



**International
Standard**

ISO 5474-4

**Electrically propelled road
vehicles — Functional and safety
requirements for power transfer
between vehicle and external
electric circuit —**

**Part 4:
Magnetic field wireless power
transfer**

*Véhicules routiers à propulsion électrique — Exigences
fonctionnelles et exigences de sécurité pour le transfert de
puissance entre le véhicule et le circuit électrique externe —
Partie 4: Transfert d'énergie sans fil par champ magnétique*

**First edition
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, SC 37, *Electrically propelled vehicles*.

This first edition cancels and replaces ISO 19363:2020, which has been technically revised.

The main changes are as follows:

- the Scope has been adjusted to include passenger cars and light commercial vehicles only;
- the terms and definitions have been aligned with the ISO 5474 series and the IEC 61980 series;
- the efficiency requirements for unmatched power levels between on-board and off-board devices have been specified;
- the source for EMC limits and the corresponding test procedure have been updated.

A list of all parts in the ISO 5474 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies requirements for the onboard side of a magnetic field wireless power transfer system for vehicles intended for passenger use and for light duty commercial applications. This document also addresses safety and functionality with off-board systems from different manufacturers.

The systems specified in this document are intended to work with off-board systems that meet the MF-WPT-related requirements of IEC 61980-1, IEC 61980-2 and IEC 61980-3.

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Electrically propelled road vehicles — Functional and safety requirements for power transfer between vehicle and external electric circuit —

Part 4: Magnetic field wireless power transfer

1 Scope

This document defines the requirements and operation of the on-board vehicle equipment that enables magnetic field wireless power transfer (MF-WPT) between supply device and electric vehicles (EV). It is intended to be used for passenger cars and light commercial vehicles.

This document addresses the following aspects for an EV device:

- safety requirements;
- transferred power and power transfer efficiency;
- ground clearance of the EV device;
- functionality with associated off-board systems under various conditions and independent of manufacturer (interoperability);
- test procedures.

This document does not provide:

- requirements for dynamic (vehicle in motion) applications;
- requirements for reverse WPT;
- requirements for the operation of EV devices specified in this document with supply devices according to IEC 61980-4.

EV devices that fulfil the requirements of this document are intended to operate with supply devices that fulfil the MF-WPT related requirements of IEC 61980-1, IEC 61980-2 and IEC 61980-3.

NOTE IEC 61980-4 specifies requirements for supply devices of power levels above the limits of the reference supply power circuits in this document. Requirements related to dynamic applications of supply devices are specified in IEC 61980-5 and IEC 61980-6.

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.

ISO 5474-1, *Electrically propelled road vehicles — Functional and safety requirements for power transfer between vehicle and external electric circuit — Part 1: General requirements for conductive power transfer*

ISO 6469-3:2021, *Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

IEC 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

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

IEC 61980-2, *Electric vehicle wireless power transfer (WPT) systems - Part 2: Specific requirements for communication between electric road vehicle (EV) and infrastructure*

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

ICNIRP *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz)*, Health Physics 99(6):818-836; 2010

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5474-1 and the following terms and definitions apply.

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

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

3.1

alignment

relative position in the x- and y-directions of the *secondary device* (3.14) to the *primary device* (3.9) for a given *secondary device ground clearance* (3.15)

Note 1 to entry: The coordinate system conforms with ISO 4130.

3.2

alignment tolerance area

intended *wireless power transfer (WPT)* (3.20) operating area in the x- and y-directions for a given *secondary device ground clearance* (3.15)

3.3

centre alignment point

spatial X, Y centre of the *alignment tolerance area* (3.2)

Note 1 to entry: The centre alignment point is not a fixed point for any single coil. It only has relevance for a primary and secondary device combination and is specific for that combination.

[SOURCE: IEC 61980-3:2022, 3.104]

3.4

EV device

on-board component assembly of *WPT system* (3.21)

Note 1 to entry: See [Figure 1](#).

3.5

EV power circuit

EVPC

on-board component assembly, comprising the *secondary device* (3.14) and *EV power electronics* (3.6), as well as the electrical and mechanical connections

Note 1 to entry: See [Figure 1](#).

3.6

EV power electronics

on-board component that converts the power and frequency from the *secondary device* (3.14) to the DC power output of the *EV power circuit (EVPC)* (3.5)

Note 1 to entry: See [Figure 1](#).

3.7

magnetic field WPT

MF-WPT

transfer of electrical energy from a power source to an electrical load via a magnetic field without galvanic connection

3.8

operational design domain

ODD

specific operating conditions in which the *EV power circuit (EVPC)* (3.5) is designed to properly operate

3.9

primary device

off-board component comprising the primary coil and its compensation network to generate and shape the magnetic field for *wireless power transfer (WPT)* (3.20)

Note 1 to entry: Includes housings, covers and cabling.

Note 2 to entry: See [Figure 1](#).

[SOURCE: IEC 61980-3:2022, 3.124, modified — “MF-WPT” changed to “WPT” and Note 2 to entry added.]

3.10

protection area

volume in and around the vehicle that has uniform requirements with regard to effects of exposure to electromagnetic fields

3.11

rated output power

maximum power the *EV power circuit (EVPC)* (3.5) is designed to deliver consistently during a charging cycle

3.12

reference EVPC

EV power circuit (EVPC) (3.5) that serves for conformance testing purposes

[SOURCE: IEC 61980-3:2022, 3.125]

3.13

reference supply power circuit

supply power circuit (3.18) that serves for conformance testing purposes

[SOURCE: IEC 61980-3:2022, 3.126]

3.14

secondary device

on-board component comprising the secondary coil and its compensating network to capture the magnetic field

Note 1 to entry: Includes housings, covers and cabling.

Note 2 to entry: See [Figure 1](#).

[SOURCE: IEC 61980-3:2022, 3.129, modified — Note 2 to entry added.]

3.15

secondary device ground clearance

vertical distance between the ground surface and the lowest point of the *secondary device* (3.14) including the housing

Note 1 to entry: The lower surface does not need to be planar or parallel to the ground surface

3.16

steady state

state of a system at which all state and output variables remain constant in time while all input variables are constant

[SOURCE: IEC 60050-351:2013, 351-45-10]

3.17

supply device

off-board component assembly of *WPT system* (3.21)

Note 1 to entry: See [Figure 1](#).

3.18

supply power circuit

off-board component assembly, comprising the *primary device* (3.9) and *supply power electronics* (3.19), as well as the electrical and mechanical connections

Note 1 to entry: See [Figure 1](#).

3.19

supply power electronics

off-board component that converts the power and frequency from the supply network to the power and frequency needed by the *primary device* (3.9)

Note 1 to entry: See [Figure 1](#).

3.20

wireless power transfer

WPT

transfer of electrical energy from a power source to an electrical load without galvanic connection

3.21

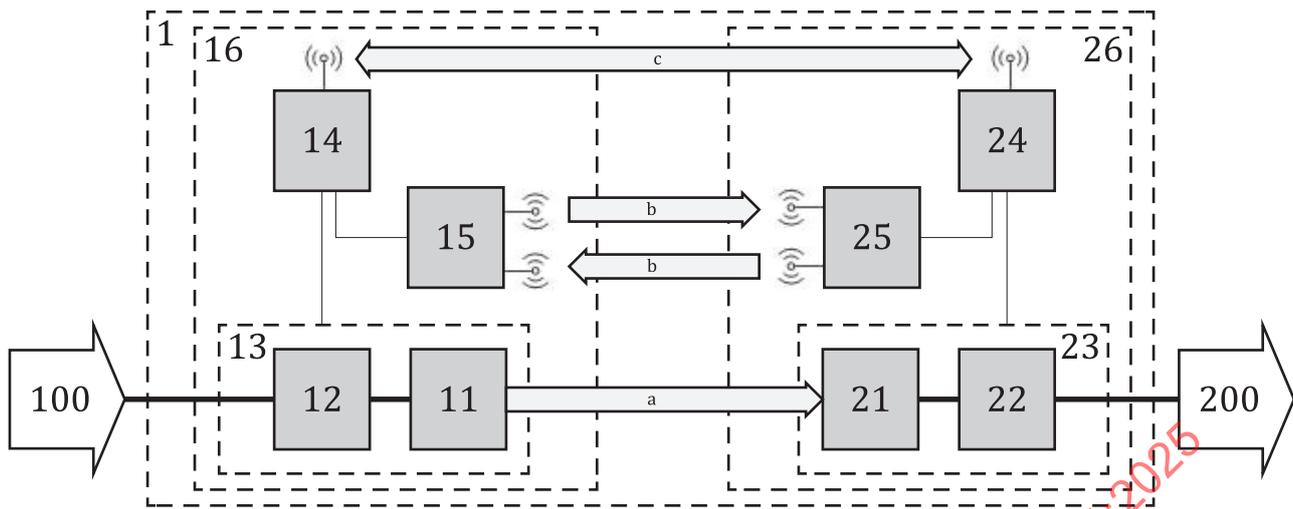
MF-WPT system

system comprising all necessary components for *magnetic field wireless power transfer (MF-WPT)* (3.7) and control

4 System structure

To establish a general baseline for the requirements defined in this document, in IEC 61980-2 and in IEC 61980-3, the MF-WPT system is structured into functional entities. [Figure 1](#) shows this structure of functional entities in an exemplary architecture.

NOTE [Figure 1](#) does not give an indication on hardware packaging.



Key

- | | |
|---|---------------------------------------|
| 1 MF-WPT system | 21 secondary device |
| 11 primary device | 22 EV power electronics |
| 12 supply power electronics | 23 EV power circuit |
| 13 supply power circuit | 24 EV communication controller (EVCC) |
| 14 supply equipment communication controller (SECC) | 25 EV device P2PS controller |
| 15 supply device P2PS controller | 26 EV device |
| 16 supply device | 200 RESS |
| 100 supply network | |

NOTE The functional elements 14, 15, 24, and 25 are addressed in IEC 61980-2.

- a Wireless power flow.
- b Wireless signalling (P2PS).
- c Wireless communication.

Figure 1 — Example of system structure

5 Requirements regarding environmental conditions

The requirements given in this document shall be met across the range of environmental conditions as specified by the vehicle manufacturer.

The environmental requirements applicable to a component depend on its mounting position. The component shall withstand and retain its degree of protection under the typical loads and stresses it is subjected to in its intended mounting position.

Components of the EV device installed at the underbody of the EV shall have IP degree IP6K7 and IP6K9K in accordance with ISO 20653.

NOTE See the ISO 16750 series, the ISO 21498 series and the ISO 19453 series for guidance.

6 Classification

This document specifies requirements that address the following aspects of MF-WPT systems:

- system safety ([Clause 10](#)),
- system performance ([Clause 7](#)),
- interoperability.

Requirements regarding system safety and system performance are relevant and applicable to any MF-WPT system (including dedicated single-supplier solutions).

The interoperability requirements supplement the safety and performance requirements in order to allow for interoperability of a supply device and an EV device provided by independent suppliers.

There are two compatibility classes to accommodate these design considerations:

- Compatibility class A: EV devices of this class are intended for interoperable application and are required to meet a set of safety and performance requirements. Cross-supplier interoperability is tested with the reference supply power circuits as specified in [Annex A](#) and [Annex B](#).
- Compatibility class B: EV devices of this class are not intended for interoperable application but still are required to meet the set of safety requirements. Performance requirements may be different than those of compatibility class A. EV devices of this class are tested with supplier-specified supply power circuits.

7 MF-WPT power transfer requirements

7.1 General

Unless otherwise specified, the requirements in [Clause 7](#) refer to EVPCs of both compatibility classes.

Conformance to the requirements in [7.2](#) to [7.6](#) is tested according to [7.7](#). EVPCs of compatibility class A are tested with the reference supply power circuits described in [Annexes A](#) and [B](#). EVPCs of compatibility class B are tested with supplier specific supply power circuits.

The supplier shall specify the ODD of an EVPC according to [Table 1](#).

Table 1 — EVPC ODD

Specifications of EVPC		Compatibility class A	Compatibility class B
Frequency range		Operation within 79 kHz – 90 kHz	
Secondary device ground clearance range		EVPC specific within 100 mm – 250 mm	EVPC specific
Alignment tolerance area	x-direction	±75 mm	EVPC specific
	y-direction	±100 mm	EVPC specific
Centre alignment point(s)		EVPC specific	
Output voltage range		EVPC specific within voltage classes A and B according to ISO 6469-3	
Rated output power		EVPC specific up to 11,1 kW	EVPC specific

NOTE 1 Typically, the output voltage range of the EVPC is aligned with the voltage range of the RESS.

NOTE 2 [7.3](#) gives additional information for the determination of centre alignment point(s).

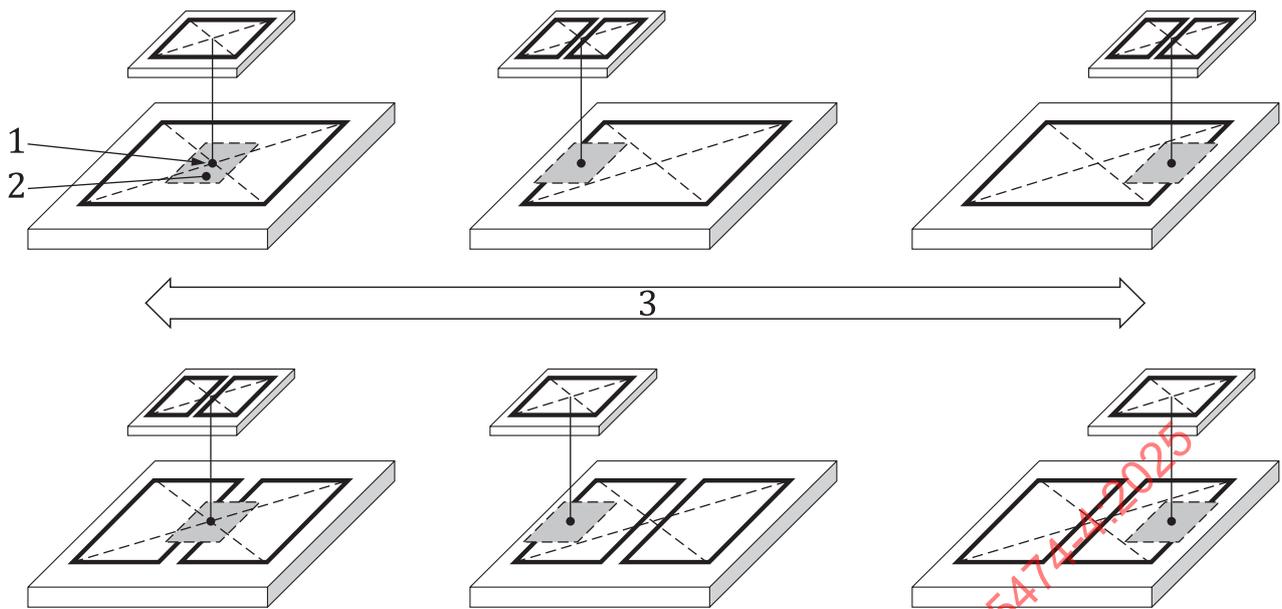
7.2 Frequency

MF-WPT for EVs operates in the frequency range of 79 kHz - 90 kHz. The operating frequency during power transfer is set by the supply device according to IEC 61980-2.

7.3 Geometrical operating space

An EVPC shall meet the requirements of [7.4](#) and [7.5](#) within its entire geometrical operating space defined by its secondary device ground clearance range and the alignment tolerance area according to [Table 1](#).

In case of MF-WPT between a primary device and a secondary device of different topologies, several centre alignment points can exist. Examples are shown in [Figure 2](#).



Key

- 1 centre alignment point of the EVPC
- 2 alignment tolerance area
- 3 direction of travel

Figure 2 — Example for centre alignment points between different coil topologies

The centre alignment points of supply power circuits are determined according to IEC 61980-3.

The centre alignment point(s) of the EVPC shall be specified with respect to the centre alignment points provided by the supply power circuit.

The requirements in this document apply to all centre alignment points specified for an EVPC.

The vehicle manufacturer may specify only one centre alignment point for alignment with a primary device of a different topology.

NOTE The selection of a single point can be due to a variety of reasons, for example the influence of the EV on the distribution of the magnetic field or the position of the EV within a parking spot.

7.4 Requirements for output power

An EVPC shall be able to deliver power up to its rated output power when operated with a supply power circuit.

An EVPC shall support the maximum ramp up rate of the supply power circuit. The maximum ramp up rate of supply circuits for EVPCs of compatibility class A is specified in IEC 61980-3.

7.5 Requirements for power transfer efficiency

Power transfer efficiency is the ratio of the output power of the EVPC (output of key label 23 in [Figure 1](#)) divided by the input power of the supply power circuit (input to key label 13 in [Figure 1](#)).

An EVPC of compatibility class B shall support the minimum power transfer efficiency according to [Table 2](#) when operated at rated output power with a supply power circuit.

Table 2 — Minimum power transfer efficiency (compatibility class B)

Alignment	Minimum power transfer efficiency
Centre alignment point	85 %
Within alignment tolerance area	80 %

IEC 61980-3 specifies several transfer power classes for supply power circuits of compatibility class A. EVPCs of compatibility class A can be operated (continuously) at power levels other than their rated output power. Thus, an EVPC of compatibility class A shall support the minimum power transfer efficiency according to [Table 3](#) when operated with a supply power circuit.

Table 3 — Minimum power transfer efficiency (compatibility class A)

Transfer power class of supply power circuit	Alignment	Rated output power of EVPC [kW]		
		≤ 3,7 kW	> 3,7 kW and ≤ 7,7 kW	> 7,7 kW and ≤ 11,1 kW
MF-WPT1	Centre alignment point	85 % ^a	82 % ^b	80 % ^b
	Within alignment tolerance area	80 % ^a	77 % ^b	75 % ^b
MF-WPT2	Centre alignment point	82 % ^a	85 % ^a	82 % ^b
	Within alignment tolerance area	77 % ^a	80 % ^a	77 % ^b
MF-WPT3	Centre alignment point	80 % ^a	82 % ^a	85 % ^a
	Within alignment tolerance area	75 % ^a	77 % ^a	80 % ^a

^a At rated output power of EVPC.
^b At rated input kVA of supply power circuit.

7.6 Requirements for output voltage

7.6.1 Performance requirements at different output voltage levels

An EVPC shall meet the requirements of [7.4](#) and [7.5](#) within its geometrical operating space according to [7.3](#) throughout its specific output voltage range when operated with a supply power circuit.

7.6.2 Voltage ripple and voltage overshoot

The vehicle manufacturer and supplier shall agree on the DC output voltage overshoot, the peak voltage and the voltage ripple amplitude of an EVPC, taking into account the implication on the RESS and other on-board components.

NOTE A typical value for DC output voltage overshoot is ±1 %/ms. A typical value for the peak voltage is 10 % of the nominal DC output voltage. A typical value of the DC output voltage ripple amplitude is ± 8 V.

7.7 MF-WPT power transfer test procedure

7.7.1 General

[Subclause 7.7](#) describes the test setup and procedure to be applied for conformance testing of the requirements specified in [7.2](#) to [7.6](#).

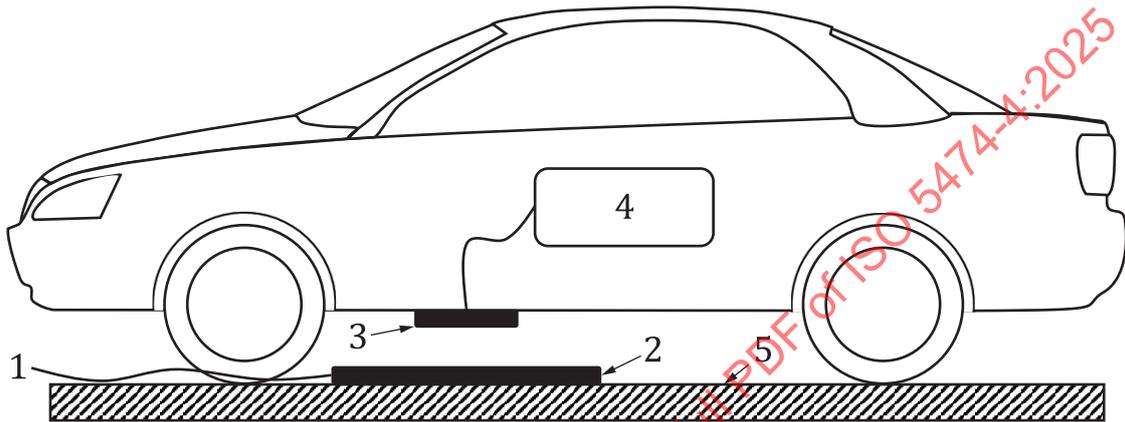
7.7.2 Test setup

7.7.2.1 General

MF-WPT is influenced by the materials in the surroundings, especially by the material structure of the EV. Reliable testing results can only be achieved when influencing materials of the EV are adequately represented in the test setup. This can either be accomplished by testing at the vehicle level or by including relevant parts of the vehicle when testing is done at component level according to [7.7.2.3](#).

7.7.2.2 Vehicle level testing

[Figure 3](#) exhibits an exemplary test setup for vehicle level testing.



Key

- 1 connection to supply network
- 2 supply power circuit
- 3 EVPC under test
- 4 RESS or representative simulated load
- 5 ground

Figure 3 — Exemplary test setup for vehicle level testing

The EVPC shall be fixed to the EV at its intended mounting position.

NOTE This includes the positions of all components of the EVPC, in case they are not within one housing.

The load shall either be an RESS or a representative simulated DC load.

The supply power circuits to be used for testing the EVPC are described in [7.7.2.2](#).

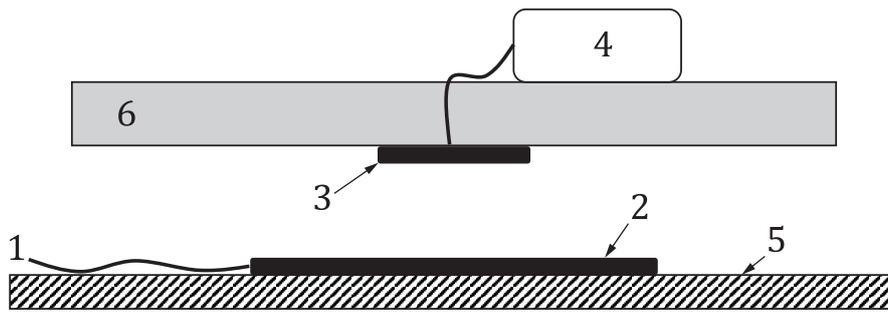
The alignment shall be adjustable in the x-, y-, and z-directions to enable measurements at the alignment points according to [Table 4](#). Alignment may be adjusted by either moving the EV, moving the supply power circuit or moving both.

The components of the test bench and the ground shall not significantly influence the MF-WPT. The entire test setup may also be lifted to a height that avoids potential influences of the ground.

7.7.2.3 Component level testing

As an alternative for the vehicle level, the testing may also be done at the component level.

[Figure 4](#) exhibits the components required for MF-WPT testing in an exemplary test setup for component level testing.



Key

- 1 connection to supply network
- 2 supply power circuit
- 3 EVPC under test
- 4 RESS or representative simulated load
- 5 ground
- 6 vehicle mimic

Figure 4 — Exemplary test setup for component level testing

Compared to vehicle level testing, a vehicle mimic shall be used instead of an EV.

The vehicle mimic shall include all components of the EV that the EVPC is intended to be mounted to, i.e. the components that significantly influence MF-WPT. This includes shielding components or metallic beams exposed to the magnetic field.

All other requirements described in the test setup for vehicle level testing in [7.7.2.2](#) shall apply to component level testing as well.

7.7.2.4 Supply power circuits to test against

An EVPC of compatibility class A shall be tested with the reference supply power circuits described in [Annexes A](#) and [B](#).

An EVPC of compatibility class B shall be tested with a supply power circuit specified and provided by the supplier. The compatibility class B supply power circuit specified and provided by the supplier can be a reference supply power circuit described in [Annex A](#) or [Annex B](#).

NOTE [Annex C](#) describes an example for a different implementation of a supply power circuit.

7.7.2.5 Test conditions

Testing is carried out under the following conditions:

- ambient temperature of (20 ± 5) °C;
- MF-WPT system in steady state.

7.7.3 Test procedure

7.7.3.1 General

The measurements described in [7.7.3.2](#) to [7.7.3.4](#) are conducted within the ODD specified by the supplier according to [Table 1](#).

Table 4 — Alignment points

Alignment point as per Figure 5	X [mm]	Y [mm]	Secondary device ground clearance range
PPP	+75	+100	max.
PPN			min.
POP		0	max.
PON			min.
PNP		-100	max.
PNN			min.
OPP	0	+100	max.
OPN			min.
OOP		0	max.
OOO			mid.
OON		-100	min.
ONP			max.
ONN	min.		
NPP	-75	+100	max.
NPN			min.
NOP		0	max.
NON			min.
NNP		-100	max.
NNN			min.

For EVPCs of compatibility class B, the values for x and y shall be in accordance with the specific alignment tolerance area of the EVPC (see [7.3](#)).

7.7.3.3 Output power and power transfer efficiency

At each alignment point described in [7.7.3.2](#), the supply power circuits according to [7.7.2.2](#) shall be operated with the MF-WPT input power that is needed by the EVPC to provide its rated output power. These measurements shall be performed at the following voltage levels:

- minimum voltage of output voltage range +50 % of output voltage range,
- maximum voltage of output voltage range -10 % of output voltage range.

EXAMPLE For an output voltage range of 200 V to 400 V, the corresponding voltage levels are 300 V and 380 V.

For EVPCs of compatibility class A, the reference supply power circuits shall be operated at 85 kHz. In case the performance requirements are not met, the frequency may be adjusted within the range described in [7.2](#).

For EVPCs of compatibility class B, the supply power circuit shall be operated at the frequency according to the specifications of the supplier within the range described in [7.2](#).

NOTE The MF-WPT input power of the reference supply power circuits is limited according to the specifications in [Annexes A](#) and [B](#), or, in case of compatibility class B testing, by the specifications of the supplier, respectively.

The test is passed when the EVPC provides 90 % of its rated output power at all measurements and fulfils the power transfer efficiency requirements according to [7.5](#) at all measurements. Examples are given in [Table 5](#).

When testing an EVPC of compatibility class A with the reference supply power circuit in [Annex A](#), exceptions apply for the following cases, where the rated output power of the EVPC cannot be reached due to the limited MF-WPT input power of the reference supply power circuit:

- a) the rated output power of the EVPC is greater than 3,7 kW;

b) the rated output power of the EVPC is equal to or less than 3,7 kW.

For case a), the test is deemed to have passed when the MF-WPT input power of the reference supply power circuit reaches 3,33 kW (90 % of 3,7 kW), the EVPC provides any output power and the EVPC fulfils the power transfer efficiency requirements according to 7.5 at all measurements.

For case b), the test is passed when the MF-WPT input power of the reference supply power circuit reaches 90 % of the rated output power of the EVPC and the EVPC fulfils the power transfer efficiency requirements according to 7.5 at all measurements.

Table 5 — Examples for power transfer testing pass criteria of EVPCs of compatibility class A

Rated output power of EVPC [kW]	Supply power circuit tested with	Minimum measured output power to fulfil the output power requirements [kW]	Minimum MF-WPT input power of the supply power circuit [kW]
2,8 kW	Annex A	2,52	—
	Annex B		—
3,7 kW	Annex A	—	3,33
	Annex B	3,33	—
7 kW	Annex A	—	3,33
	Annex B	6,3	—
11,1 kW	Annex A	—	3,33
	Annex B	—	9,99

7.7.3.4 Output voltage

In order to verify the requirements for the DC output voltage (as per 7.6.2), the following test shall be applied:

It is recommended to connect the EVPC to an RESS, as used in the EV the EVPC is designed for.

The EVPC shall be placed in one of the alignment points with maximum misalignment. The power shall be ramped up from zero to the rated output power of the EVPC with the maximum rate of supply power circuits according to 7.4. The test is passed when the DC output voltage is within the requirements of 7.6.2 during the entire test procedure.

8 Requirements for communication and MF-WPT activities

According to IEC 61980-2, the operation process for MF-WPT is modelled as a WPT session, which is organized by a sequence of activities.

These activities are executed or supported by communication between the EV device and the supply device. An EV device shall fulfil the applicable requirements given in IEC 61980-2.

9 EMC requirements

An EVPC shall conform to the limits described in IEC 61980-1, when operated with a supply device.

Conformance can be proven in a vehicle level test or component level test.

The measurement shall be done at worst-case operating conditions of the EVPC. [Clause D.2](#) gives guidance on how to determine these worst-case operating conditions.

The measurement setup shall be in accordance with IEC 61980-3.

10 Safety requirements

10.1 Emergency shutdown triggered by the EV

The MF-WPT system shall be treated as an electric power source that can be de-energized.

The vehicle manufacturer shall execute a risk assessment to identify conditions in which an emergency shutdown is required.

For the conditions identified in the risk assessment, the EV or EV device shall disconnect the power transfer to the RESS to initiate an emergency shutdown.

NOTE The specification for detection and reaction timing of the EV device is at the discretion of the supplier. Requirements for reaction times of the supply device in case of an emergency shutdown are specified in IEC 61980-2 and IEC 61980-3.

Examples for means to initiate an emergency shutdown are:

- protection measures against overcharge of the RESS (e.g. disconnection relay);
- protection measures against overcurrent of the EVPC and RESS (e.g. disconnection relay);
- protection measures against overvoltage of the EVPC (e.g. emergency short circuit device).

Conformance is checked by inspection.

10.2 Protection against electric shock

10.2.1 General

[Subclause 10.2](#) applies only to voltage class B electric circuits of an EV device.

Design and testing for protection against electric shock shall be implemented as specified by the vehicle manufacturer in accordance with ISO 6469-3, unless otherwise specified in [10.2](#).

The EV device shall fulfil the requirements for non-maintained isolation resistance according to ISO 6469-3:2021, 6.3.2.2.

NOTE Requirements on post-crash electrical safety are specified in ISO 6469-4.

10.2.2 Insulation coordination

Insulation coordination shall consider the maximum internal operational voltages and overvoltages inside the EV device. Either of the following shall be implemented:

- robust design with the capability to physically withstand possible operational voltages and overvoltages;
- means to limit the voltages to values the insulation coordination of the components is based on.

The frequency of the alternating current in the EVPC, which is considerably higher than 50 Hz or 60 Hz, shall be considered for the insulation coordination, temperature-resistance of the materials used and dimensioning of active parts and insulation.

Clearance, creepage distance and solid insulation of voltage class B components and wiring shall be designed in accordance with the applicable sections of the IEC 60664 series.

10.3 Protection against thermal incidents

10.3.1 General

Thermal loads to the insulation and active parts of the EV device shall be considered under:

- all operational situations;
- shut off situations of the vehicle;
- unintended power transfer situations.

10.3.2 Overload protection and short-circuit protection

The overload protection and short circuit protection shall be according to ISO 6469-3.

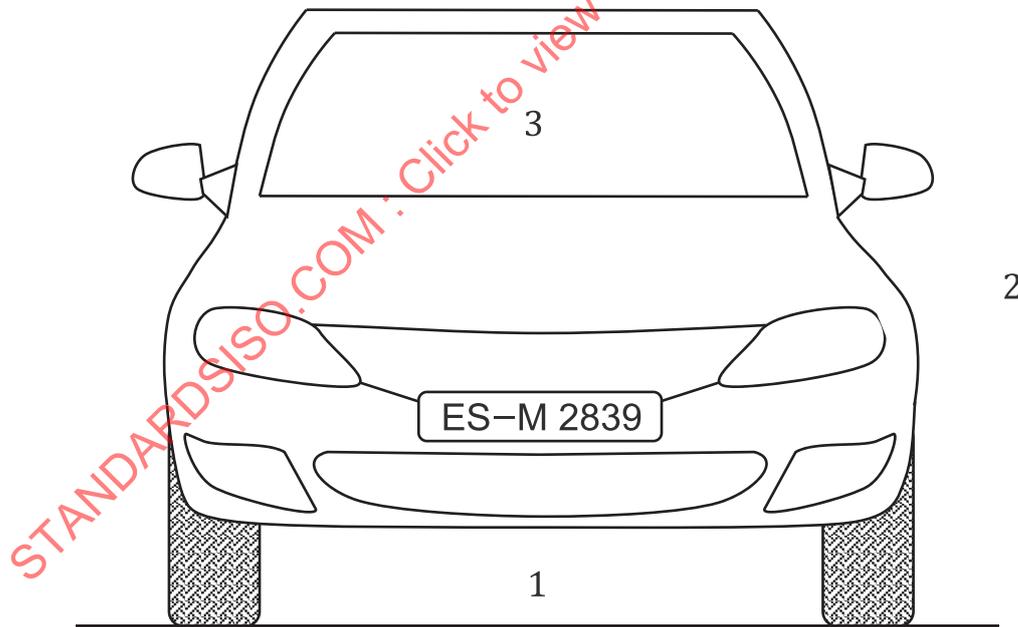
10.4 Protection of people against electromagnetic effects

10.4.1 General

[Subclause 10.4](#) specifies requirements to protect people against the effects of exposure to electromagnetic fields. This covers protection against harmful effects of exposure to electromagnetic fields and the protection of the functionality of cardiac implantable electronic devices (CIEDs). [Annex D](#) provides guidance on how fulfilment of the specified requirements can be demonstrated.

10.4.2 Protection areas

The space inside, under and around the vehicle is divided into three protection areas according to [Figure 6](#).



Key

- 1 area underneath the vehicle
- 2 area surrounding the vehicle; public area to the side, front, rear and top of the vehicle
- 3 area inside the vehicle

Figure 6 — Protection areas

10.4.3 Requirements for protection of people against exposure to hazardous electromagnetic fields

In protection areas 2 and 3, people shall not be exposed to electromagnetic fields above the applicable limits from the ICNIRP Guidelines.

NOTE In protection area 1, protection against exposure to hazardous electromagnetic fields is the responsibility of the supply device.

The basic restrictions of ICNIRP Guidelines 2010, Table 2 or the reference levels of ICNIRP Guidelines 2010, Table 4 shall be met.

10.4.4 Requirements to protect the functionality of CIEDs

Pacemakers and CIEDs are required to remain fully functional and operational when magnetically induced voltages in pacemaker leads, in the range of 3 kHz to 150 kHz are less than $V_{\text{MAX_INDUCED_RMS}} = \frac{3\sqrt{2}}{2} \text{ mV} \times \text{Frequency (kHz)}$, (e.g. 180,31 mV RMS at 85 kHz). This formula is based on the assumption that the voltage is induced into a 225 cm² lead loop and determines the limits that need to be met by MF-WPT systems.

NOTE ISO 14117 contains requirements for CIEDs.

To enable simplified and repeatable measurements, these induced voltage levels are transferred to a conservative averaged magnetic flux of 15,0 µT or a magnetic field strength of 11,9 A/m (for 79 kHz to 90 kHz) within a 225 cm² plane.

In protection areas 2 and 3, an EVPC shall comply with these limits when operated with a supply power circuit at worst-case operating conditions. [Annex D](#) gives guidance for conformance demonstration and for how to determine the worst-case operating conditions.

10.5 Protection against overheating

Means to prevent the overheating of components of the EV due to the magnetic field generated by the supply device shall be provided, if necessary. Examples of protection means are shielding, thermal sensing or cooling.

Conformance shall be declared by the vehicle manufacturer.

11 Owner's manual and marking

11.1 Owner's manual

The following information shall be included in the owner's manual:

- description of the MF-WPT system operation and location of the secondary device on the vehicle;
- functional operations to be performed by the user;
- any special precautions required by operators wearing CIEDs;
- the ODD as specified in [Table 1](#).

11.2 Marking

Marking of voltage class B components and wiring shall be in accordance with ISO 6469-3.

Annex A
(normative)

Reference supply power circuit for EVPCs with a rated output power $\leq 3,7$ kW

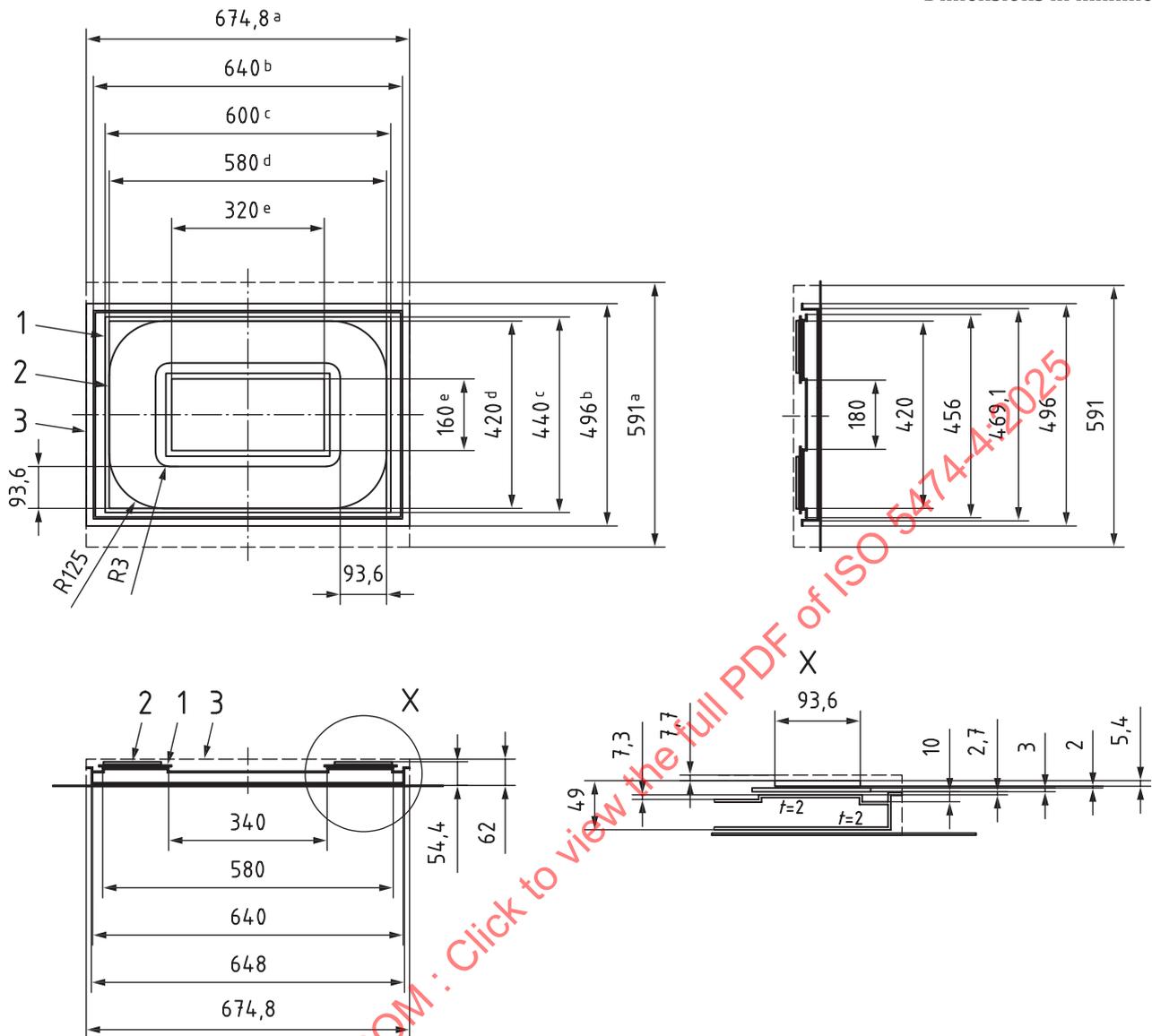
A.1 General

This annex describes the reference supply power circuit for an EVPC with a rated output power of $\leq 3,7$ kW. It is designed for on-ground mounting and operates over the system frequency range of 79 kHz to 90 kHz.

A.2 Mechanical design of the primary device

[Figure A.1](#) shows the mechanical dimensions of the primary device.

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Key

- 1 ferrite
- 2 coil (15 turns)
- 3 outer case (for reference)
- a Outer case dimension.
- b Shielding dimension.
- c Outer core dimension.
- d Coil dimension.
- e Inner core dimension.

Figure A.1 — Mechanical dimensions

The centre of this primary device (0/0 point of coordinate system) is at the midpoint of the “d” dimensions in [Figure A.1](#) and corresponds to the centre of the coil.

The coil dimension of the primary device shown in [Figure A.1](#) is 420 mm in the x-direction (direction of travel of the vehicle) and 580 mm in the y-direction.

The Litz wire is 4 200 mm × 0,05 mm with an overall diameter of approximately 5 mm.

The ferrite tiles are made of N96 material. The dimensions and the layout of the tiles are shown in [Figure A.2](#).

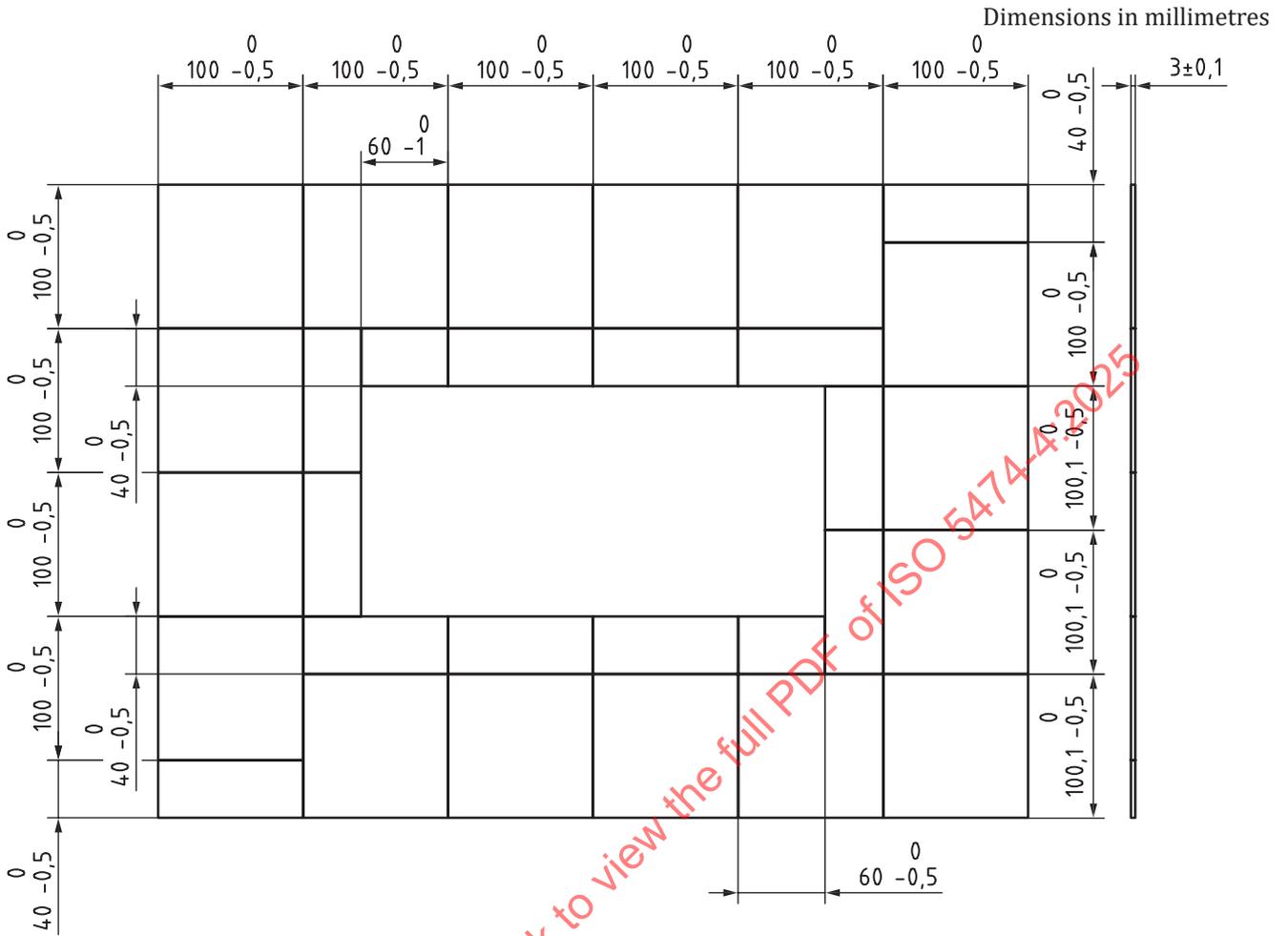
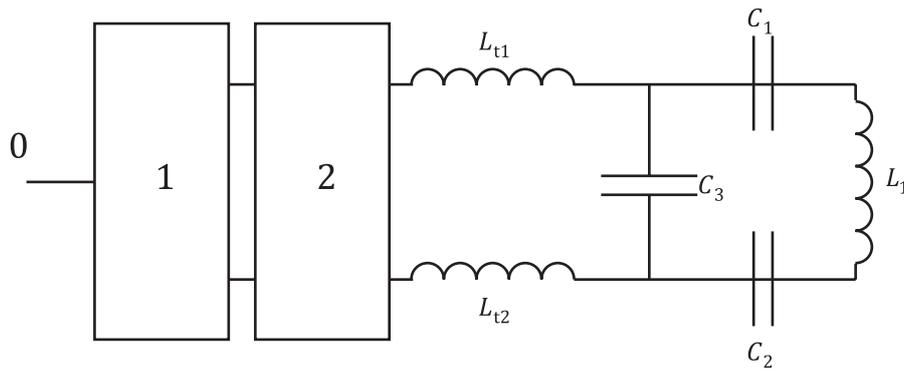


Figure A.2 — Ferrite tile dimensions and layout

A.3 Electrical design of the reference supply power circuit

[Figure A.3](#) shows the electrical schematic of the reference supply power circuit.



Key

- 0 connection to supply network
- 1 PFC
- 2 inverter
- L_1 primary device inductance
- L_{t1} and L_{t2} tuning inductances
- $C_1 - C_3$ tuning capacitors

Figure A.3 — Electrical schematic of reference supply power circuit

[Table A.1](#) shows the values of the components, currents and voltages shown in [Figure A.3](#).

Table A.1 — Values of components, currents and voltages

Component/ parameter	Value
primary device inductance (L_1)	See Table A.2
tuning inductance (L_{t1})	23,5 μ H
tuning inductance (L_{t2})	23,5 μ H
tuning capacitor (C_1)	40,4 nF
tuning capacitor (C_2)	40,4 nF
tuning capacitor (C_3)	120 nF
maximum PFC output current	9 A d.c.
maximum primary device current	30 A rms
PFC output voltage	450 V d.c.

An example of an inverter suitable to the reference supply power circuit of [Figure A.3](#) is shown in [Figure A.4](#). A typical value for a maximum inverter output current is 30 A rms.

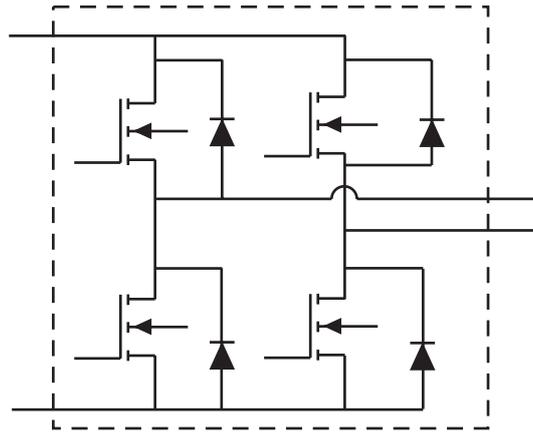


Figure A.4 — Example of electrical schematic of an inverter suitable to the coil design given in [Figure A.1](#)

A.4 Coupling and inductance information

This clause describes the coupling and inductance behaviour of the reference supply power circuit when operated with the circular reference EVPCs for MF-WPT1 specified in IEC 61980-3.

The values in [Table A.2](#) and [Table A.3](#) were determined with an aluminium shield (700 mm in x-direction, 900 mm in y-direction) and a vehicle mimic plate (1 500 mm in x-direction, 1 500 mm in y-direction) attached to the reference EVPCs.

NOTE The given values can deviate in a real vehicle environment.

The lead cable length assumed for the inductance values given in [Table A.2](#) is 1 m.

Table A.2 — Primary device inductance with MF-WPT1 reference EVPCs

Z class of reference EVPC	L_1 (min.) [μH]	L_1 (max.) [μH]
Z1	185	217
Z2	212	223
Z3	224	227

Table A.3 — Coupling with MF-WPT1 reference EVPCs

Z class of reference EVPC	k (min.)	k (max.)
Z1	0,100	0,249
Z2	0,085	0,221
Z3	0,084	0,243

Annex B (normative)

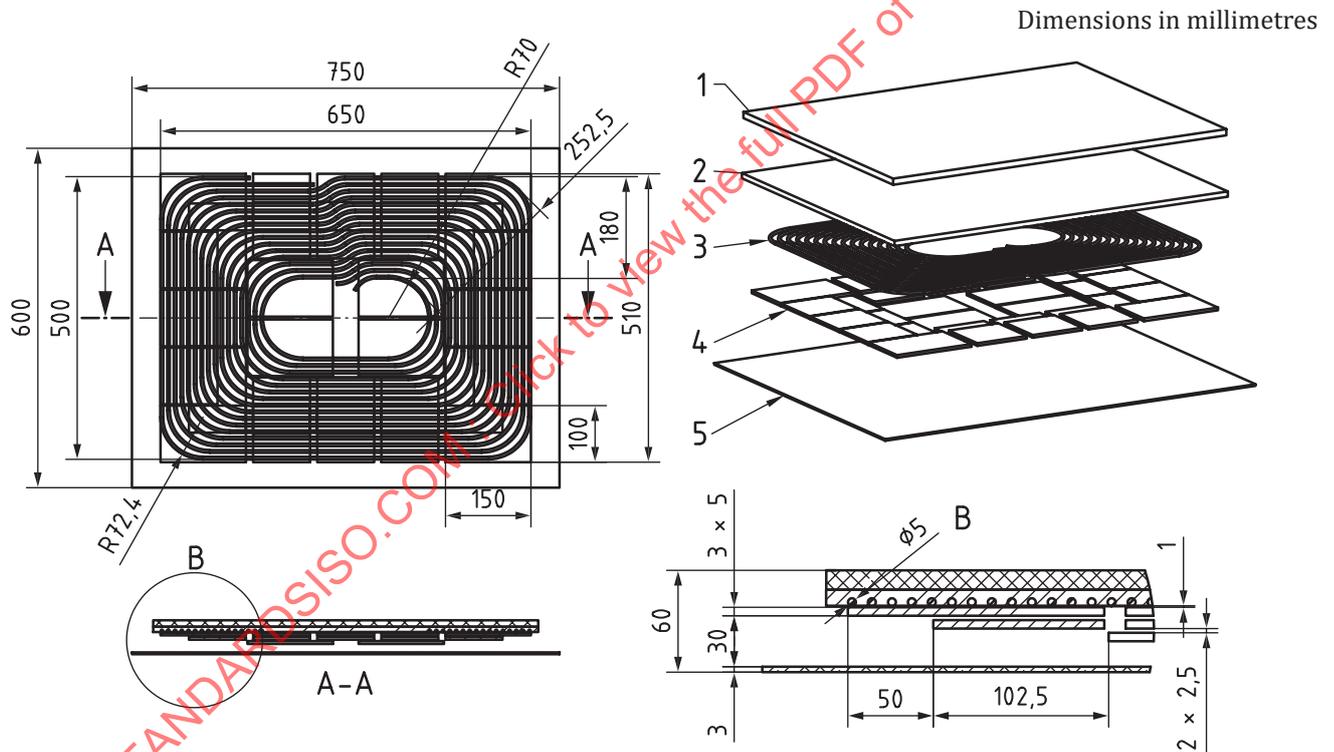
Reference supply power circuit for EVPCs with a rated output power $\leq 11,1$ kW

B.1 General

This annex describes the reference supply power circuit for an EVPC with a rated output power of $\leq 11,1$ kW. It is designed for on-ground mounting and is intended to operate at the nominal frequency of 85 kHz but performs over the system frequency range as specified in 7.2.

B.2 Mechanical design of the primary device

Figure B.1 shows the mechanical dimensions of the primary device.



Key

- 1 top cover
- 2 Litz tray
- 3 Litz wire
- 4 ferrite tiles
- 5 aluminium plate

Figure B.1 — Mechanical dimensions

The centre of this primary device (0/0 point of coordinate system) is at the midpoint of the coil in Figure B.1.

The coil dimension of the primary device shown in [Figure B.1](#) is 500 mm in the x-direction (direction of vehicle travel) and 650 mm in the y-direction.

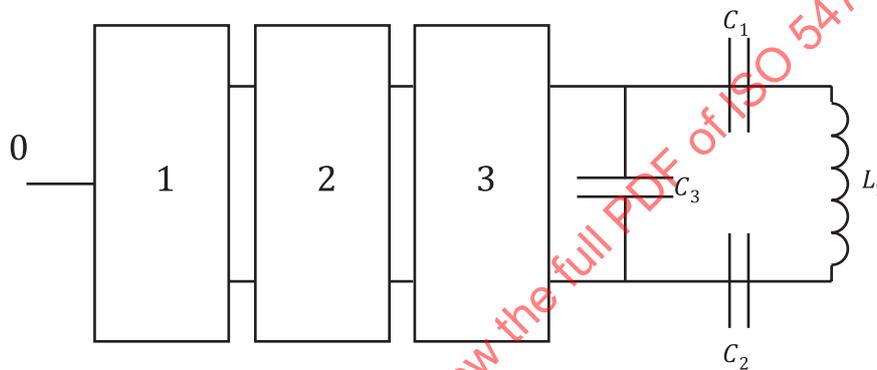
The Litz wire is 4 200 mm/0,05 mm with an overall diameter of approximately 5 mm. The coil consists of eight turns bifilar.

The ferrite layers in the primary device are made of MnZn ferrite tiles with the dimensions (100 × 150 × 5) mm and (100 × 100 × 5) mm and the following properties:

- initial permeability (25 °C) > 1 000;
- flux density, BS (100 °C; H = 1 200 A/m; 10 kHz) > 400 mT;
- core loss, PV (100 °C; 200 mT; 100 kHz) < 350 kW/m³.

B.3 Electrical design of the reference supply power circuit

[Figure B.2](#) shows the electrical schematic of the reference supply power circuit.



Key

- 0 connection to supply network
- 1 PFC
- 2 inverter
- 3 compensation network
- L₁ primary device inductance
- C₁ - C₃ tuning capacitors

Figure B.2 — Electrical schematic of reference supply power circuit

[Table B.1](#) shows the values of the components, currents and voltages in [Figure B.2](#).

Table B.1 — Values of components, currents and voltages

Component/parameter	Value
primary device inductance (L ₁)	See Tables B.4 and B.5
tuning capacitor (C ₁)	320 nF
tuning capacitor (C ₂)	320 nF
tuning capacitor (C ₃)	270 nF
maximum primary device current	75 A rms

[Table B.2](#) shows typical values for the characteristics of the PFC

Table B.2 — PFC characteristics

Component/parameter	Value
maximum PFC output current	29 A d.c.
PFC output voltage range	(380–500) V d.c.

An example of an inverter suitable to the reference coil system is shown in [Figure B.3](#).

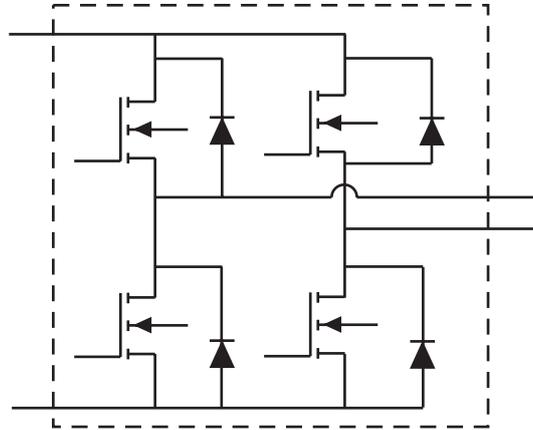


Figure B.3 — Example of electrical schematic of an inverter suitable to the coil design given in [Figure B.1](#)

[Table B.3](#) shows typical values for the inverter characteristics

Table B.3 — Inverter characteristics

Component/parameter	Value
maximum inverter output current	40 A rms

[Figure B.4](#) shows an example of a compensation network suitable for the coil design given in [B.1](#). Typical range for the variable reactances, $jX/2$, is (4–16) johms.

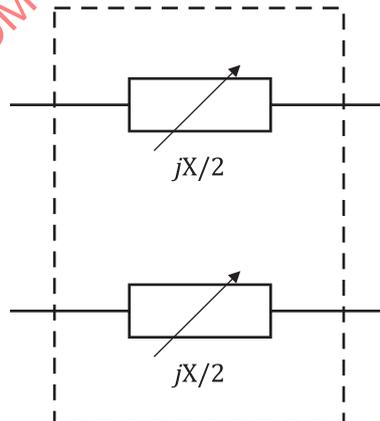


Figure B.4 — Example of electrical schematic of a compensation network suitable to the coil design given in [B.1](#)

B.4 Coupling and inductance information

This clause describes the coupling and inductance behaviour of the reference supply power circuit when operated with circular reference EVPCs for MF-WPT2 and MF-WPT3 specified in IEC 61980-3.

The values in [Tables B.4](#) to [B.7](#) were determined with an aluminium shield (800 mm in the x-direction, 800 mm in the y-direction) and a vehicle mimic plate (1 500 mm in the x-direction, 1 500 mm in the y-direction) attached to the reference EVPCs.

NOTE 1 The given values can deviate in a real vehicle environment.

The lead cable length assumed for the inductance values given in [Tables B.4](#) and [B.5](#) is 0,3 m.

NOTE 2 The reference supply power circuit can also be operated at 3,7 kW with these reference EVPCs for MF-WPT2 or MF-WPT3. The inductance and coupling values are consistent (independent from the transferred power) and are therefore not specifically indicated for MF-WPT1.

Table B.4 — Primary device inductance with MF-WPT2 reference EVPCs

Z class of reference EVPC	L_1 (min.) [μ H]	L_1 (max.) [μ H]
Z1	29,6	35,8
Z2	35,1	38,1
Z3	37,4	38,7

Table B.5 — Primary device inductance with MF-WPT3 reference EVPCs

Z class of reference EVPC	L_1 (min.) [μ H]	L_1 (max.) [μ H]
Z1	30,0	36,2
Z2	35,1	38,1
Z3	37,4	38,7

Table B.6 — Coupling with MF-WPT2 reference EVPCs

Z class of reference EVPC	k (min.)	k (max.)
Z1	0,109	0,238
Z2	0,090	0,221
Z3	0,087	0,229

Table B.7 — Coupling with MF-WPT3 reference EVPCs

Z class of reference EVPC	k (min.)	k (max.)
Z1	0,119	0,246
Z2	0,090	0,221
Z3	0,087	0,229

Annex C (informative)

Example for a different implementation of a supply power circuit

C.1 General

This annex describes an example for an implementation of a supply power circuit that is different to [Annexes A](#) and [B](#). It is designed for on-ground mounting and is intended to operate at the nominal frequency of 85 kHz.

NOTE Frequency tuning to compensate, for example, for height and alignment variation is not applied.

C.2 Mechanical design of the primary device

[Figures C.1](#) and [C.2](#) show the mechanical dimensions of the primary device.

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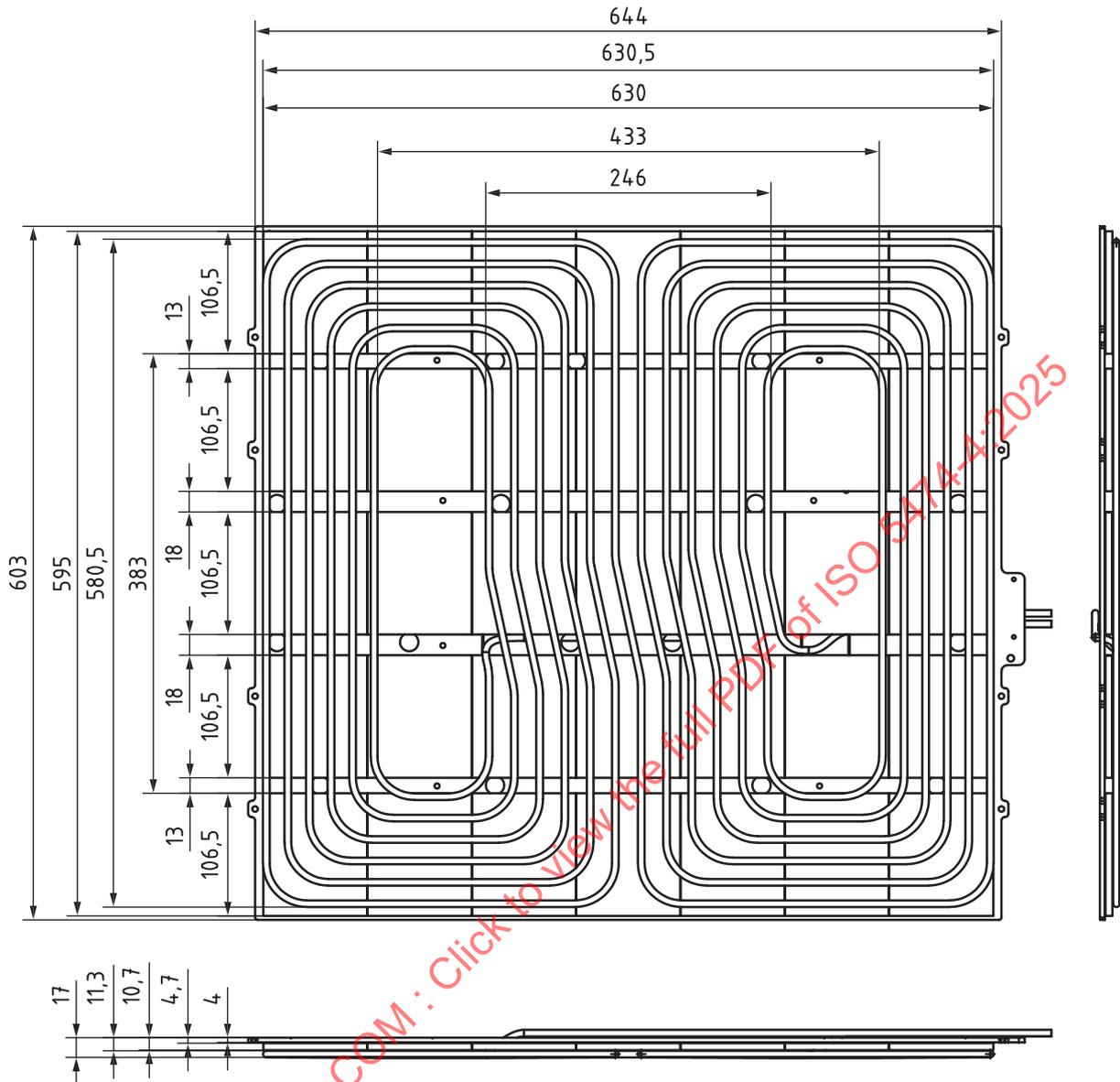
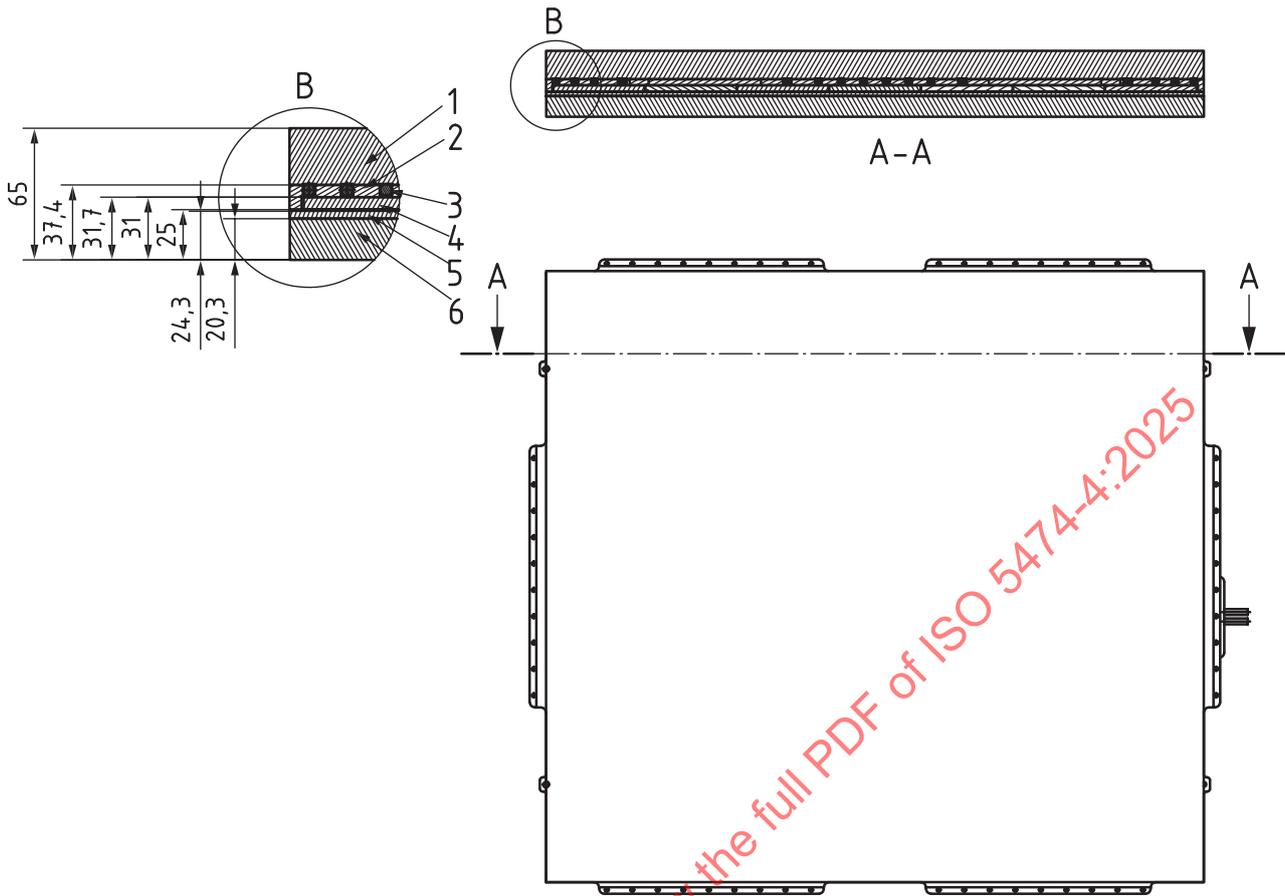


Figure C.1 — Mechanical dimensions



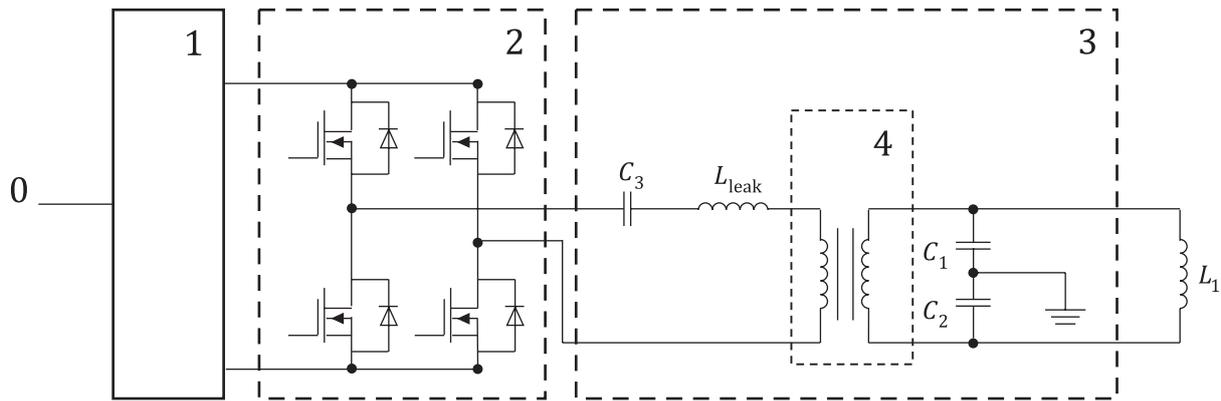
Key

- 1 top cover
- 2 Litz tray
- 3 Litz wire
- 4 ferrite tiles
- 5 aluminium plate
- 6 bottom cover

Figure C.2 — Details for mechanical dimensions

C.3 Electrical design of the supply power circuit

[Figure C.3](#) shows the electrical schematic of the supply power circuit.



Key

- 0 connection to supply network
- 1 PFC
- 2 inverter
- 3 impedance matching network
- 4 HF transformer
- L_1 primary device inductance
- L_{leak} HF transformer leakage inductance
- C_1 and C_2 tuning capacitors
- C_3 DC blocking capacitor

Figure C.3 — Electrical schematic of supply power circuit

Table C.1 shows the values of components, currents and voltages in Figure C.3.

Table C.1 — Values of components, currents and voltages

Component/ parameter	Value
primary device inductance (L_1)	See Tables C.2 and C.3
HF transformer leakage inductance (L_{leak})	22 μ H
primary / secondary inductance of HF transformer	1,7 / 11,9 mH
turn ratio of HF transformer	1:2,7 ($N_1:N_2 = 9:24$)
tuning capacitor (C_1)	98,4 nF
tuning capacitor (C_2)	98,4 nF
DC blocking capacitors (C_3)	360 nF

C.4 Coupling and inductance information

This clause describes the coupling and inductance behaviour of the supply power circuit when operated with the DD reference EVPCs for MF-WPT2 and MF-WPT3 specified in IEC 61980-3.

The values in Tables C.2 to C.5 were determined with an aluminium shield (1 100 mm in the x-direction, 1 100 mm in the y-direction) and a vehicle mimic plate (1 500 mm in the x-direction, 1 500 mm in the y-direction) attached to the reference EVPCs.

NOTE 1 The given values can deviate in a real vehicle environment.

The lead cable length assumed for the inductance values given in [Table C.2](#) and [Table C.3](#) is 3 m.

NOTE 2 The supply power circuit can also be operated at 3,7 kW with these reference EVPCs for MF-WPT2 or MF-WPT3. The inductance and coupling values are consistent (independent from the transferred power) and are therefore not specifically indicated for MF-WPT1.

Table C.2 — Primary device inductance with MF-WPT2 reference EVPCs

Z class of reference EVPC	L_1 (min.) [μH]	L_1 (max.) [μH]
Z1	54,9	62,5
Z2	62,5	65,8
Z3	65,6	68,5

Table C.3 — Primary device inductance with MF-WPT3 reference EVPCs

Z class of reference EVPC	L_1 (min.) [μH]	L_1 (max.) [μH]
Z1	56,9	64,3
Z2	68,3	72,3
Z3	67,9	71,7

Table C.4 — Coupling with MF-WPT2 reference EVPCs

Z class of reference EVPC	k (min.)	k (max.)
Z1	0,162	0,344
Z2	0,134	0,318
Z3	0,126	0,314

Table C.5 — Coupling with MF-WPT3 reference EVPCs

Z class of reference EVPC	k (min.)	k (max.)
Z1	0,170	0,388
Z2	0,160	0,385
Z3	0,140	0,344