IEC 60947-8

Edition 2.0 2021-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Low-voltage switchgear and controlgear – Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines

Appareillage à basse tension – Partie 8: Unités de commande pour la protection thermique incorporée (CTP) aux machines électriques tournantes

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines

FOREWORD

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IEC 60947-8 has been prepared by subcommittee 121A: Low voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage. It is an International Standard.

This second edition cancels and replaces the first edition published in 2003, Amendment 1:2006 and Amendment 2:2011. This edition constitutes a technical revision.

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

a) safety aspects related to:
   - general aspects;
   - limited energy circuits;
   - electronic circuits;
b) alignment to IEC 60947-1:2020;

c) wire break detection function;

d) the term detector is replaced by thermistor;

e) reference to IEC 60738-1-4.

The provisions of the general rules dealt with IEC 60947-1 are applicable to this part of IEC 60947 series where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to IEC 60947-1:2020.

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

FDIS	Report on voting
121A/424/FDIS	121A/436/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.

A list of all the parts in the IEC 60947 series, under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

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

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- withdrawn,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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Thermal protection systems which are based on the principle of monitoring the temperature of the protected parts constitute a simple and effective means of protecting rotating electrical machines, called also electric motors, against excessive temperature rises, including those caused by faults in the cooling system, or excessively high ambient temperature, whereas systems of protection based only on monitoring the current absorbed do not ensure this type of protection in every circumstances.

Since the operating temperature and response times of thermal protection systems are fixed in advance, they are not often adjusted in relation to the conditions of use of the machine and, hence, they are not completely effective for all fault conditions, or improper use of the machine.

A thermal protection system in accordance with this document can consist of a characteristic change thermal detector which has an associated control unit to convert a point on the characteristic of the detector to a switching function. A very large number of thermal protection systems are in use and, in all cases, the machine manufacturer will fit the detectors in the machine. The machine manufacturer will either supply the control unit with the machine or specify particulars of the control unit to be used.

It is also customary for the control units to be considered as part of the control system and not necessarily supplied with the machine. For this reason, it is considered useful to have an interchangeable system, where the characteristics of association between the detector and the control unit are specified. This particular system is not considered superior in any way to other systems complying with the requirements of this document, but in some fields the practice is likely to be that this interchangeable system will be used, as indicated by the designation “Mark A”.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines

1 Scope

This part of IEC 60947 series specifies requirements for control units, which control a switching device in response to the PTC thermistors incorporated in rotating electrical machines and the industrial application.

It specifies requirements for that type of system comprising a positive temperature coefficient (PTC) thermistor having particular characteristics, and its associated control unit.

This document includes:

– the characteristics, construction, performance and tests of the control unit; and

– its association with a PTC thermistor designated “Mark A”.

This document does not cover:

– the incorporation of thermal protections into rotating machines and their maximum winding temperature. See IEC 60034-11;

– use of the product within explosive atmospheres (see IEC 60079 (all parts));

– software and firmware requirements;

NOTE 1 Guidance on embedded software is given in IEC TR 63201.

– cyber security aspects (see IEC TS 63208).

NOTE 2 It is not possible to specify all the requirements for the operating characteristics of a control unit, as they are dependent on some aspects of the PTC thermistors. Some aspects of the requirements of the thermal protector system can only be specified when account is taken of the characteristics of the rotating machine to be protected and the method of installation of the PTC thermistor within the machine.

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.

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
CISPR 11:2015/AMD1:2016

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60417, *Graphical symbols for use on equipment* (available at http://www.graphical-symbols.info/equipment)

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

IEC 60738-1:2006, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*
IEC 60738-1:2006/AMD1:2009

IEC 60738-1-4:2008, *Thermistors – Directly heated positive step-function temperature coefficient – Part 1-4: Blank detail specification – Sensing application – Assessment level EZ*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

ISO 2859-1:1999, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
ISO 2859-1:1999/AMD1:2011

3 Terms and definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60947-1:2020, as well as the following terms and definitions, apply.

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

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

3.1.1
built-in thermal protection
protection of certain parts (called protected parts) of a rotating electrical machine against excessive temperatures resulting from certain conditions of thermal overload, achieved by means of a thermal protection system, the whole or part of which is a thermally sensitive device incorporated within the machine

3.1.2
thermal protection system
system intended to ensure the thermal protection of a rotating electrical machine by means of a built-in PTC thermistor together with a control unit

3.1.3
control system
system to translate a particular point on the characteristic of a PTC thermistor to a switching function on the supply to the rotating electrical machine

Note 1 to entry: The system is capable of being reset (either manually or automatically) when the temperature falls to the reset value.

3.1.4
protected part
part of a rotating electrical machine, the temperature of which is limited to a predetermined value by the action of the thermal protection system

3.1.5
abrupt characteristic change PTC thermistor
PTC thermistor for which the abrupt change in resistance for one fixed temperature is able to initiate a switching operation in the control system

3.1.6
control unit
device which converts into a switching function the variation of the characteristic of a PTC thermistor

Note 1 to entry: The control unit can be part of other devices or systems.

3.1.7
control circuit
circuit controlling the switching device which makes and breaks the power supply

3.1.8
PTC thermistor operating temperature
<TNF> thermistor temperature at which, during an increase variation of the characteristic related to the temperature is such as to cause operation of the associated control unit

3.1.9
system operating temperature
<TFS> thermistor temperature at which, during an increase of temperature, the thermistor and control unit together cause the operation of the control unit

3.1.10
reset temperature
thermistor temperature at which, during a decrease variation of the characteristic related to the temperature is such that it permits the resetting of the control unit

3.1.11
positive temperature coefficient thermistor
PTC thermistor
thermistor, the resistance of which increases with its increasing temperature throughout the useful part of its characteristic

[SOURCE: IEC 60738-1:2006, 3.4, modified – Addition of alternative term.]

3.1.12
mark A thermistor
PTC thermistor having the particular characteristics described in Annex A

3.1.13
mark A control unit
control unit having the particular characteristics specified in this document and intended for operation in conjunction with a mark A thermistor

3.1.14
short-circuit detection
control unit capable of detecting short-circuited thermistor circuits

3.1.15
wire break detection
control unit capable of detecting wire breaks within the PTC thermistor circuits

3.2 Symbols and abbreviated terms

EMC Electromagnetic compatibility

I_e Rated operational current (5.3.3)

I_{th} Conventional free air thermal current (5.3.3)

PTC Positive temperature coefficient

Q Amplification factor (9.3.3.14.3)

TFS System operating temperature (3.1.9)

TNF PTC thermistor operating temperature (3.1.8)

U_e Rated operational voltage (5.3.2)

U_i Rated insulation voltage (5.3.2)

U_{imp} Rated impulse withstand voltage (6.1)

U_r Rated voltage of the thermistor circuit (6.1)

U_s Rated control circuit supply voltage (6.1)

4 Void

5 Characteristics of control units for built-in thermal protection (PTC)

5.1 Summary of characteristics

The characteristics of a control unit shall be stated in the following terms, where such terms are applicable:

– type of equipment (see 5.2);
– rated electrical values of the control unit (see 5.3);
– rated electrical values of the characteristic of the PTC thermistors and its circuit (see 5.4);
– rated electrical values of the control supply circuit (see 5.5).

5.2 Type of equipment

5.2.1 Operating temperatures of protection systems

Each PTC thermistor, or PTC thermistor with control unit, shall have either a declared rated operating temperature in accordance with 5.2.2 (TNF), or a declared rated system operating temperature in accordance with 5.2.3 (TFS), or both.

EXAMPLE

a) Abrupt characteristic change PTC thermistor: TNF to be declared; TFS is not applicable.

b) Abrupt characteristic change PTC thermistor with its control unit: TFS can be declared. For such systems the value of TFS can coincide with the value of TNF for the PTC thermistor itself.

5.2.2 Rated PTC thermistor operating temperature

In the case of an abrupt characteristic change PTC thermistor, the value of the TNF shall be declared under item o) of 6.1.

It is recommended that the normal value of TNF, expressed in degrees Celsius, be selected from the series of numbers which are multiples of five.

5.2.3 Rated system operating temperature

When the PTC thermistor and the control unit are supplied as a combined unit, the TFS shall be declared under item o) of 6.1.

The tolerance on the declared value of the TFS shall be ±6 K unless otherwise specified.

NOTE The tolerance is the sum of the tolerances of the PTC thermistor and the control unit.

Routine tests shall be carried out to verify correct operation under normal operating conditions in accordance with 8.2.1.1.

5.2.4 Maximum permissible rated operating temperature for the system

The maximum permissible value of the TFS depends on both the particular PTC thermistor and the control unit. It shall be declared under item o) of 6.1.

NOTE For any particular device, the maximum value of the TFS will be dependent on the characteristics and the materials used in the manufacture of the PTC thermistor, or by the limits on the characteristics of the PTC thermistor which can be modified by the range of settings available with the control unit design.

5.2.5 Control unit with reset temperature

When the reset function is provided, the reset temperature value and tolerances shall be provided under item o) of 6.1.

The reset temperature is verified in accordance with 9.3.3.8.

To restart the machine (electric motor) after the tripping of the control unit (switched off), it is important for the machine winding and the PTC thermistor to cool sufficiently to permit normal machine acceleration without nuisance tripping, especially with a high inertia load. The temperature value for restarting depends on installation and service conditions. The control unit can be designed in order to permit a selection of different temperature values.

For a manual restarting system, the maximum temperature should be considered. For automatic restarting systems, the machine manufacturer should consider the minimum and maximum differential temperatures which result from choices of TNF or TFS and reset temperature with the declared tolerance values. Differential values which are too narrow might not permit sufficient cool-down for restarting without nuisance tripping. Differential temperatures that are too wide can result in an excessively long machine cooling down time or resetting can be prevented in high ambient temperatures.

5.2.6 Control unit with sensor short-circuit detection

Control unit can be declared with sensor short-circuit detection. PTC thermistors have a low resistance and therefore a special measure is necessary to recognize a reduction of the resistance to nearly zero by a short-circuit. For safety applications, or to increase the lifetime of a rotating electrical machine, it is recommended to establish a short-circuit detection system within the PTC thermistor circuit. The safety of the thermal protection, in particular, is increased by such a short-circuit detection.

Such a short-circuit detection only identifies a short-circuit but it does not automatically cover a defined action. All following actions depend on the configuration of the control unit and the application.

5.2.7 Control unit with sensor wire break detection

Control unit can be declared with sensor wire break detection. The wire break detection shall monitor the PTC thermistor circuit, detect any interruption and give a corresponding signal.

The wire break detection is based on the evaluation of the steepness of the resistance-rise in the PTC thermistor circuit, caused by wire break in the PTC thermistor cable or caused by improper temperature-rise of the motor. In both cases the resistance in the PTC thermistor circuits can be higher than 100 kΩ.

5.3 Rated electrical values of the switching device of the control unit

5.3.1 Rated electrical values of switching devices

The rated electrical values of the switching devices of control units shall be declared in accordance with 5.3.2 to 5.3.4, as appropriate.

5.3.2 Rated voltages of a control unit

The rated voltages of a control unit are the rated insulation voltage (U_i) and the rated operational voltage (U_e) as defined in 5.3.1.2 and 5.3.1.1 of IEC 60947-1:2020.

5.3.3 Rated currents of a control unit

The rated currents of a control unit are the conventional free air thermal current (I_{th}) and the rated operational current (I_e) as defined in 5.3.2.1 and 5.3.2.3 of IEC 60947-1:2020.

NOTE A control unit can be assigned a number of combinations of rated operational voltage and rated operational current.

5.3.4 Rated making and breaking capacities of a control unit

For a control unit to which a utilization category is assigned, the utilization category shall be declared according to 4.4 of IEC 60947-5-1:2016 and it is unnecessary to specify rated making and breaking capacities, since these values depend directly on the utilization category and on the rated operational voltages and currents.

5.4 Rated electrical values of characteristic variation related to PTC thermistors

5.4.1 General

The rated electrical values of the characteristic variation related to PTC thermistors shall be declared.

5.4.2 Electrical data/ratings and characteristics related to the PTC thermistor

The detail specification of IEC 60738-1-4:2008 shall be used as sensor input reference for control units, tolerances or limiting values for the following parameters. If necessary, electrical data can be listed in tabular form, with reference to styles and codes as follows:

– upper/lower category temperatures (UCT/LCT);
– operating temperature range at maximum voltage;
– maximum voltage (U_{max});
– zero-power resistance (RT);
– lowest resistance value (R_{min});
– resistance RNF at TNF (if applicable, see Figure 2 of IEC 60738-1:2006);
– isolation test voltage (insulated PTC thermistors only);
– insulation resistance (insulated PTC thermistors only);
– response time.