

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Safety of transformers, reactors, power supply units and combinations thereof –
Part 2-16: Particular requirements and tests for switch mode power supply units
and transformers for switch mode power supply units for general applications**

**Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et
combinaisons de ces éléments –
Partie 2-16: Exigences particulières et essais pour les blocs d'alimentation à
découpage et les transformateurs pour blocs d'alimentation à découpage pour
applications d'ordre général**



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF TRANSFORMERS, REACTORS, POWER SUPPLY
UNITS AND COMBINATIONS THEREOF –****Part 2-16: Particular requirements and tests for switch mode power
supply units and transformers for switch mode power supply units
for general applications**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International standard IEC 61558-2-16 has been prepared by IEC technical committee 96: Transformers, reactors, power supply units and combinations thereof.

This second edition cancels and replaces the first edition published in 2009 and amendment 1:2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) adjustment of structure and references in accordance with IEC 61558-1:2017;
- b) definitions of different voltage characteristics;
- c) partial discharge and description of constructions moved to IEC 61558-1:2017;
- d) alternative method for dimensioning of **clearances**;
- e) removal of requirements for homogeneous field conditions.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
96/509/FDIS	96/513/RVD

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 International Standard is English.

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/standardsdev/publications.

It has the status of a group safety publication in accordance with IEC Guide 104.

This International Standard is to be used in conjunction with IEC 61558-1:2017.

NOTE When "Part 1" is mentioned in this standard, it refers to IEC 61558-1:2017.

This document supplements or modifies the corresponding clauses in IEC 61558-1:2017, so as to convert that publication into the IEC standard: *Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units for general applications*.

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A list of all parts in the IEC 61558 series, published under the general title *Safety of transformers, reactors, power supply units and combinations thereof*, can be found on the IEC website.

<https://standards.iteh.ai/catalog/standards/sist/e1ab2979-76ca-430d-9e84-3c06ed27a564/iec-61558-2-16-2021>

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

Where this document states "*addition*", "*modification*" or "*replacement*", the relevant text of IEC 61558-1:2017 is to be adapted accordingly.

In this document, the following print types are used:

- requirements proper: in roman type;
- *test specifications: in italic type;*
- explanatory matter: in smaller roman type.

In the text of this document, the words in **bold** are defined in Clause 3.

Subclauses, notes, figures and tables additional to those in IEC 61558-1:2017 are numbered starting from 101; supplementary annexes are entitled AA, BB, etc.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

IEC TC 96 has a group safety function in accordance with IEC Guide 104 for transformers other than those intended to supply distribution networks, in particular transformers and power supply units intended to allow the application of protective measures against electric shock as defined by TC 64, but in certain cases including the limitation of voltage and horizontal safety function for SELV, in accordance with IEC 60364-4-41.

The group safety function (GSF) is necessary because of responsibility for safety extra-low voltage (SELV) in accordance with IEC 61140:2016, 5.2.6 and IEC 60364-4-41:2017, 414.3.1 or control circuits in accordance with IEC 60204-1:2016, 7.2.4.

The group safety function is needed for each part of IEC 61558-2 because different standards of the IEC 61558 series can be combined in one construction but in certain cases with no limitation of rated output power.

For example, an auto-transformer in accordance with IEC 61558-2-13 can be designed with a separate SELV-circuit in accordance with the particular requirements for IEC 61558-2-6 relating to the general requirements of IEC 61558-1.

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SAFETY OF TRANSFORMERS, REACTORS, POWER SUPPLY UNITS AND COMBINATIONS THEREOF –

Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units for general applications

1 Scope

Replacement

This part of IEC 61558 deals with the safety of **switch mode power supply units** and **transformers** for **switch mode power supply units**.

NOTE 1 Safety includes electrical, thermal and mechanical aspects.

Unless otherwise specified, from here onward, the term **SMPS** covers **switch mode power supply units** for general applications.

SMPS covered by this document are air cooled (natural or forced) **independent, associated, stationary, portable**, single-phase or polyphase with the **rated supply voltage** not exceeding 1 000 V AC, the **rated supply frequency** not exceeding 500 Hz, the **rated internal operating frequency** exceeding 500 Hz, but not exceeding 100 MHz, and the **rated output** not exceeding 1 kVA or 1 kW, incorporating **dry-type transformers** with encapsulated or non-encapsulated windings.

[IEC 61558-2-16:2021](https://www.intelstandards.com/standards/iec-61558-2-16-2021)

NOTE 2 As the maximum **rated supply voltage** of the internal transformer is 1 000 V AC, the maximum **rated supply voltage** of the **switch mode power supply unit** can be lower due to the type of rectification.

NOTE 3 For higher frequencies, additional requirements can be necessary. However, this document can be used for guidance.

This document is applicable to **SMPS**, converters and inverters without limitation of the **rated output** subject to an agreement between the purchaser and the manufacturer.

NOTE 4 In the context of this document, converters and inverters are considered to be **SMPS**.

This document applies to:

- a) **SMPS** incorporating **safety isolating transformers** providing **SELV, PELV**, AC or DC **output voltage(s)** or a combination thereof in accordance with IEC 61140 and IEC 60364-4-41 for use with household and other consumer products,
- b) **SMPS** with a maximum **output voltage** not exceeding 1 000 V AC or 1 415 V ripple-free DC for use with household and other consumer products, except for products covered in a),
- c) This document can be used for **transformers** for use in **SMPS** (see Annex BB).

This document does not apply to:

- motor-generator sets;
- uninterruptible power supplies (UPS) in accordance with the IEC 62040 series;
- **SMPS** covered by IEC 61204-7 (i.e. low-voltage power supply devices DC output, performance characteristics) and DC power and distribution equipment and **SMPS** for use in applications covered by IEC 61010-1 and IEC 60601-1;
- lamp control gear covered by the IEC 61347 series;

- external circuits and their components intended to be connected to the input terminals and output terminals of the **SMPS**;
- equipment in accordance with IEC 60065, IEC 60950-1 and IEC 62368-1.

This document can also be used for guidance for products not covered by the scope of this document, the scope of IEC 61204-7 or the scope of the IEC 61347 series.

This document covers the safety requirements for:

- **SMPS** incorporating **separating transformers** for general use corresponding to IEC 61558-2-1;
- **SMPS** incorporating **isolating transformers** for general use corresponding to IEC 61558-2-4;
- **SMPS** incorporating **safety isolating transformers** for general use corresponding to IEC 61558-2-6;
- **SMPS** incorporating **auto-transformers** for general use corresponding to IEC 61558-2-13.

For **SMPS** for specific applications corresponding to the other documents of the IEC 61558-2 series, the necessary requirements of the relevant documents of the IEC 61558-2 series are applicable. In addition, the requirements listed in this document apply. Where two requirements are in conflict, the more severe takes precedence.

The **no-load output voltage** or the **rated output voltage** of **SMPS** does not exceed:

- 1 000 V AC or 1 415 V ripple-free DC when **SMPS** incorporating **separating transformers** or **auto-transformers** are used;
- 500 V AC or 708 V ripple-free DC when **SMPS** incorporating **isolating transformers** are used;
- 50 V AC or 120 V ripple-free DC when **SMPS** incorporating **safety isolating transformers** is used.

The **no-load output voltage** or the **rated output voltage** of **independent SMPS** is not less than:

- 50 V AC or 120 V ripple-free DC when **separating transformers**, **isolating transformers** or **auto-transformers** are used.

Attention is drawn to the following:

- additional requirements for **SMPS** intended to be used in vehicles, on board ships and aircraft (from other applicable standards, national rules, etc.);
- measures to protect the **enclosure** and the components inside the enclosure against external influences such as fungus, vermin, termites, solar-radiation and icing;
- the different conditions for transportation, storage and operation of the **SMPS**;
- additional requirements in accordance with other appropriate standards and national rules can be applicable to **SMPS** intended for use in special environments.

Future technological development of **SMPS** can necessitate a need to increase the upper limit of the frequencies. Until then, this document can be used as a guidance document.

This group safety publication focusing on safety guidance is primarily intended to be used as a product safety standard for the products mentioned in the scope, but is also intended to be used by TCs in the preparation of publications for products similar to those mentioned in the scope of this group safety publication, in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a TC is, wherever applicable, to make use of BSPs and/or GSPs in the preparation of its publications.

2 Normative references

This clause of Part 1 is applicable except as follows:

Addition:

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 61558-2-1, *Safety of power transformers, power supplies, reactors and combinations thereof – Part 2-1: Particular requirements and tests for separating transformers and power supplies incorporating separating transformers for general applications*

IEC 61558-2-4, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers for general applications*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general applications*

IEC 61558-2-13, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-13: Particular requirements and tests for auto transformers and power supply units incorporating auto transformers*

3 Terms and definitions

This clause of Part 1 is applicable except as follows:

Replacement:

For the purposes of this document, the terms and definitions given in Part 1 apply.

The term **transformer** in Part 1 also designates an **SMPS** as defined in this document.

In Annex BB, the term **transformer** applies to a **transformer** for **SMPS**.

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>

Replacement:

3.3.8

working voltage

highest RMS value of the AC or DC voltage that can occur (locally) across any insulation at **rated supply voltage** under no-load or normal operating conditions, transients being disregarded

Note 1 to entry: The **working voltage** between any point in the circuit supplied by electrical power sources and other isolated parts shall be assumed to be:

- the rated supply voltage, or
- the measured **working voltage**

whichever is greater.

Note 2 to entry: When considering the insulation system between windings not intended to be connected together, the **working voltage** is considered to be the highest voltage occurring on any of these windings.

Note 3 to entry: On three-phase systems, the **working voltage** can be different from the nominal voltage.

3.5.101

peak working voltage

peak value of the **working voltage**, including any DC component and any repetitive peak impulses generated in the **SMPS**

Note 1 to entry: Details about **peak working voltages** can be found in IEC 60664-1:2007, Figure 1.

[SOURCE: IEC 60050-903:2014, 903-04-02, modified – "equipment" replaced by "SMPS" and Note 1 to entry has been added]

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3.5.102

rated impulse voltage

impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages

[SOURCE: IEC 60664-1:2007, 3.9.2]

3.7.101

inhomogeneous electric field

electric field which does not have an essentially constant voltage gradient between electrodes (non-uniform field)

Note 1 to entry: The inhomogeneous field condition of a point-plane electrode configuration is the worst case with regard to voltage withstand capability and is referred to as case A in IEC 60664-1. It is represented by a point electrode having a 30 µm radius and a plane of 1 m × 1 m.

Note 2 to entry: For frequencies exceeding 30 kHz, the field is considered to be inhomogeneous when the radius of curvature of the conductive parts is less than 20% of the clearance

[SOURCE: IEC 60050-442:2014, 442-09-03, modified – The term "non-uniform electric field" has been omitted, and "(non-uniform field)" has been added to the definition.]

4 General requirements

This clause of Part 1 is applicable.

5 General notes on tests

This clause of Part 1 is applicable.

6 Ratings

This clause of Part 1 is applicable, except as follows:

Addition

6.101 The **rated output voltage** shall not exceed:

- 1 000 V AC or 1 415 V ripple-free DC for **SMPS** incorporating **separating transformers** or **auto-transformers**;
- 500 V AC or 708 V ripple-free DC for **SMPS** incorporating **isolating transformers**;
- 50 V AC or 120 V ripple-free DC for **SMPS** incorporating **safety isolating transformers**.

For **independent SMPS** incorporating **separating transformers, isolating transformers** or **auto-transformers**, the **rated output voltage** shall exceed 50 V AC or 120 V ripple-free DC.

6.102 The **rated output** of the **SMPS** shall not exceed 1 kVA or 1 kW.

SMPS without limitation of the rated output shall be subject to agreement between the purchaser and the manufacturer.

NOTE See Annex BB for a **transformer** incorporated in an **SMPS**.

6.103 The rated supply frequency shall not exceed 500 Hz.

6.104 The rated internal operating frequency shall not exceed 100 MHz.

6.105 The **rated supply voltage** shall not exceed 1 000 V AC.

Compliance with 6.101 to 6.105 is checked by inspection of the marking.

7 Classification

This clause of Part 1 is applicable.

8 Marking and other information

This clause of Part 1 is applicable except as follows:

8.1 h)

Replacement





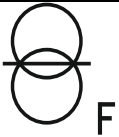
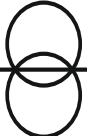
relevant graphical symbols shown in Table 101 that indicate the kind of **transformer** in addition with the symbol for **SMPS**. If an IP00 **transformer** or and **associated transformers** have circuits corresponding to different documents of the IEC 61558-2 series in the same construction (e.g. **SELV output circuit** in accordance with IEC 61558-2-6 and 230 V **output circuit** in accordance with IEC 61558-2-4), the relevant symbols have to be used. The term **transformer** shall be replaced by **SMPS**, except for the marking that applies to **incorporated transformers** and **incorporated SMPS**;

8.11*Addition*

The symbol for **SMPS** shall be used in conjunction with the symbol to indicate the type of **transformer(s)** that is/are incorporated.

Table 101 covers the symbols for **transformers** corresponding to the basic kinds of transformers.

Table 101 – Symbols used on SMPS

Symbol or graphical symbol	Explanation or title	Identification
	SMPS (Switch mode power supply unit) <i>(standards.iteh.ai)</i> https://standards.iteh.ai/catalog/standards/sist/e1ab2979-76ca-430d-9e84-3c06ed27a564/iec-61558-2-16-2021 IEC 61558-2-16:2021	IEC 60417-6190:2013-10
	SMPS incorporating a fail-safe separating transformer	IEC 60417-5156:2003-08
	SMPS incorporating a non-short-circuit-proof separating transformer	IEC 60417-5223:2002-10
	SMPS incorporating a short-circuit-proof separating transformer (inherently or non-inherently)	IEC 60417-5220:2002-10
	SMPS incorporating a fail-safe isolating transformer	IEC 60417-5221:2002-10
	SMPS incorporating a non-short-circuit-proof isolating transformer	IEC 60417-5944:2013-06