

Australian/New Zealand Standard™

Low-voltage switchgear and controlgear

**Part 4.3: Contactors and motor-starters—
A.C. semiconductor controllers and
contactors for non-motor loads**



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Australian/New Zealand Standard™

Low-voltage switchgear and controlgear

Part 4.3: Contactors and motor-starters— A.C. semiconductor controllers and contactors for non-motor loads

Originated as AS C63—1965.
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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL/6, Industrial Switchgear and Controlgear to supersede AS 1029.2—1982 *Low voltage contactors Part 2: Semiconductor (solid state) (up to and including 1000 V a.c. and 1500 V d.c.)*.

The objective of this Standard is to provide characteristics, constructional and performance requirements and tests to verify performance for a.c. semiconductor non-motor load controllers and contactors for rated voltage up to 1000 V a.c.

This Standard is Part 4.3 of a series which, when complete, will consist of the following:

AS(/NZS) 3947	Low-voltage switchgear and controlgear
AS/NZS 3947.1	Part 1: General rules
AS 3947.2	Part 2: Circuit-breakers
AS/NZS 3947.3	Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
AS/NZS 3947.3 Suppl	Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units Supplement 1: Fuse-switch-disconnectors and switch-disconnectors for use with low voltage aerial bundled cables
AS 3947.4.1	Part 4.1: Contactors and motor-starters—Electromechanical contactors and motor-starters
AS 3947.4.2	Part 4.2: Contactors and motor-starters—A.C. semiconductor motor controllers and starters
AS/NZS 3947.4.3	Part 4.3: Contactors and motor-starters—A.C. semiconductor controllers and contactors for non-motor loads
AS/NZS 3947.5.1	Part 5.1: Control circuit devices and switching elements—Electromechanical control circuit devices
AS/NZS 3947.5.2	Part 5.2: Control circuit devices and switching elements—Proximity switches
AS/NZS 3947.5.3	Part 5.3: Control circuit devices and switching elements—Requirements for proximity devices with defined behaviour under fault conditions
AS/NZS 3947.5.4	Part 5.4: Control circuit devices and switching elements—Methods of assessing the performance of low-energy contacts—Special tests
AS/NZS 3947.5.5	Part 5.5: Control circuit devices and switching elements—Electrical emergency stop devices with mechanical latching function
AS/NZS 3947.5.6	Part 5.6: Control circuit devices and switching elements—D.C. interface for proximity sensors and switching amplifiers (NAMUR)
AS 3947.6.1	Part 6.1: Multiple function equipment—Automatic transfer switching equipment
AS 3947.6.2	Part 6.2: Multiple function equipment—Control and protective switching devices (or equipment) (CPS)
AS 3947.7.1	Part 7.1: Ancillary equipment—Terminal blocks for copper conductors
AS 3947.7.2	Part 7.2: Ancillary equipment—Protective conductor terminal blocks for copper conductors
AS/NZS 3947.7.3	Part 7.3: Ancillary equipment—Safety requirements for terminal blocks for the reception of cartridge fuses

This Standard is identical with and has been reproduced from IEC 60947-4-3:1999, *Low-voltage switchgear and controlgear—Part 4-3: Contactors and motor-starters—AC semiconductor controllers and starters for non motor loads*.

A reference to an International Standard identified in the Normative References Clause by strikethrough (~~example~~) is replaced by a reference to the Australian or Australian/New Zealand Standard(s) listed immediately thereafter and identified by shading (**example**). Where the struck-through referenced document and the referenced Australian or Australian/New Zealand Standard are identical, this is indicated in parenthesis after the title of the latter.

In January 1997, the IEC commenced numbering its Standards from 60000 by adding 60000 to the number of each existing Standard. This coordinates IEC numbering with ISO numbering. During the transition period an IEC Standard might be identified by its new number or its old number (for example, IEC 60050 or IEC 50).

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (b) In the source text ‘this standard’ should read ‘this Australian/New Zealand Standard’.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the annex to which they apply. A normative annex is an integral part of a Standard, whereas an informative annex is only for information and guidance.

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INTRODUCTION

This part of IEC 60947 covers low-voltage a.c. semiconductor controllers and contactors (solid-state contactors) intended for the use with non-motor loads. As controllers, they have many capabilities beyond the simple switching on and off of non-motor loads. As contactors, they perform the same functions as mechanical contactors, but utilize one or more semiconductor switching devices in their main poles.

The devices may be single-pole or multi-pole (see 2.3.1 of IEC 60947-1). This standard refers to complete devices rated as a unit incorporating all necessary heat-sinking material and terminals. It includes devices with all necessary terminals, which are supplied with or without heat-sink in knocked-down form for combination by the users, when the manufacturer gives with the device detailed information about choosing the heat-sink and mounting the device on the heat-sink.

The generic term, "controller", is used in this standard wherever the unique features of the power semiconductor switching elements are the most significant points of interest. The generic term "contactor" is used in this standard wherever the feature of simple switching on and off is the most significant point of interest. Specific designations (for example, form 4, form HxB, etc.) are used wherever the unique features of various configurations comprise significant points of interest.

The provisions of the general rules (IEC 60947-1) are applicable to this standard, where specifically called for. Clauses and subclauses thus applicable, as well as tables, figures, and annexes, are identified by reference to IEC 60947-1, for example 1.2.3, table 4 of IEC 60947-1 or annex A of IEC 60947-1.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Low-voltage switchgear and controlgear****Part 4.3: Contactors and motor-starters—A.C. semiconductor controllers and contactors for non-motor loads**

Any IEC table, figure or passage of text that is struckthrough is not part of this Standard. Any Australian/New Zealand table, figure or passage of text that is added (and identified by shading) is part of this Standard.

1 Scope and object

This part of IEC 60947 applies to a.c. semiconductor non-motor load controllers and contactors intended for performing electrical operations by changing the state of a.c. electric circuits between the ON-state and the OFF-state. Typical applications are given in table 2.

As controllers, they may be used to reduce the amplitude of the r.m.s. a.c. voltage on the load terminals from that of the applied voltage – either continuously or for a specified period of time. The half-wave period of the a.c. wave form remains unchanged from that of the applied voltage.

They may include a series mechanical switching device and are intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V a.c.

The semiconductor controllers and contactors dealt with in this standard are not normally intended to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see 8.2.5) should form part of the installation but not necessarily of the controller itself.

In this context, this standard gives requirements for semiconductor controllers and contactors associated with separate short-circuit protective devices.

This standard does not apply to

- continuous operation of a.c. motors;
- low-voltage a.c. semiconductor motor controllers and starters covered by IEC 60947-4-2;
- electronic a.c. power controllers covered by IEC 60146;
- all-or-nothing solid-state relays.

Contactors and control-circuit devices used in semiconductor controllers and contactors should comply with the requirements of their relevant product standard. Where mechanical switching devices are used, they should meet the requirements of their own IEC product standard and the additional requirements of this standard.

The object of this standard is to state

- a) the characteristics of semiconductor controllers and contactors and associated equipment;

- b) the conditions with which semiconductor controllers and contactors should comply with reference to
 - their operation and behaviour;
 - their dielectric properties;
 - the degrees of protection provided by their enclosures, where applicable;
 - their construction;
- c) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;
- d) the information to be given with the equipment or in the manufacturer's literature.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60947. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60947 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

References to International Standards that are struck through in this Clause are replaced by references to equivalent Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is appropriately identified.

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

~~IEC 60269-1:1998, Low voltage fuses – Part 1: General requirements~~

AS/NZS 60269, *Low-voltage fuses*
AS/NZS 60269.1 *Part 1: General requirements* (Identical to IEC 60269-1:1998)

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

~~IEC 60439-1:1992, Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies~~

AS 3439, *Low-voltage switchgear and controlgear assemblies*
AS 3439.1 *Part 1: Type-tested and partially type-tested assemblies*

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

~~IEC 60947-1:1999, Low voltage switchgear and controlgear – Part 1: General rules~~

AS/(NZS) 3947, *Low-voltage switchgear and controlgear*
AS/NZS 3947.1 *Part 1: General rules*

~~IEC 60947-4-2:1995, Low-voltage switchgear and controlgear – Part 4: Contactors and motor starters – Section 2: AC semiconductor motor controllers and starters~~

AS/(NZS) 3947, *Low-voltage switchgear and controlgear*

AS 3947.4.2 Part 4.2: *Contactors and motor-starters—A.C. semiconductor motor controllers and starters* (Identical to IEC 60947-4-2:1995)

IEC 61000-2-1:1990, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 1: Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems*

~~IEC 61000-3-2:1995, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*~~

AS/NZS 61000, *Electromagnetic compatibility (EMC)*

AS/NZS 61000.3.2 Part 3.2: *Limits—Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

~~IEC 61000-4 (all parts), *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques*~~

AS/NZS 61000, *Electromagnetic compatibility (EMC)*

AS/NZS 61000.4 Part 4: *Testing and measurement techniques*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test – Basic EMC publication*

~~IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radiofrequency, electromagnetic field immunity test*~~

AS/NZS 61000, *Electromagnetic compatibility (EMC)*

AS/NZS 61000.4.3 Part 4.3: *Testing and measurement techniques—Radiated, radiofrequency, electromagnetic field immunity test* (Identical to IEC 61000-4-3:1995)

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test – Basic EMC publication.*

~~IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*~~

AS/NZS 61000, *Electromagnetic compatibility (EMC)*

AS/NZS 61000.4.5 Part 4.5: *Testing and measurement techniques—Surge immunity test* (Identical to IEC 61000-4-5:1995)

~~IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radiofrequency fields*~~

AS/NZS 61000, *Electromagnetic compatibility (EMC)*

AS/NZS 61000.4.6 Part 4.6: *Testing and measurement techniques—Immunity to conducted disturbances, induced by radiofrequency fields* (Identical to IEC 61000-4-6:1996)

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests – Basic EMC publication*

CISPR 11:1997, *Industrial, scientific and medical (ISM) radiofrequency equipment – electromagnetic disturbance characteristics – Limits and methods of measurement*

~~CISPR 14-1:1993, *Electromagnetic compatibility—Requirements for household appliances, electric tools and similar apparatus—Part 1: Emission—Product family standard*~~

AS/NZS 1044, *Electromagnetic compatibility—Requirements for household appliances, electric tools and similar apparatus —Emission—Product family standard*
(Identical to CISPR 14-1:1993)

3 Definitions

For the purposes of this part of IEC 60947, relevant definitions of clause 2 of IEC 60947-1 apply with the following additional definitions:

3.1 Definitions concerning a.c. semiconductor (non-motor-load) control devices

3.1.1 AC semiconductor controllers and contactors (solid-state contactors)

(see figure 1)

3.1.1.1

a.c. semiconductor controller

semiconductor switching device (see 2.2.3 of IEC 60947-1) that provides a switching function for an a.c. electrical load (non-motor load) and an OFF-state

NOTE 1 – Because dangerous levels of leakage currents (see 3.1.13) can exist in a semiconductor controller in the OFF-state, the load terminals should be considered to be live at all times.

NOTE 2 – In a circuit where the current passes through zero (alternately or otherwise), the effect of "not making" the current following such a zero value is equivalent to breaking the current.

3.1.1.1.1

semiconductor controller (form 4)

a.c. semiconductor controller in which the switching function may comprise any method specified by the manufacturer. It provides control functions which may include any combination of ramp-up, load control or ramp-down. A FULL-ON state may also be provided

3.1.1.1.2

Vacant

3.1.1.1.3

semiconductor direct-on-line (DOL) contactor (form 5)

special form of a.c. semiconductor controller in which the switching function is limited to the full-voltage, unramped method only and where the additional control function is limited to providing FULL-ON (also known as a semiconductor contactor or solid-state contactor).

It is a device (see 2.2.13 of IEC 60947-1) which performs the function of a contactor by utilizing a semiconductor switching device (see 2.2.3 of IEC 60947-1). It has only one position of rest (OFF-state or Open state in the case of an HxB hybrid controller) and is operated by the application of a control signal. It is capable of carrying load currents as well as changing the state of the said load (electrical circuit) between the FULL-ON and the OFF-states (Open) under normal circuit conditions including operating overload conditions.

3.1.1.2

Vacant

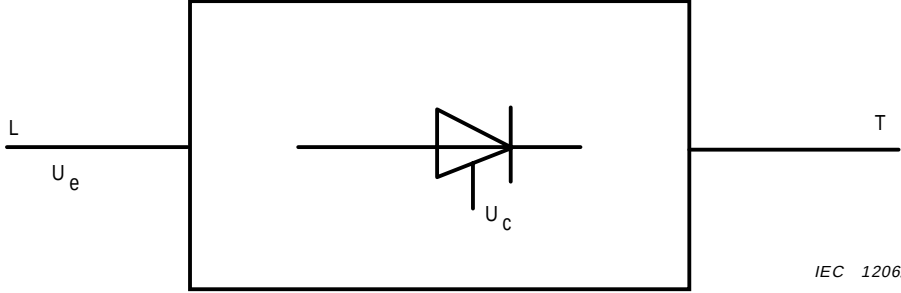
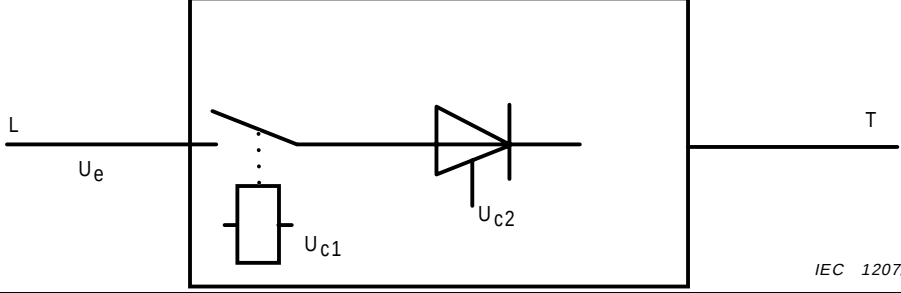
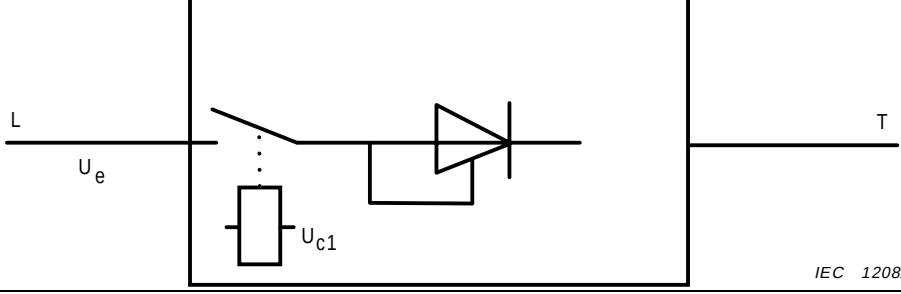
Device	
Controller (all forms)	 IEC 1206/99
Hybrid controller HxA* where x = 4 or 5	 IEC 1207/99
Hybrid controller HxB** where x = 4 or 5	 IEC 1208/99
* Two separate controls for the controller and the series mechanical switching device respectively. ** One control only for the series mechanical switching device.	

Figure 1 – Graphical possibilities of controllers

Table 1 – Functional possibilities of controllers and contactors

Device	Form 4	Form 5
Semiconductor controller	OFF-state Ramp-up Load control FULL-ON state Ramp-down	Not available
Semiconductor DOL contactor	Not available	OFF-state Switch-on function FULL-ON state
Hybrid controller HxA* where x = 4 or 5	H4A: – open state – OFF-state – ramp-up – load control – FULL-ON state – ramp-down	H5A: – open state – OFF-state – switch-on function – FULL-ON state
Hybrid controller HxB** where x = 4 or 5	H4B: – open state – ramp-up – load control – FULL-ON state – ramp-down	H5B: – open state – switch-on function – FULL-ON state
* Two separate controls for the controller and the series mechanical switching device, respectively. ** One control only for the series mechanical switching device.		

3.1.2 Hybrid controllers and contactors (see figure 1)

3.1.2.1

hybrid controllers or contactors form HxA (where x = 4 or 5)

form 4, or form 5 semiconductor controller in series with a mechanical switching device all rated as a unit. Separate control commands are provided for the series mechanical switching device and the semiconductor controller or contactor. All the control functions appropriate to the form of controller specified are provided together with an OPEN position

3.1.2.2

hybrid controllers or contactors, form HxB

form 4 or form 5 semiconductor controller in series with a mechanical switching device all rated as a unit. A single control command is provided for both the series mechanical switching device and the semiconductor controller or contactor. All the control functions appropriate to the form of controller specified are provided with the exception of an OFF-state

3.1.2.3

OPEN position

condition of a hybrid semiconductor controller when the series mechanical switching device is in the OPEN position (see 2.4.21 of IEC 60947-1)

3.1.3**current-limit function**

ability of the controller to limit the load current to a specified value. It does not include the ability to limit the instantaneous current under conditions of short circuit

3.1.4**load control**

any deliberate operation which causes changes in the effective power available to the load through variation of either

- an imposed operating cycle (i.e. variation of the cyclic duration factor F and/or the number of operating cycles per hour S , see 5.3.4.6)
- or
- the load terminal voltage (for example, through phase-angle control)
- or
- a combination of these

NOTE 1 – Switch-on is a mandatory form of load control that is recognized separately.

NOTE 2 – Load control can be performed by a form 5 controller, if an external switching device or control circuit causes the cyclic transition from the OFF-state to the FULL-ON state and back again (i.e. load control by operating cycle).

3.1.5**ramp-up**

switching (switch-on) function which causes the transition from the OFF-state (or from the Open state, in the case of a HxB hybrid controller) to the ON-state (i.e. to the FULL-ON state or to a load control operation) over a defined period of time (the ramp-up time)

3.1.6**ramp-down**

switching (switch-off) function which causes the transition from the ON-state (i.e. either from FULL-ON or from a load control operation) to the OFF-state (or the Open state, in the case of an HxB hybrid controller) over a defined period of time (ramp-down time)

3.1.7**controlled operation**

Not defined (see 3.1.4)

3.1.8

Vacant

3.1.9**ON-state**

condition of a semiconductor controller when the conduction current can flow through its main circuit

3.1.10**FULL-ON (state of controllers)**

condition of a controller when the controlling functions are set to provide normal full-voltage excitation to the load

3.1.11**minimum load current**

minimum operational current in the main circuit which is necessary for correct action of a controller in the ON-state

NOTE – The minimum load current should be given as the r.m.s. value.

3.1.11.1**minimum load current detection**

ability of the controller to detect and signal that the load current is below a specified minimum value, for which signalling can be achieved by the OFF or Open states

3.1.12**OFF-state**

condition of a controller when no control signal is applied and no current exceeding the OFF-state leakage current flows through the main circuit

3.1.13**OFF-state leakage current (I_L)**

current which flows through the main circuit of a semiconductor contactor in the OFF-state

3.1.14**operation (of a controller)**

transition from the ON-state to the OFF-state or the reverse

3.1.14.1**switching function**

function designed to make or break the current during the operation of a controller

3.1.14.2**ramp switching function**

See ramp-up and ramp-down

3.1.14.3**instantaneous switching function**

switching function which causes the instantaneous transition from the ON-state (i.e. either from FULL-ON or from a load control operation) to the OFF-state (or the Open state, in the case of an HxB hybrid controller) or vice versa.

In the case of switch-off, the term "instantaneous" is used to mean the minimum opening time (see 2.5.39 of IEC 60947-1).

In the case of switch-on, the term "instantaneous" is used to mean make time (see 2.5.43 of IEC 60947-1) plus the transient time determined only by external circuit impedance

3.1.14.4**switching point**

point on the wave form of the applied voltage (see 2.5.32 of IEC 60947-1) at which the semiconductor switching device becomes conductive during a switch-on operation

3.1.14.4.1**defined-point switching (of a semiconductor controller)**

ability of a semiconductor controller to permit the flow of current through the main circuit only as from the instant the a.c. applied voltage (see 2.5.32 of IEC 60947-1) or alternatively the a.c. control circuit voltage reaches a specified point on its wave form

This form of optimized switching may be used for rush-current damping or the "soft switching" of transformers.

3.1.14.4.2**zero-point switching (of a semiconductor controller)**

special form of defined point switching applicable only in the case of single pole semiconductor controllers for non-motor loads

The transition from the OFF-state to the ON-state after application of the control signal in such a way, that the semiconductor switching device becomes conductive at the instant a.c. applied voltage (see 2.5.32 of IEC 60947-1) passes through zero

NOTE – This type of operation is particularly suitable for resistive and incandescent light loads. It should not be used for inductive or capacitive loads since the angular displacement between load current and driving voltage in these loads would cause severe transient current peaks.

3.1.14.4.3

random point switching (of a semiconductor controller)

absence of the ability of a semiconductor controller to permit the flow of current through the main circuit only as from the instant the a.c. applied voltage (see 2.5.32 of IEC 60947-1) or alternatively the a.c. control circuit voltage reaches a specified point on its wave form

3.1.15

operating cycle (of a controller)

succession of operations from one state to the other and back to the first state

NOTE – A succession of operations not forming an operating cycle is referred to as an operating series.

3.1.16

operating capability

under prescribed conditions, ability to perform a series of operating cycles without failure

3.1.17

overload current profile

current-time coordinate specifying the requirement to accommodate overload currents for a period of time (see 5.3.5.1)

3.1.18

rating index

rating information organized in a prescribed format unifying rated operational current and the corresponding utilization category, overload current profile, and the duty cycle or OFF-time (see 6.1 e))

3.1.19

tripping operation (of a controller)

operation to establish and maintain an OFF-state (or open position in the case of a form HxB controller) initiated by a control signal

3.1.20

trip-free controller

controller which establishes and sustains an OFF-state condition which cannot be overridden in the presence of a trip condition

NOTE – In the case of form HxB, the term "OFF-state condition" is replaced by the term "OPEN position".

3.1.21

overcurrent protective means OCPM

means that cause a switching device to revert to the OFF-state or open position with or without time-delay when the current exceeds a predetermined value

3.1.22

ON-time

period of time during which the controller is on-load, for example as in figure F.1 of annex F

3.1.23**OFF-time**

period of time during which the controller is off-load, for example as in figure F.1 of annex F

3.2 EMC definitions

Various EMC definitions are given in IEC 60050, particularly chapter 161. Further explanations are given in IEC 61000-2-1. For convenience and to avoid confusion, some of the key definitions from IEC 60050(161) are reproduced here.

3.2.1**electromagnetic compatibility, EMC (abbreviation)**

ability of an equipment or system to function satisfactorily in its *electromagnetic environment* without introducing intolerable *electromagnetic disturbances* to anything in that environment [IEV 161-01-07]

3.2.2**(electromagnetic) emission**

phenomenon by which electromagnetic energy emanates from a source [IEV 161-01-08]

3.2.3**electromagnetic disturbance**

any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

NOTE – An electromagnetic disturbance may be an *electromagnetic noise*, an *unwanted signal* or a change in the propagation medium itself. [IEV 161-01-05]

3.2.4**radio(frequency) disturbance**

electromagnetic disturbance having components in the radiofrequency range [IEV 161-01-13]

3.2.5**radiofrequency interference; RFI (abbreviation)**

degradation of the reception of a wanted signal caused by *radiofrequency disturbance*

NOTE – The English words "interference" and "disturbance" are often used indiscriminately. The expression "radiofrequency interference" is also commonly applied to a radiofrequency disturbance of an *unwanted signal*. [IEV 161-01-14]

3.2.6**transient (adjective and noun)**

pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short compared with the time-scale of interest [IEV 161-02-01]

3.2.7**burst (of pulses or oscillations)**

sequence of a limited number of distinct *pulses* or an oscillation of limited duration [IEV 161-02-07]

3.2.8**voltage surge**

transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage [IEV 161-08-11]

3.2.9**immunity (to a disturbance)**

ability of a device, equipment or system to perform without *degradation* in the presence of an *electromagnetic disturbance* [IEV 161-01-20]

4 Classification

All data which could be used as criteria for classification is given in 5.2.

5 Characteristics of a.c. semiconductor controllers and contactors**5.1 Summary of characteristics**

The characteristics of controllers and contactors shall be stated in the following terms, where such terms are applicable:

- type of equipment (see 5.2);
- rated and limiting values for main circuits (see 5.3);
- utilization category (see 5.4);
- control circuits (see 5.5);
- auxiliary circuits (see 5.6);
- types and characteristics of relays and releases (see 5.7);
- coordination with short-circuit protective devices (see 5.8);
- switching overvoltages (see 5.9).

5.2 Type of equipment

The following shall be stated.

5.2.1 Form of equipment

Forms of controllers and contactors (see 3.1.1 and 3.1.2).

5.2.2 Number of poles**5.2.2.1 Number of main poles****5.2.2.2 Number of main poles where the operation is controlled by a semiconductor switching element****5.2.3 Kind of current**

AC only.

5.2.4 Interrupting medium (air, vacuum, etc.)

Applicable only to mechanical switching devices of hybrid controllers and contactors.

5.2.5 Operating conditions of the equipment**5.2.5.1 Method of operation**

For example:

- symmetrically controlled controller (such as semiconductor with fully controlled phases);
- non-symmetrically controlled controller (such as thyristors and diodes).

5.2.5.2 Method of control

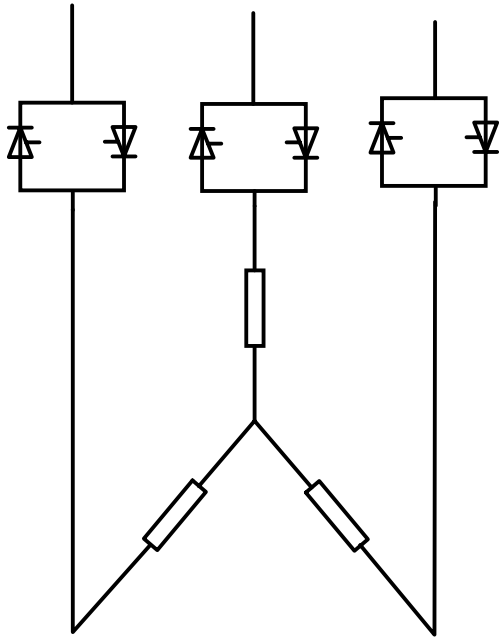
For example:

- automatic (by pilot switch or sequence control);
- non-automatic (that is push-buttons);
- semi-automatic (that is partly automatic, partly non-automatic).

5.2.5.3 Method of connecting

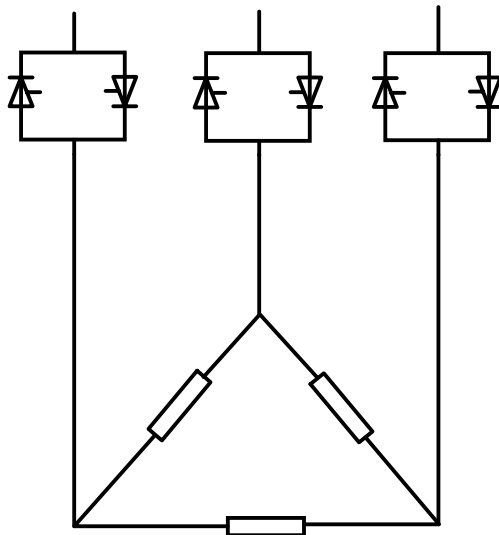
For example (see figure 2):

- load in star, thyristors connected between load and supply;
- load in delta, thyristors connected between load and supply;
- single-phase load, thyristors connected between load and supply.



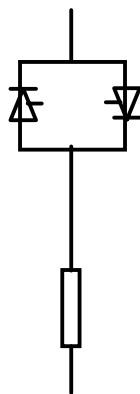
IEC 1209/99

Figure 2a – Load in star
Thyristors between load and supply



IEC 1210/99

Figure 2b – Load in delta
Thyristors between load and supply



IEC 1211/99

Figure 2c – Single-phase load
Thyristors between load and supply

Figure 2 – Methods of connecting

5.3 Rated and limiting values for main circuits

The rated and limiting values established for controllers and contactors shall be stated in accordance with 5.3.1 to 5.3.6, but it may not be necessary to establish all applicable values by tests.

5.3.1 Rated voltages

A controller is defined by the following rated voltages.

5.3.1.1 Rated operational voltage (U_e)

Subclause 4.3.1.1 of IEC 60947-1 applies.

5.3.1.2 Rated insulation voltage (U_i)

Subclause 4.3.1.2 of IEC 60947-1 applies.

5.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of IEC 60947-1 applies.

5.3.2 Currents

A controller is defined by the following currents.

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

Subclause 4.3.2.1 of IEC 60947-1 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of IEC 60947-1 applies.

5.3.2.3 Rated operational current (I_e)

The rated operational current, I_e , of controllers and contactors is the normal operating current when the device is in the FULL-ON state and takes into account the rated operational voltage (see 5.3.1.1), the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the utilization category (see 5.4), the overload characteristics (see 5.3.5) and the type of protective enclosure, if any.

5.3.2.4 Rated uninterrupted current (I_u)

Subclause 4.3.2.4 of IEC 60947-1 applies.

5.3.3 Rated frequency

Subclause 4.3.3 of IEC 60947-1 applies.

5.3.4 Rated duty

The rated duties considered as normal are as follows.

5.3.4.1 Eight-hour duty

A duty in which the controller remains in the FULL-ON state while carrying a steady current long enough for the equipment to reach thermal equilibrium but not for more than 8 h, without interruption.

5.3.4.2 Uninterrupted duty

A duty in which the controller remains in the FULL-ON state while carrying a steady current without interruption for periods of more than 8 h (weeks, months, or even years).

5.3.4.3 Intermittent periodic duty or intermittent duty

Subclause 4.3.4.3 of IEC 60947-1 applies except that the first paragraph is changed to read:

"A duty with on-load periods in which the controller remains in the FULL-ON state (or load control state), having a definite relation to off-load periods, both periods being too short to allow the equipment to reach thermal equilibrium."

5.3.4.4 Temporary duty

Duty in which the semiconductor controller remains in the FULL-ON state (or load control state) for periods of time insufficient to allow the equipment to reach thermal equilibrium, the current-carrying periods being separated by no-load periods of sufficient duration to restore equality of temperature with the cooling medium. Standard values of temporary duty are:

30 s, 1 min, 3 min, 10 min, 30 min, 60 min and 90 min.

5.3.4.5 Periodic duty

Subclause 4.3.4.5 of IEC 60947-1 applies.

5.3.4.6 Duty cycle values and symbols

For the purpose of this standard, the duty cycle is expressed by two symbols, F and S . This describes the duty and also sets the time that must be allowed for cooling.

F is the ratio of the on-load period to the total period, expressed as a percentage.

The preferred values of F are:

$F = 1\%, 5\%, 15\%, 25\%, 40\%, 50\%, 60\%, 70\%, 80\%, 90\%, 99\%$.

S is the number of operating cycles per hour. The preferred values of S are:

$S = 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 50, 60$ operating cycles per hour.

NOTE – Other values of F and/or S may be declared by the manufacturer.

5.3.5 Normal load and overload characteristics

Subclause 4.3.5 of IEC 60947-1 applies with the following additions.

5.3.5.1 Overload current profile

The overload current profile gives the current/time coordinates for the controlled overload current. It is expressed by two symbols, X and T_X .

X denotes the overload current as a multiple of I_e selected from the array of values in table 4 and represents the maximum value of operating current under operational overload conditions.

Deliberate overcurrents not exceeding ten cycles of the power-line frequency which may exceed the stated value of $X \cdot I_e$ are disregarded for the overload current profile.