



HARMONISED EUROPEAN STANDARD

**Induction loop systems
intended to assist the hearing impaired
in the frequency range 10 Hz to 9 kHz;
Harmonised Standard covering the essential requirements
of article 3.2 of Directive 2014/53/EU**

Reference

DEN/ERM-TG17WG3-16

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Foreword

This final draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the Vote phase of the ETSI standards EN Approval Procedure.

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.8] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	18 months after doa

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Introduction

Audio Frequency Induction Loop Systems (AFILS) have been on the market since the middle of the twentieth century, with the first recognizable patents appearing circa 1938. AFILS are primarily used to facilitate improved communication to people with impaired hearing and are an important tool in the reduction of discrimination against disabled people.

The present document represents the performance of equipment which is currently on the market, which has not previously been subjected to compliance to a "radio" directive.

AFILS are installed in places of worship, places of entertainment, places of education, ticket booths and service counters, etc., as well as in domestic situations, providing huge benefits to users with impaired hearing.

AFILS provide an audio frequency magnetic field that couples with a receiving coil (Telecoil) fitted in hearing aids, cochlear implants, loop listeners and testing devices. This magnetic field is generated in a wire loop that is fed by an audio frequency amplifier which is capable of driving current through the "induction loop" which, in turn, is fed from external signals such as those generated by microphones, audio-visual equipment and musical instruments.

AFILS operate below 9 kHz and have a very limited range (some few metres) and there is no known evidence of interference with radio equipment.

The market for AFILS is relatively small compared with technologies such as RFID, and is physically separated from most radio systems, so the opportunity for mutual interference problems is reduced compared to other users of the spectrum in this frequency range.

The present document has been developed in response to Directive 2014/53/EU [i.1], which is the first radio standard that has been produced for AFILS equipment and has been prepared to allow the assessment of audio frequency induction loop amplifiers and receivers for compliance with Directive 2014/53/EU [i.1].

1 Scope

The present document specifies technical characteristics and methods of measurements for audio frequency induction loop amplifiers and receivers operating from 10 Hz to 9 kHz used in audio frequency induction loop systems (AFILS).

NOTE: The object of an AFILS is to transmit an audio signal to people with hearing difficulties. The receiver in this case is normally a hearing aid with a built in telecoil.

These radio equipment types are capable of operating in the frequency band within the 10 Hz to 9 kHz range:

- either with an output connection(s) and dedicated loop(s) or with an internal loop(s);
- for audio frequency baseband transmission (un-modulated and without the use of a carrier);

The present document covers fixed induction loop amplifiers, mobile induction loop amplifiers and portable induction loop amplifiers.

The present document covers the essential requirements of article 3.2 of Directive 2014/53/EU [i.1] under the conditions identified in annex A.

2 References

2.1 Normative references

References are specific, identified by date of publication and/or edition number or version number. Only the cited version applies.

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The following referenced documents are necessary for the application of the present document.

- | | |
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| [1] | Void. |
| [2] | CEPT/ERC/Recommendation 74-01E (Siófok 98, Nice 99, Sesimbra 02, Hradec Kralove 05, Cardiff 11): "Unwanted Emissions in the Spurious Domain". |

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- | | |
|-------|--|
| [i.1] | Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC. |
| [i.2] | CEPT/ERC/REC 70-03: "Relating to the use of Short Range Devices (SRD)". |

- [i.3] CISPR 16-2-3: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements".
- [i.4] IEC 60118-4: "Electroacoustics - Hearing aids - Part 4: Induction loop systems for hearing aid purposes - Magnetic field strength".
- [i.5] IEC 62489-1 + Amd 1: "Electroacoustics - Audio-frequency induction loop systems for assisted hearing - Part 1: Methods of measuring and specifying the performance of system components".
- [i.6] IEC 61672-1: "Electroacoustics. Sound level meters. Specifications".
- [i.7] IEC 60268-10: "Sound system equipment. Methods for specifying and measuring the characteristics of peak programme level meters".
- [i.8] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.
- [i.9] ETSI TR 100 028 (all parts) (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".
- [i.10] ETSI TR 100 028-2 (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in Directive 2014/53/EU [i.1] and the following apply:

artificial loop: reduced size radiating dummy load equal to the nominal impedance of the loop specified by the manufacturer

Audio-Frequency Induction-Loop System (AFILS): system including induction loop amplifier(s), microphones and/or other signal sources, in which a magnetic field is created by the flow of audio-frequency current in a conductor arranged in the form of a loop or coil

conducted measurements: measurements that are made using a direct connection to the equipment under test

customized loop: loop built according to manufacturers' loop design rules inside tested limits

dedicated loop: removable loop supplied and type tested with the AFILS equipment, designed as an indispensable part of the equipment

NOTE: The loop has been designed or developed for one or more specific types of equipment. It is the combination of dedicated loop and induction loop amplifier that is expected to be compliant with the regulations.

hearing aid: personal amplification system, worn entirely on the listener, which is designed to enable a person with impaired hearing to hear more easily

hearing instrument: hearing aid or cochlear implant

hearing loop system: See AFILS.

in band emissions: emissions on a frequency or frequencies which are inside the occupied bandwidth (10 Hz to 9 kHz)

induction loop: current carrying loop or coil of an AFILS used to create the magnetic field

NOTE: This is equivalent to the term "antenna" used in other ETSI documents and is used in the present document as it is the term commonly understood by the AFILS industry.

induction loop amplifier: audio amplifier designed to drive an induction loop

NOTE: This is equivalent to the term "transmitter" used in other ETSI documents and is used in the present document as it is the term commonly understood by the AFILS industry.

induction loop listener: portable listening device that is designed to give an audible output in response to signals produced by an AFILS

induction loop monitor receiver: equipment designed to verify the performance of an AFILS by audio and visual means:

- a) providing visible indication that it is powered and indicating when the strength of the magnetic field produced by the loop falls within a specified range; and
- b) providing an audio-frequency output by which the sound quality of the AFILS transmissions can be assessed

induction-loop system: See AFILS.

internal loop: loop designed as a fixed part of the equipment, without the use of an external connector and as such which cannot be disconnected from the equipment by the user

loop: See induction loop.

loop listener: See induction-loop listener.

magnetic dipole moment: product of (Number of loop turns) \times (loop area) \times (loop current)

NOTE: Air loops only.

magnetic field strength level meter: instrument designed to measure magnetic field strength of audio frequency magnetic fields

NOTE: Two types are in common use; a peak-programme meter (PPM) type having dynamic characteristics similar to those of the Type II meter as specified in IEC 60268-10 [i.7], and a true rms meter type that incorporates a true rms rectifier, and meets the relevant requirements for a Class 2 sound level meter as specified in IEC 61672-1 [i.6]. Full functional specifications for both types of meter can be found in IEC 60118-4 [i.4].

mobile amplifier: equipment normally installed in a vehicle

out of band emissions: emissions on a frequency or frequencies which are outside the occupied bandwidth (10 Hz to 9 kHz), but for which the levels are in transition to a frequency where the level may be reduced without affecting the corresponding transmission of information

phased loop array: system of overlapping loops in which the currents are out of phase with each other

portable amplifier: amplifier intended to be carried or attached

radiated measurements: measurements which involve the absolute measurement of a radiated field

rated load: the load, stated by the manufacturer, to which the amplifier output is connected for measurement purposes

reference magnetic field strength level: 0 dB reference for magnetic field strength levels, which is 400 mA m^{-1}

spurious emissions: emissions on a frequency or frequencies which are outside the occupied bandwidth (10 Hz to 9 kHz) and the level of which may be reduced without affecting the corresponding transmission of information

telecoil: magnetic pickup coil intended to receive signals from an audio-frequency induction-loop system

NOTE: A telecoil can be part of a hearing aid, cochlear implant, or of any other device for receiving signals from an audio-frequency induction-loop system in accordance with IEC 60118-4 [i.4].

type designation: manufacturers' marking of the equipment

useful magnetic field volume: volume within which the AFILS provides a hearing-aid user with a signal of acceptable quality

NOTE: See IEC 60118-4 [i.4].

3.2 Symbols

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

Ω	ohm
A	loop area
C	correction factor
E	electrical field strength
f	frequency
f_C	centre frequency in Hz
H	magnetic field strength
Hf	H-field-strength limit
H_C	H-field strength at the centre of the frequency of interest
H_S	H-field-strength limit for radiated spurious emissions
I_C	audio frequency baseband output current
I_S	spurious output current
λ	wavelength
m	magnetic dipole moment
N	number of turns for a loop
P	power
t	time

3.3 Abbreviations

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

AFILS	Audio Frequency Induction Loop System, also known as a Hearing Loop
AMN	Artificial Mains Network
CDN	Coupling/Decoupling Network
CEPT	Conférence Européenne des Postes et Télécommunications
CISPR	Comité International Spécial des Perturbations Radioélectriques
EC	European Community
EFTA	European Free Trade Area
EMC	ElectroMagnetic Compatibility
ERC	European Radiocommunications Committee
EU	European Union
HF	High Frequency (range)
ISN	Impedance Stabilization Network
LISN	Line Impedance Stabilization Network
OOB	Out Of Band
RF	Radio Frequency
RFID	Radio Frequency Identification Device
rms	root mean square
SRD	Short Range Device
THD	Total Harmonic Distortion
TR	Technical Report

4 Technical requirements specifications

4.1 Environmental conditions

4.1.1 Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer. The equipment shall comply with all the technical requirements of the present document which are identified as applicable in annex A at all times when operating within the boundary limits of the declared operational environmental profile.

4.2 General requirements

4.2.1 Presentation of induction loop amplifier equipment for testing purposes

Each equipment submitted for testing shall fulfil the requirements of the present document when operated as intended.

The manufacturer shall declare the range of operating conditions and power requirements to establish the appropriate test conditions.

Additionally, technical documentation and operating manuals sufficient to make the test shall be supplied.

For equipment supplied without an internal induction loop, i.e. Product Class 2 defined in clause 5.3.2.2, the manufacturer shall supply an artificial loop as defined in clause 5.2.2.1.

In the case of equipment supplied with an internal induction loop, i.e. Product Class 1 equipment as defined in clause 5.3.2.2, it is permissible to supply a sample of the equipment with a temporary connector to facilitate testing. This shall be used to provide a method to monitor the loop current, or at the manufacturer's discretion, to use an artificial loop.

The means to access and/or implement the internal permanent or temporary loop connector shall be stated by the manufacturer with the aid of a diagram. The fact that use has been made of the internal loop connection, or of a temporary connection to facilitate measurements, shall be recorded in the test report. Such ports shall not affect the performance of the equipment.

If equipment is designed to operate with different radiated field strengths or power levels, measurement of each parameter shall be performed on samples of equipment as defined in clause 4.2.2.

4.2.2 Choice of model for testing

Stand-alone equipment shall be supplied by the manufacturer complete with any ancillary equipment needed for testing.

If an equipment has optional features, considered not to affect the RF parameters, then the tests need only to be performed on the equipment configured with that combination of features considered to be the most complex, as declared by the manufacturer.

Equipment offered for test shall provide an output connector for conducted RF measurements. For equipment with an internal loop, this can be a modification for the tests.

The performance of the equipment submitted for testing shall be representative of the performance of the corresponding production model.

4.2.3 Controls

Controls that may need to be adjusted after installation such as input gain, loop drive, bass, treble, tone or "metal compensation" may be provided. However, any controls that might increase the interfering potential of the equipment, if misadjusted, shall not be easily accessible to the user.

4.2.4 Amplifier shut-off facility

If the amplifier is equipped with an automatic shut-off facility (such as a time-out device, over or under temperature, voltage or current, etc.) it should be made inoperative for the duration of the test, or be monitored to ensure that the shut-off facility is not activated during the test.

4.2.5 Declarations by the manufacturer

When submitting equipment for test, the manufacturer shall declare any necessary information which may be required by an external laboratory.

4.2.6 Auxiliary test equipment

All necessary test signal sources and set-up information shall accompany the equipment when it is submitted for testing and shall be included in the test report.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

5.1.1 General requirements

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) to give confidence of compliance for the affected technical requirements.

5.1.2 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 %.

When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

5.1.3 Test power source

5.1.3.1 General requirements

The equipment shall be tested using the external test power source specified in clause 5.1.3.2 and/or the internal test power source specified in clause 5.1.3.2. Where equipment can be powered using either external or internal power sources, then the equipment shall be tested using the external power source specified in clause 5.1.3.2 then repeated using the internal power source specified in clause 5.1.3.3.

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

5.1.3.2 External test power source

During tests, the power source of the equipment shall be replaced by an external test power source capable of producing the test voltage specified in clause 5.1.3.3. 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. The external test power source shall be suitably de-coupled (including the use of ferrite beads, inductors, chokes, de-coupling capacitors or networks as required by specific test methods e.g. AMN, ISN, LISN, CDN, etc.) as close to the equipment input power terminals as practicable.

During tests the test power source voltages shall be within a tolerance of $< \pm 1$ % relative to the voltage at the beginning of each test.

Where it can be shown that internal regulation of power supply rails or output regulation is employed (such as in a constant-current output design) in such a way as to negate the effects of such power supply variations or fluctuations, then this tolerance may be relaxed to ± 5 % of nominal and RF emission tests shall be performed at the nominal voltage only.

5.1.3.3 Internal test power source

5.1.3.3.1 General

Where equipment is designed to operate from an internal power source, for conducted measurements or where a test fixture is used, an external power supply at the required voltage may replace the supplied or recommended internal batteries. Use of this shall be stated on the test report.

5.1.3.3.2 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 a.c. mains shall be ± 1 Hz of the mains frequency specified by the manufacturer.

5.1.3.3.3 Valve-regulated lead-acid battery power sources

When the equipment is intended for operation from valve-regulated lead-acid battery power source, the normal test voltage shall be 1,1 multiplied by the nominal voltage of the battery (e.g. 6 V, 12 V, etc.).

5.1.3.3.4 Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the manufacturer. Such values shall be stated in the test report.

5.2 General conditions

5.2.1 Normal test signals

For equipment without a connector for an external audio input (i.e. with only an internal microphone), a connector shall be added to allow testing. This shall be stated in the test report.

The normal test signal is specified as follows:

- 1 kHz sinusoidal tone

5.2.1.1 Signal input for testing

For the purpose of the measurements with and without an input test signal, there should preferably be a facility to energize the induction loop amplifier with or without an input signal source. The manufacturer shall describe the method of achieving this in the documentation and it shall be recorded in the test report. It may involve temporary internal modifications of the equipment under test.

For the purpose of testing, the normal test signal, see clause 5.2.1, shall be applied to the input of the induction loop amplifier under test with the normal input device(s) disconnected (e.g. microphone or other audio equipment).

Any 'standby' amplifier modes should be disabled for the duration of test so that the amplifier is not asleep when no signal is present for long periods.

5.2.2 Loop connections

5.2.2.1 General

For equipment supplied without an internal loop, i.e. Product Class 2 as defined in clause 5.3.2.2, the manufacturer shall supply an artificial loop (reduced radiating load).

For equipment supplied with an internal loop, i.e. Product Class 1 equipment as defined in clause 5.3.2.2, the manufacturer may decide to use the existing internal loop and provide a method to monitor the loop current, or use an artificial loop. The actual method used shall be stated within the test report.

NOTE: Typical loop impedances are described in IEC 62489-1 [i.5], annex B.

5.2.2.2 Artificial loop

For measurements of induction loop amplifiers (see clause 4.2.1), an artificial loop (reduced radiating load) connected to the loop output connectors, shall be used as agreed with the test laboratory.

The impedance shall be equal to the nominal load of the equipment specified by the manufacturer.

This method facilitates conducted measurements to be made of the following:

- induction loop amplifier loop in band currents from 10 Hz to 9 kHz;
- induction loop amplifier loop out of band currents from > 9 kHz to 20 kHz; and
- induction loop amplifier spurious loop currents from > 20 kHz to 1 MHz.

A description of the artificial loop shall be stated in the test report.

For equipment supplied with an internal loop, the manufacturer may decide to use the internal loop as the load and provide a suitable method to monitor the loop current, or use an artificial loop. The actual method used shall be stated within the test report.

Annex E describes a suitable method of assembling an artificial loop.

5.2.3 Measuring receiver

The term "measuring receiver" refers to a selective voltmeter, spectrum analyser or receiver used in the process of testing the equipment under test to the appropriate emission limits. The bandwidth and detector type of the measuring receiver are given in table 1.

Table 1

Frequency	Detector type	Measurement receiver bandwidth	Spectrum analyser bandwidth
$9 \text{ kHz} \leq f < 150 \text{ kHz}$	rms	200 Hz	300 Hz
$150 \text{ kHz} \leq f < 1 \text{ MHz}$	rms	9 kHz	10 kHz

If different bandwidths are used, follow the guidance in annex G and record this in the test report.

5.3 Induction loop amplifier

5.3.1 General

To meet the requirements of the present document, the induction loop amplifier shall be measured whilst operated at the maximum rated continuous average output level for the load under test, as declared by the manufacturer, with any tone controls set to a flat response.

When making tests on equipment designed for intermittent operation, the duty cycle of the equipment, as declared by the manufacturer, shall not be exceeded. The actual duty cycle used shall be stated on the test report.

For equipment supplied without a loop, i.e. Product Class 2 as defined in clause 5.3.2.2, the manufacturer shall supply a reduced radiating load (artificial loop) which is to be used for all tests.

For equipment supplied with an internal loop, i.e. Product Class 1 equipment as defined in clause 5.3.2.2, the manufacturer may decide to use the existing internal loop and provide a method to monitor the loop current, or use an artificial loop for conducted emission measurements below 1 MHz. The actual method used shall be stated within the test report.

5.3.2 Induction loop amplifier definitions

5.3.2.1 General

Induction loop amplifiers are divided into Product Classes (see clause 5.3.2.2) depending on the loop type to be used. Class 1 equipment is provided with an internal loop, whereas Class 2 equipment provides an external connection and may allow the customer to use his own loop design based on the manufacturer's design guidelines. AFILS manufacturers will provide written guidance and design tools, or both, to aid with practical and compliant loop design.

5.3.2.2 Product Classes

The equipment is divided into Product Classes depending on the induction loop type used.

The Product Classes according to table 2 are:

Product Class 1:

Induction loop amplifier supplied with an internal loop.

The following restrictions apply to this product class:

- no customization of the internal loop(s) is allowed in the field (or by the end user); and
- the internal loop area shall be $< 4 \text{ m}^2$.

The audio frequency baseband output and spurious emissions are limited by the maximum output loop current multiplied by the loop area, and number of turns as described in annex E and clause 5.3.4.2 and shall comply with the equivalent radiated H-field limits given in clause 5.3.4.2 and clause 5.3.4.3.

Where a manufacturer provides a range of standard internal loops, the equipment shall be tested as Product Class 1. Either each of the loop(s) shall be fitted in turn with an appropriate monitoring connector attached, or at the manufacturer's discretion, with representative artificial loops used to show compliance when operated with the minimum and maximum expected loads.

The actual method used shall be stated in the test report.

Product Class 2:

This Product Class is intended for use with external loops which may, or may not, be customized. The induction loop amplifier is tested by using an artificial loop.

The audio frequency baseband output and spurious emissions are limited by the maximum output loop current multiplied by the loop area, and number of turns as described in annex E and clause 5.3.4.2, and shall comply with the equivalent radiated H-field limits given in clause 5.3.4.2 and clause 5.3.4.3. The manufacturer shall declare the maximum size of the loop in the user's manual.

Conducted emission measurements below 1 MHz shall be carried out with representative artificial loops used to show compliance when operated with the minimum and maximum expected loads.

Table 2: Description of product classes

Product Class	Description of induction loop amplifier	Loads to be tested	Loop area	Customization of loop design allowed	Audio frequency baseband, OOB and spurious emission output limits
1	Supplied with Internal Loop(s)	Artificial or internal loop (with test connector) for all conducted measurements below 1 MHz	For internal loop(s) < 4 m ² For equipment with an external connector(s), as per class 2	For Internal loop(s) no customization is allowed. For equipment with an external connector(s), the external loop(s) may be modified as per class 2	See clause 5.3.3.3 See clause 5.3.4.3
2	Supplied with external Loop connection	Test using an artificial loop	Not Applicable	Yes	See clause 5.3.3.3 See clause 5.3.4.3

5.3.3 Audio frequency in band and out of band emission limits

5.3.3.1 Definition

Audio frequency in band limits (10 Hz to 9 kHz) are defined as the calculated equivalent emissions produced (see annex D) for the declared loop size(s), measured at the furthest point of the useful magnetic field volume as declared by the manufacturer. The manufacturer shall declare the maximum loop size and the position of the furthest point of the useful magnetic field volume and this shall be stated in the test report.

Out of band limits (> 9 kHz to 20 kHz) are defined as the calculated equivalent emissions produced (see annex D) for the declared loop size(s) measured at 10 m from the furthest point of the useful magnetic field volume.

5.3.3.2 Methods of measurement

The equipment shall be set up as follows:

- Class 1 equipment shall be connected either to an appropriate artificial loop(s), see clause 5.2.2.2 and annex E, or at the manufacturer's discretion, shall be connected to the internal loop(s), with a suitable method provided to monitor the loop current.
- Class 2 equipment shall be connected to the artificial loop(s), see clause 5.2.2.2 and annex E.

The actual method used shall be stated within the test report, along with details of any modifications to the equipment required to make the measurements possible.

The current delivered to the loop or artificial loop shall be measured up to 20 kHz. The current shall be measured either by using:

- a derived output from a calibrated artificial loop connected to a measuring receiver, see annex E; or
- a calibrated current probe connected to a measuring receiver; or
- a calibrated non-inductive resistive current sense element, whose value should not significantly affect the current delivered to the loop, for example the equipment's own internal current sense, connected to a measuring receiver.

The measuring bandwidth and detector type shall be in accordance with clause 5.2.3.

The measurements shall be made under normal test conditions, see clause 5.1.2.

5.3.3.3 Limits

The limits for the audio frequency baseband emission for both Product Classes is given in table 3.

Table 3: Equivalent H-Field limits for audio frequency in band and out of band emissions

Frequency range	Audio frequency baseband emission limit (Am^{-1})
10 Hz to 9 kHz (In band)	1,005 Am^{-1}
> 9 kHz to 20 kHz (Out of band)	0,100 Am^{-1} at 9 kHz to 15 μAm^{-1} at 20 kHz
NOTE 1: The in band limit is the equivalent H-Field limit, when calculated using the equations in annex D, and when measured at the furthest point of the useful magnetic field volume, as declared by the manufacturer. Actual equipment measurements are taken in terms of conducted loop output.	
NOTE 2: The out of band limits is the equivalent H-Field limit, when calculated using the equations in annex D, and when measured at 10 m from the furthest point of the useful magnetic field volume, as declared by the manufacturer. Actual equipment measurements are taken in terms of conducted loop output.	
NOTE 3: The 9 kHz out of band limit of 0,1 Am^{-1} at 10 m is approximately the field created by a 20 m \times 20 m loop when 1 Am^{-1} is generated 0,5 m inside (furthest point of the useful magnetic field volume) the loop using the equations in annex D.	
NOTE 4: This is as per the spectrum mask given in annex F.	

5.3.4 Spurious domain emission limits

5.3.4.1 Definition

Spurious domain emission limits are defined as the calculated equivalent emissions produced (see annex D) for the declared loop size(s) measured at 10 m from the furthest point of the useful magnetic field volume, as declared by the manufacturer. The manufacturer shall declare the maximum loop size, which shall be stated in the test report.

5.3.4.2 Methods of measurement

For Class 1 equipment, the induction loop amplifier shall be connected to an artificial loop or at the discretion of the manufacturer, into the actual loop with a suitable method provided to monitor the loop current (clause 5.2.2.2).

For Class 2 equipment, the induction loop amplifier shall be connected to an artificial loop (clause 5.2.2.2).

The measuring receiver shall be connected to the output of the artificial loop, or suitable monitoring point in the case of Class 1 equipment and the current for the spurious components shall be measured.

For further details of the artificial loop, see annex E.

The currents shall first be measured with the induction loop amplifier energized (operational) with the test signal applied (clause 5.2.1) and then repeated with the amplifier energized (operational) with the test signal removed.

5.3.4.3 Limits

The limits are specified in CEPT/ERC/Recommendation 74-01E [2], annex 2, table 2.1, reference number 2.1.3, up to 1 MHz.

This relates the output loop current, declared maximum loop area and number of turns, to the maximum equivalent radiated H-Field which may be generated.

Emission limits are stated in H-Field terms to allow comparison and interpretation with other standards and international agreements.

NOTE: The out of band limits are considered at 10 m from the furthest point of the useful magnetic field volume, as declared by the manufacturer. Therefore, any current used for testing is based on fields at this distance.

5.4 Induction loop receiver

5.4.1 General

To meet the requirements of the present document the induction loop receiver shall be measured under various magnetic field strengths with a test signal of 1 kHz, as stated in clause 5.2.1. This confirms adequate sensitivity of the equipment and its capability to operate in the maximum intended field strength without undue overload.

5.4.2 Headphone output

For AFILS receivers and loop test equipment claiming compliance with the present document and having an output suitable for connection to headphones, a field strength of 400 mA m^{-1} rms at 1 kHz shall be capable of producing an output voltage of 150 mV rms across a 32Ω resistive load. Furthermore, the equipment shall be able to operate in a field strength of 1 A m^{-1} rms with a THD of less than, or equal to, that stated by the manufacturer. This performance shall be as stated in the manufacturer's documentation and recorded in the test report.

5.4.3 Induction loop receiver definitions

There are no separate classes of induction loop receiver.

5.4.4 Methods of measurement

The following tests shall be carried out:

- a) The equipment shall be set up with the headphone port suitably loaded with a 32Ω resistive load. The actual connection(s) used shall be recorded in the test report.

The equipment shall be subjected to a field strength of 400 mA m^{-1} rms with a test signal of 1 kHz as stated in clause 5.2.1. Any available volume, gain or sensitivity adjustments shall be set to provide a minimum of 150 mV rms across the 32Ω resistive load. The actual value shall be recorded in the test report.

After a minimum of 10 seconds of conditioning, the THD at the headphone output shall be measured and recorded. This shall be less than or equal to that stated by the manufacturer.

- b) Immediately after the tests defined in clause 5.4.4, item a) are carried out, and using the same arrangement, the field strength shall be increased to a level of 1 A m^{-1} rms. Any externally available volume, gain or sensitivity adjustments may be adjusted, at the manufacturer's discretion, to provide no less than 150 mV rms across the 32Ω resistive load. The actual value shall be recorded in the test report.

After a minimum of 10 seconds of conditioning, the Total Harmonic Distortion at the headphone output shall be measured and recorded. This shall be less than or equal to that stated by the manufacturer.

Care shall be taken that at each magnetic field strength level, the magnetic field signal, or corresponding generating loop current, shall provide a THD value of less than that declared by the manufacturer for the receiving equipment.

5.4.5 Limits

AFILS receivers are designed to detect the audio frequency magnetic field from a hearing loop system. There are no oscillators and so they are not capable of radio transmission. Therefore, no limits are specified.

5.5 Interpretation of the measurement results

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

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report;
- the recorded value of the measurement uncertainty shall be, for each measurement, equal to or less than the figures in table 4.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated 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)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028 [i.9], in particular in annex D of the ETSI TR 100 028-2 [i.10].

Table 4 is based on such expansion factors.

Table 4: Maximum measurement uncertainty

Parameter	Uncertainty
Frequency	± 1 %
Loop current	± 5 %
Temperature	± 1 °C
Humidity	± 5 %

Annex A (informative): Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.8] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Table A.1: Relationship between the present document and the essential requirements of Directive 2014/53/EU

Harmonised Standard ETSI EN 303 348				
Requirement			Requirement Conditionality	
No	Description	Reference: Clause No	U/C	Condition
1	Spurious domain emission limits	5.3.4	U	
2	Audio frequency in band and out of band emission limits	5.3.3	U	
3	Induction loop receiver	5.4	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

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 unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

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

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (informative): Technical overview

B.1 Induction loop amplifiers

B.1.1 General

Induction loop amplifiers, together with an internal or external induction loop, are used to generate audio-frequency magnetic fields that may be used by a listener's hearing aid, cochlear implant or induction loop listener to provide noise-free and reverberation-free audio directly to the listener. This therefore removes the acoustic gap between talker and listener and allows what would otherwise be a difficult or unintelligible message for a hearing-impaired listener to become intelligible.

The majority of hearing instruments are equipped with a small pickup coil (the telecoil) and so no additional equipment is required to use this service. People without hearing instruments wishing to receive the AFILS signal can use dedicated portable stand-alone receivers called loop listeners.

B.1.2 Frequency response

As an audio frequency baseband transmission system, the output of an AFILS system corresponds precisely with the bandwidth of the audio input of the system. There is no carrier frequency or modulation scheme. A correctly designed and installed AFILS complying with the requirements of IEC 60118-4 [i.4] has a frequency response within the range 100 Hz to 5 kHz of ± 3 dB with reference to the response at 1 kHz. Wider frequency responses up to 9 kHz may be required for non-hearing instrument use (e.g. tour guides) and for future developments of hearing instrument technology.

B.1.3 Field strength

A correctly designed and installed AFILS, complying with the requirements of IEC 60118-4 [i.4] and with a 1 kHz sine wave input signal, is capable of producing a magnetic field strength of $400 \text{ mA}\cdot\text{m}^{-1}$ when measured with the true rms meter with 0,125 second averaging time in at least one place within the space where listeners' heads (and therefore hearing instruments) are expected to be, and should be no more than 3 dB higher for large area AFILS, and no more than 8 dB higher for small area systems. This is the level also achieved on the highest peaks in the programme material (speech or music). The average magnetic field strength is much lower and will depend on the programme content.

B.1.4 General performance criteria

For the purpose of the induction loop amplifier performance tests, the amplifier is expected to be operated as described in clause 5.1.

B.2 Induction loop receivers and test equipment

B.2.1 General

AFILS receivers, like hearing instruments, are stand-alone battery-powered devices using a telecoil to convert an AFILS magnetic field into a voltage, which can be processed and amplified to drive an earphone or headphones.

AFILS field strength meters also sense the magnetic field with a telecoil and often provide a headphone output so that the measured signal can be assessed by listening.

As there is no heterodyning of signals and no internal intermediate frequency mixer oscillators, etc., the baseband audio frequency magnetic field is transposed directly to an audio frequency baseband output signal. Antenna emissions tests are therefore not required. EMC standards cover any likely emissions from such equipment, including any internal loop(s).

Receivers and test equipment are non-critical communication devices, whose failure to operate correctly causes loss of function which can be overcome by parallel means. This classification is based upon the impact on persons in case the equipment does not operate above the specified minimum performance level.

Other hearing instruments (e.g. hearing aids, cochlear implants and loop listeners) that may be used as AFILS receivers are expected to fulfil the standards applicable to that equipment (if any).

B.2.2 Sensitivity

For AFILS receivers and loop test equipment claiming compliance with the present document and having an output suitable for connection to headphones, a field strength of 400 mA m^{-1} at 1 kHz are expected to be capable of producing an output voltage of 150 mV across a 32Ω resistive load.

The receiver's amplifier should not be overloaded by a field strength of 1 A m^{-1} .

The equipment may have a volume or gain control to provide other sensitivities.

Annex C (normative): Measurement

C.1 Standard test position to be used with internal loop equipment or equipment having a loop connector

The standard position for equipment shall be the following:

- a) for equipment with an internal loop, it shall be placed in the position closest to normal use as declared by the manufacturer.

Equipment which is intended to be worn on a person may be tested using a simulated man as support. The simulated man comprises a rotatable acrylic tube filled with salt water, placed on the ground.

The container shall have the following dimensions:

- Height: 1,7 m \pm 0,1 m.
- Inside diameter: 300 mm \pm 5 mm.
- Sidewall thickness: 5 mm \pm 0,5 mm.

The container shall be filled with a salt (NaCl) solution of 1,5 g per litre of distilled water.

The equipment shall be fixed to the surface of the simulated man, at the appropriate height for the equipment, as intended in normal use.

To reduce the weight of the simulated man it may be possible to use an alternative tube which has a hollow centre of 220 mm maximum diameter.

Annex D (normative): The relationship between loop current and H-Field strength

The H-Field at a given point for an AFILS loop may be calculated directly from the loop current using the following equations:

For an AFILS loop of rectangular dimension, the general equation relating Loop Current to the component of the H-field in the z-axis at an arbitrary point of the loop in free space is given by:

$$H_z(x, y, z) = \frac{NI}{4\pi} \sum_{i=1}^2 \sum_{j=1}^2 \frac{x_i y_j}{\sqrt{x_i^2 + y_j^2 + z^2}} \left(\frac{1}{x_i^2 + z^2} + \frac{1}{y_j^2 + z^2} \right) \text{ A/m} \quad (\text{D.1})$$

where:

- $H_z(x, y, z)$ = H-Field in the Z-axis at an arbitrary point within, above or below the AFILS loop in Am^{-1} .
- X, y, z = Arbitrary point relative to the centre of a rectangular loop in meters.
- N = Number of turns of the induction loop.
- I = Current in Ampere in the induction loop.
- A = Length of the rectangular loop in metres in the X axis.
- B = Width of the rectangular loop in metres in the Y axis.
- X_i = For each element of the sum in turn where: $x_1 = (p-x)$, $x_2 = (p+x)$ according to the diagram below.
- Y_j = For each element of the sum in turn where: $y_1 = (q-y)$, $y_2 = (q+y)$ according to the diagram below.
- P = $A/2$
- q = $B/2$

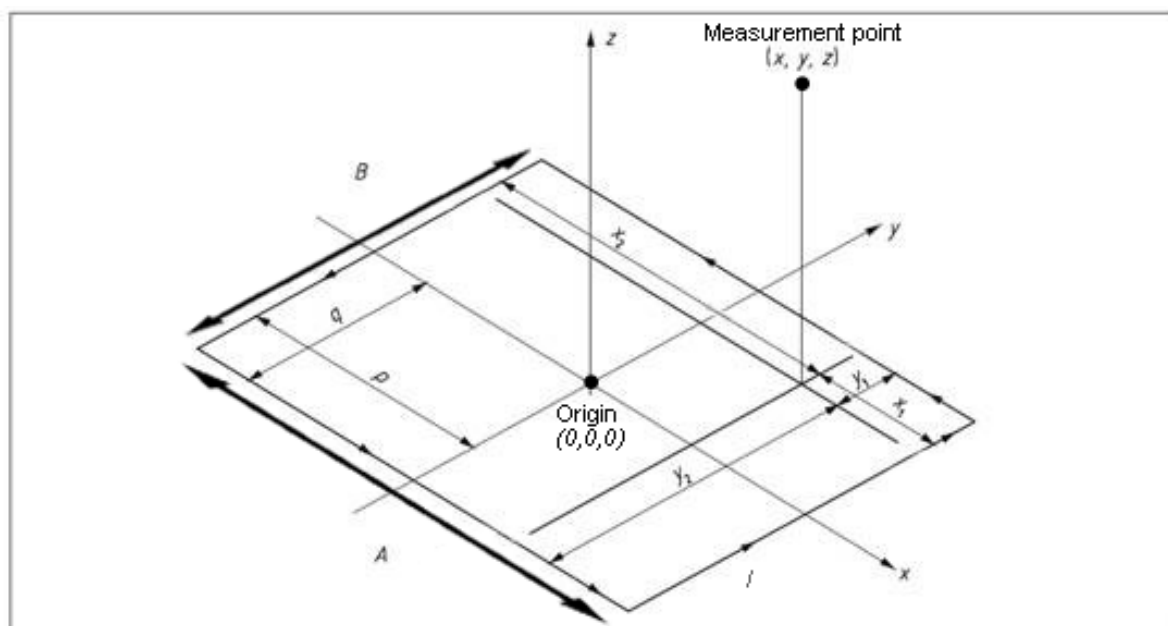


Figure D.1: Diagram for calculating magnetic field strength at point (x,y,z)

However, for ease of calculation, in the case where the measurement position is directly above or below the centre point of the AFILS loop, then the following simplified equation may be used:

$$H_{0,0,z} = \frac{I}{\pi} \left(\frac{pq}{\sqrt{p^2 + q^2 + z^2}} \right) \left(\frac{1}{p^2 + z^2} + \frac{1}{q^2 + z^2} \right) A/m \quad (\text{D.2})$$

Where:

$H_z(0,0,z)$ = H-Field in the Z-axis at, above or below the centre point of the AFILS loop in Am⁻¹

Annex E (informative): Artificial loop

Test fixture for measuring induction loop amplifier audio frequency baseband and spurious currents by use of an artificial loop.

The artificial loop may be used for equipment with a loop connector and submitted for testing without a loop. The radiated fields for the baseband and spurious emissions are proportional to the audio frequency baseband and spurious currents. Therefore, measurements are made to determine the audio frequency baseband and spurious currents in the artificial loop.

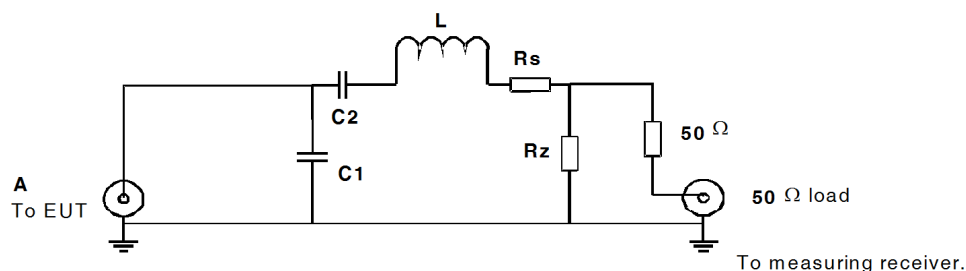


Figure E.1

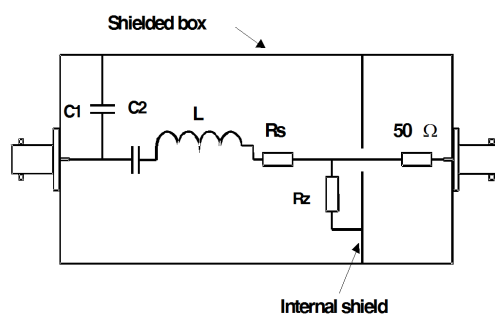


Figure E.2

An example of the mechanical layout and the equivalent electric circuit of the components are given in figure E.2 and figure E.1 respectively.

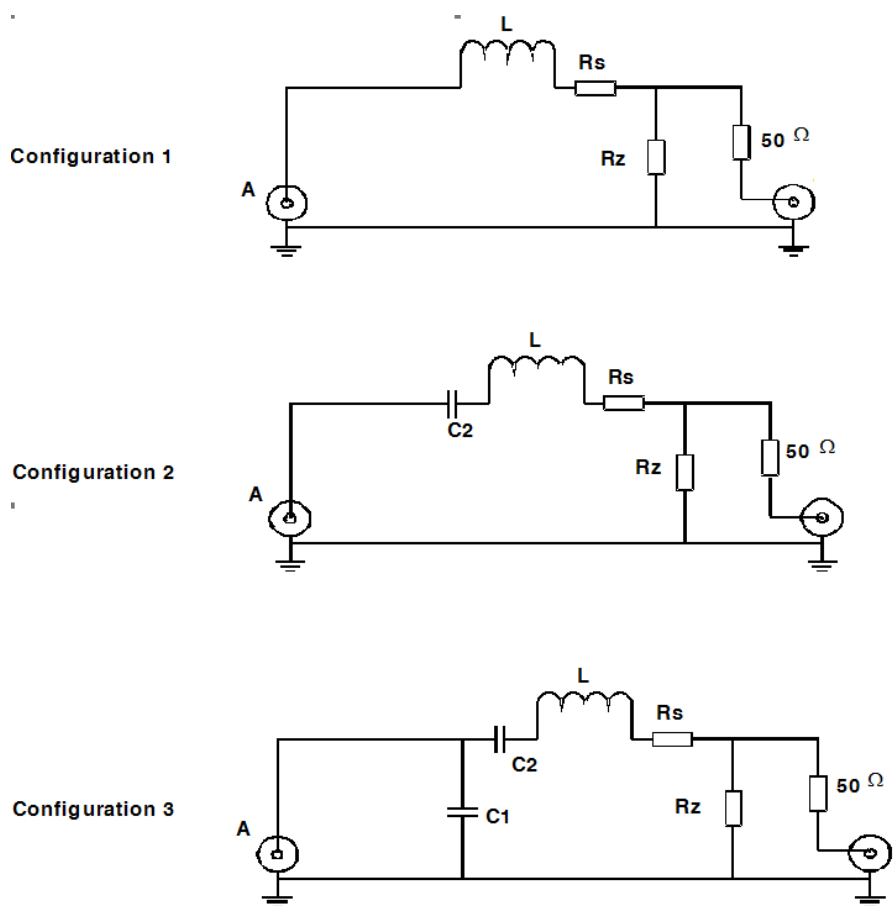
If the manufacturer specifies a range of loop dimensions, two artificial loops having maximum and minimum inductance L should be supplied. This fact should be stated in the test report.

R_z is a low value non-reactive resistor. The voltage across R_z is proportional to the conducted audio frequency baseband and spurious loop currents. These can be measured at the output connector.

R_s in combination with R_z ensures that the artificial loop has the same Q as the specified loop.

As the artificial loop does not provide galvanic isolation between the equipment under test and the test receiver, isolation may be required elsewhere in order to ensure correct and/or safe operation.

Capacitors C_1 , C_2 are optional components together with L to be used as appropriate by the manufacturer to simulate the actual loop configuration. Other possible configurations are shown in figure E.3.

**Figure E.3**

The test fixture configuration used by the manufacturer should be stated in the test report.

Annex F (normative): Induction loop amplifier emission levels and spectrum mask measurements

The present document allows spectrum measurements to be made. The measurements are relevant for AFILS operating between 0 Hz to 9 kHz.

In-band emissions are measured at the at the furthest point of the useful magnetic field volume as declared by the manufacturer. Out of band and spurious emissions are measured 10 m from the furthest point of the useful magnetic field volume as declared by the manufacturer.

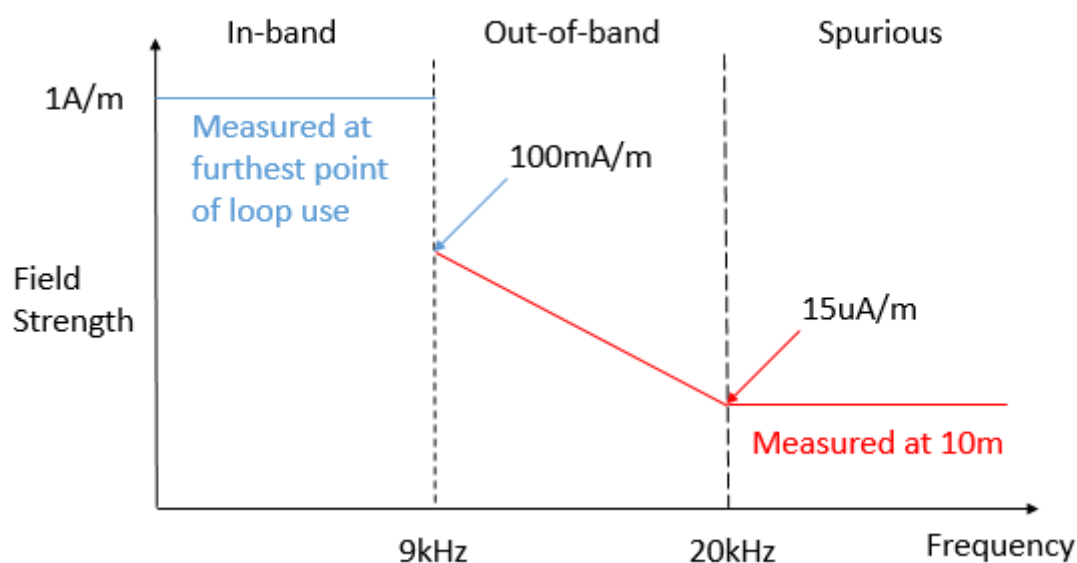


Figure F.1: Induction loop amplifier emissions levels and spectrum mask measurements

Annex G (informative): Determination and use of the measurement bandwidth

CISPR 16-2-3 [i.3] specifies a reference bandwidth for the measurement of unwanted emissions by measurement receivers and spectrum analysers.

The reference bandwidth ($BW_{REFERENCE}$) cannot always be used as the measurement bandwidth ($BW_{MEASUREMENT}$). This is particularly the case if the measurement is to be made for example on the slope of a spectrum mask or a receiver selectivity curve. In such situations the measurement should be made with a sufficiently low bandwidth in order not to distort the reading.

The actual measured value, A, should be referred back to the reference bandwidth by:

Either:

- a) Correcting the measured value, A, for any signal having a flat level spectrum with the following formula:

$$B = A + 10 \log \frac{BW_{REFERENCE}}{BW_{MEASURED}}$$

where:

- B is the measured level, A, transferred to the reference bandwidth.

Or:

- b) Use the measured value, A, directly if the measured spectrum is a discrete spectral line.

A discrete spectrum line is defined as a narrow peak with a level of at least 6 dB above the average level inside the measurement bandwidth.

Annex H (informative): Bibliography

- ERC Report 044 (1997): "Sharing between inductive systems and radiocommunication systems in the band 9 - 135 kHz".
- ERC Report 069: "Propagation model and interference range calculation for inductive systems 10 kHz - 30 MHz".
- ERC Report 092: "Sharing between inductive SRD systems and radio communication systems operating in the frequency band 10.2 - 11 MHz".
- Council Directive 2004/108/EC of 20 April 2016 on the approximation of the laws of the Member States relating to electromagnetic compatibility.
- Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility.
- ERC Decision of 12 March 2001 on harmonised frequencies, technical characteristics and exemption from individual licensing of Short Range Devices used for inductive applications operating in the frequency bands 9 - 59.750 kHz, 59.750 - 60.250 kHz, 60.250 - 70 kHz, 70 - 119 kHz, 119 - 135 kHz; (ERC/DEC(01)13).
- 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.
- ETSI EG 201 399: "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of candidate Harmonized Standards for application under the R&TTE Directive".
- CENELEC EN 55022: "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement".

Annex I (informative): Change history

Version	Information about changes
1.1.1	First published version.

History

Document history			
V1.1.0	February 2016	EN Approval Procedure	AP 20160524: 2016-02-24 to 2016-05-24
V1.1.1	May 2017	Vote	V 20170715: 2017-05-16 to 2017-07-17