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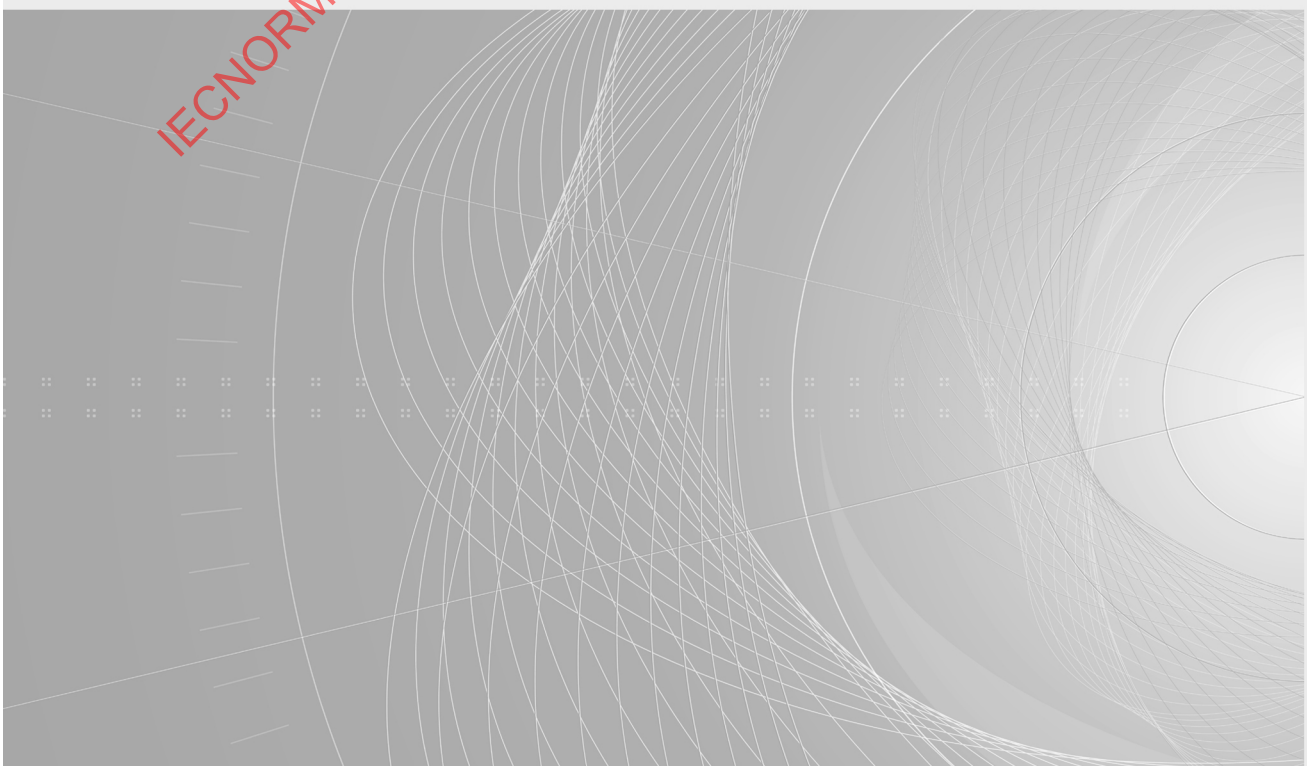
TECHNICAL REPORT

colour inside

Consideration of energy efficiency in wireless power transfer technology



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CONSIDERATION OF ENERGY EFFICIENCY IN WIRELESS POWER TRANSFER TECHNOLOGY

FOREWORD

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IEC TR 63231, which is a technical report, has been prepared by TA15: Wireless Power Transfer, of IEC technical committee TC 100: Audio, video and multimedia systems and equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
100/3186/DTR	100/3262/RVDTR

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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CONSIDERATION OF ENERGY EFFICIENCY IN WIRELESS POWER TRANSFER TECHNOLOGY

1 Scope

This Technical Report (TR) describes the technical background of current energy efficiency efforts related to wireless power transfer (WPT) technology and commercially available products related to related to audio, video and multimedia systems and equipment. This Technical Report examines use cases, standardization efforts of other standards development organizations (SDOs) and known national regulations. This document concludes with observations and recommendations for the potential future technical standards development activities within the scope of TC 100.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
WPT Tx
wireless power transfer transmitter
device that transmits power to the receiver

Note 1 to entry: Examples of WPT Tx are charging pads, which are portable, car-mounted, or furniture-mounted.

3.1.2
WPT Rx
wireless power transfer receiver
device that receives power from the transmitter, which is a charging pad

Note 1 to entry: Examples of Rx are smartphones, laptops, smartwatches.

3.2 Abbreviated terms

WPT	wireless power transfer
DTBC	device to be charged

4 Overview of the WPT system

4.1 General

Clause 4 describes an overview of WPT systems, which include WPT technologies, applications and coupling methods.

4.2 Magnetic induction WPT systems

An alternating electric current flowing through a coil (source) generates a magnetic field that acts on a receiver coil to produce a current within it, and thus electric power is transferred between the source and device-to-be-charged (DTBC) coils.

Tight magnetic coupling between the two coils helps achieve high transfer efficiency. Because the electric power transfer distance is short, typically measured in the mm range, the WPT by the electromagnetic induction is often called noncontact power transfer, or tightly-coupled WPT.

4.3 Magnetic resonance WPT systems

Magnetic resonance is a special case of electromagnetic induction where resonant coils are used such that higher efficiencies can be supported for a given coupling factor (k) in configurations designed for low (much less than 1,0) coupling factor. The magnetic resonance method utilizes a source consisting of a coil and series capacitor as a resonator, with a corresponding sink element consisting also of a coil and series capacitor as a tuned resonator. Electric power is transferred through the electromagnetic resonance between the source and DTBC coils. By matching the resonance frequency of the source coil and the DTBC coil in a high Q factor regime, electric power is transferred over a long distance (mm to m) even where magnetic coupling (k) between two coils is low.

The magnetic resonance approach is referred to interchangeably as magnetic resonant coupling, highly resonant magnetic induction, or loosely coupled WPT.

4.4 Microwave (RF) used in WPT systems

Power transfer via radio waves can be made more directional, allowing longer-distance power beaming, with shorter wavelengths of electromagnetic radiation, typically in the microwave range.

Power beaming by microwaves has the difficulty that, for most space applications, the required aperture sizes are very large owing to diffraction limiting antenna directionality.

In 2013, inventor Hatem Zeine demonstrated how wireless power transmission using phased array antennas can deliver electrical power up to 30 feet away. It uses the same radio frequencies as Wi-Fi.

In 2015, researchers at the University of Washington introduced power over Wi-Fi, which trickle-charges batteries and powered battery-free cameras and temperature sensors using transmissions from Wi-Fi routers. Wi-Fi signals were shown to power battery-free temperature and camera sensors at ranges of up to 20 feet. It was also shown that Wi-Fi can be used to wirelessly trickle-charge nickel–metal hydride and lithium-ion coin-cell batteries at distances of up to 28 feet.

4.5 Capacitive wireless power transfer (CPT)

Research efforts are being published in capacitive WPT, which uses an electric field to transfer power (in contrast with the magnetic field in 4.2 and 4.3, or coupled electro-magnetic fields in 4.4).

5 WPT product use cases

5.1 General

In order to consider energy efficiency measurements in WPT, the current scope of commercially available products needs to be explored. The products described in this clause are presented as use cases for energy efficiency considerations. A typical configuration of a commercially available system consists of a transmission or charging pad and a device with a receiver.

5.2 Receivers

5.2.1 Smartphones

Most high-end smartphones available commercially have wireless charging capability. Smartphones are the current leader in today's market with regard to wireless power transfer functionality

5.2.2 Smartwatches

Some smartwatches have wireless power functionality, even though the current market is small.

5.2.3 Laptops

While there are a few laptop models with wireless power transfer charging capability, this market is small. Most laptops do not have this capability.

5.3 Transmitters

5.3.1 Vertical figure product

Vertical charging pads are the most popular product in the wireless power transfer market of commercially available products (see Figure 1).

Figure 1 – Example of vertical charging pad

5.3.2 Car-installed product

Automakers have adopted wireless charging as a standard feature in vehicles available in the market today. Wireless charging pads are typically provided in the centre fascia (see Figure 2) or armrest in the rear seat. When the driver places a smartphone on the charging pad, the device starts to charge.

Figure 2 – Example of car-installed product

5.3.3 Car-mounted product

Wireless charging mounts are available as aftermarket products for in-vehicle usage (see Figure 3). Customers buy and install these products themselves. Some products allow the user to use the smartphone while it is charging on the mount.

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Figure 3 – Example of car mounted product

5.4 Furniture

Some furniture manufacturers have tried to combine wireless charging pads with desk lamps, tables, or provided inside drawers (see Figure 4). While there are not many furniture companies with products on the market today, the market continues to show growth.

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Figure 4 – Example of furniture charging product

6 Overview of various organization's activities including standardization

6.1 General

There are a lot of WPT products available in the market today, and the market continues to see growth. More products coming to market continue to apply WPT technology.

As technology advances, there is increased interest in safety and performance.

Some SDOs and countries have begun developing different energy efficiency measurement methods. This section provides an overview of known efforts.

6.2 National movement

6.2.1 Europe

EC/1275/2008, a regulation on standby and off mode, is applicable to a broad range of products. It is, however, unclear if it also applies to transmitters and receivers sold separately. If applicable to products, the following requirements apply:

- energy consumption in off mode: maximum 0,5 W;
- energy consumption in stand-by mode:
  - maximum 0,5 W in any condition providing only a reactivation function, or providing only a reactivation function and a mere indication of enabled reactivation function;
  - maximum 1 W in any condition providing only information or status display, or providing only a combination of reactivation function and information or status display.

EC/801/2013 amends the previous regulation with requirements for networked standby.

Regulation EC/278/2009 on external power supplies is currently considered not applicable for wireless power products. However, this might change in the future.

6.2.2 United States of America

The United Stated Department of Energy (DOE) released new energy conservation standards for battery chargers, which was published in the Federal Register as 81 FR 38266 in June 2016. However, the DOE excluded wireless charging systems designed to operate in dry environments. Only battery chargers with inductive connections designed to operate in wet conditions are addressed in the DOE rulemaking. The DOE also released new energy conservation standards on the “external power supply”, which they define as an external power supply circuit that is used to convert household electric current into DC current or lower-voltage AC current to operate a consumer product, which was published in the Federal Register as 81 FR 30157 in May 2016. Wireless power is currently excluded from the requirements for both rulemakings. However, special requirements apply for the state of California. The California Energy Commission (CEC) requires that boxed products (charger and receiver sold together) comply with the California Code of Regulations, Title 20, Public Utilities and Energy, which includes energy efficiency requirements for inductive charging systems.

The DOE regularly works with U.S. nationally recognized technical, professional, and industry SDOs in the preparation of standards that can be used by the DOE. The DOE adopts standards by referencing them in policy statements, requirements (such as rulemaking or orders), guides, and contracts. Within the U.S., Public Law (PL) 104-113 and OMB Circular A-119 encourages U.S. Federal agencies to use voluntary consensus standards in lieu of government-specific standards or regulations, unless such standards are inconsistent with law. Federal agencies are also encouraged to participate in the development of standards in the U.S. While there are some exceptions and considerations, the National Institute of Standards and Technology (NIST) provides a webpage outlining approved and draft standards by government agencies at https://www.nist.gov/standardsgov/learn-how-find-standards. A link to a searchable database of approved and draft standards by the Department of Energy can be found through the NIST website above.

6.2.3 Korea

There isn’t any regulation about energy efficiency in wireless power transfer. But major companies are paying attention to global regulation movements.

The Korea Wireless Power Transfer Promotion Forum is working to encourage the industry. They are interested in standardization and regulation.

6.2.4 China

There is no information to provide on regulations in China on energy efficiency at the time of publication.

6.2.5 Japan

There isn't any regulation about energy efficiency in wireless power transfer. But major companies are paying attention to global regulation movements.

The Broadband Wireless Forum (BWF) is working to encourage the industry. They are interested in standardization and regulation.

6.3 SDO movements

6.3.1 Wireless Power Consortium (WPC)

The WPC has drafted an efficiency testing protocol that targets consumer electronics up to 100 W. Developed with input from the US DOE and EPA, the protocol was exercised on a large sample of mobile phone transmitters, which revealed a more than 2:1 efficiency performance spread for transmitters now in the market. The WPC proposal is a system-level measurement that controls for receiver placement, load condition, battery charge state and includes AC adapter losses. At the time of writing, the WPC is calibrating the test protocol output to the efficiency performance of actual systems now in the market. This analysis will be used to finalize the test receiver design and fine-tune the test specification. The WPC expects to have the final version submitted to the US DOE during 2019. The goal of the WPC efficiency test protocol is to help the EPA compare wireless power transmitter efficiency using real-world conditions in order to help consumers make informed purchase decisions.

6.3.2 AirFuel Alliance

There is no information to provide at the time of publication.

6.3.3 Consumer Technology Association (CTA)

In 2009, the CTA began standardization efforts related to wireless charging technology. Specifically, the CTA considered usability, compatibility, range of charging options and wireless charging solutions, and user requirements. Since the initial establishment of the CTA's efforts, the AirFuel Alliance and Wireless Power Consortium published the AirFuel Resonant Baseline System Specification (BSS) and the Qi Wireless Power Transfer System - Power Class 0 Specification, respectively. The CTA's efforts were then focused on common terminology, as well as common test methodology for power transfer efficiency and standby power for consumer devices using wireless power transfer. The CTA has published the following two American National standards:

- ANSI/CTA-2042.1-B, Wireless Power Glossary of Terms
- ANSI/CTA-2042.3, Methods of Measurement for Power Transfer Efficiency and Standby Power of Wireless Power Systems (see Annex A)

6.3.4 European Telecommunications Standards Institute (ETSI)

ETSI is an independent, not-for-profit, standardization organization in the telecommunications industry in Europe. ETSI is officially responsible for the standardization of information and communication technologies within Europe.

They have several standards which are related to WPT. But there are no standards about energy efficiency.

7 Areas to consider

7.1 How to pair WPT Tx and WPT Rx

The energy efficiency varies depending on the combination of WPT Tx and WPT Rx. So when measuring the efficiency, the rule of combination needs to be set up.

One of the way is to combine it with the manufacturer's declaration. In this case, the manufacturer can design the product with the best efficiency condition in the manufacturer's suggested combination.

The other way is to use a reference WPT Tx/Rx model, which is pre-determined in the standard. WPC is working on this method.

7.2 Placement of WPT Rx on a WPT Tx charger

The coils have the highest efficiency when they are centre aligned. However, it is not easy to manually align the coils.

The WPC have developed a help guide that can assist in testing the placement of the coils.

7.3 Testing equipment

Test equipment should have high reproducibility and low variation. Calibration needs to be considered.

If it is possible, test equipment should be simple to operate.

8 New standard requirements

Transmitters and receivers may need to be considered separately due to market penetration.

Normally receiver manufacturers, such as those that develop smartphones, are from large, global companies. Such receivers provide fewer models that pair with available transmitters.

But WPT Tx manufacturer are typically a smaller sized companies than WPT Rx manufacturers. There are more companies developing WPT Tx models, as well as more WPT Tx models available in the market.

Additionally, it can be difficult to measure voltage and current in mobile phones, which are securely assembled.

So a TC may develop first a "measuring method of energy efficiency in WPT transmitter" and then develop a "measuring method of energy efficiency in WPT receiver".

The contents may include the following:

a) general condition of measuring equipment and environment;

b) paring condition with WPT Tx and WPT Rx;

c) positioning device under test;

d) test procedure and recording data.

Standards may be developed step by step, taking into account technology development and market conditions.