# ETSI EN 302 609 V1.1.1 (2008-11)

*Harmonized European Standard (Telecommunications series)*

**Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment for Euroloop railway systems; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive**

Reference
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# Foreword

This Harmonized European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document has been produced by ETSI in response to a mandate from the European Commission issued under Council Directive 98/34/EC [i.5] (as amended) laying down a procedure for the provision of information in the field of technical standards and regulations.

The present document is intended to become a Harmonized Standard, the reference of which will be published in the Official Journal of the European Communities referencing the Directive 1999/5/EC [i.6] of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity ("the R&TTE Directive").

Technical specifications relevant to Directive 1999/5/EC [i.6] are given in annex A.

The Euroloop transmission system operates in accordance with ERC Recommendation 70-03, annex 4.

These specifications are complementary with the system and interoperability requirements for these devices established under Commission Decision 2004/447/EC [i.7].

| **National transposition dates** | |
|---|---|
| Date of adoption of this EN: | 28 October 2008 |
| Date of latest announcement of this EN (doa): | 31 January 2009 |
| Date of latest publication of new National Standard or endorsement of this EN (dop/e): | 31 July 2009 |
| Date of withdrawal of any conflicting National Standard (dow): | 31 July 2010 |

# Introduction

The present document is part of a set of standards developed by ETSI and is designed to fit in a modular structure to cover all radio and telecommunications terminal equipment within the scope of the R&TTE Directive. The modular structure is shown in EG 201 399 [i.2].

The Euroloop communication system is defined by the specifications of the UNISIG consortia [i.3].

# 1 Scope

The present document covers the technical requirements for radio transmitters and receivers used in the Euroloop transmission system. The system is only used in railway systems.

It applies to the following two equipment units as is shown in figure 1:

- The On-Board Equipment (OBE) receiving the Euroloop signal and the OBE comprises a receiver fitted with a dedicated antenna.
- The Track-Side Equipment (Euroloop) transmitting the Euroloop signal that is always installed in an inner or outer foot of a rail.

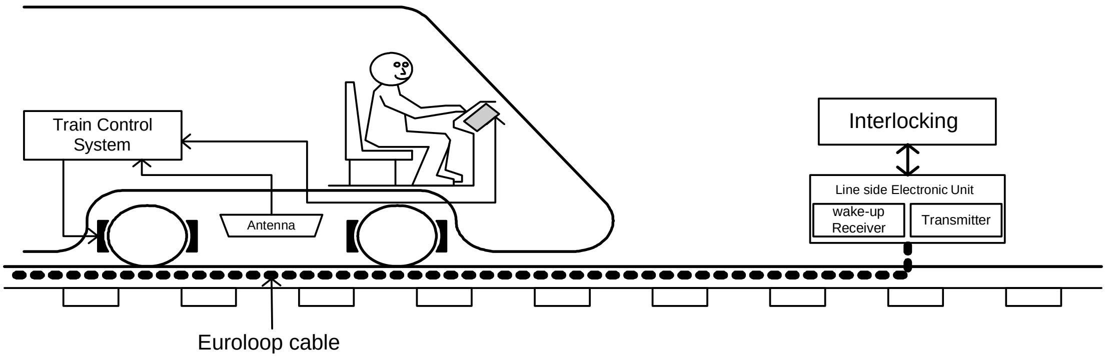


**Figure 1: Euroloop situation on railway track**

The Euroloop comprises DSSS-BPSK-modulated transmitter fitted with a dedicated antenna. It is always switched on but is only transmitting in the presence of a train.

These radio equipment types are capable of operating at the following frequencies as given below in table 1.

**Table 1: Radiocommunications service frequency bands**

| | Radiocommunications service frequency bands |
|---|---|
| OBE receive centre frequency | 13,547 MHz |
| Euroloop receiver centre frequency | 27,095 MHz |
| Euroloop transmit centre frequency | 13,547 MHz |
| Euroloop transmit modulation | BPSK, DSSS chip rate 4,516 MHz |

The present document is intended to cover the provisions of Directive 1999/5/EC [i.6] (R&TTE Directive) article 3.2, which states that "… radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communications and orbital resources so as to avoid harmful interference".

NOTE: A list of such ENs is included on the web site http://www.newapproach.org.

# 2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

## 2.1 Normative references

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

[1] ETSI TR 100 028 (2001) (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[2] ERTMS/ETCS - CLASS 1, SUBSET-044 FFFIS for Euroloop.

## 2.2 Informative references

The following referenced documents are not essential to the use of the ETSI deliverable but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TR 102 273 (2001) (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

[i.2] ETSI EG 201 399 (V2.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of candidate Harmonized Standards for application under the R&TTE Directive".

[i.3] The UNISIG Consortium was composed of the following European Companies working in the Railway Signalling area: Alstom, Ansaldo Signal, Bombardier, Invesys Rail, Siemens, and Thales.

[i.4] ETSI EN 302 608 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio Equipment for Eurobalise railway systems; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.5] Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations.

[i.6] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[i.7] Commission Decision 2004/447/EC of 29 April 2004 modifying annex A to Decision 2002/731/EC of 30 May 2002 and establishing the main characteristics of Class A system (ERTMS) of the control-command and signalling subsystem of the trans-European conventional rail system referred to in Directive 2001/16/EC of the European Parliament and of the Council.

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

**dedicated antenna:** removable antenna supplied and tested with the radio equipment, designed as an indispensable part of the equipment

**euroloop:** wayside transmission unit that uses the magnetic transmission technology

NOTE: Its main function is to transmit signals through the air gap. The Euroloop is a single device mounted on the track, which communicates with a train passing over it.

**magnetic transmission technology:** method that uses magnetic coupling in the air gap between a transmitter and a receiver

NOTE: In the Euroloop transmission system context, it considers systems using the 13,547 MHz for Uplink (track to train) transmission.

**rf carrier:** fixed radio frequency prior to modulation

**uplink:** transmission link from the Euroloop to the OBE

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

| | |
|---|---|
| f | Frequency |
| $f_H$ | Highest frequency of the power envelope |
| $f_L$ | Lowest frequency of the power envelope |
| Ω | ohm |
| R | Distance |
| λ | wavelength |

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

| | |
|---|---|
| BPSK | Binary Phase Shift Keying |
| dB | deciBel |
| DSSS | Direct Sequence Spread Spectrum |
| OBE | On-Board Equipment |
| R&TTE | Radio and Telecommunications Terminal Equipment |
| RF | Radio Frequency |
| RMS | Root Mean Square |
| SRD | Short Range Device |
| VSWR | Voltage Standing Wave Ratio |

# 4 Technical requirements specification

## 4.1 OBE unwanted emissions

### 4.1.1 Definition

This test only applies to the OBE.

NOTE: Eurobalise-OBU tele-powering is used for wake-up of the Euroloop. The Eurobalise OBE transmitter mask is defined in EN 302 608 [i.4].

### 4.1.2 Test procedure

This test is performed using a radiated measurement for frequencies below 30 MHz and a conducted measurement for frequencies from 30 MHz to 1 000 MHz (see clause 7.1).

### 4.1.3 Limit

The spurious components between 9 kHz and 10 MHz shall not exceed a generated H-field at a distance of 10 m of 5,5 dBµA/m at 9 kHz descending 3 dB/oct. and -22 dBµA/m between 10 MHz and 30 MHz measured in 10 kHz bandwidth.

The spurious components above 30 MHz shall not exceed the conducted power of 2 nW into 50 Ω resistive load.

## 4.2 Euroloop field strength

### 4.2.1 Definition

This test only applies to the Euroloop transmitter.

### 4.2.2 Test procedure

This test is performed using a radiated measurement (see clause 7.3).

### 4.2.3 Limit

The transmitted magnetic field strength shall not exceed -7 dBµA/m at 10 m distance within the frequency range of 11,1 MHz to 16,0 MHz measured in a bandwidth of 10 kHz spatially averaged over any 200 m length of the loop.

## 4.3 Euroloop transmitter mask

### 4.3.1 Definition

This test only applies to Euroloop transmitters.

### 4.3.2 Test procedure

This test is performed using conducted measurement (see clause 7.2).

### 4.3.3 Limit

The measured spectrum (field strength) shall not exceed the relative frequency mask values of figure 2.

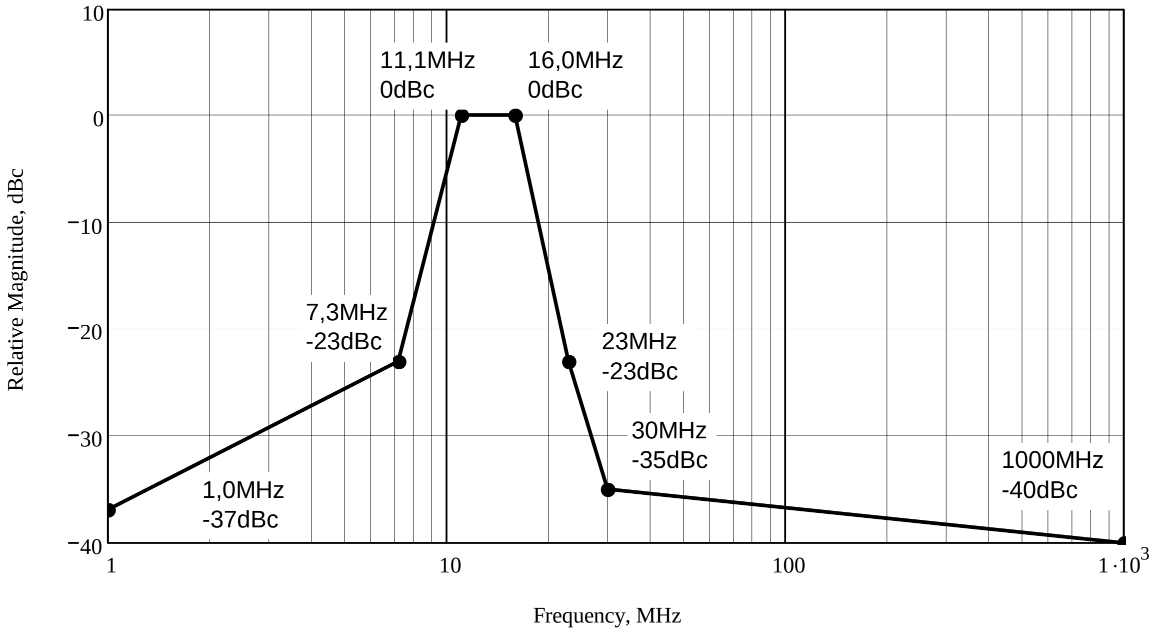


**Figure 2: Euroloop transmitter spectrum and spurious mask**

The limit at 1 MHz shall also apply for frequencies below 1 MHz.

## 4.4 Maximum allowable measurement uncertainty

See clause 6, table 3.

# 5 Test conditions

## 5.1 Test conditions

Testing shall be made under normal test conditions.

NOTE: The Euroloop system components (OBE as well as the Euroloop) are built for interoperability and the UNISIG specifications apply over the full operating temperature range (including the spectrum masks).

The test conditions and procedures shall be as specified in clauses 5.2 to 5.6.

## 5.2 Test power source

The OBE and Euroloop equipment shall be tested using the appropriate test power source.

The test power source used shall be stated in the test report.

During the tests, the power source of the equipment shall be replaced by an external test power source capable of producing normal test voltages as specified in clauses 5.3.2. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible. For the purpose of the tests, the voltage of the external test power source shall be measured at the input terminals of the equipment. For radiated measurements any external power leads should be so arranged so as not to affect the measurements.

During tests the test power source voltages shall be within a tolerance of < ±1 % relative to the voltage at the beginning of each test. The value of this tolerance can be critical for certain measurements. Using a smaller tolerance will provide a better uncertainty value for these measurements.

## 5.3 Normal test conditions

### 5.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature: +15 °C to +35 °C;
- relative humidity: 20 % to 75 %.

The test conditions are only for the test equipment and not for the installed Euroloop system.

### 5.3.2 Normal test power source

#### 5.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages, for which the equipment was designed.

The frequency of the test power source corresponding to the ac mains shall be between 49 Hz and 51 Hz.

#### 5.3.2.2 Other power sources

For operation from other power sources, the normal test voltage shall be that declared by the equipment provider and agreed by the test laboratory. Such values shall be stated in the test report.

## 5.4 Requirements for the Euroloop test modulation

The applied DSSS code during tests shall be the Euroloop test-code #15 specified in SUBSET-044 [2].

The manufacturer shall provide the means to operate the transmitter during the tests.

## 5.5 Choice of equipment for test suites

### 5.5.1 Choice of model

The tests shall be carried out on one or more production models or equivalent preliminary models, as appropriate. If testing is performed on (a) preliminary model(s), then the corresponding production models shall be identical to the tested models in all respects relevant for the purposes of the present document.

If equipment has several optional features that are considered to affect directly the RF parameters then tests need only be performed on the equipment configured with the considered worst case combination of features as declared by the manufacturer.

The tests shall be performed as radiated - and conducted test using the appropriate measurement procedures.

The manufacturer shall provide one or more samples of the equipment, as appropriate for testing. Additionally, technical documentation and operating manuals, sufficient to make the test, shall be supplied.

## 5.6 Measuring receiver

The term "measuring receiver" refers to a spectrum analyser. The bandwidth and detector type of the measuring receiver are given in table 2 unless otherwise specified.

**Table 2: Measuring receiver**

| Frequency: (f) | Detector type | Spectrum analyzer bandwidth |
|---|---|---|
| 9 kHz ≤ f < 150 kHz | RMS | 300 Hz |
| 150 kHz ≤ f < 30 MHz | RMS | 10 kHz |
| 30 MHz ≤ f ≤ 1 000 MHz | RMS | 100 kHz |

# 6 Measurement uncertainty

The interpretation of the results recorded in the test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit shall be used to decide whether equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be separately included in the test report;
- the value of the measurement uncertainty should be, for each measurement, equal to or lower than the figures in table 3.

**Table 3: Absolute measurement uncertainties: maximum values**

| Parameter | Uncertainty |
|---|---|
| Radiated field strength | ±6 dB |
| Conducted RF power | ±1,25 dB |
| Temperature | ±1 °C |
| Humidity | ±10 % |

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR 100 028 [1] and shall correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Table 4 is based on such expansion factors.

The particular expansion factor used for the evaluation of the measurement uncertainty shall be stated.

TR 102 273 [i.1] provides further information concerning the usage of test sites.

# 7 Test procedures for essential radio test suites

## 7.1 OBE unwanted emissions

For the test conditions, see clause 5.1.

The emissions shall be measured over the frequency range 1 MHz to 1 000 MHz.

At each frequency at which a relevant spurious signal is detected the OBE under test and the test antenna shall be rotated around the vertical axle until maximum field strength is indicated on the measuring receiver. This level shall be noted.

For measuring equipment calibrated in dBμV/m, the reading should be reduced by 51,5 dB to be converted to dBμA/m or vice-versa.

The spectrum analyser shall be configured as follows unless otherwise stated:

- Resolution bandwidth: In accordance with table 2 in clause 5.6.
- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: Quasi Peak.

The OBE unwanted emissions are measured:

Step 1 For frequencies below 30 MHz the H-field strength shall be measured at 10 m distance by using Quasi Peak detector and the resolution bandwidth as given in table 2 of clause 5.6. The results are recorded in the test report as the total field strength.

Where a measurement distance of 10 m is not practical, e.g. due to physical size of the equipment including the antenna or with use of special field cancelling antenna, then other distances may be used. When another distance is used, the distance used and the field strength value measured shall be stated in the test report. In this case, the measured value at actual test distance shall be extrapolated to 10 m according to annex E and these calculations shall be stated in the test report. The H-field is measured with a shielded loop antenna connected to a measurement receiver below 30 MHz.

Step 2 For frequencies above 30 MHz the dedicated antenna shall be replaced by a non-reactive non radiating resistive 50 Ω termination. The Voltage Standing Wave Ratio (VSWR) at the 50 Ω connector shall not be greater than 1,5: 1 over the frequency range of the measurement. The conducted power into the termination shall be measured.

## 7.2 Euroloop transmitter conducted measurements

See clause 5.1 for the test conditions.

The measurements shall cover the frequency range 9 kHz to 1 000 MHz.

The measurements of the conducted transmitter spectrum shall be carried out in a test lab.

The Euroloop transmitter spectrum shall be measured and recorded. The Euroloop transmitter shall be activated according to the specification of the manufacturer. During spectrum measurements the Euroloop transmitter shall be terminated by a non-reactive, non radiating resistive 50 Ω power termination instead of the dedicated leaky feeder cable. The Voltage Standing Wave Ratio (VSWR) at the 50 Ω connector shall not be greater than 1,5: 1 over the frequency range of the measurement.

The spectrum analyser shall be configured as follows unless otherwise stated:

- Resolution bandwidth: In accordance with table 2 in clause 5.6.
- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: RMS.

## 7.3 Euroloop field strength measurements

See clause 5.1 for the test conditions.

Euroloop field strength measurements shall be carried out at appropriate installation sites in railway environment. At least at one side of the track enough space to carry out measurements at 10 m distance is required.

For safety reasons all field measurements shall be made at railway tracks without any railway traffic during the measurements. As no train is present the Euroloop shall be activated according to the specification of the manufacturer.

The measurement range along the Euroloop shall cover the whole length of the Euroloop leaky feeder cable in the track, however, this shall not exceed the length of 1 km.

The field strength spectrum shall be measured over the frequency range 10,8 MHz to 16,3 MHz, step size 30 kHz.

Any measured values shall be at least 6 dB above noise level of the measuring equipment. The measurement results will also include the signals of other services.

The measurement system shall be configured as follows unless otherwise stated:

- Antenna location: 10 m orthogonal distance from Euroloop and 1 m above ground.
- Resolution bandwidth: 10 kHz.
- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: RMS.
- Averaging: 5 times.

Step 1 The magnetic field strength spectrum shall be measured and recorded every 5 m along the Euroloop in x- (along Euroloop), y- (horizontal orthogonal to Euroloop), and z-direction (vertical to Euroloop).

Step 2 Utilize the measurement results according to annex D. The limit shall not be exceeded over any 200 m length of the loop.

# Annex A (normative): HS Requirements and conformance Test specifications Table (HS-RTT)

The HS Requirements and conformance Test specifications Table (HS-RTT) in table A.1 serves a number of purposes, as follows:

- it provides a statement of all the requirements in words and by cross reference to (a) specific clause(s) in the present document or to (a) specific clause(s) in (a) specific referenced document(s);
- it provides a statement of all the test procedures corresponding to those requirements by cross reference to (a) specific clause(s) in the present document or to (a) specific clause(s) in (a) specific referenced document(s);
- it qualifies each requirement to be either:
  - Unconditional: meaning that the requirement applies in all circumstances, or
  - Conditional: meaning that the requirement is dependant on the manufacturer having chosen to support optional functionality defined within the schedule.
- in the case of Conditional requirements, it associates the requirement with the particular optional service or functionality;
- it qualifies each test procedure to be either:
  - Essential: meaning that it is included with the Essential Radio Test Suite and therefore the requirement shall be demonstrated to be met in accordance with the referenced procedures;
  - Other: meaning that the test procedure is illustrative but other means of demonstrating compliance with the requirement are permitted.

**Table A.1: HS Requirements and conformance Test specifications Table (HS-RTT)**

| **Harmonized Standard EN 302 609**<br>The following technical requirements and test specifications are relevant to the presumption of conformity under the article 3.2 of the R&TTE Directive | | | | | | |
|---|---|---|---|---|---|---|
| **Requirement** | | | **Requirement Conditionality** | | **Test Specification** | |
| **No** | **Description** | **Reference: Clause No** | **U/C** | **Condition** | **E/O** | **Reference: Clause No** |
| 1 | OBE unwanted emissions | 4.1 | C | Applies to OBE only | E | 7.1 |
| 2 | Euroloop magnetic radiated field strength | 4.2 | C | Applies to Euroloop only | E | 7.3 |
| 3 | Euroloop transmitter mask | 4.3 | C | Applies to Euroloop only | E | 7.2 |

**Key to columns:**

**Requirement:**

**No** A unique identifier for one row of the table which may be used to identify a requirement or its test specification.

**Description** A textual reference to the requirement.

**Clause Number** Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

**Requirement Conditionality:**

**U/C** Indicates whether the requirement is to be *unconditionally* applicable (U) or is *conditional* upon the manufacturers claimed functionality of the equipment (C).

**Condition** Explains the conditions when the requirement shall or shall not be applicable for a technical requirement which is classified "conditional".

**Test Specification:**

**E/O** Indicates whether the test specification forms part of the Essential Radio Test Suite (E) or whether it is one of the Other Test Suite (O).

NOTE: All tests whether "E" or "O" are relevant to the requirements. Rows designated "E" collectively make up the Essential Radio Test Suite; those designated "O" make up the Other Test Suite; for those designated "X" there is no test specified corresponding to the requirement . The completion of all tests classified "E" as specified with satisfactory outcomes is a necessary condition for a presumption of conformity. Compliance with requirements associated with tests classified "O" or "X" is a necessary condition for presumption of conformity, although conformance with the requirement may be claimed by an equivalent test or by manufacturer's assertion supported by appropriate entries in the technical construction file.

**Clause Number** Identification of clause(s) defining the test specification in the present document unless another document is referenced explicitly. Where no test is specified (that is, where the previous field is "X") this field remains blank.

# Annex B (informative): The EN title in the official languages

The enlargement of the European Union (EU) resulted in a requirement from the EU for a larger number of languages for the translation of the titles of Harmonized Standards and mandated ENs that are to be listed in the Official Journal to support the implementation of this legislation.

For this reason the title translation concerning the present document can be consulted via the e-approval application.

# Annex C (normative): Radiated measurement

Improvement of radiated methods of measurement and evaluation of the corresponding measurement uncertainties are also described in TR 102 273 [i.1].

# Annex D (normative): Field strength measurements along the Euroloop

The measured field strength spectrum contains the signals of other services also. To extract the representative maximum the ideal envelope of the Euroloop spectrum is fitted to the measured values:

Step 1 Calculate the magnitude of magnetic field strength for every measurement location and all frequencies using the components of the x-, y- and z-direction:

$$|H| = \sqrt{|H_x|^2 + |H_y|^2 + |H_z|^2} \quad \text{(D.1)}$$

Step 2 Determine the maximum field strength for every measurement location by fitting the ideal field strength spectrum envelope S(*f*) to the measured field strength spectrum M(*f*).

$$S(f) = A \cdot \frac{\sin\left(\frac{\pi \cdot (f - f_0)}{R_C}\right)}{\frac{\pi \cdot (f - f_0)}{R_C}}$$

**$f_0$: carrier frequency 13,547 MHz**

**$R_C$: chip rate 4,516 MHz**

***A*: normalizing Factor µA/m**

Determine A so that the following condition is met:

$$\left| \sum_f \left[ 20 \cdot \log M(f) - 20 \cdot \log S(f) \right] \right| = \min \quad \text{(D.2)}$$

The resulting maximum field strength at the measurement location is A.

Step 3 Calculate the arithmetic mean of maximum magnetic field strength values (in µA/m) determined in step 2 above over any sub-range of consecutive measurement locations covering a range of 200 m each.

If the length of the Euroloop leaky feeder cable is shorter than 200 m then the mean magnetic field strength is calculated over the actual length.

Step 4 The limit shall not be exceeded by the mean magnetic field strength of any of the 200 m long sub-ranges of an Euroloop.

# Annex E (informative): E-fields in the near field at low frequencies

E-field at low frequencies is often in the near field and it is in reality only possible to measure the H-field component with the shielded loop antenna; in this case there is also a relation between the E-field and the H-field by the wave impedance Z. In the near field the wave impedance is highly dependent on the type of radiating antenna (loop or open end wire) and the wavelength. If the power density at a certain distance is the same for an H-field and an E-field generated signal, the following calculation can be made:

In the direction of maximum power in the near field, the power density S is:

$$S = \frac{E^2}{Z_e} = H_e^2 Z_e = H_m^2 Z_m \qquad \text{(E.1)}$$

where:

- S = power density.
- E = electrical field generated by an E-field antenna at distance d.
- $H_e$ = magnetic field generated by an E-field antenna at distance d.
- $H_m$ = magnetic field generated by an H-field antenna at distance d.
- $Z_e$ = wave impedance of a field generated by an E-field antenna at distance d.
- $Z_m$ = wave impedance of a field generated by an H-field antenna at distance d.

$$Z_m = Z_o 2\pi \frac{d}{\lambda} \; if \; d < \frac{\lambda}{2\pi} \text{ (near field)} \qquad \text{(E.2)}$$

$$Z_e = Z_0 \frac{\lambda}{2\pi d} \; if \; d < \frac{\lambda}{2\pi} \text{ (near field)} \qquad \text{(E.3)}$$

Equation (E.1) gives:

$$H_e = H_m \sqrt{\frac{Z_m}{Z_e}} (A/m) \qquad \text{(E.4)}$$

Equation (D.2) and (D.3) into (D.4) gives:

$$H_e = H_m \frac{2\pi d}{\lambda} = H_m \frac{2\pi d \, f_c}{300} \qquad \text{(E.5)}$$

where fc is the carrier frequency in MHz.

For $2\pi d/\lambda = 1$, d = 10 and $f_c$ = 4,78 MHz, and using equation (E.5), this gives:

$$H_e = H_m \frac{f_c}{4{,}78} \; (f \text{ in MHz}) \qquad \text{(E.6)}$$

For $2\pi d/\lambda < 1$ if $f_c$ < 4,78 MHz then equation (E.5) is valid, (i.e. near field).

For $2\pi d/\lambda \geq 1$ if $f_c$ > 4,78 MHz then $H_e = H_m$, (i.e. far field).

The method allows an electric generated E-field to be measured as a magnetic generated H-field by adding a correction factor derived from (E.6).

For a graphical representation of the correction factor, see figure E.1.

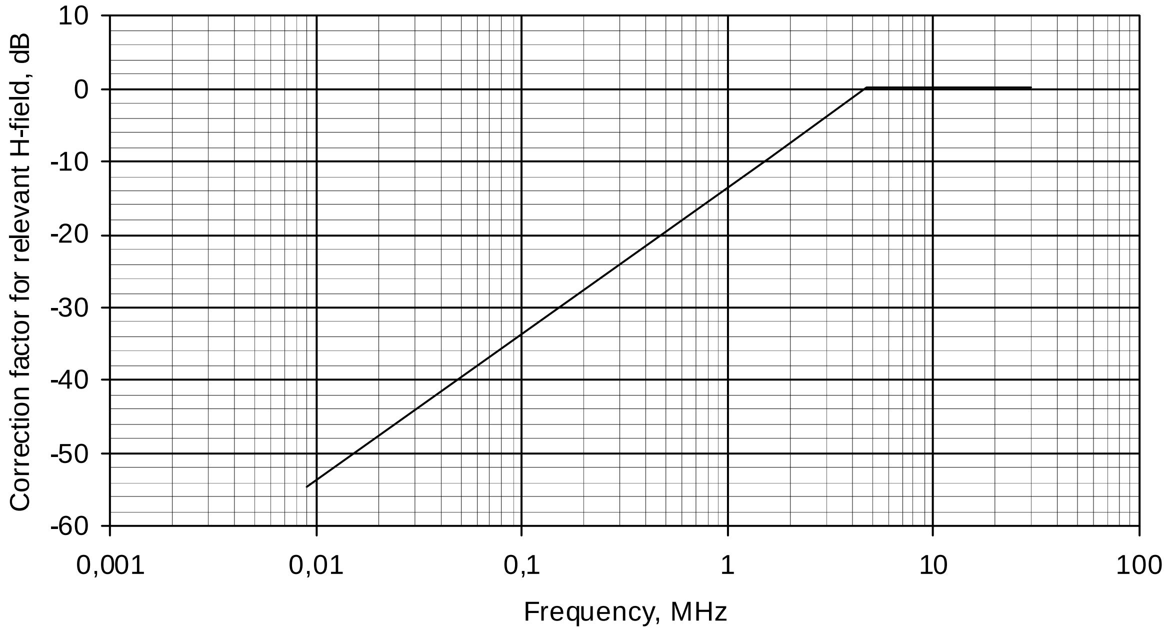


**Figure E.1: Conversion factor C30 versus frequency**

# Annex F (normative): H-field measurements and limits at 3 m and 30 m

The present document allows field measurements to be made at other distances than 10 m. In this case, the appropriate H-field limit, $H_x$, for provider requested measurement distance, $d_x$, shall be determined by the provider. Both the requested measurement distance and the appropriate limit shall be stated in the Test Report.

The conversion of the H-field limits at 10 m to a new measurements distance is not trivial as the near-field to far-field boundary is changing with both frequency and distance. Different combinations of near/far-field and maximum radiated field strength in either the coaxial or coplanar direction of the loop antenna result in conversions of the H-field limits for 3 m or 30 m as specified in clauses F.1 and F.2.

The conversion methods of this annex are only applicable if the maximum dimension of the loop coil is small in relation to the measurement distance.

# F.1 Limits for measurements at 30 m distance

The H-field limit at 30 m, $H_{30m}$, is determined by the following equation:

$$H_{30m} = H_{10m} + C_{30} \tag{F.1}$$

where:

$H_{10m}$ is the H-field limit in dBµA/m at 10 m distance according to the present document; and

$C_{30}$ is a conversion factor in dB which is determined from figure F.1.

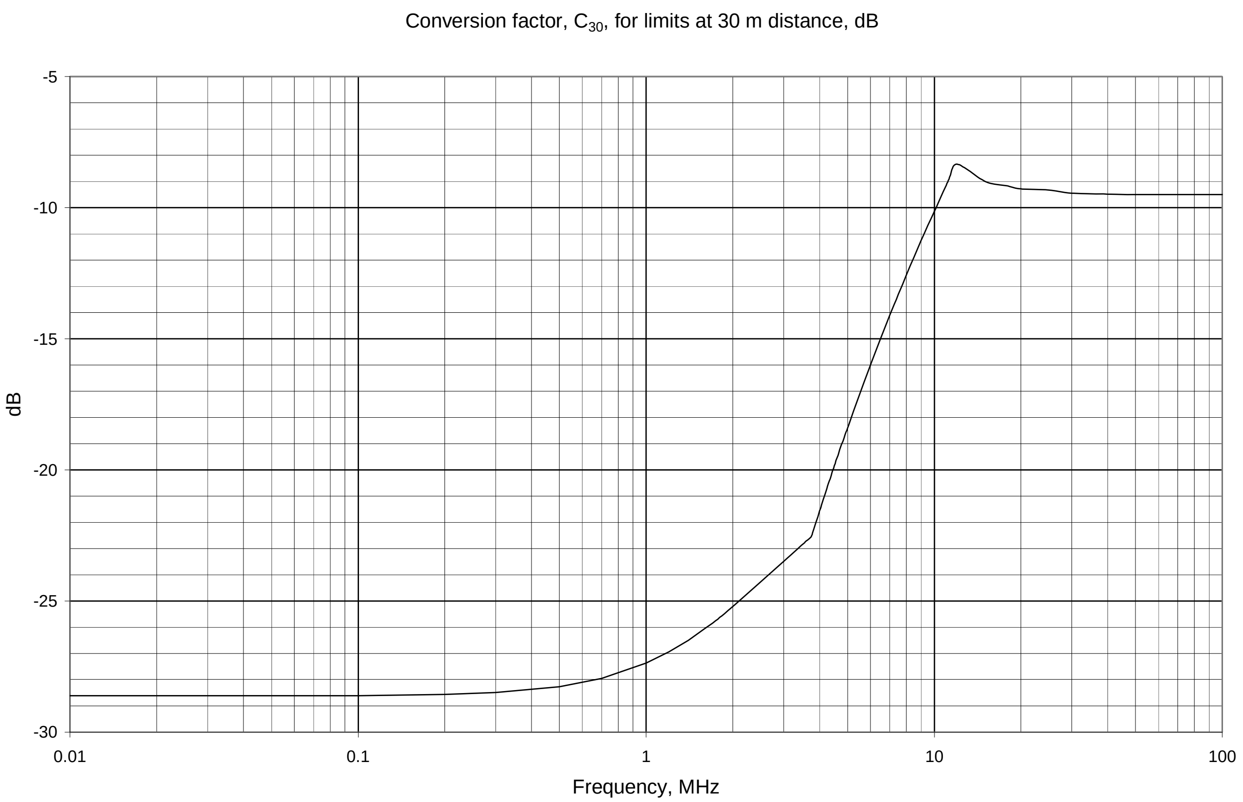


**Figure F.1: Conversion factor C30 versus frequency**

# F.2 Limits for measurements at 3 m distance

The H-field limit in dBµA/m at 3 m, $H_{3m}$, is determined by the following equation:

$$H_{3m} = H_{10m} + C_3 \qquad (F.2)$$

where:

$H_{10m}$ is the H-field limit in dBµA/m at 10 m distance according to the present document; and

$C_3$ is a conversion factor in dB determined from figure F.2.

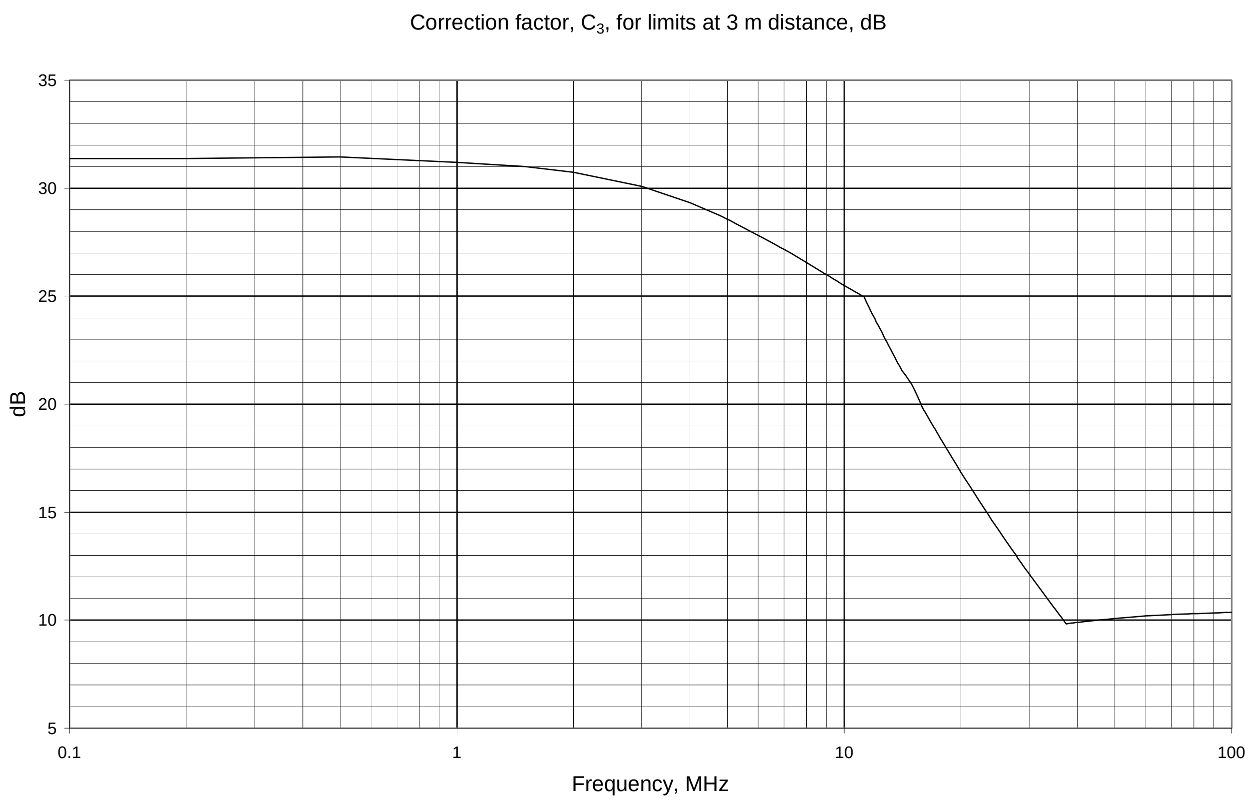


**Figure F.2: Conversion factor C3 versus frequency**

# Annex G (informative): Bibliography


Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive).

Council Directive 73/23/EEC of 19 February 1973 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits (LV Directive).

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# History

| Document history | | | | |
|---|---|---|---|---|
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