is small e.g. a sensor belong with a PLS/ PLi, this sensor can be tested by using Helmholtz coils. Here too, for commercially available Helmholtz coils the upper frequency is restricted to about 10 MHz.

7.2.4 30 MHz – 1 GHz

Similar to the RF emission testing, the three methods can be applied for which the first two are RF power efficient as low RF losses occur between the RF disturbance source and the PLS/ PLi under test.

7.2.4.1 Conducted immunity

The RF immunity measurement is equal to the method described in clause 6.2.3.1. The frequency of application is restricted to about 300 MHz. Above this frequency; it is recommended to use the radiated field measurement method.

In addition to the conducted RF immunity measurements on the cables, also the RF voltage occurring between the chassis of the PLS/ PLi and a metal reference plate in front of or underneath the PLS/ PLi shall be injected from a 50 Ω disturbance source generator impedance while all other connections are in position When a dedicated PE terminal plus earth wire is connected to the PLS/ PLi at this location, this wire shall be replaced by an earth ground choke of 50 μH and sufficient current rating.

7.2.4.2 Surface currents

The test method is identical to the one described in clause 6.2.3.2. However, with this set-up in this frequency range of interest, the conductive wire of maximum 1 meter length shall be routed in various orientations tight over the surface of the PLS/ PLi and shall be routed over slits, displays, front panel to frame transitions, etc. which are expected to make electrical contact to one another.

7.2.4.3 RF fields

Directional antennae, like log-per or horn antenna shall be used at close distance to the PLS/ PLi with their main receiving lob pointing at the PLS/ PLi. The opening angle of the main lob is expected between 40 to 65 degrees.

Due to the smaller opening angle of directive antenna, the RF field shall be exposed to the PLS/ PLi by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to set the forward power of the RF disturbance generator to a fixed level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

The radiated fields shall be applied at the location of the electronics; racks, cabinets, etc. No further measurements shall be carried out beyond 1 ± 0,1 meter aside the surface of the cabinets with electronics.

7.2.5 1 – 40 GHz

Above 1 GHz, all RF field shall be exposed to the PLS/ PLi by small directional horn antennae at close distance to the PLS/ PLi with its main receiving lob pointing at the PLS/ PLi.

Due to the smaller opening angle of these horn antennae, the RF field shall be exposed to the PLS/ PLi by partial surface scans at a distance of 1 ± 0,1 meter from the surface of the PLS/ PLi. It is recommended to set the forward power of the RF disturbance generator to a fixed level while scanning over the PLS/ PLi surface at intervals of 1 ± 0,1 meter along the circumference of the PLS/ PLi at 1 and 2 ± 0,1 meter height.

The fieldstrength required can be calculated from the horn antenna gain; 1 to 16 dBi, the generator's output level; typ. 0 dBm, the modulator's losses; less than 6 dB, the cable losses; less than a few dB and the RF power amplifier's gain; typically > 40 dB. The total RF disturbance generator output power needs to be less than 5 Watt to fulfill this condition.

No radiated fields shall be applied at the locations where no electronics are involved; cable conduits, metal structure as coupling will occur quite close to the cabinets with electronics only. No further measurements shall be carried out at 0,5 ± 0,1 meter aside the surface of the cabinets with electronics.

Test report

The test report shall be in accordance with the requirements of IEC xxxxx

8 EMC Acceptance Level

The EMC acceptance level of a PLS/ PLi, if any, is to be agreed upon between the manufacturer and the user of the PLS/ PLi.

For those cases, where due to orthogonality, no interaction can be expected between RF emitting parts from one PLS/ PLi and parts of another PLS/ PLi which can be RF susceptible, the requirements can be relaxed accordingly. For this purpose, an EMC interaction matrix can be used to indicate the possible parts of interaction.

9 Bibliography

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Annex 1 – RF emission requirement selection
(informative)

Selecting RF emission classes

The RF emission classes are determined by the installation environment in which the PLS/ PLi is to be used.

Similar to IEC 61000-6-1/2/3/4, three environmental classes are determined:

- General i.e. domestic environment, commonly known as the class B environment
- Industrial environment, commonly known as the class A environment
- In-situ, where levels need to be negotiated between the manufacturer and the end-user

With in-situ environments it is recommended that the RF emission levels from class B are satisfied as for the immunity levels, the requirements applicable for an industrial environment are addressed, see Annex B.

NOTE Though it is theoretically incorrect to express equivalent radiated emission by just measuring common-mode currents and surface currents from in a non-defined impedance network i.e. circuit topology, it is assumed that certain nominal common-mode impedances are achieved.

DC – 50 (60) Hz

According to the requirements for residual current breakers, no DC current components are allowed on the mains distribution networks.

At the mains frequency, high leakage currents can be expected of several Amps due to the summation of mains filtering applied in the PLS/ PLi. Sub-harmonic mains frequency signals can be expected from mains cycle controlled heating systems, typically down to one-tent or one-sixteenth of the mains frequency (10 or 16 mains periods control). Non-correlated mains period control may occur as a result of thermal sensed switching. In this case, the flicker requirements from IEC 61000-3-3 apply.

50 (60) Hz – 150 kHz

In the frequency range up to the 20^{th} harmonic (or even 40^{th} harmonic) mains current requirements are defined in IEC 61000-3-2.

In the frequency range from 2 to 150 kHz, no legal enforced requirements are given.

150 kHz – 30 MHz

With class B, the following limits for conducted emission are recommended:

Table A1 – Conducted requirements in 150 kHz to 30 MHz range

Frequency range [MHz]	Port voltage level [dBµV] measured in 9 or 10 kHz bandwidth
0,15 – 0,5	84
0,5 - 30	74

30 MHz – 1 GHz

With class B, the following limits for conducted emission are recommended:

Table A2 – Conducted requirements in 30 MHz to 1GHz range

Frequency range [MHz]	Port voltage level [dBµV] measured in 100 or 120 kHz bandwidth
30 – 230	54
230 - 1000	61

With class B, the following limits for radiated emission are recommended @ 1m distance:

Table A3 – Radiated requirements in 30 MHz to 1 GHz range

Frequency range [MHz]	Field strength level [dBµV/m] measured in 100 or 120 kHz bandwidth
30 – 230	60
230 - 1000	67

1 GHz – 40 GHz

The following limits for radiated emission are recommended @ 1m distance:

Table A4 – Radiated requirements in 1 GHz to 18 GHz range

Frequency range [GHz]	Power strength level [dBpW/m^2] measured in 100 or 120 kHz bandwidth
1 – 6	38
6 - 18	45

Annex 2 – RF immunity requirement selection (informative)

Selecting RF immunity classes

The RF immunity classes are determined by the installation environment in which the PLS/ PLi is to be used.

Similar to IEC 61000-6-1/2/3/4, three environmental classes are determined:

- General i.e. domestic environment, commonly known as the class B environment
- Industrial environment, commonly known as the class A environment
- In-situ, where levels need to be negotiated between the manufacturer and the end-user

With in-situ environments it is recommended that the RF emission levels from class B are satisfied, see Annex A, as for the immunity levels, the requirements applicable for an industrial environment are addressed.

NOTE In order not to violate any RF radiation requirements, the local transmitted ERP, exposed to the PLS under test at frequencies above 150 kHz shall be restricted to 5 Watt forward power maximum. Due to reflections, the measured power, expressed in H-field, induced currents, etc. will typically indicate less as in-situ field impedance and termination impedances are less well-defined.

DC – 50 (60) Hz

Typically no DC current components can be expected on the power mains distribution network.

In some installations, where high DC currents are distributed as DC supply network e.g. 48 Volts, or where DC current is used for industrial purposes, high DC fields can be expected near to those conductors which are typically routed at close distance.

Mains frequency magnetic fields and their sub-harmonics can be expected from mains distribution systems in particular where the mains phase conductors are routed separately. Mains frequency magnetic fields and their sub-harmonics do occur at close proximity of current saturated mains transformers and near transductor applications

50 (60) Hz – 150 kHz

Limited by the mains harmonic emission requirements, low levels of mains harmonic currents can be expected in the frequency range up to 2 kHz. In this frequency range in interest, mains' signaling is typically applied at 20 Volt_{rms} superimposed on the mains frequency signal. Frequency used range from 600 to 1000 Hz.

Above 2 kHz, no RF emission requirements apply and therefore all levels in interference can be expected. According IEC 61800 (EMC requirements for UPS and PWM applications) levels up to 10 Volt_{rms} can be expected.

150 kHz – 30 MHz

With industrial environments, the following levels for conducted immunity are recommended:

Table B1 Conducted requirements 150 kHz - 30 MHz

Frequency range [MHz]	RF disturbance source level [dBV_{emf}]
0,15 – 0,5	20
0,5 - 30	20

30 MHz – 1 GHz

With industrial environments, the following levels for conducted immunity apply:

Table B2 Conducted requirements 30 MHz – 1 GHz

Frequency range [MHz]	RF disturbance source level [dBV_{emf}]
30 - 80	20
80 - 1000	10

With industrial environments, the following levels for radiated immunity are recommended:

Table B3 Radiated requirements 30 MHz – 1 GHz

Frequency range [MHz]	RF disturbance source level [dBV/m]
30 - 80	20
80 - 800	10
800 - 1000	20

1 GHz – 40 GHz

With industrial environments, the following levels for radiated immunity are recommended:

Table B4 Conducted requirements 1 GHz – 40 GHz

Frequency range [GHz]	RF disturbance source level [dBV/m]
1 - 3	20
3 - 40	10

Annex 3 – Additional immunity requirements (informative)

In addition to the RF testing of PLS/ PLI, also impulse immunity shall be tested; ESD, EFT.

Mains related surge tests typically cannot be applied in-situ due to the way these pulses have to be coupled into the PLS/ PLi concerned.

Similar constraints apply for voltage fluctuation and voltage interrupts, as these tests can only be performed after decoupling the power mains cabling.

For ESD tests, the in-situ test method is well described in the annex of IEC 61000-4-2.

EFT test using surface current sense wires

When the surface current sense wires are attached to the PLS/ PLi under test, the same near-end ports can be used to inject EFT pulses as surface currents over the metal parts of the PLS/ PLi.

After the update of IEC 61000-4-4, the EFT pulses shall only be applied in a common-mode way to the mains port cable as well as to all other ports. Typically a factor of 2 applies for the severity level required at the mains port versus the requirements at all other ports.

When applying EFT to the surface current sense wires individually, also the lower stress level shall be applied as only a local surface current is excited at a time (which in reality will be a fraction of the EFT injected at the mains port).