ETSI EN 303 447 V1.3.1.1 (2017-09 (2022-07)

Short Range Devices (SRD);
Harmonised Standard for access to radio spectrum;
Inductive loop systems for robotic mowers operating ~~in~~within the frequency range ~~0~~100 Hz to 148,5 kHz~~;~~
~~Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU~~

Reference
~~DEN~~REN/ERM-TG28-~~541~~552

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Foreword

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

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.6] 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.3].

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.

National transposition dates	
Date of adoption of this EN:	~~14 August 2017~~27 June 2022
Date of latest announcement of this EN (doa):	30 ~~November 2017~~September 2022
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 ~~May 2018~~March 2023
Date of withdrawal of any conflicting National Standard (dow):	31 ~~May 2019~~March 2024

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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The present document covers Robotic Mowers with Inductive loop systems (RMI) using the frequency range below 148,5 kHz. An RMI system includes:

- RMI docking station: charging stations for the robotic mower and the signal generator/antenna connecting point for the signals on the integral antenna and boundary wire.
- Robotic Mower: receiving part inside the RMI.
- Boundary Wire: user installed antenna.

The present document is structured as follows:

- Clauses 1 ~~through~~, 2 and 3 provide a general description on the types of equipment covered by the present document and the ~~definitions~~definition of terms, symbols and abbreviations used.
- Clause 4 provides the technical requirements specifications, limits and conformance relative to transmitter and receiver.
- Clause 5 specifies the conditions and information for testing of the equipment and interpretation of the measurement results ~~with the maximum measurement uncertainty values~~.
- Clause 6 specifies the required measurement methods.
- Annex A (informative) provides the relationship between the present document and the essential requirements of Directive 2014/53/EU [i.3].
- Annex B (normative) provides necessary information on used test sites and procedures.
- Annex C (informative) provides the justification for missing RX-requirements from ETSI EG 203 336 [i.5].
- Annex D (informative) provides information on TX spurious emission limit assessment below 9 kHz.
- Annex E (informative) provides information on Change history.

1 Scope

The present document specifies technical characteristics and methods of measurements for Robotic Mowers with Inductive loop systems (RMI) ~~below~~operating within the frequency range 100 Hz to 148,5 kHz.

The present document covers the following RMI systems:

- RMI1 systems: RMI systems without receive only mode
- RMI2 systems: RMI systems with receive only mode

NOTE 1: In RMI1 systems the robotic mower is not able to restart automatically if the boundary signal comes back after the loss of the boundary signal (safe mode, see clause 4.2.2.3), while in RMI2 systems the robotic mower is able to restart automatically after the boundary signal is back. This differentiation has been introduced to cover receiver spurious emissions for RMI2 systems.

These radio equipment types are capable of operating in all or part of the frequency bands given in table 1.

Table 1: Permitted range of operation

Permitted range of operation	
Transmit	~~0~~100 Hz to 148,5 kHz
Receive	~~0~~100 Hz to 148,5 kHz
NOTE: It should be noted that the frequency range between 9 kHz and 148,5 kHz is EU wide harmonised for inductive Short Range Devices according to EC Decision ~~2013/752/EU [i.2].~~2017/1483/EU [i.2].	

~~The present document does not cover other devices using the frequency range below 148,5 kHz, e.g. ETSI EN 303 348 [i.9] (Inductive loop for hearing impaired in 0 kHz to 20 kHz), ETSI EN 303 454 [i.10] (metal sensors).~~

~~The present document covers the~~NOTE 2: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.3] ~~under the conditions identified in annex~~is given in Annex A.

The present document only covers RMI systems with antenna sizes smaller than 1,67 km, see CEPT/ERC/REC 70-03 [i.1], Annex 9.

NOTE 3: The antenna size is described by the distance between those two points on the antenna that have the largest distance between them (e.g. for a rectangle shaped antenna the largest diagonal; for a circular shaped antenna the diameter).

2 References

2.1 Normative 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.

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

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

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

[1] ETSI EN 300 330 (V2.1.1) (02-2017): "Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

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.

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

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] CEPT/ERC/REC 70-03: "Relating to the use of Short Range Devices (SRD)".

[i.2] ~~EC~~Commission Implementing Decision ~~2013/752/~~(EU~~: "Commission implementing Decision~~) 2017/1483 of ~~11 December 2013~~8 August 2017 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision ~~2005/928~~2006/804/EC~~".~~.

[i.3] 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.4] CEPT/ERC/REC 74-01: "Unwanted emissions in the spurious domain".

[i.5] ETSI EG 203 336~~: "Electromagnetic compatibility and Radio spectrum Matters (ERM);~~ (V1.2.1): "Guide for the selection of technical parameters for the production of Harmonised Standards covering article- 3.1(b) and article 3.2 of Directive 2014/53/EU".

[i.6] 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.7] EGMF Robotic Mowers Boundary Wire Standard RLM003-1.~~0/2014~~1/2016.

[i.8] ~~CENELEC~~ EN 50636-2-107:2015: "Safety of household and similar appliances - Part 2-107: Particular requirements for robotic battery powered electrical lawnmowers~~".~~", produced by CENELEC.

~~[i.9] ETSI EN 303 348: "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".~~

] Void.

[i.10] ETSI EN 303 454~~:~~ (V1.1.1): "Short Range Devices (SRD); Metal and object detection sensors in the frequency range 1 kHz to 148,5 kHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

~~[i.11] Directive 2006/42/EC or the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast).~~] Void.

~~3 Definitions~~[i.12] Void.

[i.13] EN 55016-1-1:2010 + A1:2010 + A2:2014: "Specification for radio disturbance and immunity measuring apparatus and methods -Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus", produced by CENELEC.

[i.14] ETSI TS 103 567 (V1.1.1): "Requirements on signal interferer handling".

[i.15] ETSI TS 103 051 (V1.1.1) (08-2011): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Expanded measurement uncertainty for the measurement of radiated electromagnetic fields".

3 Definition of terms, symbols and abbreviations

3.1 ~~Definitions~~Terms

For the purposes of the present document, the terms ~~and definitions~~ given in ETSI EN 300 330 [1] and the following apply:

99 % OBW function: measurement function of a spectrum analyser to measure the OBW

antenna: ~~factory defined loop(s) (e.g.~~ integral antenna~~) and/or user defined loop(s) (e.g.,~~ boundary ~~wire,~~loop, and/or guidance ~~wire),~~loop (both dependent and independent) which are used ~~for the functional mode of~~in the RMI

NOTE 1: The inductive wire loops are installed dependent from the shape of the garden. ~~A current is fed into these inductive~~

NOTE 2: To clarify the different loops ~~to generate a magnetic field intended for guidance and/or communication with the robotic mower~~see figure 2.

boundary ~~wire~~loop: inductive wire loop which ~~will be~~is defined~~/~~ by manufacturer and prepared by the user

NOTE 1: It can be implemented as a single or multiple turn coil installed by the user in accordance with instruction from the manufacturer for the purpose of generating magnetic fields to determine the working area.

~~**factory defined loop:** either integral antenna or inductive wire loop that may reach outside the docking station and needs to be completed by the user according to manufacturer specifications in size and shape~~

~~**guidance wire:** electrical wire~~ NOTE 2: To clarify the different loops see figure 2.

dependent guidance loop: guidance loop which is connected to boundary loop (e.g. via a T-junction) and the RMI docking station

NOTE: To clarify the different loops see figure 2.

guidance loop: inductive wire loop which is defined by manufacturer and prepared by the user

NOTE: To clarify the different loops see figure 2.

inductive loop: all electrical loop either wire or coil, where current is fed in order to generate a magnetic field intended for guidance and/or communication with the robotic mower

NOTE: In figure 2 different inductive loops are shown and named based on their function within the RMI system, e.g. boundary loop, guidance loop.

integral antenna: single or multiple turn ~~coil~~inductive loop preinstalled inside the RMI docking station ~~for the purpose of generating magnetic fields such as for guidance and or communication with the robotic mower~~

NOTE: To clarify the different loops see figure 2.

integral receiving antenna: single or multiple turn inductive loop preinstalled inside the robotic mower

Occupied BandWidth (OBW): width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0,5 % of the total mean power of a given emission

NOTE: To clarify ~~occupied bandwidth~~Occupied BandWidth (OBW), see figure 1.

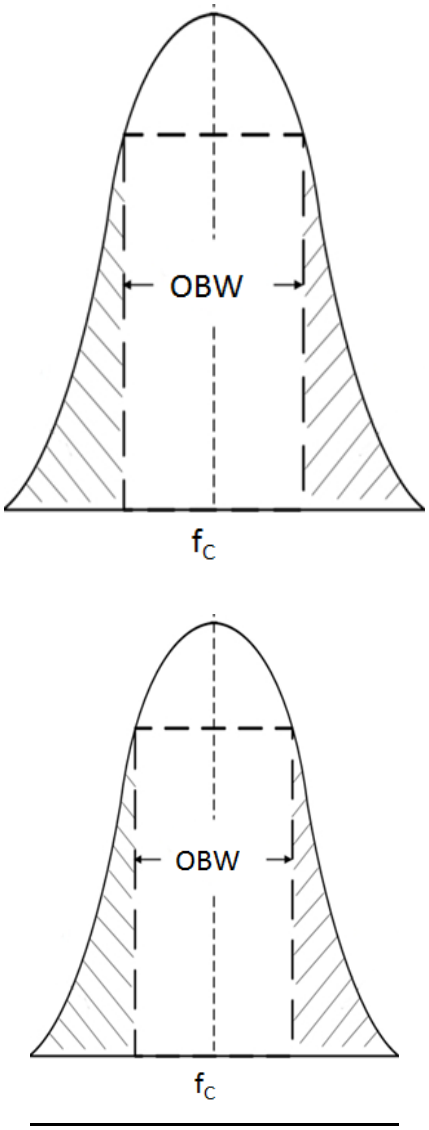


Figure 1: Occupied ~~bandwidth~~BandWidth (OBW)

RMI docking station: charging ~~stations~~station for the robotic mower and the signal generator for the ~~signals on the~~inductive loop(s) and, if applicable, integral antenna ~~and boundary wire~~(s)

NOTE: The RMI docking station can be seen as the signal generator/antenna connecting point. In addition, it is the automatic battery charging facility located on or within the working area.

robotic mower: mobile part of the RMI including cutting means~~. It is the receiving part inside the RMI~~

NOTE: It is the receiving part inside the RMI.

Robotic Mower with Inductive loop system (RMI): system that ~~include~~includes robotic mower, ~~boundary wire~~power supply, docking station ~~with integral antenna, guiding wires, power supply~~

~~**user defined**~~, and inductive loop~~: single or multiple turn coil installed by the user in accordance with instruction from the manufacturer for the purpose of generating magnetic fields such as for guidance and/or communication with the robotic mower and/or to determine the working area~~(s)

working area: area in which the RMI can function

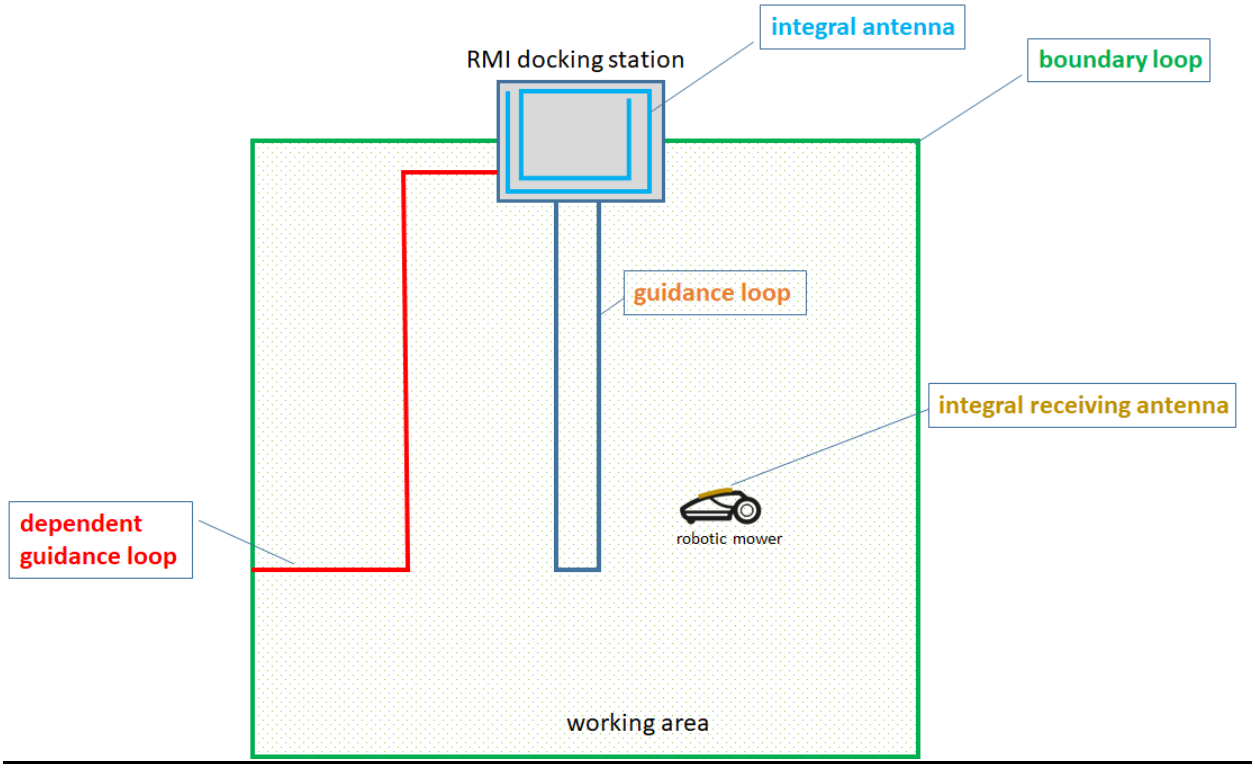


Figure 2: Overview of an RMI system, including the different possible antenna/loops

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 300 330 [1] and the following apply:

C_A	filtering capacitors of the artificial antenna
~~f_c~~ f_C	centre frequency of the OFR
f_H	highest frequency of the OFR
f_L	lowest frequency of the OFR
f_{SH}	higher frequency border between OOB and spurious domain
f_{SL}	lower frequency border between OOB and spurious domain
I_{CM}	~~Common~~common mode current
I_{DM}	~~Differential~~differential mode current
L_A	inductive part of the artificial antenna
R_A	low frequency resistive part of the artificial antenna
R_C	common mode resistive part of the artificial antenna
R_D	high frequency resistive part of the artificial antenna
t_{SWT}	sweept time for TX measurement

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 300 330 [1] and the following apply:

CDMA	Code Division Multiple Access
CF	Conversion Factor
CM	Common Mode
CW	Continuous Wave
DM	Differential Mode
EGMF	European Garden Machinery industry Federation
IHR	Interferer Handling Requirements
LO	Local Oscillator
OBW	~~Operating~~Occupied BandWidth
OFR	Operating Frequency Range

OOB	Out Of Band
PT SRD-MG	Project Team Short Range Device-Maintenance Group
RBR	Receiver Baseline Resilience
RMI	Robotic Mower with Inductive loop system
RX	Receiver
TX	Transmitter
WG FM	Working Group Frequency Management

4 Technical requirements specifications

4.1 Environmental ~~conditions~~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.~~in accordance with its intended use. 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~~. The conditions shall be used as descripted in clause 5.3~~ defined by its intended use.

4.2 General

4.2.1 Wanted technical performance criteria

In general, the robotic mower shall stay in its current operational mode (see clause 4.2.2.2), this is the wanted technical performance criteria of the RMI system.

For the purpose of the receiver performance tests, the RMI shall ~~produce an appropriate output under normal conditions as indicated below:~~

- ~~use as intended without degradation of performance; or~~
- ~~a degradation of the performance is indicated by the RMI as described in the manual.~~

~~The manufacturer shall declare the performance criteria used.~~

~~A robotic mower inside an RMI will only work if:~~

- ~~there will be a signal on the boundary wire; and~~
- ~~this signal is received by the robotic mower.~~

~~If there is no reception of the boundary signal by the robotic mower, then the robotic mower has to switch into the safe mode (see clause 4.2.2.3). The robotic mower has to switch into this safe mode also if it is not~~ be able to ~~receive the boundary signal based on the presence of other signals/interferer.~~handle two interference scenarios:

- ~~When~~Scenario 1: under the ~~robotic mower is operating~~presence of an interfering signal, the robotic mower shall ~~not~~ be able to ~~leave~~detect a loss of the ~~working area,~~ boundary loop signal (see clause 6.3.3.2).
- If the mower detects the loss of boundary signal, it shall react in the same way as required within the "safe mode" (see clause 4.2.2.~~2~~3). The loss of the boundary loop signal can be based on, but not limited to, switching off the boundary loop signal, disconnection of the boundary loop, or blocking of the receiver within the mower.
- Scenario 2: under the presence of an interfering signal, the robotic mower shall be able to detect the passage of the boundary wire (see clause 6.3.3.3).

4.2.2 RMI ~~functional mode~~modes

4.2.2.1 General

In this clause all general considerations for the testing of the inductive parts for the RMI in the frequency range from ~~0~~100 Hz to 148,5 ~~Hz~~kHz are given.

~~Typical functional modes~~Modes being part of an RMI are explained in the following clauses.

~~An RMI can have different user defined loops and factory defined loops. The requirements tests shall be performed for each loop separately.~~

~~If additional mode/antenna/user defined loops are implemented by the manufacturer, then this mode shall be declared for the preparation of the tests.~~

The manufacturer shall provide information (e.g. installation requirements), number and kind of antennas used by the RMI (e.g. boundary loop(s), guidance loop(s), integral antenna(s), etc.), see figure 2. A RMI is fabricated by one manufacturer. There is no option to swap e.g. a mower to another boundary installation. Based on the general nature (TX and RX) of an RMI, covered by the present document, the RMI shall be tested as a system.

The test set-up of the different modes shall be performed as described in clause 6.1 and ~~annex~~Annex B.

4.2.2.2 Operational ~~Mode~~Modes

~~Operational mode is the working mode of the RMI. During this mode the robotic mower is cutting the grass inside the working area and it shall not be possible for the robotic mower to cross the boundary by a distance of more than one full length of the robotic mower, see CENELEC EN 50636-2-107 [i.8], clause 22.104.2.~~

~~The generated signal will be transmitted on the declared user defined loops and factory defined loops. The manufacturer shall declare the active antennas for this mode.~~

~~If the RMI has an additional mode (other combination of active antennas) the manufacturer shall declare this additional mode and the test shall be performed according to this operational mode.~~

Operational modes of an RMI are when the robotic mower is travelling around, mowing grass, returning to the docking station and charging the battery in the docking station.

During the operational modes different combinations of the RMI antennas are active.

The test shall be performed for each active antenna in each operational mode, unless the transmitting signal to the same antenna is identical over different modes, the test of the active antenna shall be performed only once.

4.2.2.3 Safe Mode

~~Safe~~If the robotic mower does not receive its boundary signal adequately, the robotic mower switches into safe mode~~:~~. This loss of signal may either be caused by a stop of the signal generation or by interference.

The safe mode is indicated that after a loss of signal~~,~~ the ~~RMI shall~~robotic mower does not travel more than 1 m and the cutting means ~~shall stop~~stops within 5 ~~s~~seconds, see ~~CENELEC~~ EN 50636-2-107 [~~i.8~~i.8], clause 22.104.2.~~ It is not possible to start the robotic mower in automatic mode.~~

4.2.3 Presentation of equipment for testing purposes

Each RMI submitted for testing shall fulfil the requirements of the present document.

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

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

~~If an RMI system is designed to operate with different operational modes (see clause 4.2.2.2), measurement of each mode shall be performed, according to the present document on samples of equipment defined in clause 4.2.2 of ETSI EN 300 330 [1].~~

To simplify and harmonise the testing procedures between different testing laboratories, measurements shall be performed, according to the present document, on samples defined in clause 4.2.2 of ETSI EN 300 330 [1].

4.3 Transmitter conformance requirements

4.3.1 Operating Frequency Range (OFR)

4.3.1.1 Applicability

This requirement applies to all RMI systems.

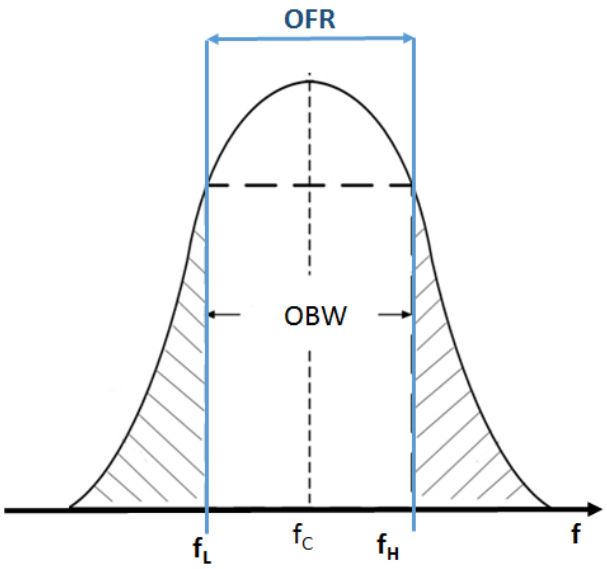
4.3.1.2 Description

The operating frequency range is the frequency range over which the RMI is ~~intentionally~~ transmitting. The operating frequency range of the RMI is determined by the lowest (f_L) and highest frequency (f_H~~).~~):

$$OFR = f_H - f_L$$

An RMI can have more than one operating frequency range (relating to the operational modes and antennas of the RMI system, see clause 4.2.2).

For a single frequency system the OFR is equal to the ~~occupied bandwidth~~Occupied BandWidth (OBW) of the RMI system as described in figure ~~2~~3.



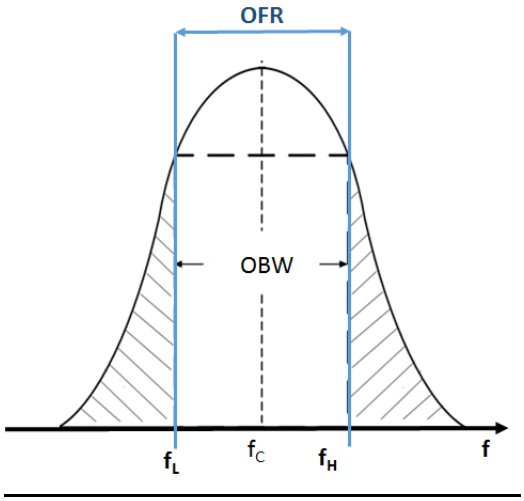


Figure ~~2~~3: Operating Frequency Range (OFR)

4.3.1.3 Limits

The operating frequency range for intentional emissions shall be within the following limits:

- Upper edge of the operating frequency range: $f_H \leq$ 148,-5 kHz.
- Lower edge of the operating frequency range: $f_L \geq$ ~~0~~100 Hz.

For the ~~later~~ spurious and OOB emission measurement procedures in clauses 4.3.3 and 4.3.4 the OFR shall be calculated as: ~~$f_H - f_L$ and the centre frequency as: $f_c = \frac{f_H+f_L}{2}$~~.

$f_H - f_L$

and the centre frequency as: ~~NOTE: If the result for f_L is lower than 500 Hz the value of f_L = 500 Hz is appropriate in the calculation of f_C and OFR. This limit of f_L = 500 Hz is based on available test equipment in order to achieve reliable test results (measurement uncertainty).~~

$$f_c = \frac{f_H+f_L}{2}$$

4.3.1.4 Conformance

The conformance test suite for operational frequency range shall be as defined in clause 6.2.1 ~~(table 8).~~.

~~Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.~~

~~The interpretation of the results for the measurements uncertainty shall be as given in clause 5.7.~~

4.3.2 Transmitter H-field requirements

4.3.2.1 Applicability

This requirement applies to all RMI systems.

4.3.2.2 Description

The radiated H-field is defined in the direction of maximum field strength of the RMI.

4.3.2.3 Limits

The H-field limits for the ~~band below 9~~bands 100 Hz to 148,5 kHz are provided in table 2 ~~and for the band 9 kHz to 148,5 kHz in table 3~~.

~~For the frequency range below 9 kHz no frequency usage conditions were known and available at the time of preparation of the present document. However, the H-field limits in table 2 are suggested to improve the intra-RMI coexistence.~~

Table 2: H-field limits ~~below 9~~between 0,1 kHz and 148,5 kHz

Frequency range (kHz)	H-field strength limit (H_f) dBµA/m at 10 m
0,~~3~~1 ≤ f ~~< 0,~~ < 9	82
~~0,~~9 ~~≤~~ ≤ f ~~< 9~~ < 60	~~82~~72 descending 10- dB/dec above 0,03 MHz
60 ≤ f < 90	42
90 ≤ f < 119	42
119 ≤ f < 135	42
135 ≤ f < 140	42
140 ≤ f < 148,5	37,7
NOTE: For the range 0,1 kHz to 9 kHz the limit is in line with CEPT/ERC/REC 70-03 [i.1], Annex 9. For the range 9 kHz to 148,5 kHz it is in line with EC Decision 2017/1483/EU [i.2].	

~~**Table 3: H-field limits between 9 kHz and 148,5 kHz [i.2]**~~

~~Frequency range (MHz)~~	~~H-field strength limit (H_f) dBµA/m at 10 m~~
~~0,009 ≤ f < 0,060~~	~~72 descending 10 dB/dec above 0,03 MHz~~
~~0,060 ≤ f < 0,090~~	~~42~~
~~0,09 ≤ f < 0,119~~	~~42~~
~~0,119 ≤ f < 0,135~~	~~42~~
~~0,135 ≤ f < 0,140~~	~~42~~
~~0,140 ≤ f < 0,1485~~	~~37,7~~
~~NOTE: The H-field limits in this table are complying with the limits for "inductive SRD devices" in EC Decision 2013/752/EU [i.2]. Further information is available in CEPT/ERC/REC 70-03 [i.1].~~	

4.3.2.4 Conformance

The conformance test suite for transmitter H-field requirements shall be as defined in clause 6.~~1 (table 8).~~2.2.

~~Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.~~

~~The interpretation of the results for the measurements uncertainty shall be as given in clause 5.7.~~

4.3.3 Transmitter spurious emissions

4.3.3.1 Applicability

This requirement applies to all RMI systems.

4.3.3.2 Description

The transmitter spurious emissions ~~for a single frequency system~~ are to be considered in frequency ranges defined ~~in figure 3 (~~by $f < f_{SL}$ and $f > f_{SH}$~~)~~. For a single frequency system the ranges are illustrated in figure 4.

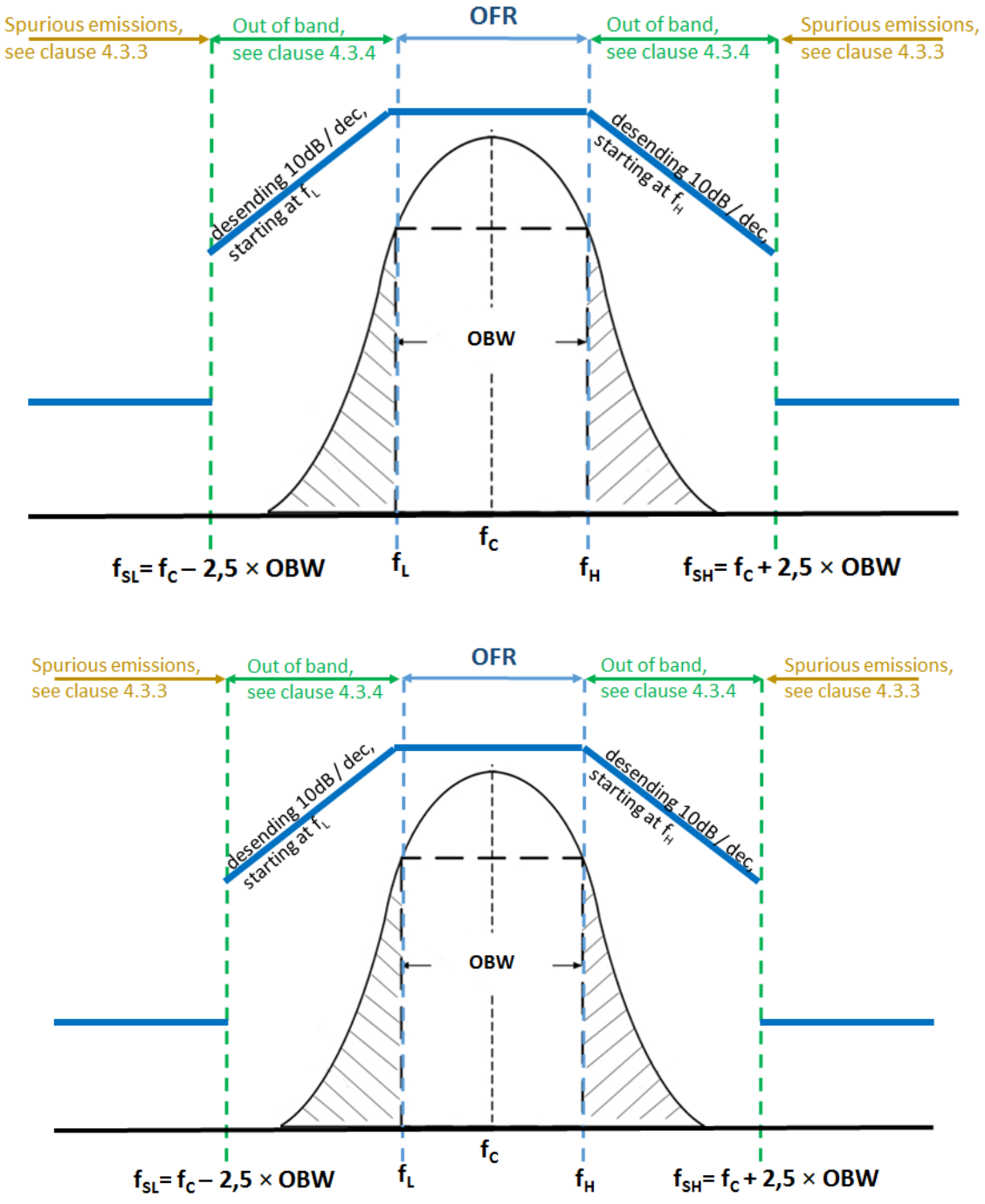


Figure ~~3~~4: Out of band and spurious domain of a single frequency system

The following additional conditions applying for f_{SH}:

1) For systems with $f_H \leq 9$ kHz: f_{SH} shall be set to 27 kHz.

2) For systems with $f_H > 9$ kHz: f_{SH} is the smallest of:

   - $f = f_C + 2{,}5 \times OFR$; or

   ~~or~~

   - $f = 148{,}5$ kHz.

NOTE 1: f_{SH} under number 1) above was calculated based on an assumed f_C of 4,5 kHz and OBW of 9 kHz.

NOTE 2: Bullet two of number 2) above ensures that the spurious limits of CEPT/ERC/REC 74-01 [i.4] ~~applies~~apply above 148,5 kHz.

The following additional conditions applying for f_{SL}:

1) For systems with calculated $f_{SL} < 100$ Hz: f_{SL} is set to 100 Hz.

2) The f_{SL} and f_{SH} shall be calculated based on the OFR result, see clause 4.3.1 (definition OFR) and figure 4 for the calculation.

4.3.3.3 Limits

The spurious emissions shall not exceed the limits given in table ~~4 and table 5~~ 3.

~~Table 4: Magnetic field limits of CEPT/ERC/REC 74-01 [i.4] at 10 m distance~~

Table 3: TX spurious emissions

State	~~Frequency 9 kHz~~100 Hz ≤ f < 10 MHz	~~Frequency~~ 10 MHz ≤ f < 30 MHz	30 MHz ≤ f < 1 GHz
Operating	~~27~~46,5 dBµA/m at ~~9 kHz~~100 Hz descending 3 dB/oct (note 3)	-3,5 dBµA/m (note 3)	-36 dBm (note 4)
	100 Hz ≤ f < 4,78 MHz	**4,78 MHz ≤ f < 30 MHz**	**30 MHz ≤ f < 1 GHz**
Standby	~~5,5~~25 dBµA/m at ~~9 kHz~~100 Hz descending 3 dB/oct (note 3)	~~-25~~22 dBµA/m (note 3)	-57 dBm (note 4)
~~NOTE: There are no spurious emission limits < 9 kHz.~~NOTE 1: For the frequency range below 9 kHz: the limits are on voluntary basis, based on an EC request. ETSI proposed the limits to ECC to be implemented in CEPT/ERC/REC 74-01 [i.4], for more details see Annex D of the present document. NOTE 2: For the frequency range above 9 kHz: the limits are in line with CEPT/ERC/REC 74-01 [i.4], Annex 2. NOTE 3: The limit is specified at a distance of 10 m. NOTE 4: The limit is specified as e.r.p.			

~~The power of any conducted spurious emission (at the antenna port) shall not exceed the values given in table 5.~~

~~Table 5: Spurious emission limits of CEPT/ERC/REC 74-01 [i.4] between 30 and 1 000 MHz~~

~~State~~	~~47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 790 MHz~~	~~Other Frequencies between 30 MHz to 1 000 MHz~~
~~Operating~~	~~4 nW~~	~~250 nW~~
~~Standby~~	~~2 nW~~	~~2 nW~~

4.3.3.4 Conformance

The conformance test suite for transmitter spurious emissions shall be as defined in clause 6.~~1 (table 8).~~2.3.

~~Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.~~

~~The interpretation of the results for the measurements uncertainty shall be as given in clause 5.7.~~

4.3.4 Transmitter ~~out of band~~Out Of Band (OOB) emissions

4.3.4.1 Applicability

This requirement applies to all RMI systems.

4.3.4.2 Description

The transmitter ~~out of band~~Out Of Band emissions are to be considered in the frequency ranges ~~defined in figure 3 (~~between f_{SL} and f_L ($f_{SL} \leq f < f_L$) and between f_H and f_{SH}~~).~~ ($f_H > f \geq f_{SH}$). For a single frequency system, the ranges are illustrated in figure 4.

The f_{SL} and f_{SH} shall be calculated based on the OFR result, see clause 4.3.1 (definition OFR) and clause 4.3.3.2, figure 4 for the calculation.

4.3.4.3 Limits

The OOB limits are visualized in figure 4 (clause 4.3~~;~~.3.2); they are descending from the ~~intentional~~ limits from table 2 ~~and table 3~~ at f_H/ f_L with 10 dB/decade.

~~NOTE: There are no OOB limits < 9 kHz.~~

4.3.4.4 Conformance

The conformance test suite for Transmitter out of band emissions is provided in clause 6.~~1 (table 8).~~2.3.

~~Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.~~

~~The interpretation of the results for the measurements uncertainty shall be as given in clause 5.7.~~

4.4 Receiver ~~Conformance~~conformance requirements

4.4.1 Introduction

~~ETSI EG 203 336 [i.5] lists candidate technical parameters to be included in a Harmonised Standard aimed at providing a presumption of conformity of radio equipment with the essential requirements in articles 3.1(b) and 3.2 of the Radio Equipment Directive 2014/53/EU [i.3].~~

~~Essential requirements are high level objectives described in European Directives. The purpose of the present document is to translate those high level objectives into detailed technical specifications.~~

The justification for the RX-requirements of RMI is provided in Annex C. The receiver concept on signal interferer handling in ETSI TS 103 567 [i.14] is used. The specific RMI justification for the receiver requirements is provided:

- For Receiver Baseline Sensitivity and Receiver Baseline Resilience, see clause C.1.

4.4.2 Receiver ~~unwanted~~Spurious Emissions

4.4.2.1 Applicability

This requirement applies only to RMI2 systems.

4.4.2.2 Description

The receiver spurious emissions

~~The robotic mower~~ of the RMI system is in the receive only ~~part of~~mode, e.g. if the ~~RMI which is receiving.~~

~~But~~mower is in sleep/standstill mode after the ~~mowers cannot be used without any~~ loss of the boundary signal~~, see listed harmonised standard CENELEC EN 50636-2-107 [i.8] under the European Machinery Directive 2006/42/EC [i.11].~~.

~~During normal operation the robotic mower is co-located within the boundary wire/loop and therefore it is not possible to differentiate between the unwanted emissions from the transmitter and from the RX part of the robotic mower. Therefore, this test is not applicable.~~

~~4.4.3~~ 4.4.2.3 Limits

The receiver spurious emissions shall not exceed the limits given in table 4a.

Table 4a: Receiver ~~blocking~~spurious emissions

State	100 Hz ≤ f < 9 kHz (note 1)	9 kHz ≤ f < 4,78 MHz	4,78 MHz ≤ f < 30 MHz	30 MHz ≤ f < 1 GHz
Operating	5,5 dBµA/m	5,5 dBµA/m at 9 kHz descending 3 dB/oct (note 3)	-22 dBµA/m (note 3)	-57 dBm (note 4)
NOTE 1: For the frequency range below 9 kHz: the limits are on voluntary basis, in CEPT/ERC/REC 74-01 [i.4], there are no limits proposed. See similar information in table 3. NOTE 2: For the frequency range above 9 kHz: the limits are in line with CEPT/ERC/REC 74-01 [i.4], Annex 2. NOTE 3: The limit is specified at a distance of 10 m. NOTE 4: The limit is specified as e.r.p.				

4.4.2.4 Conformance

The conformance test suite for Receiver Spurious Emission shall be as defined in clause 6.3.1.

4.4.3 Receiver Baseline Sensitivity

4.4.3.1 Applicability

This requirement applies to all RMI.

4.4.3.2 Description

~~Blocking~~The robotic mower is operating within the test garden (see clause B.1.5) without switching into a safe mode. The largest distance to the boundary wire will happen if the mower is in the middle to the test set-up, see clause 6.3.2, figures 5 and 6 and related parameter for an artificial antenna in clause B.1.1.

4.4.3.3 Limits

The robotic mower has to run longer than 60 seconds without switching into the safe mode, see clause 4.2.2.3.

4.4.3.4 Conformance

The conformance test suite for Receiver Baseline Sensitivity shall be as defined in clause 6.3.2.

4.4.4 Receiver Baseline Resilience

4.4.4.1 Applicability

This requirement applies to all RMI.

4.4.4.2 Description

Receiver Baseline Resilience is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequencies other than those of the receiver spurious responses.

The test shall be in the ~~typical~~ operational mode (real scenario, see clause 4.2.2.2).

The RMI shall achieve the wanted technical performance criteria~~(~~, see clause 4.2.1~~) will be used for the receiver blocking tests~~, in the presence of the interfering signal.

4.4.4.3~~.3~~ Limits

The ~~receiver blocking~~Receiver Baseline Resilience limits in table ~~6~~4b shall be fulfilled.

Table ~~6~~4b: Receiver ~~blocking limits~~Baseline Resilience requirements

	In-band signal	OOB signal	Remote-band signal
~~Frequency~~Interferer signal frequency	$f = f_c$	$f = f_c \pm OFR$	$f = f_c \pm 10 \times OFR$
~~receiver blocking limits~~Interferer signal level	98 dBµA/m - 20log10 (f/10 kHz)	98 dBµA/m - 20log10 (f/10 kHz)	98 dBµA/m - 20log10 (f/10 kHz)
Kind of interferer signal	CW	CW	CW
NOTE: ~~Background for limits in table 6:~~ ~~—~~The industry standard for RMI (Source: EGMF [~~i.7~~i.7]) proposes that robotic mower installations should never be closer than 1 ~~meter~~m and the RMS current in the wire should never exceed 500 mA. ~~—~~ When an interfering standard garden is located at a distance of 1 m with long side to long side the H field from a 500 mA current will be 98 dBuA/m (or 100 nT for B-field). ~~—~~ Robotic mowers use coils as antennas and the ~~electromagnetic force~~Electromagnetic Force (EMF) generated in those antennas are proportional to the derivative of the signals. Therefore, when doubling the frequency of the interfering signal the voltage generated in the antenna will also double. ~~—~~ The 100- nT is therefore normalized to a ~~typical~~state of the art value for robotic mower signal centre frequency of 10- kHz.			

~~The RMI shall achieve the wanted performance criteria, see clause 4.2.1, in the presence of the blocking signal.~~

4.4.4~~.3~~.4 Conformance

The conformance test suite for ~~operational frequency range~~Receiver Baseline Resilience shall be as defined in clause 6.~~1 (table 8).~~3.3.

~~Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.~~

~~The interpretation of the results for the measurements uncertainty shall be as given in clause 5.7.~~

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the ~~declared~~ operational environmental profile defined by its intended use.

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 defined by its intended use) to give confidence of compliance for the affected technical requirements.

5.2 General conditions for testing

~~5.2.1 Product information~~

~~The provisions~~Clause 5.3 of ETSI EN 300 330 [1~~], clause 5.2.1 shall apply except as varied herein.~~

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

~~5.3 Normal and extreme~~] provides information on test conditions

~~The provisions of~~, power supply and ambient temperature. ETSI ~~EN 300 330~~TS 103 051 [~~1~~], clause i.15] provides additional information on measurement uncertainty.

5.3 ~~shall apply.~~

~~5.4~~ Artificial antenna

~~Tests using the~~ The artificial antenna ~~are specified~~is described in clause B.~~2. Table 8 gives an overview of conformance tests for which the artificial antenna shall be selected by the manufacturer~~1.1.

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

- ~~transmitter loop currents within OFR up to 148,5 kHz;~~
- ~~transmitter spurious and OOB currents up to 30 MHz.~~

~~The artificial antenna of annex C shall be used.~~

~~5.5 Test sites and general arrangements for radiated measurements~~

~~Tests to be carried out using a test site shall be selected according to table 8.~~

~~Due to the mechanical size of the user defined antennas it has to be noted that the emissions test for such dimensions cannot be realized on a turn table. Therefore artificial antennas or a representative test garden shall be used.~~

~~This method facilitates radiated measurements to be made of the following:~~

- ~~RMI radiated H-field within OFR up to 148,5 kHz;~~
- ~~RMI spurious and OOB H-field up to 30 MHz.~~

~~The required test setups and procedures are provided in annex B.~~

~~5.6~~ 5.4 Measuring receiver

The term "measuring receiver" refers to a selective voltmeter, oscilloscope ~~or,~~ a spectrum analyser~~. The~~ or a measurement instrument according to EN 55016-1-1:2010 + A1:2010 + A2:2014 [i.13]. The resolution bandwidth and detector type of the measuring receiver are given in ~~table 7~~tables 5 and 6.

~~If a different detector type shall be used for the conformance test this is specified in the related subclauses of clause 6.~~

Table ~~7.~~5: Resolution Bandwidth and detector type for ~~the measuring receiver~~magnetic field measurements

Frequency: (f)	Detector type	~~Measurement receiver~~Resolution bandwidth	~~Spectrum analyser bandwidth~~
~~300~~100 Hz ≤ f ~~<~~ 9 kHz ~~<~~ 500 Hz	~~Quasi~~ Peak	~~200~~10 Hz	~~300 Hz~~
500 Hz ≤ f < 9 kHz	Peak	200 Hz	
9 kHz ≤ f ~~<~~ ≤ 150 kHz	Quasi Peak	200 Hz	~~300 Hz~~
150 kHz ≤ f ~~<~~ ≤ 30 MHz	Quasi Peak	9 kHz	~~10 KHz~~
30 MHz ≤ f ≤ 1 000 MHz	Quasi Peak	120 kHz	~~100 kHz~~

~~**Different bandwidths may be used if agreed with**~~**Table 6: Resolution Bandwidth and detector type for spurious and OOB measurements according to CEPT/ERC/REC 74-01 [i.4]**

Frequency: (f)	Detector type	Resolution bandwidth
100 Hz ≤ f < 500 Hz	RMS	10 Hz
500 Hz ≤ f < 9 kHz	RMS	100 Hz
9 kHz ≤ f < 150 kHz	RMS	1 kHz
150 kHz ≤ f < 30 MHz	RMS	10 kHz
30 MHz ≤ f ≤ 1 000 MHz	RMS	100 kHz

In tables 5 and 6 a resolution bandwidth of 10 Hz is requested for the ~~test laboratory.~~measurements up to 500 Hz. If such resolution bandwidth is not available in the measurement receiver a resolution bandwidth up to 100 Hz shall be used. The measurement bandwidths and any related calculations shall be stated in the test report.

~~5.7 Measurement uncertainty~~

~~The provisions of ETSI EN 300 330 [1], clause 5.13 shall apply.~~

~~5.8 Interpretation of the measurement results~~

~~The provisions of ETSI EN 300 330 [1], clause 5.14 shall apply.~~

If a different detector type and resolution bandwidth will be used for the conformance test this is specified in the related subclauses of clause 6.

5 Conformance methods of measurement for transmitters and receivers

6.1 General

~~For the conformance test of the essential requirements in clause 4, table 8~~Table 7 gives an overview of the ~~relevant~~ conformance tests~~ and test conditions for the essential requirements, which shall be selected by the manufacturer~~.

Table ~~8~~7: Overview of Conformance tests

Essential requirements	**Conformance tests**	**~~Test setup and procedure~~**	**~~Test conditions~~**	**~~Measurement uncertainty~~**		
		~~User defined antennas~~	**~~Factory defined antenna~~**			
OFR, clause~~-~~ 4.3.1	6.2.1	~~B.1 or B.2~~		~~B.1 or B.3~~	~~5.3~~	~~5.7~~
H-field, clause~~-~~ 4.3.2	6.2.2	~~B.1 or B.2~~		~~B.1 or B.3~~	~~5.3~~	~~5.7~~
Transmitter unwanted emission (spurious and out of band emissions), clauses~~-~~ 4.3.3 and 4.3.4	6.2.3	~~for f < 30 MHz: B.1 or B.2~~ ~~for 30 MHz < f < 1 GHz: not applicable~~		~~B.1 or B.3~~	~~5.3~~	~~5.7~~
Receiver spurious emissions clause 4.4.2	6.3.1					
Receiver Sensitivity, clause 4.4.3	6.3.2					
Receiver Blocking, clause~~-~~ 4.4.~~3~~4	6.3.2~~3~~	~~B.1~~		~~B.1~~	~~5.3~~	~~5.7~~

6.2 Transmitter conformance methods

6.2.1 OFR

The measurement ~~shall be made with one of the test setups~~procedure depends from ~~annex B.~~ the used RMI antennas:

- For ~~user defined loops (~~boundary and guidance ~~and boundary wires)~~ loops the ~~test~~conducted setup and procedure from clause B.1 (~~test garden) or clause B.2 (~~artificial antenna) ~~and for factory defined~~shall be used.
- For integral antennas the ~~test~~radiated setup and procedure from clause B.~~1 (test garden) or from clause B.3 (anechoic chamber)~~2 shall be used.

~~A representative test signal from the RMI shall be measured with a spectrum analyser. The RMI system shall be modulated with standard test modulation (see clause 5.2).~~

Based on the very low frequencies the test has to be performed within two steps.

Step 1:

The transmission shall be measured using a ~~spectrum analyser~~measuring receiver according to clause 5.4 with the following settings:

- Start frequency: ~~500~~ 100 Hz~~.~~

- ~~Stop frequency: higher than the upper edge of the permitted frequency range/requested by the essential requirements in clause 4.~~
- Stop frequency: 148,5 kHz
- Resolution Bandwidth: ~~200 Hz.~~
- Video Bandwidth: ~~≥~~ 300 Hz~~.~~
- Detector mode: ~~RMS.~~
- Display mode: ~~maxhold~~ max hold over ~~>~~ 10 ~~s.~~sweeps (one measurement)
- ~~Sweep time, Averaging time: ≥ 1 ms per sweep point.~~
- Sweep time: increase the sweep time and reset max hold after each measurement until the difference between two consecutive measurements of the amplitude of the spectrum is less than 0,5 dB

The following values shall be recorded:

- f_{H_step1} as the right most frequency above the centre frequency f_c shall be recorded where the level is 23 dB lower as the maximum.
- f_{L_step1} as the left most frequency below the centre frequency shall be recorded where the level is 23 dB lower as the maximum.
- f_{H_step1} and f_{L_step1} shall be recorded.
- t_{SWT}: final sweep time of step 1.

Step 2:

- Start frequency: 100 Hz or 0,8 × f_{L_step1} whatever is higher
- Stop frequency: 148,5 kHz or 1,5 × f_{H_step1} whatever is lower
- Resolution Bandwidth:
  - 30 Hz if start frequency is below 500 Hz
  - 200 Hz if start frequency is above 500 Hz
- Video Bandwidth: larger than the resolution bandwidth
- Detector mode: RMS
- Display mode: max hold over 10 sweeps
- Sweep time: t_{SWT}

The following values shall be recorded:

- f_H as the frequency of the upper marker resulting from the "OBW"-function of a spectrum analyser, using 99 % of the power (see figure ~~2~~3). Alternatively the- right most frequency above the centre frequency f_c shall be recorded where the level is 23 dB lower as the maximum.
- f_L as the frequency of the ~~upper~~lower marker resulting from the "OBW"-function of a spectrum analyser, using 99 % of the power (see figure ~~2~~3). Alternatively, the- left most frequency below the centre frequency shall be recorded where the level is 23 dB lower as the- maximum.
- ~~f_c~~ f_C is the centre frequency. ~~$f_c = \frac{f_H + f_L}{2}$~~.
- OFR= f_H - f_L.

The results out of step 2 are to be compared with the limits in clause 4.3.1.3.

NOTE: Justification why a measurement below 100 Hz for TX emissions of an RMI systems is not considered:

- Some RMI are sending a DC current or voltage in the loop wire to feed slave devices. This DC signal will always have a small bandwidth, but will never create high radiated emission via the loop and the interference on radio devices at these frequencies will be low (no radio application known in the range < 100 Hz).
- State of the art power supply installation (50 Hz) and AC/DC converters may create high EMC emissions. Therefore, it is not possible to differentiate the radiated emission of an RMI system from the EMC emission from the power supply parts.

6.2.2 H-field

The measurement ~~shall be made with one of the test setups from annex B.~~ procedure depends from the used RMI antennas:

- For ~~user defined loops (guidance and~~ boundary ~~wires) the test setup and procedure from clause B.1 (radiated tests with test garden) or clause B.2 (current measurements with artificial antenna) and for factory defined antennas the test~~and guidance loops the conducted setup and procedure from clause B.1 (~~test garden) or~~artificial antenna) shall be used.
- For integral antennas the radiated setup and procedure from clause B.~~3 (radiated tests within anechoic chamber)~~2 shall be used.

~~A representative test signal from the RMI shall be measured with a spectrum analyser. The RMI system shall be modulated with standard test modulation (see clause 5.2).~~

The transmission shall be measured using a ~~spectrum analyser~~measuring receiver according to clause 5.4 with the following settings:

- Start frequency: ~~500 Hz.~~$0{,}8 \times f_L$ (see clause 6.2.1)
- Stop frequency: ~~higher than~~$1{,}2 \times f_H$ ~~from~~(see clause ~~4.3~~6.2.1~~.~~)
- Resolution Bandwidth: according to clause 5.~~6.~~4, table 5
- Video Bandwidth: ≥ ~~RBW.~~Resolution Bandwidth
- Detector mode: according to clause 5.~~6.~~4, table 5
- Display mode: ~~maxhold~~max hold over ~~>~~ 10 ~~s.~~sweeps
- Sweep time~~, Averaging time: ≥ 1 ms per sweep point.~~: t_{SWT} (see clause 6.2.1)

The maximum H-Field results are to be compared with the limits in clause 4.3.2.3.

6.2.3 Transmitter unwanted emissions (spurious and OOB emissions)

The measurement ~~shall be made with one of the test setups and procedures~~procedure depends from ~~annex B.~~ the used RMI antennas:

- For ~~user defined loops (~~boundary and guidance ~~and boundary wires)~~ loops the ~~test~~conducted setup and procedure from clause B.1 (~~radiated tests with test garden) or clause B.2 (current measurements with~~ artificial antenna) ~~and for factory defined~~shall be used.
- For integral antennas the ~~test~~radiated setup and procedure from clause B.~~1 (test garden) or from clause B.3 (radiated tests within anechoic chamber)~~ 2 shall be used.

~~A representative test signal from the RMI shall be measured with a spectrum analyser. The RMI system shall be modulated with standard test modulation (see clause 5.2).~~

The transmission shall be measured using a ~~spectrum analyser~~measuring receiver according to clause 5.4 with the following settings:

- Start frequency: ~~9 kHz.~~100 Hz
- Stop frequency: dependant from RMI antenna:
  - For boundary and guidance loops: 30 MHz
  - For integral antennas: 1 GHz~~.~~

NOTE 1: Artificial antenna for boundary and guidance loops is only specified for the frequency range below 30 MHz. In a real scenario a large boundary loop is low pass filter and therefore radiates no TX unwanted emissions above 30 MHz. In addition the harmonics of the fundamental will not be present above 30 MHz (e.g. at 30 MHz it would be the 202nd harmonic of the highest fundamental frequency).

NOTE 2: For each frequency range out of table 6 one measurement is to be performed.

- Resolution Bandwidth: according to clause 5.4, table 6~~.~~
- Video Bandwidth: ≥ ~~RBW.~~Resolution Bandwidth
- Detector mode: according to clause 5.4, table 6~~.~~
- Display mode: maxhold over > 10 ~~s.~~sweeps
- ~~Sweep time, Averaging time: ≥ 1 ms per sweep point.~~
- Sweep time: increase the sweep time and reset max hold after each measurement until the difference between two consecutive measurements of the amplitude of the spectrum is less than 0,5 dB

The maximum unwanted emission (spurious and OOB) results are to be compared with the limits in clause 4.3.3.3.

6.3 Receiver conformance methods

6.3.1 Receiver spurious emissions

~~Not applicable, see~~The radiated setup and procedure from clause ~~4.4~~B.2~~.~~

~~6.3.2 Receiver blocking~~

~~This measurement~~ shall be used.

For the receiver spurious emissions, the robotic mower shall be set to the receive only mode (or sleep/idle mode).

To reach the receive only mode the same set-up and steps for the receiver baseline sensitivity (see clauses 6.3.2.1 and 6.3.2.2) shall be used. After step 4 of clause 6.3.2.2 the boundary signal shall be switched off. Now the mover is in receive only mode and the receiver spurious can be measured.

The transmission shall be measured using a measuring receiver according to clause 5.4 with the following settings:

- Start frequency: 100 Hz
- Stop frequency: 1 GHz; according to CEPT/ERC/REC 74-01 [i.4], table 1

NOTE: For each frequency range out of table 6 one measurement is to be performed ~~under normal conditions~~.

~~The fulfillment of the RMI performance criteria in the operational mode (see clause 4.2.2.2) shall be tested in presence of an inference signal according to clause 4.4.3.3, table 6 (frequencies, magnetic field).~~

~~The RMI shall initially operate without interference.~~

- Resolution Bandwidth: according to clause 5.4, table 6
- Video Bandwidth: ≥ Resolution Bandwidth
- Detector mode: according to clause 5.4, table 6
- Display mode: maxhold over > 10 sweeps
- Sweep time: increase the sweep time and reset max hold after each measurement until the difference between two consecutive measurements of the amplitude of the spectrum is less than 0,5 dB

The maximum receiver spurious emission results are to be compared with the limits in clause 4.4.2.3.

6.3.2 Receiver Baseline Sensitivity

6.3.2.1 General

The test setup is visualized in ~~figure 4~~figures 5 and ~~figure 5~~6.

The RMI docking station shall be operated with a boundary ~~wire~~loop according to ~~figure 4~~figures 5 and ~~figure 5~~6 with an artificial antenna (or artificial load with 2 ~~Ohm~~Ω and 200 µH, see clause B.~~2~~1.1) as load in series.

The test shall be carried out ~~inside a test~~on an anechoic chamber ~~according to~~as described in clause C.1.1 ~~and clause C.1.2 in~~ of ETSI EN 300 330 [1].

The boundary wire shall lie on a non-metallic ground and the minimum distance to a metallic ground plane shall be 0,75 m.

The geometrical centre of the receiver(s) in the robotic mower shall be placed to the centre of the test-loop (e.g. X=0 (see figure 6)) and shall stay there during the test (e.g. the robotic mower wheels may be deactivated or lifted from the ground). Any possible switch off mechanism (e.g. if the robotic mower detects no movement) shall not affect the test.

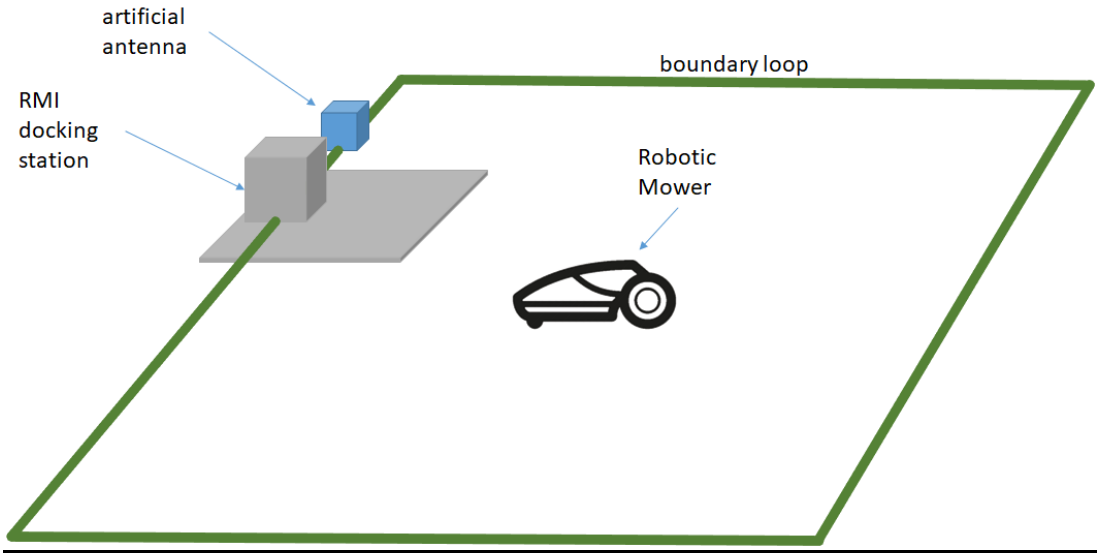


Figure 5: Schematic test set-up for RX-Sensitivity test

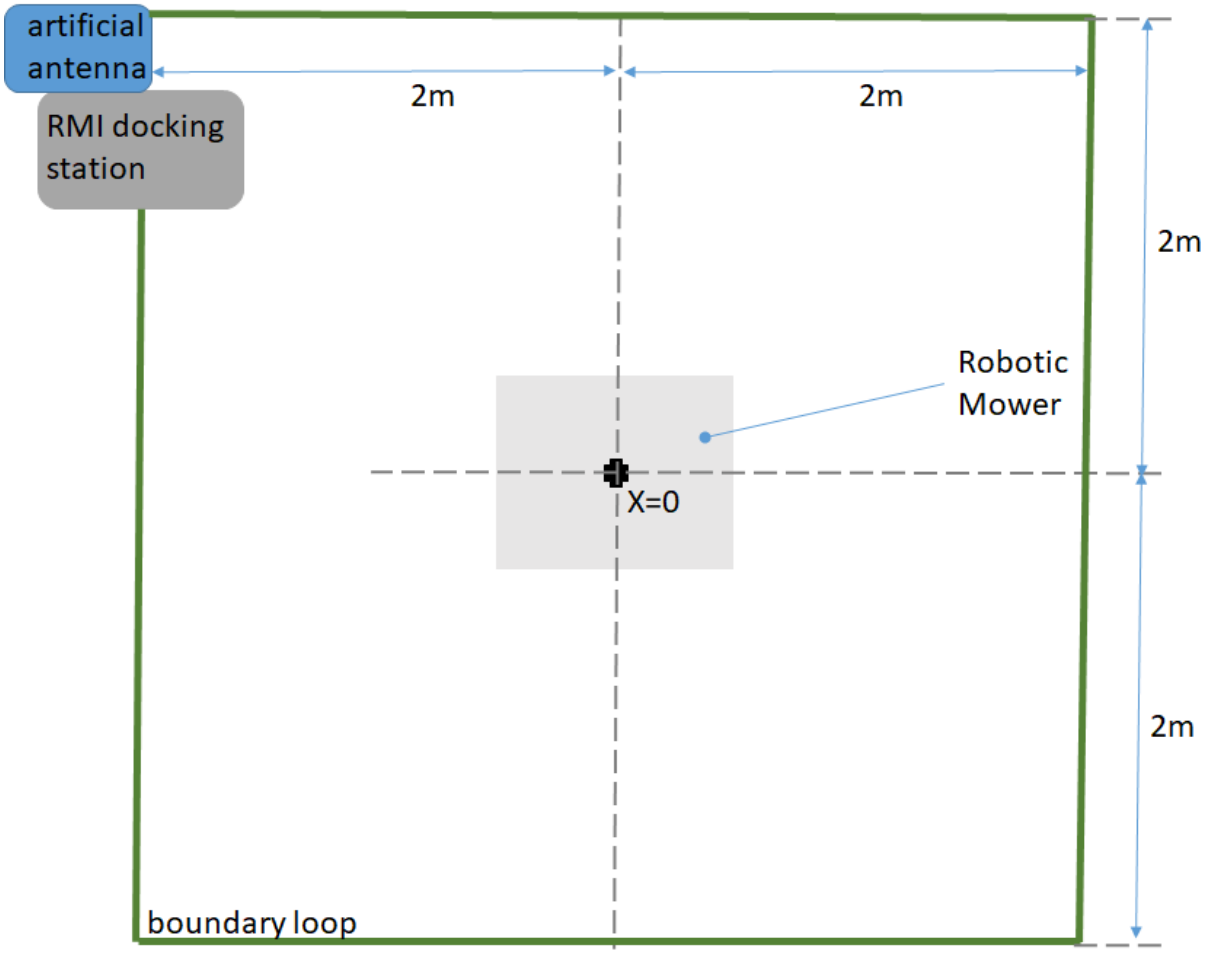


Figure 6: Schematic test set-up for RX-Sensitivity test (view from top)

6.3.2.2 Receiver-Baseline Sensitivity Test

Step 1: Place the robotic mower in the middle of the test set-up.

Step 2: Activate the RMI system.

Step 3: Start the robotic mower with the operation mode. The robotic mower shall be adjusted in such a way that the robotic mower will keep the position in the middle of the test set-up (e.g. by deactivation of the wheel, lifting up).

Step 4: If the RMI meets the wanted technical performance criteria (see clause 4.2.1) at all times, this means working longer than 60 seconds as intended, then the test shall be considered as passed.

Otherwise, the test is considered as failed.

~~1~~6.3.3 Receiver Baseline Resilience (RBR)

6.3.3.1 General

The fulfilment of the RMI performance criteria in the operational mode (see clause 4.2.1) shall be tested in presence of an inference signal according to clause 4.4.4.3, table 4b (frequencies, magnetic field).

The test setup is visualized in figures 7 and 8.

The RMI docking station shall be operated with a boundary wire arrangement according to figures 7 and 8 in combination with an artificial antenna (or artificial load with 2 Ω and 200 µH, see clause B.1.1) as load in series.

The test shall be carried out on an anechoic chamber as described in clause C.1.1 of ETSI EN 300 330 [1].

A test loop with a radius R shall be used to create an interfering magnetic field. The test loop shall lie on a non-metallic ground and the minimum distance to metallic ground plane shall be 0,75 m. The test loop and the boundary wire shall be on the same horizontal level.

The geometrical centre of the receiver(s) in the robotic mower shall be placed to the centre of the test-loop (e.g. X=0 (see figure 58)) and shall stay there during the test (e.g. the robotic mower wheels may be deactivated or lifted from the ground). Any possible switch off mechanism (e.g. if the robotic mower detects no movement) shall not affect the test.

The radius R of the test-loop shall be in minimum 4 times the maximum dimension r of the robotic mower (see figure 58).

The maximum interfering H-Field at X = 0 can be calculated from the loop current I (into the test-loop) with the following formula:

$$H = \frac{I}{2R} \quad (1)$$

The required output current to achieve the magnetic field from clause 4.4.334.3, table 64b at the robotic mower shall be generated with a test signal generator at the test frequencies from table 64b.

For each test frequency the "reaction" of the RMI shall be recorded and checked against the wanted technical performance criteria from clause 4.2.1.

The RX test includes two separate test scenarios:

- Test 1: ifsee clause 6.3.3.2, to test that the robotic mower can handle a lost signal.
- Test 2: ifsee clause 6.3.3.3, to test that the robotic mower can handle a passage of the boundary wire.

6.3.3.2 RBR Test 1: **Test if** to test that the robotic mower can handle a lost signal

Step 1.1: Initially, the test signal generator shall be switched off.

Step 1.2: The RMI system shall be configured so that the wanted technical performance criteria are met: the wanted criteria are considered to be met as long as the receiver always works as intended. Calculate the limit of the interferer current according to clause 4.4.334.3, table 64b and equation (1).

Step 1.3: The test signal generator is then switched on at f_C.

Step 1.4: The test signal generator shall then be adjusted in carrier current from zero up to the limit given in clause 4.4.334.3, table 64b.

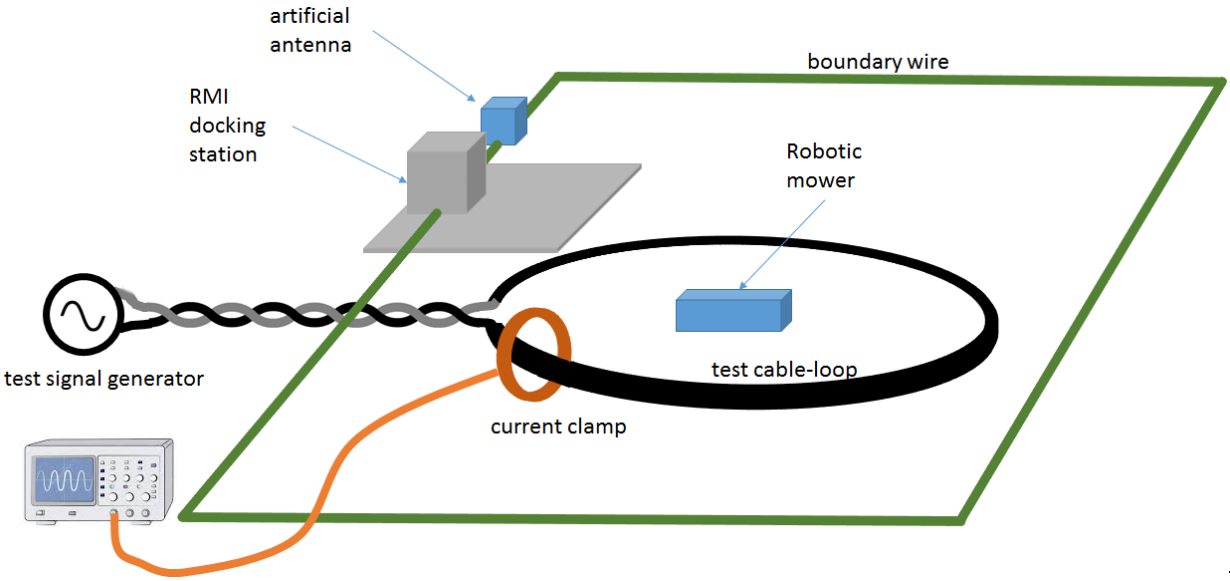
Step 1.5: If the robotic mower goes into safe mode or into a state which is not declared then this magnetic field shall be noted.

Step 1.6: With the interferer limit according to clause 4.4.334.3, table 64b, turn off the RMI transmitter, so there is only the signal from the interferer. The robotic mower has to detect the loss of its signal and go into safe mode (see clause 4.2.1).

Step 1.7: The measurements steps 1.1 to 1.6 shall be repeated at the frequency for OOB and remote-signal as requested in clause 4.4.334.3, table 64b.

If the RMI meets the wanted technical performance criteria (see clause 4.2.1) at all times, then the test shall be considered as passed.

Otherwise, the test is considered as failed.



Otherwise, the test is considered as failed.

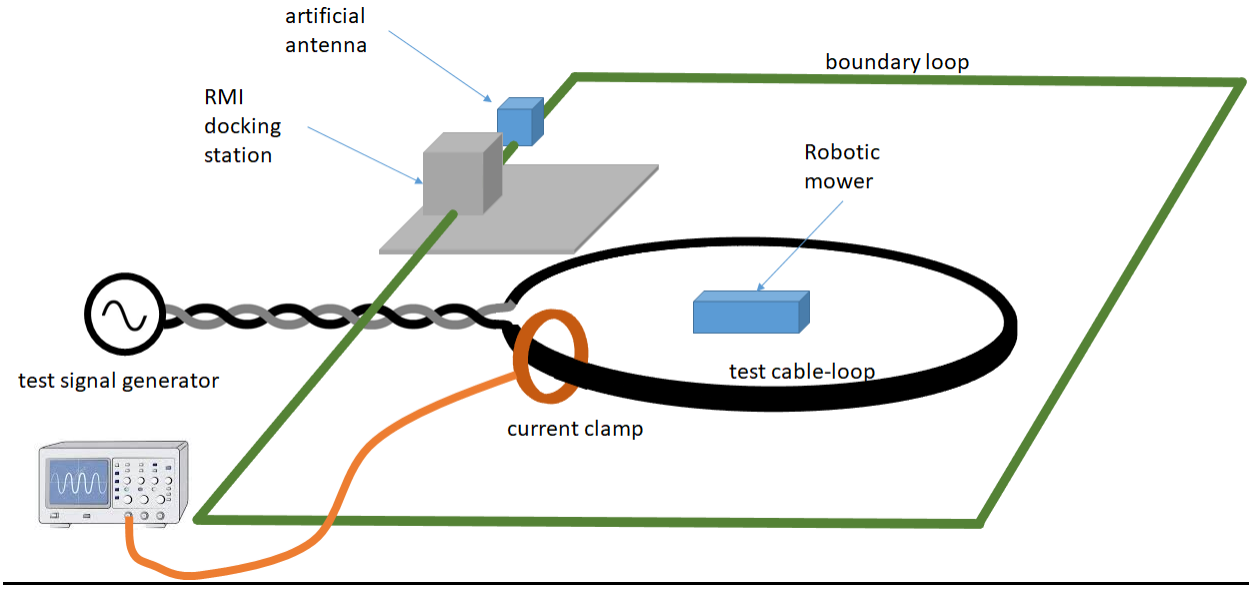


Figure 47: Schematic test set-up for the RX-blocking test 1

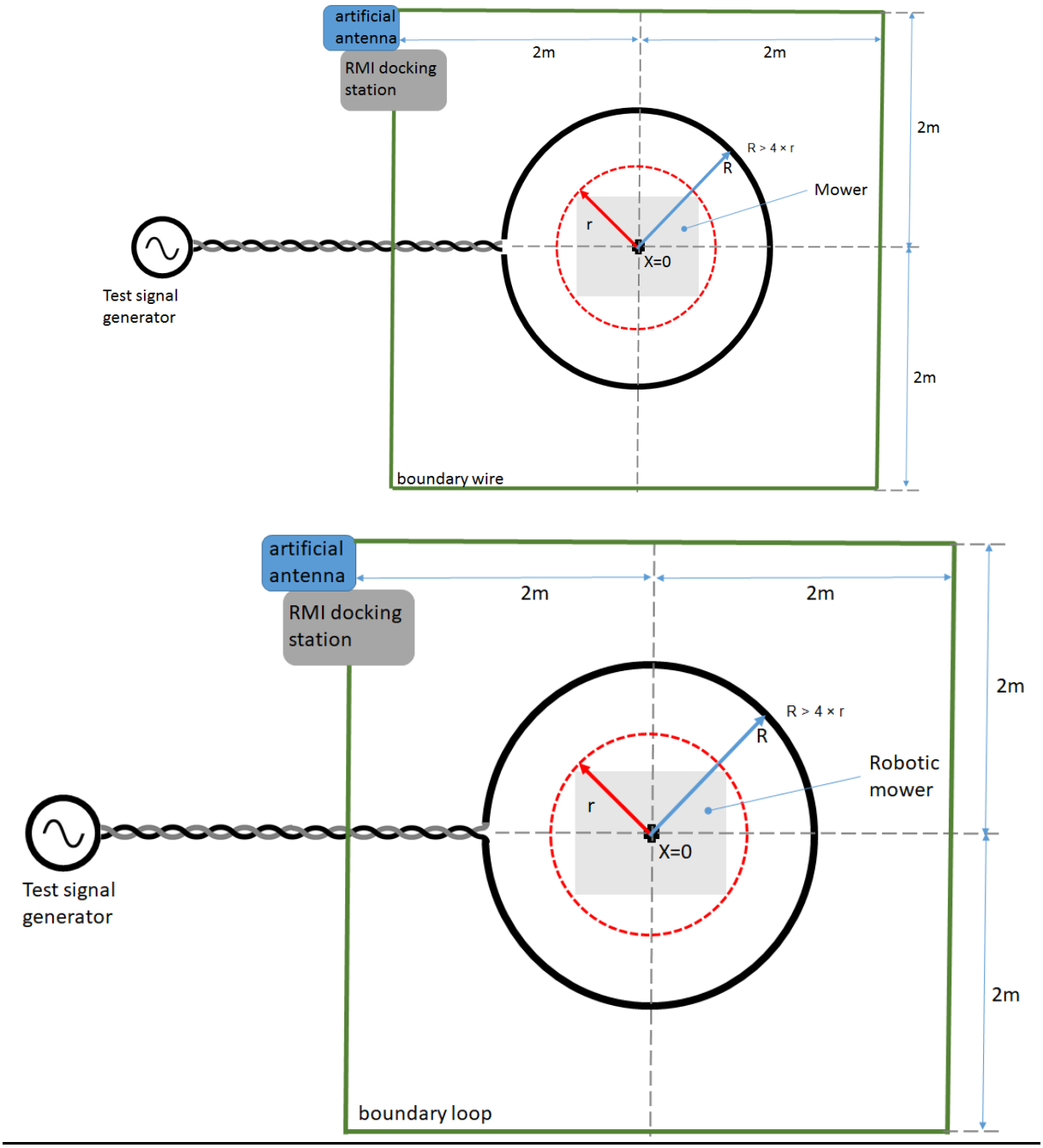


Figure ~~58~~: Schematic test set-up with dimensional specification for the RX-blocking test 1 (top view)

6.3.3.3 RBR Test 2: ~~Test if~~ to test that the robotic mower can handle a passage of the boundary wire~~.~~

Step 2.1: Initially, the test signal generator shall be switched off.

Step 2.2: The RMI system shall be configured so that the wanted technical performance criteria are met: the wanted criteria are considered to be met as long as the RMI system works as intended. Calculate the limit of the interferer current according to clause 4.4.~~3~~4.3, table ~~6~~4b and equation (1).

Step 2.3: The test signal generator is then switched on at f_C.

Step 2.4: The test signal generator should then be adjusted in carrier current from zero up to the limit given in clause 4.4.~~3~~4.3, table ~~6~~4b.

Step 2.5: The boundary wire should then be moved under or over the robotic mower so that the robotic mower is outside the boundary wire (leaving the working area). The boundary wire should never be moved faster than the speed of the robotic mower so that a normal mode boundary wire passage can be observed, see figure ~~6~~9.

~~Step 2.6: The robotic mower should indicate to fulfil the performance criteria from clause 4.2.1.~~

Step 2.6: The robotic mower shall react as intended in the RMI manual for the case "passing of the boundary wire" (e.g. the mower shall continue to operate as intended and its reaction (turning back, going to sleep, etc.) has to be noted in the test report).

Step 2.7: The measurements steps 2.3 to 2.6 shall be repeated at the frequency for OOB and remote-signal as requested in clause 4.4.~~3~~4.3, table ~~6~~4b.

If the robotic mower operates in normal mode or in safe mode at all times, then the test shall be considered as passed.

If the robotic mower does not react as intended, then the test is considered as failed.

The results are to be compared with the limits in clause 4.4.3.3.

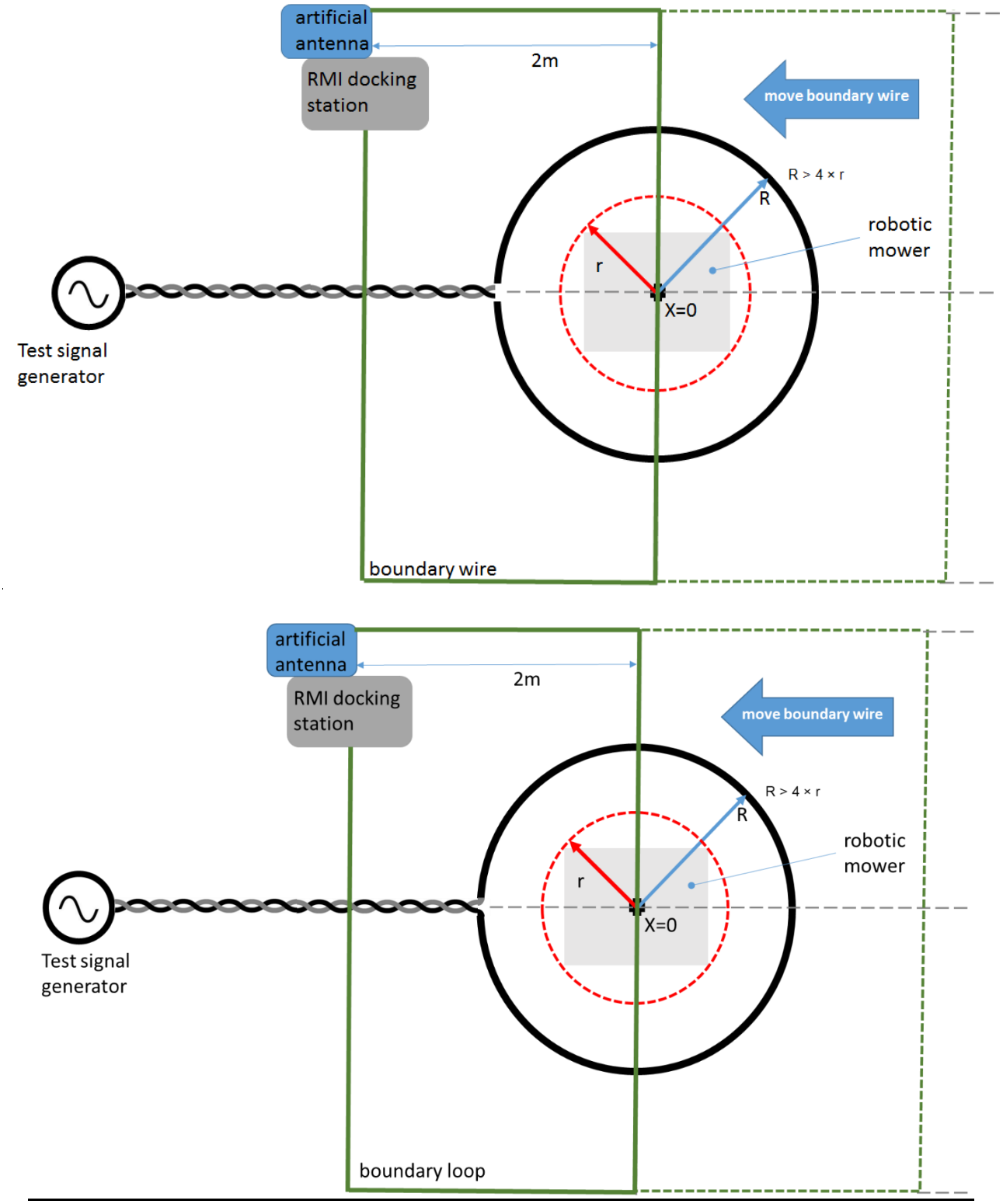


Figure ~~69~~: Schematic test set-up for the RX-blocking test 2

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.6] 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.3].

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 303 447					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	~~Reference:~~ Clause ~~No~~(s) of the present document	U/C	Condition
1	Operating ~~frequency range~~Frequency Range (OFR)	3.2	4.3.1	U	
2	Transmitter H-field requirements	3.2	4.3.2	U	
3	Transmitter spurious emissions	3.2	4.3.3	U	
4	Transmitter ~~out of band~~Out Of Band (OOB) emissions	3.2	4.3.4	U	
5	Receiver Spurious Emissions	3.2	4.4.2	C	RMI2 systems only
6	Receiver Baseline Sensitivity	3.2	4.4.3	U	
~~5~~7	Receiver ~~blocking~~Baseline Resilience	3.2	4.4.~~3~~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.

Essential requirements of Directive

Identification of article(s) defining the requirement in the Directive.

Clause ~~Number~~(s) of the present document

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.

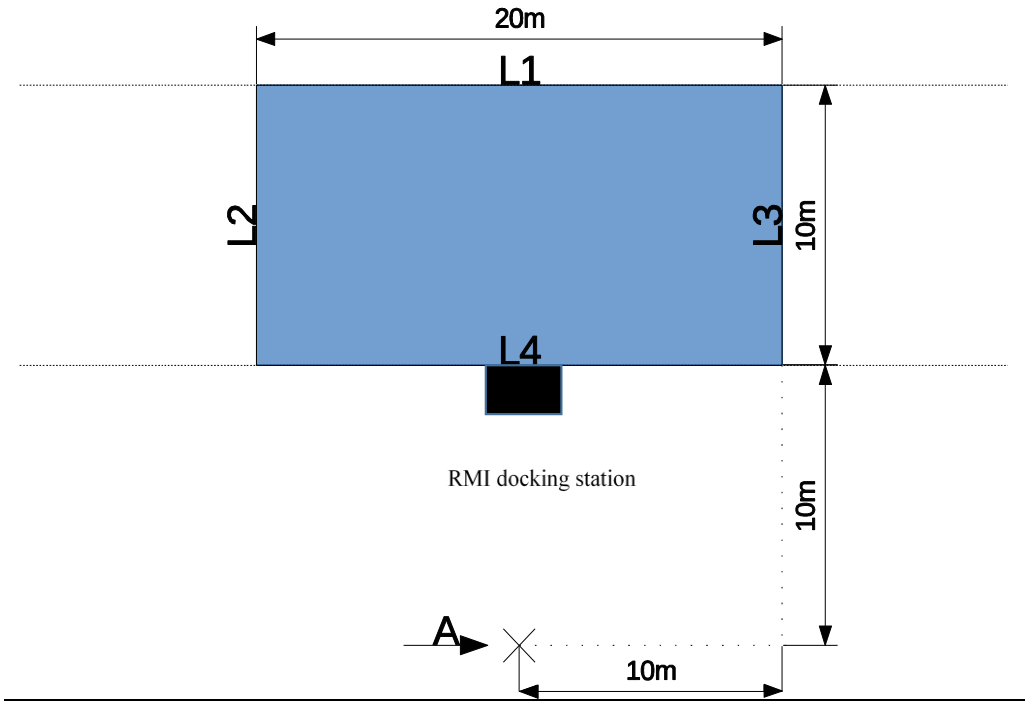
Annex B (normative): Test sites and procedures

B.1 ~~Set-up 1: Magnetic field measurements at a Test Garden~~

~~The test shall be performed for each user defined loop separately.~~

~~The test garden is a 20 m × 10 m garden. The transmitter antenna is bounding the edges of the garden.~~

~~The measurement point A is located at a distance of 10 m from the middle of the long side (see figure B.1~~Boundary~~). The measurement antenna shall be there at a height of 1 m.~~



~~Figure B.1: The test garden~~

~~Requirements for the open test site are described in ETSI EN 300 330 [1], clause C.1.3.~~

~~The maximum transmissions at 10 m distance are to be recorded with the three possible orthogonal orientations (x/y/z) of the shielded loop antenna in the direction of the maximum radiation of the RMI system.~~

B.2 ~~Set-up 2: Carrier current measurements using an artificial antenna~~

B.2.1 ~~General~~

~~The test shall be performed for each user defined loop separately (independent~~ and dependent guidance loops~~). Independent loops are electrically connected only inside the RMI docking station while dependent loops are electrically connected outside the RMI docking station, e.g. by a T-junction.~~

- For each independent user defined loop:
  - The test shall be performed for each independent user defined loop separately while all other loops are connected to artificial loads in order to keep the RMI system in normal operation, e.g. one resistor of 2 Ω and one inductor of 200 µH in series if not otherwise specified by the manufacturer.
  - The transmitter of the RMI shall be connected to an artificial antenna according to clause 5.4.
- For dependent user defined loops:
  - The test shall be performed for each dependent user defined loop separately.
  - The transmitter of the RMI shall be connected to an artificial antenna according to clause 5.4, so every combination of possible single loops is measured once. If needed for function of the RMI an artificial load shall be connected to ports that enables function of the RMI, e.g. one resistor of 2 Ω and one inductor of 200 µH in series if not otherwise specified by the manufacturer.

The measuring receiver shall be connected to the current clamps of the measurement setup.

Tests shall be performed for differential mode (DM, see clause B.2.2) and common mode (CM, see clause B.2.3) separately.

B.2.2 Differential mode measurement

The differential mode current I_{DM} delivered to the artificial antenna during a transmission duty cycle shall be measured up to 30 MHz. The maximum H-field shall be calculated from the current I_{DM} using formula (B.1):

$$H/dB\mu A/m \text{ at } 10 \text{ m} = I_{DM}/dB\mu A - CF$$

$$\text{for } f < 1 \text{ MHz: } CF = 46 \quad \text{(B.1)}$$

$$\text{for } 1 \text{ MHz} < f < 30 \text{ MHz: } CF = 39$$

NOTE: The conversion factor CF has been derived by a full Maxwell solution for the standard test garden antenna with a simulation software.

B.2.3 Common mode measurement

The common mode current I_{CM} delivered to the artificial antenna during a transmission duty cycle shall be measured between 1 MHz and 30 MHz. The maximum H-field shall be calculated from the current I_{CM} using formula (B.2):

$$H/dB\mu A/m \text{ at } 10 \text{ m} = I_{CM}/dB\mu A - CF$$

B.1.1

$$CF = 39{,}5 + 5{,}4 \times \log_{10}(f[\text{MHz}]) \quad \text{(B.2)}$$

NOTE: The conversion factor CF has been derived by a full Maxwell solution for the standard test garden antenna with a simulation software.

B.3 Radiated measurements using anechoic chamber or open area test site

The measurements shall be made according to clause 6.2 of ETSI EN 300 330 [1].

For the spurious emission test > 30 MHz in an anechoic test chamber the artificial antenna according to clause 5.4 or an equivalent load shall be used as load for user defined antennas.

~~Annex C (normative):~~ Artificial antenna for conducted measurements below 30 MHz

The artificial antenna (see figure B.1) is used for equipment with an antenna connector and submitted for testing without an antenna. The radiated fields are a function of the RF energy radiated by the currents. Therefore, measurements are made to determine those currents in the artificial antenna.

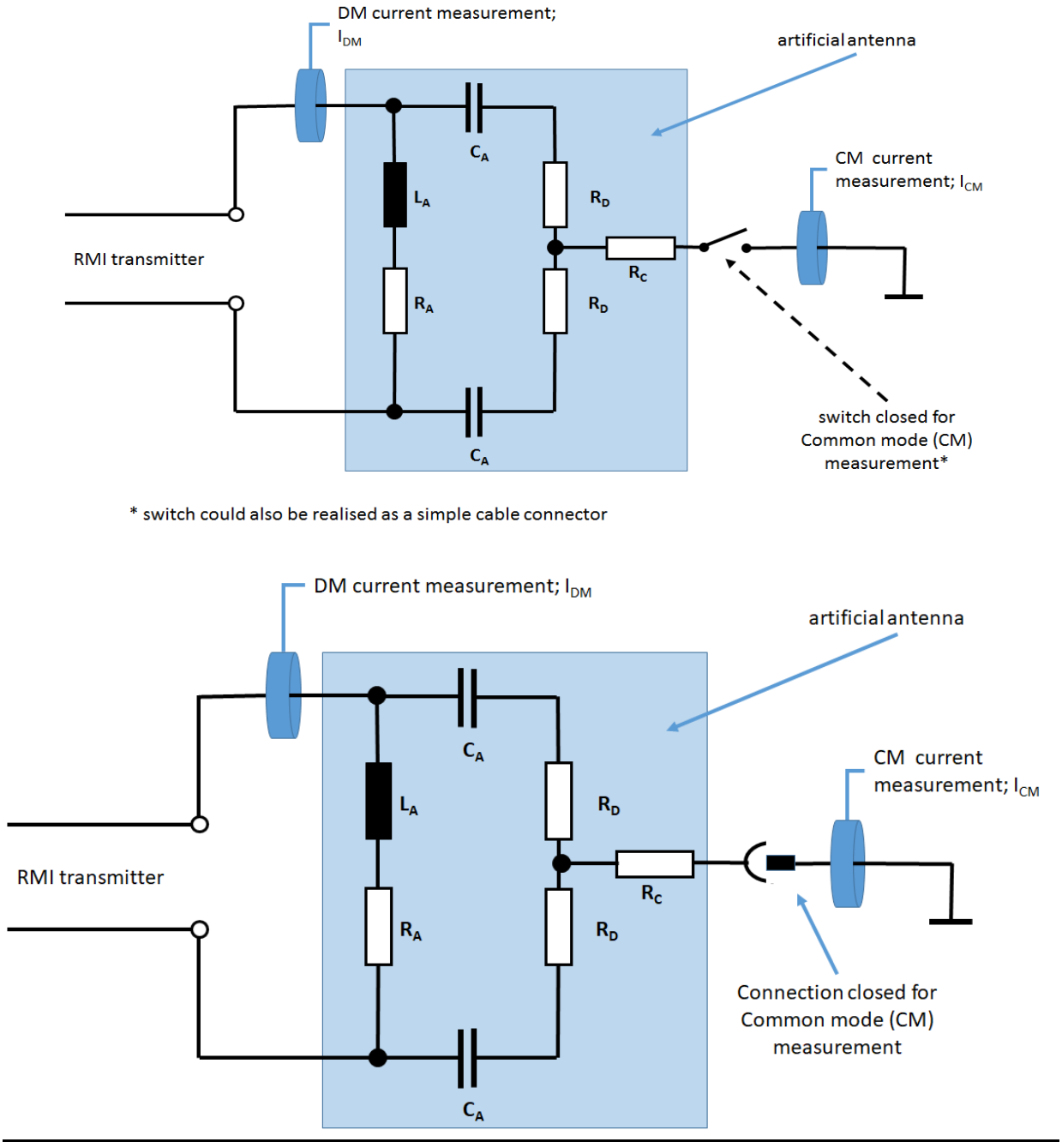


Figure ~~C~~B.1: Schematic of artificial antenna

The artificial antenna consists of one resistor (R_A) and one inductor (L_A) in series connected to the boundary wire connector of the RMI docking station. The total impedance shall be R_A = 2 Ω ~~± 1 %~~ in series with L_A = 200 µH ~~± 5 %.~~ ~~The manufacturer can declare other values for~~to simulate a garden with the ~~artificial antenna parameters but then he shall verify the parameters in the test report.~~dimension if 10 m × 20 m (see clause B.1.5).

The nominal value for capacitors C_A = 40 nF ~~± 5 %~~

The nominal value for resistors R_D = 75 Ω ~~± 5 %~~

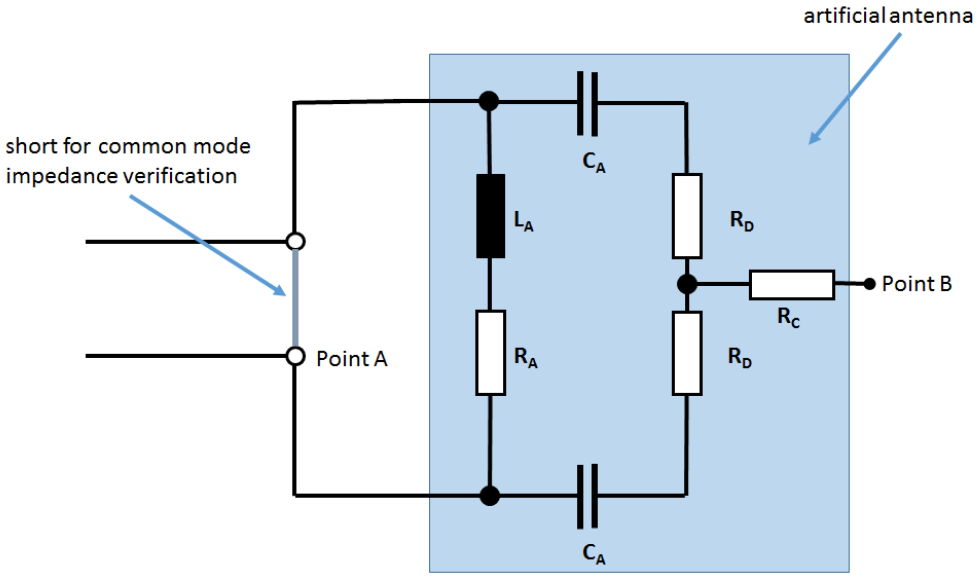
The nominal value for resistor R_C = 110 Ω ~~± 5 %~~

NOTE ~~1~~: The values for C_A, R_D and R_C have been chosen so~~,~~ that the high frequency current path does not affect the impedance of the artificial antenna in the operating frequency range. The high frequency differential mode impedance of 150 Ω has been identified as worst case real part of the standard test garden loop in the frequency range between 150 kHz and 30 MHz.

The artificial antenna shall be put in a shielded box. It shall be taken care when choosing the layout and components to avoid resonances within the measurement frequency range. Between 150 kHz to 30 MHz both the differential mode impedance and the common mode impedance shall always be within a magnitude of 150 Ω ± 40 Ω.

~~To verify the common mode impedance of the artificial antenna~~ All impedances for both ~~inputs~~modes (Differential Mode (DM) and Common Mode (CM)) shall be ~~shorten and used as one terminal (Point A)~~verified based on the tolerances given for DM in table B.1 and ~~the related second terminal is Point B, see~~ figure ~~C~~B.2~~.~~

~~NOTE~~ and for the CM in table B.2~~: For the verification of the artificial antenna common mode impedance, the antenna needs to be disconnected from the RMI transmitter~~.



~~Figure C.2: Schematic~~The validation set-up for the ~~verification of the~~ artificial antenna is specified in clause B.1.6.

The specific test setup for the validation of the differential mode impedance is provided in clause B.1.6.2, figure B.6.

The specific test setup for the validation of the common mode impedance is provided in clause B.1.6.3, figure B.7.

The inductance at 10 kHz shall be verified that it is within ±20 % of 200 µH.

For the mechanical/electrical realization of the artificial antenna it shall be taken into account that the current into the antenna can be larger than 1 A. This current into 2 ~~Ohm~~Ω would create a loss of power of ~~min~~minimum. 2 W in this resistor. This power needs to be taken into account when choosing the electronic parts for the artificial antenna.

The saturation current of the inductor shall be at least 2 A or 1,5 × peak current of the RMI docking station.

Table B.1: Differential Mode Impedance for the RMI artificial antenna

Frequency [Hz]	Differential Mode Impedance [Ohm]		
	Calculated	Tolerance	
		High	Low
500	2,12	2,65	1,59
1 000	2,43	3,04	1,82
10 000	14,20	17,75	10,65
25 000	37,84	47,30	28,38
50 000	85,60	106,99	64,20
75 000	125,32	156,65	93,99
95 000	141,67	177,09	106,26
100 000	144,08	180,10	108,06
110 000	147,55	184,44	110,66
125 000	150,48	188,10	112,86
135 000	151,52	189,40	113,64
140 000	151,87	189,84	113,90
145 000	152,13	190,16	114,10
150 000	152,32	190,40	114,24
175 000	152,66	190,83	114,50
1 000 000	150,17	187,71	112,62
10 000 000	150,00	187,50	112,50
30 000 000	150,00	187,50	112,50

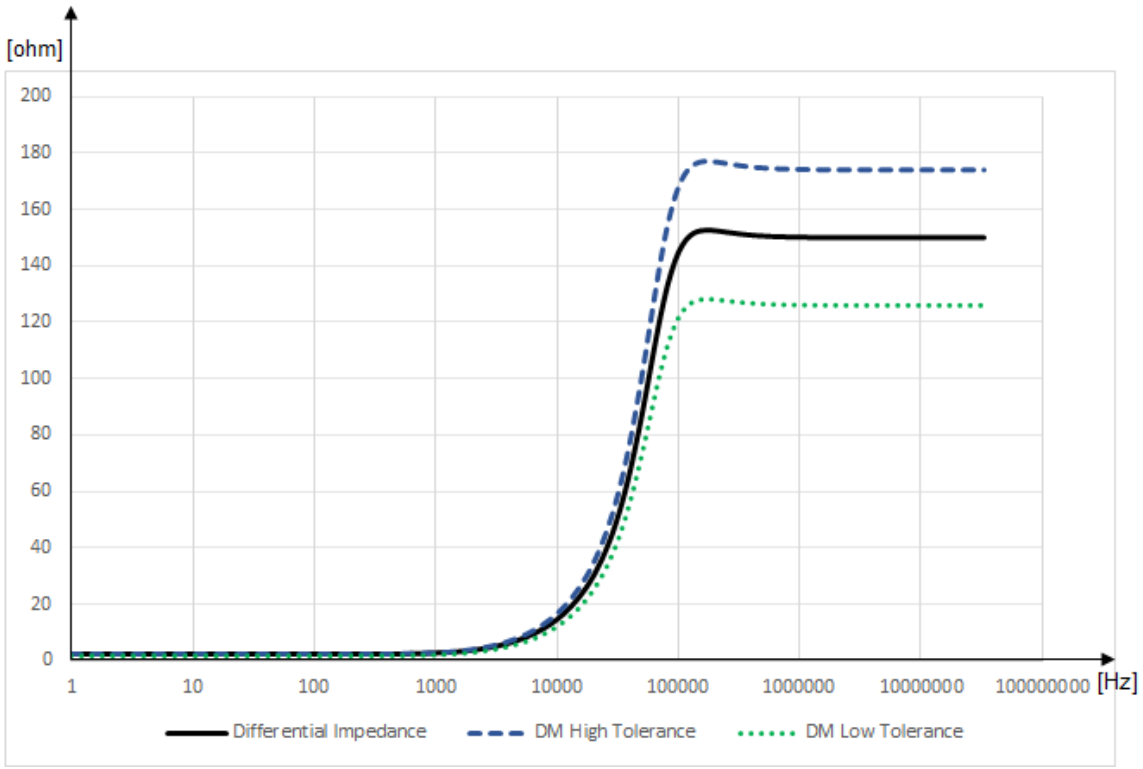


Figure B.2: Differential Mode Impedance for the RMI artificial antenna

Table B.2: Common Mode Impedance for the RMI artificial antenna

Frequency [Hz]	Common Mode Impedance [Ohm]		
	Calculated	Tolerance	
		High	Low
150 000	148,10	185,12	111,07
175 000	147,94	184,92	110,95
1 000 000	147,51	184,39	110,64
10 000 000	147,50	184,38	110,63
30 000 000	147,50	184,38	110,63

B.1.2 General setup and measurement procedure for the current measurement with artificial antenna

Mechanical setup, see figure B.3:

- The equipment shall be placed on a horizontal metal ground plane (reference ground plane), but isolated from it by a non-metallic support of 0,1 m ± 25 % in height.
- The ~~lead wire~~reference ground plane can either be separated in two directly connected parts as displayed in figure B.3 or shall ~~be led downward along~~extend at least 0,5 m beyond the boundaries of the RMI docking station ~~to the level of the non-metallic support~~ and ~~be led horizontally to the artificial antenna~~shall have minimum dimensions of 2 m by 2 m.
- The artificial antenna shall be bonded to the reference ground plane as short as possible. The reference ground plane shall extend at least 0,5 m beyond the boundaries of the RMI docking station and shall have minimum dimensions of 2 m by 2 m.
- The RMI docking station is connected as short as possible to the artificial antenna by a twisted 2 lead wire except where the current clamp is. The distance from the outer boundary of the RMI docking station to the artificial antenna shall not exceed ~~30 cm~~1 m.
- The differential mode current clamp shall be placed at one of the two lead wires a maximum of 5 cm away from the artificial antenna input port, see figure ~~C~~B.3.
- The common mode current clamp shall be placed on the ground wire above the non-metallic support, see figure ~~C~~B.3.

NOTE ~~3~~: If no switch is available in the artificial antenna, the common mode conductor to the ground plane can alternatively be removed during the differential mode measurement.

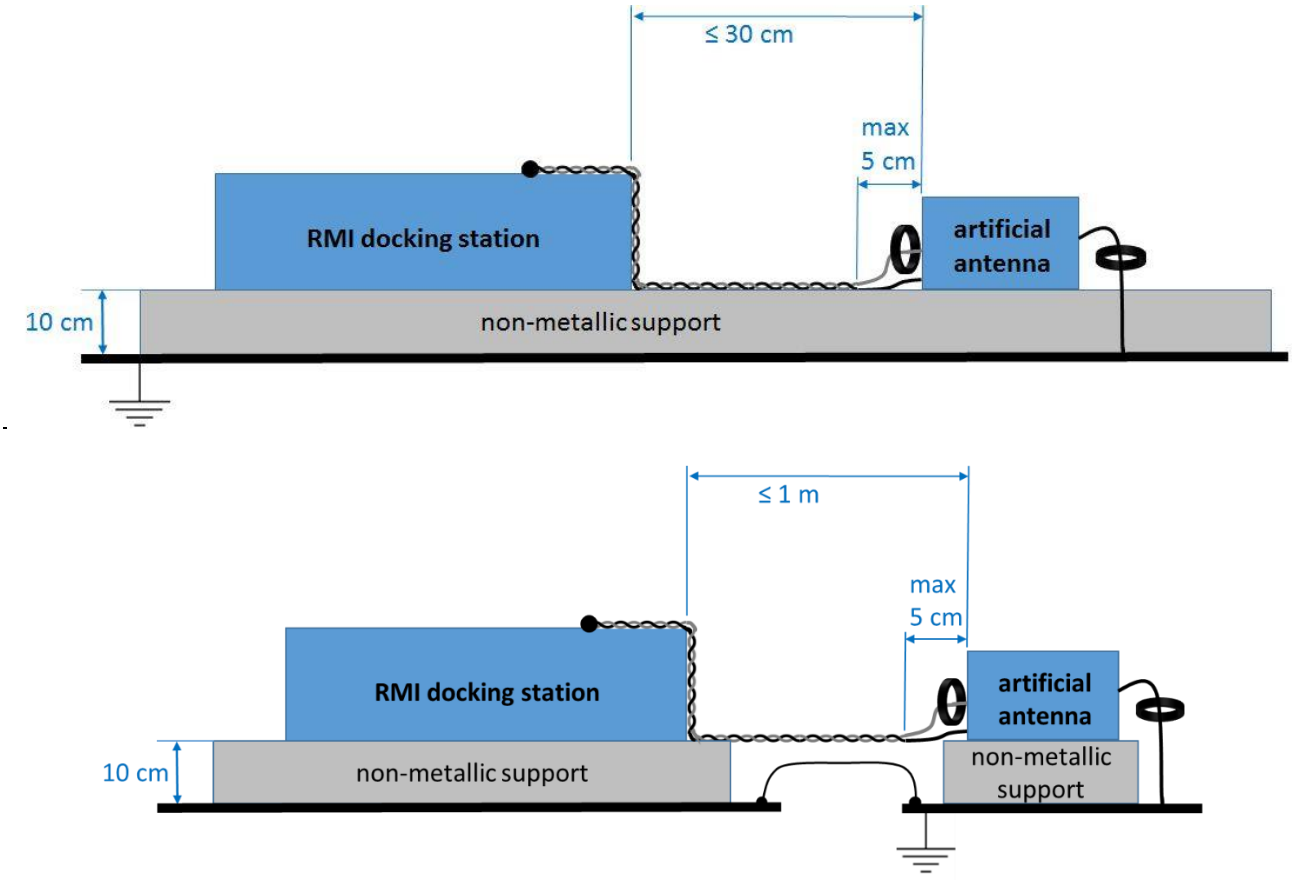


Figure ~~C~~B.3: Mechanical setup for measurement

The ground connection between the two ground planes in figure B.3 shall be made with a copper braiding presenting low impedance, not exceeding 10 Ω on all test frequencies.

The test shall be performed for each boundary and (dependent) guidance loop separately. Boundary loops are electrically connected only inside the RMI docking station while (dependent) guidance loops are electrically connected outside the RMI docking station.

- For each boundary loop:
  - The test shall be performed for each boundary loop separately while all other loops are connected to artificial loads in order to keep the RMI system in normal operation.
  - The transmitter of the RMI shall be connected to an artificial antenna according to clause B.1.1.
- For (dependent) guidance loops:
  - The test shall be performed for each (dependent) guidance loop separately.
  - The transmitter of the RMI shall be connected to an artificial antenna according to clause B.1.1 so every combination of possible single loops is measured once. If needed for function of the RMI an artificial load shall be connected to ports that enable function of the RMI, e.g. one resistor of 2 Ω and one inductor of 200 µH in series if not otherwise specified by the manufacturer.

The measuring receiver shall be connected to the current clamps of the measurement setup.

Tests shall be performed for Differential Mode (DM, see clause B.1.3) and Common Mode (CM, see clause B.1.4) separately.

B.1.3 Differential mode measurement

The differential mode current I_{DM} delivered to the artificial antenna during a transmission duty cycle shall be measured up to 30 MHz. The maximum H-field shall be calculated from the current I_{DM} using formula (B.1):

$$H/dB\mu A/m \text{ at } 10 \text{ m} = I_{DM}/dB\mu A - CF \quad \text{(B.1)}$$

for f < 1 MHz: CF = 46

for 1 MHz < f < 30 MHz: CF = 39

NOTE: The conversion factor CF has been derived by a full Maxwell solution for the standard test garden with defined reference measurement point (see clause B.1.5) with a simulation software.

B.1.4 Common mode measurement

The common mode current I_{CM} delivered to the artificial antenna during a transmission duty cycle shall be measured between 1 MHz and 30 MHz. The maximum H-field shall be calculated from the current I_{CM} using formula (B.2):

$$H/dB\mu A/m \text{ at } 10 \text{ m} = I_{CM}/dB\mu A - CF \quad \text{(B.2)}$$

$$CF = 39{,}5 + 5{,}4 \times \log_{10}(f[MHz])$$

NOTE: The conversion factor CF has been derived by a full Maxwell solution for the standard test garden with defined reference measurement point (see clause B.1.5) with a simulation software.

B.1.5 The reference test garden

A reference test garden has been used as a theoretical reference to dimension the artificial antenna with the related limits. This size represents the average of garden sizes in the EU.

The measurement point A is located at a distance of 10 m from the middle of the long side (see figure B.4). The measurement antenna shall be there at a height of 1 m.

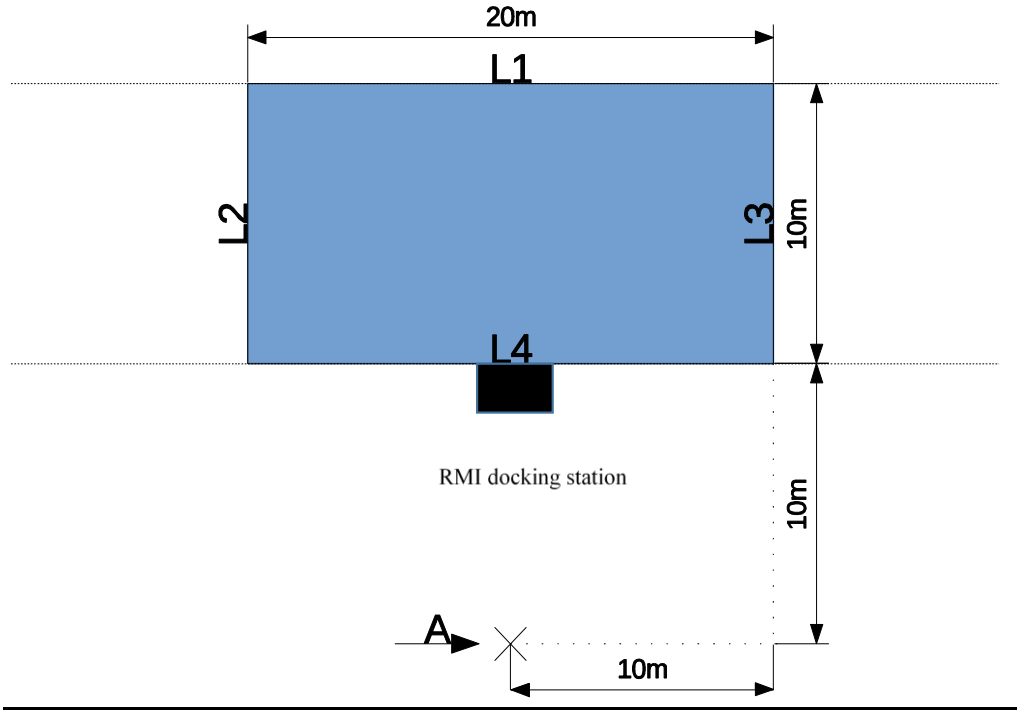


Figure B.4: The test garden

B.1.6 Test setup for verification artificial antenna

B.1.6.1 General

For the verification of the artificial antenna a calibrated impedance analyser is necessary. The analyser shall provide a symmetrical measurement solution with two cables.

To connect the artificial antenna with the impedance analyser two cables with matching connectors shall be used. For the calibration of the test setup the measurement cables and the matching connectors shall be considered in the calibration procedure, see figure B.5.

The calibration of the impedance analyser together with the measurement cables and matching connectors shall be from 100 Hz to 30 MHz.

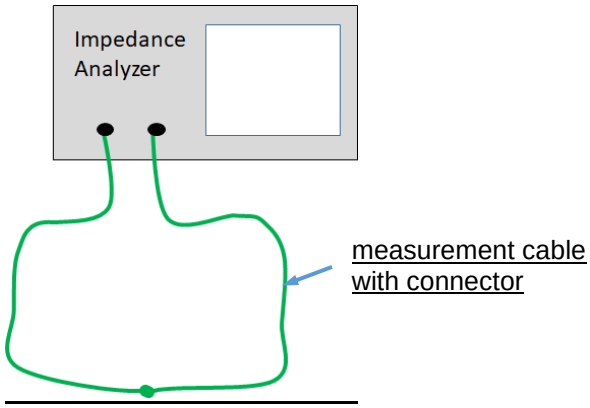


Figure B.5: Calibration of the validation set-up

For the verification of the artificial antenna, the antenna needs to be disconnected from the RMI transmitter.

The test setup for the verification of the differential mode impedance is provided in clause B.1.6.2, figure B.6.

The test setup for the verification of the common mode impedance is provided in clause B.1.6.3, figure B.7.

B.1.6.2 For Differential Mode Impedance verification

Figure B.6 shows as test setup for the verification of the differential mode impedance of the artificial antenna.

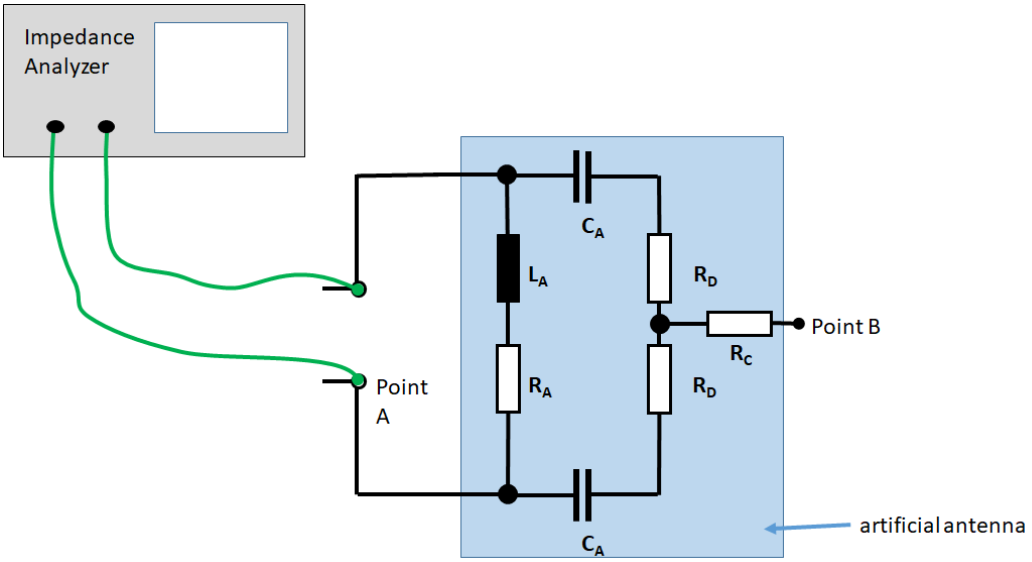


Figure B.6: Validation test setup for the differential mode impedance

B.1.6.3 For Common Mode Impedance verification

Figure B.7 shows as test setup for the verification of the common mode impedance of the artificial antenna.

To verify the common mode impedance of the artificial antenna both inputs shall be shortened and used as one terminal (Point A) and the related second terminal is Point B, see figure B.7.

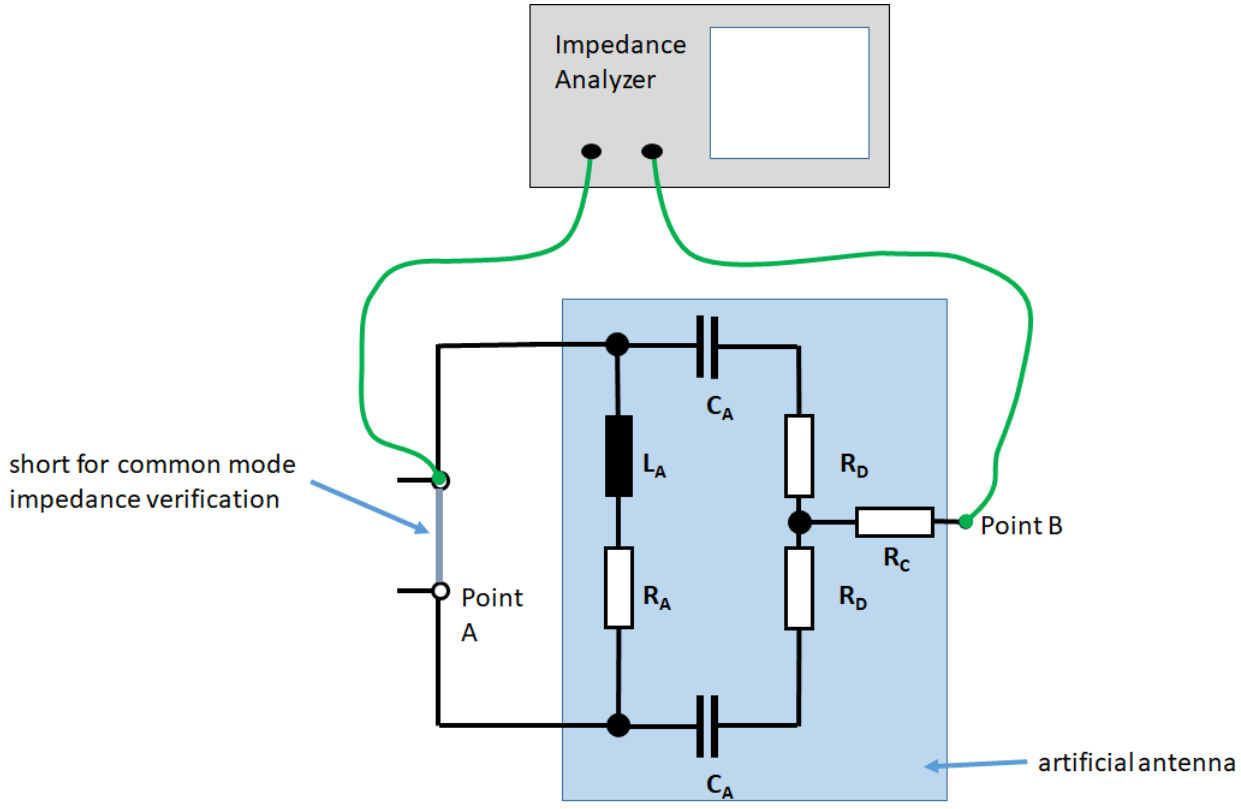


Figure B.7: Verification test setup for the common mode impedance

B.2 Radiated measurements using anechoic chamber or open area test site

B.2.1 General

This clause provides radiated measurement procedures for integral antennas, which are integral parts of the RMI docking station (transmitter antennas) and of the robotic mower (receiving antenna).

The following guidance should be taken from ETSI EN 300 330 [1]:

- For the test site according to clause C.1.1 (anechoic chamber).
- A test antenna according to clauses C.1.4, C.1.5 and C.1.6.
- Additional guidance according to clauses C.2, C.3 and C.4 as appropriate.

The equipment under test and test antenna shall be arranged according to the guidance given for the chosen test site (see ETSI EN 300 330 [1], clause C.1).

B.2.2 Radiated emission measurements < 30 MHz

The equipment under test shall be measured at a distance of 3 m or 10 m. The limit conversion factor for 3 m to 10 m measurement distance is provided in ETSI EN 300 330 [1], clause H.2.

The test antenna shall be a calibrated shielded magnetic field antenna. Measurements shall be done in all three dimensions of the test antenna. The output of the test antenna shall be connected to a measuring receiver.

A pre-scan shall be done first using a peak detector to measure the emissions around the EUT. The points and frequencies shall be noted where the limit is exceeded.

The final measurements shall then be done at the noted points and frequencies from the pre-scan.

B.2.3 Radiated emission measurements 30 MHz to 1 000 MHz

The equipment under test shall be measured at a distance between 3 m to 10 m.

The measurements shall be done with vertical and horizontal polarization of the test antenna. The output of the test antenna shall be connected to a measuring receiver.

A pre-scan shall be done first using a peak detector to measure the emissions around the EUT. The points and frequencies shall be noted where the limit is exceeded.

The final measurements shall then be done at the noted points and frequencies from the pre-scan.

For the TX spurious emission test > 30 MHz the artificial antenna according to clause B.1.1 shall be used as load.

Annex C (informative): Justification for missing RX-requirements from ETSI EG 203 336

C.1 Justification for other RX-requirements

A RMI is fabricated by one manufacturer. There is no option to use a mower at another boundary installation from another manufacturer. Based on the general functionality (TX and RX) of an RMI covered by the present document it is necessary to test the RX-requirements in combination with the specific TX-hardware (loops). The TX/RX combinations and the related signals between TX and RX are limited by the RMI itself. Based on this system peculiarities only interferences from other systems/EUT could have impact to the RX.

In addition following documents were considered for the justification of the RX parameters: RX parameters in ETSI EG 203 336 [i.5] and ETSI TS 103 567 [i.14] on Signal interferer handling.

Based on the technical nature of an RMI system and the assessment of the RX parameters the signal interferer handling concept according to ETSI TS 103 567 [i.14] is used for the RX-tests. A RX-requirement mapping is provided in table C.1.

Table C.1: RX-requirement mapping

Interferer Handling Requirements	Receiver Baseline Sensitivity	Receiver Baseline Resilience		
		In-band Interferer	Interferer in the OOB	Interferer in the Remote range
Based on the RMI nature the IHR has the same influence to RX than RX-requirement given in ETSI EG 203 336 [i.5]	Sensitivity	Co-channel rejection Indirectly cover: Intermodulation Reciprocal Mixing	Adjacent channel selectivity	Blocking Indirectly cover: Spurious response rejection
Indirectly covered	Dynamic range	Dynamic range passing the boundary wire, clause 6.3.3.3	Dynamic range passing the boundary wire, clause 6.3.3.3	Dynamic range passing the boundary wire, clause 6.3.3.3
	Desensitization	Desensitization in the middle of the test set-up, clause 6.3.3.2		

A detailed justification for RMI systems is provided in table C.2.

Table C.2: RX-requirement justification

Requirement from ETSI EG 203 336 [i.5]	Applicable/tested	Comment
Sensitivity	Yes	See clause 4.4.3.
Blocking	Yes, interferer on the Remote-band of the RX, see clause 4.4.3	See clause 4.4.4.3 with the requirements in table 4b; column named "remote band signal" according to ETSI EN 303 454 [i.10].
Co-channel rejection	Yes, interferer in the in-band of the RX, see clause 4.4.4	See clause 4.4.3 with the requirements in table 4; column named "in-band signal". Based on that there are lot of different TX signals (and related RX-concepts) used for RMI systems it is not possible to specify a generic test signal which is representative for all RMI systems. But for RMI and the used technologies it is sufficient to check the effect inside the receiver if a CW signal is used with the same energy than another RMI and/or other inductive system nearby.

Requirement from ETSI EG 203 336 [i.5]	Applicable/tested	Comment
Adjacent channel selectivity	Yes, interferer in the OOB of the RX, see clause 4.4.4	Is covered in the blocking RX test (see clause 4.4.4) if the interfering signals will be @ fc-/+OBW. In the Blocking test it is named as OOB test. Based on that there are lot of different TX signals (and related RX-concepts) used for RMI systems it is not possible to specify a generic test signal which is representative for all RMI systems. But for RMI and the used technologies it is sufficient to check the effect inside the receiver if a CW signal is used with the same energy than another RMI and/or other inductive system nearby.
Intermodulation	Indirectly covered by in-band test, see clause 4.4.4.3, table 4b	RMI are single carrier transmitters and receivers. Channel separation is done using different period times (not same as frequency) or CDMA. Therefore no intermodulation can happen. But it can be noted that if an interference, based on the current radio services and applications in the range below 30 MHz, an Intermodulation effect in the OBW will take place it is not possible that such "intermodulation" result will create more energy than a direct interference by a "direct" signal from e.g. another RMI system or other SRD. Therefore an additional intermodulation requirement is not applicable, the effect is covered by the in-band test, see table 4b, clause 4.4.4.3.
Spurious response rejection	Indirectly covered by Remote-band test, see clause 4.4.4.3, table 4b	According to ETSI TS 103 567 [i.14]: The spurious response rejection is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation into the presence of an unwanted signal at any frequency at which a response is obtained. The frequencies of the adjacent signals (channels) are excluded. Based on the definition of this RX-requirement, the effect inside the receiver is covered by the "interference test" at frequencies in the Remote-Band (see clause 4.4.4.3, table 4b) and the case that the test will be performed in the scenario that the receiver with the largest distance to the boundary, see clause 6.3.3.2.
Dynamic range	Indirectly	This requirement is indirectly covered by the two tests: 1) sensitivity in clause 6.3.2 (lowest signal present at the RX); 2) in clause 6.3.3.3, mower passing the boundary wire. At this situation the highest receiving signal will be present at the RX.
Desensitization (In-band signals)	Indirectly covered by Sensitivity test (see clause 4.4.3) and Interfering test in the in-band (see clause 4.4.4)	This receiver effect is tested based on the Sensitivity (clause 4.4.3) and see Co-channel rejection requirement, similar to in-band interferer test (clause 4.4.4). Both tests (Sensitivity and Co-channel) require that the receiver inside the mower is working at "min" sensitivity level (middle of the test garden).
Reciprocal Mixing	Indirectly covered by in-band test, see clause 4.4.4.3, table 4b	Reciprocal mixing is an phenomena that depends on the mixer and LO. Robotics mower work on baseband frequency without any mixers, so Reciprocal Mixing could never happen inside RMI RX. In addition it can be noted that if a reciprocal mixing effect will happen, based on the effect of an noise increase in the OBW will take place, it is not possible that such "noise increase" result will create more energy than a direct interference by a "direct" signal from e.g. another RMI system or other SRD. Therefore an additional Reciprocal Mixing requirement is not applicable, the effect is covered by the in-band test, see table 4b, clause 4.4.4.3.
RX spurious emission	RMI2 systems	Only mowers of RMI2 systems do continue to receive without any emission from the boundary signal. In this receive only mode (comfort function) the mower (receiver) has the function to detect the "re-covering" of the boundary signal. For RMI1 systems the RX-receiver emissions cannot be assessed because in parallel the TX emission from the boundary signal is present. The source of the spurious emissions cannot be separated for RMI1 systems.

Annex D (informative): TX spurious emission limit assessment below 9 kHz

TX spurious emissions below 9 kHz were discussed and evaluated during the revision work of ETSI EN 303 447 V1.1.1 to V1.2.1.

A proposal for spurious emission limit for < 9 kHz has been prepared based on the current knowledge of:

- the robotic mowers systems (ETSI EN 303 447 V1.1.1) and their known emissions; and
- the emission of the metal sensors below 9 kHz (ETSI EN 303 454 [i.10]).

The proposal/development of the proposal took in addition into account:

- Spurious requirement above 9 kHz.
- Possible sensitivity of measurement equipment.
- Human exposure limit.
- Discussions in ECC (WG FM and PT SRD-MG) on possible generic SRD regulation < 9 kHz.

The proposal is based on the extrapolation of the existing spurious limits for SRDs below 10 MHz to the band below 9 kHz (27 dBµA/m @ 10 m at 9 kHz descending 3 dB/oct). The proposal is summarized in tables D.1 and D.2 and it considers a reference bandwidth of 200 Hz.

ETSI TC ERM informed ECC with a Liaision Statement in June 2018 about this assessment/proposal. ECC answered in a positive way and the ETSI proposal will be considered during a future revision of CEPT/ERC/REC 74-01 [i.4].

Table D.1: Proposal TX spurious emissions for operating mode

Frequency	Existing TX spurious limits in dBµA/m @ 10 m	New proposal starting at 100 Hz TX spurious limits in dBµA/m @ 10 m
100 Hz		46,6
500 Hz		39,6
1 kHz		36,6
5 kHz		29,6
9 kHz	27	27,0
10 kHz	26,5	
19 kHz	23,8	
50 kHz	19,5	
10 000 kHz	-3,5	

Table D.2: Possible change in CEPT/ERC/REC 74-01 [i.4], Annex 2 for inductive SRDs

Magnetic field limits of CEPT/ERC/REC 74-01 at 10 m distance		
State	**Frequency 100 Hz ≤ f < 10 MHz**	**Frequency 10 MHz ≤ f < 30 MHz**
Operating	46,5 dBµA/m at 100 Hz descending 3 dB/oct	-3,5 dBµA/m
Standby	25 dBµA/m at 100 Hz descending 3 dB/oct	-3,5 dBµA/m

Annex E (informative): Change history

Version	Information about changes
1.1.1	First version of the present document to cover the essential requirements for RMI systems in the frequency range below 148,5 kHz on article 3.2 of Directive 2014/53/EU [i.3].
1.2.1	Focus to solve points raised in EC assessment; Ares(2017)5304326 - ETSI EN 303 447 (V1.1.1) Main changes: • Clarification TX emissions < 9 kHz • Clarification start frequency of 100 Hz • Spurious emission requirement < 9 kHz • Clarification wanted performance requirement • Antenna dimension restriction • Conformance measurement procedures, clarification artificial antenna • Clarification RX-requirements and related test • New RX-test for sensitivity, and receiver spurious emissions for receiver only mode • Alignment of reference measurement BW for spurious emissions with CEPT/ERC/REC 74-01 • Impedance verification procedure for the artificial antenna
1.3.1	Main changes: • Add new category of devices with a receive only mode • New justification test for the artificial antenna

History

Document history		
~~V1.1.0~~	~~December 2016~~	~~EN Approval Procedure AP 20170315: 2016-12-15 to 2017-03-15~~
~~V1.1.1~~	~~June 2017~~	~~Vote V 20170812: 2017-06-13 to 2017-08-14~~
V1.1.1	September 2017	Publication
V1.2.0	July 2020	EN Approval Procedure AP 20201004: 2020-07-06 to 2020-10-05
V1.3.0	September 2021	EN Approval Procedure AP 20211223: 2021-09-24 to 2021-12-23
V1.3.1	April 2022	Vote V 20220626: 2022-04-27 to 2022-06-27
V1.3.1	July 2022	Publication