PD IEC PAS 61980-5:2024

BSI Standards Publication

Electric vehicle wireless power transfer (WPT) systems

Part 5: Interoperability and safety of dynamic wireless power transfer (D-WPT) for electric vehicles

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The UK participation in its preparation was entrusted to Technical Committee PEL/69, Electric vehicles.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC VEHICLE WIRELESS POWER TRANSFER (WPT) SYSTEMS –

Part 5: Interoperability and safety of dynamic wireless power transfer (D-WPT) for electric vehicles

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IEC PAS 61980-5 has been prepared by IEC technical committee 69: Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks. It is a Publicly Available Specification.

The text of this Publicly Available Specification is based on the following documents:

Draft	Report on voting
69/975/DPAS	69/1011/RVDPAS

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

The language used for the development of this Publicly Available Specification is English.

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This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

This document is to be read in conjunction with IEC 61980-1:2020.

The clauses of the particular requirements in this document supplement or modify the corresponding clauses in IEC 61980-1:2020. Where the text indicates an "addition" to or a "replacement" of the relevant requirement, test specification or explanation of IEC 61980-1:2020, these changes are made to the relevant text of IEC 61980-1:2020, which then becomes part of the standard. Where no change is necessary, the words "Clause/Subclause xx of IEC 61980-1:2020 is applicable" are used. Additional items to those of IEC 61980-1:2020 are numbered starting 101. Annexes are lettered from A onwards.

A list of all parts in the IEC 61980 series, published under the general title *Electric vehicle wireless power transfer (WPT) systems*, can be found on the IEC website.

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

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INTRODUCTION

The IEC 61980 series is published in separate parts according to the following structure:

– IEC 61980-1 covers general requirements for electric road vehicle (EV) wireless power transfer (WPT) systems including general background and definitions (e.g. efficiency, electrical safety, EMC, EMF);

– IEC 61980-2 applies to magnetic field wireless power transfer (MF-WPT) for electric road vehicles and covers specific requirements for system activities and communication between the electric road vehicle side and the off-board side, including general background and definitions;

– IEC 61980-3 covers specific power transfer requirements for the off-board side of magnetic field wireless power transfer systems for electric road vehicles (e.g. efficiency, electrical safety, EMC, EMF);

– IEC PAS 61980-4[1] covers specific power transfer requirements for the off-board side of magnetic field high power wireless power transfer (H-WPT) systems for electric road vehicles (e.g. efficiency, electrical safety, EMC, EMF).

– IEC 61980-5 covers specific power transfer requirements for the off-board side of magnetic field dynamic wireless power transfer (MF-D-WPT) systems for electric road vehicles (e.g. efficiency, electrical safety, EMC, EMF). This document is IEC 61980-5 and is under development as a PAS.

– IEC 61980-6[2] applies to magnetic field dynamic wireless power transfer for electric road vehicles (EV) and covers specific requirements for system activities and communication between the electric road vehicle side and the off-board side, including general background and definitions.

Requirements for the on-board side of MF-WPT and MF-D-WPT for electric road vehicles are covered in ISO PAS 5474-6[3].

This document is being published as a PAS for information about how dynamic charging systems can work, as evidenced by demonstration systems described in Annex A to Annex D.

[1] Under preparation. Stage at the time of publication: IEC CD PAS 61980-4:2024.

[2] Under development.

[3] Under preparation. Stage at the time of publication: ISO CD PAS 5474-6:2023.

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ELECTRIC VEHICLE WIRELESS POWER TRANSFER (WPT) SYSTEMS –

Part 5: Interoperability and safety of dynamic wireless power transfer (D-WPT) for electric vehicles

1 Scope

This part of IEC 61980 applies to the off-board supply equipment for dynamic wireless power transfer via magnetic field (MF-D-WPT) to electric road vehicles in motion for purposes of supplying electric energy to the RESS (rechargeable energy storage system) and/or other on-board electrical systems.

The system operates at standard supply voltage ratings per IEC 60038 up to 1 000 V AC and up to 1 500 V DC from the supply network. The power transfer takes place primarily while the electric vehicle (EV) is in motion, but can continue to take place under certain conditions while the vehicle is not in motion.

Off-board supply equipment fulfilling the requirements in this document are intended to operate with EV devices fulfilling the requirements of ISO 5474-4[4] and ISO 5474-6.

The aspects covered in this document includes

– the characteristics and operating conditions,
– specific power transfer requirements for the off-board side of magnetic field dynamic wireless power transfer systems for electric road vehicles, and
– the general requirement of electrical safety and EMC for MF-D-WPT.

Examples of D-WPT systems are described in the informative Annex A to Annex D.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 61980-1, *Electric vehicle wireless power transfer (WPT) systems – Part 1: General requirements*

IEC 61980-3, *Electric vehicle wireless power transfer (WPT) systems – Part 3: Specific requirements for magnetic field wireless power transfer systems*

ITU-R Recommendation SM.2110.1:2019, *Guidance on frequency ranges for operation of non-beam wireless power transmission for electric vehicles*

[4] Under preparation. Stage at the time of publication: ISO DIS 5474-4:2024.

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3 Terms and definitions

For the purposes of this document, he terms and definitions given in IEC 61980-1, IEC 61980-3 and the following terms and definitions apply, except as follows.

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

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

Additional terms and definitions:

3.101
dynamic wireless power transfer
D-WPT
WPT while vehicle is in motion

3.102
embedded depth
Z_{RS}
distance between the road surface and the top of housing in the primary device

3.103
embedded mounting
mounting of a primary device in such a manner that the top covering of the primary device is buried (embedded) in the pavement.

3.104
inverter
power electronic device or circuitry that changes direct current (DC) to alternating current (AC)

Note 1 to entry: Inverter is a part of a power electronics.

3.105
magnetic gap
vertical (z-direction) distance between the coil of the primary device and the coil of the secondary device

3.106
standby state
state where power transfer is stopped and power electronics is not ready to transfer power for a short period, but communication stays up

3.107
segment
unit of coil(s) and core(s) controlled independently in the primary device

Note 1 to entry: Depending on the system structure, a switch for energization, supply device P2PS controller and supply power electronics might be part of a segment. See Figure 2.

3.108
segment switching
turn on/off function that energizes the primary coil(s) of the segment

3.109
steady state
state of a system at which quasi-constant power is transferred

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4 Abbreviated terms

IEC 61980-1:2020, Clause 4, does not apply.

5 General

IEC 61980-1:2020, Clause 5, applies, except as follows.

Replacement of the first paragraph :

The supply device (see Figure 2) shall be rated for one or a range of standard nominal voltages and frequencies as listed in IEC 60038.

6 Classification

Replacement:

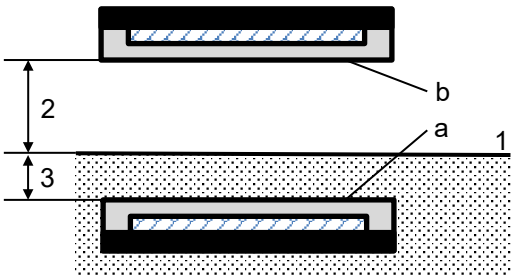
6.1 Compatibility class A and compatibility class B

The supply device is classified according to the compatibility class:

– compatibility class A supply device;
– compatibility class B supply device.

6.2 Installation

For dynamic wireless power transfer, the primary device shall be embedded per Figure 1. Z_{RS} gives the distance under road surface between the road surface and the top of the housing in the primary device as shown in Figure 1.



Key

a primary device
b secondary device
1 top of road surface
2 secondary device ground clearance (Z)
3 embedded depth (Z_{RS})

Figure 1 – Embedded mounting

The magnetic gap is the vertical (z-direction) distance between the coil of the primary device and the coil of the secondary device.

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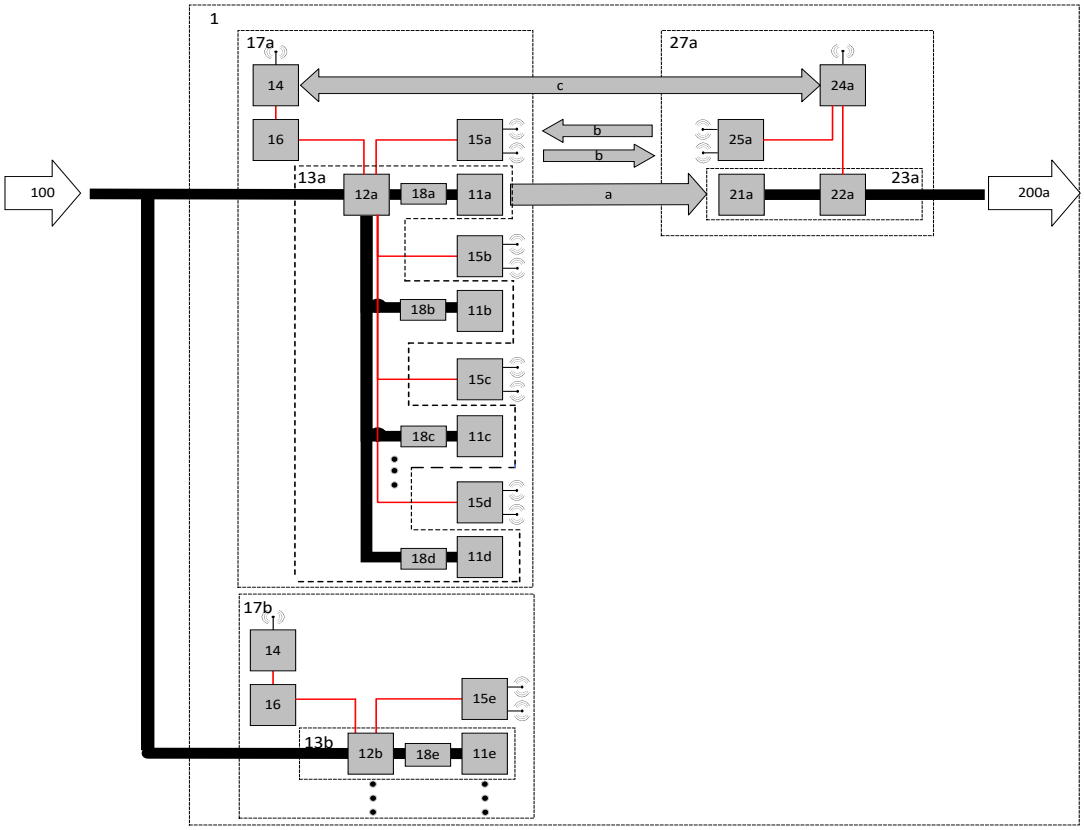
7 General supply device requirements

IEC 61980-1:2020, Clause 7, applies except as follows:

7.1 General architecture

Replacement:

Figure 2 shows an example for the structure of the components referred to in this document.



Key	Name	Key	Name
1	MF-D-WPT system		
11	primary device	21	secondary device
12	supply power electronics	22	EV power electronics
13	supply power circuit	23	EV power circuit (EVPC)
14	dynamic WPT SECC (D-SECC)	24	dynamic WPT EVCC (D-EVCC)
15	supply device P2PS controller	25	EV device P2PS controller
16	D-WPT management unit (DWMM)		
17	supply device	27	EV device
18	switch	200	RESS / motor
100	supply network	b	uni/bi-directional wireless signalling
a	wireless power flow	c	cellular/cloud/Wi-Fi with mobility support
18x+15x+11x	segment		

Figure 2 – Example of MF-D-WPT system

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In dynamic wireless power transfer (D-WPT) system for electric vehicles, primary infrastructure is divided into several segments. Only small number of segments will be turned on at specific time for dynamic wireless power transfer while electric vehicle passes by those segments. In order to support this segment switching operation, wireless communication support with low latency and P2PS signalling can be used.

7.2 Power transfer requirements

Additional subclauses:

7.2.1 General

Unless otherwise stated in any of the subsequent clauses of this document, requirements apply to supply devices and their component parts.

7.2.2 Frequency requirements

For both compatibility class A supply devices and compatibility class B supply devices, the supply device shall utilize magnetic resonance to perform power transfer within the fundamental frequency range of 79 kHz to 90 kHz in accordance with ITU-R Recommendation SM.2110.1:2019, Table 1.

7.2.3 Input voltage and kVA levels

For both compatibility class A and compatibility class B supply devices, the manufacturer shall specify the input voltage range of operation and the rated input kVA.

7.2.4 Output voltage and power when stationary

7.2.4.1 Compatibility class A device

For a compatibility class A supply device, the reference EVPC shall provide an output which covers the reference EVPC output range at the rated output power when stationary.

7.2.4.2 Compatibility class B device

For a compatibility class B supply device, the specific class B EVPC specified by the manufacturer shall provide an output which covers the reference EVPC output range at the rated output power when stationary.

7.2.5 Speed of travel

7.2.5.1 Compatibility class A device

A compatibility class A supply device shall be able to transfer power to all reference EVPCs over the specified output voltage range, power and efficiency when mounted on a test vehicle traveling at a maximum speed up to 120 kph. The required parameters (voltage, power, efficiency) are part of the reference EVPC specification.

7.2.5.2 Compatibility class B device

A compatibility class B supply device shall be able to transfer power to the EVPCs specified by the manufacturer over the specified output voltage range, power and efficiency when mounted on a test vehicle traveling at a maximum speed specified by manufacturer. The required parameters (voltage, power, efficiency) are part of the EVPC specification.

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7.2.6 Safety performance

In the event of an emergency shutdown condition, the supply device shall immediately reduce primary device coil current to zero and turn off all high voltages in order to make the system safe.

7.3 Efficiency

Additional subclauses:

7.3.1 General

The power transfer efficiency in case of D-WPT is the ratio of the sum of the output power (i.e. energy) in the EVPC divided by the sum of the input power (i.e. energy) in the SPC for each segment from the phase "inverter rise" to the phase "inverter fall".

Measured efficiency values according to 7.3.3 are representative values for evaluating products, but they do not correspond to actual efficiency values.

NOTE 1 Measurement of the power transfer efficiency and determination of conformance with the eventual requirements in this document will be made by a test vehicle receiving energy while in motion over a test track with the candidate supply device(s) installed and reference EVPCs installed on the test vehicle. In order to develop confidence that the supply device being developed will meet the performance requirements, there are preliminary steps which can give theoretical results that can indicate likelihood of conformance. These are specified in 7.3.2 and 7.3.3.

NOTE 2 The static measurement on the efficiency of D-WPT with dynamic parameters includes speed information, which is an important difference between static and dynamic WPT. Although it is possible the D-WPT efficiency measurement does not exactly match reality, efficiency can be expressed in a normalized equation. The D-WPT efficiency measurement method includes factors such as segment length, vehicle speed, and waiting time to derive efficiency that is close to reality.

7.3.2 Dynamic power transfer phases

The phases described in 7.3.2 are relevant for the determination of the electrical efficiency of D-WPT systems. These phases apply while a vehicle is driving over a road D-WPT segment, having requested wireless power from that segment. The requirement for power transfer efficiency in under consideration.

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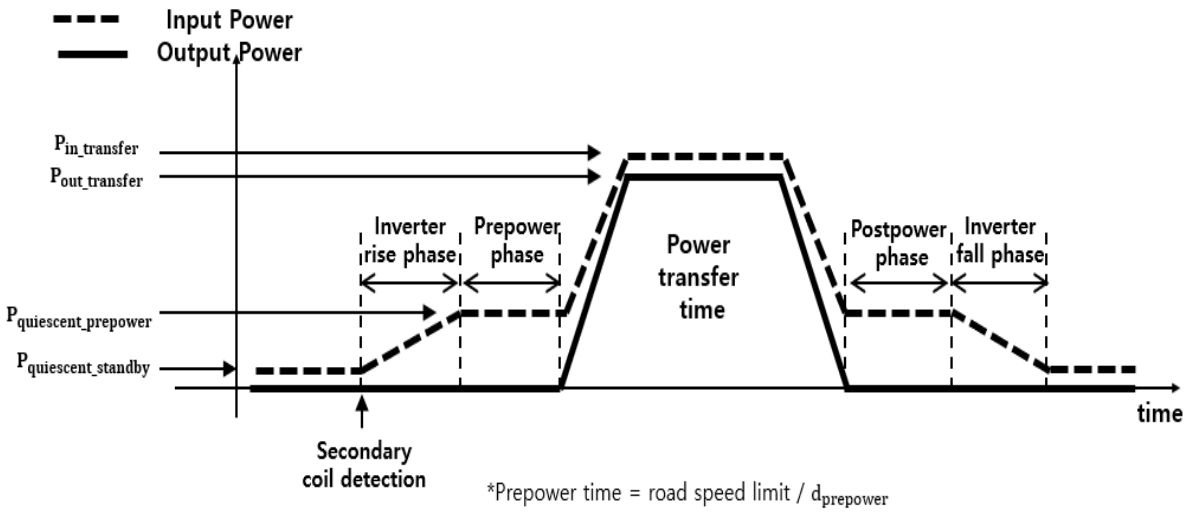

Key

$P_{quiescent_prepowe}$ quiescent power required to maintain the coil current required in a single primary coil segment in order to begin power transfer once the secondary coil becomes coupled with the primary coil segment

$P_{quiescent_standby}$ quiescent power required to be ready for power ramp up in detecting the secondary coil at the DWPT system segment

Figure 3 – Definition of phases for each road segment in D-WPT

7.3.3 Brief description of the individual phases

7.3.3.1 Phase "inverter rise"

Phase required to ramp up the high frequency inverter that provides current to the primary coil to a ready state just prior to power transfer to a secondary coil

Inverter rise is the phase from $P_{quiescent_standby}$ to $P_{quiescent_prepower}$. At the light load condition, the rated current is supplied to the primary coil. The rated current is maintained before the inverter fall.

7.3.3.2 Phase "pre-power"

Phase "pre-power" is the period that the high frequency primary inverter remains in a ready state after the inverter rise time and before power transfer to a secondary coil begins.

7.3.3.3 Phase "power transfer ramp-up"

Phase "power transfer ramp-up" is the period required for the secondary to ramp up from zero power to its peak or steady-state received power level when coupling to a single segment.

7.3.3.4 Phase "power transfer ramp-down"

Phase "power transfer ramp-down" is the period required for the secondary to ramp down from its peak or steady-state power level to zero power when decoupling from a single segment.

7.3.3.5 Phase "inverter fall"

Phase required for the high frequency primary inverter to ramp down the current to the primary coil to be in a standby state. Inverter rise is the phase from $P_{quiescent_standby}$ to $P_{quiescent_prepower}$. At the light load condition, the rated current is supplied to the primary coil. The rated current is maintained before the inverter fall.

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7.3.4 Methods of measuring power transfer efficiency in D-WPT

Measuring the efficiency of power transfer in D-WPT shall be performed as shown in the following procedure and Figure 4.

- Efficiency shall be measured in static condition with a secondary placed in 4 positions over the primary segment being energized.
- Perfect matching.
- Lowest Z level with max. side offset.
- Highest Z level with max. side offset.
- Medium Z level centered with worst case coupling.
- The average of the 4 values shall be stated as system efficiency.
- Power (out, in) measurement points:
  - at nominal, max., min. heights;
  - centred along X-axis at entry, centre, exit;
  - worst-case offset in X-axis at entry, centre, exit;
  - average static power:

$$P_{\text{in_average}} = \left(\sum P_{\text{in@each point}}\right) / \text{ number of points}$$

$$P_{\text{out_average}} = \left(\sum P_{\text{out@each point}}\right) / \text{ number of points}$$

  - measure $P_{\text{quiescent_standby}}$, $P_{\text{quiescent_prepower}}$, d_{prepower} and $t_{\text{postpower}}$;
  - calculate $t_{\text{prepower}} = d_{\text{prepower}}/v_{\text{speed_limit}}$;
  - calculate $\eta_{\text{effective}}$

$$\eta_{\text{effective}} = \frac{P_{\text{out_average}} \times \frac{L_{\text{segment}}}{v_{\text{speed}_{\text{limit}}}}}{P_{\text{in_average}} \times \frac{L_{\text{segment}}}{v_{\text{speed}_{\text{limit}}}} + P_{\text{quiescent}_{\text{prepower}}} \times \left(t_{\text{prepower}} + t_{\text{postpower}}\right) + \left(\frac{P_{\text{quiescent}_{\text{prepower}}} + P_{\text{quiescent}_{\text{standby}}}}{2}\right) \times \left(t_{\text{inverter_rise}} + t_{\text{inverter_fall}}\right)}$$

Report $\eta_{\text{effective}}$

where

d_{prepower}	is the distance distance between vehicle entry sensor and segment;
$\eta_{\text{effective}}$	is the effective system efficiency calculated with dynamic parameters;
L_{segment}	is the length of segment;
$P_{\text{quiescent_prepower}}$	is the quiescent power required to maintain the coil current required in a single primary coil segment in order to begin power transfer once the secondary coil becomes coupled with the primary coil segment;
$P_{\text{quiescent_standby}}$	is the quiescent power required to be ready for power ramp up in detecting the secondary coil at the DWPT system segment;
$P_{\text{in_average}}$	is the summation of power at each measuring points (primary side) divided by the number of measuring points;
$P_{\text{out_average}}$	is the summation of power at each measuring points (secondary side) divided by the number of measuring points.

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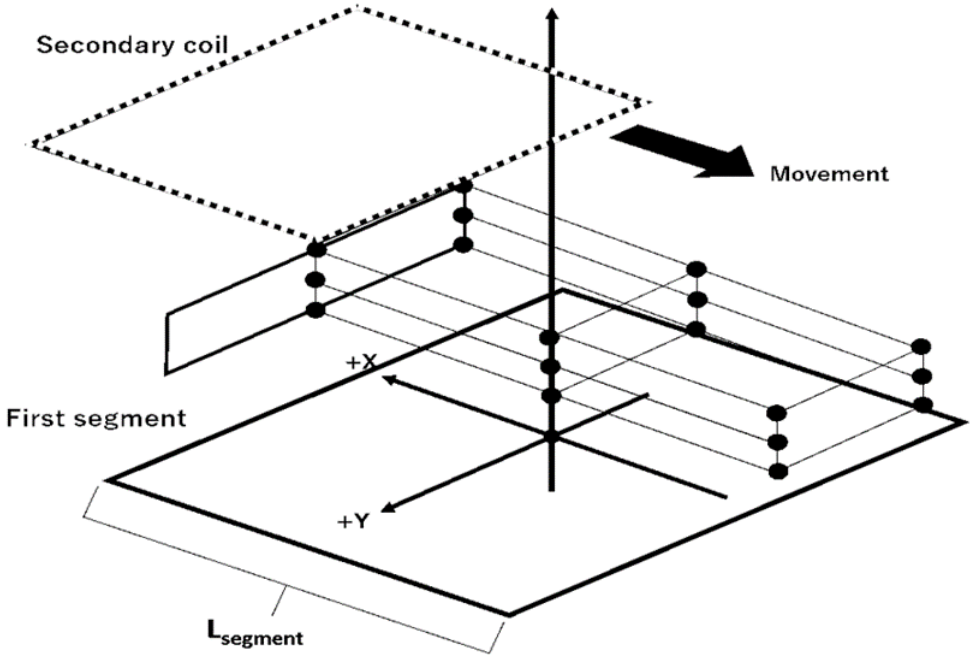

Figure 4 – Measuring the efficiency in D-WPT

7.4 Alignment

Replacement:

7.4 Alignment in D-WPT

The alignment tolerances in Y-axis relative to the centre alignment point for the primary device of a supply device shall be considered as ±200 mm.

NOTE The alignment tolerance with the support of autonomous driving can be ±50 mm.

8 Communication

IEC 61980-1:2020, Clause 8, applies except as follows:

Addition:

The communication and control concept for both compatibility class A supply devices and compatibility class B supply devices will be described in IEC 61980-6.

The communication and control requirements for compatibility class A supply devices will be described in IEC 61980-6.

The hardware to support the communication which will be described in IEC 61980-6 between the D-EVCC and D-SECC is not specified in this document. See future IEC 61980-6 for details.

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9 Power transfer interoperability

IEC 61980-1:2020, Clause 9, applies except as follows.

Addition:

Interoperability refers to D-WPT between a supply device and an EV device that were not specifically designed with each other, for example, D-WPT between devices from different vendors or devices of different power classes.

For a compatibility class A supply device, interoperability shall be verified with the normative reference EVPCs (under consideration), meeting all the requirements for a compatibility class A supply device listed in Clause 7.

Interoperability of a compatibility class B supply device does not apply since the supply device is meant to work with specific EVPCs. It is verified with each of those EVPCs to meet all the requirements for a compatibility class B supply device listed in Clause 7.

10 Protection against electric shock

IEC 61980-1:2020, Clause 10, applies.

NOTE Specific requirements for D-WPT are under consideration.

11 Specific requirements for WPT systems

IEC 61980-1:2020, Clause 11, applies.

NOTE Specific requirements for D-WPT are under consideration.

12 Power cable requirements

IEC 61980-1:2020, Clause 11, applies.

NOTE Specific requirements for D-WPT are under consideration.

13 Constructional requirements

IEC 61980-1:2020, Clause 13, applies.

NOTE Specific requirements for D-WPT are under consideration.

14 Strength of materials and parts

IEC 61980-1:2020, Clause 14, is applicable.

NOTE Specific requirements for D-WPT are under consideration.

15 Service and test conditions

IEC 61980-1:2020, Clause 15, applies.

NOTE Specific requirements for D-WPT are under consideration.

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16 Electromagnetic compatibility (EMC)

IEC 61980-1:2020, Clause 16, applies.

NOTE Specific requirements for D-WPT are under consideration.

17 Marking and instructions

IEC 61980-1:2020, Clause 17, applies.

NOTE Specific requirements for D-WPT are under consideration.

Additional clause:

18 Test procedure for protection against heating effects of foreign objects

Test procedure for D-WPT is under consideration.

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