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System Reference document (SRdoc);
Wireless Power Transmission (WPT) systems
operating below 30 MHz

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DTR/ERM-563

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document contains necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT).

Modal verbs terminology

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

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Executive summary

The present document analyses the technical specifications and the need for regulatory and standard improvements of all kinds of Wireless Power Transmission (WPT) systems/applications, other than WPT for Electric Vehicles (EV) to be operated in the range of 79 - 90 kHz.

Introduction

The present document was prepared to clarify whether WPT systems using the inductive frequency range below 30 MHz could be seen as "inductive SRDs" and could use the frequency allocations from Decision 2013/752/EU [i.3] and the ERC/REC 70-03 [i.2], annex 9.

1 Scope

The present document provides information of existing and future wireless power transmission (WPT) systems using technologies other than radio frequency beam, operating in the frequency range below 30 MHz and complements the published ETSI TR 103 409 [i.20], which contains information about WPT systems for electrical vehicles (WPT-EV) in the frequency range 79 - 90 kHz.

The related harmonised standard for WPT systems is ETSI EN 303 417 [i.11] and it currently applies to WPT technologies other than radio frequency beam, in the frequency ranges 19 - 21 kHz, 59 - 61 kHz, 79 - 90 kHz, 100 - 300 kHz and 6 765 - 6 795 kHz.

During the development of ETSI EN 303 417 [i.11], concerns were raised whether the frequency allocations for inductive SRDs according to EC Decision 2013/752/EU [i.3] and the ERC/REC 70-03 [i.2], annex 9 are applicable for WPT systems.

Therefore the present document aims to request CEPT to clarify whether the WPT systems using the inductive frequency range below 30 MHz could be seen as "inductive SRDs" and could use the frequency allocations from Decision 2013/752/EU [i.3] and the ERC/REC 70-03 [i.2], annex 9.

The present document deals only with WPT based on technologies other than radio frequency beam (e.g. magnetic induction).

It reviews the present regulations for inductive WPT systems, the related markets and the evolution of the technology, and it identifies requirements to amend the limits for WPT systems operating below 30 MHz.

The present document contains the necessary information to support the possible co-existence and compatibility studies to be conducted by the CEPT/ECC, including:

- market information;
- technical information;
- regulatory issues.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

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] ETSI EN 300 330: "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".

[i.2] ERC Recommendation 70-03 (5 October 2018): "Relating to the use of Short Range Devices (SRD)".

[i.3] EC Decision (EU) 2017/1483: Commission Implementing Decision of 8 August 2017 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2006/804/EC.

[i.4] ECC Report 135: "Inductive Limits in the Frequency Range 9 kHz to 148.5 kHz", Bordeaux, September 2009.

[i.5] ITU-R Report SM.2303-2 (06/2017): "Wireless power transmission using technologies other than radio frequency beam".

[i.6] ITU-R, Annex to Resolution 958 (WRC-15): " Urgent studies required in preparation for the 2019 World Radiocommunication Conference".

[i.7] CEPT/ERC/REC 74-01: "Spurious Emissions".

[i.8] Question ITU-R 210-3/1 (04-07-2017): "Wireless power transmission".

NOTE: Available at http://www.itu.int/pub/R-QUE-SG01.210.

[i.9] ETSI EN 302 195 (V2.1.1): "Short Range Devices (SRD); Ultra Low Power Active Medical Implants (ULP-AMI) and accessories (ULP-AMI-P) operating in the frequency range 9 kHz to 315 kHz Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.10] Radio Regulations, Edition 2016.

[i.11] ETSI EN 303 417 (V1.1.1) (09/2017): "Wireless power transmission systems, using technologies other than radio frequency beam in the 19 - 21 kHz, 59 - 61 kHz, 79 - 90 kHz, 100 - 300 kHz, 6 765 - 6 795 kHz ranges; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[i.12] ECC Report 123: "The impact of Object Discrimination and Characterization (ODC) applications using Ultra-Wideband (UWB) technology on radio services", Vlinius, September 2008.

[i.13] Recommendation ITU-R SM.2028 (09/2012): "Protection distance calculation between inductive systems and radiocommunication services using frequencies below 30 MHz".

[i.14] Recommendation ITU-R SM.2180 (09/2010): "Impact of industrial, scientific and medical (ISM) equipment on radiocommunication services".

[i.15] Report Recommendation ITU-R SM.2028-2 (06/2017): "Monte Carlo simulation methodology for the use in sharing and compatibility studies between different radio services or systems (Question ITU-R 211/1)".

[i.16] Qi Specification: "The Qi Wireless Power Transfer System".

NOTE 1: The most recent WPC publications and specifications can be downloaded from http://www.wirelesspowerconsortium.com.

NOTE 2: Also published as:

- IEC 62827-1:2016: "Wireless power transfer - Management - Part 1: Common components".
- IEC 62827-2:2017: "Wireless power transfer - Management - Part 2: Multiple device control management".
- IEC 62827-3:2016: "Wireless power transfer - Management - Part 3: Multiple source control management".
- IEC PAS 63095-2:2017: "The Qi wireless power transfer system - Power class 0 specification - Part 2: Reference Designs Version.1.1.2".

[i.17] CISPR 14-1:2016: "Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission".

[i.18] CISPR 32:2015: "Electromagnetic compatibility of multimedia equipment - Emission requirements".

[i.19] CISPR 11:2015: "Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement".

[i.20] ETSI TR 103 409 (V1.1.1) (10-2016): "System Reference document (SRdoc); Wireless Power Transmission (WPT) systems for Electric Vehicles (EV) operating in the frequency band 79 - 90 kHz".

[i.21] ERC Report 44: "Sharing between Inductive Systems and Radiocommunications Systems in the Band 9 - 135 kHz", Sesimbra, January 1997.

[i.22] ECC Report 67: "Compatibility study for generic limits for the emission levels of inductive SRDs below 30 MHz", Hradec Kralove, October 2005.

[i.23] ECC Report 001: "Compatibility between inductive LF and HF RFID transponder and other radio communications systems in the frequency ranges 135-148.5 kHz, 4.78-8.78 MHz and 11.56-15.56 MHz", Beaune, February 2002.

[i.24] ERC Report 69: "Propagation model and interference range calculation for inductive systems 10 kHz - 30 MHz", Marbella, February 1999.

[i.25] CENELEC EN 55011 (2009/A1: 2010): "Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics -Limits and methods of measurement".

[i.26] CENELEC EN 55014-1 (2006 + A1:2009 + A2:2011): "Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus -Part 1: Emission".

[i.27] CENELEC EN 55015 (2013): "Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment EMCD".

[i.28] CENELEC EN 55032 (2012/AC:2013): "Electromagnetic compatibility of multimedia equipment -Emission Requirements".

[i.29] A4WP-S-0001 v1.3 (Version 1.3), 05 November 2015: "A4WP Wireless Power Transfer System Baseline System Specification (BSS)".

[i.30] ETSI EN 300 330-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); 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; Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.31] IEC 62827-2: "Wireless power transfer - Management - Part 2: Multiple device control management".

[i.32] CISPR/I/542/DC: " Proposal for limits and methods of measurement for MME with Wireless Power".

[i.32] ITU-R Report SM.2303-1: "Wireless power transmission using technologies other than radio frequency beam".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI EN 303 417 [i.11] and the following apply:

class A equipment: equipment suitable for use in all locations other than those allocated in residential environments and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes

class B equipment: equipment suitable for use in locations in residential environments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes

primary device: primary part of the Wireless Power Transmission (WPT) system, a combination of a coil, communication device and/or connection to an energy supply

NOTE: Other expressions: charger, charging pad or primary coil.

secondary device: mobile part/energy receiving part of the Wireless Power Transmission (WPT) system, comprising the combination of a coil, communication device and/or energy storage in one housing

Wireless Power Transmission (WPT): transmission of electrical energy from a power source to an electrical load via electric and or magnetic fields or waves between a primary and a secondary device

3.2 Symbols

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

dBµA	dBmicroampere
P	Power
f	frequency
H	magnetic field strength

3.3 Abbreviations

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

AI	Agenda ITEM
AMI	Active Medical Implant
CD	Committee Draft
CDV	Committee Draft for Voting
CEPT	European Conference of Postal and Telecommunications Administrations
CG	Correspondence Group
CISPR	Comité International Spécial des Perturbations Radioélectriques
CPM	Conference Preparatory Meeting of ITU-R
EAS	Electronic Article Surveillance
ECC	Electronic Communications Committee
EMC	ElectroMagnetic Compatibility
EMCD	EMC Directive
EN	European standard
ERC	European Radiocommunications Committee
EU	European Union
EV	Electric Vehicle
GPS	Global Positioning System
IEC	International Electrotechnical Commission
IHS	Information Handling Services
IPT	Inductive Power Transfer
IoT	Internet of Things
ISM	Industrial Scientific Medical
ISO	International Standards Organization
LED	Light Emitting Diode
LF	Low Frequency
LORAN	LOng RAnge Navigation system
NFC	Near Field Communications
PDN	Preliminary Draft New
RA	Radiocommunication Assembly
REC	RECommendation
RES	RESolution
RF	Radio Frequency
RFID	Radio Frequency IDentification
RR	Radio Regulations

SAE	Society of Automotive Engineers
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SRD	Short Range Device
SG	Study Group
SM	Spectrum Management
SSPS	Space Solar Power System
TR	Technical Report
WP	Working Party
WPC	Wireless Power Consortium
WPT	Wireless Power Transmission
WPT-EV	Wireless Power Transmission for Electric Vehicles
WRC	World Radiocommunication Conference

4 Comments on the System Reference Document

4.1 Statements by ETSI members

Statement from BBC/EBU:

- *"The frequency band 85 - 205 kHz overlaps the region 1 licensed broadcast band (LF frequency band 148,5 kHz - 283,5 kHz) and the devices use significant power and will cause interference.*

  Therefore it is proposed: Remove the overlap with this band in order to offer protection to this broadly used broadcast band.

- *Qi Specification (WPC): The frequencies used by the Qi specification ranges from 87 kHz up to 205 kHz. There are emerging applications under development (such as two new Power Classes being actively developed), and operation at frequencies above or below this existing range may need to be considered. As technology advances, higher frequencies (approaching to 500 kHz) may become beneficial when previously it was not commercially feasible.*

  Therefore it is proposed: See comment above and remove overlap with the licensed broadcast band mentioned above.

- *The frequency band 100 - 300 kHz overlaps the licensed region 1 broadcast band (LF frequency band 148,5 kHz - 283,5 kHz) and the devices use significant power and will cause interference."*

  Therefore it is proposed: Remove the overlap with this band in order to offer protection to this broadly used broadcast band.

5 Presentation of the system or technology

5.1 The WPT technology

5.1.1 Types of WPTsystems

Recommendation ITU-R SG 1 has defined two kinds of WPT systems for which reference can be found in ITU-R Report SM.2303-2 [i.5]:

WPT via radio frequency beam:

Transfer of power obtained from sun by using microwave frequencies. The most important application of WPT via radio frequency beam is Space Solar Power System (SSPS). SSPS converts solar energy to electricity with solar cell arrays placed on the geostationary earth orbit, provides power to microwave generators, sends power beam through transmitting antennas to rectennas (Rectifier + antenna) on the ground for 24 hours a day under any weather condition.

A wide variety of potential application concepts exists. These include "ground-to-ground transmission", "ground-to-air transmission", "ground-to-space transmission (including ground-to-space-to-ground)", "space-to-ground transmission", and "space-to-space transmission". Applications can also be classified by the range of power transmission, including "short-range transmission (less than a kilometre)", "intermediate range (tens or hundreds of kilometres), and "long-range transmission (thousands of kilometres)". Power levels and frequencies are very dependent on the application.

These kind of WPT systems are outside the scope of the present document.

WPT by using technologies other than radio frequency beam:

Transfer of power is done via the technologies not using radio frequency beam, such as inductive and resonant technologies, also called "wireless charging" which is the main focus of the present document.

These technologies can be categorized in different ways according to:

- the physical operation principle;
- the power levels;
- the operating frequencies;
- the operating distances;
- the detection or communication methods;
- the applications.

The present document explains first the physical operation principle and describes afterwards further aspects.

5.1.2 Methods of WPT-Systems

There are a number of methods which can be used to wirelessly transmit power. A schematic presentation of these methods is given in figure 1.

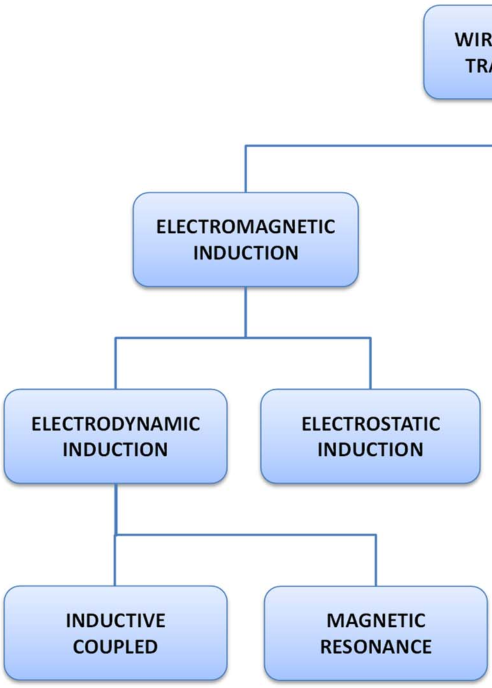

Figure 1: Methods of Wireless Power Transmission (WPT)

The scope of the present document is limited to inductive coupled and magnetic resonance methods.

More background about the history and the technical and physical principles of WPT can be found in ITU-R Report SM.2303-2 [i.5].

5.2 Applications developed for use by WPT technologies

5.2.1 Introduction

The wireless transmission of electrical energy can make charging of electrical devices very easy, comfortable and user-friendly. A selection of typical applications for WPT is given in the following clauses.

More information on WPT applications can be found in ITU-R Report SM.2303-2 [i.5].

5.2.2 WPT for portable and mobile devices

Inductive or magnetic resonant WPT can be used for the following applications:

- Mobile and portable devices: Cellular phones, smartphones, tablets, notebooks, wearable devices.
- Audio-Visual equipment: Digital still cameras, digital video cameras, music players, portable TVs.
- Business equipment: Handy-digital-tools, table-order-systems.
- Others: Lighting equipment (e.g. LED), robots, toys, car-mounted devices.

Some technologies of this type may require exact device positioning on the power source. In general, the device to be charged needs to be in close contact with the power source such as the power tray.

This type of WPT typically uses operating frequencies between 100 - 300 kHz (based on standards developed by the AirFuel Alliance and the Wireless Power Consortium [i.16]), 6,765 - 6,795 MHz (based on standards developed by the AirFuel Alliance [i.29]).

Other proprietary systems such as the "Apple watch©" charging solution uses frequencies in the range of 300 - 400 kHz, this has been found to be an optimum frequency, for a number of reasons when integrated into a device that supports a number of other wireless technologies.

5.2.3 WPT for home appliances and logistics applications

Magnetic induction and magnetic resonance methods can be applied to various types of home and logistics applications:

- Home appliance applications: Household electrical appliances, furniture, cooker, mixer, television, small robots, audio-visual equipment, lighting equipment and power tools.

As with the mobile devices (clause 5.2.2), this type of WPT also typically uses operating frequencies between 100 - 300 kHz or 6,765 - 6,795 MHz, depending on which of the above-mentioned standards is implemented.

5.2.4 WPT for electric vehicles

These applications need high power - dependent on the type of vehicles in the range from several kilowatts to 10 s of kilowatts.

WPT is intended to become a ubiquitous power source for EV, which may lead to a reduction of EV battery size and to unlimited drive when used dynamically (i.e. charging while driving).

This type of WPT typically uses operating frequencies between 79 - 90 kHz (based on already existing international standardization approaches in IEC, ISO and SAE).

ETSI TR 103 409 (V1.1.1) [i.20] is the ETSI reference for WPT for EV-system.

5.2.5 WPT for Medical equipment

In medical applications WPT are used to recharge battery of Active Medical Implant (AMI) such as neurostimulators and external instruments with rechargeable battery. The use of WPT provide a mean to reduce invasive surgery in case of active medical implant with depleted battery and provide a safer and more sanitary environment in regards to rechargeable instrument by reducing cables and reducing leakage current risks since the medical instrument is no longer directly connected to the power network. WPT approach works well because of the excellent penetration of magnetic fields through the human body at these frequencies as well as the acceptable penetration of hermetically sealed metallic enclosures (metallic enclosures of active medical implant).

The WPT frequencies are broad within the 2 - 315 kHz range and depends greatly on the therapeutic function and location of the active medical implant. The WPT system transmit a field strength up to 400 A/m at 10 cm from the body and rechargeable active medical implant. The magnetic field limit between 9 kHz and 315 kHz is 30 dBμA/m at 10 m distance according to ETSI EN 302 195 [i.9].

5.3 Overview of frequency ranges used by WPT systems worldwide (below 30 MHz)

Currently, various companies/manufacturers are considering different frequencies for the implementation of WPT systems in several standards and industry alliances worldwide. Industrial alliances, consortia, and academia have investigated several frequency bands for WPT technologies; the most promising bands with the potential for worldwide harmonization are:

- 19 - 21 kHz shaped magnetic field in resonance for Electric Vehicles; WPT systems for trucks/buses, (typically > 20 kW) - already used in e.g. Korea, UK and Germany.

- 59 - 61 kHz for shaped magnetic field in resonance for Electric Vehicles.

- 79 - 90 kHz for magnetic resonant technology for Electric Vehicles; Frequency range is planned for WPT systems for electrical vehicles (EV) (main focus: passenger cars), power transfer typically 3,7 kW - 20 kW; plan to be used worldwide.

- 100 - 205/300 kHz for magnetic resonant and induction technology for mobile devices; WPT systems for consumer devices, power transfer typically < 200 W; plan to be used worldwide.

- 6 765 - 6 795 kHz for magnetic resonant technology for mobile devices; WPT systems for consumer devices, power transfer typically < 30 W; plan to be used.

Other frequency bands are listed below:

- 9 - 315 kHz WPT used for Medical application, 400 A/m at 10 cm; currently in use according to ETSI EN 302 195 [i.9].
- 36 - 40 kHz and 55 to 65 kHz, additional frequency ranges for Electric Vehicles (EV); under discussion in CISPR.
- 20 to 80 kHz for kitchen appliances, (typically 200 W - 2,4 kW); under discussion in wireless power consortium [i.16]; planned to be used worldwide.
- 300 - 500 kHz: WPT systems for consumer devices, power transfer typically < 5 W; plan to be used for smaller devices.
- 900 - 1 000 kHz: WPT systems for consumer devices, power transfer typically < 5 W; plan to be used for smaller devices.
- 2,050 - 2,150 MHz: WPT systems for consumer devices, power transfer typically < 5 W; plan to be used for smaller devices.
- 13,553 - 13, 567 MHz: WPT systems for consumer devices, power transfer typically < 5 W; plan to be used worldwide.

NOTE: The "worldwide" use does not mean that the technical requirements for these frequency bands are harmonised.

5.4 Power classes

WPT systems are used/planned for usage within a lot of different scenarios. The categorization of WPT could therefore also be possible over the "power" transmissed in the WPT system. The level of the power transmission may have an influence to the "frequency range for the transmission".

Details for possible power classes are given within clause 7.1.2.

6 Market information

6.1 General

6.1.1 WPT systems for charging consumer devices

While exact numbers are unknown, it is estimated that the market size for wireless power transmission was at 200 Million units in 2016.

While a majority of the receivers are currently mobile phones, the market for other products, such as wearable devices, is rapidly growing with a number around 20 million units in 2015.

An indication of the expected market size is given in figure 2, also according to IHS (source: "Wireless charging - from industry push to consumer pull, an IHS white paper on the rise of wireless power", freely available at https://technology.ihs.com/550357).

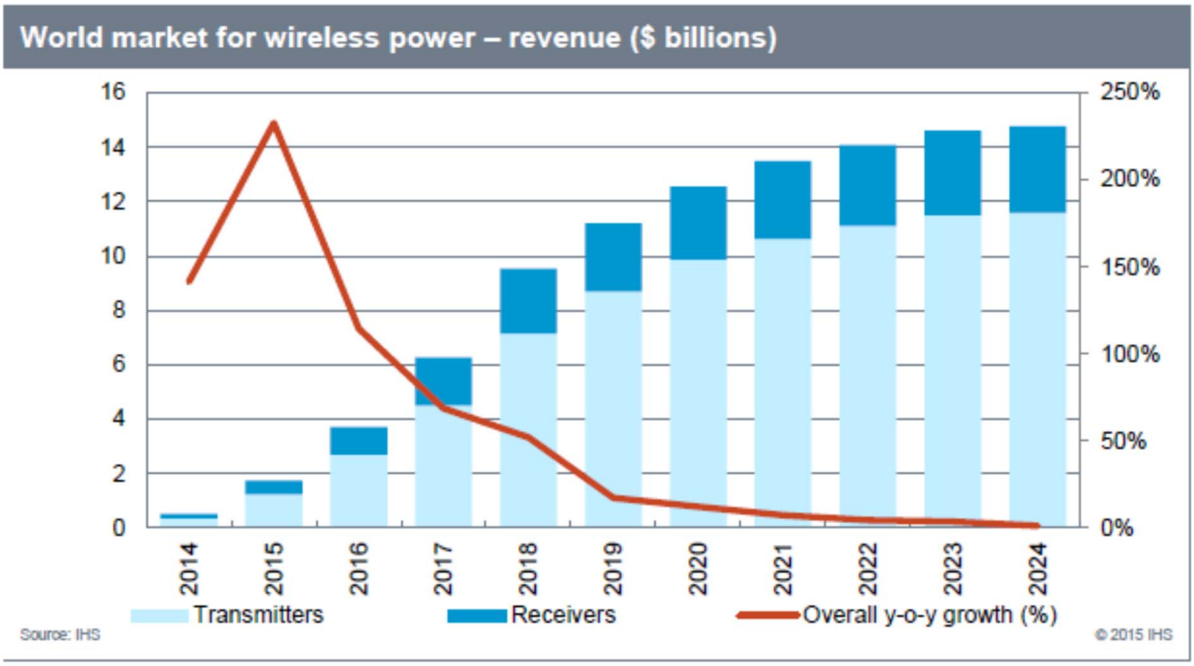

Figure 2: World market for wireless power

Another view (see figure 3) from IHS is the number of receivers in the market (source: http://news.ihsmarkit.com/press-release/technology/high-growth-wireless-charging-market-matures-2016-ihs-says) .

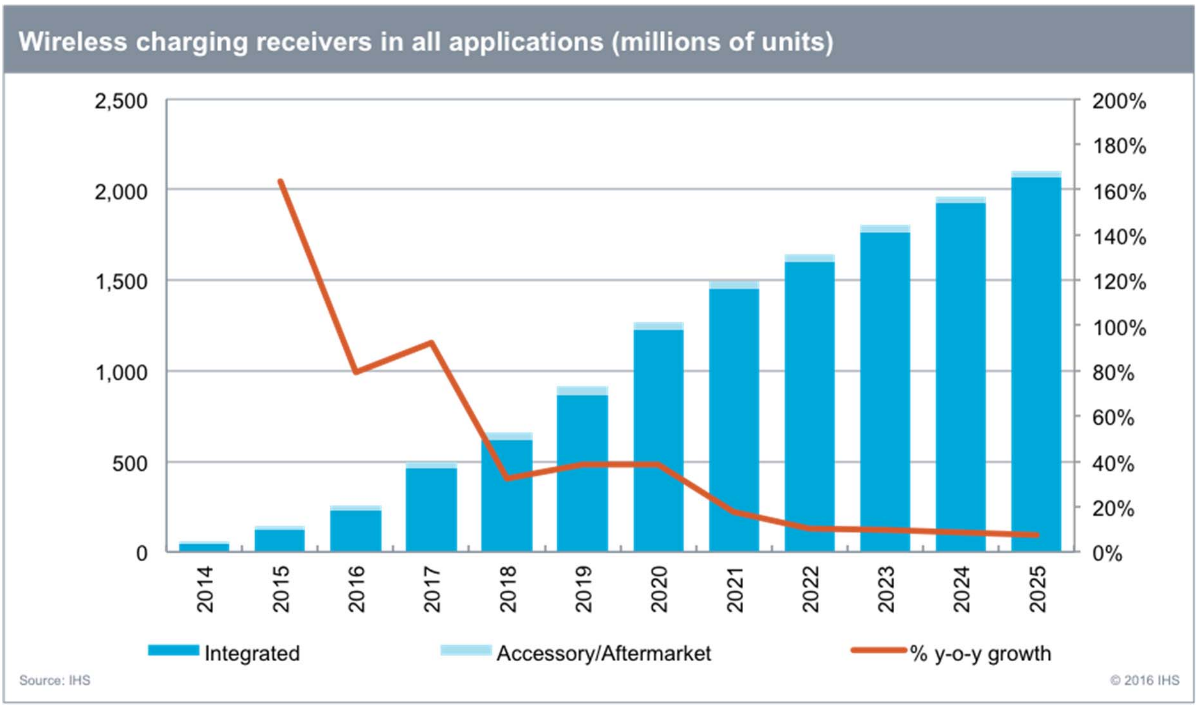

Figure 3: Number of wireless charging receiver

Further market information on the specific power classes and use-cases are provided in clause 7.

7 Technical information

7.1 Detailed technical description

7.1.1 General

More details of the working principle of WPT can be found within ITU-R Report SM.2303-2 [i.5].

The selected frequency of a WPT system is directly related to the level of power transmission and the size of the device. Typically the frequency for the power transmission goes down with the increase of the power level.

The following should be noted on expected density and number of WPT devices in the clause 7.1.2:

a) The expected density and number of devices of WPT devices/systems are based on worst-cases assumptions. The number of WPT devices are based on the assumption that all WPT devices could use all frequency ranges listed within a power classes. But most of the devices will only able to transfer energy within one frequency range based on the coil size, energy transmission level and charging time, etc.

b) The secondary device could operate in multi-mode, working with different primary devices. The used frequencies of the WPT system are mainly dependent from the primary device (depending specifications including frequency range). The primary device is typically the part generating the signal for the power transmission.

7.1.2 Power Classes

The following power classes, describing the maximum transferred energy/power, are used within different WPT system specifications. The distinction in power classes, instead of frequencies is used in the present document to consider the huge variety of use-case, size of the device, etc.

P < 1 W:

- for charging small IoT sensors;
- currently realized within 13,553 - 13,567 MHz.

1 W < P < 5 W

- for charging e.g. Mobile Phones, smartwatches, wearables, tablets, netbooks, camera's, audio/video equipment, lighting, battery-chargers, furniture, medical devices;
- currently WPT systems/solution available within 85 - 205 kHz, 300 - 500 kHz, 900 - 1 000 kHz, 2,050 - 2,150 MHz, 6,765 - 6,795 MHz and 13,553 - 13,567 MHz.

5 W < P < 31,5 W

- tablets, netbooks, camera's, AV equipment, Lighting, battery-chargers, furniture, medical devices;
- currently WPT systems/solution available within 85 - 205 kHz, 6,765 - 6,795 MHz and 13,553 - 13,567 MHz.

31,5 W < P < 200 W

- power tools, laptops, lighting, household devices, furniture, television, robots (both domestic and industrial), healthcare, e-bikes, drones, garden equipment;
- currently WPT systems/solution available within 85 - 205 kHz.

P < 2,4 kW

- Kitchen appliances (blender, rice-cooker, fryer, mixer), lighting, kitchen countertops.
- currently WPT systems/solution available within 20 - 80 kHz.

P > 2,4 kW

- electrical vehicle charging;
- these systems are described in ETSI TR 103 409 [i.20].

7.1.2.1 Power Class: P < 1W

Table 1 provides the details for WPT systems with a power transmission level < 1 W.

Table 1: Summary information for WPT power class: P < 1 W

Application area	IoT mobile sensors
Power level of the transmission	< 1 W
Magnetic field at 10 m	< 42 dBµA/m
Frequency band	13,553 - 13,567 MHz
Use-cases	Charging and communication (on the same frequency) of temp sensors, motion detectors, pressure sensor, weather station, etc.
Power transfer scenario	Energy transfer from the primary to the secondary device typically over a few cm distance in an indoor environment
Energy coupling technique	Resonant inductive coupling
Activity Factor	Communication of the sensor node is active 100 % but power consumption requests charging (power transfer) only 1 time / week for 1 hr
Expected density	Around 3 - 4 devices/household
Current regulation	42 dBµA/m at 10 m distance from 13,553 - 13,567 MHz (see clause 9.1)
Comments on regulation	The current limits of the generic SRD regulation is sufficient
More info	Working principle, see figure 4 Charging distance around 5 cm Data transfer in the same range possible (e.g. NFC technology)

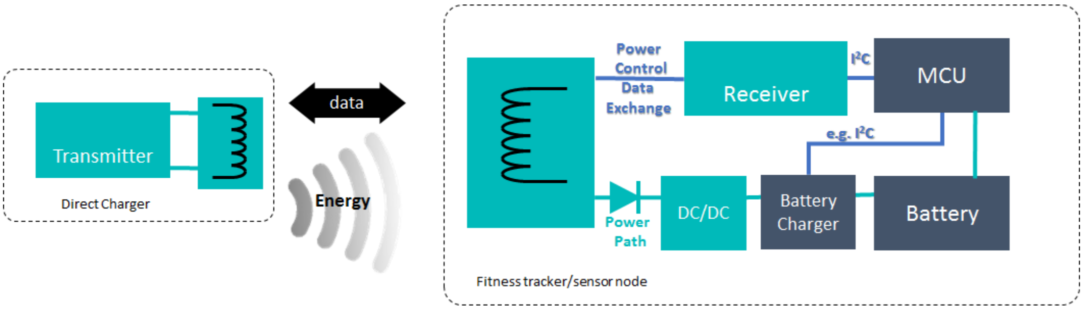

Figure 4: Working principle for WPT systems < 1 W

7.1.2.2 Power Class: P ≤ 5W

Table 2 provides the details for WPT systems with a power transmission level ≤ 5 W.

Table 2: Summary information for WPT power class: P ≤ 5 W

Application area	Mobile Phones, smartwatches, wearables, tablets, netbooks, camera's, AV equipment, Lighting, battery-chargers, furniture, medical devices	
Power levels of the transmission	0 - 5 W	
Magnetic field at 10 m	90 - 119 kHz:	< 42 dBµA/m
	119 - 135 kHz:	< 42 dBµA/m
	135 - 140 kHz:	< 42 dBµA/m
	140 - 148,5 kHz:	< 37,7 dBuA
	148,5 - 205 kHz:	< -15 dBµA/m (see note)
	300 - 500 kHz:	< -15 dBµA/m (see note)
	900 - 1 000 kHz:	< -15 dBµA/m (see note)
	2,050 - 2,150 MHz:	< -15 dBµA/m (see note)
	6,765 - 6,795 MHz:	< 42 dBµA/m
	13,553 - 13,567 MHz:	< 42 dBµA/m
Frequency band	Band 3: 90 kHz - 205 kHz	
	Band 4: 300 - 500 kHz	
	Band 5: 900 - 1 000 kHz	
	Band 6: 2 050 - 2,150 MHz	
	Band 7: 6,765 - 6,795 MHz	
	Band 8: 13,553 - 13,567 MHz	
Use-cases	Home, office, in-car, infrastructure. Consider a "convenience-charging" situation: rather than charging a full cycle once or twice a day a WPT user typically charges many times a day for shorter periods (top-up). The portability of the device being charged makes this application area very low threshold for consumers to use Examples for wearables: Charging and communication between base-station and fitness tracker Examples of generic use: Charging of e.g. consumer devices, like MP3 player, cameras, etc.	
Power transfer scenario	Energy transfer from the primary to the secondary device typically over a few cm in an indoor scenario	
Energy coupling technique	Inductively close coupled	
Market information	Currently > 150 million Rx-units shipped annually. Currently attach rate of primary to secondary device is about 3-to-1 (people owning a charger at home, in the office, etc.) but less sales per year (phone is replaced more frequently). In future: it can be expected that the interoperability of WPT systems will increase [i.16] and [i.29] different secondary devices will be able to be charged with the same primary device Estimated growth to > 2 billion secondary and > 750 million primary units by 2025.	

Activity Factor	Convenience charging, people will use it wherever a WPT charging option is available. The possibility that the secondary device is placed at charging pad is very high. Estimated time (device at a charging pad) 8 hr at home 8 hr in the office 1 hr inside car / on the road / train But the energy transfer/charging time is dependent on the power level within the battery and depending on the user or manufacturer set-up (charging will start @X% of the energy level of the battery and will be stopped if the energy level reaches 100 %. Following additional assumptions: the secondary device needs to be charged 1 per day: leads to an average DC for the energy transfer/ per device of: 10 %/hr
Expected density	Multiple mobile devices per person: 2 or 3 Typically one device is in use the other will be charged/placed on primary device/charging pad. Primary device per person: 3 (1 home, 1 office, 1 car) + number of installed devices @ public areas (airports, trains, shops and restaurants/coffee shops) Assumption for wearables: 5 000 citizen/km^2, assume 10 out of 100 using a fitness tracker/watches: 500 devices/km^2 Assumption for generic mobile devices: 5 000 devices/km^2 will be charged.
Current regulation	See clause 9.1
Comments on regulation	The current SRD regulation is sufficient
More info	[i.16] and [i.29]
NOTE: The maximum allowed total field strength is -5 dBμA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (-15 dBμA/m in a bandwidth of 10 kHz).	

7.1.2.3 Power Class: 5 W < P < 31,5 W

Table 3 provides the details for WPT systems with a power transmission level between:

5 W < P ≤ 31,5 W

Table 3: Summary information for WPT power class: 5 W < P ≤ 31,5 W

Application area	Tablets, netbooks, cameras, AV equipment, lighting, battery-chargers, furniture, medical devices	
Power levels	5 - 31,5 W	
Magnetic field at 10 m	90 - 119 kHz:	< 42 dBµA/m
	119 - 135 kHz:	< 42 dBµA/m
	135 - 140 kHz:	< 42 dBµA/m
	140 - 148,5 kHz:	< 37,7 dBuA
	148,5 - 205 kHz:	< -15 dBµA/m (see note)
	300 - 500 kHz:	< -15 dBµA/m (see note)
	900 - 1 000 kHz:	< -15 dBµA/m (see note)
	2,050 - 2,150 MHz:	< -15 dBµA/m (see note)
	6,765 - 6,795 MHz:	< 42 dBµA/m
	13,553 - 13,567 MHz:	< 42 dBµA/m
Frequency bands	Band 3: 90 kHz - 205 kHz	
	Band 4: 300-500 kHz	
	Band 5: 900 - 1 000 kHz	
	Band 6: 2,050 - 2,150 MHz	
	Band 7: 6,765 - 6,795 MHz	
	Band 8: 13,553 - 13,567 MHz	
Use-cases	Home, office, in car, infrastructure. Consider a "convenience-charging" situation: rather than charging a full cycle once or twice a day a WPT user typically charges many times a day for shorter periods (top-up). The portability of the device being charged makes this application area very low threshold for consumers to use.	
Power transfer scenario	Energy transfer from the primary to the secondary device typically over a few cm with a powermat in an indoor scenario.	
Energy coupling technique	Inductive coupling (< 205 kHz), inductive resonant coupling (6,7 MHz).	
Market information	Currently > 150 million Rx-units shipped annually. Currently attach rate of primary to secondary device is about 3-to-1 (people owning a charger at home, in the office, etc.) but less sales per year (phone is replaced more frequently). In future: is could be expected that the interoperability of WPT systems will increase [i.16] and [i.29] different secondary devices will be able to be charged with the same primary device Estimated growth to > 2 billion secondary and > 750 million primary units by 2025.	
Activity Factor	Convenience charging, people will use it wherever available. The possibility that the secondary device is placed at charging pad is very high. Estimated time (device at a charging pad) 8 hr at home 8 hr in the office 1 hr inside car / on the road / train But the energy transfer/charging time is dependent on the power level within the battery- and depending on the user or manufacturer set-up (charging will start @X% of the energy level of the battery) and will be stopped if the energy level reaches 100 %. Following additional assumptions: the secondary device needs to be charged 1 time per da, this leads to an average DC for the energy transfer/ per device of: 10 %/hr.	
Expected density	Multiple Mobile Devices per person: 2 to 3. Primary device: 3 (1 home, 1 office, 1 car) Assumption for devices: 5 000 devices/km^2 will be charged.	
Current regulation	See clause 9.1	
Comments on regulation	The current SRD regulation is sufficient.	
More info	[i.16]	
NOTE: The maximum allowed total field strength is - 5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (-15 dBµA/m in a bandwidth of 10 kHz).		

7.1.2.4 Power Class: P < 200 W

Table 4 provides the details for WPT systems with a power transmission level below 200 W.

Table 4: Summary information for WPT power class: P < 200 W

<table>
<tr><td>Application area</td><td colspan="3">Power tools, laptops, lighting, household devices, furniture, television, robots (both domestic and industrial), healthcare, e-bikes, drones, garden equipment</td></tr>
<tr><td>Power levels</td><td colspan="3">30 W - 200 W</td></tr>
<tr><td rowspan="5">Magnetic field at 10 m</td><td>90 - 119 kHz:</td><td>< 42 dBμA/m</td><td rowspan="5"></td></tr>
<tr><td>119 - 135 kHz:</td><td>< 42 dBμA/m</td></tr>
<tr><td>135 - 140 kHz:</td><td>< 42 dBμA/m</td></tr>
<tr><td>140 - 148,5 kHz:</td><td>< 37,7 dBuA</td></tr>
<tr><td>148,5 - 205 kHz:</td><td>< -15 dBμA/m (see note 1)</td></tr>
<tr><td>Frequency band</td><td colspan="3">Band 3: 90 - 205 kHz</td></tr>
<tr><td>Use-cases</td><td colspan="3">Home, office, car, workplace (include coffee-shops), bars, restaurants. Typically applies to locations where users reside for a duration longer than 30 minutes (due to the lower portability of the devices being charged).</td></tr>
<tr><td>Power transfer scenario</td><td colspan="3">Energy transfer from the primary to the secondary device typically over a few cm.</td></tr>
<tr><td>Energy coupling technique</td><td colspan="3">Inductive coupling.</td></tr>
<tr><td>Activity Factor</td><td colspan="3">Convenience charging, wherever the device or person can stay stationary for at least 30 minutes.

"Laptop" use-case
8 hr at home
8 hr in the office/work place
With Assumption that the secondary device needs to charged 1 time / day for 1 hr:
Average DC 5 %/hr
"Working tool" use-case / incl. "invehicle charging of working tools"
8 to 10 working hr of the "worker" and charging device during night with the assumption that the secondary device needs to be charged 2 times per day around for 1 hr each;
Average DC 10 %/hr (during the working time).</td></tr>
<tr><td>Expected density</td><td colspan="3">Professional usage: 10 WPT system per office.
Domestic usage: 5 WPT systems per household (see note 2).</td></tr>
<tr><td>Current regulation</td><td colspan="3">See clause 9.1.</td></tr>
<tr><td>Comments on regulation</td><td colspan="3">The current SRD regulation is sufficient.</td></tr>
<tr><td>Thoughts</td><td colspan="3">A very wide range of applications is covered in this power class. Perhaps a division between professional and domestic use could be helpful in assessing better numbers on activity factor, density, and use-cases.</td></tr>
<tr><td colspan="4">NOTE 1: The maximum allowed total field strength is -5 dBμA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (-15 dBμA/m in a bandwidth of 10 kHz).
NOTE 2: Highest density of households in EU: Urban with 6 700 per km^2, sub-urban with 460 per km^2 [i.12].</td></tr>
</table>

7.1.2.5 Power class: P < 2,4 kW

Table 5 provides the details for WPT systems with a power transmission level between: P < 2,4 kW.

Table 5: Summary information for WPT power class: P < 2,4 kW

Application area	Kitchen appliances (blender, rice-cooker, fryer, mixer), lighting, kitchen countertops
Power levels	200 W - 2,4 kW
Magnetic field at 10 m	20 - 79 kHz: < 42 dBµA/m
Frequency band	Band 1: 20 - 79 kHz
Use-cases	Kitchen countertop, anytime when meals are prepared: 3 times per day. For heating equipment: Not battery-charging but power transmission. Future application: "intelligent cook-pot" energy transfer to power up communication transceiver (e.g. Bluetooth low energy) in the pot. For "tools" like mixer: power transmission to battery, technical solution comparable to "power tool".
Power transfer scenario	Energy transfer from the primary to the secondary device typically over a few cm.
Energy coupling technique	Inductive coupling.
Market information	Inductive cooking is replacing the electric and gas stoves. This use-case will be the evolution of inductive cooking with IoT technology (power efficiency + communication).
Activity Factor	**Private use-case:** Typical use 2 - 3 times per day for about an hour each time. During usage: DC between 50 - 100 %/hr. **Professional use-case:** Typical usage: 16 hr/day. During usage: DC between 50 - 100 %/hr.
Expected density	1 kitchen per household, up to 5 appliances.
Current regulation	See clause 9.1.
Comments on regulation	The current SRD regulation is sufficient.
Thoughts	WPT systems in this power class are limited to kitchen installations; use-cases fortify that only reasonable usage is in a kitchen environment.
More info	[i.16]

7.2 Technical parameters and implications on spectrum use

7.2.1 Status of technical parameters

7.2.1.1 Current ITU and European Common Allocations in the candidate bands

Based on the huge number of frequency ranges for WPT systems:

- The current ITU allocations in the frequency bands considered in the present document for WPT systems below 30 MHz are listed in Radio Regulations [i.10] (Edition 2016), Article 5 "Frequency Allocations").
- The current European allocation in the frequency bands, see ERC Report 25 [i.27] and/or efis database (https://www.efis.dk/).

7.2.1.2 Sharing and compatibility studies already available

Sharing and compatibility studies have already been conducted to assess the impact of inductive systems on radio devices:

- ERC Report 44 (1997) [i.21]:

  This report was the basis for the inductive limits currently available. This report proposes to divide the frequency band 9 - 135 kHz into sub-bands in order to minimize the risk of interference and to ensure enough suitable frequencies for both services; the higher field strength level with 72 dBµA/m at 10 m at 0,03 MHz decreasing at 3,5 dB/octave are proposed to be allowed in the bands 9 - 70 kHz and 119 - 135 kHz and 42 dBµA/m at 10m distance in the 70 - 119 kHz range.

- ECC Report 67 (2005) [i.22]:

  The report analyses the feasibility to establish a new generic limit of -5 dBµA/m @ 10 m measured in a 10 kHz bandwidth in the frequency range 148,5 kHz to 30 MHz. The report proposes a maximum field strength of -15 dBµA/m @ 10 m in a bandwidth of 10 kHz allowing a total field strength up to -5 dBµA/m @ 10 m for systems with an operating bandwidth larger than 10 kHz whilst keeping the density limit above.

- ECC Report 135 (2009) [i.4]:

  The report considers a possible relaxation of the limits for the magnetic field strength for inductive applications operating in the frequency range 70 - 90 kHz from 42 dBµA/m to approximately 68 dBµA/m. It was concluded that, with reduced limits in a few bands (see figure 3 and table 3 in ECC Report 135 [i.4]), harmful interference would not appear outside a radius of about 100 m around the proposed inductive devices. As a consequence of this report, EC Decision 2013/752/EU [i.3], ERC/REC 70-03 [i.2] and also ETSI EN 300 330-1 [i.1] were modified to fit the revised limit of approximately 68 dBµA/m (at 70 kHz, descending with 3 dB/octave).

- ECC Report 001 (2002) [i.23]:

  This report assesses the impact of RFID transponders transmitting a field strength of -40 dBµA/m at 10 m distance on primary and secondary services. The report concludes that there is no harmful interference expected.

- ERC Report 69 [i.24]:

  Inductive short range radio systems are increasingly being introduced into the frequency bands below 30 MHz. These systems are normally allowed to operate on a non-interference basis to existing services, after appropriate compatibility studies have been made. The ERC could not identify a suitable propagation model for inductive systems which is necessary for the compatibility studies. There is no suitable model available in ITU-R, although there is some relevant information. With the assistance of manufacturers of inductive systems, the ERC has produced the Report 69 on a propagation model and interference range calculation for use in compatibility studies concerning inductive systems in the frequency range 10 kHz - 30 MHz.

- Recommendation ITU-R SM.2028 [i.13]:

  This Recommendation addresses the compatibility between inductive systems operating at frequencies below 30 MHz and the existing radiocommunication services and provides a summary of a straightforward procedure to calculate the protection distance to protect radiocommunication services with regard to interference by inductive systems.

- Report Recommendation ITU-R SM.2180 [i.14]:

  The industrial, scientific and medical (ISM) equipment for non-communications applications has been extensively used for various purposes, i.e. drying, melting, heating, welding, defrosting, cooking, tempering, soldering, brazing, moulding, imaging, and so on.

  It is expected that both ISM equipment and radio transceivers are used in close proximity with each other since the number of these RF devices is increasing. Thus, there is a need to examine impact of ISM equipment on radio services.

- Report Recommendation ITU-R SM.2028-2 [i.15]:

  In this report background information on a Monte Carlo radio simulation methodology is given. Apart from giving general information this text also constitutes a specification for the first generation of spectrum engineering advanced Monte Carlo analysis tool (SEAMCAT) software which implements the Monte Carlo methodology applied to radiocommunication interference scenarios.

7.2.1.3 Sharing and compatibility issues still to be considered

It should be considered, that the location of receivers are relevant. Some countries have abandoned transmitting within Europe, however the broadcast service is still being received throughout the EU.

Former/existing sharing studies were conducted for inductive devices in the frequency range 9 kHz to 148,5 kHz under the assumption that the current long wave radio receivers are not used in an area of about 100 m around short range devices considered, with the exclusion of 5 frequencies used for standard frequency and time signal service. This assumption needs to be confirmed for WPT devices. Since the broad expected use of WPT, those systems can be virtually everywhere, in households, in commercial and industrial areas, but also in cars, planes or on board ships.

Furthermore it is very likely to have multiple WPT systems in close proximity. Such a situation may i.e. occur in households (smart kitchen and multiple charging applications), but also in the street, where i.e. parking lots offer car charging in every slot. Multiple e-bike charging may also be an application where a large number of primary coils are in close proximity (i.e. 20 cm).

There is a public discussion arising to reintroduce new eLORAN systems for radiolocation on ships due to the fact, that GPS poses a high risk of locally being disturbed or manipulated (see: http://www.reuters.com/article/us-shipping-gps-cyber-idUSKBN1AN0HT).

7.2.2 System parameters

The present document covers WPT systems which consist of:

1) A primary device, with possible additional communication capability to control the charge function in conjunction with the receiving part.

   The power transmitter could also be named as transmitter, charger or base station.

2) A secondary device which supplies the received energy to a battery or device and performs a control/supervision function for the battery status and charge operation.

   The power receiver could also be named as receiver, battery or mobile device.

Both parts in combination are able to transmit and receive data in addition to the power transmission mode e.g. to control the battery status and to optimize the transmission mode.

Because of the close interaction and distance between charger and battery the emission requirements are applied to the WPT as a system, and not individually to the transmitter/primary coil and the receiver/secondary coil.

Technical parameters are provided in clause 7.1.2.

7.3 Information on relevant standard(s)

7.3.1 Standard overview

Table 6 provides an overview of standards for WPT. Table 6 also contains EMC standards due to the agreement between ETSI and CENELEC from 2012 for the division of work for WPT:

- Case 1) when the charging device operates without a data communication function between the charger and the charge receiving device, then the EMC standards can define an adequate path for compliance.

- Case 2) when a data communication function exists between the charger and the charge receiving device at the same frequency as the charging energy transfer, then additionally the R&TTE (SRD) framework and applicable EN can provide an adequate path for compliance.

It should be noted that the EMC standards from CISPR/CENELEC are providing electromagnetic radiation disturbance limits and the radio standards from ETSI limits for wanted and unwanted emissions.

Table 6: Overview of standards for WPT

Standard	EC Directive and related listed version of the standard	Comments
ETSI EN 300 330 [i.1] (SRDs 9 kHz bis 30 MHz)	R&TTE: ETSI EN 300 330-2 (V1.6.1) [i.30] RED: ETSI EN 300 330 (V2.1.1) [i.1]	This standard covers Generic Short range Devices including transmitters and receivers operating in the range from 9 kHz to 25 MHz and inductive loop transmitters and receivers operating from 9 kHz to 30 MHz. WPT is not excluded in the scope of this standard. It includes limits for wanted emissions according to EC Decision for SRDs [i.3] and ERC REC 70-03 [i.2] and limits for unwanted emissions according to ERC/REC 74-01 [i.7].
ETSI EN 303 417 [i.11] (WPT in the frequency ranges 19 - 21 kHz, 59 - 61 kHz, 79 - 90 kHz, 100 - 300 kHz, 6 765- 6 795 kHz)	New standard for RED; voting ended at 14 August 2017, the vote was successful and ETSI published the EN. But no listing within OJEU.	This standard covers wireless power transmission systems which are regarded as radio equipment since including inherent radio communication functionality or radiodetermination via the WPT interface or port at the specific WPT frequency ranges. It includes limits for wanted emissions according to EC Decision for SRDs [i.3] and ERC REC 70-03 [i.2], but only for the frequency ranges 19 - 21 kHz, 59 - 1 kHz, 79 - 90 kHz, 100 - 300 kHz, 6 765 - 6 795 kHz and limits for unwanted emissions according to ERC/REC 74-01 [i.7]
CENELEC EN 55011 [i.25] Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EMCD CENELEC EN 55011: 2009/A1: 2010 [i.25] New version with WPT limits below 150 kHz under development at CISPR/B (CISPR11)	The published version from 2010 contains electromagnetic radiation disturbance limits (magnetic field) below 150 kHz only for induction cooking applications for commercial use. This standard classifies all radiated limits as electromagnetic radiation disturbance limits, while radio standards differentiate between wanted and unwanted emissions. Currently the draft CISPR 11 [i.19] standard propose limits for WPT systems generic: from 150 kHz to 30 MHz. EV-WPT only: 9 kHz to 30 MHz.
CENELEC EN 55014-1 [i.26] Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission	EMCD CENELEC EN 55014-1:2006 + A1:2009 + A2:2011 [i.26] New version under development at CISPR/F	The published version from 2011 contains electromagnetic radiation disturbance limits (magnetic field) below 150 kHz only for induction cooking applications for commercial use (same limits as in CENELEC EN 55011 [i.25]). A new version of this standard is under development and there it is proposed to include the limits for inductions cooking applications for commercial use also for the IPT (inductive power transfer) function. (see CISPR/F/710/CD [i.17]). For limits overview see figure 8.

Standard	EC Directive and related listed version of the standard	Comments
CENELEC EN 55015 [i.27] Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment	EMCD CENELEC EN 55015:2013 [i.27] New version under development at CISPR/F	There are limits for electromagnetic radiation disturbance from 9 kHz to 30 MHz contained but as a current limit (dBµA) which is induced by the lighting equipment into a loop antenna with a size between 2 m and 4 m.
CENELEC EN 55032 [i.28] Electromagnetic compatibility of multimedia equipment - Emission Requirements	EMCD CENELEC EN 55032: 2012/AC:2013 [i.28] New version under development at CISPR/I	A new version of this standard is under development and there it is proposed to include the limits for inductions cooking applications from CISPR 11 [i.19] also for the WPT function (CISPR/I/542/DC) [i.31]. Limits overview see figure 9.
IEC 62827-2 [i.31]/Ed.1.0		WPC specifications are listed as IEC standard IEC PAS 63095-1:2017 [i.16] for power class 0. Qi Specification (WPC): The frequencies used by the Qi specification [i.16] ranges from 87 kHz up to 205 kHz. There are emerging applications under development (such as two new Power Classes being actively developed), and operation at frequencies above or below this existing range may need to be considered. As technology advances, higher frequencies (approaching to 500 kHz) may become beneficial when previously it was not commercially feasible.

7.3.2 Overview current/proposed limit requirements for WPT

A comparison of current/proposed limits for WPT is given below (status November 2017):

- Figure 5: Emission limits from ERC REC 70-03 Annex 9 [i.2] and ETSI EN 303 417 [i.11], including spurious limits from ERC REC 74-01 [i.7] for inductive SRDs.
- Figure 6: Emission limits from ETSI EN 303 417 [i.11] within the range of 50 - 205 kHz.
- Figure 7: Electromagnetic radiation disturbance limits from CENELEC EN 55011 [i.25], ERC REC 70-03 [i.2] and ERC REC 74-01 [i.7].
- Figure 8: Comparison CISPR 14-1 (CISPR/F/710/CD) [i.17], and ERC REC 70-03 [i.2].
- Figure 9: Comparison CISPR 32 (CISPR/I/542/DC) [i.18], and ERC REC 70-03 [i.2].

And for information:

- Figure 10: Comparison CISPR 11 (CDV) [i.19] for WPT-EV and ETSI EN 303 417 [i.11] (all use-cases).

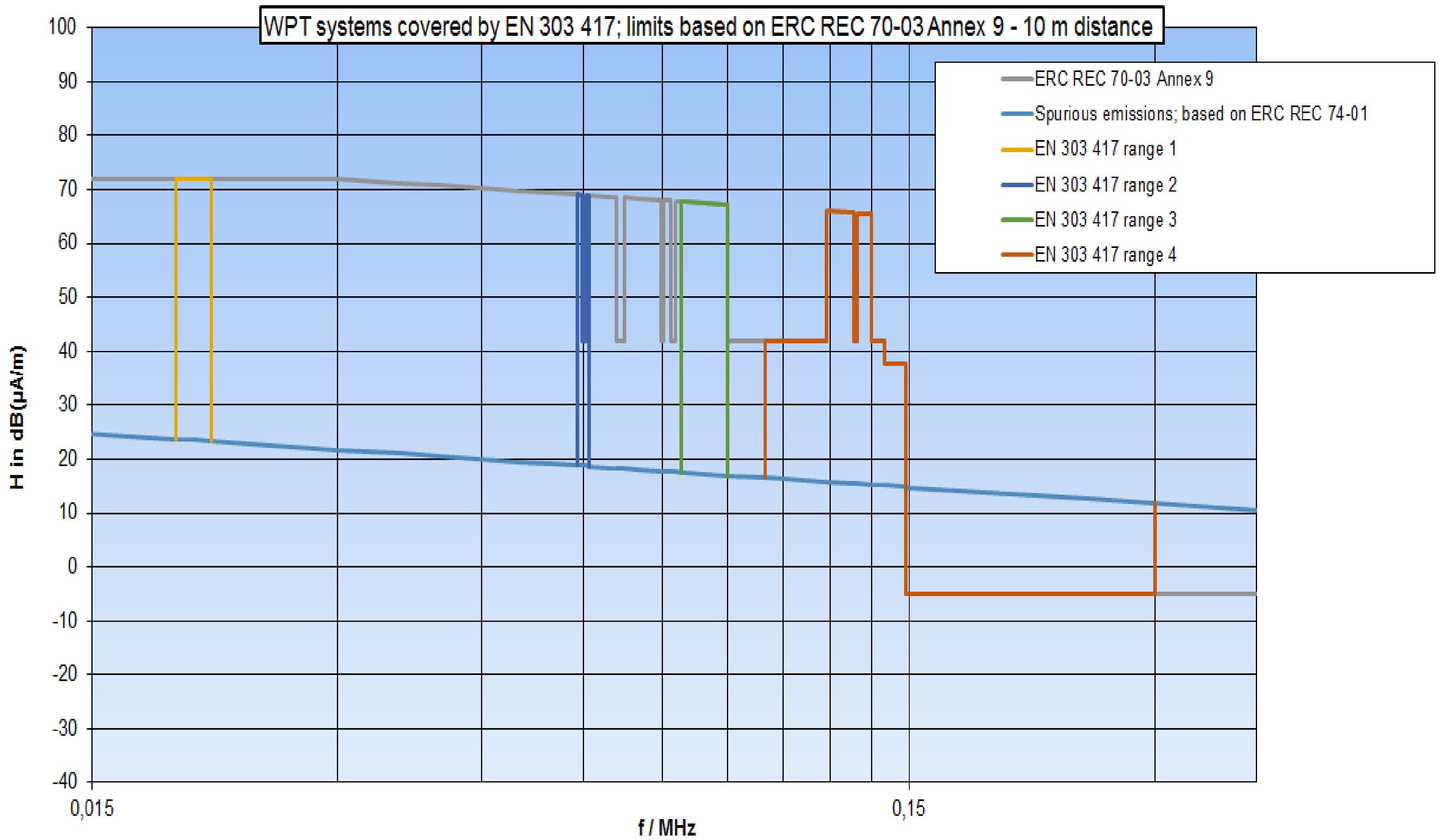

Figure 5: Emission limits from ETSI EN 303 417 [i.11] and ERC REC 70-03 [i.2] and ERC REC 74-01 [i.7]

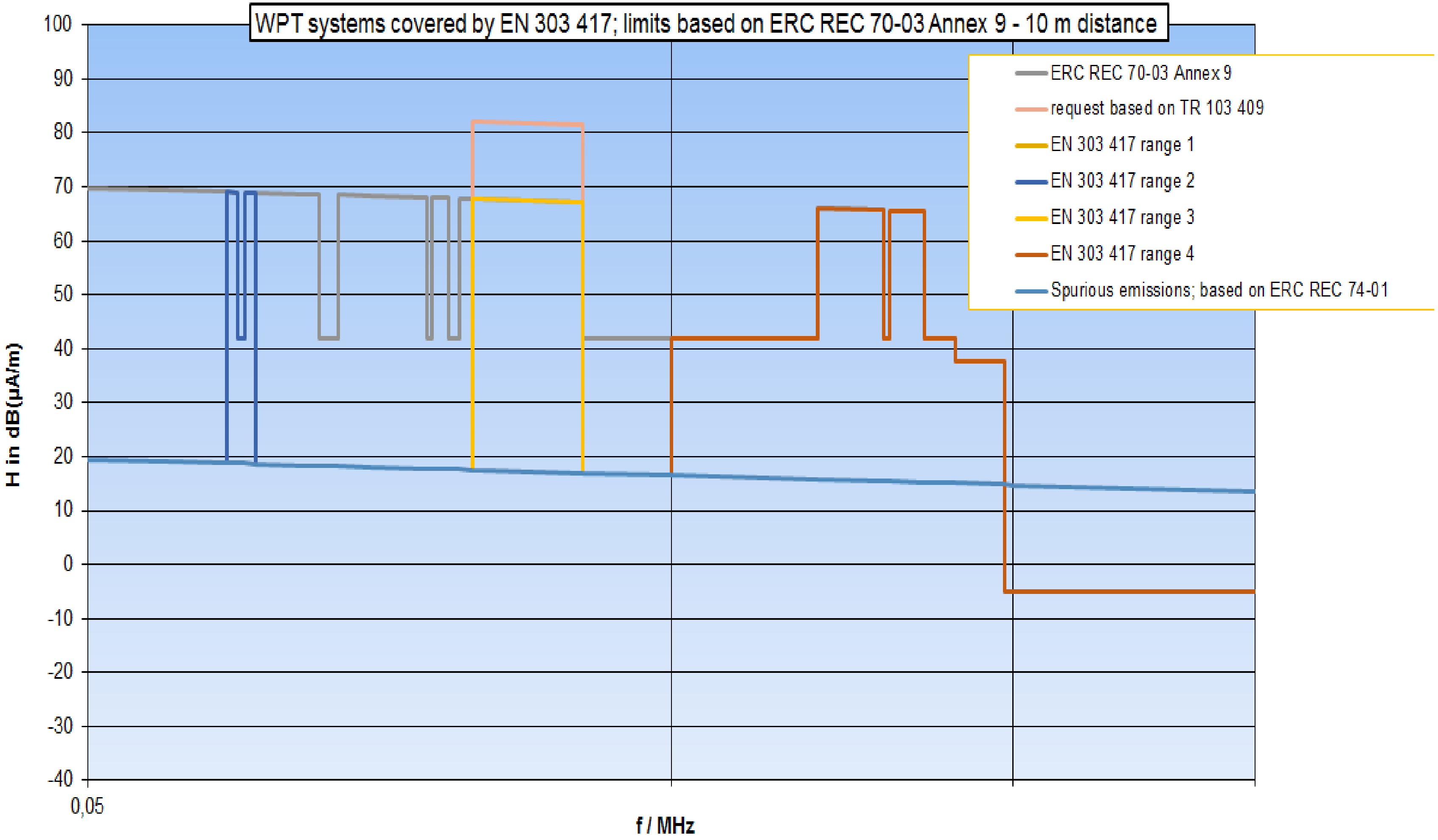

Figure 6: Emission limits from ETSI EN 303 417 [i.11]

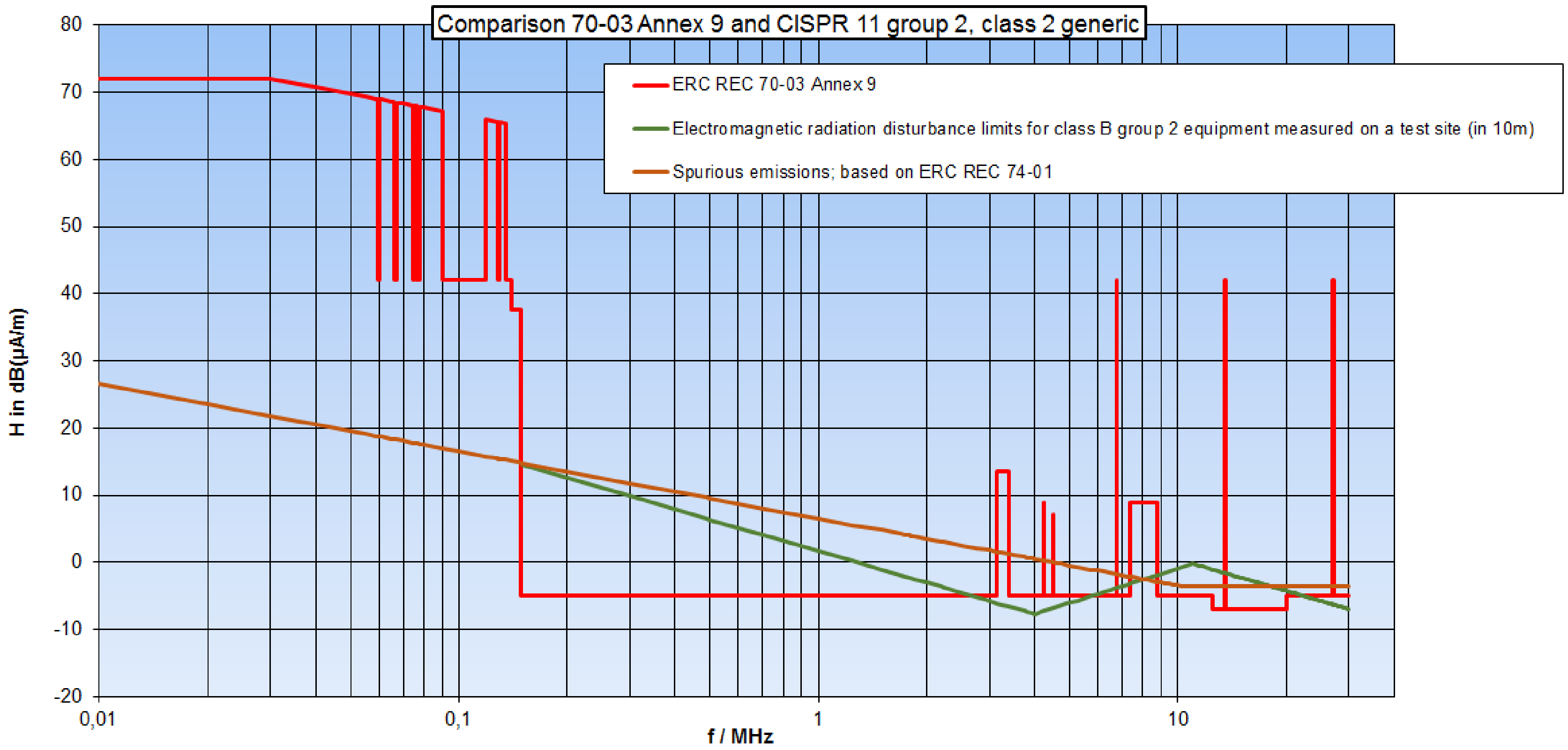

Figure 7: Electromagnetic radiation disturbance limits from CENELEC EN 55011 [i.25], ERC REC 70-03 [i.2] and ERC REC 74-01 [i.7]

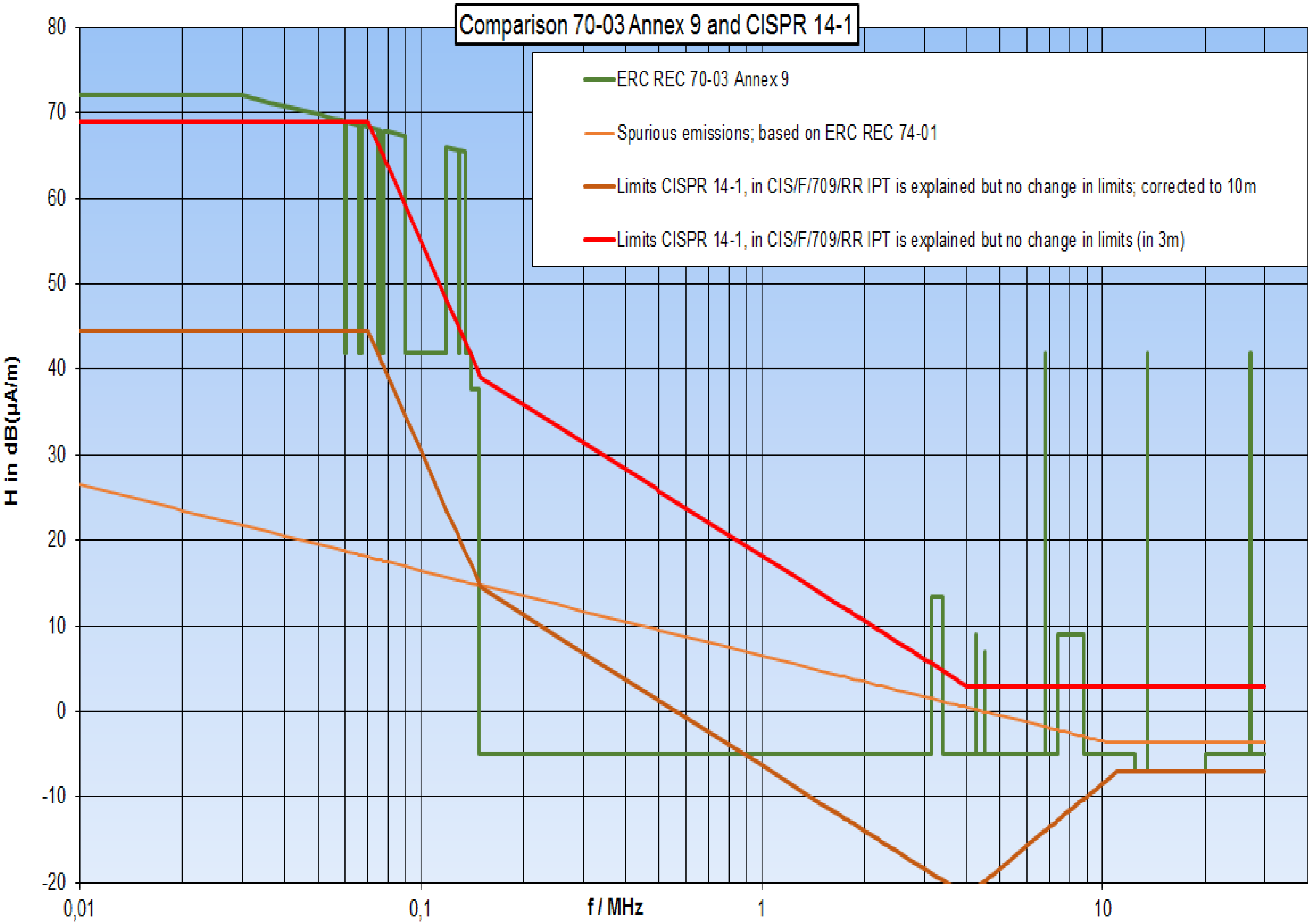

Figure 8: Comparison CISPR 14-1 [i.17], and ERC REC 70-03 [i.2]

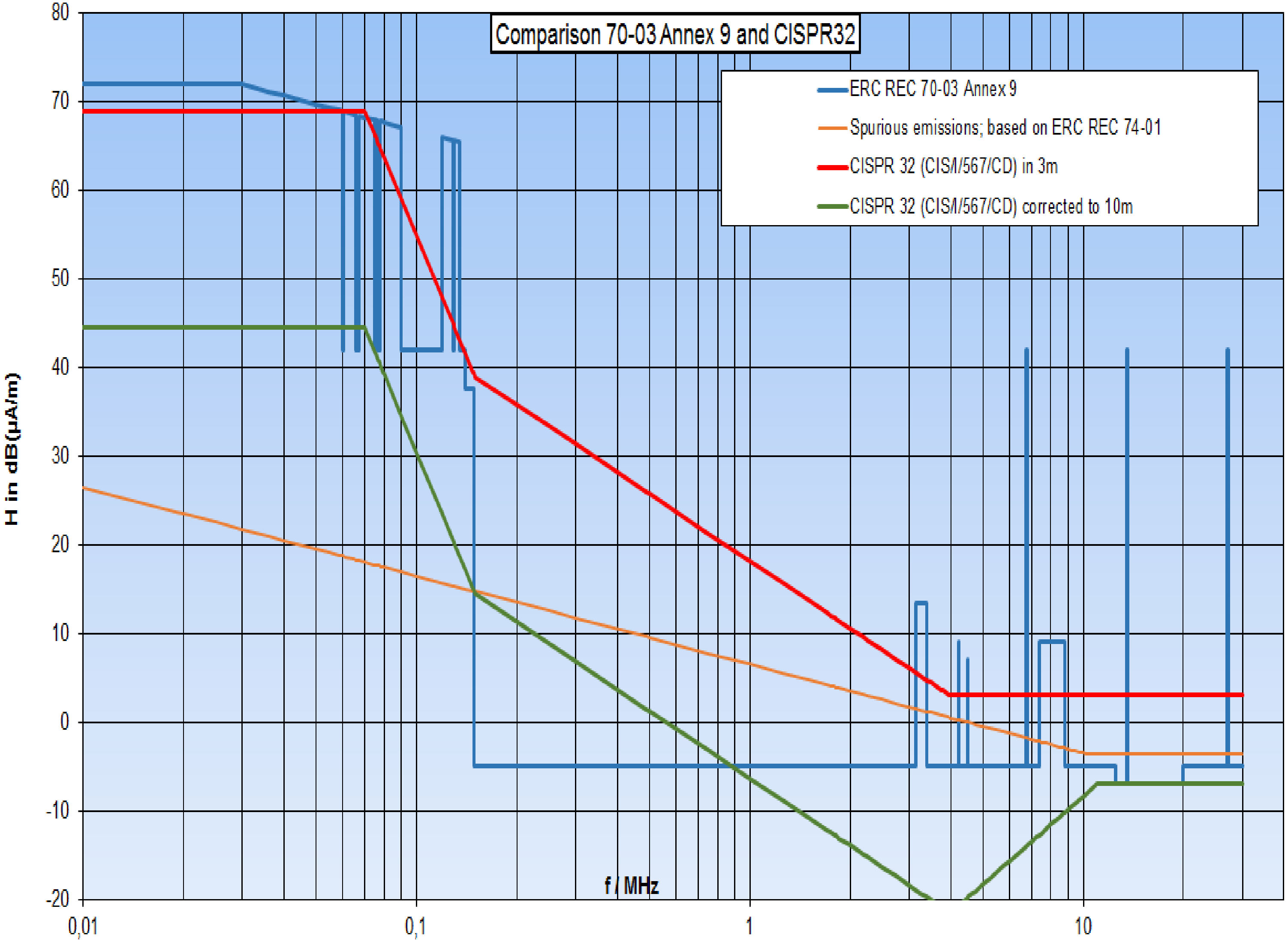

Figure 9: Comparison CISPR 32 [i.18] and ERC REC 70-03 [i.2]

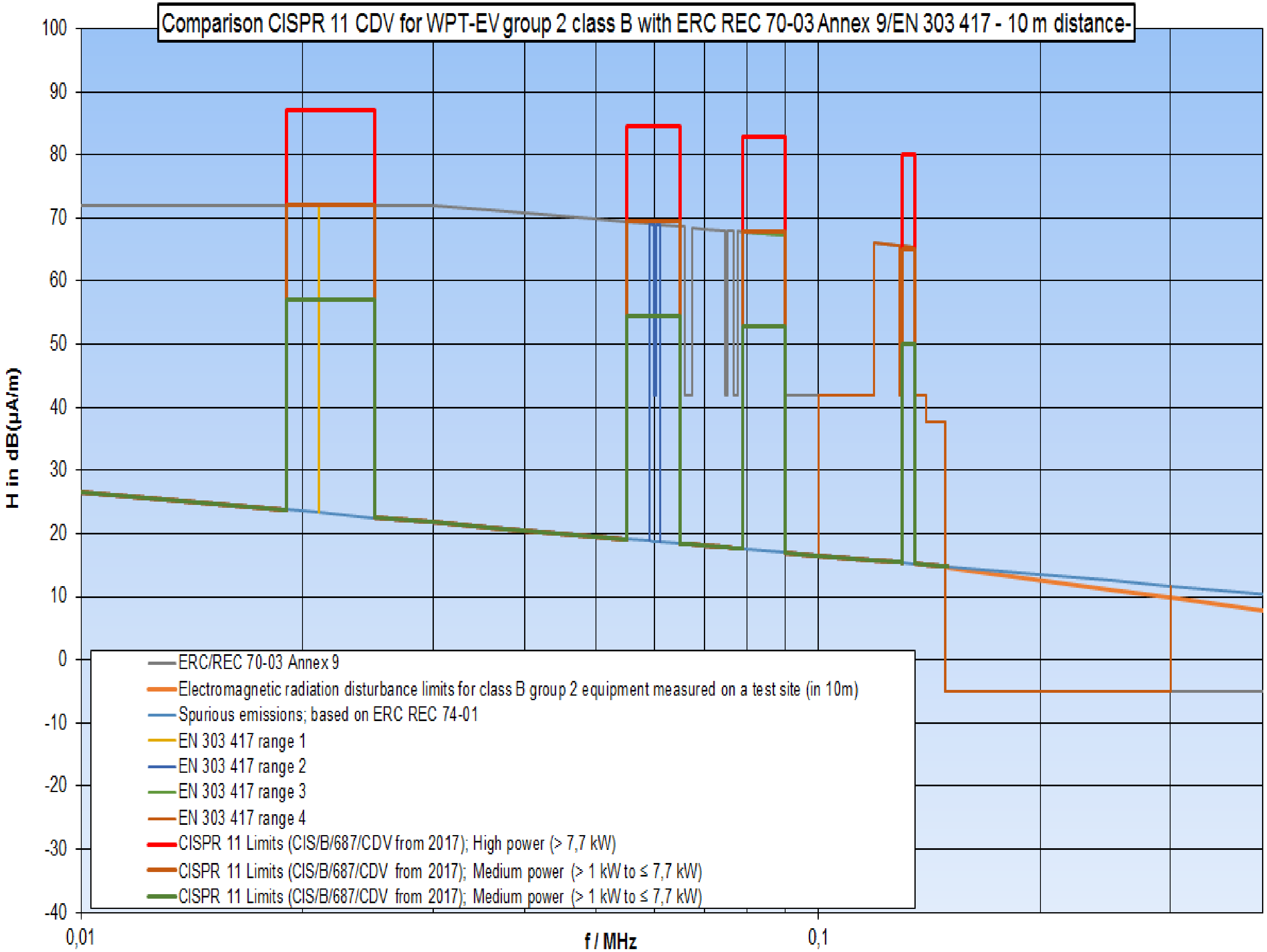

Figure 10: Electromagnetic radiation disturbance limits for WPT proposed for WPT-EV in CISPR 11 [i.19] and ETSI TR 103 409 [i.20]

8 Radio spectrum request and justification

Based on the analysis of the needs of WPT systems other than WPT-EV in the present document it is proposed to introduce different WPT limits and frequency ranges according to the transferred energy/power level and the according use cases. The proposal is summarized in table 7.

Table 7: Summary Overview: Frequency Bands and Power Classes for WPT

Band	Frequency [kHz]	P < 31,5 W (field strength @ 10 m)	P 31,5 - 200 W (field strength @ 10 m)	P 0,2 - 2,4 kW (field strength @ 10 m)	P 2,4 - 20 kW
		WPT Mobile consumer devices	WPT Mobile consumer devices	WPT Kitchen, Lighting	WPT-EV
1	20 - 79			< 42 dBµA/m	
2	79 - 90				(note 1)
3	90 - 205 with:				
	90 -119	< 42 dBµA/m	< 42 dBµA/m		
	119 - 135	< 42 dBµA/m	< 66 dBµA/m		
	135 - 140	< 42 dBµA/m	< 42 dBµA/m		
	140 - 148,5	< 37,7dBuA	< 37,7 dBuA or		
	148,5 - 205	< -15 dBµA/m (Note 2)	introduce a transition area between 148,5 and 205/300 kHz e.g. a linear slope from 37,5 at 148,5 kHz and -15 at 300 kHz.		
4	300 - 500	< -15dBµA/m (Note 2)			
5	900 - 1 000	< -15dBµA/m (Note 2)			
6	2 050 - 2 150	< -15dBµA/m (Note 2)			
7	6 765 - 6 795	< 42 dBµA/m			
8	13,553 - 13,567 MHz	< 42 dBµA/m			

NOTE 1: Covered by ETSI TR 103 409 [i.20], WPT-EV (outside the scope of the present document).
NOTE 2: The maximum allowed total field strength is -5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (-15 dBµA/m in a bandwidth of 10 kHz).

It should be noted that currently the following frequency ranges are studied within ITU-R SG1 and therefore these ranges have the highest potential for world-wide harmonisation:

- 19 - 21 kHz;
- 59 - 61 kHz;
- 79 - 90 kHz;
- 100 - 300 kHz; and
- 6,765 - 6,795 MHz.

It is important that there is a significant choice in available spectrum for wireless power transfer as the choice on frequency is very closely related to the size and form of the device to be charged. In some instances generic chargers, although desirable may not be suitable for applications and therefore specific charging docks would be designed and needed to ensure the best customer experience.

9 Regulations

9.1 Current regulations

9.1.1 EC/ECC

Table 8 provides and overview of the frequency assignment for inductive SRDs which are relevant for the present document.

Table 8: Harmonised frequency bands and technical parameters for inductive devices according to the ERC/REC 70-03 [i.2]

Frequency range (kHz)	Field strength limit (dBµA/m at 10m distance)	Notes
9 - 90	72 (see note)	Field strength level descending 3 dB/oct at 30 kHz
90 - 119	42	
119 - 135	66 (see note)	Field strength level descending 3 dB/oct at 119 kHz
135 - 140	42	
140 - 148,5	37,7	
148,5 - 5 000	-15	The maximum field strength is specified in a bandwidth of 10 kHz. The maximum allowed total field strength is -5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (-15 dBµA/m in a bandwidth of 10 kHz)
6 765 - 6 795	42	
13 553 - 13 567	42	
NOTE: The limit is reduced to 42 dBµA/m at 10 m according to table 7.		

Table 9: Standard frequency and time signals to be protected within 9 - 90 kHz and 119 - 135 kHz

Stations	Frequency	Protection bandwidth	Maximum field strength at 10 m	Location
MSF	60 kHz	+/-250Hz	42 dBuA/m	United Kingdom
RBU	66.6 kHz	+/-750Hz	42 dBµA/m	Russian Federation
HBG	75 kHz	+/-250Hz	42 dBµA/m	Switzerland
DCF77	77.5 kHz	+/-250Hz	42 dBµA/m	Germany
DCF49	129.1 kHz	+/-500Hz	42 dBµA/m	Germany

These frequency assignments are applying for inductive devices, which is a category of Short Range Devices according to EC Decision for SRDs [i.3]. The definitions according to [i.2] and [i.3] are:

- Inductive devices in note 14 of [i.3]: The inductive device category covers radio devices that use magnetic fields with inductive loop systems for near field communications. Typical uses include devices for car immobilisation, animal identification, alarm systems, cable detection, waste management, personal identification, wireless voice links, access control, proximity sensors, anti-theft systems, including RF anti-theft induction systems, data transfer to hand-held devices, automatic article identification, wireless control systems and automatic road tolling.

- Scope of Annex 9 of ERC/REC 70-03: This annex covers frequency bands and regulatory as well as informative parameters recommended for inductive applications including for example car immobilisers, radio frequency identification (RFID) applications including for example automatic article identification, asset tracking, alarm systems, waste management, personal identification, access control, proximity sensors, anti-theft systems, location systems, data transfer to handheld devices (e.g. NFC) and wireless control systems, animal identification, cable detection, wireless voice links, automatic road tolling and anti-theft systems including RF anti-theft induction systems (e.g. EAS). It should be noted that other types of anti-theft systems can be operated in accordance with other relevant annexes.

Systems used for the wireless transmission of energy are not mentioned in these definitions.

9.2 Proposed regulation and justification

Table 10 shows the proposed new WPT entries for all kind of WPT (non WPT-EV) systems for ERC Recommendation 70-03 (for the planned new Annex for WPT). In table 10 the requested requirements for WPT-EV (see [i.20]) was added for information.

Table 10: Proposed regulation for WPT

Frequency range kHz	**Existing limit for inductive SRDs [dBµA/m at 10 m]**	**Proposed limit for WPT up to 31,5 W [dBµA/m at 10 m]**	**Proposed limit for WPT 31,5 to 200 W [dBµA/m at 10 m]**	**Proposed limit for WPT 200 W to 2 kW [dBµA/m at 10 m]**	**Proposed limit for WPT-EV [dBµA/m at 10 m]**
Examples for applications	**Generic WPT / non WPT-EV**				WPT for Electric vehicles
	Generic SRDs	WPT Mobile consumer devices	WPT Mobile consumer devices	WPT Kitchen, Lighting	
20 - 79	72 descending 3 dB/oct at 3 kHz (Note 1)			42	
79 - 90					82 descending 3 dB/oct at 79 kHz (note 3)
90 - 119	42	42	42		
119 - 135	66 descending 3 dB/oct at 119 kHz (note 1)	42	66 descending 3 dB/oct at 119 kHz (note 1)		
135 - 140	42	42	42		
140 - 148,5	37,7	37,7	37,7		
148,5 - 205	-15 (note 2)	- 15 (note 2)	introduce a transition area between 148,5 and 205/300 kHz e.g. a linear slope from 37,5 at 148,5 kHz and -15 at 300 kHz		
205 - 300					
300 - 500		- 15 (note 2)			
500 - 900					
900 - 1 000		- 15 (note 2)			
1 000 - 2 050					
2 050 - 2 150		- 15 (note 2)			
2 150 - 5 000					
6 765 - 6 795	42	42			
13 553 - 13 567	42	42			

NOTE 1: The limit is reduced to 42 dBµA/m at 10 m according to table 9.
NOTE 2: The maximum field strength is specified in a bandwidth of 10 kHz. The maximum allowed total field strength is -5 dBµA/m at 10 m for systems operating at bandwidths larger than 10 kHz whilst keeping the density limit (-15 dBµA/m in a bandwidth of 10 kHz).
NOTE 3: Covered by ETSI TR 103 409 [i.20], WPT-EV (outside the scope of the present document).

Annex A: Information about the status and history of WPT in ITU

The ITU Radiocommunication Assembly RA-97 approved a question on "Wireless Power Transmission" (Question ITU-R 210/1) in 1997. WP 1A agreed at its meeting in June 2012 to revise the question with a deadline of 2014 for completion of studies as Question ITU-R 210-3/1 [i.8].

In June 2013, WP 1A started developing a working document towards preliminary draft new Report ITU-R SM.[WPT. non-beam] (Wireless power transmission using technologies other than radio frequency beam), a working document towards preliminary draft new Report ITU-R SM.[WPT.BEAM] (Wireless power transmission via radio frequency beam) and a working document towards a preliminary draft new Recommendation ITU-R SM. [WPT] (Wireless Power Transmission (WPT) systems) to address the requirements given in Question ITU-R 210-3/1 [i.8].

i) Report ITU-R SM.2303-2 [i.5] (06/2017) refers to "Tightly Coupled" WPT using inductive technologies and "Loosely Coupled" WPT using resonance technologies which do not use radio beam. At its June 2014 meeting, WP 1A approved the draft new Report ITU-R SM.[WPT.non-beam] and submitted to SG1 for final approval, which was adopted by SG1 as ITU-R Report SM.2303-1 [i.32] for publication.

   One year after the publication of ITU-R Report SM.2303-1 [i.32], WP 1A revised the report in June 2015, in particular for the purpose of inserting elements regarding the human hazards issue. The revised version of the report has been approved by SG1 at its June 2015 meeting and published as ITU-R Report SM.2303-1 [i.32].

ii) Recommendation ITU-R SM.2110-0 (09/2017) sets the technical characteristics, operating parameters, and frequency bands for portable/mobile WPT devices, electric vehicle WPT systems and home appliances WPT devices.

   WP 1A also established a Correspondence Group (CG) in June 2013 for further development of possible outputs mentioned above. CG worked until the June 2015 session of WP 1A and it was agreed in June 2015 to convert the CG into a Rapporteur Group in order to work more efficiently.

   The CG worked until June 2016 and submitted its report to WP1A. WP 1A approved the draft Recommendation, however, there was only one frequency band covered by the Recommendation and some European Countries did not agree to the publication of the Recommendation in 2016.

   WP 1A agreed not to publish it in 2016 with the condition that it should be approved for publication at the June 2017 meeting of WP1A and SG1. At the meeting of WP 1A and 1B, in November 2016, the CG was converted to a CG of both WP 1A and 1B. The work is still ongoing and the draft recommendation will be considered at the June 2017 session of WP 1A with the aim of finalizing and publishing the recommendation.

   After having the recommendation published, WP 1B will start its consideration of WPT for frequency management purposes in the light of report(s) and recommendation developed by WP 1A.

iii) In November 2015, a proposal was submitted to the World radiocommunication Conference (WRC-15) asking for studies to be conducted by ITU-R for the identification of suitable frequencies for the worldwide implementation of WPT systems. After long debates, WRC-15 agreed that this proposal should be considered within the context of "Urgent studies required in preparation for the 2019 World Radiocommunication Conference" and instructed the Director of the Radiocommunication Bureau to report on these studies under agenda item 9.1 of WRC-19, as appropriate, based on the results of studies. However, the agreement of the Conference was only for electric vehicles.

   Annex to ITU-Resolution 958 (WRC-15) [i.6] on "Urgent studies required in preparation for the 2019 World Radiocommunication Conference" defines the studies concerning Wireless Power Transmission (WPT) for electric vehicles, which asks for the following:

   a) to assess the impact of WPT for electric vehicles on radiocommunication services;

b) to study suitable harmonised frequency ranges which would minimize the impact on radiocommunication services from WPT for electrical vehicles.

These studies should take into account that the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO) and the Society of Automotive Engineers (SAE) are in the process of approving standards intended for global and regional harmonisation of WPT technologies for electric vehicles.

The first Conference Preparatory Meeting for WRC-19 Conference (CPM-19-1), held right after the WRC-15 Conference identified WP 1B as the responsible group and WP 1A as the contributing Group for the preparations on WPT for WRC-19 Conference. Preliminary studies started by WP 1B in 2016 on AI 9.1.6 (WPT for electric vehicles). A draft CPM text and a working document towards a preliminary draft new report ITU-R SM.[WPT.SPEC.MNGM] was developed. Recently, the title of the draft report has been changed to Report ITU-R SM.[WPT_EV_IMPACT] which will cover only the WPT for EV. A draft new report will soon be developed to cover the WPT applications other than WPT-EV.

Annex B: Bibliography

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NOTE: Available at http://www.efis.dk.

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History

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