# EGMF ROBOTIC MOWERS BOUNDARY WIRE STANDARD RLM003-1.1/2016

*Proprietary information*

Revised version amended- August 2016
EGMF RLM003-1.1/2016

## Industry Standard for current signal intended for guidance of Robotic Lawnmowers

*European Garden Machinery Federation*

Diamant Building, 80 Boulevard A Reyers, 1030 Brussels, Belgium.
telephone: +32 2 706 82 30 | facsimile: +32 2 706 82 50 | email: secretariat@egmf.org | website: www.egmf.org

**CONTENTS**

## FOREWORD

The target for this standard is, in the absence of any harmonised standard, to set measurable limits to the electromagnetic emissions from the **guidance wires** such that **robotic lawnmowers** can operate adjacent to each other.

The immunity of the system is not covered by this standard; it is up to every manufacturer to ensure a level of electromagnetic immunity to enable operation adjacent to other robotic mowers which comply with the emissions limits specified in this standard.

1. The European Garden Machinery industry Federation (EGMF) is a European Association representing major garden, landscaping, forestry and turf equipment manufacturers to develop the highest standards of quality, safety, ergonomics, environment-friendliness and energy efficiency.
2. Membership of the working group responsible for the creation of this document has been open to all manufacturers including non- members of the EGMF.
3. All users should ensure that they have the latest edition of this publication.
4. No liability shall attach to the EGMF or its directors, employees, servants or agents including individual experts and members of its technical committee for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon this EGMF publication.
5. This standard has been prepared by EGMF Task Force committee - Robotic lawnmowers.

NOTE 1 Whenever the word standard is used in this document it should be interpreted as industry standard.

NOTE 2 Adjacent means 1m between neighbouring installations.

NOTE 3 The following print types are used:

- Requirements: in roman type
- Test specification: in *italic type*
- Notes: in small roman type

Words in bold in the text are defined in clause 3. When a definition concerns an adjective, the adjective and the associated noun are also in bold.

## 1 Scope

This standard applies to all **robotic lawnmowers** that use **guidance wires**, through which signal(s) for guidance and/or communication is transmitted.

Electromagnetic immunity is not covered by this standard; it is the duty of manufacturers to make sure that their **robotic lawnmower** has a sufficient level of immunity.

This standard is not applicable to machines which are manufactured before 2015-01-01.

## 2 References

## 3 Definitions

**3.101**
**charging station**
automatic battery charging facility located on or within the **working area**

**3.102**
**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 (see Figure 4).

**3.103**
**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 (see Figure 5).

**3.104**
**guidance wire**

all electrical cables that are defined by 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.

**3.105**
**perimeter delimiter**

a device(s) that defines the perimeter of the area within which the **robotic lawnmower** can operate automatically

**3.106**
**robotic lawnmower**

unattended **lawnmower** that operates automatically

NOTE When term 'machine' is used in the text of this standard, it is used to denote a **robotic lawnmower**

**3.107**
**system**

separate parts and functions that together enable automatic grass cutting, e.g machine, **charging station**, **guidance wires**, signal generator and connection to mains power

**3.108**
**working area**

any defined area in which the machine can function automatically

# 4 Requirements

### 1.1. Magnetic fields generated by current in guidance wires

The magnetic fields generated by the current in **guidance wires** shall, at a distance of 1m outside the loop, not exceed $100nT_{RMS}$.

*Compliance is checked by measurements and calculations according to 5.2, 5.4 and 5.5.1. The sum of all magnetic fields shall be less than or equal to 100*$nT_{RMS}$

If **factory defined loops** are included in the **system**, the sum of all magnetic fields at a distance of 1m outside the loop, shall not exceed $100nT_{RMS}$.

*Compliance is checked by measurements and calculations according to 5.2, 5.4, 5.5.1 for **user defined loops** and 5.2, 5.4 and 5.5.2 or magnetic field measurement or full Biot-Savart calculations that meet at least the same accuracy level for **factory defined loops**. The sum of all magnetic fields is calculated by adding the calculated and/or measured values from all **guidance wires** (**user defined loop** 1 + **user defined loop** 2+…+ **factory defined loop** 1 + **factory defined loop** 2 + …).*

NOTE 1 The intention of this document is to minimize the interference caused by magnetic fields generated by current through loops. For loops that have a limited area the magnetic field will decay faster with distance compared to the loops surrounding the garden. Therefore different magnetic field approximations are used for **user defined loops** and **factory defined loops**.

NOTE 2 The sum of all magnetic fields means the magnetic field from all **user defined loops** + the magnetic field from all **factory defined loops**. See Figure 4 and Figure 5 for examples.

# 5 Test setup

## 5.1 Garden setup

Measurements with at least two different loads, emulating a small and a large garden, shall be performed. The loads consist of one resistor (R) and one inductor (L) in series and are inserted as shown in Figure 1 and Figure 2. With the loads the total impedance, including cables and connectors and possible shunt resistor, shall be:

a. Representing a small garden: 2 Ω ±5% in series with 200 µH ±5%

b. Representing a large garden: 8 Ω ±5% in series with 800 µH ±5%

In cases where the signal is not operable at the above mentioned settings, the load shall be either increased from the small garden or decreased from the large garden, to the first point at which the signal is fully operable. The ratio between the resistance and the inductance shall at all times be 100 µH /Ω.

The magnetic field measured shall be interpreted as reflecting the magnetic field generated by the **guidance wire**. The magnetic field is amplified by the number of turns of the loop. Therefore, in any case where any loop has more than one turn the current shall either be measured with a current clamp including all the turns of the loop OR the current shall be measured in one loop and be multiplied by the total number of turns.

The current must in all cases, operable or not, be below the acceptance level as specified in ▯.

NOTE If using a clamp current probe (see Figure 1) the total resistance is calculated: $R=R_{resistor}+R_{Inductor}+R_{wire}$

If using a shunt resistor (see Figure 2) the total resistance is calculated $R=R_{shunt}+R_{resistor}+R_{Inductor}+R_{wire}$

### 5.2 Current measurement

A measurement shall be made with a current probe according to 5.3 and an oscilloscope. The oscilloscope shall be set to DC measurement and the sampling frequency to at least 100kHz. The oscilloscope shall have an accuracy of at least ±1%

#### 5.2.1 Current measurement period

The current measurement shall be made over at least 10 full repetitions of the signal cycle or, if the signal repetition time is greater than 10 s, the measurement shall be made over a period of at least 10 s

### 5.3 Current probe

The current shall either be measured using a clamp probe (see Figure 1) or by measuring the voltage across a shunt resistor (see Figure 2).
The probe shall at least have the following measuring properties:

Current probe bandwidth: DC – ≥100 kHz

Current probe accuracy: 5 % or better

Shunt resistor accuracy: 5 % or better

### 5.4 RMS calculation

The RMS shall be calculated using the following procedure:

1. The current is measured according to 5.2
2. Calculate an average of the signal and use that as zero reference ($\bar{I}$) in the RMS calculation

$$\bar{I} = \frac{1}{n}(i_1 + i_2 + \cdots + i_n)$$

Where $n$ is the number of samples for the Current measurement period

3. The RMS value over at least one Current measurement period is calculated using the following RMS formula:

$$I_{RMS} = \sqrt{\frac{1}{n}((i_1 - \bar{I})^2 + (i_2 - \bar{I})^2 + \cdots + (i_n - \bar{I})^2)}$$

### 5.5 Magnetic field calculations

For the calculation of magnetic field RMS the following formulas shall be used

#### 5.5.1 Magnetic fields calculation for user defined loops

For all **user defined loops** the following formula shall be used:

$$B_{RMS}[nT] = I_{RMS} * 200$$

NOTE The formula approximates wire to be a single long lead at a distance of 1m and is a simplification from the formula that describes the magnetic flux around a long straight wire:

$$B = \frac{\mu_0}{4\pi} * \frac{2I}{d}$$

Where $\mu_0 = 4\pi * 10^{-7}$ and $d$ is the distance to the wire (1m)

#### 5.5.2 Magnetic field calculation for factory defined loops

The magnetic field as a function of the size of the loop and the RMS current in the loop shall be calculated according to the following procedure:

1. The RMS current is calculated according to 5.4.
2. The height $(h)$ and the width $(w)$ of the loop is set so that $h$ is the largest value of the rectangular approximation of the geometry of the loop and $w$ is the shortest, see examples in Figure 3.
3. The magnetic field, in nT, is calculated according to the following simplified formula:

$$B_{RMS}[nT] = I_{RMS} * w\left(1 - \frac{1}{(1+h)^2}\right) * 100$$

Where $w$ is the rectangular width in metres of the loop and $h$ is the rectangular height in metres of the loop and $I_{RMS}$ is the current in amperes.

For a factory defined loop with a width not greater than 1 metre, and having a height greater than 0.5 metre, the height value in the equation should be set to infinite. In this case the formula would read $B_{RMS}[nT] = I_{RMS} * w * 100$

If the width is greater than 1 metre, then it is to be considered as user defined loop.

NOTE 1 This approximation is calculating the magnetic field at one (1) m distance outside of the periphery of the antennae The approximation is not valid for antennas that are larger than 0.5 $m^2$.

NOTE 2 The approximated formula is derived from the Biot-Savart law

$$B = \frac{\mu_0 I}{4\pi} \int \frac{dl * \hat{r}}{r^2}$$

Where

- $dl$ approximates to be the entire width of the loop and therefore equals $w$
- r is the distance from the cable

- $\hat{r}$ approximates to be 1 as there is only one element and the centre of it is at an angle of 90 degrees to the calculation point.

As $w$ is the entire length the integral consists of only one element and therefore is removed. This gives the following approximation

$$B = I * w * K\frac{1}{r^2}, \;\; Where\ K = \frac{\mu_0}{4\pi}, \; \mu_{0=}4\pi * 10^{-7} \Rightarrow K = 10^{-7}$$

The **factory defined loop** is approximated to two separate wires that are at a distance of h from each other. The loop is placed with the first wire at x m from the measurement point. This gives the following formula.

$$B = I * w * K\frac{1}{x^2} - I * w * K\frac{1}{(x+h)^2} = I * w * K\left(\frac{1}{x^2} - \frac{1}{(x+h)^2}\right)$$

The magnetic field at 1m (x=1) shall be calculated. The formula can therefore be simplified to:

$$B = I * w * K\left(\frac{1}{1^2} - \frac{1}{(1+h)^2}\right) = \; I * w * K\left(1 - \frac{1}{(1+h)^2}\right)$$

NOTE 3 For more complex antenna shapes and for larger antennas a full magnetic field calculation according to the Biot-Savart law can be performed to prove compliance.

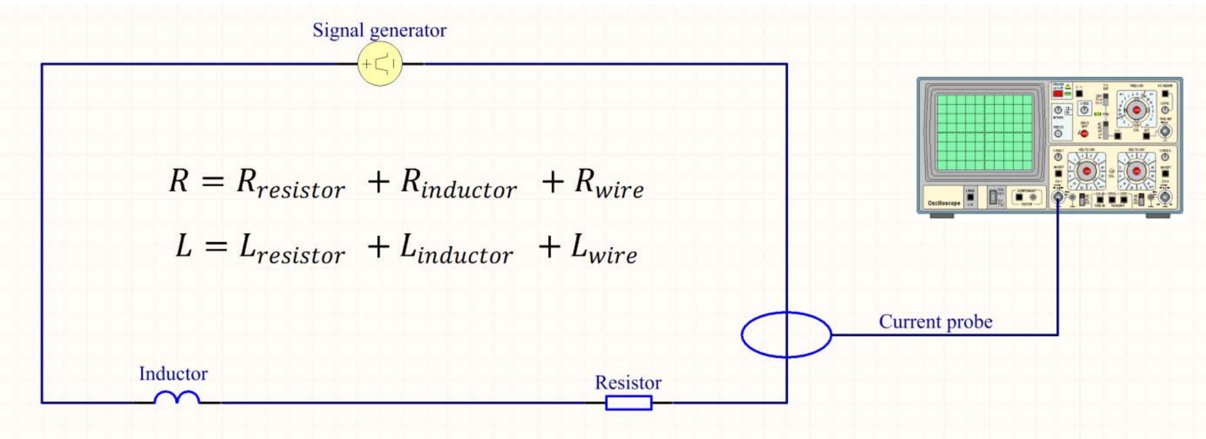


**Figure 1: Measurement setup with current clamp probe**

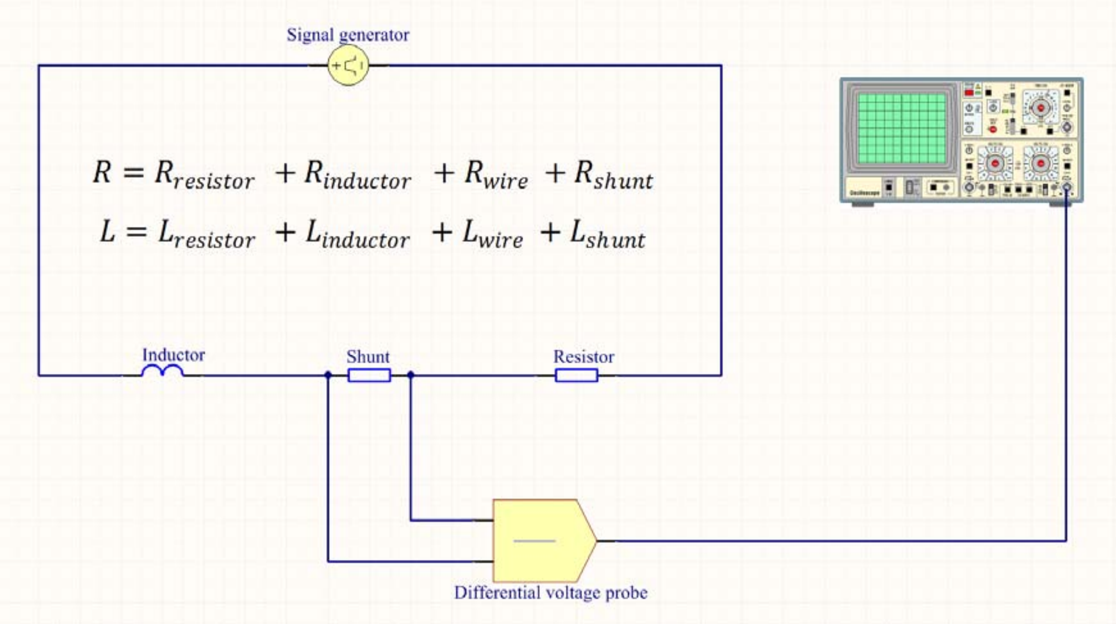


**Figure 2: Measurement setup with Differential voltage probe**

265 The drawings illustrate how to define $h$ and $w$. The solid line represents the loop and dashed line is the rectangular approximation of the geometry of the loop.

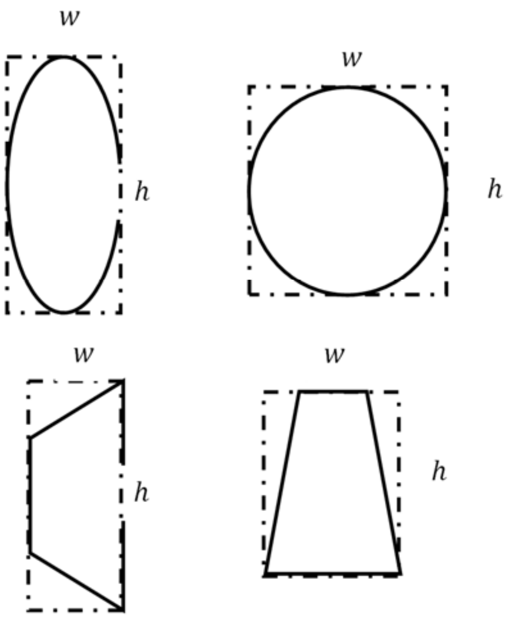


**Figure 3 How to define h and w of a factory defined loop**

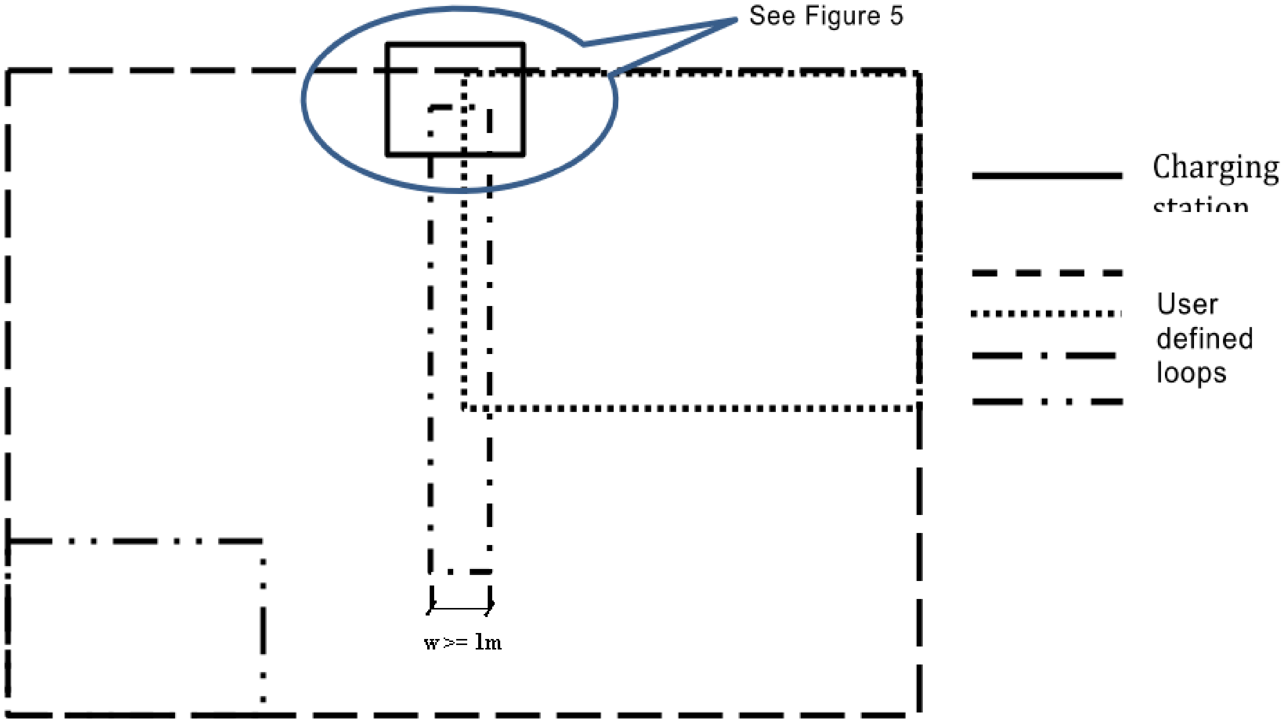


Figure 4 Examples of user defined loops

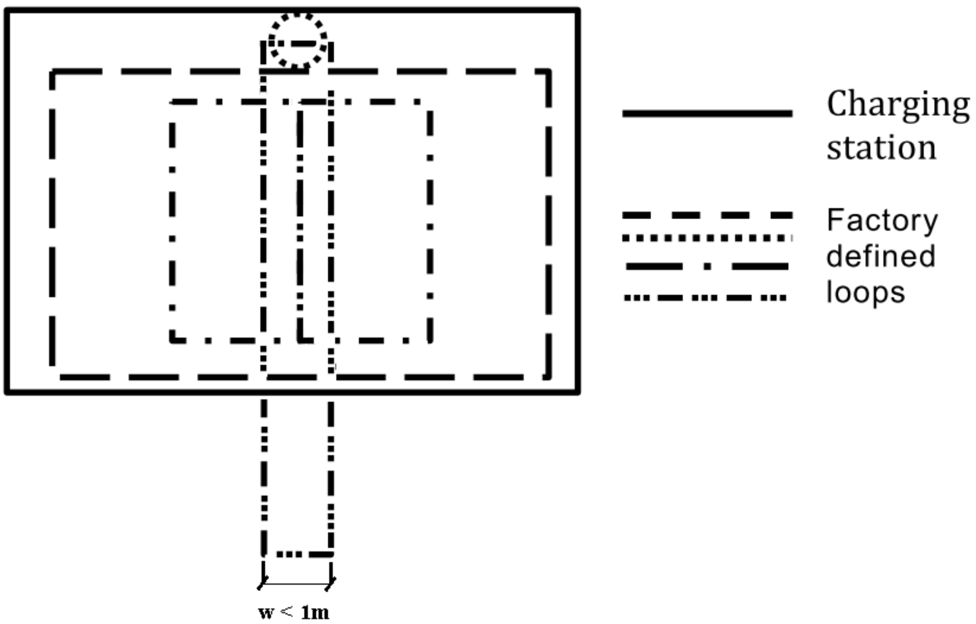


Figure 5 Examples of factory defined loops

NOTE the **factory defined loops** are contained within the **charging station**