Draft ETSI EN 303 447 V1.1.0 (2016-12)

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

Reference
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Contents

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Foreword

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

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

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

Modal verbs terminology

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

"**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.

- Integral antenna: integral inductive antenna integrated inside the RMI docking station.

The present document is structured as follows:

Clauses 1 through 3 provide a general description on the types of equipment covered by the present document and the definitions, symbols and abbreviations used.

Clause 4 provides the technical requirements specifications, limits and conformance relative to transmitter and receiver.

Clause 5 specifies the conditions 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.

1 Scope

The present document specifies technical characteristics and methods of measurements for Robotic Mowers with inductive loop systems (RMI) below 148,5 kHz.

The present document covers all Robotic Mowers that use guidance Inductive loop wire 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.
- Integral antenna: integral inductive antenna integrated inside the RMI docking station.

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

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 Hz to 148,5 kHz
Receive	0 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].	

The present document covers the essential requirements of article 3.2 of Directive 2014/53/EU [i.3] under the conditions identified in annex A.

2 References

2.1 Normative references

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

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) (11-2016): "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 Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

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

[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".

[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".

[i.10] ETSI EN 303 454: "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 the 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).

[i.12] ITU Radio Regulations.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

antenna: all integral, user or factory defined antennas which are specified by manufacturer to run the functional mode of the RMI

NOTE: See details in clause 4.2.2.

boundary wire: inductive wire loop which will be defined/prepared by the user

NOTE: 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 (see figure 3).

guidance wire: electrical cable which is defined by manufacturer

NOTE: The wire is dependent from the shape of the garden including perimeter delimiter and all electrical conductors external to the machine through which current is fed to generate a magnetic field intended for guidance and/or communication with the machine.

integral antenna or factory defined loop: single or multiple turn coil preinstalled or specified by the manufacturer for the purpose of generating magnetic fields such as for guidance and or communication with the machine

NOTE: The integral inductive antenna is integrated inside the RMI docking station.

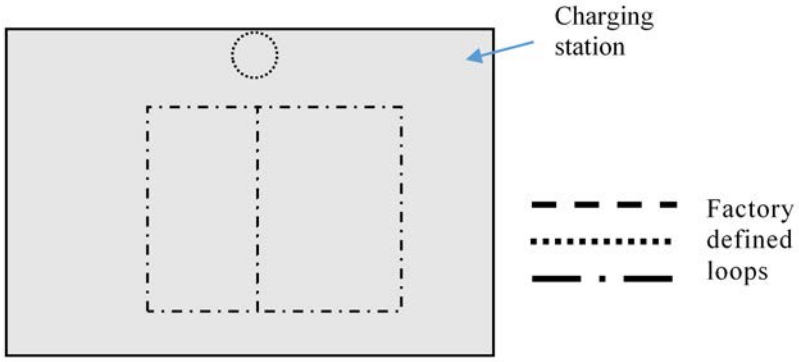

Figure 1: RMI docking station with examples of integral antenna loops

operating frequency range: 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

power envelope: power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions

NOTE: As RR 1.157 [i.12].

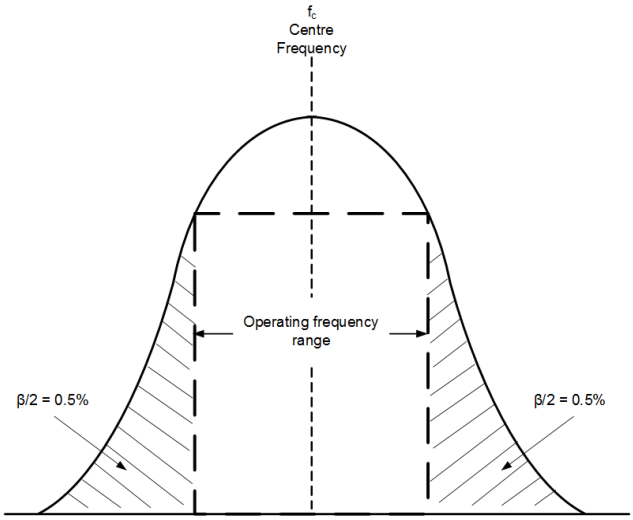

Figure 2: Operating Frequency Range

99 % OBW function: measurement function of a spectrum analyser

RMI docking station: charging stations for the robotic mower and the signal generator for the signals on the integral antenna and boundary wire

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: receiving part inside the RMI

Robotic Mower with Inductive loop system (RMI): system that include robot mower, boundary wire, docking station with integral antenna, guiding wires, power supply (solar panels, windmills,230 V 50Hz (/110V60Hz) mains connected, batteries)

user defined 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 machine and/or determine the working area

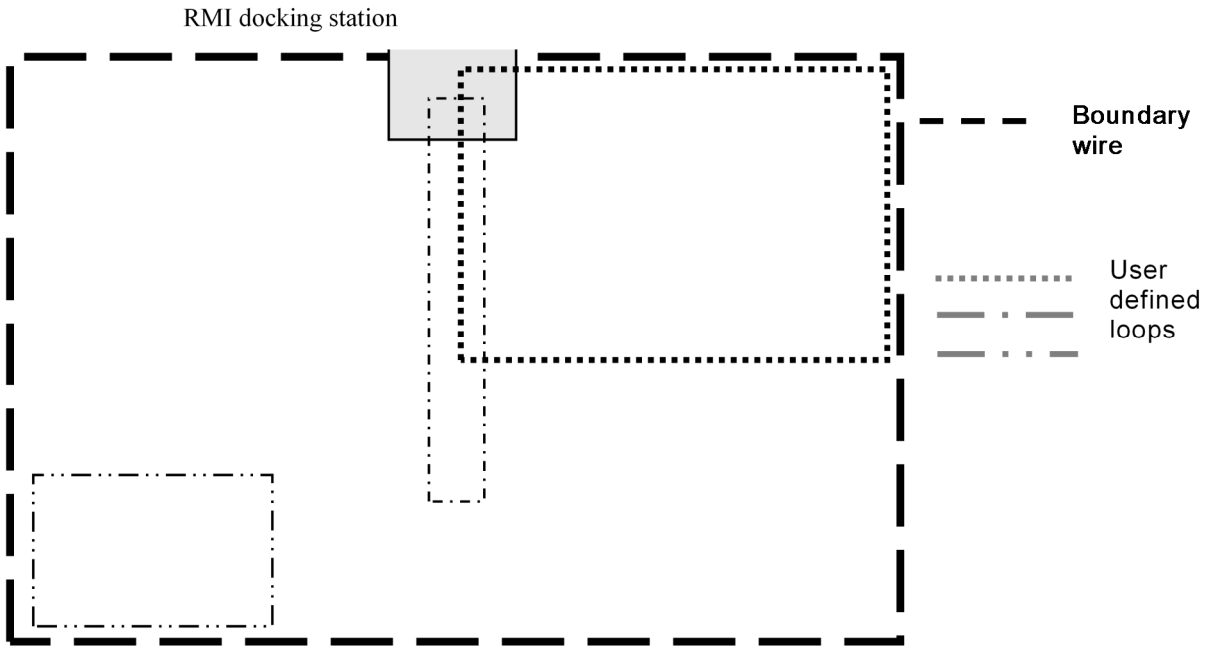

Figure 3: Example of an RMI system including an RMI docking station (grey box) and possible boundary wires (dotted and dashed lines)

3.2 Symbols

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

f_c	centre frequency of the OFR
f_H	highest frequency of the OFR
f_L	lowest frequency of the OFR
I_{CM}	Common mode current
I_{DM}	Differential mode current

3.3 Abbreviations

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

CM	Common Mode
DM	Differential Mode
EGMF	European Garden Machinery industry Federation
OBW	Operating BandWidth
OFR	Operating Frequency Range
RMI	Robotic Mower with Inductive loop system
RR	Radio Regulations

4 Technical requirements specifications

4.1 Environmental conditions

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer. The equipment shall comply with all the technical requirements of the present document which are identified as applicable in annex A at all times when operating within the boundary limits of the declared operational environmental profile. The conditions shall be used as descripted in clause 5.3.

4.2 General

4.2.1 Wanted performance criteria

A mower inside an RMI will only work if:

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

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

4.2.2 RMI functional mode

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 Hz to 148,5 Hz are given.

Typical functional mode being part of an RMI are explained in the following clauses.

An RMI could have different user defined loops and factory defined loops, see figures 1 and 3. The requirements test 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 test set-up of the different modes shall be performed as described in clause 6.1 and annex B.

4.2.2.2 Operational Mode

Operational mode is the working mode of the RMI. During this mode the mowers is cutting the grass inside the working area and shall not be possible for the machine to cross the boundary by a distance of one full length of the machine, see CENELEC EN 50636-2-107:2015 [i.8], clause 22.104.2.

The generated signal will be transmitted on the declared user defined loops and integral antennas. 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.

4.2.2.3 Safe Mode

Safe mode: after a loss of signal, the RMI shall not travel more than 1m and the cutting means shall stop within 5 s, see CENELEC EN 50636-2-107:2015 [i.8], clause 22.104.2. It is not possible to start the machine 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 system mode (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 harmonize 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.

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) as occupied by the power envelope.

An RMI could have more than one operating frequency range, see clause 4.2.2.

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: $f_L \geq 0$ Hz.

For the later unwanted emission measurement procedure in clause 4.3.3.3 the OFR shall be calculated as: $f_H - f_L$ and the centre frequency as: $f_c = \frac{f_H + f_L}{2}$.

NOTE: If the result for f_L is lower than 300 Hz the value of f_L = 300Hz is appropriate in the calculation of f_C and OFR. This limit of f_L = 300 Hz is based on available test equipment in order to achieve reliable test results (measurement uncertainty).

4.3.1.4 Conformance

The conformance test suite for operational frequency range shall be as defined in clause 6.1 (table 7).

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.

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 kHz are provided in table 2 and for the band 9 kHz to 148,5 kHz in table 3.

The H-field limits in table 3 are EU wide harmonised for the SRD category "inductive devices" according to EC Decision 2013/752/EU [i.2]. Further information is available in CEPT/ERC/REC 70-03 [i.1].

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 kHz

Frequency range (kHz)	H-field strength limit (H_f) dBµA/m at 10 m
0,3 ≤ f < 0,9	82
0,9 ≤ f < 9	82 descending 10 dB/dec

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

4.3.2.4 Conformance

The conformance test suite for transmitter H-field requirements shall be as defined in clause 6.1 (table 7).

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 unwanted emissions

4.3.3.1 Applicability

This requirement applies to all RMI.

4.3.3.2 Description

The lower and upper edge (f_s) of the measured frequency range for unwanted emissions depends on the operating frequency range of the system (f_H, f_L, f_C, OFR, see clause 4.3.1):

$$f_S = f_C \pm 2{,}5 \times OFR.$$

1) For RMI systems with $f_H \leq 9$ kHz the unwanted emission test shall be applied from:

   - $f \geq 27$kHz.

2) For RMI systems with $f_H > 9$ kHz the test shall be applied from:

   - $f \geq f_S$,
   - or $f \geq 148,5$ kHz,

     whichever is the smallest.

NOTE: This bullet above ensures that the spurious limits of CEPT/ERC/REC 74-01 [i.4] apply above 148,5 kHz.

3) For RMI systems with $f_L > 9$ kHz the test shall be applied between:

   - 9 kHz $\leq f < f_S$.

4.3.3.3 Limits

The unwanted emissions shall not exceed the limits given in table 4 and table 5.

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

State	Frequency 9 kHz ≤ f < 10 MHz	Frequency 10 MHz ≤ f < 30 MHz
Operating	27 dBµA/m at 9 kHz descending 3 dB/oct	-3,5 dBµA/m
Standby	5,5 dBµA/m at 9 kHz descending 3 dB/oct	-25 dBµA/m

For the unwanted emission test >30 MHz the artificial antenna shall be used, see clause 5.4.

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

Table 5: unwanted emission limits of 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

In the ranges between f_S to f_L and f_H to f_s the limits of table 2 and table 3 apply.

4.3.3.4 Conformance

The conformance test suite for transmitter unwanted emissions shall be as defined in clause 6.1 (table 7).

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 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.

4.4.2 Receiver unwanted emissions

The mower is the only part of the RMI which is receiving.

But the mowers cannot be used without any boundary signal, see listed harmonised standard CELENEC EN 50636-2-107 [i.8] under the European Machinery Directive 2006/42/EC [i.11].

During normal operation the 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 mower. Therefore, this test is not applicable.

4.4.3 Receiver blocking

4.4.3.1 Applicability

This requirement applies to the RMI.

4.4.3.2 Description

Blocking 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).

Therefore if an interferer is present, the mower shall react as intended (declared by the manufacturer) like:

- mower will work as intended (no influence from the interferer);
- mower will go into the "safe mode";
- will run back to the docking station;
- inform the user.

The wanted performance criteria (clause 4.2.1) will be used for the receiver blocking tests.

4.4.3.3 Limits

The receiver blocking limits in table 6 shall be fulfilled.

Table 6: receiver blocking limits

	In-band signal	**OOB signal**	**Remote-band signal**
Frequency	$f = f_c$	$f = f_c \pm F$	$f = f_c \pm 10 \times F$
receiver blocking limits	98 dBµA/m - 20log10 (f/10 kHz)	98 dBµA/m - 20log10 (f/ 10kHz)	98 dBµA/m - 20log10 (f/10 kHz)
F = OFR			
NOTE: Background for limits in table 6: The industry standard for RMI (Source: EGMF [i.7]) propose that mower installations should never be closer than 1 meter 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 (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 mower signal centre frequency of 10 kHz.			

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

4.4.3.4 Conformance

The conformance test suite for operational frequency range shall be as defined in clause 6.1 (table 7).

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.

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

5.2 General conditions for testing

5.2.1 Product information

The provisions 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 test conditions

The provisions of ETSI EN 300 330 [1], clause 5.3 shall apply.

5.4 Artificial antenna

Artificial antenna(s) shall simulate the actual antenna configuration specified by the manufacturer. Tests to be carried out using an artificial antenna shall be selected according to table 7.

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

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

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 7.

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 unwanted H-field up to 30 MHz.

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

5.6 Measuring receiver

The provisions of ETSI EN 300 330 [1], clause 5.12 shall apply.

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.

6 Conformance methods of measurement for transmitters and receivers

6.1 General

For the conformance test of the essential requirements in clause 4, table 7 gives an overview of the relevant conformance tests and test conditions for the essential requirements.

Table 7: Overview of Conformance tests

Essential requirements	Conformance tests	Test setup and procedure		Test conditions	Measurement uncertainty
		User defined antennas	Integral antennas		
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, clause 4.3.3	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 Blocking, clause 4.4.3	6.3.2	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 from annex B. For user defined loops (guided and boundary wires) the test setup and procedure from clause B.1 (test garden) or clause B.2 (artificial antenna) and for integral antennas the test setup and procedure from clause B.1 (test garden) or from clause B.3 (anechoic chamber) 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 with the following settings:

- Start frequency: 200 Hz.
- Stop frequency: higher than the upper edge of the permitted frequency range/requested by the essential requirements in clause 4.
- Resolution Bandwidth: 200 Hz.
- Video Bandwidth: ≥ 300 Hz.
- Detector mode: RMS.
- Display mode: maxhold over >10 s.
- Sweep time, Averaging time: ≥ 1 ms per sweep point.

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). Alternatively the frequency above the centre frequency fc shall be recorded where the level is 10 dB lower as the maximum.
- f_L as the frequency of the upper marker resulting from the "OBW"-function of a spectrum analyser, using 99 % of the power (see figure 2). Alternatively the frequency below the centre frequency shall be recorded where the level is 10 dB lower as the maximum.
- f_c is the centre frequency. $f_c = \frac{f_H + f_L}{2}$.
- OFR= f_H - f_L.

The results are to be compared with the limits in clause 4.3.1.3.

6.2.2 H-field

The measurement shall be made with one of the test setups from annex B. For user defined loops (guided 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 integral antennas the test setup and procedure from clause B.1 (test garden) or from clause B.3 (radiated tests within anechoic chamber) 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 with the following settings:

- Start frequency: 200 Hz.
- Stop frequency: higher than f_H from clause 4.2.1.
- Resolution Bandwidth: according to clause 5.6.

- Video Bandwidth: ≥ RBW.
- Detector mode: according to clause 5.6.
- Display mode: maxhold over >10 s.
- Sweep time, Averaging time: ≥ 1 ms per sweep point.

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

6.2.3 Transmitter unwanted emissions

The measurement shall be made with one of the test setups and procedures from annex B. For user defined loops (guided 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 integral antennas the test setup and procedure from clause B.1 (test garden) or from clause B.3 (radiated tests within anechoic chamber) 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 with the following settings:

- Start frequency: 200 Hz.
- Stop frequency: higher than f_H from clause 4.2.1.
- Resolution Bandwidth: according to clause 5.6.
- Video Bandwidth: ≥ RBW.
- Detector mode: according to clause 5.6.
- Display mode: maxhold over >10 s.
- Sweep time, Averaging time: ≥ 1 ms per sweep point.

The maximum unwanted emission 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 clause 4.4.1.

6.3.2 Receiver blocking

This measurement shall be performed under normal conditions.

Step 1: The RMI system shall be tested with the test garden (see clause B.1) and shall be used with normal operational mode. A signal generator B (unmodulated) with a test loop shall be used to produce a field strength at the mower. The test loop shall be sufficiently large so that the magnetic field can be calculated according to H = I/(2 × pi × r). Initially signal generator B shall be switched off.

Step 2: The RMI system shall be configured so that the wanted performance criterion is met: the wanted criterion is considered to be met as long as the receiver always works as intended.

Calculate the limit of the interferer current according to table 6.

Step 3: Signal generator B is then switched on at approximately ±1 kHz from f_C. Signal generator B should then be adjusted in carrier current from zero up to the limit given in table 6.

Step 4: If the mower goes into safe mode then the limit when the mower goes into safe mode shall be noted.

Step 5: With the interferer limit according to table 6, turn off the RMI transmitter, so there is only the signal from the interferer.

Step 6: The measurements step 3 to 6 shall be repeated at approximately the frequency for OOB and remote-signal as requested in table 6.

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

If the 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.

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**	**Reference: Clause No**	**U/C**	**Condition**
1	Operating frequency range	4.3.1	U	
2	Transmitter H-field requirements	4.3.2	U	
3	Transmitter unwanted emissions	4.3.3	U	
4	Receiver blocking	4.4.3	U	

Key to columns:

Requirement:

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

Description A textual reference to the requirement.

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

Requirement Conditionality:

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

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

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

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

Annex B (normative): Test sites and procedures

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

Tests to be carried out using a test garden shall be selected according to table 7. The test shall be performed for each user defined loop separately.

The test setup or test garden specified in the standard is a 20 x 10 sq m garden with the transmitter antenna (user defined loop). The transmitter antenna is bounding the edges of the garden.

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

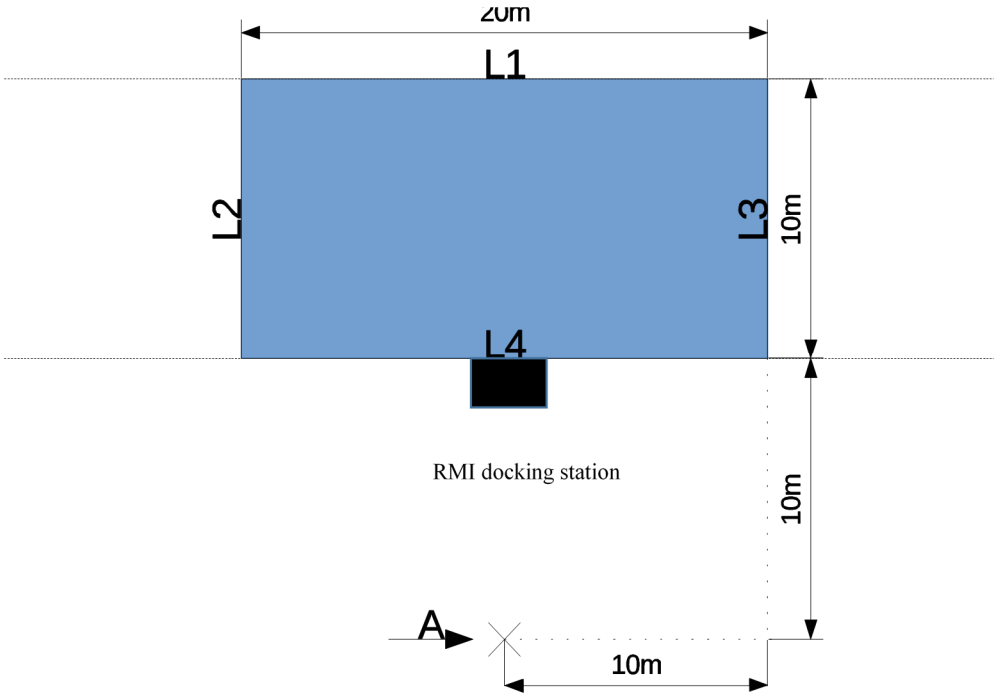

Figure B.1: The test garden

The environment for the test garden can be seen as open field test site. More requirements for the open test site are described in ETSI EN 300 330 [1], clause D.1.3.

The maximum transmissions at 10 m distance are to be recorded are the maximum transmissions from 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

Tests to be carried out using artificial antenna(s) shall be selected according to table 7.

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

- 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 loop 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) and common mode (CM) separately.

B.2.2 Differential mode measurement

The differential mode current I_{DM} delivered to this 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 the following formula:

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

$$\text{for } f < 1\ MHz: CF = 46$$

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

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 this 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 the following formula:

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

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

NOTE: The conversion factor CF has been derived by a full Maxwell solution for the standard test garden 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 6.2.4 of ETSI EN 300 330 [1].

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

The artificial antenna 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 spurious currents. Therefore, measurements are made to determine those currents in the artificial antenna.

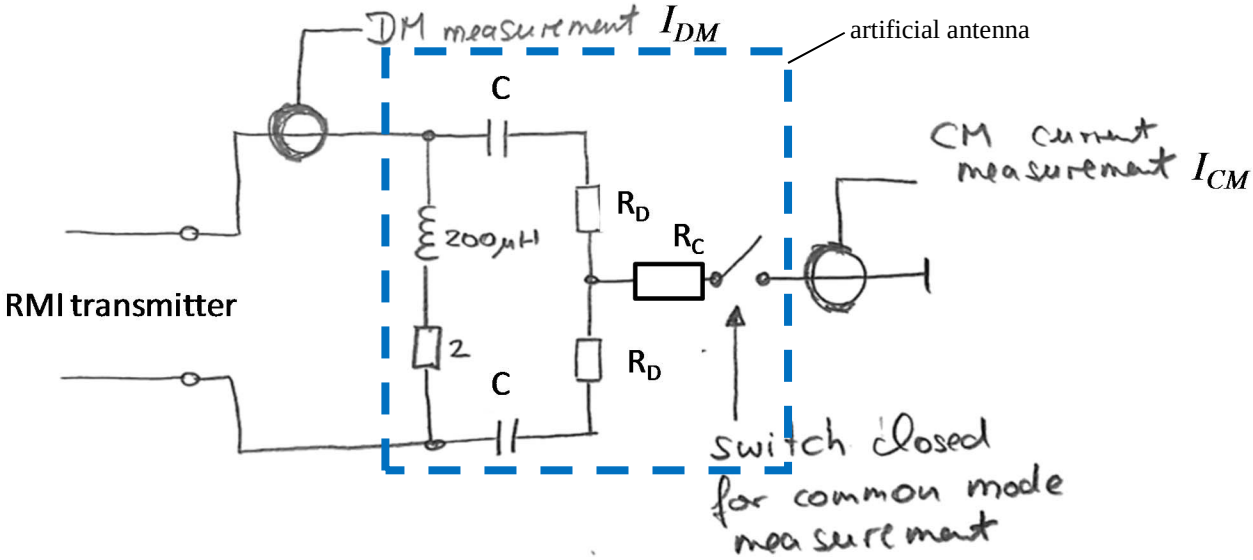

Figure C.1: Schematic of artificial antenna

The artificial antenna consists of one resistor (R) and one inductor (L) in series connected to the boundary wire connector of the RMI docking station. The total impedance shall be 2 Ω ±1 % in series with 200 µH ±5 %. The manufacturer can declare other values for the artificial antenna parameters but therefore he shall show the evaluation of the parameters. This fact is stated in the test report.

The capacitor C = 20 nF

The resistors R_D = 75 Ω

The resistor R_C = 110 Ω

NOTE 1: The values 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 found as worst case real part of the standard test garden loop in the frequency range between 1 MHz and 30 MHz.

The artificial antenna shall be put in a shielded box. It should be taken care when choosing the layout and components to avoid resonances within the measurement frequency range. Above 1 MHz both the differential mode impedance and the common mode impedance shall always be within 150 Ω ± 50 Ω.

Mechanical setup:

- 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 shall be led downward along the RMI docking station to the level of the non-metallic support and be led horizontally to the artificial antenna.
- 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.
- The differential mode current clamp shall be placed at one of the two leads a maximum of 5 cm away from the artificial antenna input port. see figure C.2.
- The common mode current clamp shall be placed on the ground wire above the non-metallic support, see figure C.2.

NOTE 2: 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.

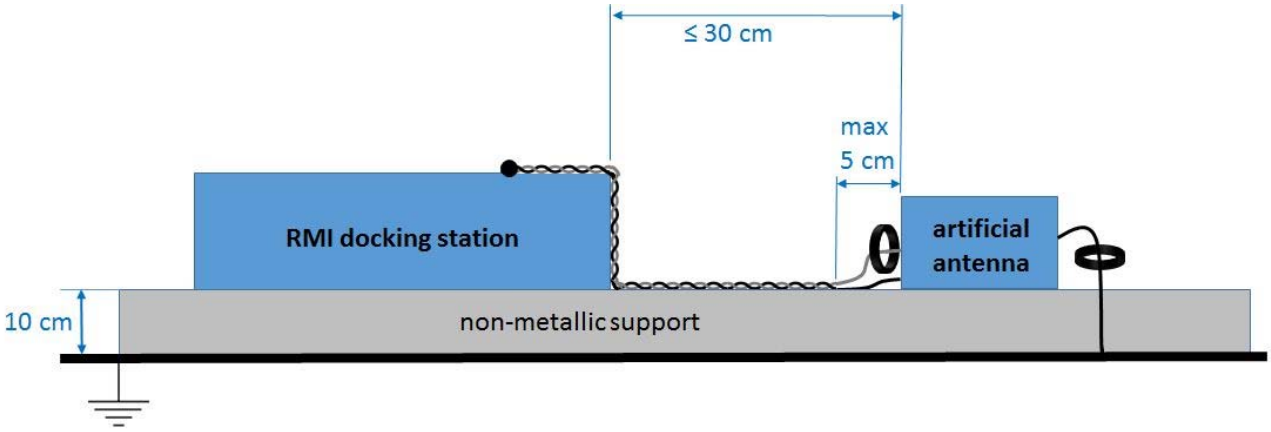

Figure C.2: Mechanical setup for artificial antenna

Annex D (informative): Change History

Version	Information about changes
1.1.0	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

History

Document history			
V1.1.0	December 2016	EN Approval Procedure	AP 20170315: 2016-12-15 to 2017-03-15