

# Railway applications — Electromagnetic compatibility —

## Part 5: Emission and immunity of fixed power supply installations and apparatus

The European Standard EN 50121-5:2006 has the status of a British Standard

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## National foreword

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A list of organizations represented on GEL/9 can be obtained on request to its secretary.

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

### Foreword

This European Standard was prepared by Technical Committee TC 9X: Electrical and electronic applications for railways. The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50121-5 on 2006-07-01.

This European Standard supersedes EN 50121-5:2000.

This European Standard is to be read in conjunction with EN 50121-1.

This standard forms Part 5 of the European Standard series EN 50121, published under the general title "Railway applications - Electromagnetic compatibility". The series consists of

- Part 1 : General
- Part 2 : Emission of the whole railway system to the outside world
- Part 3-1 : Rolling stock - Train and complete vehicle
- Part 3-2 : Rolling stock - Apparatus
- Part 4 : Emission and immunity of the signalling and telecommunications apparatus
- Part 5 : Emission and immunity of fixed power supply installations and apparatus

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- latest date by which the national standards conflicting  
with the EN have to be withdrawn (dow) 2009-07-01

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 89/336/EEC. See Annex ZZ.

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**Contents**

Introduction .....4

1 Scope .....4

2 Normative references .....5

3 Definitions .....6

4 Performance criteria .....6

5 Emission tests and limits .....6

    5.1 Emission from the substation to the outside world .....6

    5.2 Emission test for apparatus operating at less than 1 000 V r.m.s. a.c. ....7

    5.3 Emission values within the boundary of the substation .....7

6 Immunity tests and limits .....7

7 Fixed power supplies on railway property which are not used for railway traction purposes .....7

Annex A (informative) Emission within the boundary of the substation for normal operation and during the operation of switches .....14

Annex ZZ (informative) Coverage of Essential Requirements of EC Directives .....17

Bibliography .....18

**Figures**

Figure A.1 – Emission from switches – Peak .....15

Figure A.2 – Emission within substation boundary – Peak .....16

**Tables**

Table 1 – Immunity – Enclosure port .....9

Table 2 – Immunity – Ports for signal lines and data buses not involved in process control .....10

Table 3 – Immunity – Ports for process, measurement and control lines, and long bus and control lines .....11

Table 4 – Immunity – D.C. input and d. c. output power ports .....12

Table 5 – Immunity – A.C. input and a.c. output power ports .....13

Table 6 – Immunity – Earth port .....13

## Introduction

The requirements of this standard have been specified so as to ensure a level of electromagnetic emission which will cause minimal disturbance to other equipment. The levels, however, do not cover the following cases:

- a) where the probability of an occurrence likely to produce emissions in excess of those which would normally be experienced is extremely low,
- b) where highly susceptible apparatus will be used in close proximity of the equipment covered by this standard, in which case further measures may have to be taken.

The emission limits given are on the basis that the equipment of the product family range is installed in railway substation areas.

## 1 Scope

This European Standard applies to emission and immunity aspects of EMC for electrical and electronic apparatus and systems intended for use in railway fixed installations associated with power supply. This includes the power feed to the apparatus, the apparatus itself with its protective control circuits, trackside items such as switching stations, power autotransformers, booster transformers, substation power switchgear and power switchgear to other longitudinal and local supplies.

Filters operating at railway system voltage (for example, for harmonic suppression or power factor correction) are not included in this standard since each site has special requirements. Filters would normally have separate enclosures with separate rules for access. If electromagnetic limits are required, these will appear in the specification for the equipment.

The limits in this standard do not apply to intentional communication signals.

The frequency range considered is from d.c. to 400 GHz. No measurements need to be performed at frequencies where no requirement is specified.

Emission and immunity limits are given for items of apparatus which are situated:

- a) within the boundary of a substation which delivers electric power to a railway;
- b) beside the track for the purpose of controlling or regulating the railway power supply, including power factor correction and filtering;
- c) along the track for the purpose of supplying electrical power to the railway other than by means of the conductors used for contact current collection, and associated return conductors. Included are high voltage feeder systems within the boundary of the railway which supply substations at which the voltage is reduced to the railway system voltage.

NOTE 1 Examples are one conductor of a 25-0-25 kV 50 Hz system and the 110 kV 16,7 Hz supply systems.

NOTE 2 Similar conductors which are outside the railway boundary are treated as in the public area and are considered to be general overhead power lines although they feed only the railway.

- d) beside the track for controlling or regulating electric power supplies to ancillary railway uses. This category includes power supplies to marshalling yards, maintenance depots and stations;
- e) various other non-traction power supplies from railway sources which are shared with railway traction.

Apparatus and systems which are in an environment which can be described as residential, commercial or light industry, even when placed within the physical boundary of the railway substation, shall comply with the relevant generic European EMC standard.

Excluded from the immunity requirements of this standard is power supply apparatus which is intrinsically immune to the tests defined in Tables 1 to 6 of this standard.

NOTE 3 An example is an 18 MVA 230 kV to 25 kV power supply transformer.

These specific provisions are to be used in conjunction with the general provisions in EN 50121-1.

This part of the standard covers requirements for both apparatus and fixed installations. The sections for fixed installations are not relevant for CE marking.

## 2 Normative 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.

EN 50121-1	Railway applications – Electromagnetic compatibility – Part 1: General
EN 50121-2	Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world
EN 55016-1-1	Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus (CISPR 16-1-1)
EN 55022	Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement (CISPR 22, mod.)
EN 61000-3-2	Electromagnetic compatibility (EMC) Part 3-2: Limits – Limits for harmonic current emissions (equipment input current up to and including 16 A per phase) (IEC 61000-3-2)
EN 61000-3-3	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 61000-3-3)
EN 61000-4-2	Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test (IEC 61000-4-2)
EN 61000-4-3	Electromagnetic compatibility (EMC) Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3)
EN 61000-4-4	Electromagnetic compatibility (EMC) Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test (IEC 61000-4-4)
EN 61000-4-5	Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques – Surge immunity test (IEC 61000-4-5)
EN 61000-4-6	Electromagnetic compatibility (EMC) Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields (IEC 61000-4-6)
EN 61000-4-8	Electromagnetic compatibility (EMC) Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test (IEC 61000-4-8)
EN 61000-4-12	Electromagnetic compatibility (EMC) Part 4-12: Testing and measurement techniques – Oscillatory waves immunity test (IEC 61000-4-12)

EN 61000-6-2	Electromagnetic compatibility (EMC) Part 6-2: Generic standards – Immunity for industrial environments (IEC 61000-6-2)
EN 61000-6-4	Electromagnetic compatibility (EMC) Part 6-4: Generic standards – Emission standard for industrial environments (IEC 61000-6-4, mod.)

### 3 Definitions

For the purpose of this Part 5 of the European Standard the following definitions apply.

#### 3.1

##### **apparatus**

electric or electronic product with an intrinsic function intended for implementation into a fixed railway installation.

#### 3.2

##### **environment**

surrounding objects or region which may influence the behaviour of the system and or may be influenced by the system

#### 3.3

##### **external interface**

boundary where a system interacts with any other or where a system interacts with its environment

#### 3.4

##### **railway substation**

installation, the main function of which is to supply a contact line system at which the voltage of a primary supply system, and in some cases the frequency, is transformed to the voltage and frequency of the contact line

#### 3.5

##### **railway supply lines**

conductors running within the boundary of the railway which supply power to only the railway but are not energised at railway system voltage

### 4 Performance criteria

The variety and diversity of the apparatus within the scope of this document makes it difficult to define precise criteria for the evaluation of the immunity test results. Three general levels of performance are therefore used, as defined in EN 50121-1.

### 5 Emission tests and limits

#### 5.1 Emission from the substation to the outside world

Limit values for this emission, over the frequency range 9 kHz to 1 GHz are given in EN 50121-2.

NOTE 1 Guidance values are given in EN 50121-2 for emission of d.c. and power frequency magnetic fields.

Conductors (overhead or underground) between the substation and the railway are part of the railway installation, but because of their wide variety of positions and ampere loadings, limit values cannot be set for the magnetic fields which they produce.

For apparatus which is under ground, measurements shall be made in the frequency range 9 kHz to 150 kHz at the surface of the ground above the apparatus.

NOTE 2 No limits are set for emissions into the active space of the underground railway due to the complexities of obtaining measurements in the confined space and the lack of a precise method of relating the measured values to the degree of disturbance which other apparatus would suffer.

### **5.2 Emission test for apparatus operating at less than 1 000 V r.m.s. a.c.**

The emission limits for apparatus covered by this standard which is supplied with electrical power at a voltage below 1 000 V r.m.s. are given on a port by port basis in EN 61000-6-4, Table 1.

### **5.3 Emission values within the boundary of the substation**

Because there is such a wide variety of options for the design and the construction of the substation, limits are not given for emission within the general space inside the boundary of the substation. Practical measurements have been made and guidance values are given in Annex A. These are for information only and are not part of the normative content of this standard.

## **6 Immunity tests and limits**

The immunity test requirements for apparatus covered by this standard are given on a port by port basis in Tables 1 to 6.

Tests shall be conducted in a well-defined and reproducible manner. The tests shall be carried out as single tests in sequence. The sequence of testing is optional.

The description of the tests, the test generator, the test methods, and the test set-up are given in the Basic Standards which are referred to in Tables 1 to 6. The contents of the Basic Standards are not repeated here, however modifications or additional information needed for the practical application of the tests are given in this standard.

Where possible, the tests shall be made with a typical operating mode chosen to produce the maximum susceptibility to noise in the frequency band being investigated, consistent with normal applications. The manufacturer shall define the conditions of the test in the test plan.

NOTE If the apparatus is part of a system or can be connected to auxiliary apparatus, then the apparatus should preferably be tested while connected to the minimum configuration of auxiliary apparatus necessary to exercise the test point in accordance with the general methods of EN 55022 and EN 61000-4-x.

The configuration and mode of operation during the tests shall be precisely noted in the test report. It is not always possible to test every function of the apparatus; in such cases the most critical mode of operation should be selected.

The tests shall be carried out within the specified operating range for the apparatus and at its rated supply voltage.

Some of the immunity levels are higher than those of the heavy industrial Generic Standard because this has been found necessary in practice.

Voltages induced by traction currents are not treated here. They have to be covered by the functional specification.

## **7 Fixed power supplies on railway property which are not used for railway traction purposes**

These are used for example for signalling systems: station services, office building services, freight cranes and yard lighting.

They fall into two categories:

- a) those that are supplied from non-railway sources. Examples are supplies from the local public electricity supplier or from separate generators. These are outside the scope of this standard. For products in the scope of EN 61000-3-2 or EN 61000-3-3, the requirements of those standards apply.
- b) those that are supplied from railway sources which are shared with train traction. The supply voltage may have a substantial harmonic content. It is the responsibility of the body which puts the apparatus into service to establish the levels of immunity and emission which will ensure EMC. Examples are: supplies from tertiary windings on rectifier transformers or from the railway a.c. overhead via transformers.

Table 1 – Immunity – Enclosure port

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
1.1	Radio-frequency electromagnetic field. Amplitude modulated	80 MHz ... 1 000 MHz 10 V/m (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-3	EN 61000-4-3	The test level specified is the r.m.s. value of the unmodulated carrier	A
1.2	Radio-frequency electromagnetic field, from digital mobile telephones	800 MHz ... 1 000 MHz 20 V/m (r.m.s) 80 % AM, 1 kHz ----- 1 400 MHz...2 100 MHz 10 V/m (r.m.s) 80 % AM, 1 kHz ----- 2 100 MHz...2 500 MHz 5 V/m (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier ----- Unmodulated carrier ----- Unmodulated carrier	EN 61000-4-3	EN 61000-4-3		A
1.3	Power - frequency magnetic field	16,7 Hz 50 Hz 0 Hz 100 A/m (r.m.s) 300 A/m	d.c a.c. systems d.c. systems	EN 61000-4-8	EN 61000-4-8	See note 1 All frequencies have to be tested	A
1.4	Electrostatic discharge	± 6 kV ± 8 kV	Contact discharge Air discharge	EN 61000-4-2	EN 61000-4-2	See note 2	B
NOTE 1 Test only applies to apparatus containing devices sensitive to magnetic fields e.g. Hall elements, electro-dynamic microphones etc. Unshielded CRT displays can exhibit interference effects above 1A/m (r.m.s)							
NOTE 2 See Basic Standard for applicability of contact and/or air discharge test.							

Table 2 – Immunity – Ports for signal lines and data buses not involved in process control

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
2.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note 1 The test level specified is the r.m.s. value of the unmodulated carrier	A
2.2	Fast transients	$\pm 2$ kV 5/50 ns 5 kHz	Peak $T_r / T_h$ Repetition frequency	EN 61000-4-4	EN 61000-4-4	See note 2 Capacitive clamp used	B
NOTE 1 The test level can also be defined as the equivalent current into a 150 $\Omega$ load.							
NOTE 2 Applicable only to ports interfacing with cables whose total length according to the manufacturers functional specification may exceed 1 m.							

Table 3 – Immunity – Ports for process, measurement and control lines, and long bus and control lines

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
3.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note The test level specified is the r.m.s. value of the unmodulated carrier	A
3.2	Damped oscillatory voltage (oscillatory waves)	2,5 kV 1 kV	Line to earth Line to line	EN 61000-4-12	EN 61000-4-12	Both 100 kHz and 1 MHz	B
3.3	Fast transients	± 2 kV 5/50 ns 5 kHz	Peak $T_r / T_h$ Repetition frequency	EN 61000-4-4	EN 61000-4-4	Capacitive clamp used	B
3.4	Surges	1,2 / 50 µs ± 2 kV ± 1 kV	Open circuit test voltage, line to earth Open circuit test voltage, line to line	EN 61000-4-5	EN 61000-4-5		B
NOTE The test level can also be defined as the equivalent current into a 150 Ω load.							

Table 4 – Immunity – D.C. input and d. c. output power ports

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
4.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note 1 The test level specified is the r.m.s. value of the unmodulated carrier	A
4.2	Fast transients	± 4 kV 5/50 ns 5 kHz	Peak $T_r / T_h$ Repetition frequency	EN 61000-4-4	EN 61000-4-4	See note 2	B
4.3	Surges	1,2 / 50 µs ± 2 kV ± 1 kV	Open circuit test voltage, line to earth Open circuit test voltage, line to line	EN 61000-4-5	EN 61000-4-5	See note 2	B
NOTE 1 The test level can also be defined as the equivalent current into a 150 Ω load.							
NOTE 2 Not applicable to input ports intended for connection to a battery or a rechargeable battery which must be removed or disconnected from the apparatus for recharging.							

Table 5 – Immunity – A.C. input and a.c. output power ports

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
5.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note 1 The test level specified is the r.m.s. value of the unmodulated carrier	A
5.2	Fast transients	± 4 kV 5/50 ns 5 kHz	Peak $T_r / T_h$ Repetition frequency	EN 61000-4-4	EN 61000-4-4		B
5.3	Surges	1,2 / 50 µs ± 4 kV ± 2 kV	Open circuit test voltage, line to earth Open circuit test voltage, line to line	EN 61000-4-5	EN 61000-4-5		B
NOTE 1 The test level can also be defined as the equivalent current into a 150 Ω load.							

Table 6 – Immunity – Earth port

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
6.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note 1 & 2 The test level specified is the r.m.s. value of the unmodulated carrier	A
6.2	Fast transients	± 1 kV 5/50 ns 5 kHz	Peak $T_r / T_h$ Rep. frequency	EN 61000-4-4	EN 61000-4-4	See note 1	A
NOTE 1 Test may not be practicable with cable length less than 3 m.							
NOTE 2 The test level can also be defined as the equivalent current into a 150 Ω load.							

**Annex A**  
(informative)

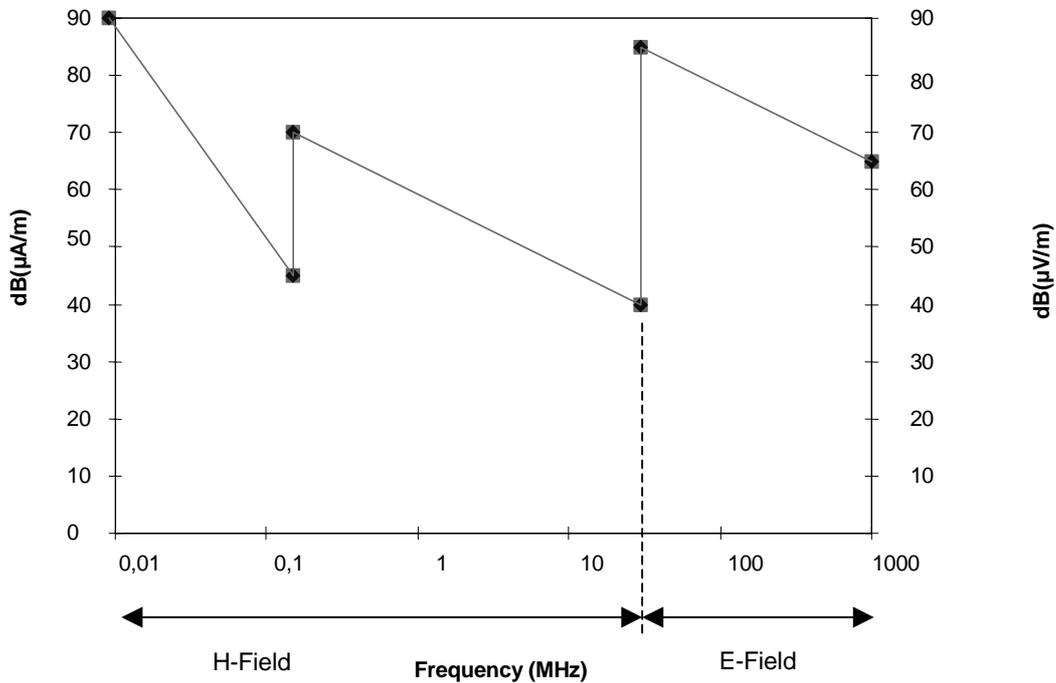
**Emission within the boundary of the substation  
for normal operation and during the operation of switches**

As part of the programme of work to measure the emission from the boundary of the substation, measurements were made of emissions at radio frequencies inside the substation boundary. The antennas were placed in safe positions and fields were measured during normal operation and during the operation of switches. Peak values of field strength were found. Similar values were found in both a.c. and d. c. systems. Antennae were 3 m from switches during tests.

A sufficient number of results were obtained to allow the Figures A.1 and A.2 to be drawn. These show the upper boundary of all results, for the frequency range 9 kHz to 1 000 MHz. Values are peak fields, measured with EN 55016-1-1 test apparatus and with the recommended bandwidths.

Values are included in this annex for information only and must not be interpreted as being the basis for limits. They are an indication of the performance of apparatus of different ages and designs, now in use in railway substations.

Substations have a wide range of configurations, ratings and system voltages. It has not been found possible to set emission limits for apparatus which will be installed within the boundary of the substation. Each specific substation will need to be the subject of detailed study to ensure EMC between the various apparatus used inside the boundary.



NOTE Operation of switches will generate transient radio fields and when the switch interrupts nominal rated current under conditions of rated voltage, the emission when measured with EN 55016-1-1.equipment at 3 m from the apparatus is not expected to exceed:

Frequency (MHz)	Field dB(µA/m) Peak
0,009	90
0,15-	45
0,15+	70
30-	40

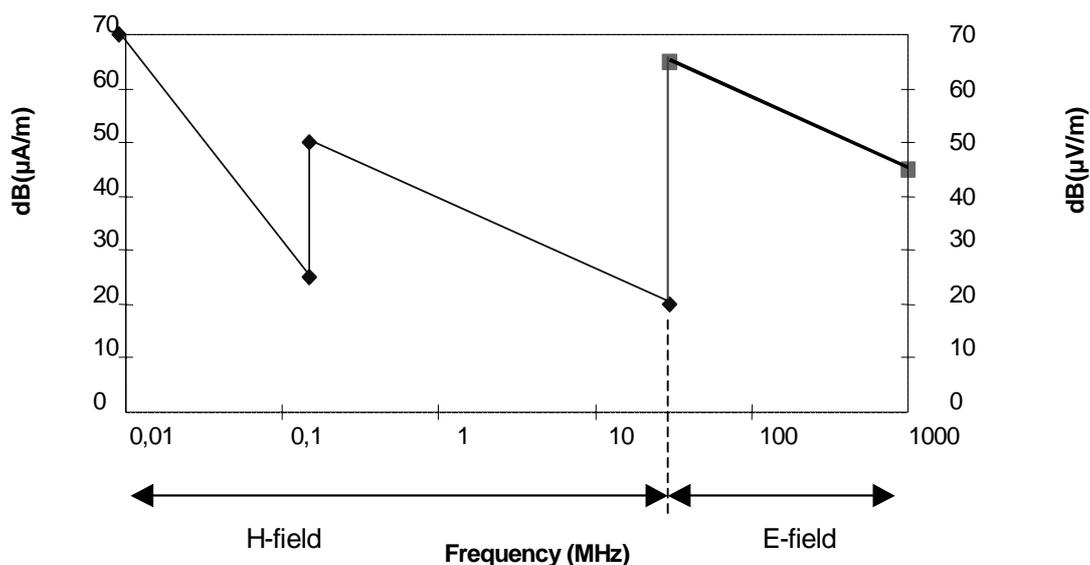
measured by a loop antenna with the base between 1 and 1,5 m above ground level,

Frequency (MHz)	Field dB(µV/m) Peak Vertical polarisation
30+	85
1 000	65

measured with dipole antennae with the centre of the antenna 3 m above ground level, the values being the end points of straight lines on dB / log(f) plots.

The measuring distance is referred to the nearest point of the individual item of apparatus, or its enclosure.

**Figure A.1 – Emission from switches – Peak**



NOTE Due to the wide variety of construction, no limits are set for the emission within the substation boundary (but outside the building) . Measurements have been made in typical substations with CISPR 16-1 equipment and the following values are representative.

Frequency (MHz)	Field dB(µA/m) Peak
0,009	70
0,15-	25
0,15+	50
30-	20

measured by a loop antenna with the base between 1 and 1,5 m above ground level,

Frequency (MHz)	Field dB(µV/m) Peak Vertical polarisation
30+	65
1 000	45

measured with dipole antennae with the centre of the antenna 3 m above ground level, the values being the end points of straight lines on a dB/log(f) graph.

**WARNING**  
 There is a danger of electric shock from uninsulated conductors in most substations and any attempt to measure emissions from these conductors must be done with the most careful attention to ensuring safe methods of working.

Figure A.2 – Emission within substation boundary – Peak

**Annex ZZ**  
(informative)

**Coverage of Essential Requirements of EC Directives**

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Article 4 of the EC Directive 89/336/EEC.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

**WARNING:** Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

### Bibliography

Other standards which are relevant to the EMC behaviour of apparatus used in railway substations are listed below. Where limits are in conflict, those contained within this standard shall take precedence.

- EN 50152-1      Railway applications – Fixed installation – Particular requirements for a.c. switchgear – Part 1: Single phase circuit breakers with Um above 1 kV
- EN 60255 series      Electrical relays (IEC 60255 series, partly mod.)
- EN 60694      Common specifications for high-voltage switchgear and controlgear standards (IEC 60694)
- CISPR 18 series      Radio interference characteristics of overhead power lines and high-voltage equipment
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