# ETSI TR 103 409 V1.1.1 (2016-10)


**System Reference document (SRdoc);**
**Wireless Power Transmission (WPT) systems for Electric Vehicles (EV) operating in the frequency band 79 - 90 kHz**

Reference
DTR/ERM-556

Keywords
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***ETSI***

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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 includes 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 potential and status of Wireless Power Transmission (WPT) systems for Electric Vehicles (EV) - in the following called WPT-EV systems - and the need for regulatory and standard improvements.

Recent developments in the evolution of the WPT-EV technology, evolving ISO and IEC standards (e.g. ISO 19363 [i.15] and IEC 61980 [i.14]) as well as market developments and requirements in private, public, commercial and industrial areas have shown the need for amending ERC/REC 70-03 [i.2], annex 9 and the EC Decision 2013/752/EU [i.3].

Specifically, the present document proposes an H-field limit that is approximately 15 dB higher than what is given in the ERC/REC 70-03 [i.2] and EC Decision 2013/752/EU [i.3] for WPT-EV systems in the frequency band 79 - 90 kHz.

Other WPT applications in the frequency bands 19 - 21 kHz, 59 - 61 kHz, 100 - 300 kHz and 6,765 - 6,795 MHz can be covered by the existing regulations. Therefore, the present document does not propose any change in these bands.

# Introduction

Historically, ETSI EN 300 330-1 [i.1] and ETSI EN 300 330-2 [i.12] had been developed for Short Range Devices (SRD) in the band 9 kHz -30 MHz, like e.g. RFID systems operating at 13,56 MHz. When developing those standards, the primary intention was not to apply them also to WPT-EV systems. Despite that fact, WPT is explicitly mentioned in the scope of the latest revision of ETSI EN 300 330-1 (V1.8.1) [i.1] and thus the contained H-field emission limits are also applicable to WPT-EV systems. However, it was noted by the concerned industry that the H-field emission limits outlined there are not appropriate for high-power WPT-EV systems. Such systems can typically transmit power in the kilowatt range (e.g. 7,2 kW or 11 kW), which inevitably results in higher magnetic fields needed for the power transmission compared to low-power WPT systems which are e.g. used for charging mobile phones or toothbrushes. This issue is addressed in the present document.

It should be remembered that ERC/REC 70-03 [i.2] clearly notes in support of any requested changes: *"The pattern of radio use is not static. It is continuously evolving to reflect the many changes that are taking place in the radio environment; particularly in the field of technology. Spectrum allocations must reflect these changes and the position set out in this Recommendation is therefore subject to continuous review."*

# 1 Scope

The present document provides information on WPT-EV systems operating in the frequency band 79 - 90 kHz. It applies to inductive WPT systems as presently covered by the EC Decision 2013/752/EU [i.3] and the ERC/REC 70-03 [i.2], annex 9. 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-EV systems in the 79 - 90 kHz band.

The present document includes the necessary information to support the co-operation between ETSI and the 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 300 330-1: "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 1: Technical characteristics and test methods".

[i.2] ERC Recommendation 70-03 (30 September 2015): Relating to the use of Short Range Devices (SRD).

[i.3] 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.4] ETSI TR 102 756 (V1.1.1) (2008-10): "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document for revised spectrum requirements for RFID equipment and inductive loop systems operating in the frequency range 9 kHz to 148,5 kHz".

[i.5] ECC Report 135: "Inductive Limits in the Frequency Range 9 kHz to 148.5 kHz", Bordeaux, September 2009.

[i.6] ITU-R Report SM.2303-1 (06/2015): "Wireless power transmission using technologies other than radio frequency beam".

[i.7] Information and project report from the German national funded project "InterOp".

NOTE: Available at http://www.erneuerbar-mobil.de/de/projekte/foerderung-von-vorhaben-im-bereich-der-elektromobilitaet-ab-2012/kopplung-der-elektromobilitaet-an-erneuerbare-energien-und-deren-netzintegration/interop.

[i.8] Information and project report from the EU FP7-funded project "UNPLUGGED".

NOTE: Available at http://www.unplugged-project.eu.

[i.9] Information from the EU FP7-funded project "FABRIC".

NOTE: Available at http://www.fabric-project.eu.

[i.10] ITU-R Working Party 1A, Contribution 1A/4 (2016), Spectra of wireless power transfer base stations, Germany (Federal Republic of).

[i.11] IHS.

NOTE: Available at http://press.ihs.com/press-release/technology/high-growth-wireless-charging-market-matures-2016-ihs-says

[i.12] 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.13] CEPT/ERC/REC 74-01: "Spurious Emissions".

[i.14] IEC 61980 (parts 1 to 3): "Electric vehicle wireless power transfer (WPT) systems".

[i.15] ISO 19363: "Electrically propelled road vehicles - Inductive wireless connection to an external electric power supply - Interoperability and Safety requirements".

[i.16] SAE J2954: "Hybrid Wireless Charging".

[i.17] Question ITU-R 210-3/1: "Wireless power transmission".

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

[i.18] ETSI EN 303 417: "Wireless power transmission using technologies other than radio frequency beam Harmonised Standard covering the essential requirements of art.3.2 of the Directive 2014/53/EU".

[i.19] Final Acts of ITU World Radiocommunication Conference WRC-15

[i.20] ITU Radio Regulations Edition 2012.

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

**Electric Vehicle (EV):** car that is propelled by an electric motor drawing current from a rechargeable storage battery or from other portable energy storage devices (rechargeable, using energy from a source off the vehicle such as a residential or public electric service), which is manufactured primarily for use on public streets, roads or highways

**primary device:** device (external to the EV) which provides the contactless coupling to the secondary device

**secondary device:** device mounted on the EV which provides the contactless coupling to the primary device

**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:

| | |
|---|---|
| P | Power |
| f | frequency |
| H | magnetic field strength |

## 3.3 Abbreviations

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

| | |
|---|---|
| CD | Committee Draft |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| CG | Correspondence Group |
| CISPR | Comité International Spécial des Perturbations Radioélectriques |
| ECC | Electronic Communications Committee |
| EMC | ElectroMagnetic Compatibility |
| ERC | European Research Council |
| EV | Electric Vehicle |
| FCC | Federal Communications Commission |
| FM | Frequency Modulation |
| GPS | Global Positioning System |
| IEC | International Electrotechnical Commission |
| IHS | Information Handling Services |
| ISM | Industrial Scientific Medical |
| ISO | International Standards Organization |
| LED | Light Emitting Diode |
| LS | Liaison Statement |
| PDN | Preliminary Draft New |
| RA | Radiocommunication Assembly |
| REC | RECommendation |
| RES | RESolution |
| RFID | Radio Frequency IDentification |
| RR | Radio Regulations |
| SAE | Society of Automotive Engineers |
| SDO | Standards Development Organization |
| SRD | Short Range Device |
| TIR | Technical Information Report |
| WD | Working Draft |
| WP | Working Party |
| WPT | Wireless Power Transmission |
| WPT-EV | Wireless Power Transmission for Electric Vehicles |
| WRC | World Radio Conference |

# 4 Comments on the System Reference Document

IARU (International Amateur Radio Union) submitted the following comment:

*"IARU has the concerns about the implication of WPT charging for electric vehicles will densely populate residential areas and thus shortwave reception will be compromised significant. The spurious domain limits provided in ETSI EN 300 330 do not protect shortwave reception for some reasons. First the limits have been designed to reflect only sparsely populated scenarios since the number of high power SRD applications is very limited in residential areas now. In future however every household will use a WPT charging device. Secondly the H-Field measurement and limitation in the spurious domain does not catch any emission transmitted by a common mode current on the line to the coil or be the apparatus itself (enclosure port). Those spurious currents exist and will be radiated as near electric field due to the large size of the whole apparatus. IARU suggests a thorough compatibility study."*

# 5 Background information

## 5.1 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.

An overview of frequency ranges used by WPT systems worldwide (below 30 MHz) is given below:

- 19 - 21 kHz; 59 - 61 kHz: WPT systems for trucks/buses, (typically > 20 kW) - used in Korea and UK (Milton Keynes)
- 79 - 90 kHz: WPT systems for EV (passenger cars), (typically 3,7 kW - 20 kW) - used worldwide
- 100 - 300 kHz: WPT systems for consumer devices (typically < 150 W) - used worldwide
- 6,765 - 6,795 MHz: WPT systems for consumer devices, (typically < 50 W) - used worldwide

Worldwide use does not mean that the technical requirements for these frequency bands are harmonised.

## 5.2 The WPT technology

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.

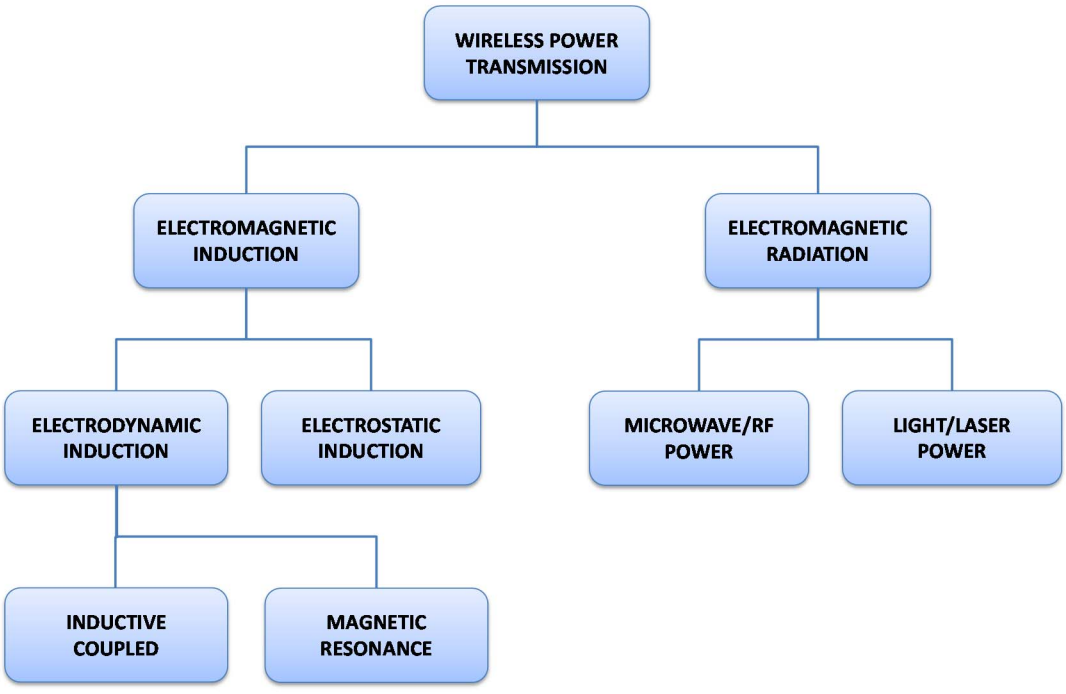


**Figure 1: Methods of wireless power transmission (WPT)**

The present document deals only with WPT based on the principle of electromagnetic induction. Wireless power transmission using electromagnetic radiation is out of the scope of the present document.

More background about the history of WPT and the technical and physical principles of WPT can be found in Recommendation ITU-R Report SM.2303 [i.6].

## 5.3 Applications developed for use of WPT technologies

### 5.3.1 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.

### 5.3.2 WPT for mobile devices

Inductive - or sometimes also called 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) or 6,765 - 6,795 MHz (based on standards developed by the AirFuel Alliance).

### 5.3.3 WPT for Home appliances

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, healthcare devices and power tools.

As with the mobile devices, 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.

### 5.3.4 WPT for Electric vehicles

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

## 5.4 The societal benefits

WPT systems in general could reduce the demand for power cables while making gadgets more durable and perhaps even accelerate the adoption of electric cars.

Many people would like to buy an electric car but are dogged by doubts about whether it has the range to get where they want to go, or worry that plugging it in will be a hassle. WPT-EV systems could blunt both of these concerns - and even make the gas station burdensome by comparison.

Several companies are developing wireless hubs for electric car charging. By placing a transmission coil on the ground and a receiver coil underneath the car, an EV driver could charge by simply parking his car. Looking even further ahead, some researchers are exploring the idea of embedding resonant coils in the roadway itself, meaning that a car could charge itself while driving.

In terms of efficiency, WPT-EV systems have their benefits. WPT-EV systems could even be more efficient than standard charging, with intelligent systems that identify devices and monitor the power level, and turning off the power when a device is charged. Energy is a valuable resource and should be used with as much restraint as possible. Having an energy source that uses "smart" technology in terms of only using power needed and no more, is going to maximize use of generated energy. This indirectly reduces the dependence on fuels. In terms of the ethics of energy conservation, doing away with extreme energy consumption and reducing use of energy in general allows wireless power to become an environmentally sound technology that has the potential to be implemented on a wide scale.

Electric vehicle charging is a potential application of near field wireless power on a large scale which can be used for charging also hybrid cars. Instead of having a wire plug in for these vehicles, as currently exists today, the wireless technology can be integrated into parking lots and bus stations, allowing charging to occur instantly and without the actual effort of "plugging in". This would allow a seamless integration of hybrid and electric cars into commercial use on a large scale. This would not only save time and reduce servicing logistics, but also have environmental implications by reducing the carbon footprints of each vehicle since power will be generated electrically as compared to with fuel. Clearly, the environmental implications of WPT-EV systems are large and far-reaching but the ethical benefits extend to health benefits as well.

# 6 Market information

## 6.1 General

### 6.1.1 WPT systems for charging consumer devices

Such systems are already available on the market since a few years. They are getting more and more popular for the easy and convenient charging of e.g. power tools, mobile phones or toothbrushes. As an example, inductively charged power tools operating in the range 110 - 148 kHz are existing on the market today at least in the USA, Canada and the EU. Those systems are currently regulated under existing rules, which means e.g. RS216 Issue 2 for Canada, FCC Part 15 for the USA and for the EU/CEPT, see [i.2] and [i.3].

According to IHS [i.11], the wireless charging receiver market grew more than 160 percent in 2015 over the previous year, as annual global shipments reached 144 million units. Integrated receivers hit mainstream devices, and refinements to system design and diversification for various applications and power ratings is now driving the development of the technology. Annual shipment volume is expected to top one billion units by 2020 and two billion by 2025.

### 6.1.2 WPT-EV systems

Such systems are currently in pre-series production stadium. Several field trials and prototypes were shown in the past 5 years, e.g. in the German national funded project "InterOp" from the year 2012 - 2015 [i.7], or in the FP7-funded European project "UNPLUGGED", also from 2012 - 2015 [i.8]. Other currently ongoing projects follow up on certain aspects of these projects, like "dynamic" wireless charging, i.e. charging of the EV while it is driving. Worth mentioning in this context is e.g. the FP7.funded project "FABRIC" [i.9]. The market entry, i.e. first series-EV which will be commercially available with wireless battery charging, are expected for 2017. For a broad market deployment of such systems - which are expected to have charging powers of up to 22 kW - it is essential to have a reliable standards framework available, which enables interoperability between different types of WPT systems.

## 6.2 Overview of standards for WPT-EV systems

Due to the fact that the present document focuses on WPT-EV systems in the 79 - 90 kHz band, this clause is consequently also focused on the current standardization situation for WPT-EV systems according to clause 5.3.4 only.

Currently, there are - besides ETSI - at least three other SDO dealing with the topic of WPT for EV, namely IEC, ISO and SAE. All of them have established respective working groups or topic teams which are in the process of developing standards for EV WPT systems. Their progress of work is quite different and can as of today (May 2016) be briefly described as follows:

- In ISO, the Project Team 19363 is currently developing a standard for the vehicle-side part of the WPT system. This means, that all requirements outlined in that standard will focus on the standardization of the vehicle-side components (e.g. the receiver coil size and position). Current stage is Working Draft (WD). Publication as a Technical Specification (TS) is expected for end of 2016.
- In IEC, the Project Team 61980 was tasked to develop a product standard for the counterpart, i.e. for the infrastructure-sided parts of the WPT-EV system. The document which outlines the general requirements (IEC 61980-1 [i.14]) was published in 2015. Finalization of the more specific document parts IEC 61980-2 and IEC 61980-3 is expected for early 2017. Current stage of these documents is 2nd CD.
- In CISPR, a "Taskforce WPT" within CISPR/B has been established to work on the EMC requirements for WPT systems in the frequency range 9 - 150 kHz. The group was established in 2014 and has met a couple of time since then. A first result of their work (i.e. a CD document) is expected within the coming months.
- In SAE, the Project Team J2954 is currently developing a standard for the entire WPT system (i.e. including both requirements for the primary and the secondary device). A Technical Information Report (TIR) is expected within the coming months. The actual standard should be published in 2017.

# 7 Technical information

## 7.1 Detailed technical description

According to Figure 2, a typical WPT-EV system consists of a primary device (on the infrastructure side) and a secondary device (on the vehicle side). The primary device generates a magnetic field, which is picked up by the secondary side, and then transformed back into an electrical power which can be supplied to the EV battery. Typical technical parameters for such systems will be elaborated in the following clauses.

**ITU Radio Regulations Edition 2012**


**Figure 2: Schematical design of a typical WPT-EV system logo qualcomm**

# 7.2 Technical parameters and implications on spectrum

## 7.2.1 Status of technical parameters

### 7.2.1.1 Current ITU and European Common Allocations in the candidate band

The current ITU allocations in the frequency band considered in the present document for WPT-EV systems (i.e. 79 - 90 kHz) are as follows (note 1 to note 4 in table 1 are a direct quotation from the ITU Radio Regulations [i.20] (Edition 2012), Article 5 "Frequency Allocations").

**Table 1**

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>72 - 84 Khz<br>FIXED<br>MARITIME MOBILE 5.57<br>(see note 2)<br>RADIONAVIGATION 5.60<br>(see note 4)<br>5.56</td><td rowspan="3">70 - 90 kHz<br>FIXED<br>MARITIME MOBILE 5.57 (see note 2)<br>MARITIME RADIO-NAVIGATION 5.60 (see note 4)<br>Radiolocation</td><td>72 - 84 kHz<br>FIXED<br>MARITIME MOBILE 5.57<br>(see note 2)<br>RADIONAVIGATION 5.60<br>(see note 4)</td></tr>
<tr><td>84 - 86 kHz<br>RADIONAVIGATION 5.60<br>(see note 4)</td><td>84 - 86 kHz<br>RADIONAVIGATION 5.60<br>(see note 4)<br>Fixed<br>Maritime mobile 5.57<br>(see note 2)<br>5.59</td></tr>
<tr><td>86 - 90 kHz<br>FIXED<br>MARITIME MOBILE 5.57 (see note 2)<br>RADIONAVIGATION</td><td>86 - 90 kHz<br>FIXED<br>MARITIME MOBILE 5.57<br>(see note 2)<br>RADIONAVIGATION 5.60<br>(see note 4)</td></tr>
<tr><td colspan="3">NOTE 1: 5.56: The stations of services to which the bands 14 - 19,95 kHz and 20,05 - 70 kHz and in Region 1 also the bands 72 - 84 kHz and 86 - 90 kHz are allocated may transmit standard frequency and time signals. Such stations shall be afforded protection from harmful interference. In Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan, the frequencies 25 kHz and 50 kHz will be used for this purpose under the same conditions. (WRC-12)<br>NOTE 2: 5.57: The use of the bands 14 - 19,95 kHz, 20,05 - 70 kHz and 70 - 90 kHz (72 - 84 kHz and 86 - 90 kHz in Region 1) by the maritime mobile service is limited to coast radiotelegraph stations (A1A and F1B only). Exceptionally, the use of class J2B or J7B emissions is authorized subject to the necessary bandwidth not exceeding that normally used for class A1A or F1B emissions in the band concerned.<br>NOTE 3: 5.59: Different category of service: in Bangladesh and Pakistan, the allocation of the bands 70 - 72 kHz and 84 - 86 kHz to the fixed and maritime mobile services is on a primary basis (see No. 5.33). (WRC-2000)<br>NOTE 4: 5.60: In the bands 70 - 90 kHz (70 - 86 kHz in Region 1) and 110 - 130 kHz (112 - 130 kHz in Region 1), pulsed radio navigation systems may be used on condition that they do not cause harmful interference to other services to which these bands are allocated.</td></tr>
</table>

The current European Common Allocations in the frequency band considered in the present document for WPT-EV systems (i.e. 79 - 90 kHz) are as follows.

**Table 2**

| *RR Region 1 Allocation and RR footnotes applicable to CEPT* | *European Common Allocation* | *ECC/ERC harmonisation measure* | *Applications* | *Standard* | *Notes* |
|---|---|---|---|---|---|
| **72 - 84 kHz** | | | | | |
| FIXED | FIXED | ERC/REC 70-03 | Active medical implants | EN 302 195 | Within the band 9-315 kHz |
| MARITIME MOBILE 5.57 | MARITIME MOBILE 5.57 | ERC/REC 70-03 | Inductive applications | EN 300 330 | Within the band 9-148.5 kHz |
| RADIONAVIGATION 5.60 | RADIONAVIGATION 5.60 | | | | |
| 5.56 | 5.56 EU36 | | Land military systems | | |
| | | | Maritime military systems | | |
| | | | Standard frequency and time signal | | 77.5 kHz DCF time signal |
| **84 - 86 kHz** | | | | | |
| RADIONAVIGATION 5.60 | RADIONAVIGATION 5.60 | ERC/REC 70-03 | Active medical implants | EN 302 195 | Within the band 9-315 kHz |
| | | ERC/REC 70-03 | Inductive applications | EN 300 330 | Within the band 9-148.5 kHz |
| | EU36 | | | | |
| | | | Land military systems | | |
| | | | Maritime military systems | | |
| **86 - 90 kHz** | | | | | |
| FIXED | FIXED | ERC/REC 70-03 | Active medical implants | EN 302 195 | Within the band 9-315 kHz |
| MARITIME MOBILE 5.57 | MARITIME MOBILE 5.57 | ERC/REC 70-03 | Inductive applications | EN 300 330 | Within the band 9-148.5 kHz |
| RADIONAVIGATION | RADIONAVIGATION | | | | |
| 5.56 | 5.56 EU36 | | Land military systems<br>Maritime military systems | | |

EU36 A frequency band, which has been harmonised between NATO member states for which a permanent essential military requirement exists in NATO Europe as defined in the NATO Joint Civil/Military Frequency Agreement (NJFA) 2014.

### 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:

- In a contribution which was published in January 2016 by Germany (Bundesnetzagentur) [i.10], typical emission masks from WPT-EV systems were examined. It is shown for example that the spurious emission levels of a typical WPT-EV system in the frequency range of the standard time signals (below 85 kHz) are well below the limit from CEPT/ERC/REC 74-01 [i.13], typically by 20 dB.

- ETSI TR 102 756 [i.4], which was published 2008, pointed out that it is important to note that the band from 79 - 90 kHz is and remains allocated to naval navigation. A major use was Decca in which the transmitters were mounted on coastal stations. The Decca receivers were mounted on board ships and operated off-shore and would therefore never have been in proximity with WPT-EV systems. It is important to note that the Decca system operation was discontinued in the year 2000. Naval navigation systems are today served by means of the Global Position System (GPS). Thus, one potential victim for coexistence with WPT-EV systems has disappeared more than 15 years ago.

- ECC Report 135 [i.5] on inductive limits in the frequency range 9 - 148,5 kHz [i.5] was published in 2009 and considered 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 (approx.) 68 dBµA/m. It was concluded that, with reduced limits in a few bands (see Figure 3 and Table 3, which were copied from ECC Report 135 [i.5]), harmful interference would not appear outside a radius of about 100m 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 that revised limit of approximately 68 dBµA/m (at 70 kHz, descending with 3 dB/oct, see Figure 3).

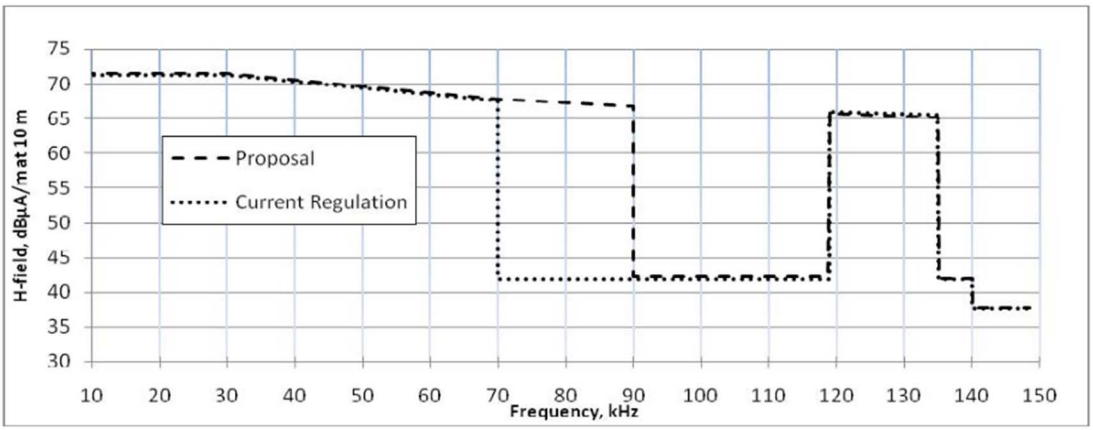


**Figure 3: Existing regulations given in ERC/REC 70-03 versus the proposal for relaxed emission limits (note the notches given in Table 3 are not shown for simplification)**

**Table 3: Standard frequencies and time standards inside to be protected 9 - 90 kHz and 119 - 135 kHz**

| Station | Frequency | Protection bandwidth | Maximum Field strength at 10 m | Location |
|---|---|---|---|---|
| MSF | 60 kHz | +/-250Hz | 42 dBµA/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 |

Once again, it is pointed out that the relaxation request made within the present document (see clause 9) applies only to the 79 - 90 kHz band, i.e. none of the above-mentioned frequency bands needing a special protection (i.e. 42 dBµA/m limit instead of approximately 68 dBµA/m) are affected.

#### 7.2.1.3 Sharing and compatibility issues still to be considered

Due to the relatively high field strengths at 10 m distance that can be produced by WPT-EV systems, there could be potential interference to radiocommunication services operating in the same bands. However, it may be assumed that there will be no harmful interference with the proposed limit due to the fact that WPT-EV systems are operating in the reactive near field where the radiated magnetic field strength decreases with 60 dB/decade versus distance. This fast roll-off, together with near field propagation characteristics, may result in a well-controlled area of operation for any inductive WPT-EV system.

### 7.2.2 System parameters

The present document covers WPT-EV systems which consist of:

1) A transmitter, with possible additional communication capability to control the charge function in conjunction with the receiving part. The power transmitter could also be named as charger.

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

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.

Typical parameters for a WPT-EV system are summarized in Table 4:

**Table 4:**

| | |
|---|---|
| Transmission power (see note 1) | WPT1 = 3,7 kW<br>WPT2 = 7,4 kW<br>WPT3 = 11 kW<br>WPT4 = 22 kW |
| Frequency range | 79 - 90 kHz |
| Out-of-band and spurious emissions | See CEPT/ERC/REC 74-01 [i.13] |
| Emission limit | 82 dBµA/m (at 79 kHz, decreasing with 3 dB/dec, at 10 m distance) |
| Primary and secondary coil design (see note 2) | See IEC 61980 [i.14], ISO 19363 [i.15], SAE J2954 [i.16] |
| NOTE 1: According to IEC 61980 [i.14], ISO 19363 [i.15] and SAE J2954 [i.16], there are currently four power classes defined for WPT-EV systems.<br>NOTE 2: The electrical design and the mechanical dimensions of the primary and secondary device are well described in the IEC/ISO/SAE standards [i.14], [i.15] and [i.16]. Detailed information can be found in those documents. | |

# 8 Radio spectrum request and justification

The present document does not ask for any new frequency band designation for WPT-EV systems.

# 9 Regulations

## 9.1 Current regulations

i) Annex 9 of ERC Recommendation 70-03 [i.2] provides the regulation for inductive applications which can be used for WPT-EV systems in the 79 - 90 kHz band:

**Table 5**

| Frequency Band | | Power / Magnetic Field | Spectrum access and mitigation requirements | Modulation/ maximum occupied bandwidth | ECC/ERC deliverable | Notes |
|---|---|---|---|---|---|---|
| **a1** | 9 - 90 kHz | 72 dBµA/m at 10 m | No requirement | Not specified | | In case of external antennas only loop coil antennas may be employed. Field strength level descending 3 dB/oct at 30 kHz |

ii) Commission Decision 2013/752/EU [i.3] on harmonisation of the radio spectrum for use by short-range devices gives the harmonised conditions for SRDs in the European Union. Below is an excerpt from that decision for the band which is discussed in the present document (79 - 90 kHz).

**Table 6**

| Band no | Frequency band [i] | Category of short-range devices [ii] | Transmit power limit/ field strength limit/power density limit [iii] | Additional parameters (channelling and/or channel access and occupation rules) [iv] | Other usage restrictions [v] | Implemen-tation deadline |
|---|---|---|---|---|---|---|
| 8 | 77,750 - 90 kHz | Inductive devices | 72 dBµA/m at 10 metres | | | 1 July 2014 |

## 9.2 Proposed regulation and justification

The H-field emission limit in the 79 - 90 kHz band as provided in ERC REC 70-03 [i.2] and in the EC Decision 2013/752/EU [i.3] is insufficient to provide a useful high-power (> 3,7 kW) energy transmission which is e.g. needed for WPT systems that charge EV batteries. The maximum permissible H-field levels have to be increased due to the following reasons:

- The currently permitted H-field strength of approx. 68 dBµA/m (in 10 m) in the frequency band from 79 - 90 kHz would only allow rather low-power WPT systems (approx. up to 3,7 kW at maximum). However, for charging an EV, a much higher power is desirable to allow charging times as short as possible. The WPT-EV product standards which are currently being developed in IEC, ISO and SAE consider a charging power up to 11 kW (WPT3) or even 22 kW (WPT4).

- Beside the power level, the H-field emissions are furthermore dependant on the offset between the primary (ground) coil and the secondary (vehicle) coil. The H-field emissions have a minimum at zero offset (i.e. perfect alignment), and increase with increasing offset. As it is technically almost impossible - and economically not feasible - to always ensure a perfect alignment, ISO 19363 [i.15], IEC 61980 [i.14] and SAE J2954 [i.16] define a maximum permissible offset of ±75 mm (in driving direction) respectively ±100 mm (perpendicular to the driving direction). Also for this parameter, simulations and measurements on current WPT systems for EV have shown that the current H-field limits in the 79 - 90 kHz band are not sufficient to cover that permissible offset.

To satisfy the above requirements for WPT-EV systems it is proposed to review the present regulation and change the limits in the frequency range from 79 - 90 kHz to 82 dBµA/m (at 79 kHz, descending with 3 dB/oct).

ETSI ERM has approved a new work item to treat this issue via a new harmonised EN which will deal specifically only with WPT systems (project number ETSI EN 303 417 [i.18]). The proposed limit should be adopted in this future ETSI EN 303 417 [i.18].

ECC working group FM is requested to review the proposal for the revision of the ERC/REC 70-03 [i.2], annex 9, with regard to the proposed change of the emission levels in the frequency range 79 - 90 kHz.

The EC is requested to consider the proposed change in the regulation at the next update of the EC Decision on harmonisation of the radio spectrum for use by short range devices for inductive devices.

# Annex A:
# Information about the situation 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.17].

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.17].

i) PDN Rep. ITU-R SM.[WPT.non-beam]: PDNRep. ITU-R SM.[WPT.non-beam] 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.6] for publication.

   One year after the publication of ITU-R Report SM.2303-1 [i.6], 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.6].

ii) PDNRec. ITU-R SM.[WPT] intends to set 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 work is still ongoing and the draft recommendation will be considered at the June 2016 session of WP 1A with the aim of finalizing the recommendation in 2016.

   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 (WRC15) [i.19] 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 for the preparations on WPT for WRC-19 Conference. The next meeting of WP 1B will be held in June 2016 at which the preliminary studies will start on WPT for electric vehicles.

# Annex B: Bibliography

- EFIS (ECO Frequency Information System).

NOTE http://www.efis.dk/views2/search-allocations.jsp.

# History

| Document history | | |
|---|---|---|
| V1.1.1 | October 2016 | Publication |
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