IEC 62236-2

Edition 3.0 2018-02
REDLINE VERSION

INTERNATIONAL STANDARD

Railway applications – Electromagnetic compatibility –
Part 2: Emission of the whole railway system to the outside world

IEC 62236-2:2018-02 RLV(en)

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colour inside

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100; 45.060.01

ISBN 978-2-8322-5392-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 2: Emission of the whole railway system to the outside world

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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 organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 62236-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This third edition cancels and replaces the second edition published in 2008. It constitutes a technical revision and has been developed on the basis of EN 50121-2:2015.

This edition includes the following significant technical changes with respect to the previous edition:

a) clarification of scope (Clause 1);
b) combination of former Clause 5 and Annex A related to method of measurement for moving trains and traction substations (5.1);
c) moving emission values for radiated H-fields in the frequency range 9 kHz to 150 kHz to new Annex C due to the fact that:
   – there are very few outside world victims;
   – there is low reproducibility.
d) clarification of acquisition method (5.2).

This International Standard is to be read in conjunction with IEC 62236-1.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
9/2336/FDIS	9/2366/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 62236, published under the general title *Railway applications – Electromagnetic compatibility*, can be found on the IEC website.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

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RAILWAY APPLICATIONS –
ELECTROMAGNETIC COMPATIBILITY –

Part 2: Emission of the whole railway system to the outside world

1 Scope

This part of IEC 62236 ~~sets~~ is intended to define the ~~emission limits from~~ electromagnetic environment of the whole railway system including urban ~~vehicles for use in city streets~~ mass transit and light rail system. It describes the measurement method to verify the emissions, and gives the cartography values of the fields most frequently encountered.

This document specifies the emission limits of the whole railway system to the outside world.

The ~~limits~~ emission parameters refer to the particular measuring points defined in Clause 5 ~~and Annex A~~. These emissions ~~should be~~ are assumed to exist at all points in the vertical planes which are 10 m from the centre lines of the outer electrified railway tracks, or 10 m from the fence of the substations.

Also, the zones above and below the railway system may be affected by electromagnetic emissions and particular cases ~~shall be~~ are considered individually.

These specific provisions are ~~to be~~ used in conjunction with the general provisions in IEC 62236-1.

For existing railway lines, it is assumed that compliance with the emission requirements of IEC 62236-3-1, IEC 62236-3-2, IEC 62236-4 and IEC 62236-5 will ensure the compliance with the emission values given in this document.

For newly built railway systems, it is best practice to provide compliance to the emission limits given in this document (to be defined in the EMC plan according to IEC 62236-1).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility (EMC)*~~

IEC 62236-1:2018, *Railway applications – Electromagnetic compatibility – Part 1: General*

~~IEC 62236-3-1, *Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle*~~

CISPR 16-1-1:2015, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*
CISPR 16-1-4:2010/AMD1:2012
CISPR 16-1-4:2010/AMD2:2017

~~CISPR 22, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*~~

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions ~~of IEC 60050-161 and the following~~ apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
apparatus
~~electric or electronic product with an intrinsic function intended for implementation into a fixed railway installation~~
device or assembly of devices which can be used as an independent unit for specific functions

[SOURCE: IEC 60050-151:2001, 151-11-22]

3.1.2
environment
~~the surrounding objects or region which may influence the behaviour of the system and/or may be influenced by the system~~
surroundings in which a product or system exists, including air, water, land, natural resources, flora, fauna, humans and their interrelation

[SOURCE: IEC Guide 109:2012, 3.3]

[SOURCE: IEC 60050-901:2013, 901-07-01]

~~**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~~

3.1.3
traction substation, <in electric traction>
substation, <in electric traction>
substation the main function of which is to supply an electric traction system

Note 1 to entry: The synonym substation is used only when the context is clear.

[SOURCE: IEC 60050-811:2017, 811-36-02]

3.1.4
rolling stock
all vehicles with or without motors

Note 1 to entry: Examples of vehicles include a locomotive, a coach and a wagon.

[SOURCE: IEC 60050-811:2017, 811-02-01]

3.2 Abbreviated terms

AC	Alternating current
BW	Band width
DC	Direct current
E	Electric (field)
EMC	Electromagnetic Compatibility
FFT	Fast Fourier transform
H	Magnetic (field)
HV	High voltage
ITU	International Telecommunication Union
r.m.s.	root mean square

4 Emission limits

4.1 Emission from the open railway ~~route~~ system during train operation

The emission limits in the frequency range ~~9~~ 150 kHz to 1 GHz are given in Figure 1 and the measurement method is defined in Clause 5. ~~For non-electrified lines, the limits are the same as those given for 750 V d.c.~~

Annex B gives guidance values for typical maximum field values at fundamental frequency of different ~~electrification~~ traction power systems which ~~may~~ can occur. They depend on numerous geometrical and operational parameters which ~~may~~ can be obtained from the infrastructure ~~controller~~ manager.

~~For urban vehicles operating in city streets, the emission limits given in Figure 1 for 750 V d.c. conductor rail shall not be exceeded.~~

~~NOTE 1 There are very few external radio services operating in the range 9 kHz to150 kHz with which the railway can interfere. If it can be demonstrated that no compatibility problem exists, any emission level exceeding the relevant limits given in Figure 1 may be acceptable.~~

NOTE ~~2~~ It is not possible to undertake complete tests with quasi-peak detection due to the reasons stated in Annex A.

There may be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the railway system. The EMC management plan covers these cases and an adequate level of emission from the railway system on these working frequencies may be found in the values given in informative Annex C, hence no guarantee can be given for an undisturbed operation.

4.2 Radio frequency emission from ~~railway~~ traction substations

Radio frequency ~~noise~~ emission from the ~~railway~~ traction substation to the outside environment measured according to the method defined in ~~Annex A~~ Clause 5 shall not exceed the limits in Figure 2.

The limits are defined as quasi-peak values and the bandwidths are those used in CISPR 16-1-1:

	Bandwidth
~~frequencies up to 150 kHz~~	~~200 Hz~~
Frequencies from 150 kHz to 30 MHz	9 kHz (BW 1)
Frequencies above 30 MHz	120 kHz (BW 2)

The distance of 10 m defined in ~~Annex A~~ Clause 5 shall be measured from the fence of the substation. If no fence exists, the measurements shall be taken at 10 m from the apparatus or from the outer surface of the enclosure if it is enclosed.

~~Emission of trains shall not enter into the measurement.~~

~~NOTE 1 There are very few external radio services operating in the range 9 kHz to 150 kHz with which the railway can interfere. If it can be demonstrated that no compatibility problem exists, any emission level exceeding the relevant limits given in Figure 2 may be acceptable.~~

~~NOTE 2~~ For other kinds of fixed installations like auto-transformers, the same limit and measuring distance shall be applied.

There may be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the traction substation. The EMC management plan covers these cases and an adequate level of emission from traction substation on these working frequencies may be found in the values given in informative Annex C, hence no guarantee can be given for an undisturbed operation.

5 Method of measurement of emission from moving ~~trains~~ rolling stock and substations

5.1 General and specific measurement parameters

NOTE The method of measurement is adapted from CISPR ~~16-1-1~~ 16-2-3 to a railway system with moving ~~vehicles~~ rolling stock and substations. The background to the method of measurement of moving rolling stock is given in Annex A.

~~The electromagnetic fields generated by rail vehicles when operating on a railway network are measured by means of field strength meters with several different set frequencies. The horizontal component of the magnetic field perpendicular to the track and both the vertical and horizontal (parallel to the track) components of the radiated electric field are measured.~~

5.1.1 General measurement parameters

5.1.1.1 Frequency bands

~~The peak measurement method is used. The duration at selected frequency shall be sufficient to obtain an accurate reading. This is a function of the measuring set and the recommended value is 50 ms.~~

Frequency bands and bandwidths at –6 dB used for measurements are in accordance with CISPR 16-1-1.

These are:

Frequency bands:	~~9-150 kHz~~	0,15 MHz to 30 MHz	30 MHz to 300 MHz	300 MHz to 1 GHz
Bandwidth:	~~200 Hz~~	9 kHz (BW 1)	120 kHz (BW 2)	120 kHz (BW 2)

~~When connected to the antenna, the error of measurement of the strength of a uniform sine-wave field shall not differ more than ± 4,0 dB from CISPR 16-1-1 equipment.~~

Other bandwidth for peak measurement can be chosen according to CISPR 16-1-1. Data measured with the reference bandwidth shall take precedence.

~~The noise may not attain its maximum value as the traction vehicle passes the measuring point, but may occur when the vehicle is a long distance away. Therefore, the measuring set shall be active for a sufficient duration before and after the vehicle passes by to ensure that the maximum noise level is recorded.~~

5.1.1.2 Measurement uncertainty

The measurement uncertainty of the measuring equipment shall comply with the requirements in CISPR 16-1-1 and CISPR 16-1-4.

Due to the measurement method, the normalized site attenuation may not be considered in the measurement uncertainty.

5.1.1.3 Types of antennas

To cover the full frequency range, antennas of different design are required. Typical equipment is described below:

- ~~for 9 kHz to 30 MHz, a loop or frame antenna is used to measure H field (see Figure 3);~~
- for 150 kHz to 30 MHz, a loop or frame antenna is used to measure H field (see Figure 3);
- for 30 MHz to 300 MHz, a biconical dipole is used to measure E field (see Figure 4);
- for 300 MHz to 1,0 GHz, a log-periodic antenna is used to measure E field (see Figure 5).

For measurements in the frequency range of 30 MHz to 1 GHz a combined antenna may be used.

Calibrated antenna factors are used to convert the terminal voltage of the antenna to field strength.

5.1.1.4 Measurement distance and height

The preferred distance of the measuring antenna from the centreline of the track on which the vehicle is moving (Test track) is 10 m. In the case of the log-periodic antenna, the 10 m distance is measured to the mechanical centre of the array.

~~It is not considered necessary to carry out two tests to examine both sides of the vehicle, even if it contains different apparatus on the two sides, since the majority of the emission is produced by the sliding contact if the train is moving.~~

The preferred distance of the measuring antenna while measuring the emission of the substation is 10 m from the outer fence of the substation, at the midpoints of the three sides, excluding the side which faces the railway system, unless this side is more than 30 m from the centre of the nearest electrified railway track. In this case all four sides shall be measured. If the length of the side of the substation is more than 30 m, measurements shall be taken additionally at the corners.

Where the tests are carried out at a site which meets all the recommended criteria except that the antennas are not at 10 m from the track centreline, the results can be converted to an equivalent 10 m value by using the following formula:

$$E_{10} = E_x + n \times 20 \times \log_{10} (D/10)$$

where

E_{10} is the value at 10 m;

E_x is the measured value at D m;

n is a factor taken from Table 1 below.

Table 1 – Conversion factor *n*

Frequency range	*n*
9 kHz to 150 kHz	2
0,15 MHz to 0,4 MHz	1,8
0,4 MHz to 1,6 MHz	1,65
1,6 MHz to 110 MHz	1,2
110 MHz to 1 000 MHz	1,0

The measured values (at the equivalent 10 m distance) shall not exceed the limits given in Figure1 for the appropriate system voltage.

Where the physical layout of the railway totally prevents the use of reference distances, a method shall be agreed to suit the particular circumstances. For example, if the railway is in tunnel, miniature antennas can be used on the wall of the tunnel. In such a case, the limits selected shall take into account the method of measurement.

No measurements are necessary for total underground railway systems with no surface operation (no victim outside this railway system can be affected).

The height above rail reference level of the antenna centre shall be within the range 1,0 m to 2,0 m for the loop antenna, and within 2,5 m to 3,5 m to the centre of dipole or log-periodic antennas measuring antenna above 30 MHz. One measuring height within the given range is sufficient and it is not required to do measurements with several antenna heights within this range. The selected height shall be noted in the test report.

The reference level for the substation is the ground.

The reference level for moving trains is the top of the rail.

If the actual level of the ground at the antenna differs from the top of the rail level by more than 0,5 m, the actual value shall be noted in the test report.

It is accepted that the fixed antenna position may result in values being less than the absolute maximum at some frequencies.

5.1.1.5 Values of measurement

The values measured are expressed as:

– dBµA/m for magnetic fields,
– dBµV/m for electric fields.

These are obtained by using the appropriate antenna factors and conversions.

5.1.1.6 Antenna position and orientation

The plane of the loop antenna shall be ~~vertical and parallel to the line of the track~~ positioned to measure the horizontal component of the magnetic field perpendicular to the track respectively to the wall of the substation. The biconical dipole shall be placed in the vertical and horizontal axis. The log periodic antenna shall be arranged to measure the vertical and horizontal polarization signal, with the antenna directed towards the track respectively to the wall of the substation.

The test locations should whenever possible avoid objects with changing of field characteristic like turnouts, walls and under bridges.

Figures 3, 4 and 5 show the positions and vertical alignments of the antennas as an example for measurements at the track.

5.1.1.7 Ambient noise

At the beginning and at the end of the test series the ambient noise shall be recorded.

If at specific frequencies or in specific frequency ranges the ambient noise is higher than the limit values less 6 dB (ambient noise > (emission limit – 6 dB)), the measurements at these frequencies need not be considered. These frequencies shall be noted in the test report.

5.1.2 Measurement parameter for moving trains

This subclause summarizes the specific conditions for the measurement of moving rolling stock.

– It is not considered necessary to carry out two tests to examine both sides of the rolling stock, even if it contains different apparatus on the two sides, as in the majority of cases the level of fields is due to the radiation of catenary and not to the direct radiation from the train. For systems with a third rail, measurements have to be performed at the same side of it.
– The peak measurement method is used. The duration at selected frequency shall be sufficient to obtain an accurate reading. This is a function of the measuring set and the recommended value is 50 ms.
– The noise may not attain its maximum value as the traction vehicle passes the measuring point, but may occur when the vehicle is a long distance away. Therefore, the measuring set shall be active for a sufficient duration before and after the vehicle passes by to ensure that the maximum noise level is recorded.
– In the case of elevated railway systems, if the antenna heights specified above cannot be achieved, the height of the antenna centre can be referenced to the level of the ground instead of to the top of the rail ~~level~~. The conversion formula in 5.1.1.4 shall be employed where D is the slant distance between the train and the antenna. The train shall be visible from the location of the antenna and the axis of the antenna shall be elevated to point directly at the train. A measurement distance of 30 m from the track centreline is preferred for highly elevated railway~~s~~ systems. Full details of the test configuration shall be noted in the test report.
– If tests are being carried out on a railway system with overhead electrified supply, the measuring point shall be at ~~the mid-point~~ midspan between the support masts of the overhead contact line and not at a discontinuity of the contact wire. It is recognized that resonance can exist in an overhead system at radio frequencies and this may require

changes in the values of frequency chosen for measurement. If resonance exists, this ~~should~~ shall be noted in the test report.

The radio frequency emission will be affected by the state of the railway system supply system. Switching of feeder stations and temporary works will influence the response of the system. It is therefore necessary to note the condition of the system in the test record and, if possible, all similar tests should be carried out within the same working day. Where the railway system has a track-side conductor rail power supply, the test location should be at least 100 m from gaps in the rail, to avoid inclusion of the transient fields associated with the make and break of collector contact. The conductor rail and the antennas shall be on the same side of the track.

– The test sites do not correspond to the definition of a completely clear site because they are influenced by overhead structures, rails and the catenary. However, wherever possible, antennas shall be ~~placed~~ installed well away from reflecting objects. If ~~overhead~~ HV power lines are nearby, other than those which are part of the railway network, they should be no closer than 100 m to the test site.

~~Background noise shall be measured at the test site in the absence of train effects. This will give the noise values from the energised power supply conductors. If this is significant, it is advisable to measure also at 100 m from the test site, to identify any high non-railway sources of noise.~~

5.1.3 Measurement parameter for traction substations

This subclause summarizes the specific conditions for the measurement of substations.

– Test configurations: In view of the special geometry of a railway system traction supply system, it is necessary to perform the measurement of emission of electromagnetic fields under normal feeding configuration of the traction supply system.
– Substation load: A feature of traction substations is that the load can change widely in short times. Since emission can be related to load, the actual loading of the substation shall be noted during emission tests.
– Each measurement shall be started with a peak max hold sweep. If the limits are exceeded due to the substation then it is required to take a measurement from a quasi-peak over the specific frequency range where these limits have been overrun. It is known that the load condition cannot be reproduced exactly during quasi-peak measurement, hence these load conditions should be at least comparable.

~~5.2 Frequency selection~~

~~5.2.1 Selected frequencies~~

~~The selection of the actual frequencies to be measured will depend on the circumstances of the test site.~~

~~If high signals exist, for example from public broadcasting stations, the selection of test frequencies shall take this into account.~~

~~It is recommended that test frequencies are selected so that there are at least three frequencies per decade.~~

~~5.2.2 Sweep frequency~~

~~In view of the short time available for measurement in one train passage, the use of a sweep frequency measuring technique, in which the peak noise is measured with a peak-hold circuit as the frequency is changed, may offer adequate information concerning generation of noise. There will still remain problems of time because the rate of change of frequency is a function of the bandwidth, due to considerations of accuracy. A sweep analyser will usually set its own sweep rate to meet this requirement. If this method is used, sweep rate as well as bandwidth shall be noted.~~

5.2 Acquisition methods

5.2.1 General

The electromagnetic disturbances generated by railway network including operating rolling stock are measured by the two following methods:

a) the fixed frequency method;

b) the frequency sweeping method.

The measurement method shall be chosen according to the rolling stock operating modes (see 5.4.2) depending on the train speed.

– For test at high speed the following has to be taken into account:

The fixed frequency method can be used, because it allows continuous monitoring at each frequency.

Alternative methods are allowed if the equivalent scan rate is at least that defined in Table 2 which is sufficiently short for such a moving source.

This ensures that the frequency results are measured at least every 5 m of train movement.

At higher speeds a spectrum analysis swept frequency method is unlikely to be practical, but FFT techniques may be feasible. The measurement equipment shall comply with CISPR 16-1-1.

Table 2 – Scan rate

Speed of train km/h	Speed of train m/s	Time for an observation width of 5 m (scan rate) s
60	16,67	0,300
100	27,78	0,180
200	55,56	0,090
300	83,33	0,060
320	88,89	0,056
NOTE Observation width is the part of rolling stock to be observed in given time.		

– When the rolling stock will be moving at a slower speed with the maximum rated power (see 5.4.2), the frequency sweeping method shall be used.

5.2.2 Fixed frequency method

The fixed frequency method consists of measuring the radiated emissions at only some frequencies (it is recommended to take at least 3 frequencies per decade) using the zero span mode of the spectrum analyser or setting the measuring receiver at the frequency to be checked.

The fixed frequencies shall be chosen according to the ambient noise, i.e. in the areas where the ambient field is the lowest.

The measurement of the field level shall be performed for each frequency during a complete passage of the train.

5.2.3 Frequency sweeping method

For the frequency sweeping method, the frequency range shall be divided into several sub-ranges according to the train speed in order to have a relevant sweep time in comparison with the train speed.

The measurement of the field level shall be performed in each sub-range during a complete passage of the train. The max-hold function of the spectrum analyser shall be used.

5.3 Transients

During the test, transients due to switching may be detected, such as those caused by operation of power circuit breakers. These shall be disregarded when selecting the maximum signal level found for the test.

5.4 Measuring conditions

5.4.1 Weather conditions

To minimize the possible effect of weather on the measured values, measurements should be carried out in dry weather, (after 24 h during which not more than 0,1 mm rain has fallen), with a minimum temperature of ~~at least~~ 5 °C, and a wind velocity of less than 10 m/s.

Humidity should be low enough to prevent condensation on the power supply conductors.

Since it is necessary to plan the tests before the weather conditions can be known, tests will ~~have to~~ be carried out in the weather conditions ~~which do not meet the target conditions~~ found. In these circumstances, the actual weather conditions shall be recorded with the test results.

5.4.2 Railway system operating modes

Two test conditions are specified for the traction mode and are:

a) measurement at a speed of more than 90 % of the maximum service speed, (to ensure that the dynamics of current collection are involved in the noise level) and at the maximum power which can be delivered at that speed;

b) at the maximum rated power and at a selected speed~~, (particularly if the lower frequencies are of concern)~~.

If the vehicle is capable of electric braking, tests are required at a brake power of at least 80 % of the rated maximum brake power.

5.4.3 Multiple sources from remote trains

For the purpose of limits, the presence of “physically-remote but electrically-near” vehicles out of the test zone is regarded as insignificant when considering radio noise.

5.5 Test report

The test report shall contain the following information:

– description of site;
– description of measuring system;
– description of railway vehicle (type, configuration and mode of electric braking);
– numerical results;
– graphical results where relevant (The results shall include information such as bandwidths, date, time, ambient noise and excluded frequencies (see 5.1.1.7));

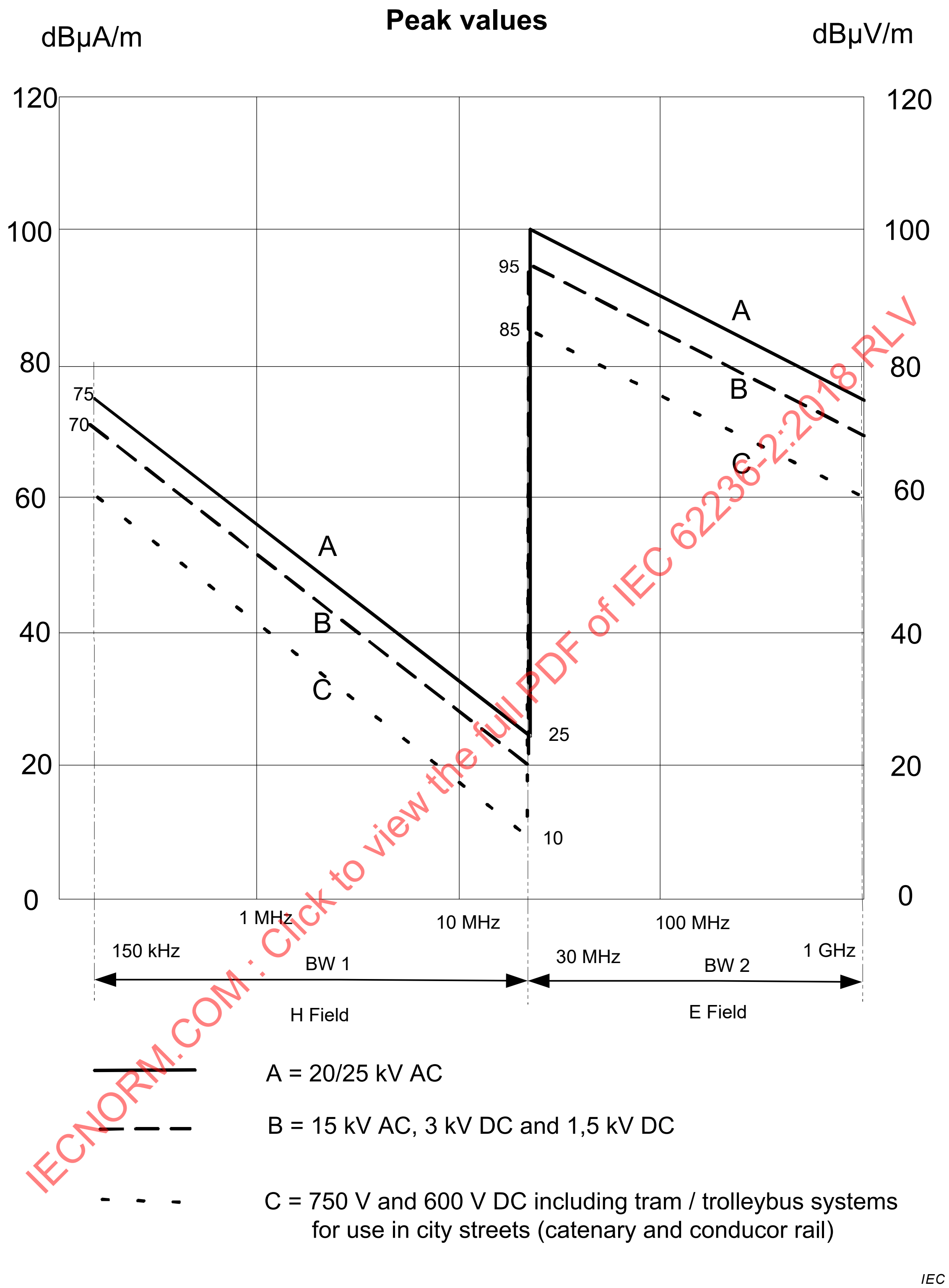
– weather conditions;
– name(s) or equivalent identification of person(s) in charge at site authorizing the test report.

5.6 Antenna positions

Figure 3 shows the position of the antenna for measurement of the magnetic field in the 9 kHz to 30 MHz frequency band.

Figure 4 shows the position (vertical polarisation) of the antenna for measurement of the electric field in the 30 MHz to 300 MHz frequency band. For the measurement of the horizontal field parallel to the track, the antenna is turned by 90°.

Figure 5 shows the position (vertical polarisation) of the antenna for measurement of the electric field in the 300 MHz to 1 GHz frequency band. For the measurement of the horizontal field parallel to the track, the antenna is turned by 90°.



~~NOTE 1 The discontinuities of the curves are due to changing of the bandwidth of the measurement receiver: bw1 = 200 Hz; bw2 = 9 kHz; bw3 = 120 kHz.~~

~~NOTE 2~~ Values are 10 m from the railway track.

Figure 1 – Emission limits in frequency range ~~9~~ 150 kHz to 1 GHz

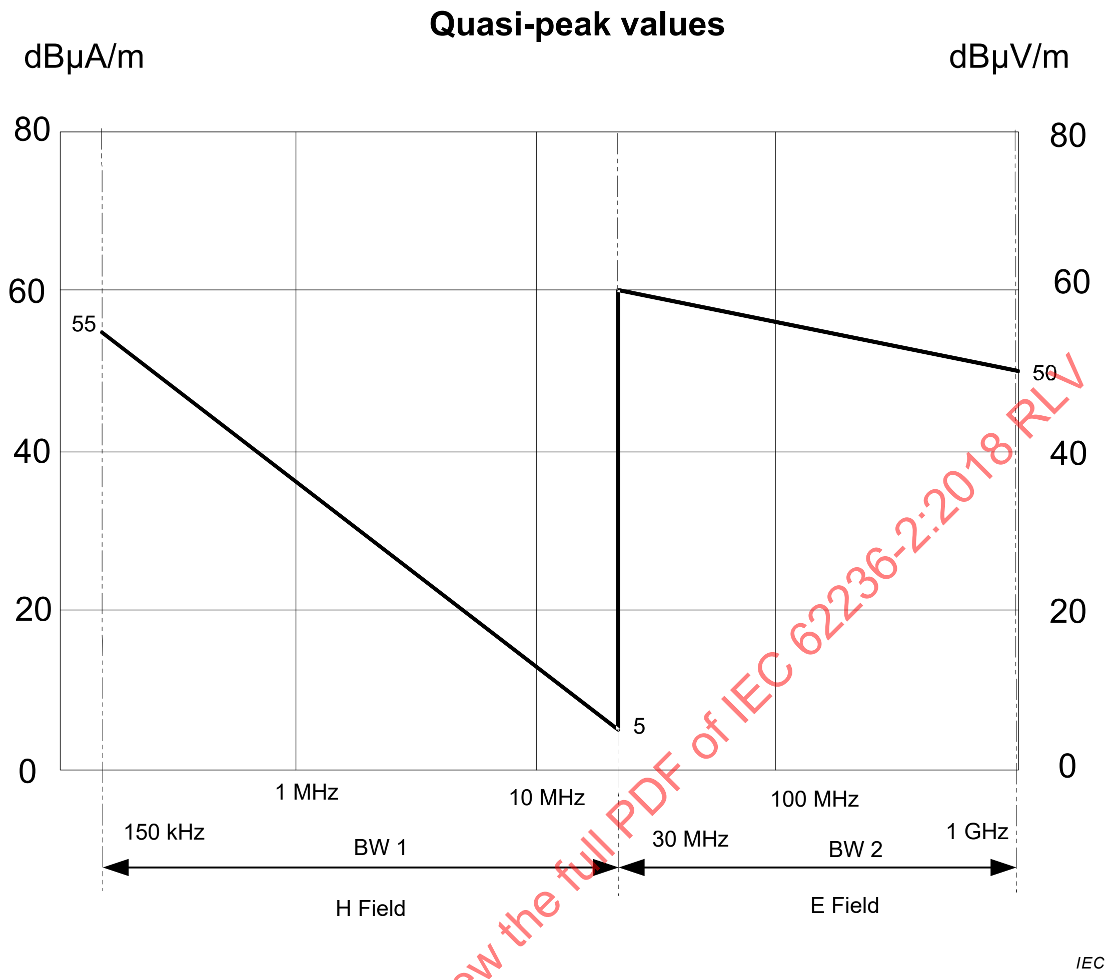


Figure 2 – Emission limit for substations

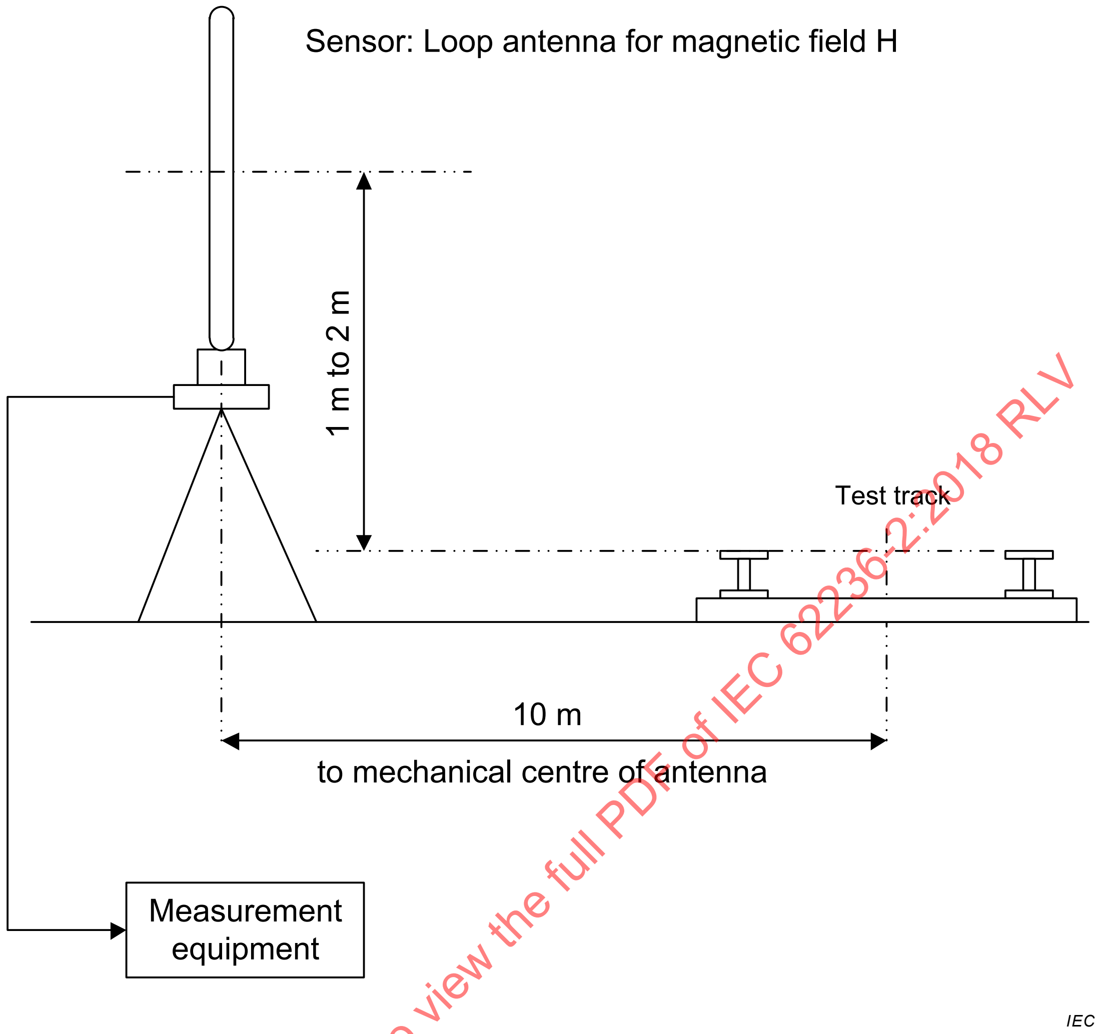


Figure 3 – Position of antenna for measurement of horizontal component of magnetic field in the ~~9~~ 150 kHz to 30 MHz frequency band

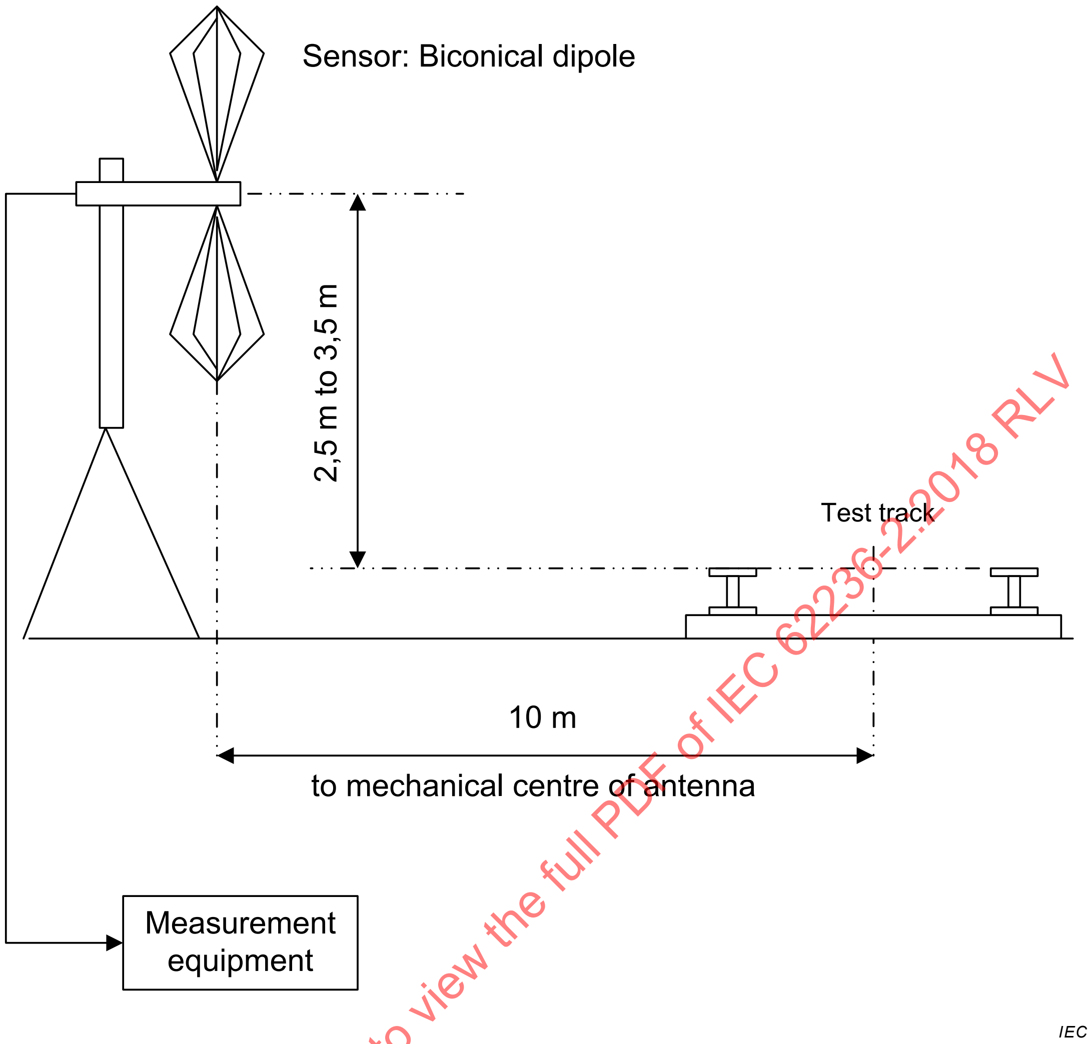


Figure 4 – Position (vertical polarization) of antenna for measurement of electric field in the 30 MHz to 300 MHz frequency band

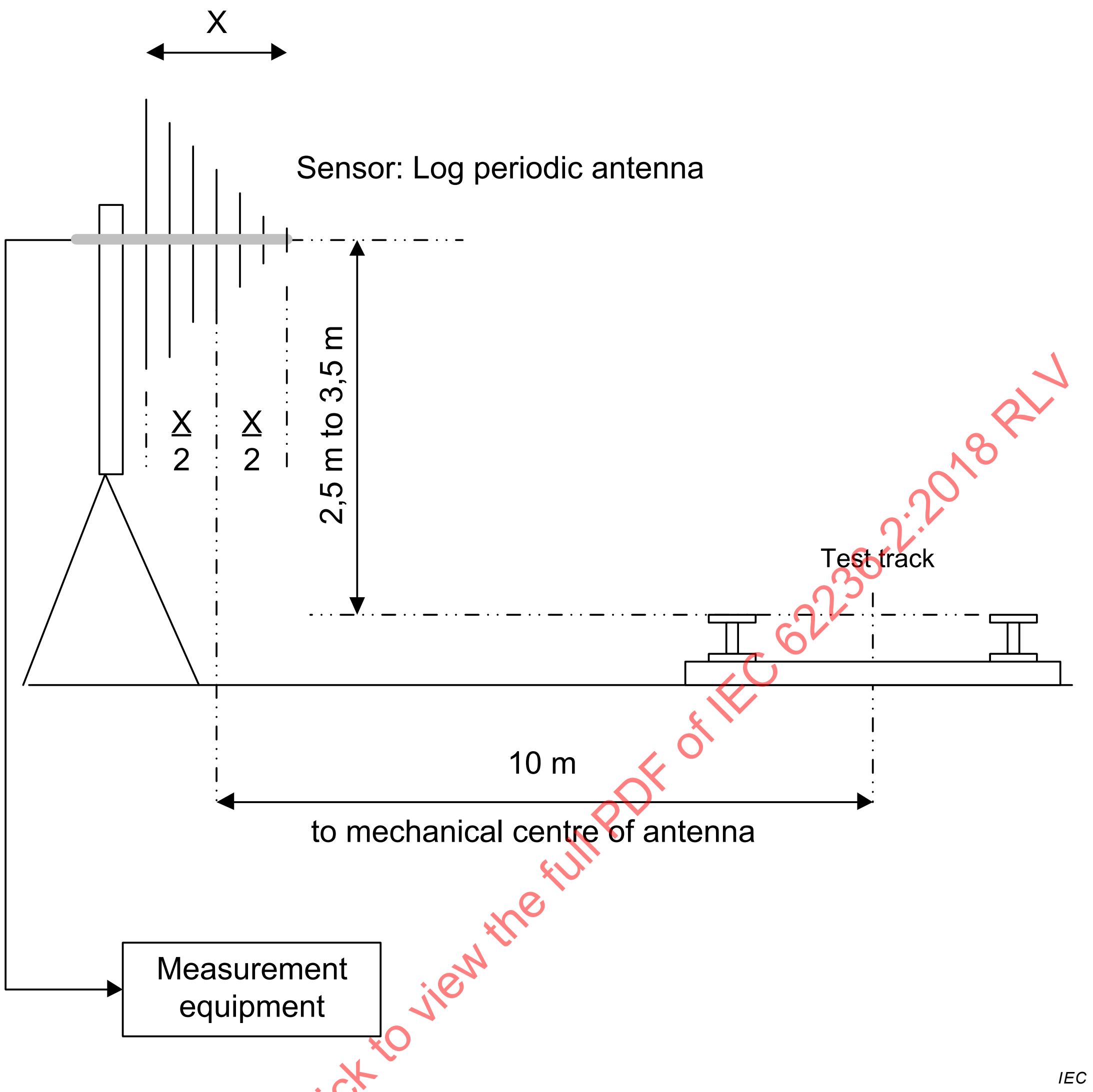


Figure 5 – Position (vertical polarization) of antenna for measurement of electric field in the 300 MHz to 1 GHz frequency band

Annex A
(normative)

Method of measurement of electromagnetic emission from railway substations

A.1 Positions for tests

In view of the special geometry of a railway traction supply system, it is necessary to define the conditions for the measurement of emission of electromagnetic fields under normal load conditions.

A.2 Substation load

A feature of railway substations is that the load can change widely in short times. Since emission can be related to load, the actual loading of the substation shall be noted during emission tests.

A.3 Method of measurement

Emission shall be measured at a distance of 10 m from the outer fence of the substation, at the midpoints of the three sides, excluding the side which faces the railway, unless this side is more than 30 m from the centre of the nearest electrified railway track. In this case all four sides shall be measured. If the length of the side of the substation is more than 30 m, measurements shall be taken additionally at the corners.

The accuracy of the measuring equipment for the radio frequency tests shall not differ by more than ± 4,0 dB from the requirements of CISPR 16-1-1.

At each measuring position, the following shall be measured:

a) the maximum radio emission at a frequency in the neighbourhood of 1 MHz (selected on site to avoid other transmissions), measured by vertical plane loop antenna, noting the orientation of the antenna. The loading of the substation shall be at least 30 % of the rated load. The base of the loop antenna shall be between 1 m and 1,5 m above ground;

b) the radio emission over the frequency range 9 kHz to 30 MHz, measured with the loop in the maximum orientation position as under a). The loading of the substation shall be at least 30 % of the rated load during these measurements;

NOTE It is accepted that the fixed antenna position may result in values being less than the absolute maximum at some frequencies.

c) the maximum radio emission over the frequency range 30 MHz to 300 MHz, measured typically by vertical dipole or vertical biconical antenna. The loading of the substation shall be at least 15 % of the rated load during the measurements. The centre of the antenna shall be 3 m above ground,

d) the maximum radio emission at a frequency in the neighbourhood of 350 MHz (selected on site to avoid other transmissions), measured typically by vertical polarised log-periodic antenna, noting the orientation of the antenna. The loading of the substation shall be at least 15 % of the rated load. The centre of the antenna shall be 3 m above ground,

e) the radio emission over the frequency range 300 MHz to 1 GHz, be measured typically with the log-periodic antenna in the maximum orientation position as under d). The loading of the substation shall be at least 15 % of the rated load during these measurements. The centre of the antenna shall be 3 m above ground.

Annex A
(informative)

Background to the method of measurement

A.1 General

This annex describes a method of measuring the electromagnetic noise emitted by a railway network when railway vehicles are moving on the network. Existing methods are not considered to be appropriate, because the vehicles may be moving at significant speeds. A separate document (IEC 62236-3-1:2018) covers the case of stationary and slow moving vehicles. Both traction and trailer vehicles should be examined since the trailers may contain electric equipment which can emit noise. It is also necessary to test diesel traction vehicles since they may contain sources of radio emission. The method allows an assessment to be made of the disturbance which would be caused to other users of the electromagnetic spectrum. The document describes a reference method of measurement.

A.2 Requirement for a special method of measurement

For frequencies above ~~9~~ 150 kHz, there is a standard method of measuring radio fields and this is described in CISPR 16-1-1.

A railway network has particular features which make necessary the use of a special method of measurement. These features include a rapidly moving source and the possibility of radiation from the long antenna formed by the electrical supply conductors of an electrified railway system.

~~The example given in Figure B.1 shows the time variation of emission from a moving train with many transient events.~~

This method of measuring railway system noise does not ~~follow~~ always use the quasi-peak method of CISPR 16-1-1 because measurements conducted on the basis of that method are not sufficient (due to the moving source) to enable the full extent of the disturbances affecting other systems in the vicinity to be identified. ~~The method of CISPR 16-1-1 is only designed to protect radio communication from interference and takes no account of electronic safety systems such as those used beside the railway track or at airports, where short-time transients may cause interference. If the CISPR 16-1-1 method were to be selected as a basis for European Standards, it would still be necessary to apply peak detection methods to meet the needs of local industry and undertake realistic simulation exercises. In the case of railways, this need for double testing would lead to difficulties.~~

It appears difficult to establish an exact link between the values obtained with the peak and quasi-peak methods, in view of the fact that the disturbances created by the vehicle may be almost constantly sinusoidal at the working frequency of some of the on-board ground-to-train transmission equipment, or a series of repeated pulses for other sources, for example the pantograph/overhead line contact. However, in all cases, the value measured with a peak detection system will be greater than or equal to the value obtained with a quasi-peak system in accordance with CISPR 16-1-1.

A.3 Justification for a special method of measurement

Fields are not measured using the method of CISPR 16-1-1, but with peak detection within a short time window, 50 ms being recommended, at the selected frequency because:

– this gives a better representation of the effect on any system (electronic or computer), whereas the weighting principles applied with quasi-peak detection are only representative of interference in relation to radio transmission. The time window of 50 ms will capture the peak emission from AC railways systems which tends to occur at current reversals. On 16,7 Hz, these reversals are 33 ms apart and one will always be detected within the 50 ms window;

– it is also faster, for with. For some quasi-peak detector systems as much as up to 1 s is necessary because of the requirements of galvanometer-type instruments. This is far too long in the case of a moving train,

– it gives the maximum value that could be measured with the method of CISPR 16-1-1 and is representative of the "worst possible case" for interference to radio transmission.

A.4 Frequency range

Although the railway vehicle and sliding contact current collection are also sources of noise above 1 GHz, the emission levels are low and attenuation with distance is high. Therefore, no proposals are made at present for measurements above 1 GHz.

~~B.5 Comments to bandwidth~~

~~Bandwidths other than those given in 5.1.2 are available in suitable measuring equipment, such as 300 Hz for the 9 kHz to 150 kHz band, and 7,5 kHz or 10 kHz for 0,15 MHz to 30 MHz. In the 9 kHz to 150 kHz band, the bandwidth is small, but this is valuable since it improves the ability to find specific sources of noise. In the 0,15 MHz to 30 MHz range, the difference between 7,5 kHz, 9 kHz and 10 kHz will not be significant in terms of identification. If bandwidths other than those given above are used, the results shall be converted to the approved bandwidth on the basis that the noise is impulsive in nature~~

~~B.6 Accuracy of the measurement equipment~~

~~The accuracy value ± 4 dB given in 5.1.3 is chosen since it is known that a test repeatability of ± 10 dB or more is found for nominally similar conditions. The measuring sets defined in CISPR 16-1-1 are very accurate but this accuracy is unreal when the emission varies so much between tests. The use of measuring apparatus of less accuracy may be permitted (sweep frequency analysers for example), where it has been verified that the results do not differ by more than ± 4 dB from CISPR 16-1-1 apparatus. Sweep analysers are available with peak and quasi-peak detection, and bandwidths given in CISPR 16-1-1.~~

A.5 Antenna positions

There are options for choosing the distance of the antenna from the centre-line of the track. The usual distances used for radio frequency tests are 1 m, 3 m, 10 m and 30 m. A value of 1,0 m is impossible and if 3 m is chosen, there is a possibility that the vehicle body will have a very strong local effect and this may give a false impression of the field at greater distances. A distance of 10 m is preferred since, with an electric traction supply, the sliding contact is directly viewed by the antenna and body effects are less. Another standard distance is 30 m and this may be easier to provide at particular sites, but the signal strength is lower and local noise may make it more difficult to obtain values of railway system noise. Hence, the distance selected for measurements is 10 m in relation to the centre line of the track on which the vehicles are running.

NOTE Steps should be taken to ensure that the measuring equipment and any associated power supply and apparatus does not affect the readings.

A.6 Conversion of results if not measured at 10 m

The values of n are based on observations made with overhead power lines and are for open country sites. In built-up urban areas, higher values of n will be found. The values of n listed in 5.1.1.4 are known to be adequately accurate since the value of n for 100 MHz was specifically measured for a railway system and was found to be 1,25, for distances up to 100 m. CISPR 22 uses –20 dB per decade of distance (n = 1), but this is a special case for a conducting ground plane.

When testing at 10 m, it is important to recall that the induction field and the radiation field have different characteristics near to the source. If the distance is small compared to the wavelength, the induction field will predominate. The position with respect to a point source at which these two fields have equal magnitudes is at a theoretical distance of (wavelength/2π). Hence, if 10 m is taken as the measuring distance, all tests below about 5 MHz are in the near field where the magnetic induction signal dominates. Results are then most accurately expressed in A/m. In the near field, the E field is low and is not usually a cause of disturbance. With an extended source such as a train, the near field zone may extend further than the “point source” theory would suggest.

For the purposes of this method, the ampere per metre fields are converted to volts per metre by multiplying by the impedance of free space (120 π Ω).

A single height is used for the dipole and log-periodic antenna since variable height cannot be used as is usual for emission testing.

The position of antennas in the middle between masts reduces the screening effect of the masts and the local transients due to sparking which are commonly found at the mast, where the mechanical impedance may change suddenly. Similarly, booster transformers, overlaps, section insulators, neutral sections and other major irregularities should be avoided.

A.7 Measuring scales

On the log scale: 1 µV/m is 0 dBµV/m and 1,0 V/m is 120 dBµV/m. (A similar relationship applies for µA/m and dBµA/m).

Limit values may be expressed in A/m and V/m and these can be derived as necessary.

Electrical field strength in dBµV/m = magnetic field strength in dBµA/m + 51,5 if the measurement is taken in the far field (51,5 = 20 $\log_{10}$(impedance of free space wave)).

A.8 Repeatability of results

A special problem with measurements of railway system radio frequency emissions is that the source is moving along the railway system. This makes it difficult to collect a large number of results from the trackside and it is therefore necessary to define the conditions for measurement so that some degree of repeatability can be achieved.

To reduce the chance that remote vehicles will produce significant emissions at the test point, by phenomena such as resonance, any other vehicles supplied on the same catenary or supply rail should be at sufficient distance from the test point. For catenary supply, a distance of 20 km is suggested and for supply rail systems a distance of 2 km.

Even under these conditions, substantial variation between test results is to be expected.

~~B.11 Frequency selection~~

~~Another consideration, due to the movement of the vehicle, is that measurements at different frequencies across the required range are difficult due to the short time of the test. Three methods can be used to allow sufficient data to be captured. Tests can be done at several selected frequencies during one train passage; a frequency sweep technique can be used during one train passage; or one frequency is measured for each passage, requiring many passages of the train.~~

~~To obtain short time windows, use can be made of computer driven measuring sets in which the frequency is reset and held only long enough to take a reading. This allows 5 or more frequencies per second to be measured. To give adequate cover of the spectrum, a minimum of at least three frequencies per decade should be examined.~~

~~In the range 9 kHz to 150 kHz, the traction equipment may be a source of noise at clearly identifiable frequencies. It is desirable that a search be made in this range to find these noise maxima and to measure at these frequencies. Note that radio signals from outside transmitters can be found, even at these low frequencies, and these should be identified and avoided. For frequencies above 150 kHz, it is not considered necessary to make a separate search for characteristic frequencies from the vehicle.~~

~~Another option would be to use fewer frequencies and assume a linear characteristic. However, this linear assumption is not soundly based, since the vehicle may produce strong signals at a specific frequency and additionally the overhead may exhibit resonant behaviour. The use of three frequencies per decade is therefore the minimum requirement and it is advantageous if more frequencies can be used.~~

A.9 Railway system conditions

A.9.1 Weather

When the railway system is an outdoor network, weather will affect the level of radio noise which is produced. For HV power lines, the noise increases by about 20 dB during rain. With railway~~s~~ systems, the noise from the pantograph contact may reduce with rain, as the carbon film on the contact wire is removed, giving a closer contact between wire and pantograph. If ice has formed on the supply conductor, increased arcing will take place and give increased noise. If the wind velocity is high, the mechanics of the overhead conductor will be affected and the contact between wire and pantograph will be affected. The effect of weather on the emission of noise from railway vehicles is not yet fully understood.

A.9.2 Speed, traction power

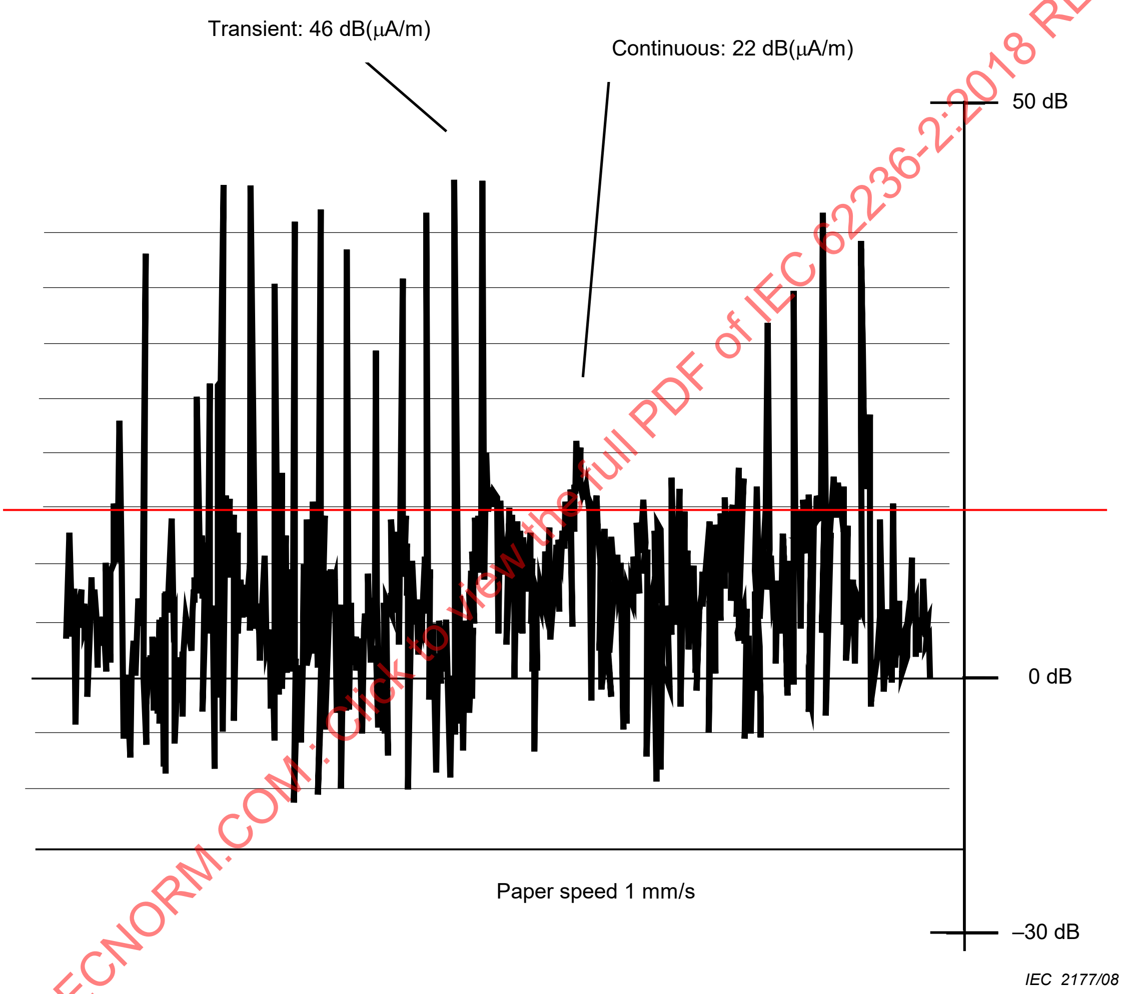
To give some valid comparison, noise measurements of a moving vehicle ~~shall be~~ are made under specified conditions when the vehicle is travelling at some selected proportion of its maximum speed and, if it is a traction vehicle, is delivering some selected proportion of its continuous rated power. Values for these proportions need to be selected and this process needs to take into account the operating envelope of the vehicle. An ideal provision is that the vehicle should operate at the condition which produces the maximum radio noise, but since there is as yet no method by which this can be defined, such a requirement is not used.

A.9.3 Multiple sources from remote trains

In real cases, more than one traction vehicle may be within the disturbance zone of an affected object. For the purpose of limits, the presence of "physically-remote but electrically-near" vehicles out of the test zone is regarded as insignificant when considering radio noise. This recognizes that the sources are moving and that although the remote vehicles are sources of noise, the attenuation with distance for the higher frequencies is normally high. When fields at the lower frequencies of measurement are considered, the attenuation is low and all vehicles within the zone of influence (which may extend several km) can affect the noise level. The effect of addition is however within the repeatability error of the tests and the emission from a single train can be assessed against the limit.

A.10 Number of traction vehicles per train

When traction vehicles are coupled, the contact quality of the trailing pantographs can be disturbed and a higher noise emission may occur. If tests are to be done in the maximum train consist, with coupled vehicles, they should be the subject of a specific request. Related to the permitted emission from this test ~~should take into account the fact~~ it is mentioned that trains may operate in multiple ~~units~~ and thereby generate more noise.



~~**Figure B.1 – Time variation of emissions from a moving train with many transient events**~~

Annex B
(informative)

Cartography – Electric and magnetic fields at traction frequencies

Table B.1 gives typical numerical values of quantities describing the emission of the railway system to the outside world (cartography).

The quantities given are the electric field E and the magnetic field H of the DC or the AC fundamental component, calculated for conductor arrangements regarded to be typical for the respective type of electrification.

Table B.1 – Typical maximum electric and magnetic field values at fundamental frequency of different electrification systems

System	Freq.	E-field		H-field		Reference conditions	Reference documentation
	Hz	V/m	dBµV/m	µT	dBµA/m		
750 V to 1 200 V conductor rail	0	< 10		46	151	I_c = 4 000 A 50 % return current in rails	
600 V to 750 V ~~catenary~~ power supply line	0	35		15		I_c = 1 000 A 50 % return current in rails	IEC TR 61000-2-7
1 500 V ~~catenary~~ power supply line	0	63	156	111	159	I_c = 8 000 A U = 1 800 V No aerial wire	ITU(T) Directives ~~CIGRE WG 3601~~
3 kV	0	50	154	28	147	I_c = 3 000 A, U = 3,6 kV Aerial wire	ITU(T) Directives ~~CIGRE WG 3601~~
15 kV	16,7	750	177	40	150	I_c = 2 000 A, r.m.s. U = 17,25 kV No aerial wire	ITU(T) Directives ~~CIGRE WG 3601~~
25 kV	50	1 000	180	16	142	I_c = 1 500 A, r.m.s. U = 27,5 kV With feeder wire autotransformer	ITU(T) Directives ~~CIGRE WG 3601~~

NOTE 1 Calculated values for 10 m distance from the centre line of the nearest track, 1 m above top of the rail ~~level~~.

NOTE 2 Double track assumed for calculation. I_c = current in one conductor rail or catenary of each track.

The electric fields at harmonic frequencies (mainly third and fifth harmonic of AC supply frequency or 300 Hz and 600 Hz ripple of DC supply) may be in the order of 5 % of the fundamental.

The magnetic fields at AC harmonic frequencies range up to 10 % of the fundamental or up to 2 % at 300 Hz and 600 Hz for DC systems.

The lateral decrease of the electric and of the magnetic fields may be assumed to decrease linearly with distance.

The magnetic field can be calculated linearly with the current.

Annex C
(informative)

Emission values for lower frequency range

In the early 1990s measurements of emission from railway systems and vehicles in railway systems were undertaken to get information about the values to be expected in the neighbourhood of railway systems. It was particularly noted that the results of magnetic field measurements, at 10 m distance, gave a poor reproducibility for frequencies below 150 kHz due to several reasons.

Due to the large variation in measured value (up to 20 dB) on the same vehicle depending on the location and other circumstances the reproducibility could not be achieved and its usefulness is in question.

Since these emission values were published in the first editions of IEC 62236-2 the graphs are shown in this informative annex without being a requirement to be fulfilled (Figure C.1 and Figure C.2).

Where the antennas are not at 10 m, the results can be converted to an equivalent 10 m value by using the following formula:

$$E_{10} = E_x + 2 \times 20 \times \log_{10}(D/10)$$

where

E_{10} is the value at 10 m;

E_x is the measured value at D m.

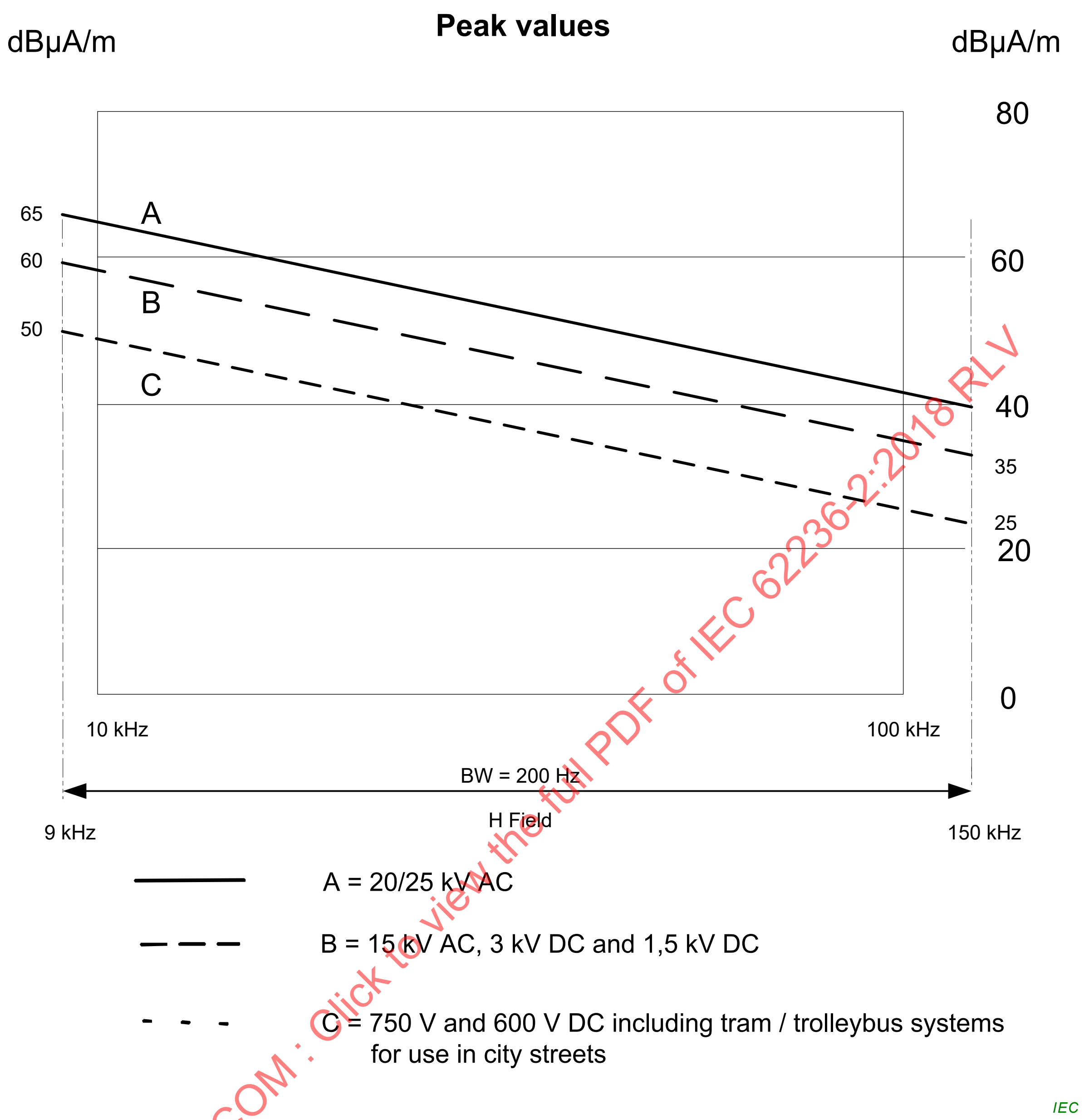


Figure C.1 – Emission values for the open railway system route

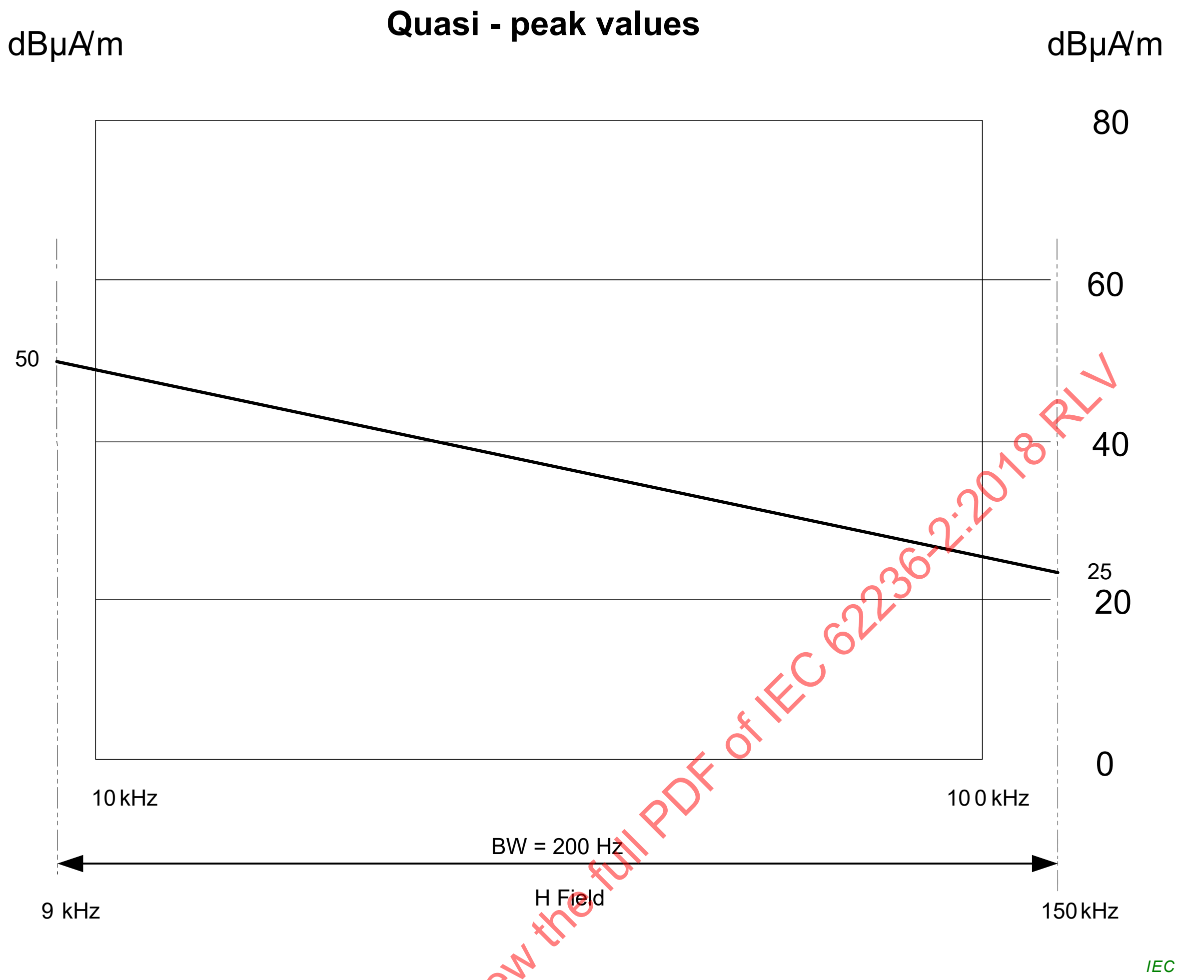


Figure C.2 – Emission values for substations

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 take precedence.~~

IEC TR 61000-2-7:1998, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 7: Low frequency magnetic fields in various environments*

IEC 61000-6-4:2006, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*
IEC 61000-6-4:2006/AMD1:2010

IEC 62236-3-1:2018, *Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle*

IEC 62236-3-2:2018, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

IEC 62236-4:2018, *Railway applications – Electromagnetic compatibility – Part 4: Emission and immunity of the signalling and telecommunications apparatus*

IEC 62236-5:2018, *Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of fixed power supply installations and apparatus*

CISPR 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

ITU(T) Directives, available from www.itu.int

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IEC 62236-2

Edition 3.0 2018-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Railway applications – Electromagnetic compatibility –
Part 2: Emission of the whole railway system to the outside world**

**Applications ferroviaires – Compatibilité électromagnétique –
Partie 2: Émission du système ferroviaire dans son ensemble vers le monde extérieur**

IEC 62236-2:2018-02(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**RAILWAY APPLICATIONS –
ELECTROMAGNETIC COMPATIBILITY –**

Part 2: Emission of the whole railway system to the outside world

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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 organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62236-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This third edition cancels and replaces the second edition published in 2008. It constitutes a technical revision and has been developed on the basis of EN 50121-2:2015.

This edition includes the following significant technical changes with respect to the previous edition:

a) clarification of scope (Clause 1);
b) combination of former Clause 5 and Annex A related to method of measurement for moving trains and traction substations (5.1);
c) moving emission values for radiated H-fields in the frequency range 9 kHz to 150 kHz to new Annex C due to the fact that:
   – there are very few outside world victims;

– there is low reproducibility.

d) clarification of acquisition method (5.2).

This International Standard is to be read in conjunction with IEC 62236-1.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
9/2336/FDIS	9/2366/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 62236, published under the general title *Railway applications – Electromagnetic compatibility*, can be found on the IEC website.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 2: Emission of the whole railway system to the outside world

1 Scope

This part of IEC 62236 is intended to define the electromagnetic environment of the whole railway system including urban mass transit and light rail system. It describes the measurement method to verify the emissions, and gives the cartography values of the fields most frequently encountered.

This document specifies the emission limits of the whole railway system to the outside world.

The emission parameters refer to the particular measuring points defined in Clause 5. These emissions are assumed to exist at all points in the vertical planes which are 10 m from the centre lines of the outer electrified railway tracks, or 10 m from the fence of the substations.

Also, the zones above and below the railway system may be affected by electromagnetic emissions and particular cases are considered individually.

These specific provisions are used in conjunction with the general provisions in IEC 62236-1.

For existing railway lines, it is assumed that compliance with the emission requirements of IEC 62236-3-1, IEC 62236-3-2, IEC 62236-4 and IEC 62236-5 will ensure the compliance with the emission values given in this document.

For newly built railway systems, it is best practice to provide compliance to the emission limits given in this document (to be defined in the EMC plan according to IEC 62236-1).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 62236-1:2018, *Railway applications – Electromagnetic compatibility – Part 1: General*

CISPR 16-1-1:2015, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*
CISPR 16-1-4:2010/AMD1:2012
CISPR 16-1-4:2010/AMD2:2017

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
apparatus
device or assembly of devices which can be used as an independent unit for specific functions

[SOURCE: IEC 60050-151:2001, 151-11-22]

3.1.2
environment
surroundings in which a product or system exists, including air, water, land, natural resources, flora, fauna, humans and their interrelation

[SOURCE: IEC Guide 109:2012, 3.3]

[SOURCE: IEC 60050-901:2013, 901-07-01]

3.1.3
traction substation, <in electric traction>
substation, <in electric traction>
substation the main function of which is to supply an electric traction system

Note 1 to entry: The synonym substation is used only when the context is clear.

[SOURCE: IEC 60050-811:2017, 811-36-02]

3.1.4
rolling stock
all vehicles with or without motors

Note 1 to entry: Examples of vehicles include a locomotive, a coach and a wagon.

[SOURCE: IEC 60050-811:2017, 811-02-01]

3.2 Abbreviated terms

AC	Alternating current
BW	Band width
DC	Direct current
E	Electric (field)
EMC	Electromagnetic Compatibility
FFT	Fast Fourier transform
H	Magnetic (field)
HV	High voltage
ITU	International Telecommunication Union
r.m.s.	root mean square

4 Emission limits

4.1 Emission from the open railway system during train operation

The emission limits in the frequency range 150 kHz to 1 GHz are given in Figure 1 and the measurement method is defined in Clause 5.

Annex B gives guidance values for typical maximum field values at fundamental frequency of different traction power systems which can occur. They depend on numerous geometrical and operational parameters which can be obtained from the infrastructure manager.

It is not possible to undertake complete tests with quasi-peak detection due to the reasons stated in Annex A.

There may be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the railway system. The EMC management plan covers these cases and an adequate level of emission from the railway system on these working frequencies may be found in the values given in informative Annex C, hence no guarantee can be given for an undisturbed operation.

4.2 Radio frequency emission from traction substations

Radio frequency emission from the traction substation to the outside environment measured according to the method defined in Clause 5 shall not exceed the limits in Figure 2.

The limits are defined as quasi-peak values and the bandwidths are those used in CISPR 16-1-1:

	Bandwidth
Frequencies from 150 kHz to 30 MHz	9 kHz (BW 1)
Frequencies above 30 MHz	120 kHz (BW 2)

The distance of 10 m defined in Clause 5 shall be measured from the fence of the substation. If no fence exists, the measurements shall be taken at 10 m from the apparatus or from the outer surface of the enclosure if it is enclosed.

For other kinds of fixed installations like auto-transformers, the same limit and measuring distance shall be applied.

There may be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the traction substation. The EMC management plan covers these cases and an adequate level of emission from traction substation on these working frequencies may be found in the values given in informative Annex C, hence no guarantee can be given for an undisturbed operation.

5 Method of measurement of emission from moving rolling stock and substations

5.1 General and specific measurement parameters

NOTE The method of measurement is adapted from CISPR 16-2-3 to a railway system with moving rolling stock and substations. The background to the method of measurement of moving rolling stock is given in Annex A.

5.1.1 General measurement parameters

5.1.1.1 Frequency bands

Frequency bands and bandwidths at –6 dB used for measurements are in accordance with CISPR 16-1-1.

These are:

Frequency bands:	0,15 MHz to 30 MHz	30 MHz to 300 MHz	300 MHz to 1 GHz
Bandwidth:	9 kHz (BW 1)	120 kHz (BW 2)	120 kHz (BW 2)

Other bandwidth for peak measurement can be chosen according to CISPR 16-1-1. Data measured with the reference bandwidth shall take precedence.

5.1.1.2 Measurement uncertainty

The measurement uncertainty of the measuring equipment shall comply with the requirements in CISPR 16-1-1 and CISPR 16-1-4.

Due to the measurement method, the normalized site attenuation may not be considered in the measurement uncertainty.

5.1.1.3 Types of antennas

To cover the full frequency range, antennas of different design are required. Typical equipment is described below:

– for 150 kHz to 30 MHz, a loop or frame antenna is used to measure H field (see Figure 3);

– for 30 MHz to 300 MHz, a biconical dipole is used to measure E field (see Figure 4);

– for 300 MHz to 1,0 GHz, a log-periodic antenna is used to measure E field (see Figure 5).

For measurements in the frequency range of 30 MHz to 1 GHz a combined antenna may be used.

Calibrated antenna factors are used to convert the terminal voltage of the antenna to field strength.

5.1.1.4 Measurement distance and height

The preferred distance of the measuring antenna from the centreline of the track on which the vehicle is moving (Test track) is 10 m. In the case of the log-periodic antenna, the 10 m distance is measured to the mechanical centre of the array.

The preferred distance of the measuring antenna while measuring the emission of the substation is 10 m from the outer fence of the substation, at the midpoints of the three sides, excluding the side which faces the railway system, unless this side is more than 30 m from the centre of the nearest electrified railway track. In this case all four sides shall be measured. If the length of the side of the substation is more than 30 m, measurements shall be taken additionally at the corners.

Where the antennas are not at 10 m, the results can be converted to an equivalent 10 m value by using the following formula:

$$E_{10} = E_x + n \times 20 \times \log_{10} (D/10)$$

where

E_{10} is the value at 10 m;

E_x is the measured value at D m;

n is a factor taken from Table 1 below.

Table 1 – Conversion factor *n*

Frequency range	*n*
0,15 MHz to 0,4 MHz	1,8
0,4 MHz to 1,6 MHz	1,65
1,6 MHz to 110 MHz	1,2
110 MHz to 1 000 MHz	1,0

The measured values (at the equivalent 10 m distance) shall not exceed the limits given in Figure 1 for the appropriate system voltage.

No measurements are necessary for total underground railway systems with no surface operation (no victim outside this railway system can be affected).

The height above reference level of the antenna centre shall be within the range 1,0 m to 2,0 m for the loop antenna, and within 2,5 m to 3,5 m to the centre of measuring antenna above 30 MHz. One measuring height within the given range is sufficient and it is not required to do measurements with several antenna heights within this range. The selected height shall be noted in the test report.

The reference level for the substation is the ground.

The reference level for moving trains is the top of the rail.

If the actual level of the ground at the antenna differs from the top of the rail by more than 0,5 m, the actual value shall be noted in the test report.

It is accepted that the fixed antenna position may result in values being less than the absolute maximum at some frequencies.

5.1.1.5 Values of measurement

The values measured are expressed as:

– dBµA/m for magnetic fields,

– dBµV/m for electric fields.

These are obtained by using the appropriate antenna factors and conversions.

5.1.1.6 Antenna position and orientation

The plane of the loop antenna shall be positioned to measure the horizontal component of the magnetic field perpendicular to the track respectively to the wall of the substation. The biconical dipole shall be placed in the vertical and horizontal axis. The log periodic antenna shall be arranged to measure the vertical and horizontal polarization signal, with the antenna directed towards the track respectively to the wall of the substation.

The test locations should whenever possible avoid objects with changing of field characteristic like turnouts, walls and under bridges.

Figures 3, 4 and 5 show the positions and vertical alignments of the antennas as an example for measurements at the track.

5.1.1.7 Ambient noise

At the beginning and at the end of the test series the ambient noise shall be recorded.

If at specific frequencies or in specific frequency ranges the ambient noise is higher than the limit values less 6 dB (ambient noise > (emission limit – 6 dB)), the measurements at these frequencies need not be considered. These frequencies shall be noted in the test report.

5.1.2 Measurement parameter for moving trains

This subclause summarizes the specific conditions for the measurement of moving rolling stock.

– It is not considered necessary to carry out two tests to examine both sides of the rolling stock, even if it contains different apparatus on the two sides, as in the majority of cases the level of fields is due to the radiation of catenary and not to the direct radiation from the train. For systems with a third rail, measurements have to be performed at the same side of it.

– The peak measurement method is used. The duration at selected frequency shall be sufficient to obtain an accurate reading. This is a function of the measuring set and the recommended value is 50 ms.

– The noise may not attain its maximum value as the traction vehicle passes the measuring point, but may occur when the vehicle is a long distance away. Therefore, the measuring set shall be active for a sufficient duration before and after the vehicle passes by to ensure that the maximum noise level is recorded.

– In the case of elevated railway systems, if the antenna heights specified above cannot be achieved, the height of the antenna centre can be referenced to the level of the ground instead of to the top of the rail. The conversion formula in 5.1.1.4 shall be employed where D is the slant distance between the train and the antenna. The train shall be visible from the location of the antenna and the axis of the antenna shall be elevated to point directly at the train. A measurement distance of 30 m from the track centreline is preferred for highly elevated railway systems. Full details of the test configuration shall be noted in the test report.

– If tests are being carried out on a railway system with overhead electrified supply, the measuring point shall be at midspan between the support masts of the overhead contact line and not at a discontinuity of the contact wire. It is recognized that resonance can exist in an overhead system at radio frequencies and this may require changes in the values of frequency chosen for measurement. If resonance exists, this shall be noted in the test report.

  The radio frequency emission will be affected by the state of the railway system supply system. Switching of feeder stations and temporary works will influence the response of the system. It is therefore necessary to note the condition of the system in the test record and, if possible, all similar tests should be carried out within the same working day. Where the railway system has a track-side conductor rail power supply, the test location should be at least 100 m from gaps in the rail, to avoid inclusion of the transient fields associated with the make and break of collector contact. The conductor rail and the antennas shall be on the same side of the track.

– The test sites do not correspond to the definition of a completely clear site because they are influenced by overhead structures, rails and the catenary. However, wherever possible, antennas shall be installed well away from reflecting objects. If HV power lines are nearby, other than those which are part of the railway network, they should be no closer than 100 m to the test site.

5.1.3 Measurement parameter for traction substations

This subclause summarizes the specific conditions for the measurement of substations.

– Test configurations: In view of the special geometry of a railway system traction supply system, it is necessary to perform the measurement of emission of electromagnetic fields under normal feeding configuration of the traction supply system.

– Substation load: A feature of traction substations is that the load can change widely in short times. Since emission can be related to load, the actual loading of the substation shall be noted during emission tests.

– Each measurement shall be started with a peak max hold sweep. If the limits are exceeded due to the substation then it is required to take a measurement from a quasi-peak over the specific frequency range where these limits have been overrun. It is known that the load condition cannot be reproduced exactly during quasi-peak measurement, hence these load conditions should be at least comparable.

5.2 Acquisition methods

5.2.1 General

The electromagnetic disturbances generated by railway network including operating rolling stock are measured by the two following methods:

a) the fixed frequency method;

b) the frequency sweeping method.

The measurement method shall be chosen according to the rolling stock operating modes (see 5.4.2) depending on the train speed.

– For test at high speed the following has to be taken into account:

The fixed frequency method can be used, because it allows continuous monitoring at each frequency.

Alternative methods are allowed if the equivalent scan rate is at least that defined in Table 2 which is sufficiently short for such a moving source.

This ensures that the frequency results are measured at least every 5 m of train movement.

At higher speeds a spectrum analysis swept frequency method is unlikely to be practical, but FFT techniques may be feasible. The measurement equipment shall comply with CISPR 16-1-1.

Table 2 – Scan rate

Speed of train km/h	Speed of train m/s	Time for an observation width of 5 m (scan rate) s
60	16,67	0,300
100	27,78	0,180
200	55,56	0,090
300	83,33	0,060
320	88,89	0,056
NOTE Observation width is the part of rolling stock to be observed in given time.		

– When the rolling stock will be moving at a slower speed with the maximum rated power (see 5.4.2), the frequency sweeping method shall be used.

5.2.2 Fixed frequency method

The fixed frequency method consists of measuring the radiated emissions at only some frequencies (it is recommended to take at least 3 frequencies per decade) using the zero span mode of the spectrum analyser or setting the measuring receiver at the frequency to be checked.

The fixed frequencies shall be chosen according to the ambient noise, i.e. in the areas where the ambient field is the lowest.

The measurement of the field level shall be performed for each frequency during a complete passage of the train.

5.2.3 Frequency sweeping method

For the frequency sweeping method, the frequency range shall be divided into several sub-ranges according to the train speed in order to have a relevant sweep time in comparison with the train speed.

The measurement of the field level shall be performed in each sub-range during a complete passage of the train. The max-hold function of the spectrum analyser shall be used.

5.3 Transients

During the test, transients due to switching may be detected, such as those caused by operation of power circuit breakers. These shall be disregarded when selecting the maximum signal level found for the test.

5.4 Measuring conditions

5.4.1 Weather conditions

To minimize the possible effect of weather on the measured values, measurements should be carried out in dry weather, (after 24 h during which not more than 0,1 mm rain has fallen), with a minimum temperature of 5 °C, and a wind velocity of less than 10 m/s.

Humidity should be low enough to prevent condensation on the power supply conductors.

Since it is necessary to plan the tests before the weather conditions can be known, tests will be carried out in the weather conditions found. In these circumstances, the actual weather conditions shall be recorded with the test results.

5.4.2 Railway system operating modes

Two test conditions are specified for the traction mode and are:

a) measurement at a speed of more than 90 % of the maximum service speed, (to ensure that the dynamics of current collection are involved in the noise level) and at the maximum power which can be delivered at that speed;
b) at the maximum rated power and at a selected speed.

If the vehicle is capable of electric braking, tests are required at a brake power of at least 80 % of the rated maximum brake power.

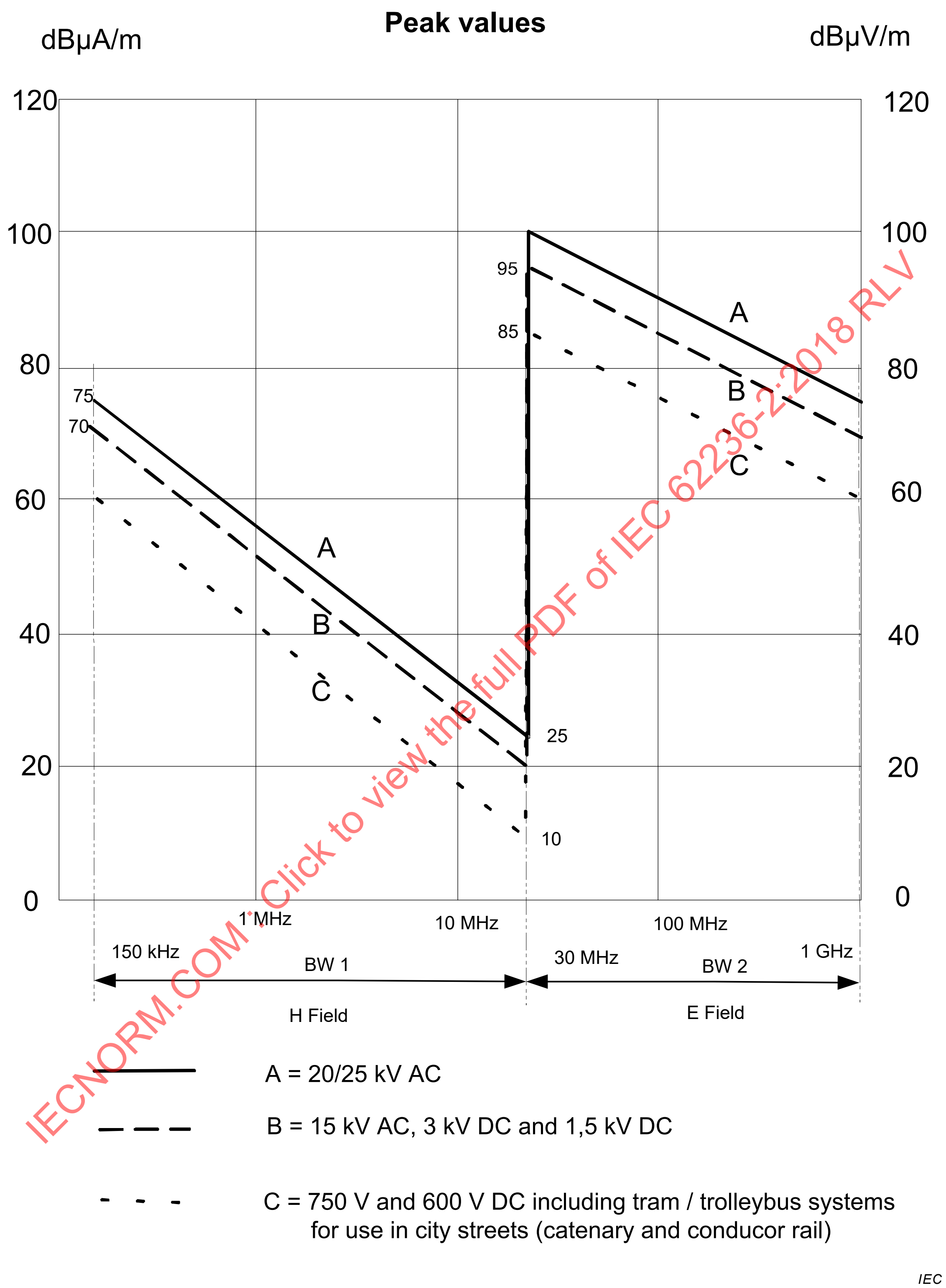
5.4.3 Multiple sources from remote trains

For the purpose of limits, the presence of "physically-remote but electrically-near" vehicles out of the test zone is regarded as insignificant when considering radio noise.

5.5 Test report

The test report shall contain the following information:

- description of site;
- description of measuring system;
- description of railway vehicle (type, configuration and mode of electric braking);
- numerical results;
- graphical results where relevant (The results shall include information such as bandwidths, date, time, ambient noise and excluded frequencies (see 5.1.1.7);
- weather conditions;
- name(s) or equivalent identification of person(s) authorizing the test report.



Values are 10 m from the railway track.

Figure 1 – Emission limits in frequency range 150 kHz to 1 GHz

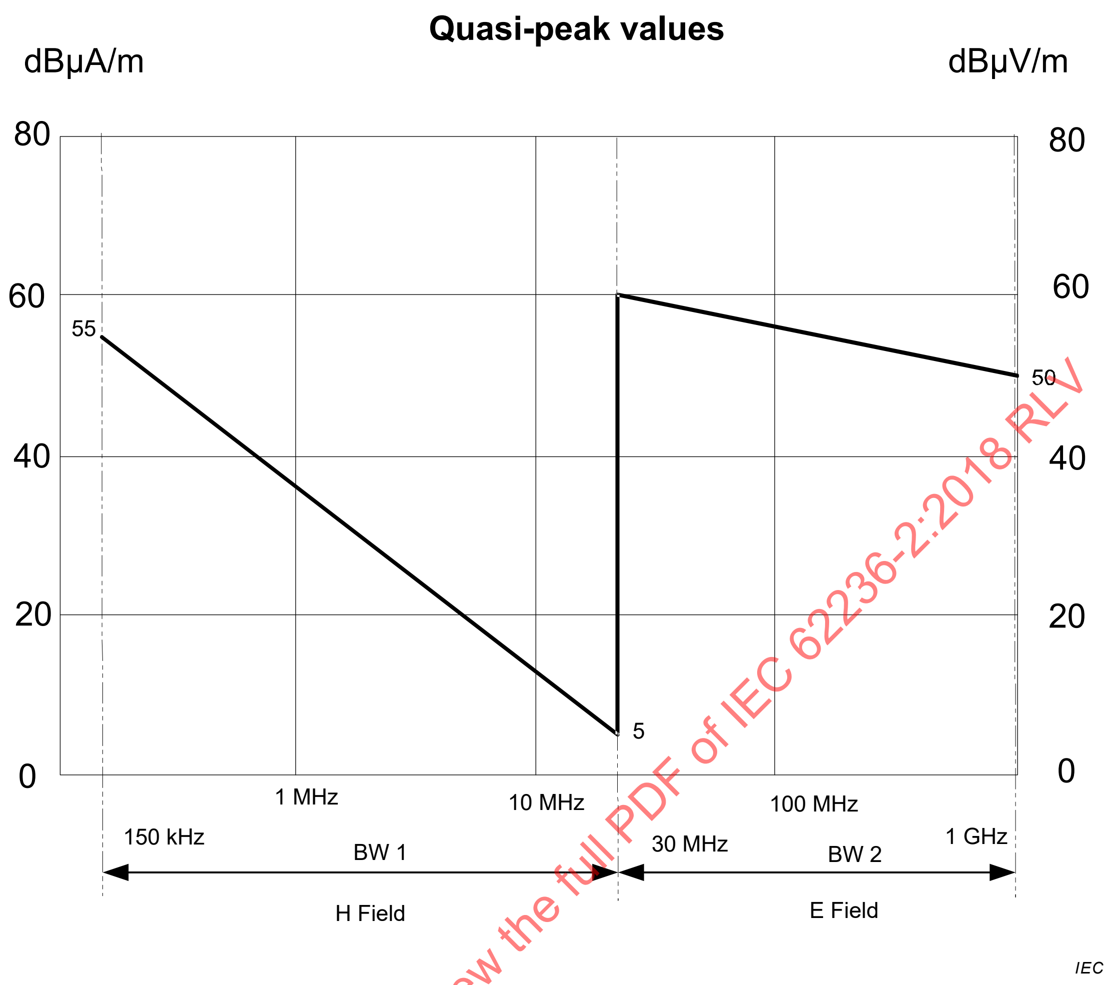


Figure 2 – Emission limit for substations

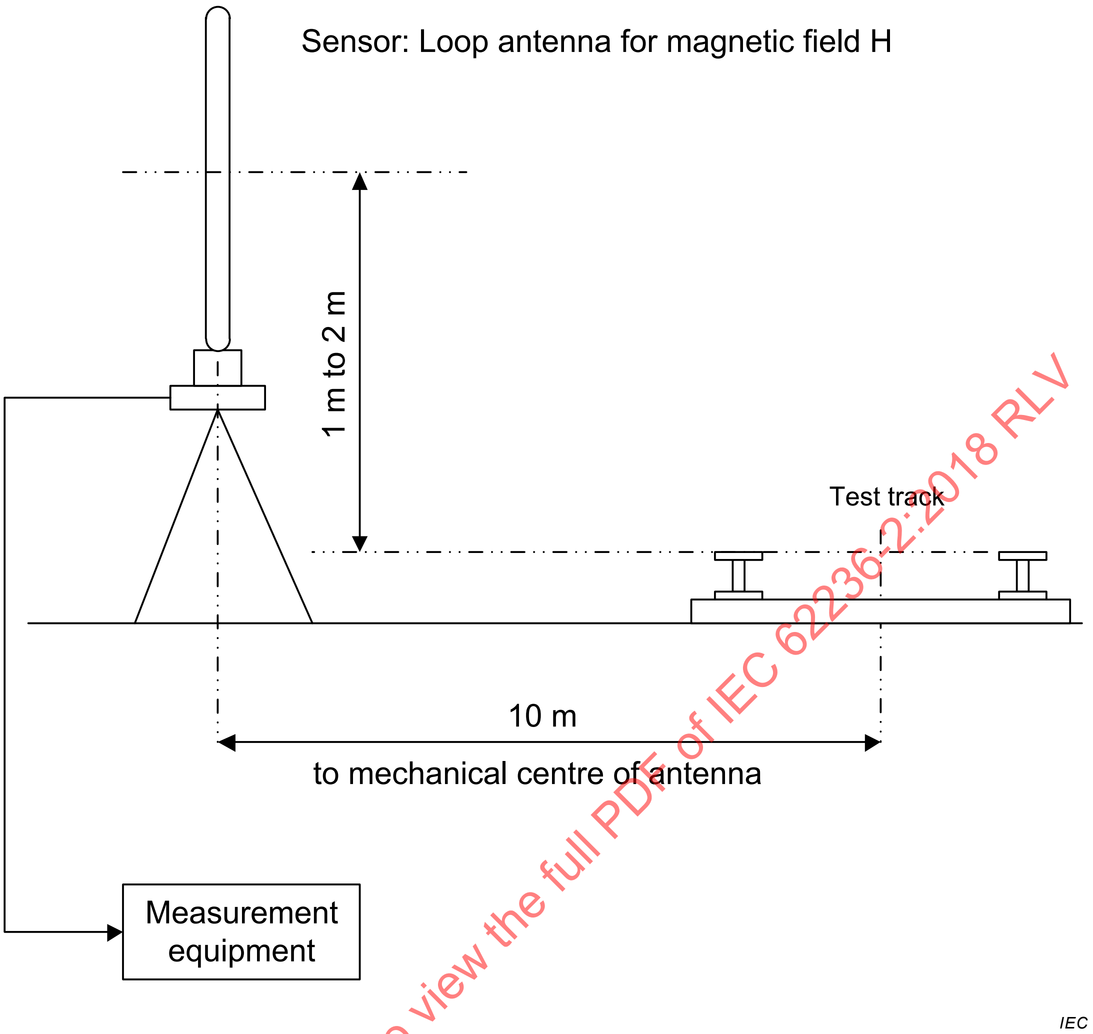


Figure 3 – Position of antenna for measurement of horizontal component of magnetic field in the 150 kHz to 30 MHz frequency band

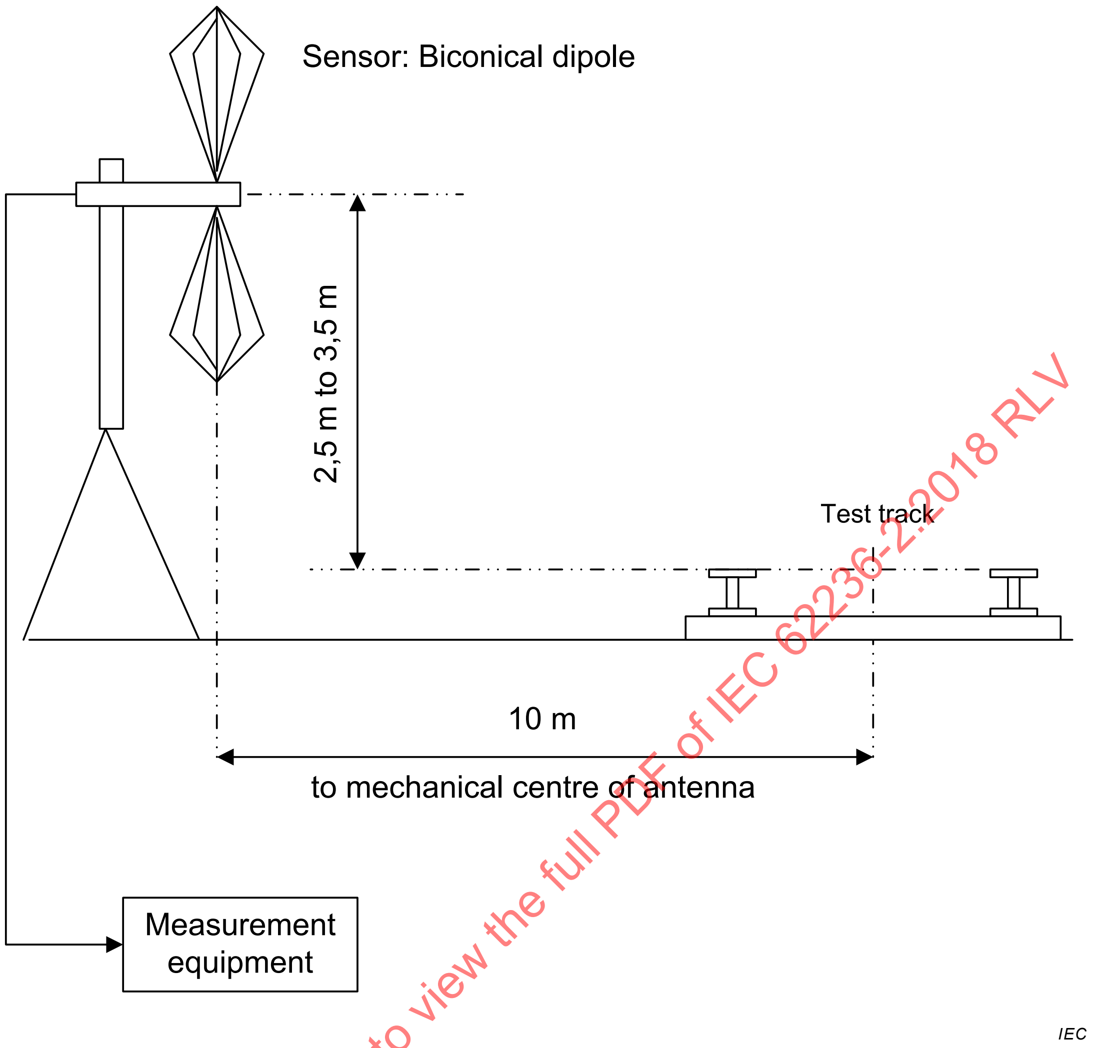


Figure 4 – Position (vertical polarization) of antenna for measurement of electric field in the 30 MHz to 300 MHz frequency band

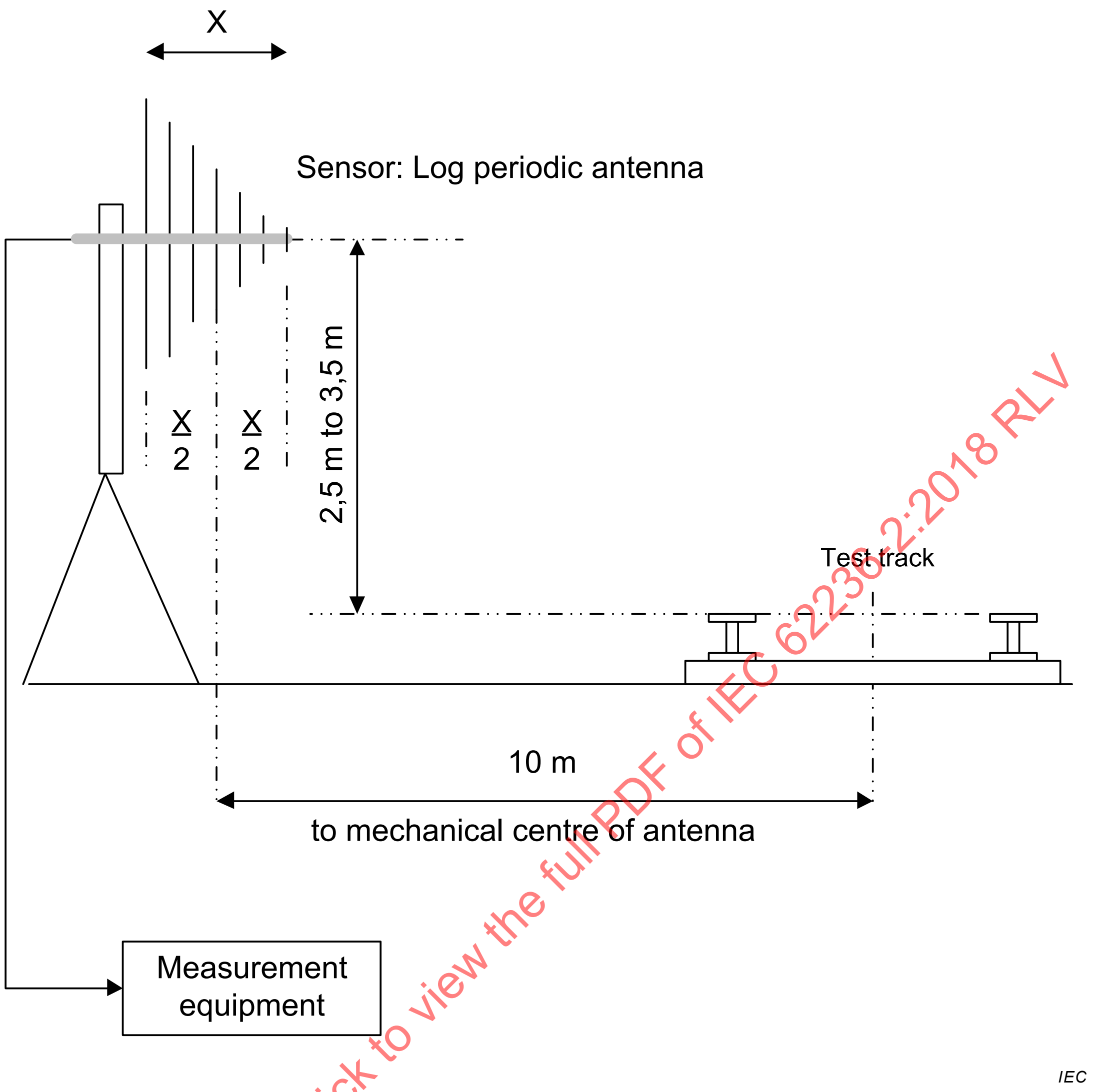


Figure 5 – Position (vertical polarization) of antenna for measurement of electric field in the 300 MHz to 1 GHz frequency band

Annex A
(informative)

Background to the method of measurement

A.1 General

This annex describes a method of measuring the electromagnetic noise emitted by a railway network when railway vehicles are moving on the network. Existing methods are not considered to be appropriate, because the vehicles may be moving at significant speeds. A separate document (IEC 62236-3-1:2018) covers the case of stationary and slow moving vehicles. Both traction and trailer vehicles should be examined since the trailers may contain electric equipment which can emit noise. It is also necessary to test diesel traction vehicles since they may contain sources of radio emission. The method allows an assessment to be made of the disturbance which would be caused to other users of the electromagnetic spectrum. The document describes a reference method of measurement.

A.2 Requirement for a special method of measurement

For frequencies above 150 kHz, there is a standard method of measuring radio fields and this is described in CISPR 16-1-1.

A railway network has particular features which make necessary the use of a special method of measurement. These features include a rapidly moving source and the possibility of radiation from the long antenna formed by the electrical supply conductors of an electrified railway system.

This method of measuring railway system noise does not always use the quasi-peak method of CISPR 16-1-1 because measurements conducted on the basis of that method are not sufficient (due to the moving source) to enable the full extent of the disturbances affecting other systems in the vicinity to be identified.

It appears difficult to establish an exact link between the values obtained with the peak and quasi-peak methods, in view of the fact that the disturbances created by the vehicle may be almost constantly sinusoidal at the working frequency of some of the on-board ground-to-train transmission equipment, or a series of repeated pulses for other sources, for example the pantograph/overhead line contact. However, in all cases, the value measured with a peak detection system will be greater than or equal to the value obtained with a quasi-peak system in accordance with CISPR 16-1-1.

A.3 Justification for a special method of measurement

Fields are not measured using the method of CISPR 16-1-1, but with peak detection within a short time window, 50 ms being recommended, at the selected frequency because:

– this gives a better representation of the effect on any system (electronic or computer), whereas the weighting principles applied with quasi-peak detection are only representative of interference in relation to radio transmission. The time window of 50 ms will capture the peak emission from AC railway systems which tends to occur at current reversals. On 16,7 Hz, these reversals are 33 ms apart and one will always be detected within the 50 ms window;

– it is also faster. For some quasi-peak detector systems up to 1 s is necessary because of the requirements of galvanometer-type instruments. This is far too long in the case of a moving train,

– it gives the maximum value that could be measured with the method of CISPR 16-1-1 and is representative of the “worst possible case” for interference to radio transmission.

A.4 Frequency range

Although the railway vehicle and sliding contact current collection are also sources of noise above 1 GHz, the emission levels are low and attenuation with distance is high. Therefore, no proposals are made for measurements above 1 GHz.

A.5 Antenna positions

There are options for choosing the distance of the antenna from the centre-line of the track. The usual distances used for radio frequency tests are 1 m, 3 m, 10 m and 30 m. A value of 1,0 m is impossible and if 3 m is chosen, there is a possibility that the vehicle body will have a very strong local effect and this may give a false impression of the field at greater distances. A distance of 10 m is preferred since, with an electric traction supply, the sliding contact is directly viewed by the antenna and body effects are less. Another standard distance is 30 m and this may be easier to provide at particular sites, but the signal strength is lower and local noise may make it more difficult to obtain values of railway system noise. Hence, the distance selected for measurements is 10 m in relation to the centre line of the track on which the vehicles are running.

Steps should be taken to ensure that the measuring equipment and any associated power supply and apparatus does not affect the readings.

A.6 Conversion of results if not measured at 10 m

The values of n are based on observations made with overhead power lines and are for open country sites. The values of n listed in 5.1.1.4 are known to be adequately accurate since the value of n for 100 MHz was specifically measured for a railway system and was found to be 1,25, for distances up to 100 m.

When testing at 10 m, it is important to recall that the induction field and the radiation field have different characteristics near to the source. If the distance is small compared to the wavelength, the induction field will predominate. The position with respect to a point source at which these two fields have equal magnitudes is at a theoretical distance of (wavelength/2π). Hence, if 10 m is taken as the measuring distance, all tests below about 5 MHz are in the near field where the magnetic induction signal dominates. Results are then most accurately expressed in A/m. In the near field, the E field is low and is not usually a cause of disturbance. With an extended source such as a train, the near field zone may extend further than the “point source” theory would suggest.

A single height is used for the dipole and log-periodic antenna since variable height cannot be used as is usual for emission testing.

The position of antennas in the middle between masts reduces the screening effect of the masts and the local transients due to sparking which are commonly found at the mast, where the mechanical impedance may change suddenly. Similarly, booster transformers, overlaps, section insulators, neutral sections and other major irregularities should be avoided.

A.7 Measuring scales

On the log scale: 1 μV/m is 0 dBμV/m and 1,0 V/m is 120 dBμV/m. (A similar relationship applies for μA/m and dBμA/m).

Limit values may be expressed in A/m and V/m and these can be derived as necessary.

Electrical field strength in dBμV/m = magnetic field strength in dBμA/m + 51,5 if the measurement is taken in the far field (51,5 = 20 $\log_{10}$(impedance of free space wave)).

A.8 Repeatability of results

A special problem with measurements of railway system radio frequency emissions is that the source is moving along the railway system. This makes it difficult to collect a large number of results from the trackside and it is therefore necessary to define the conditions for measurement so that some degree of repeatability can be achieved.

To reduce the chance that remote vehicles will produce significant emissions at the test point, by phenomena such as resonance, any other vehicles supplied on the same catenary or supply rail should be at sufficient distance from the test point. For catenary supply, a distance of 20 km is suggested and for supply rail systems a distance of 2 km.

Even under these conditions, substantial variation between test results is to be expected.

A.9 Railway system conditions

A.9.1 Weather

When the railway system is an outdoor network, weather will affect the level of radio noise which is produced. For HV power lines, the noise increases by about 20 dB during rain. With railway systems, the noise from the pantograph contact may reduce with rain, as the carbon film on the contact wire is removed, giving a closer contact between wire and pantograph. If ice has formed on the supply conductor, increased arcing will take place and give increased noise. If the wind velocity is high, the mechanics of the overhead conductor will be affected and the contact between wire and pantograph will be affected. The effect of weather on the emission of noise from railway vehicles is not yet fully understood.

A.9.2 Speed, traction power

To give some valid comparison, noise measurements of a moving vehicle are made under specified conditions when the vehicle is travelling at some selected proportion of its maximum speed and, if it is a traction vehicle, is delivering some selected proportion of its continuous rated power. Values for these proportions need to be selected and this process needs to take into account the operating envelope of the vehicle. An ideal provision is that the vehicle should operate at the condition which produces the maximum radio noise, but since there is as yet no method by which this can be defined, such a requirement is not used.

A.9.3 Multiple sources from remote trains

In real cases, more than one traction vehicle may be within the disturbance zone of an affected object. For the purpose of limits, the presence of “physically-remote but electrically-near” vehicles out of the test zone is regarded as insignificant when considering radio noise. This recognizes that the sources are moving and that although the remote vehicles are sources of noise, the attenuation with distance for the higher frequencies is normally high. When fields at the lower frequencies of measurement are considered, the attenuation is low and all vehicles within the zone of influence (which may extend several km) can affect the noise level. The effect of addition is however within the repeatability error of the tests and the emission from a single train can be assessed against the limit.

A.10 Number of traction vehicles per train

When traction vehicles are coupled, the contact quality of the trailing pantographs can be disturbed and a higher noise emission may occur. If tests are to be done in the maximum train consist, with coupled vehicles, they should be the subject of a specific request.

Related to the permitted emission from this test, it is mentioned that trains may operate in multiple and thereby generate more noise.

Annex B
(informative)

Cartography – Electric and magnetic fields at traction frequencies

Table B.1 gives typical numerical values of quantities describing the emission of the railway system to the outside world (cartography).

The quantities given are the electric field E and the magnetic field H of the DC or the AC fundamental component, calculated for conductor arrangements regarded to be typical for the respective type of electrification.

Table B.1 – Typical maximum electric and magnetic field values at fundamental frequency of different electrification systems

System	Freq.	E-field		H-field		Reference conditions	Reference documentation
	Hz	V/m	dBµV/m	µT	dBµA/m		
750 V to 1 200 V conductor rail	0	< 10		46	151	I_c = 4 000 A 50 % return current in rails	
600 V to 750 V power supply line	0	35		15		I_c = 1 000 A 50 % return current in rails	IEC TR 61000-2-7
1 500 V power supply line	0	63	156	111	159	I_c = 8 000 A U = 1 800 V No aerial wire	ITU(T) Directives
3 kV	0	50	154	28	147	I_c = 3 000 A, U = 3,6 kV Aerial wire	ITU(T) Directives
15 kV	16,7	750	177	40	150	I_c = 2 000 A, r.m.s. U = 17,25 kV No aerial wire	ITU(T) Directives
25 kV	50	1 000	180	16	142	I_c = 1 500 A, r.m.s. U = 27,5 kV With feeder wire autotransformer	ITU(T) Directives

NOTE 1 Calculated values for 10 m distance from the centre line of the nearest track, 1 m above top of the rail.

NOTE 2 Double track assumed for calculation. I_c = current in one conductor rail or catenary of each track.

The electric fields at harmonic frequencies (mainly third and fifth harmonic of AC supply frequency or 300 Hz and 600 Hz ripple of DC supply) may be in the order of 5 % of the fundamental.

The magnetic fields at AC harmonic frequencies range up to 10 % of the fundamental or up to 2 % at 300 Hz and 600 Hz for DC systems.

The lateral decrease of the electric and of the magnetic fields may be assumed to decrease linearly with distance.

The magnetic field can be calculated linearly with the current.

Annex C
(informative)

Emission values for lower frequency range

In the early 1990s measurements of emission from railway systems and vehicles in railway systems were undertaken to get information about the values to be expected in the neighbourhood of railway systems. It was particularly noted that the results of magnetic field measurements, at 10 m distance, gave a poor reproducibility for frequencies below 150 kHz due to several reasons.

Due to the large variation in measured value (up to 20 dB) on the same vehicle depending on the location and other circumstances the reproducibility could not be achieved and its usefulness is in question.

Since these emission values were published in the first editions of IEC 62236-2 the graphs are shown in this informative annex without being a requirement to be fulfilled (Figure C.1 and Figure C.2).

Where the antennas are not at 10 m, the results can be converted to an equivalent 10 m value by using the following formula:

$$E_{10} = E_x + 2 \text{ x } 20 \times \log_{10}(D/10)$$

where

E_{10} is the value at 10 m;

E_x is the measured value at D m.

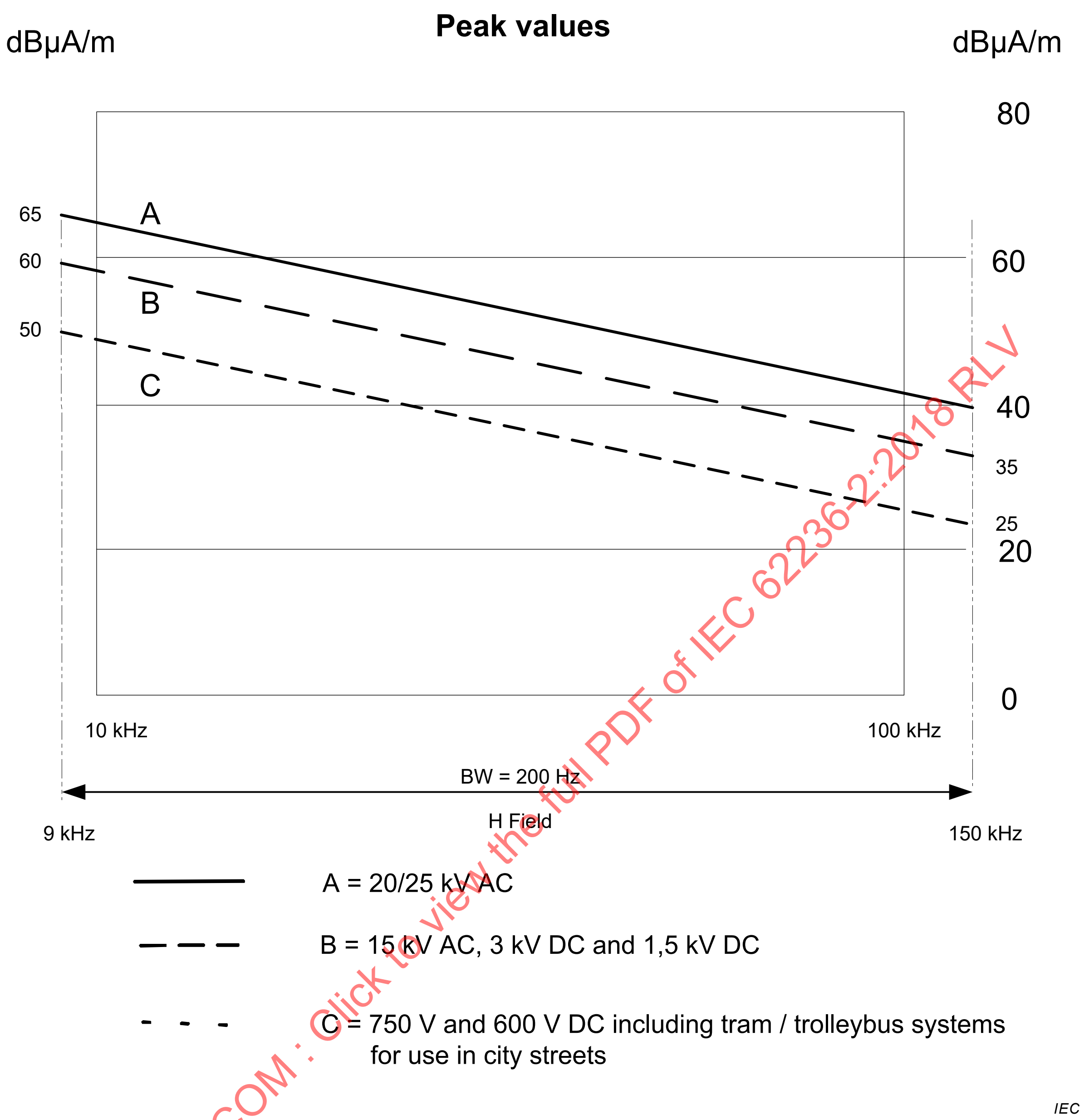


Figure C.1 – Emission values for the open railway system route

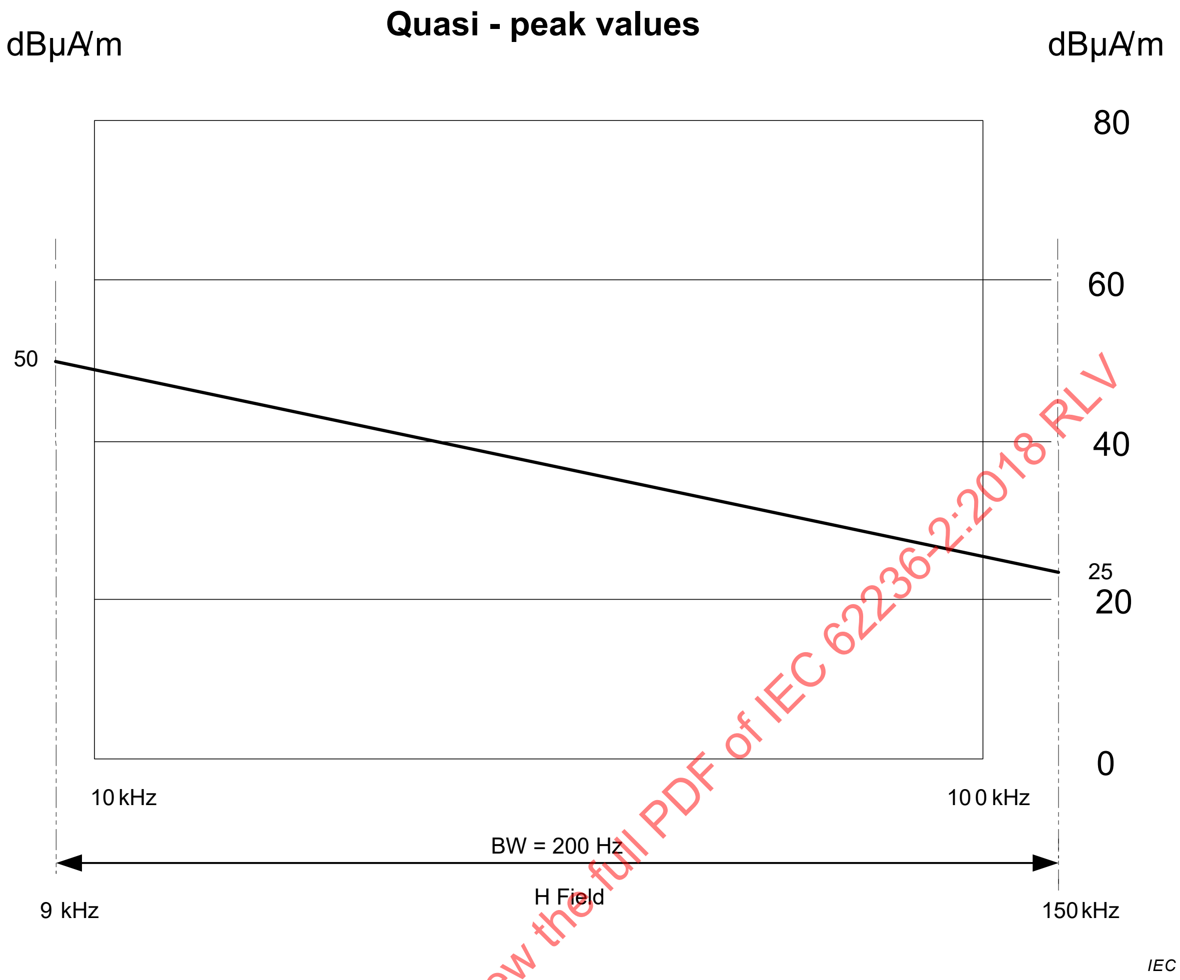


Figure C.2 – Emission values for substations

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ITU(T) Directives, available from www.itu.int

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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APPLICATIONS FERROVIAIRES – COMPATIBILITÉ ÉLECTROMAGNÉTIQUE –

Partie 2: Émission du système ferroviaire dans son ensemble vers le monde extérieur

AVANT-PROPOS

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La Norme internationale IEC 62236-2 a été établie par le comité d'études 9 de l'IEC: Matériels et systèmes électriques ferroviaires.

Cette troisième édition annule et remplace la deuxième édition publiée en 2008. Elle constitue une révision technique et a été développée sur la base de EN 50121-2:2015.

Cette édition inclut les changements techniques significatifs suivants par rapport à l'édition précédente:

a) clarification du domaine d'application (Article 1);
b) combinaison de l'Article 5 et de l'Annexe A liée à la méthode de mesurage pour les trains en mouvement et les sous-stations de traction (5.1);

c) déplacement des valeurs d'émissions pour les champs H rayonnés de largeurs de bande 9 kHz à 150 kHz dans l'Annexe C pour les raisons suivantes:
   – il y a très peu de victimes du monde extérieur;
   – la reproductibilité est faible;
d) clarification de la méthode d'acquisition (5.2).

Cette Norme internationale doit être lue conjointement avec l'IEC 62236-1.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
9/2336/FDIS	9/2366/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Une liste de toutes les parties de la série IEC 62236, publiées sous le titre général *Applications ferroviaires – Compatibilité électromagnétique*, peut être consultée sur le site web de l'IEC.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

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APPLICATIONS FERROVIAIRES – COMPATIBILITÉ ÉLECTROMAGNÉTIQUE –

Partie 2: Émission du système ferroviaire dans son ensemble vers le monde extérieur

1 Domaine d'application

La présente partie de l'IEC 62236 est destinée à définir l'environnement électromagnétique de l'ensemble du système ferroviaire, y compris les systèmes de transport en commun urbain et de réseau ferré léger. Elle décrit la méthode de mesure à utiliser pour vérifier les émissions et donne la cartographie des niveaux de champ rencontrés le plus fréquemment.

Le présent document spécifie les limites d'émission de l'ensemble du système ferroviaire vers le monde extérieur.

Les paramètres d'émission se réfèrent aux points de mesure particuliers définis à l'Article 5. Il est considéré que ces émissions existent en tout point dans les plans verticaux situés à 10 m des lignes centrales des voies de chemin de fer électrifiées en zone extérieure ou à 10 m de la clôture des sous-stations.

Les zones situées au-dessus et en dessous du système ferroviaire peuvent également être affectées par des émissions électromagnétiques et les cas particuliers sont pris en compte de manière individuelle.

Ces dispositions spécifiques sont utilisées avec les dispositions générales données dans l'IEC 62236-1.

Pour les voies de chemin de fer existantes, la conformité aux exigences d'émission des normes IEC 62236-3-1, IEC 62236-3-2, IEC 62236-4 et IEC 62236-5 est considérée garantir la conformité aux valeurs d'émission indiquées dans le présent document.

Pour les systèmes ferroviaires récemment construits, il est préférable de garantir la conformité aux limites d'émission indiquées dans le présent document (à définir dans le plan CEM conformément à l'IEC 62236-1).

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 62236-1:2018, *Applications ferroviaires – Compatibilité électromagnétique – Partie 1: Généralités*

CISPR 16-1-1:2015, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques — Appareils de mesure*

CISPR 16-1-4:2010, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-4:*

Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Antennes et emplacements d'essai pour les mesures des perturbations rayonnées
CISPR 16-1-4:2010/AMD1:2012
CISPR 16-1-4:2010/AMD2:2017

3 Termes, définitions et termes abrégés

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC entretiennent des bases de données terminologiques à l'usage de la normalisation aux adresses suivantes:

- IEC Electropedia: disponible à http://www.electropedia.org/
- ISO Online browsing platform: disponible à http://www.iso.org/obp

3.1 Termes et définitions

3.1.1
appareil
dispositif ou assemblage de dispositifs qui peut être utilisé comme unité indépendante pour remplir des fonctions particulières

[SOURCE: IEC 60050-151:2001, 151-11-22]

3.1.2
environnement
milieu dans lequel un produit ou un système existe, incluant l'air, l'eau, le sol, les ressources naturelles, la flore, la faune, les êtres humains et leurs interrelations

[SOURCE: IEC Guide 109:2012, 3.3]

[SOURCE: IEC 60050-901:2013, 901-07-01]

3.1.3
sous-station de traction, <en traction électrique>
poste dont la fonction principale consiste à alimenter un réseau de traction

Note 1 à l'article: Le synonyme de sous-station est utilisé uniquement lorsque le contexte est clair.

[SOURCE: IEC 60050-811:2017, 811-36-02]

3.1.4
matériel roulant
ensemble des véhicules, motorisés ou non

Note 1 à l'article: Des exemples de véhicules incluent une locomotive, une voiture, un wagon.

[SOURCE: IEC 60050-811:2017, 811-02-01]

3.2 Termes abrégés

CA	Courant alternatif
BW	Band width (largeur de bande)
CC	Courant continu
E	(champ) Electrique
CEM	Compatibilité électromagnétique
FFT	Fast Fourier Transform (transformation de Fourier rapide)
H	(champ) Magnétique
HT	Haute tension
UIT	Union Internationale des Télécommunications
r.m.s.	root mean square value (valeur efficace)

4 Limites d'émission

4.1 Émission provenant d'un système ferroviaire de surface pendant le fonctionnement des trains

Les limites d'émission dans la plage de fréquences de 150 kHz à 1 GHz sont données à la Figure 1 et la méthode de mesure est définie à l'Article 5.

L'Annexe B donne à titre indicatif des valeurs typiques de champ maximum à la fréquence fondamentale des différents systèmes d'énergie de traction qui peuvent se produire. Elles dépendent de nombreux paramètres opérationnels et géométriques qui peuvent être obtenus auprès du gestionnaire d'infrastructure.

Il n'est pas possible de réaliser des essais complets avec détection de quasi-crête à cause des raisons énoncées à l'Annexe A.

Dans certains cas, des services radio ou autres services externes au système ferroviaire peuvent fonctionner à des fréquences de fonctionnement inférieures à 150 kHz près du système ferroviaire. Le plan de gestion de la CEM couvre ces cas, et un niveau approprié d'émission du système ferroviaire à ces fréquences de fonctionnement peut être trouvé dans les valeurs indiquées dans l'Annexe C informative. Un fonctionnement exempt de perturbation ne peut donc être garanti.

4.2 Émission radio fréquence provenant des sous-stations de traction

L'émission de perturbation radioélectrique provenant de la sous-station de traction vers l'environnement extérieur mesurée selon la méthode définie à l'Article 5 ne doit pas dépasser les limites données à la Figure 2.

Les limites sont définies en valeurs quasi-crête et les largeurs de bande sont celles qui sont utilisées dans la CISPR 16-1-1:

	Largeur de bande
Fréquences de 150 kHz à 30 MHz	9 kHz (BW 1)
Fréquences supérieures à 30 MHz	120 kHz (BW 2)

La distance de 10 m définie à l'Article 5 doit être mesurée à partir de la clôture de la sous-station. S'il n'y a pas de clôture, les mesures doivent être réalisées à 10 m de l'appareil ou de la surface extérieure de l'enceinte s'il y en a une.

Pour les autres types d'installations fixes comme les autotransformateurs, la même limite et la même distance de mesure doivent s'appliquer.

Dans certains cas, des services radio ou autres services externes au système ferroviaire peuvent fonctionner à des fréquences de fonctionnement inférieures à 150 kHz près de la sous-station de traction. Le plan de gestion de la CEM couvre ces cas, et un niveau approprié d'émission de la sous-station de traction à ces fréquences de fonctionnement peut être trouvé dans les valeurs indiquées dans l'Annexe C informative. Un fonctionnement exempt de perturbation ne peut donc être garanti.

5 Méthode de mesure des émissions du matériel roulant en mouvement et des sous-stations

5.1 Paramètres de mesure généraux et spécifiques

NOTE La méthode de mesure est une adaptation de celle de CISPR 16-2-3 au système ferroviaire avec matériel roulant en mouvement et les sous-stations. Les éléments de base de cette méthode de mesure du matériel roulant en mouvement sont donnés à l'Annexe A.

5.1.1 Paramètres de mesure généraux

5.1.1.1 Bandes de fréquences

Les bandes de fréquences et les largeurs de bande à –6 dB utilisées pour les mesures sont conformes à la CISPR 16-1-1.

Il s'agit des valeurs suivantes:

Bandes de fréquences:	0,15 MHz à 30 MHz	30 MHz à 300 MHz	300 MHz à 1 GHz
Largeur de bande:	9 kHz (BW 1)	120 kHz (BW 2)	120 kHz (BW 2)

D'autres largeurs de bande pour la mesure de crête peuvent être choisies conformément à la CISPR 16-1-1. Les données mesurées avec la largeur de bande de référence doivent prévaloir.

5.1.1.2 Incertitude de mesure

L'incertitude de mesure de l'équipement de mesure doit se conformer aux exigences des normes CISPR 16-1-1 et CISPR 16-1-4.

Selon la méthode de mesure, l'affaiblissement normalisé de l'emplacement peut ne pas être pris en compte dans l'incertitude de mesure.

5.1.1.3 Types d'antennes

Pour couvrir la plage complète de fréquences, il est nécessaire de prévoir différentes antennes. L'équipement type est décrit ci-dessous:

– pour la plage de 150 kHz à 30 MHz, une antenne-cadre est utilisée pour mesurer le champ H (voir Figure 3);
– pour la plage de 30 MHz à 300 MHz, un dipôle biconique est utilisé pour mesurer le champ E (voir Figure 4);
– pour la plage 300 MHz à 1,0 GHz, une antenne log-périodique est utilisée pour mesurer le champ E (voir Figure 5).

Pour les mesures dans la plage de fréquences de 30 MHz à 1 GHz, une antenne combinée peut être utilisée.

Des facteurs d'antenne étalonnés sont utilisés pour convertir la tension aux bornes de l'antenne en niveau de champ.

5.1.1.4 Distance et hauteur de mesure

La distance préférentielle de l'antenne de mesure par rapport à la ligne centrale de la voie sur laquelle se déplace le véhicule (voie d'essai) est de 10 m. Dans le cas d'une antenne log-périodique, la distance de 10 m est mesurée par rapport au centre mécanique des éléments de l'antenne.

La distance préférentielle de l'antenne de mesure au cours de la mesure des émissions de la sous-station est de 10 m de la clôture extérieure de la sous-station, aux points centraux des trois côtés, à l'exception du côté qui fait face au système ferroviaire, sauf si ce côté se situe à plus de 30 m du centre de la voie de chemin de fer électrifiée la plus proche. Dans ce cas, tous les quatre côtés doivent être mesurés. Si la longueur du côté de la sous-station est supérieure à 30 m, des mesures supplémentaires doivent être également réalisées aux angles.

Si les antennes ne se trouvent pas à 10 m, les résultats peuvent être convertis en une valeur équivalant à 10 m en utilisant la formule suivante:

$$E_{10} = E_{\mathrm{x}} + n \times 20 \times \log_{10} (D/10)$$

où

E_{10} est la valeur à 10 m;

E_{x} est la valeur mesurée à D m;

n est un facteur pris dans le Tableau 1 ci-dessous.

Tableau 1 – Facteur de conversion *n*

Plage de fréquences	*n*
0,15 MHz à 0,4 MHz	1,8
0,4 MHz à 1,6 MHz	1,65
1,6 MHz à 110 MHz	1,2
110 MHz à 1 000 MHz	1,0

Les valeurs mesurées (à la distance équivalant à 10 m) ne doivent pas dépasser les limites données à la Figure 1 pour la tension réseau appropriée.

Il n'est pas nécessaire d'effectuer des mesures pour les systèmes ferroviaires souterrains sans fonctionnement en surface (aucune victime à l'extérieur de ce système ferroviaire ne peut être affectée).

La hauteur au-dessus du niveau de référence du centre de l'antenne doit être comprise entre 1,0 m et 2,0 m pour l'antenne-cadre et entre 2,5 m et 3,5 m par rapport au centre de l'antenne de mesure au-dessus de 30 MHz. Une hauteur de mesure dans la plage donnée est suffisante et il n'est pas exigé d'effectuer des mesures avec plusieurs hauteurs d'antenne dans cette plage. La hauteur sélectionnée doit être notée dans le rapport d'essai.

Le niveau de référence pour la sous-station est le sol.

Le niveau de référence pour les trains en mouvement est le haut du rail.

Si le niveau réel du sol au point où se situe l'antenne diffère du haut du rail de plus de 0,5 m, la valeur réelle doit être notée dans le rapport d'essai.

Il est accepté que la position d'antenne fixe puisse donner des valeurs inférieures à la valeur maximale absolue à certaines fréquences.

5.1.1.5 Valeurs de mesure

Les valeurs mesurées sont exprimées en:

– dBµA/m pour les champs magnétiques,

– dBµV/m pour les champs électriques.

Elles sont obtenues en utilisant les facteurs d'antenne et les conversions qui conviennent.

5.1.1.6 Position et orientation de l'antenne

Le plan de l'antenne-cadre doit être placé de façon à mesurer la composante horizontale du champ magnétique perpendiculaire à la voie par rapport à la paroi de la sous-station. L'antenne biconique doit être placée dans l'axe vertical et horizontal. L'antenne log-périodique doit être disposée pour mesurer le signal en polarisation verticale et horizontale, l'antenne étant dirigée vers la voie par rapport à la paroi de la sous-station.

Dans la mesure du possible, il convient que les emplacements d'essai évitent les objets dont les caractéristiques de champ varient (les points d'évitement, les parois et les passages inférieurs, par exemple).

Les Figures 3, 4 et 5 montrent les positions et les alignements verticaux des antennes à titre d'exemple de mesures sur la voie.

5.1.1.7 Bruit ambiant

Le bruit ambiant doit être enregistré au début et à la fin de la série d'essais.

Si, à des fréquences spécifiques ou dans des plages de fréquences spécifiques, le bruit ambiant est supérieur aux valeurs limites inférieures à 6 dB (bruit ambiant > (limite d'émission – 6 dB)), les mesures à ces fréquences peuvent ne pas être envisagées. Ces fréquences doivent être notées dans le rapport d'essai.

5.1.2 Paramètre de mesure pour les trains en mouvement

Ce paragraphe résume les conditions spécifiques pour la mesure du matériel roulant en mouvement.

– Il n'est pas jugé nécessaire de réaliser deux essais pour examiner les deux côtés du matériel roulant, même s'il contient des appareils différents des deux côtés, dans la mesure où la plupart du temps, le niveau des champs est dû au rayonnement de caténaire et pas au rayonnement direct issu du train. Pour les réseaux dotés d'un troisième rail, les mesures doivent être réalisées du même côté de ce rail.

– La méthode de mesure de crête est utilisée. La durée à une fréquence choisie doit être suffisante pour obtenir une lecture précise. C'est une fonction du dispositif de mesure et la valeur recommandée est de 50 ms.

– Le bruit peut ne pas atteindre sa valeur maximale lorsque le véhicule de traction passe devant le point de mesure, mais cela peut se produire lorsque le véhicule se trouve à une grande distance de celui-ci. Le dispositif de mesure doit donc être actif pendant une durée suffisante avant et après le passage du véhicule afin de s'assurer que le niveau maximum de bruit est enregistré.

– Dans le cas de systèmes ferroviaires aériens, si les hauteurs d'antenne spécifiées ci-dessus ne peuvent pas être respectées, la hauteur du centre de l'antenne peut être référencée au niveau du sol au lieu du haut du rail. La formule de conversion donnée en 5.1.1.4 doit être utilisée avec D égale à la pente entre le train et l'antenne. Le train doit être visible de l'endroit où est placée l'antenne et l'axe de l'antenne doit être orienté directement vers le train. Une distance de mesure de 30 m à partir de la ligne centrale de la voie est privilégiée pour les systèmes ferroviaires fortement surélevés. Tous les détails de la configuration d'essai doivent être notés dans le rapport d'essai.

– Si les essais sont réalisés dans un système ferroviaire doté d'une alimentation électrique aérienne, le point de mesure doit se situer à mi-distance entre les pylônes porteurs de la ligne de contact aérienne, et pas à l'emplacement d'une discontinuité du fil de contact. Il est reconnu qu'il peut y avoir une résonance dans un réseau de lignes aériennes en radiofréquences, et ceci peut nécessiter des modifications dans les valeurs des fréquences choisies pour la mesure. Les éventuelles résonances doivent être notées dans le rapport d'essai.

  L'émission radiofréquence est affectée par l'état du système d'alimentation ferroviaire. La commutation des stations d'alimentation et les travaux temporaires influencent la réponse du système. C'est pourquoi il est nécessaire de noter l'état du système dans le rapport d'essai et il convient, dans la mesure du possible, que tous les essais similaires soient effectués pendant la même journée de travail. Lorsque le système ferroviaire possède une alimentation par rail de contact côté voie, il convient que l'emplacement d'essai soit situé à au moins 100 m des discontinuités du rail, pour éviter d'inclure les champs transitoires associés à l'ouverture et à la fermeture du contact de captation. Le rail de contact et les antennes doivent être situés du même côté de la voie.

– Les emplacements d'essai ne correspondent pas à la définition d'un emplacement complètement à l'abri de perturbations, car ils subissent les influences des structures aériennes, des rails et de la caténaire. Cependant, dans la mesure du possible, les antennes doivent être placées très loin des objets réfléchissants. Si des lignes électriques à haute tension sont à proximité, autres que celles qui font partie du réseau ferroviaire, il convient qu'elles ne soient pas à moins de 100 m de l'emplacement d'essai.

5.1.3 Paramètre de mesure pour les sous-stations de traction

Ce paragraphe résume les conditions spécifiques pour la mesure des sous-stations.

– Configuration des essais: Compte tenu de la géométrie particulière d'un réseau d'alimentation pour la traction ferroviaire, il est nécessaire de mesurer les émissions des champs électromagnétiques en configuration normale d'alimentation du réseau d'alimentation pour la traction.

– Charge de la sous-station: Une des caractéristiques des sous-stations de traction est que la charge peut varier de manière importante en très peu de temps. Étant donné que l'émission peut être liée à la charge, la charge réelle de la sous-station doit être notée pendant les essais d'émission.

– Chaque mesure doit commencer par un balayage de maintien des maximums de crête. Si les limites sont dépassées en raison de la sous-station, une mesure de quasi-crête doit être prise pour la plage de fréquences spécifique dépassant les limites. Il est admis que les conditions de charge ne peuvent être reproduites exactement pendant la mesure de quasi-crête, et qu'il convient donc que ces conditions de charge soient au moins comparables.

5.2 Méthodes d'acquisition

5.2.1 Généralités

Les perturbations électromagnétiques générées par le réseau ferroviaire, y compris le matériel roulant en fonctionnement, sont mesurées grâce aux deux méthodes suivantes:

a) la méthode à fréquences fixes;

b) la méthode de balayage en fréquence.

La méthode de mesure doit être choisie selon les modes de fonctionnement du matériel roulant (voir 5.4.2) en fonction de la vitesse du train.

– Pour les essais à vitesse élevée, les points suivants doivent être pris en compte: