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INTERNATIONAL STANDARD

NORME INTERNATIONALE

GROUP SAFETY PUBLICATION
PUBLICATION GROUPÉE DE SÉCURITÉ

Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V –
Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units

Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V –
Partie 2-16: Règles particulières et essais pour les blocs d'alimentation à découpage et les transformateurs pour blocs d'alimentation à découpage

IEC 61558-2-16:2009

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SAFETY OF TRANSFORMERS, REACTORS, POWER SUPPLY UNITS AND SIMILAR PRODUCTS FOR SUPPLY VOLTAGES UP TO 1 100 V –

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

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 similar products for low voltage up to 1 100 V.

This first edition of IEC 61558-2-16 cancels and replaces IEC 61558-2-17, published in 1997. It constitutes a technical revision.

This part has the status of a group safety publication in accordance with IEC Guide 104 (1997): *The preparation of safety publications and the use of basic safety publications and group safety publications.*

The text of this standard is based on the following documents:

FDIS	Report on voting
96/330/CDV	96/333/RVC

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

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

This Part 2-16 is intended to be used in conjunction with the latest edition of IEC 61558-1 and its amendments. It is based on the second edition (2005) of that standard.

This part supplements or modifies the corresponding clauses in IEC 61558-1, 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.*

A list of all parts of the IEC 61558 series can be found on the IEC website under the title: *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V*.

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 a particular subclause of Part 1 is not mentioned in this part, that subclause applies as far as is reasonable. Where this part states "addition", "modification" or "replacement", the relevant text of Part 1 is to be adapted accordingly.

In this part, 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 part, the words in **bold** are defined in Clause 3.

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

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

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

NOTE The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC publication in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this publication be adopted for implementation nationally not earlier than 12 months from the date of publication.

SAFETY OF TRANSFORMERS, REACTORS, POWER SUPPLY UNITS AND SIMILAR PRODUCTS FOR SUPPLY VOLTAGES UP TO 1 100 V –

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

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**. **Transformers** incorporating **electronic circuits** are also covered by this standard.

NOTE 1 Safety includes electrical, thermal and mechanical aspects.

This part applies to:

a) **switch mode power supply units** incorporating **safety isolating transformers** providing **SELV, PELV** or **FELV** a.c. or d.c. **output voltage(s)**, or a combination thereof according to IEC 61140 and IEC 60364-4-41 for use with household and other consumer products, except for products covered by IEC 60065, IEC 61347 series, IEC 61204-7 and IEC 60950-1;

b) **switch mode power supply units** with a maximum **output voltage** not exceeding 1 000 V a.c. or 1 414 V ripple-free d.c. for use with household and other consumer products, except for products covered in a) and products covered by IEC 60065, IEC 61347 series, IEC 61204-7 and IEC 60950-1;

c) this standard may be used for **transformers** for use in **switch mode power supply units** (see Annex BB).

This part covers the safety requirements for:

- separating SMPS for general use corresponding to Part 2-1;
- isolating SMPS for general use corresponding to Part 2-4;
- safety isolating SMPS for general use corresponding to Part 2-6;
- auto-SMPS for general use corresponding to Part 2-13.

For SMPS for specific application corresponding to the other Parts 2 of 61558 series, the necessary requirements of the relevant Parts 2 are applicable. In addition, the requirements listed in this part apply. Where the two requirements are in conflict, the most severe take precedence.

NOTE 2 As the maximum **rated supply voltage** of the internal **transforme**r is 1 000 V, the maximum **rated supply voltage** of the **switch mode power supply** may be lower due to type of rectification.

Switch mode power supply units covered by this standard are air cooled (natural or forced) **independent**, **associated**, **stationary**, **portable**, single-phase, or polyphase, with the **rated supply voltage** not exceeding 1 100 V a.c., 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.

Associated transformers for **switch mode power supply units** covered by Annex BB of this standard shall have a **rated output** not exceeding:

– 25 kVA for single-phase **transformers**;

– 40 kVA for polyphase **transformers**.

NOTE 3 For higher frequencies, additional requirements may be necessary. However, this standard may be used as a guide.

The **no-load output voltage** or **the rated output voltage** of **switch mode power supply units** shall not exceed:

– 1 000 V a.c. or 1 415 V ripple-free d.c. when **separating transformers** or **auto-transformers** are used;

– 500 V a.c. or 708 V ripple-free d.c. when **isolating transformers** are used;

– 50 V a.c. or 120 V ripple-free d.c. when **safety isolating transformers** are used.

The **no-load output voltage** or the **rated output voltage** of **independent switch mode power supply units** shall not be less than:

– 50 V a.c. or 120 V ripple-free d.c. when **separating transformers** or **autotransformers** are used.

This standard is also applicable to **switch mode power supply units**, converters and inverters without limitation of the **rated output**. However, such **switch mode power supply units** are for special applications and are subject to an agreement between the purchaser and the manufacturer.

NOTE 4 In the context of this standard, converters and invertors are considered to be **switch mode power supply units**.

This standard may also be used as a guide for products not covered by the scope of this standard, the scope of IEC 61204-7, or the scope of IEC 61347 series.

This standard does not apply to:

– motor-generator sets;

– uninterruptible power supplies (UPS) according to IEC 62040;

– **switch mode power supply units** covered by IEC 61204-7 (i.e., low-voltage power supply devices, d.c. output, performance characteristics) and d.c. power and distribution equipment and **switch mode power supply units** for use in applications covered by IEC 60950-1, IEC 61010-1, IEC 60601-1, and IEC 60065;

– lamp control gear covered by IEC 61347-1;

– external circuits and their components intended to be connected to the input terminals and output terminals of the **transformers**.

NOTE 5 IEC 61204-7 will be updated by SC 22E.

NOTE 6 Attention is drawn to the following:

– for **transformers** intended to be used in vehicles, on board ships and aircraft, additional requirements (from other applicable standards, national rules, etc.) may be necessary;

– measures to protect the **enclosure** and the components inside the enclosure against external influences such as fungus, vermin, termites, solar-radiation, and icing should also be considered;

– the different conditions for transportation, storage, and operation of the **transformers** should also be considered;

– additional requirements in accordance with other appropriate standards and national rules may be applicable to **transformers** intended for use in special environments, such as tropical environment.

NOTE 7 Future technological development of **transformers** may necessitate a need to increase the upper limit of the frequencies; until then, this part may be used as a guidance document.

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

2 Normative references

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

Addition:

IEC 60227 (all parts), *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60950-1, *Information technology equipment – Safety – Part 1:General requirements*

IEC 60601-1, *Medical electrical equipment – Part 1:General requirements for basic safety and essential performance*

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

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1:General requirements*

IEC 61204-7:2006, *Low voltage power supplies, d.c. output – Part 7:Safety requirements*

IEC 61347 (all parts), *Lamp controlgear*

IEC 61558-1:2005, *Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests*

IEC 61558-2-1, *Safety of power transformers, power supplies, reactors and similar products – 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 similar products for supply voltages up to 1 100 V – Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 61558-2-13, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-13: Particular requirements and tests for auto transformers and power supply units incorporating auto transformers*

IEC 62040 (all parts), *Uninterruptible power systems (UPS)*

3 Terms and definitions

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

Addition:

The term **transformer** in Part 1 also designates a **SMPS** as defined by this part.

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

In this standard, the actual applicable terms are used.

Replacement

3.3.8

working voltage

highest r.m.s. value of the a.c. or d.c. voltage which may occur (locally) across any insulation at **rated supply voltage** under no-load or normal operating conditions, transients being disregarded. The **working voltage** between any point in the circuit supplied by the mains and other isolated parts shall be assumed:

- the rated input voltage, or
- the measured working voltage

whichever is greater

NOTE 1 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 2 On three phase systems, the **working voltage** can be different from the nominal voltage.

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 a.c. or 1 415 V ripple-free d.c. for **SMPS** incorporating **separating transformers** or **auto-transformers**;

– 500 V a.c. or 708 V ripple-free d.c. for **SMPS** incorporating **isolating transformers**;

– 50 V a.c. or 120 V ripple-free d.c. for **SMPS** incorporating **safety isolating transformers**.

For **independent SMPS** incorporating **separating transformers** or **auto-transformers**, the **rated output voltage** shall exceed 50 V a.c. or 120 V ripple-free d.c. and not exceed 1 000 V a.c. or 1 415 V ripple-free d.c.

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

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 1 100 V a.c.

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

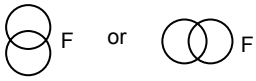
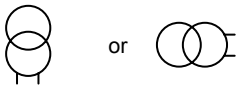
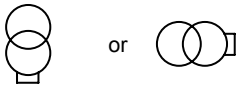
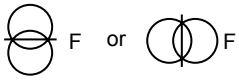
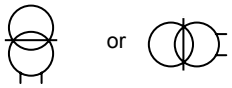
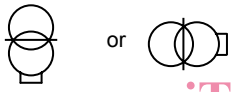
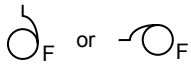
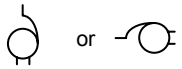
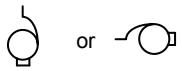
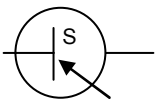
This clause of Part 1 is applicable, except as follows:

8.1 h) *Replacement*:

relevant graphical symbols shown in 8.11 indicating the kind of **transformer** in addition with the symbol for **SMPS**; if an IP00 **transformer** or and **associated transformers** have circuits corresponding to different parts 2 in the same construction (e.g. **SELV output circuit** according to Part 2-6 and 230 V **output circuit** according to Part 2-4) the relevant symbols have to be used. The term **transformer** shall be replaced by **SMPS**, except for the marking which applies to **incorporated transformers** and **incorporated SMPS**;

8.11 *Addition:*

The following symbols shall be used to indicate the type of **transformer**(s) that are incorporated:

Symbol or graphical symbol	Explanation or title	Identification
	**SMPS** incorporating a **fail-safe separating transformer**	
	**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**	
	**SMPS** incorporating a **non-short-circuit-proof isolating transformer**	
	**SMPS** incorporating a **short-circuit-proof isolating transformer** (inherently or non-inherently)	
	**SMPS** incorporating a **fail-safe safety isolating transformer**	
	**SMPS** incorporating a **non-short-circuit-proof safety isolating transformer**	
	**SMPS** incorporating a **short-circuit-proof safety isolating transformer** (inherently or non-inherently)	
	**SMPS** incorporating a fail-safe **auto-transformer**	
	**SMPS** incorporating a **non-short-circuit proof auto-transformer**	
	**SMPS** incorporating a **short-circuit proof auto-transformer** (inherently or non-inherently)	
	**SMPS** (Switch mode power supply unit)	

9 Protection against electric shock

This clause of Part 1 is applicable.

10 Change of input voltage setting

This clause of Part 1 is applicable except as follows:

Addition:

10.101 A wide range (e.g. 100 V a.c. to 240 V a.c.) of **supply voltage** is allowed if the **output voltage** does not exceed the **rated output voltage** and the **no-load output voltage** does not exceed the limits of the output voltage deviation according to the type of **transformer** feeding the appropriate **output circuit**.

11 Output voltage and output current under load

This clause of Part 1 is applicable.

12 No-load output voltage

This clause of Part 1 is applicable except as follows:

Addition:

The **no-load output voltage** is measured when the **SMPS** is connected to the **rated supply voltage** at the **rated supply frequency** at ambient temperature.

12.101 The **no-load output voltage** shall not exceed:

– 1 000 V a.c. or 1 415 V ripple-free d.c. for **SMPS** incorporating **separating transformers** or **auto-transformers**;

– 500 V a.c. or 708 V ripple-free d.c. for **SMPS** incorporating **isolating transformers**;

– 50 V a.c. or 120 V ripple-free d.c. for **SMPS** incorporating **safety isolating transformers**.

For **independent transformers**, this **output voltage** limitation applies even when **output windings**, not intended for interconnection, are connected in series.

12.102 The difference between the **no-load output voltage** and the **output voltage** under rated load shall not be excessive.

*The difference between the **no-load output voltage** measured in this clause and the **output voltage** under load measured during the test of Clause 11, expressed as a percentage of the latter voltage, shall not exceed the values shown in Table 101.*

NOTE 1 The ratio is defined as follows: $\frac{U_{\text{no-load}} - U_{\text{load}}}{U_{\text{load}}} \times 100\ \%$

where $U_{\text{no-load}}$ is the no-load output voltage and U_{load} is the output voltage under load.

Table 101 – Output voltages ratio

Type of transformer Rated output VA	Ratio between no-load output voltage and output voltage under load %
Up to and including 63	20
Over 63 up to and including 250	15
Over 250 up to and including 630	10
Over 630	5

Compliance with the requirements of 12.101 and 12.102 is checked by measuring the **no-load output voltage** at the **ambient temperature** when the **SMPS** is connected to **the rated supply voltage** at the **rated supply frequency**.

The difference shall not exceed the values shown in Table 101.

NOTE 2 The values of Table 101 are based on the values of Part 2-4 and are also applicable to **SMPS** according to Part 2-1, 2-6, and 2-13.

12.103 Unless otherwise specified by the manufacturer, **SMPS** with high frequency **output rating** shall be tested with 20 cm to 200 cm length of wire connected to the **output terminals** under the most unfavourable conditions. Two twisted wires or cables rated 60227 IEC 53 may be used. The cross sectional area of the conductors shall be determined according to the **rated output** of the **SMPS**, and the current density shall not exceed 5 A/mm^2 in normal use.

13 Short circuit voltage

This clause of Part 1 is applicable.

14 Heating

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

Addition:

14.101 For **SMPS** incorporating **transformers** with internal frequencies higher than 1 kHz, thermocouples or equivalent means of measuring the temperatures may be used to determine the temperature of the windings and the insulating materials.

The maximum values of Table 1 in Part 1 for winding temperatures shall be reduced by 10 °C for the thermocouple measurements. The thermocouples shall be mounted only on accessible surfaces of the incorporated transformers.

NOTE The thermo-couples should not be integrated in the windings.

15 Short-circuit and overload protection

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

Addition:

15.101 Electronic circuits shall be so designed and applied that a fault condition within the **SMPS** will not cause electric shock, or fire hazard, and unintentional operation of the appliance will not impair safety.