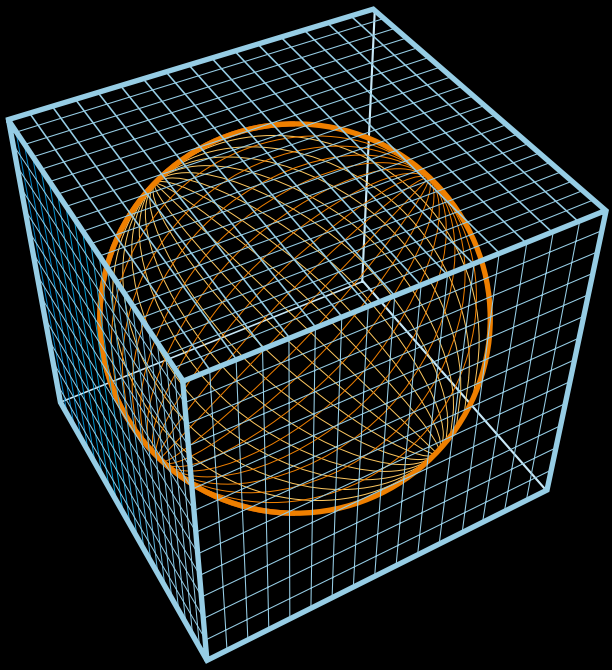

Technical guide - 6th edition 2010

Electrical installation handbook
Protection, control and electrical devices

Power and productivity
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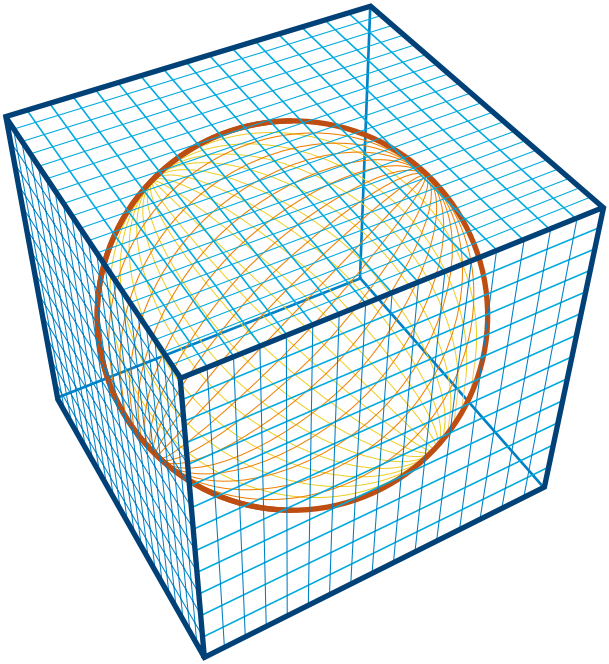
Electrical installation handbook
Protection, control and electrical devices



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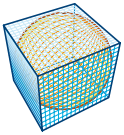

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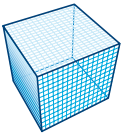

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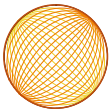

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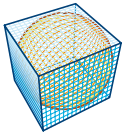


General aspects

Index

Introduction

Scope and objectives

The scope of this electrical installation handbook is to provide the designer and user of electrical plants with a quick reference, immediate-use working tool. This is not intended to be a theoretical document, nor a technical catalogue, but, in addition to the latter, aims to be of help in the correct definition of equipment, in numerous practical installation situations.

The dimensioning of an electrical plant requires knowledge of different factors relating to, for example, installation utilities, the electrical conductors and other components; this knowledge leads the design engineer to consult numerous documents and technical catalogues. This electrical installation handbook, however, aims to supply, in a single document, tables for the quick definition of the main parameters of the components of an electrical plant and for the selection of the protection devices for a wide range of installations. Some application examples are included to aid comprehension of the selection tables.

Electrical installation handbook users

The electrical installation handbook is a tool which is suitable for all those who are interested in electrical plants: useful for installers and maintenance technicians through brief yet important electrotechnical references, and for sales engineers through quick reference selection tables.

Validity of the electrical installation handbook

Some tables show approximate values due to the generalization of the selection process, for example those regarding the constructional characteristics of electrical machinery. In every case, where possible, correction factors are given for actual conditions which may differ from the assumed ones. The tables are always drawn up conservatively, in favour of safety; for more accurate calculations, the use of DOCWin software is recommended for the dimensioning of electrical installations.

1 Standards

1.1 General aspects

In each technical field, and in particular in the electrical sector, a condition sufficient (even if not necessary) for the realization of plants according to the **"status of the art"** and a requirement essential to properly meet the demands of customers and of the community, is the respect of all the relevant laws and technical standards.
Therefore, a precise knowledge of the standards is the fundamental premise for a correct approach to the problems of the electrical plants which shall be designed in order to guarantee that **"acceptable safety level"** which is never absolute.

Juridical Standards
These are all the standards from which derive rules of behavior for the juridical persons who are under the sovereignty of that State.

Technical Standards
These standards are the whole of the prescriptions on the basis of which machines, apparatus, materials and the installations should be designed, manufactured and tested so that efficiency and function safety are ensured.
The technical standards, published by national and international bodies, are circumstantially drawn up and can have legal force when this is attributed by a legislative measure.

	Application fields		
	Electrotechnics and Electronics	**Telecommunications**	**Mechanics, Ergonomics and Safety**
International Body	IEC	ITU	ISO
European Body	CENELEC	ETSI	CEN

This technical collection takes into consideration only the bodies dealing with electrical and electronic technologies.

IEC International Electrotechnical Commission

The *International Electrotechnical Commission* (IEC) was officially founded in 1906, with the aim of securing the international co-operation as regards standardization and certification in electrical and electronic technologies. This association is formed by the International Committees of over 40 countries all over the world.
The IEC publishes international standards, technical guides and reports which are the bases or, in any case, a reference of utmost importance for any national and European standardization activity.
IEC Standards are generally issued in two languages: English and French.
In 1991 the IEC has ratified co-operation agreements with CENELEC (European standardization body), for a common planning of new standardization activities and for parallel voting on standard drafts.

1 Standards

CENELEC European Committee for Electrotechnical Standardization

The *European Committee for Electrotechnical Standardization* (CENELEC) was set up in 1973. Presently it comprises 31 countries (Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Portugal, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom) and cooperates with 12 affiliates (Albania, Belarus, Georgia, Bosnia and Herzegovina, Tunisia, Former Yugoslav Republic of Macedonia, Serbia, Libia, Montenegro, Turkey, Ukraine and Israel) which have first maintained the national documents side by side with the CENELEC ones and then replaced them with the Harmonized Documents (HD).
There is a difference between EN Standards and Harmonization Documents (HD): while the first ones have to be accepted at any level and without additions or modifications in the different countries, the second ones can be amended to meet particular national requirements.
EN Standards are generally issued in three languages: English, French and German.
From 1991 CENELEC cooperates with the IEC to accelerate the standards preparation process of International Standards.
CENELEC deals with specific subjects, for which standardization is urgently required.
When the study of a specific subject has already been started by the IEC, the European standardization body (CENELEC) can decide to accept or, whenever necessary, to amend the works already approved by the International standardization body.

EC DIRECTIVES FOR ELECTRICAL EQUIPMENT

Among its institutional roles, the European Community has the task of promulgating directives which must be adopted by the different member states and then transposed into national law.
Once adopted, these directives come into juridical force and become a reference for manufacturers, installers, and dealers who must fulfill the duties prescribed by law.
Directives are based on the following principles:
- harmonization is limited to essential requirements;
- only the products which comply with the essential requirements specified by the directives can be marketed and put into service;
- the harmonized standards, whose reference numbers are published in the Official Journal of the European Communities and which are transposed into the national standards, are considered in compliance with the essential requirements;
- the applicability of the harmonized standards or of other technical specifications is facultative and manufacturers are free to choose other technical solutions which ensure compliance with the essential requirements;
- a manufacturer can choose among the different conformity evaluation procedure provided by the applicable directive.

The scope of each directive is to make manufacturers take all the necessary steps and measures so that the product does not affect the safety and health of persons, animals and property.

1 Standards

"Low Voltage" Directive 2006/95/CE

The Low Voltage Directive refers to any electrical equipment designed for use at a rated voltage from 50 to 1000 V for alternating current and from 75 to 1500 V for direct current.
In particular, it is applicable to any apparatus used for production, conversion, transmission, distribution and use of electrical power, such as machines, transformers, devices, measuring instruments, protection devices and wiring materials.
The following categories are outside the scope of this Directive:
- electrical equipment for use in an explosive atmosphere;
- electrical equipment for radiology and medical purposes;
- electrical parts for goods and passenger lifts;
- electrical energy meters;
- plugs and socket outlets for domestic use;
- electric fence controllers;
- radio-electrical interference;
- specialized electrical equipment, for use on ships, aircraft or railways, which complies with the safety provisions drawn up by international bodies in which the Member States participate.

Directive EMC 2004/108/CE ("Electromagnetic Compatibility")

The Directive on electromagnetic compatibility regards all the electrical and electronic apparatus as well as systems and installations containing electrical and/or electronic components. In particular, the apparatus covered by this Directive are divided into the following categories according to their characteristics:
- domestic radio and TV receivers;
- industrial manufacturing equipment;
- mobile radio equipment;
- mobile radio and commercial radio telephone equipment;
- medical and scientific apparatus;
- information technology equipment (ITE);
- domestic appliances and household electronic equipment;
- aeronautical and marine radio apparatus;
- educational electronic equipment;
- telecommunications networks and apparatus;
- radio and television broadcast transmitters;
- lights and fluorescent lamps.

The apparatus shall be so constructed that:
a) the electromagnetic disturbance it generates does not exceed a level allowing radio and telecommunications equipment and other apparatus to operate as intended;
b) the apparatus has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended.

An apparatus is declared in conformity to the provisions at points a) and b) when the apparatus complies with the harmonized standards relevant to its product family or, in case there aren't any, with the general standards.

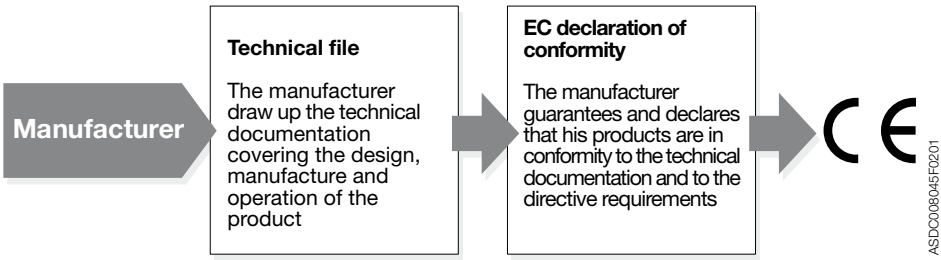
1 Standards

CE conformity marking

The CE conformity marking shall indicate conformity to all the obligations imposed on the manufacturer, as regards his products, by virtue of the European Community directives providing for the affixing of the CE marking.

When the CE marking is affixed on a product, it represents a declaration of the manufacturer or of his authorized representative that the product in question conforms to all the applicable provisions including the conformity assessment procedures. This prevents the Member States from limiting the marketing and putting into service of products bearing the CE marking, unless this measure is justified by the proved non-conformity of the product.

Flow diagram for the conformity assessment procedures established by the Directive 2006/95/CE on electrical equipment designed for use within particular voltage range:



Naval type approval

The environmental conditions which characterize the use of circuit breakers for on-board installations can be different from the service conditions in standard industrial environments; as a matter of fact, marine applications can require installation under particular conditions, such as:
- environments characterized by high temperature and humidity, including salt-mist atmosphere (damp-heat, salt-mist environment);
- on board environments (engine room) where the apparatus operate in the presence of vibrations characterized by considerable amplitude and duration.

In order to ensure the proper function in such environments, the shipping registers require that the apparatus has to be tested according to specific type approval tests, the most significant of which are vibration, dynamic inclination, humidity and dry-heat tests.

1 Standards

ABB SACE circuit-breakers (Tmax-Emax) are approved by the following shipping registers:

• **RINA**	Registro Italiano Navale	Italian shipping register
• **DNV**	Det Norske Veritas	Norwegian shipping register
• **BV**	Bureau Veritas	French shipping register
• **GL**	Germanischer Lloyd	German shipping register
• **LRs**	Lloyd's Register of Shipping	British shipping register
• **ABS**	American Bureau of Shipping	American shipping register

It is always advisable to ask ABB SACE as regards the typologies and the performances of the certified circuit-breakers or to consult the section certificates in the website **http://bol.it.abb.com.**

Marks of conformity to the relevant national and international Standards

The international and national marks of conformity are reported in the following table, for information only:

COUNTRY	Symbol	Mark designation	Applicability/Organization
EUROPE		–	Mark of compliance with the harmonized European standards listed in the ENEC Agreement.
AUSTRALIA		AS Mark	Electrical and non-electrical products. It guarantees compliance with SAA (Standard Association of Australia).
AUSTRALIA		S.A.A. Mark	Standards Association of Australia (S.A.A.). The Electricity Authority of New South Wales Sydney Australia
AUSTRIA		Austrian Test Mark	Installation equipment and materials

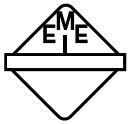
1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
AUSTRIA		ÖVE Identification Thread	Cables
BELGIUM		CEBEC Mark	Installation materials and electrical appliances
BELGIUM		CEBEC Mark	Conduits and ducts, conductors and flexible cords
BELGIUM		Certification of Conformity	Installation material and electrical appliances (in case there are no equivalent national standards or criteria)
CANADA		CSA Mark	Electrical and non-electrical products. This mark guarantees compliance with CSA (Canadian Standard Association)
CHINA		CCC Mark	This mark is required for a wide range of manufactured products before being exported to or sold in the Peoples Republic of China market.
Czech Republic		EZU' Mark	Electrotechnical Testing Institute
Slovakia Republic		EVPU' Mark	Electrotechnical Research and Design Institute

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
CROATIA	KONČAR	KONKAR	Electrical Engineering Institute
DENMARK	D	DEMKO Approval Mark	Low voltage materials. This mark guarantees the compliance of the product with the requirements (safety) of the “Heavy Current Regulations”
FINLAND	SÄHKÖTARKASTUSLAITOKSEN HYVÄKSYMÄ GODKÄND AV ELEKTRISKA INSPEKTORATET	Safety Mark of the Elektriska Inspektoratet	Low voltage material. This mark guarantees the compliance of the product with the requirements (safety) of the “Heavy Current Regulations”
FRANCE	CONTRÔLE NF LIMITÈ À LA SÈCURITÈ	ESC Mark	Household appliances
FRANCE	NF	NF Mark	Conductors and cables – Conduits and ducting – Installation materials
FRANCE		NF Identification Thread	Cables
FRANCE	OUTILLAGE NF ÉLECTRICITÉ	NF Mark	Portable motor-operated tools
FRANCE	NF ÉLECTRICITÉ	NF Mark	Household appliances

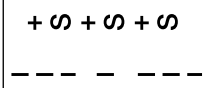
1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
GERMANY		VDE Mark	For appliances and technical equipment, installation accessories such as plugs, sockets, fuses, wires and cables, as well as other components (capacitors, earthing systems, lamp holders and electronic devices)
GERMANY		VDE Identification Thread	Cables and cords
GERMANY		VDE Cable Mark	For cables, insulated cords, installation conduits and ducts
GERMANY		VDE-GS Mark for technical equipment	Safety mark for technical equipment to be affixed after the product has been tested and certified by the VDE Test Laboratory in Offenbach; the conformity mark is the mark VDE, which is granted both to be used alone as well as in combination with the mark GS
HUNGARY		MEEI	Hungarian Institute for Testing and Certification of Electrical Equipment
JAPAN		JIS Mark	Mark which guarantees compliance with the relevant Japanese Industrial Standard(s).
IRELAND		IIRS Mark	Electrical equipment
IRELAND		IIRS Mark	Electrical equipment

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
ITALY		IMQ Mark	Mark to be affixed on electrical material for non-skilled users; it certifies compliance with the European Standard(s).
NORWAY		Norwegian Approval Mark	Mandatory safety approval for low voltage material and equipment
NETHERLANDS	KEMA KEUR KEMA-KEUR	KEMA-KEUR	General for all equipment
POLAND	B	KWE	Electrical products
RUSSIA		Certification of Conformity	Electrical and non-electrical products. It guarantees compliance with national standard (Gosstandard of Russia)
SINGAPORE	APPROVED TO SINGAPORE STANDARD SISIR	SISIR	Electrical and non-electrical products
SLOVENIA	SIQ SIQ - Slovenia	SIQ	Slovenian Institute of Quality and Metrology
SPAIN	MARCA DE CONFORMIDAD A NORMAS UNE AEE	AEE	Electrical products. The mark is under the control of the Asociación Electrotécnica Española (Spanish Electrotechnical Association)

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
SPAIN		AENOR	Asociación Española de Normalización y Certificación. (Spanish Standarization and Certification Association)
SWEDEN		SEMKO Mark	Mandatory safety approval for low voltage material and equipment.
SWITZERLAND	 * PZ 1	Safety Mark	Swiss low voltage material subject to mandatory approval (safety).
SWITZERLAND		–	Cables subject to mandatory approval
SWITZERLAND		SEV Safety Mark	Low voltage material subject to mandatory approval
UNITED KINGDOM		ASTA Mark	Mark which guarantees compliance with the relevant “British Standards”
UNITED KINGDOM		BASEC Mark	Mark which guarantees compliance with the “British Standards” for conductors, cables and ancillary products.
UNITED KINGDOM		BASEC Identification Thread	Cables

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
UNITED KINGDOM		BEAB Safety Mark	Compliance with the “British Standards” for household appliances
UNITED KINGDOM		BSI Safety Mark	Compliance with the “British Standards”
UNITED KINGDOM		BEAB Kitemark	Compliance with the relevant “British Standards” regarding safety and performances
U.S.A.	LISTED (Product Name) (Control Number)	UNDERWRITERS LABORATORIES Mark	Electrical and non-electrical products
U.S.A.	UL U.S.A.	UNDERWRITERS LABORATORIES Mark	Electrical and non-electrical products
U.S.A.	UL U.S.A.	UL Recognition	Electrical and non-electrical products
CEN		CEN Mark	Mark issued by the European Committee for Standardization (CEN): it guarantees compliance with the European Standards.
CENELEC	HAR	Mark	Cables

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
CENELEC		Harmonization Mark	Certification mark providing assurance that the harmonized cable complies with the relevant harmonized CENELEC Standards – identification thread
EC		Ex EUROPEA Mark	Mark assuring the compliance with the relevant European Standards of the products to be used in environments with explosion hazards
CEEel		CEEel Mark	Mark which is applicable to some household appliances (shavers, electric clocks, etc).

EC - Declaration of Conformity

The EC Declaration of Conformity is the statement of the manufacturer, who declares under his own responsibility that all the equipment, procedures or services refer and comply with specific standards (directives) or other normative documents.
The EC Declaration of Conformity should contain the following information:
- name and address of the manufacturer or by its European representative;
- description of the product;
- reference to the harmonized standards and directives involved;
- any reference to the technical specifications of conformity;
- the two last digits of the year of affixing of the CE marking;
- identification of the signer.

A copy of the EC Declaration of Conformity shall be kept by the manufacturer or by his representative together with the technical documentation.

1 Standards

1.2 IEC Standards for electrical installation

The following pages list the main Standards which refer to the most common low voltage electrical applications and report their publication years.
The Standards might have been amended, but the relevant amendaments are not mentioned here.

STANDARD	YEAR	TITLE
IEC 60027-1	1992	Letter symbols to be used in ectrical technology - Part 1: General
IEC 60034-1	2010	Rotating electrical machines - Part 1: Rating and performance
IEC 60617-DB-Snapshot	2010	Graphical symbols for diagrams
IEC 61082-1	2006	Preparation of documents used in electrotechnology - Part 1: Rules
IEC 60038	2009	IEC standard voltages
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests
IEC 60909-0	2001	Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents
IEC 60865-1	1993	Short-circuit currents - Calculation of effects - Part 1: Definitions and calculation methods
IEC 60076-1	2000	Power transformers - Part 1: General
IEC 60076-2	1993	Power transformers - Part 2: Temperature rise
IEC 60076-3	2000	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-5	2006	Power transformers - Part 5: Ability to withstand short circuit
IEC/TR 60616	1978	Terminal and tapping markings for power transformers
IEC 60076-11	2004	Power transformers - Part 11: Dry-type transformers
IEC 60445	2010	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals and conductor terminations
IEC 60073	2002	Basic and safety principles for man-machine interface, marking and identification – Coding for indicators and actuators
IEC 60447	2004	Basic and safety principles for man-machine interface, marking and identification - Actuating principles
IEC 60947-1	2007	Low-voltage switchgear and controlgear - Part 1: General rules
IEC 60947-2	2009	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers

1 Standards

STANDARD	YEAR	TITLE
IEC 60947-3	2008	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
IEC 60947-4-1	2009	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters
IEC 60947-4-2	2007	Low-voltage switchgear and controlgear - Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters
IEC 60947-4-3	2007	Low-voltage switchgear and controlgear - Part 4-3: Contactors and motor-starters – AC semiconductor controllers and contactors for non-motor loads
IEC 60947-5-1	2009	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 60947-5-2	2007	Low-voltage switchgear and controlgear - Part 5-2: Control circuit devices and switching elements – Proximity switches
IEC 60947-5-3	2005	Low-voltage switchgear and controlgear - Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behaviour under fault conditions
IEC 60947-5-4	2002	Low-voltage switchgear and controlgear - Part 5: Control circuit devices and switching elements – Section 4: Method of assessing the performance of low energy contacts. Special tests
IEC 60947-5-5	2005	Low-voltage switchgear and controlgear - Part 5-5: Control circuit devices and switching elements - Electrical emergency stop device with mechanical latching function
IEC 60947-5-6	1999	Low-voltage switchgear and controlgear - Part 5-6: Control circuit devices and switching elements – DC interface for proximity sensors and switching amplifiers (NAMUR)
IEC 60947-6-1	2005	Low-voltage switchgear and controlgear - Part 6-1: Multiple function equipment – Transfer switching equipment
IEC 60947-6-2	2007	Low-voltage switchgear and controlgear - Part 6-2: Multiple function equipment - Control and protective switching devices (or equipment) (CPS)
IEC 60947-7-1	2009	Low-voltage switchgear and controlgear - Part 7: Ancillary equipment - Section 1: Terminal blocks for copper conductors

1 Standards

STANDARD	YEAR	TITLE
IEC 60947-7-2	2009	Low-voltage switchgear and controlgear - Part 7: Ancillary equipment - Section 2: Protective conductor terminal blocks for copper conductors
IEC 61439-1	2009	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
IEC 60439-2	2005	Low-voltage switchgear and controlgear assemblies - Part 2: Particular requirements for busbar trunking systems (busways)
IEC 60439-3	2001	Low-voltage switchgear and controlgear assemblies - Part 3: Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards
IEC 60439-4	2004	Low-voltage switchgear and controlgear assemblies - Part 4: Particular requirements for assemblies for construction sites (ACS)
IEC 60439-5	2006	Low-voltage switchgear and controlgear assemblies - Part 5: Particular requirements for assemblies for power distribution in public networks
IEC 61095	2009	Electromechanical contactors for household and similar purposes
IEC/TR 60890	1987	A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear
IEC/TR 61117	1992	A method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)
IEC 60092-303	1980	Electrical installations in ships. Part 303: Equipment - Transformers for power and lighting
IEC 60092-301	1980	Electrical installations in ships. Part 301: Equipment - Generators and motors
IEC 60092-101	2002	Electrical installations in ships - Part 101: Definitions and general requirements
IEC 60092-401	1980	Electrical installations in ships. Part 401: Installation and test of completed installation
IEC 60092-201	1994	Electrical installations in ships - Part 201: System design - General
IEC 60092-202	1994	Electrical installations in ships - Part 202: System design - Protection

1 Standards

STANDARD	YEAR	TITLE
IEC 60092-302	1997	Electrical installations in ships - Part 302: Low-voltage switchgear and controlgear assemblies
IEC 60092-350	2008	Electrical installations in ships - Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications
IEC 60092-352	2005	Electrical installations in ships - Part 352: Choice and installation of electrical cables
IEC 60364-5-52	2009	Electrical installations of buildings - Part 5-52: Selection and erection of electrical equipment – Wiring systems
IEC 60227		Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
	2007	Part 1: General requirements
	2003	Part 2: Test methods
	1997	Part 3: Non-sheathed cables for fixed wiring
	1997	Part 4: Sheathed cables for fixed wiring
	2003	Part 5: Flexible cables (cords)
	2001	Part 6: Lift cables and cables for flexible connections
	2003	Part 7: Flexible cables screened and unscreened with two or more conductors
IEC 60228	2004	Conductors of insulated cables
IEC 60245		Rubber insulated cables - Rated voltages up to and including 450/750 V
	2008	Part 1: General requirements
	1998	Part 2: Test methods
	1994	Part 3: Heat resistant silicone insulated cables
	2004	Part 4: Cord and flexible cables
	1994	Part 5: Lift cables
	1994	Part 6: Arc welding electrode cables
	1994	Part 7: Heat resistant ethylene-vinyl acetate rubber insulated cables
	2004	Part 8: Cords for applications requiring high flexibility
IEC 60309-2	2005	Plugs, socket-outlets and couplers for industrial purposes - Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
IEC 61008-1	2010	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) - Part 1: General rules
IEC 61008-2-1	1990	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's). Part 2-1: Applicability of the general rules to RCCB's functionally independent of line voltage

1 Standards

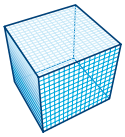
STANDARD	YEAR	TITLE
IEC 61008-2-2	1990	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's). Part 2-2: Applicability of the general rules to RCCB's functionally dependent on line voltage
IEC 61009-1	2010	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) - Part 1: General rules
IEC 61009-2-1	1991	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) Part 2-1: Applicability of the general rules to RCBO's functionally independent of line voltage
IEC 61009-2-2	1991	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) - Part 2-2: Applicability of the general rules to RCBO's functionally dependent on line voltage
IEC 60670-1	2002	Boxes and enclosures for electrical accessories for household and similar fixed electrical installations - Part 1: General requirements
IEC 60669-2-1	2009	Switches for household and similar fixed electrical installations - Part 2-1: Particular requirements – Electronic switches
IEC 60669-2-2	2006	Switches for household and similar fixed electrical installations - Part 2: Particular requirements - Section 2: Remote-control switches (RCS)
IEC 60669-2-3	2006	Switches for household and similar fixed electrical installations - Part 2-3: Particular requirements – Time-delay switches (TDS)
IEC 60079-10-1	2009	Explosive atmospheres Part 10 -1: Cassification of area - explosive gas atmospheres
IEC 60079-14	2007	Explosive atmospheres Part 14: Electrical installation design, selection and erection
IEC 60079-17	2007	Electrical apparatus for explosive gas atmospheres - Part 17: Inspection and maintenance of electrical installations in hazardous areas (other than mines)
IEC 60269-1	2009	Low-voltage fuses - Part 1: General requirements
IEC 60269-2	2010	Low-voltage fuses. Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) examples of standardized system of fuses A to J

1 Standards

STANDARD	YEAR	TITLE
IEC 60269-3	2010	Low-voltage fuses - Part 3-1: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) - Sections I to IV: examples of standardized system of fuses A to F
IEC 60127-1/10		Miniature fuses -
	2006	Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links
	2010	Part 2: Cartridge fuse-links
	1988	Part 3: Sub-miniature fuse-links
	2005	Part 4: Universal Modular Fuse-Links (UMF) Through-hole and surface mount types
	1988	Part 5: Guidelines for quality assessment of miniature fuse-links
	1994	Part 6: Fuse-holders for miniature cartridge fuse-links
	2001	Part 10: User guide for miniature fuses
EC 60364-1	2005	Low-voltage electrical installations Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364-4-41	2005	Low-voltage electrical installations Part 4-41: Protection for safety - Protection against electric shock
IEC 60364-4-42	2010	Electrical installations of buildings Part 4-42: Protection for safety - Protection against thermal effects
IEC 60364-4-43	2008	Electrical installations of buildings Part 4-43: Protection for safety - Protection against overcurrent
IEC 60364-4-44	2007	Electrical installations of buildings Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances
IEC 60364-5-51	2005	Electrical installations of buildings Part 5-51: Selection and erection of electrical equipment Common rules
IEC 60364-5-52	2009	Electrical installations of buildings Part 5-52: Selection and erection of electrical equipment Wiring systems
IEC 60364-5-53	2002	Electrical installations of buildings Part 5-53: Selection and erection of electrical equipment Isolation, switching and control
IEC 60364-5-54	2002	Electrical installations of buildings Part 5-54: Selection and erection of electrical equipment Earthing arrangements, protective conductors and protective bonding conductors

1 Standards

STANDARD	YEAR	TITLE
IEC 60364-5-55	2008	Electrical installations of buildings Part 5-55: Selection and erection of electrical equipment Other equipment
IEC 60364-6	2006	Electrical installations of buildings Part 6: Verification
IEC 60364-7	2004…2010	Electrical installations of buildings Part 7: Requirements for special installations or locations
IEC 60529	2001	Degrees of protection provided by enclosures (IP Code)
IEC 61032	1997	Protection of persons and equipment by enclosures - Probes for verification
IEC/TR 61000-1-1	1992	Electromagnetic compatibility (EMC) Part 1: General - Section 1: application and interpretation of fundamental definitions and terms
IEC/TR 61000-1-3	2002	Electromagnetic compatibility (EMC) Part 1-3: General - The effects of high-altitude EMP (HEMP) on civil equipment and systems

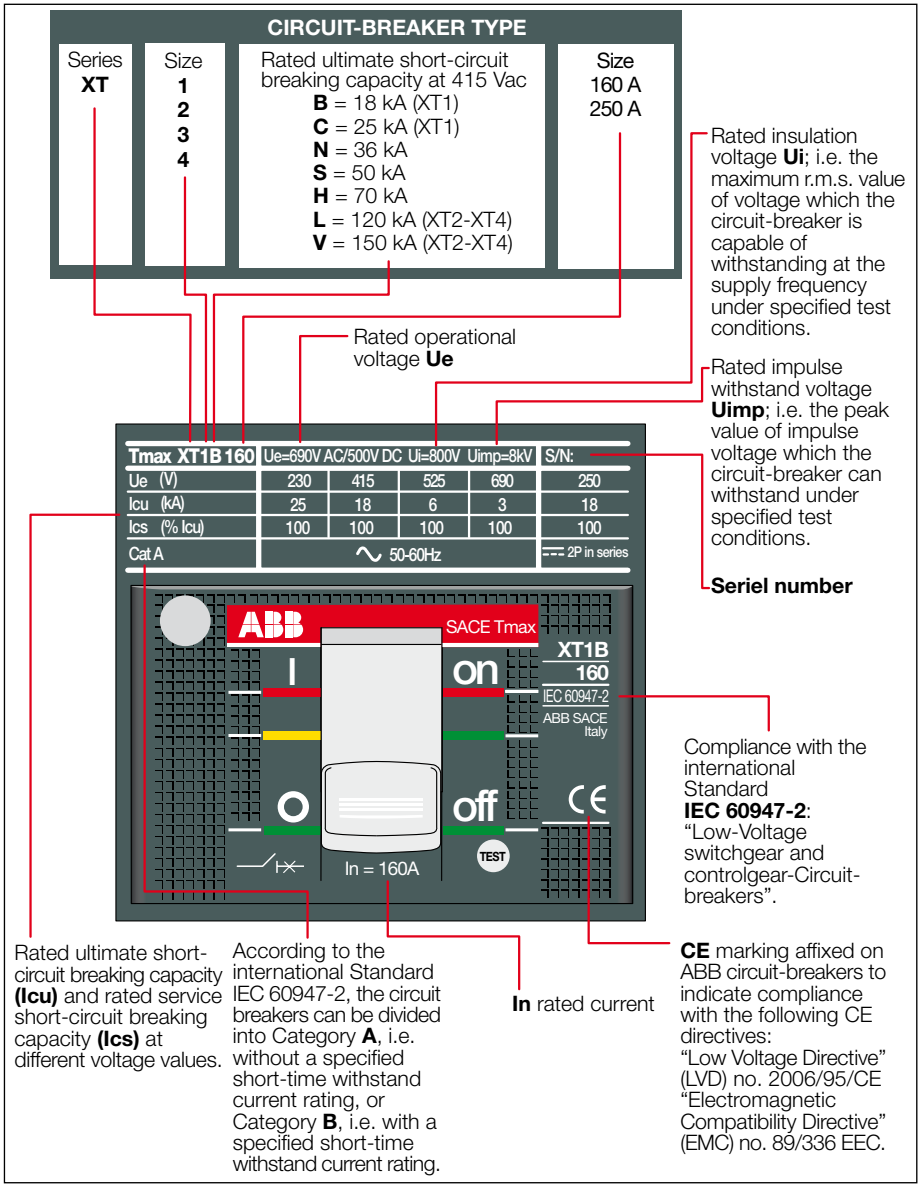


Part 1
Protection and control devices

Index

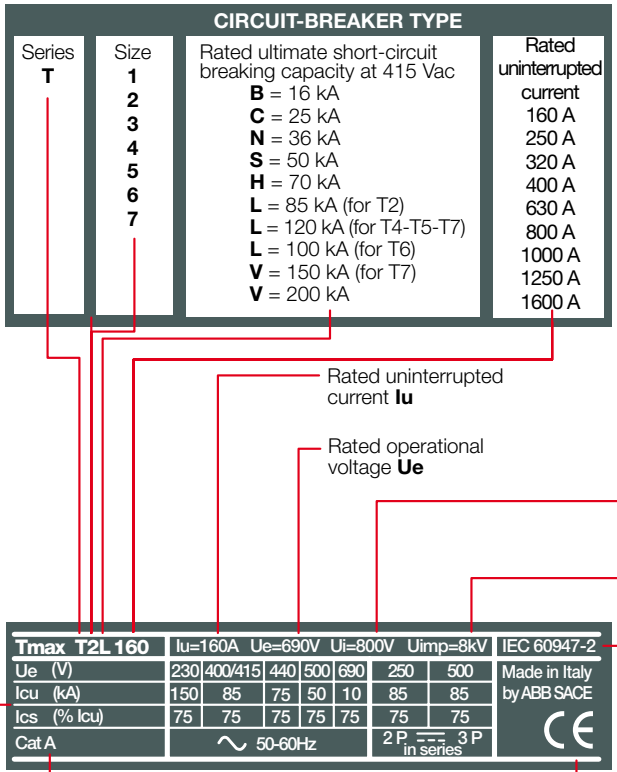
1.1 Circuit-breaker nameplates

Moulded-case circuit-breaker: SACE Tmax XT



1 Protection and control devices

Moulded-case circuit-breaker: Tmax T



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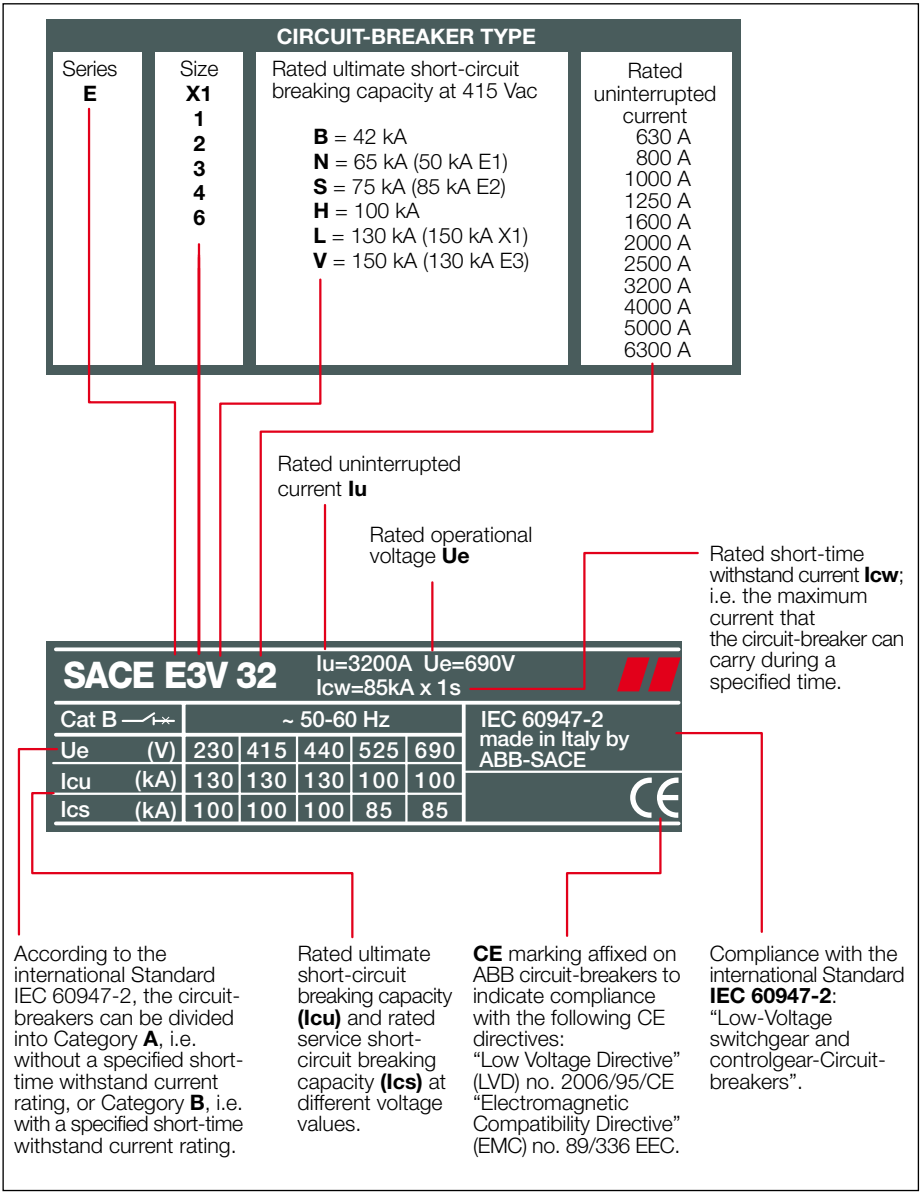
1 Protection and control devices

Air circuit-breaker: Emax



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1.2 Main definitions

The main definitions regarding LV switchgear and controlgear are included in the international Standards IEC 60947-1, IEC 60947-2 and IEC 60947-3.

Main characteristics

Circuit-breaker
A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short-circuit.

Current-limiting circuit-breaker
A circuit-breaker with a break-time short enough to prevent the short-circuit current reaching its otherwise attainable peak value.

Plug-in circuit-breaker
A circuit-breaker which, in addition to its interrupting contacts, has a set of contacts which enable the circuit-breaker to be removed.

Withdrawable circuit-breaker
A circuit-breaker which, in addition to its interrupting contacts, has a set of isolating contacts which enable the circuit-breaker to be disconnected from the main circuit, in the withdrawn position, to achieve an isolating distance in accordance with specified requirements.

Moulded-case circuit-breaker
A circuit-breaker having a supporting housing of moulded insulating material forming an integral part of the circuit-breaker.

Disconnector
A mechanical switching device which, in the open position, complies with the requirements specified for the isolating function.

Release
A device, mechanically connected to a mechanical switching device, which releases the holding means and permits the opening or the closing of the switching device.

1 Protection and control devices

Fault types and currents

Overload
Operating conditions in an electrically undamaged circuit which cause an over-current.

Short-circuit
The accidental or intentional connection, by a relatively low resistance or impedance, of two or more points in a circuit which are normally at different voltages.

Residual current (I_Δ)
It is the vectorial sum of the currents flowing in the main circuit of the circuit-breaker.

Rated performances

Voltages and frequencies

Rated operational voltage (U_e)
A rated operational voltage of an equipment is a value of voltage which, combined with a rated operational current, determines the application of the equipment and to which the relevant tests and the utilization categories are referred to.

Rated insulation voltage (U_i)
The rated insulation voltage of an equipment is the value of voltage to which dielectric tests voltage and creepage distances are referred. In no case the maximum value of the rated operational voltage shall exceed that of the rated insulation voltage.

Rated impulse withstand voltage (U_{imp})
The peak value of an impulse voltage of prescribed form and polarity which the equipment is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

Rated frequency
The supply frequency for which an equipment is designed and to which the other characteristic values correspond.

Currents

Rated uninterrupted current (I_n)
The rated uninterrupted current for a circuit-breaker is a value of current, that the circuit-breaker can carry during uninterrupted service.

Rated residual operating current ($I_{\Delta n}$)
It is the r.m.s. value of a sinusoidal residual operating current assigned to the CBR by the manufacturer, at which the CBR shall operate under specified conditions.

Performances under short-circuit conditions

1 Protection and control devices

Rated making capacity
The rated making capacity of an equipment is a value of current, stated by the manufacturer, which the equipment can satisfactorily make under specified making conditions.

Rated breaking capacity
The rated breaking of an equipment is a value of current, stated by the manufacturer, which the equipment can satisfactorily break, under specified breaking conditions.

Rated ultimate short-circuit breaking capacity (I_{cu})
The rated ultimate short-circuit breaking capacity of a circuit-breaker is the maximum short-circuit current value which the circuit-breaker can break twice (in accordance with the sequence O – t – CO), at the corresponding rated operational voltage. After the opening and closing sequence the circuit-breaker is not required to carry its rated current.

Rated service short-circuit breaking capacity (I_{cs})
The rated service short-circuit breaking capacity of a circuit-breaker is the maximum short-circuit current value which the circuit-breaker can break three times in accordance with a sequence of opening and closing operations (O - t - CO - t – CO) at a defined rated operational voltage (U_e) and at a defined power factor. After this sequence the circuit-breaker is required to carry its rated current.

Rated short-time withstand current (I_{cw})
The rated short-time withstand current is the current that the circuit-breaker in the closed position can carry during a specified short time under prescribed conditions of use and behaviour; the circuit-breaker shall be able to carry this current during the associated short-time delay in order to ensure discrimination between the circuit-breakers in series.

Rated short-circuit making capacity (I_{cm})
The rated short-circuit making capacity of an equipment is the value of short-circuit making capacity assigned to that equipment by the manufacturer for the rated operational voltage, at rated frequency, and at a specified power-factor for ac.

1 Protection and control devices

Utilization categories

The utilization category of a circuit-breaker shall be stated with reference to whether or not it is specifically intended for selectivity by means of an intentional time delay with respect to other circuit-breakers in series on the load side, under short-circuit conditions (Table 4 IEC 60947-2).

Category A - Circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. without a short-time withstand current rating.

Category B - Circuit-breakers specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. with and intentional short-time delay provided for selectivity under short-circuit conditions. Such circuit-breakers have a short-time withstand current rating.
A circuit-breaker is classified in category B if its I_{cw} is higher than (Table 3 IEC 60947-2):

12·In or 5 kA, whichever is the greater	for In ≤ 2500A
30 kA	for In > 2500A

Electrical and mechanical durability

Mechanical durability
The mechanical durability of an apparatus is expressed by the number of no-load operating cycles (each operating cycle consists of one closing and opening operation) which can be effected before it becomes necessary to service or replace any of its mechanical parts (however, normal maintenance may be permitted).

Electrical durability
The electrical durability of an apparatus is expressed by the number of on-load operating cycles and gives the contact resistance to electrical wear under the service conditions stated in the relevant product Standard.

1.3 Types of releases

A circuit-breaker must control and protect, in case of faults or malfunctioning, the connected elements of a plant. In order to perform this function, after detection of an anomalous condition, the release intervenes in a definite time by opening the interrupting part.
The protection releases fitted with ABB SACE moulded-case and air circuit-breakers can control and protect any plant, from the simplest ones to those with particular requirements, thanks to their wide setting possibilities of both thresholds and tripping times.
Among the devices sensitive to overcurrents, the following can be considered:

- thermomagnetic releases and magnetic only releases;
- microprocessor-based releases;
- residual current devices.

The choice and adjusting of protection releases are based both on the requirements of the part of plant to be protected, as well as on the coordination with other devices; in general, discriminating factors for the selection are the required threshold, time and curve characteristic.

1.3.1 THERMOMAGNETIC RELEASES AND MAGNETIC ONLY RELEASES

The thermomagnetic releases use a bimetal and an electromagnet to detect overloads and short-circuits; they are suitable to protect both alternating and direct current networks.

The following table shows the types of thermo-magnetic and magnetic only trip units available for SACE Tmax XT and Tmax T circuit-breakers.

SACE Tmax XT

CBs	thermomagnetic releases				
	MF	MA	TMD	TMA	TMG
XT1	-	-	■	-	-
XT2	■	■	■	■	■
XT3	-	■	■	-	■
XT4	-	■	■	■	-

Legenda

MF Fixed magnetic only releases
MA Adjustable magnetic only releases
TMG Thermomagnetic release for generator protection
TMD Thermomagnetic release with adjustable thermal and fixed magnetic threshold
TMA Thermomagnetic release with adjustable thermal and magnetic threshold

1 Protection and control devices

Power distribution

MCCBs	XT1	XT2	XT3	XT4
In \ Iu	160	160	250	250
1,6		TMD		
2				
2,5				
3,2				
4				
5				
6,3				
8				
10				
12.5				
16	TMD	TMD TMG		TMD
20				
25				
32				
40		TMA TMG	TMD TMG	TMA
50				
63				
80				
100				
125				
160				
200			-	
225				
250			TMD/TMG	

Motor protection

MCCBs	XT2	XT3	XT4
In \ Iu	160	250	250
1	MF		
2			
4			
8,5			
10			MA
12,5	MF		
20	MA		
32			
52			
80			
100		MA	
125			
160			
200			

Legenda

MF Fixed magnetic only releases
MA Adjustable magnetic only releases
TMG Thermomagnetic release for generator protection
TMD Thermomagnetic release with adjustable thermal and fixed magnetic threshold
TMA Thermomagnetic release with adjustable thermal and magnetic threshold

1 Protection and control devices

Tmax T

CBs	thermomagnetic releases					
	MF	MA	TMF	TMD	TMA	TMG
T1	-	-	■	■	-	-
T2	■	■	-	■	-	■
T3	-	■	-	■	-	■
T4	-	■	-	■	■	-
T5	-	-	-	-	■	■
T6	-	-	-	-	■	-

Power distribution

MCCBs	T1	T2	T3	T4	T5		T6	
In \ Iu	160	160	250	250	400	630	630	800
1,6		TMD						
2								
2,5								
3,2								
4								
5								
6,3								
8								
10								
12.5								
16	TMF TMD	TMD TMG						
20		TMD		TMD				
25		TMD TMG						
32		TMD		TMD				
40		TMD TMG	TMG					
50		TMD		TMD				
63		TMD TMG	TMD TMG					
80				TMA				
100								
125								
160								
200					TMA TMG	TMA TMG		
250								
320								
400								
500								
630							TMA	
800								TMA

MCCBs	T2	T3	T4
In \ Iu	160	250	250
1	MF		
1,6			
2			
2,5			
3,2			
4			
5			
6,5			
8,5			
10			MA
11			
12,5			
20	MA		
25			MA
32	MA		
52			
80			
100			MA
125		MA	
160			
200			

Legenda

MF Fixed magnetic only releases
MA Adjustable magnetic only releases
TMG Thermomagnetic release for generator protection
TMF Thermomagnetic release with thermal and fixed magnetic threshold
TMD Thermomagnetic release with adjustable thermal and fixed magnetic threshold
TMA Thermomagnetic release with adjustable thermal and magnetic threshold

1 Protection and control devices

1.3.2 ELECTRONIC RELEASES

These releases are connected with current transformers (three or four according to the number of conductors to be protected), which are positioned inside the circuit-breaker and have the double functions of supplying the power necessary to the proper functioning of the release (self-supply) and of detecting the value of the current flowing inside the live conductors; therefore they are compatible with alternating current networks only.
The signal coming from the transformers and from the Rogowsky coils is processed by the electronic component (microprocessor) which compares it with the set thresholds. When the signal exceeds the thresholds, the trip of the circuit-breaker is operated through an opening solenoid which directly acts on the circuit-breaker operating mechanism.
In case of auxiliary power supply in addition to self-supply from the current transformers, the voltage shall be 24 Vdc ± 20%.

Besides the standard protection functions, releases provide:

- measurements of currents (Ekip LSI/LSIG + Ekip COM, Ekip M LRIU + Ekip COM, PR222, PR232, PR331, PR121);
- measurement of currents,voltage,frequency,power,energy,power factor (PR223,PR332,PR122) and moreover for PR333 and PR123, the measurement of harmonic distortions is available;
- serial comunication with remote control for a complete management of the plant (Ekip LSI/LSIG + Ekip COM, Ekip M LRIU + Ekip COM, PR222, PR223, PR232, PR331, PR332, PR333, PR121, PR122, PR123).

The following table shows the types of electronic trip units available for SACE Tmax XT, Tmax T and Emax circuit-breakers.

CBs	electronic releases with ABB circuit breakers													
	Ekip	Ekip G	Ekip N	PR221	PR222	PR223	PR231	PR232	PR331	PR332	PR333	PR121	PR122	PR123
	I LS/I LSI LSIG	**LS/I**	**LS/I**	**I LS/I**	**LSI LSIG**	**LSIG**	**I LS/I**	**LSI**	**LSIG**	**LI LSI LSIG LSRc**	**LI LSI LSIG**	**LI LSI LSIG**	**LI LSI LSIG LSRc**	**LI LSI LSIG**
XT2	■	■	■	-	-	-	-	-	-	-	-	-	-	-
XT4	■	■	■	-	-	-	-	-	-	-	-	-	-	-
T2	-	-	-	■	-	-	-	-	-	-	-	-	-	-
T4	-	-	-	■	■	■	-	-	-	-	-	-	-	-
T5	-	-	-	■	■	■	-	-	-	-	-	-	-	-
T6	-	-	-	■	■	■	-	-	-	-	-	-	-	-
T7	-	-	-	-	-	-	■	■	■	■	-	-	-	-
X1	-	-	-	-	-	-	-	-	■	■	■	-	-	-
E1	-	-	-	-	-	-	-	-	-	-	-	■	■	■
E2	-	-	-	-	-	-	-	-	-	-	-	■	■	■
E3	-	-	-	-	-	-	-	-	-	-	-	■	■	■
E4	-	-	-	-	-	-	-	-	-	-	-	■	■	■
E5	-	-	-	-	-	-	-	-	-	-	-	■	■	■
E6	-	-	-	-	-	-	-	-	-	-	-	■	■	■

1 Protection and control devices

The following table shows the available rated currents with the SACE Tmax XT, Tmax T and Emax circuit- breakers.

MCCBs	XT2	XT4		T2	T4		T5		T6			T7			
In \ Iu	160	160	250	160	250	320	400	630	630	800	1000	800	1000	1250	1600
10	■ (1)	-	-	■	-	-	-	-	-	-	-	-	-	-	-
25	■ (1)	-	-	■	-	-	-	-	-	-	-	-	-	-	-
40	-	■	■	-	-	-	-	-	-	-	-	-	-	-	-
63	■	■	■	■	-	-	-	-	-	-	-	-	-	-	-
100	■	■	■	■	■	■	-	-	-	-	-	-	-	-	-
160	■ (1)	■	■	■	■	■	-	-	-	-	-	-	-	-	-
250	-	-	■ (1)	-	■	■	-	-	-	-	-	-	-	-	-
320	-	-	-	-	-	■	■	■	-	-	-	-	-	-	-
400	-	-	-	-	-	-	■	■	-	-	-	■	■	■	■
630	-	-	-	-	-	-	-	■	■	-	-	■	■	■	■
800	-	-	-	-	-	-	-	-	-	■	-	■	■	■	■
1000	-	-	-	-	-	-	-	-	-	-	■	-	■	■	■
1250	-	-	-	-	-	-	-	-	-	-	-	-	-	■	■
1600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	■

(1) Not available for Ekip N and Ekip I; only for XT2 In=10 A not available with Ekip G

The following table shows the available rated currents for motor protection with the SACE Tmax XT and Tmax T circuit- breakers.

SACE Tmax XT				
MCCBs	XT2 160		XT4 160	XT4 250
Trip units / In	Ekip M I	Ekip M LIU or LRIU		
20	■	-	-	-
25	-	■	-	-
32	■	-	-	-
40	-	-	■	■
52	■	-	-	-
63	-	■	■	■
100	■	■	■	■
160	-	-	-	■

Tmax T				
MCCBs	T2 160	T4 250	T5 400	T6 800
Trip units / In	PR221MP LI	PR222MP LRIU		
40	■	-	-	-
63	■	-	-	-
100	■	■	-	-
160	-	■	-	-
200	-	■	-	-
320	-	-	■	-
400	-	-	■	-
630	-	-	-	■

1 Protection and control devices

ACBs		E3H-V	E3 N-S-H-V		E3 S-H-V-L		E3 N-S-H-V	E4S-H-V		E6V	E6H-V		
		E2S	E2N-S-L	E2B-N-S-L	E2B-N-S								
		E1B-N											
		X1B-N-L		X1B-N									
In \ Iu	630	800	1250 [2]	1600	2000	2500	3200		4000	3200	4000	5000	6300
400	■	■	■	■	■	■	■	-	-	-	-	-	-
630	■	■	■	■	■	■	■	-	-	-	-	-	-
800	-	■	■	■	■	■	■	-	-	-	-	-	-
1000	-	-	■	■	■	■	■	-	-	-	-	-	-
1250	-	-	■	■	■	■	■	■	■	-	-	-	-
1600	-	-	-	■	■	■	■	■	■	-	-	-	-
2000	-	-	-	-	■	■	■	■	■	-	-	-	-
2500	-	-	-	-	-	■	■	■	■	-	-	-	-
3200	-	-	-	-	-	-	■	■	■	■	■	■	■
4000	-	-	-	-	-	-	-	-	■	-	■	■	■
5000	-	-	-	-	-	-	-	-	-	-	-	■	■
6300	-	-	-	-	-	-	-	-	-	-	-	-	■

[2] Also for Iu = 1000 A (not available for E3V and E2L).

Example of reading from the table
The circuit-breaker type E3L is available with Iu=2000A and Iu=2500A, but it is not available with Iu=3200A.

1 Protection and control devices

1.3.2.1 PROTECTION FUNCTIONS OF ELECTRONIC RELEASES

The protection functions available for the electronic releases are:

L - Overload protection with inverse long time delay
Function of protection against overloads with inverse long time delay and constant specific let-through energy; it cannot be excluded.

L - Overload protection in compliance with Std. IEC 60255-3
Function of protection against overloads with inverse long time delay and trip curves complying with IEC 60255-3; applicable in the coordination with fuses and with medium voltage protections.

S - Short-circuit protection with adjustable delay
Function of protection against short-circuit currents with adjustable delay; thanks to the adjustable delay, this protection is particularly useful when it is necessary to obtain selective coordination between different devices.

S_2- Double S
This function allows two thresholds of protection function S to be set independently and activated simultaneously, selectivity can also be achieved under highly critical conditions.

D - Directional short-circuit protection with adjustable delay
The directional protection, which is similar to function S, can intervene in a different way according to the direction of the short-circuit current; particularly suitable in meshed networks or with multiple supply lines in parallel.

I - Short-circuit protection with instantaneous trip
Function for the instantaneous protection against short-circuit.

EFDP - Early Fault Detection and Prevention
Thanks to this function, the release is able to isolate a fault in shorter times than the zone selectivities currently available on the market.

Rc - Residual current protection
This function is particularly suitable where low-sensitivity residual current protection is required and for high-sensitivity applications to protect people against indirect contact.

G - Earth fault protection with adjustable delay
Function protecting the plant against earth faults.

U - Phase unbalance protection
Protection function which intervenes when an excessive unbalance between the currents of the single phases protected by the circuit-breaker is detected.

OT - Self-protection against overtemperature
Protection function controlling the opening of the circuit-breaker when the temperature inside the release can jeopardize its functioning.

UV - Undervoltage protection
Protection function which intervenes when the phase voltage drops below the preset threshold.

OV - Overvoltage protection
Protection function which intervenes when the phase voltage exceeds the preset threshold.

RV - Residual voltage protection
Protection which identifies anomalous voltages on the neutral conductor.

RP - Reverse power protection
Protection which intervenes when the direction of the active power is oppo-

1 Protection and control devices

to normal operation.

UF - Under frequency protection
This frequency protection detects the reduction of network frequency above the adjustable threshold, generating an alarm or opening the circuit.

OF - Overfrequency protection
This frequency protection detects the increase of network frequency above the adjustable threshold, generating an alarm or opening the circuit.

M - Thermal memory
Thanks to this function, it is possible to take into account the heating of a component so that the tripping is the quicker the less time has elapsed since the last one.

R - Protection against rotor blockage
Function intervening as soon as conditions are detected, which could lead to the block of the rotor of the protected motor during operation.

Iinst - Very fast instantaneous protection against short-circuit
This particular protection function has the aim of maintaining the integrity of the circuit-breaker and of the plant in case of high currents requiring delays lower than those guaranteed by the protection against instantaneous short-circuit. This protection must be set exclusively by ABB SACE and cannot be excluded.

Dual setting
With this function it is possible to program two different sets of parameters (LSIG) and, through an external command, to switch from one set to the other.

K - Load control
Thanks to this function, it is possible to engage/disengage individual loads on the load side before the overload protection L trips.

1 Protection and control devices

The following table summarizes the types of electronic release and the functions they implement:

Ekip	Ekip-G	Ekip-N	PR221	PR222	PR223	PR231	PR232	PR331	PR332	PR333	PR121	PR122	PR123	Protection functions	
Tmax XT			Tmax T					T7/X1		X1	Emax				
■	■	■	■	■	■	■	■	■	■	■	■	■	■	**L** (t=k/I²)	Protection against overload
							■	■		■	■		■	**L**	Standard trip curve according to IEC 60255-3
■	■	■		■	■		■	■	■	■	■	■	■	**S1** (t=k)	Protection against short-circuit with time delay
■			■	■	■	■	■	■	■	■	■	■	■	**S1** (t=k/I²)	Protection against short-circuit with time delay
								■	■	■			■	**S2** (t=k)	Protection against short-circuit with time delay
								■	■	■			■	**D** (t=k)	Protection against directional short-circuit
■	■	■	■	■	■	■	■	■	■	■	■	■	■	**I** (t=k)	Protection against instantaneous short-circuit
■			■	■			■	■	■	■	■	■	■	**G** (t=k)	Protection against earth fault with adjustable delay
			■	■			■	■	■	■	■	■	■	**G** (t=k/I²)	Protection against earth fault with adjustable delay
								■	■	■		■	■	**Gext** (t=k)	Protection against earth fault with adjustable delay
								■	■	■		■	■	**Gext** (t=k/I²)	Protection against earth fault with adjustable delay
								■	■	■		■	■	**Gext** (Idn)	Protection against earth fault with adjustable delay
								○	■	■		○	■	**Rc** (t=k)	Residual current protection
								■	■	■		■	■	**U** (t=k)	Protection against phase unbalance
								■	■	■		■	■	**OT**	Protection against temperature out of range
								○	■	■		○	■	**UV** (t=k)	Protection against undervoltage
								○	■	■		○	■	**OV** (t=k)	Protection against overvoltage
								○	■	■		○	■	**RV** (t=k)	Protection against residual voltage
								○	■	■		○	■	**RP** (t=k)	Protection against reverse active power
								○	■	■		○	■	**UF**	Protection against underfrequency
								○	■	■		○	■	**OF**	Protection against overfrequency
								■	■	■	■	■	■	**linst**	Instantantaneous self-protection
				■										**EF**	Early Fault Detection and Prevention

○ Only with PR120/V for Emax and PR330/V for X1

1 Protection and control devices

1.3.3 RESIDUAL CURRENT DEVICES

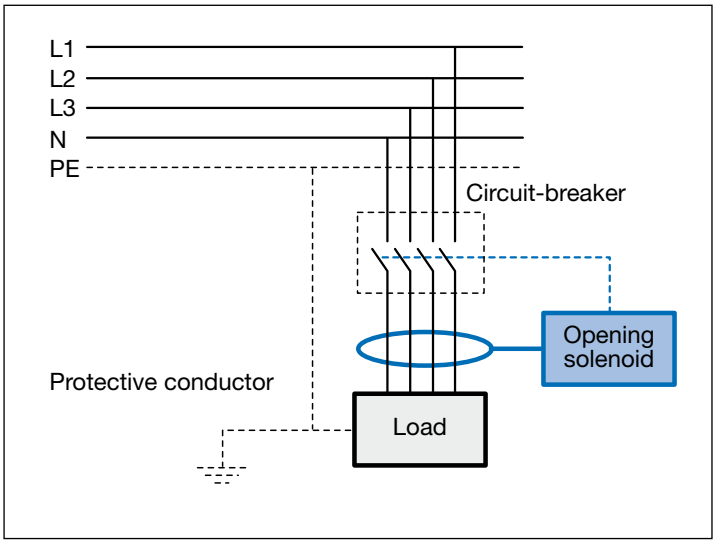
The residual current releases are associated with the circuit-breaker in order to obtain two main functions in a single device:
- protection against overloads and short-circuits;
- protection against indirect contacts (presence of voltage on exposed conductive parts due to loss of insulation).

Besides, they can guarantee an additional protection against the risk of fire deriving from the evolution of small fault or leakage currents which are not detected by the standard protections against overload.
Residual current devices having a rated residual current not exceeding 30 mA are also used as a means for additional protection against direct contact in case of failure of the relevant protective means.
Their logic is based on the detection of the vectorial sum of the line currents through an internal or external toroid.
This sum is zero under service conditions or equal to the earth fault current (I_Δ) in case of earth fault.

When the release detects a residual current different from zero, it opens the circuit-breaker through an opening solenoid.

As we can see in the picture the protection conductor or the equipotential conductor have to be installed outside the eventual external toroid.

Generic distribution system (IT, TT, TN)

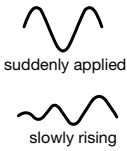
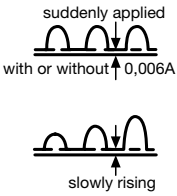


The operating principle of the residual current release makes it suitable for the distribution systems TT, IT (even if paying particular attention to the latter) and TN-S, but not in the systems TN-C. In fact, in these systems, the neutral is used also as protective conductor and therefore the detection of the residual current would not be possible if the neutral passes through the toroid, since the vectorial sum of the currents would always be equal to zero.

1 Protection and control devices

One of the main characteristics of a residual current release is its minimum rated residual current $I_{\Delta n}$. This represents the sensitivity of the release.
According to their sensitivity to the fault current, the residual current circuit-breakers are classified as:

- type AC: a residual current device for which tripping is ensured in case of residual sinusoidal alternating current, in the absence of a dc component whether suddenly applied or slowly rising;
- type A: a residual current device for which tripping is ensured for residual sinusoidal alternating currents in the presence of specified residual pulsating direct currents, whether suddenly applied or slowly rising.
- type B residual current device for which tripping is ensured for residual sinusoidal alternating currents in presence of specified residual pulsanting direct currents whether suddenly applied or slowy rising, for residual directs may result from rectifying circuits.

	Form of residual current	Correct functioning of residual current devices Type		
		AC	A	B
Sinusoidal ac		+	+	+
Pulsating dc			+	+
Smooth dc				+

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In presence of electrical apparatuses with electronic components (computers, photocopiers, fax etc.) the earth fault current might assume a non sinusoidal shape but a type of a pulsating unidirectional dc shape. In these cases it is necessary to use a residual current release classified as type A.
In presence of rectifying circuits (i.e. single phase connection with capacitive load causing smooth direct current, three pulse star connection or six pulse bridge connection, two pulse connection line-to-line) the earth fault current might assume a unidirectional dc shape. In this case it is necessary to use a residual current release classified as type B.

1 Protection and control devices

In order to fulfill the requirements for an adequate protection against earth faults ABB SACE has designed the following product categories:

- Miniature circuit-breakers:

- RCBOs(residual currentoperated circuit-breakers with integral overcurrent protection) DS201, DS202C series with rated current from 1 A up to 40 A;
- RCBOs (residual current operated circuit-breakers with integral overcurrent protection) DS200 with rated cur-rent from 6A up to 63A;
- RCBOs (residual current operated circuit-breakers with integral overcurrent protection) DS800 with 125A rated current;
- RCDblocks(residual current blocks) DDA 200 type to be coupled with the thermal magnetic circuit-breakers type S200 with rated current from 0.5 A to 63 A;
- RCDblocks (residual current blocks) DDA 60, DDA 70, DD 90 type to be coupled with the thermal magnetic circuit-breakers type S290 with rated current from 80 A to 100 A with C characteristic curve;
- RCDblocks (residual current blocks) DDA 800 type to be coupled with the thermal magnetic circuit-breakers type S800N and S800S with rated current up to 100 A. These blocks are available in two sizes: 63 A and 100 A;
- RCCBs (residual current circuit-breakers) F200 type, with rated current from 16 A to 125 A.
- RD2-RD3: residual current monitor for fixing on DIN rail.

- Tmax XT moulded case circuit breakers:

- RC Sel 200mm XT1 (with adjustable time of non trip): residual current releases can be installed in 200mm modules; it can be coupled with X1 circuit breakers with a rated current up to 160A.
- RC Sel XT1-XT3 (with adjustable time of non trip): residual current releases to be coupled with circuit breakers XT1, XT3 with a rated current up to 160A with XT1 and 250A with XT3

1 Protection and control devices

- RC Inst XT1-XT3 (instantaneous): residual current releases to be coupled with circuit breakers XT1, XT3 with a rated current up to 160A.
- RC Sel XT2-XT4 (with adjustable time of non trip): residual current releases to be coupled with circuit breakers XT2, XT4 with a rated current up to 160A with XT2 and 250A with XT4
- RC B Type XT3 (with adjustable time of non trip): residual current releases to be coupled with circuit breaker XT3 with a rated current up to 225A
- Electronic trip units Ekip LSIG for circuit breakers XT2 and XT4 with a rated current from 10 to 250A.

		RC Sel 200mm XT1	RC Inst XT1-XT3	RC Sel XT1-XT3	RC Sel XT2-XT4	RC B Type XT3
Type		"L" shaped	"L" shaped	"L" shaped	Placed below	Placed below
Technology		Microprocessor - based				
Primary power supply voltage	[V]	85...500	85...500	85...500	85...500	85...500
Operating frequence	[Hz]	45...66	45...66	45...66	45...66	45...66
Self-supply		■	■	■	■	■
Test operation range		85...500	85...500	85...500	85...500	85...500
Rated service current	[A]	up to 160	up to 160-XT1 up to 250-XT3	up to 160-XT1 up to 250-XT3	up to 160-XT2 up to 250-XT4	up to 225
Rated residual current trip	[A]	0.03-0.05-0.1-0.2-0.3-0.5-1-3-5-10	0.03-0.1-0.3-0.5-1-3	0.03-0.05-0.1-0.3-0.5-1-3-5-10	0.03-0.05-0.1-0.3-0.5-1-3-5-10	0.03-0.05-0.1-0.3-0.5-1
Adjustable NON-trip time settings et 2xIΔn	[s]	Instantaneous 0.1-0.2-0.3-0.5-1-2-3	Instantaneous	Instantaneous 0.1-0.2-0.3-0.5-1-2-3	Instantaneous 0.1-0.2-0.3-0.5-1-2-3	Instantaneous 0.1-0.2-0.3-0.5-1-2-3

	In \ Type	RC Sel 200mm	RC Inst	RC Sel	RC Sel	RC B Type	Ekip LSIG
		A	A	A	A	B	-
XT1	16÷160	■	■	■	-	-	-
XT2	1.6÷160	-	-	-	■	-	■
XT3	63÷250	-	■	■	-	■ (1)	-
XT4	16÷250	-	-	-	■	-	■

(1) Up to 225 A

1 Protection and control devices

- Tmax T moulded case circuit breakers:

- RC221 residual current releases to be coupled with circuit-brakers Tmax T1, T2, T3 with rated current from 16 A to 250A;
- RC222 residual current releases to be coupled with circuit-breakers Tmax T1,T2,T3,T4,T5 with rated currents from 16A to 500A;
- RC223 residual current releases to coupled with circuit-breaker Tmax T4 with rated currents up to 250A;
- electronic releases PR222DS/P, PR223 DS/P LSIG for circuit breakers T4, T5, T6 with rated current from 100A to 1000A;
- electronic releases PR331, PR332 LSIG for the circuit breaker Tmax T7 with rated currents from 800A to 1600A;
- electronic release R332 with residual current integrated protection for the circuit-breaker type Tmax T7 with rated uninterrupted current from 800A to 1600A.

		RC221	RC222		RC223
Circuit-breaker size		T1-T2-T3	T1-T2-T3	T4 and T5 4p	T4 4p
Type		"L" shaped		placed below	
Technology		microprocessor-based			
Action		With trip coil			
Primary service voltage (1)	[V]	85…500	85…500	85…500	110…500
Operating frequence	[Hz]	45…66	45…66	45…66	0-400-700-1000
Self-supply		■	■	■	■
Test operation range (1)		85…500	85…500	85…500	110…500
Rated service current	[A]	up to 250 A	up to 250 A	up to 500 A	up to 250 A
Rated residual current trip	[A]	0.03-0.1-0.3 0.5-1-3	0.03-0.05-0.1-0.3 0.5-1-3-5-10	0.03-0.05-0.1 0.3-0.5-1-3-5-10	0.03-0.05-0.1 0.3-0.5-1
Time limit for non-trip	[s]	Istantaneous	Istantaneous - 0.1 -0.2-0.3-0.5-1-2-3	Istantaneous - 0.1 -0.2-0.3-0.5-1-2-3	Istantaneous -0- 0.1 -0.2-0.3-0.5-1-2-3
Tolerance over trip times			±20%	±20%	±20%

(1) Operation up to 50 V phase-neutral (55 V for RC223).

		RC 221	RC 222	RC 223	PR332 LSIRc	PR222 LSIG	PR223 LSIG	PR332 LSIRc
	In \ Type	A-AC	A-AC	B	A-AC	-	-	-
T1	16÷160	■	■	-	-	-	-	-
T2	10÷160	■	■	-	-	-	-	-
T3	63÷250	■	■	■ (1)	-	-	-	-
T4	100÷320	-	■	■ (2)	-	■	■	-
T5	320÷630	-	■	-	-	■	■	-
T6	630÷1000	-	-	-	-	■	■	-
T7	800÷1600	-	-	-	■	-	-	■

(1) Up to 225 A
(2) Up to 250 A

1 Protection and control devices

- Emax air circuit breaker:

- PR331, PR332, PR333 LSIG electronic releases for the circuit breaker Emax X1 with rated uninterrupted currents from 630A to 1600A;
- Air circuit breaker equipped with electronic releases type PR121, PR122, PR123 LSIG for the circuit breaker Emax E1 to E6 with rated uninterrupted currents from 400A to 6300A.
- PR332, PR333 electronic releases with residual current integrated protection for circuit-breaker Emax X1 with rated uninterrupted currents from 630A to 1600A;
- PR122 and PR123 electronic releases with residual current integrated protection for circuit-breakers Emax E1 to E6 with rated uninterrupted currents from 400A to 6300A

		PR332 PR333 LIRc	PR122 LIRc	PR331 PR332 PR333 LSIG	PR121 PR122 PR123 LSIG
	In \ Type	A-AC	A-AC	-	-
X1	400÷1600	■	-	■	-
E1	400÷1600	-	■	-	■
E2	400÷2000	-	■	-	■
E3	400÷3200	-	■	-	■
E4	1250÷4000	-	-	-	■
E6	3200÷6300	-	-	-	■

Residual current relay with external transformer

ABB SACE circuit breaker can be combined also with the residual current relays RCQ 020/A with separate toroid in order to fulfill the requirements when the installation conditions are particulary restrictive, such as with circuit breakers already installed, limited space in the circuit breaker compartment etc.
Thanks to the settings characteristics of the residual current and of the trip times, the residual current relays with external transformer can be easily installed also in the final stages of the plant; in particolar, by selecting the rated residual current IΔn=0.03A with instantaneous tripping, the circuit-breaker guarantees protection against indirect contact and represents an additional measure against direct contact also in the presence of particulary high earth resistance values. Such residual current relays are of the type with indirect action: the opening command given by the relay must cause the tripping of the circuit-breaker through a shunt opening release (to be provided by the user).

Residual current relays		SACE RCQ 020/A
Power supply voltage	AC [V]	115-230…415
Operating frequency	[Hz]	45÷66
TripThreshold adjustement IΔn	[A]	0.03-0.05-0.1-0.3-0.5-1-3-5-10-30
Trip time adjustement	[s]	Inst-0.1-0.2-0.3-0.5-0.7-1-2-3-5

2 General characteristics

2.1 Electrical characteristics of circuit-breakers

Pro M compact miniature circuit-breakers

The following table shows an overview of the MCBs, for further details please refer to the technical catalogue.

Series				S200	S200 M	S200 P			SN 201 L	SN 201
Characteristics				B, C, D, K, Z	B, C, D, K, Z	B, C, D, K, Z			B, C	B, C, D
Rated current	[A]			0.5 ≤ In ≤ 63	0.5 ≤ In ≤ 63	0.2 ≤ In ≤ 25	32 ≤ In ≤ 40	50 ≤ In ≤ 63	2 ≤ In ≤ 40	2 ≤ In ≤ 40
Breaking capacity	[kA]									
Reference standard		Nr. poles	Ue [V]							
IEC 23-3/EN 60898	Icn		230/400	6	10	25	15	15	4.5	6
IEC/EN 60947-2	Icu	1, 1P+N	133	20	25[2]	40	25	25	10	15
			230	10	15[2]	25	15	15	6	10
		2, 3, 4	230	20	25[2]	40	25	25		
			400	10	15[2]	25	15	15		
		2, 3, 4	500							
			690							
	Ics	1, 1P+N	133	15	18.7[2]	20	18.7	18.7	6	10
			230	7.5	11.2[2]	12.5	11.2	7.5	4.5	6
		2, 3, 4	230	15[1]	18.7[2]	20	18.7	18.7		
			400	7.5	11.2[2]	12.5	11.2	7.5		
		2, 3, 4	500							
			690							
IEC/EN 60947-2	Icu	1, 1P+N	24	20						
Direct cuttent			60	10	10	15	10	10	10	15
T=l/R≤5ms for all			125							
series, except S280 UC			250							
and S800-UC		2	48	20						
whwre T=l/R<15ms			125	10	10	15	10	10	10	15
			250							
			500							
			600							
			800							
		3, 4	375							
			500							
			750							
			1000							
			1200							
	Ics	1, 1P+N	24	20						
			60	10	10	15	10	10	10	15
			125							
			250							
		2	48	20						
			125	10	10	15	10	10	10	15
			250							
			500							
			600							
			800							
		3, 4	375							
			500							
			750							

[1] Only up to 40 A; 10 kA up to 50/63 A
[2] < 50 A
[3] Only for D characteristic
[4] Values are not for all rated currents
[5] 3 poles
[6] 4 poles

2 General characteristics

SN 201 M	S 280	S 280 UC		S 290	S800S					S800N	S800C
B, C	B, C	B, K, Z	K, Z	C. D, K	B, C, D	K	KM	UCB	UCK	B, C, D	B, C, D, K
2 ≤ In ≤ 40	80 ≤ In ≤ 100	0.2 ≤ In ≤ 40	50 ≤ In ≤ 63	80 ≤ In ≤ 125	10 ≤ In ≤ 125	10 ≤ In ≤ 125	20 ≤ In ≤ 80	10 ≤ In ≤ 125	10 ≤ In ≤ 125	10 ≤ In ≤ 125	10 ≤ In ≤ 125
10	6			10	25					20	15
20	15	10	6								
10	6	6	4.5	20 (15)[3]	50	50	50			36	
	10	10	6	25	50	50	50			36	25
	6	6	4.5	20 (15)[3]	50	50	50			36	25
					15[4]	15[4]	15[4]			10[4]	25
					6[4]	6[4]	6[4]			4.5	
10	15	7.5	6								
7.5	6	6	4.5	10 (7.5)[3]	40	40	40			30	18
	10	7.5	6	12.5	40	40	40			30	18
	6	6	4.5	10 (7.5)[3]	40	40	40			30	18
					11[4]	11[4]	11[4]			8[4]	
					4[4]	4[4]	4[4]			3	
15	10			25							
		6	4.5		30	30	30				
								50	50	20	10
15	10										
		6	4.5		30	30	30			20	10
								50	50		
					30[5]	30[5]	30[5]	30[5]	30[5]	20[5]	10[5]
					30[6]	30[6]	30[6]	30[6]	30[6]	20[6]	10[6]
								50	50		
15	10			12.5							
		6	4.5		30	30	30			20	10
								50	50		
15	10										
		6	4.5		30	30	30			20	10
								50	50		
					30[5]	30[5]	30[5]	30[5]	30[5]	20[5]	10[5]
					30[6]	30[6]	30[6]	30[6]	30[6]	20[6]	10[6]
								50	50		

2 General characteristics

Tmax XT moulded-case circuit-breakers

			XT1				
Size		[A]	160				
Poles		[Nr.]	3, 4				
Rated service voltage, **Ue**	(AC) 50-60Hz	[V]	690				
	(DC)	[V]	500				
Rated insulation voltage, **Ui**		[V]	800				
Rated impulse withstand voltage, **Uimp**		[kV]	8				
Version			Fixed, Plug-in[2]				
Breaking capacities			**B**	**C**	**N**	**S**	**H**
Rate ultimate short-circuit breaking capacity, Icu							
Icu @ 220-230V 50-60Hz (AC)		[kA]	25	40	65	85	100
Icu @ 380V 50-60Hz (AC)		[kA]	18	25	36	50	70
Icu @ 415V 50-60Hz (AC)		[kA]	18	25	36	50	70
Icu @ 440V 50-60Hz (AC)		[kA]	15	25	36	50	65
Icu @ 500V 50-60Hz (AC)		[kA]	8	18	30	36	50
Icu @ 525V 50-60Hz (AC)		[kA]	6	8	22	35	35
Icu @ 690V 50-60Hz (AC)		[kA]	3	4	6	8	10
Icu @ 250V (DC) 2 poles in series		[kA]	18	25	36	50	70
Icu @ 500V (DC) 2 poles in series		[kA]	18	25	36	50	70
Rate service short-circuit breaking capacity, Ics							
Icu @ 220-230V 50-60Hz (AC)		[kA]	100%	100%	75% (50)	75%	75%
Icu @ 380V 50-60Hz (AC)		[kA]	100%	100%	100%	100%	75%
Icu @ 415V 50-60Hz (AC)		[kA]	100%	100%	100%	75%	50% (37.5)
Icu @ 440V 50-60Hz (AC)		[kA]	75%	50%	50%	50%	50%
Icu @ 500V 50-60Hz (AC)		[kA]	100%	50%	50%	50%	50%
Icu @ 525V 50-60Hz (AC)		[kA]	100%	100%	50%	50%	50%
Icu @ 690V 50-60Hz (AC)		[kA]	100%	100%	75%	50%	50%
Icu @ 250V (DC) 2 poles in series		[kA]	100%	100%	100%	75%	75%
Icu @ 500V (DC) 2 poles in series		[kA]	100%	100%	100%	75%	75%
Rate short-circuit making capacity, Icm							
Icu @ 220-230V 50-60Hz (AC)		[kA]	52.5	84	143	187	220
Icu @ 380V 50-60Hz (AC)		[kA]	36	52.5	75.6	105	154
Icu @ 415V 50-60Hz (AC)		[kA]	36	52.5	75.6	105	154
Icu @ 440V 50-60Hz (AC)		[kA]	30	52.5	75.6	105	143
Icu @ 500V 50-60Hz (AC)		[kA]	13.6	36	63	75.6	105
Icu @ 525V 50-60Hz (AC)		[kA]	9.18	13.6	46.2	73.6	73.5
Icu @ 690V 50-60Hz (AC)		[kA]	4.26	5.88	9.18	13.6	17
Category of use (IEC 60947-2)			A				
Reference standard			IEC 60947-2				
Isolation behaviour			■				
Mounted on DIN rail			DIN EN 50022				
Mechanical life		[No. Operations]	25000				
		[No. Hourly Operations]	240				
Electrical life @ 415 V (AC)		[No. Operations]	8000				
		[No. Hourly Operations]	120				

(1) 90kA @ 690V only for XT4 160. Available shortly, please ask ABB SACE
(2) XT1 plug in version only with In max = 125A

2 General characteristics

XT2					XT3		XT4				
160					250		160/250				
3, 4					3, 4		3, 4				
690					690		690				
500					500		500				
1000					800		1000				
8					8		8				
Fixed, Withdrawable, Plug-in					Fixed, Plug-in		Fixed, Withdrawable, Plug-in				
N	**S**	**H**	**L**	**V**	**N**	**S**	**N**	**S**	**H**	**L**	**V**
65	85	100	150	200	50	85	65	85	100	150	200
36	50	70	120	200	36	50	36	50	70	120	150
36	50	70	120	150	36	50	36	50	70	120	150
36	50	65	100	150	25	40	36	50	65	100	150
30	36	50	60	70	20	30	30	36	50	60	70
20	25	30	36	50	13	20	20	25	45	50	50
10	12	15	18	20	5	8	10	12	15	20	25 (90°)
36	50	70	120	150	36	50	36	50	70	120	150
36	50	70	120	150	36	50	36	50	70	120	150
100%	100%	100%	100%	100%	75%	50%	100%	100%	100%	100%	100%
100%	100%	100%	100%	100%	75%	50% (27)	100%	100%	100%	100%	100%
100%	100%	100%	100%	100%	75%	50% (27)	100%	100%	100%	100%	100%
100%	100%	100%	100%	100%	75%	50%	100%	100%	100%	100%	100%
100%	100%	100%	100%	100%	75%	50%	100%	100%	100%	100%	100%
100%	100%	100%	100%	100%	75%	50%	100%	100%	100%	100%	100%
100%	100%	100%	100%	75%	75%	50%	100%	100%	100%	100%	75% (20)
100%	100%	100%	100%	100%	100%	75%	100%	100%	100%	100%	100%
100%	100%	100%	100%	100%	100%	75%	100%	100%	100%	100%	100%
143	187	220	330	440	105	187	143	187	220	330	440
75.6	105	154	264	440	75.6	105	75.6	105	154	264	330
75.6	105	154	264	330	75.6	105	75.6	105	154	264	330
75.6	105	143	220	330	52.5	84	75.6	105	143	220	330
63	75.6	105	132	154	40	63	63	75.6	105	132	154
40	52.5	63	75.6	105	26	40	40	52.5	94.5	105	105
17	24	30	36	40	7.65	13.6	17	24	84	40	52.5
A					A		A				
IEC 60947-2					IEC 60947-2		IEC 60947-2				
■					■		■				
DIN EN 50022					DIN EN 50022		DIN EN 50022				
25000					25000		25000				
240					240		240				
8000					8000		8000				
120					120		120				

2 General characteristics

Tmax T moulded-case circuit-breakers

			Tmax T1 1P	Tmax T1			Tmax T2			
Rated uninterrupted current, **Iu**		[A]	160	160			160			
Poles		[Nr]	1	3/4			3/4			
Rated service current, **Ue**	(AC) 50-60 Hz	[V]	240	690			690			
	(DC)	[V]	125	500			500			
Rated impulse withstand voltage, **Uimp**		[kV]	8	8			8			
Rated insulation voltage, **Ui**		[V]	500	800			800			
Test voltage at industrial frequency for 1 min.		[V]	3000	3000			3000			
Rated ultimate short-circuit breaking capacity, **Icu**			**B**	**B**	**C**	**N**	**N**	**S**	**H**	**L**
(AC) 50-60 Hz 220/230 V		[kA]	25*	25	40	50	65	85	100	120
(AC) 50-60 Hz 380/415 V		[kA]	–	16	25	36	36	50	70	85
(AC) 50-60 Hz 440 V		[kA]	–	10	15	22	30	45	55	75
(AC) 50-60 Hz 500 V		[kA]	–	8	10	15	25	30	36	50
(AC) 50-60 Hz 690 V		[kA]	–	3	4	6	6	7	8	10
(DC) 250 V - 2 poles in series		[kA]	25 (at 125 V)	16	25	36	36	50	70	85
(DC) 250 V - 3 poles in series		[kA]	–	20	30	40	40	55	85	100
(DC) 500 V - 2 poles in series		[kA]	–	–	–	–	–	–	–	–
(DC) 500 V - 3 poles in series		[kA]	–	16	25	36	36	50	70	85
(DC) 750 V - 3 poles in series		[kA]	–	–	–	–	–	–	–	–
Rated service short-circuit breaking capacity, **Ics**										
(AC) 50-60 Hz 220/230 V		[%Icu]	75%	100%	75%	75%	100%	100%	100%	100%
(AC) 50-60 Hz 380/415 V		[%Icu]	–	100%	100%	75%	100%	100%	100%	75% (70 kA)
(AC) 50-60 Hz 440 V		[%Icu]	–	100%	75%	50%	100%	100%	100%	75%
(AC) 50-60 Hz 500 V		[%Icu]	–	100%	75%	50%	100%	100%	100%	75%
(AC) 50-60 Hz 690 V		[%Icu]	–	100%	75%	50%	100%	100%	100%	75%
Rated short-circuit making capacity, **Icm**										
(AC) 50-60 Hz 220/230 V		[kA]	52.5	52.5	84	105	143	187	220	264
(AC) 50-60 Hz 380/415 V		[kA]	–	32	52.5	75.6	75.6	105	154	187
(AC) 50-60 Hz 440 V		[kA]	–	17	30	46.2	63	94.5	121	165
(AC) 50-60 Hz 500 V		[kA]	–	13.6	17	30	52.5	63	75.6	105
(AC) 50-60 Hz 690 V		[kA]	–	4.3	5.9	9.2	9.2	11.9	13.6	17
Opening time (415 V)		[ms]	7	7	6	5	3	3	3	3
Utilisation category (IEC 60947-2)			A	A			A			
Reference Standard			IEC 60947-2	IEC 60947-2			IEC 60947-2			
Isolation behaviour			■	■			■			
Interchangeability			–	–			–			
Versions			F	F			F-P			
Mechanical life		[No. operations]	25000	25000			25000			
		[No. Hourly operations]	240	240			240			
Electrical life @ 415 V AC		[No. operations]	8000	8000			8000			
		[No. Hourly operations]	120	120			120			

F = fixed circuit-breakers
P = plug-in circuit-breakers
W = withdrawable circuit-breakers

(*) The breaking capacity for settings In=16 A and In=20 A is 16 kA

2 General characteristics

Tmax T3		Tmax T4					Tmax T5					Tmax T6				Tmax T7			
250		250/320					400/630					630/800/1000				800/1000/1250/1600			
3/4		3/4					3/4					3/4				3/4			
690		690					690					690				690			
500		750					750					750				–			
8		8					8					8				8			
800		1000					1000					1000				1000			
3000		3500					3500					3500				3500			
N	**S**	**N**	**S**	**H**	**L**	**V**	**N**	**S**	**H**	**L**	**V**	**N**	**S**	**H**	**L**	**S**	**H**	**L**	**V**[6]
50	85	70	85	100	200	200	70	85	100	200	200	70	85	100	200	85	100	200	200
36	50	36	50	70	120	200	36	50	70	120	200	36	50	70	100	50	70	120	150
25	40	30	40	65	100	180	30	40	65	100	180	30	45	50	80	50	65	100	130
20	30	25	30	50	85	150	25	30	50	85	150	25	35	50	65	40	50	85	100
5	8	20	25	40	70	80	20	25	40	70	80	20	22	25	30	30	42	50	60
36	50	36	50	70	100	150	36	50	70	100	150	36	50	70	100	–	–	–	–
40	55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	25	36	50	70	100	25	36	50	70	100	20	35	50	65	–	–	–	–
36	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	16	25	36	50	70	16	25	36	50	70	16	20	36	50	–	–	–	–
75%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	100%	100%	100%	100%
75%	50% (27 kA)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	100%	100%	100%	100%
75%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	100%	100%	100%	100%
75%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%[1]	100%[2]	100%	100%	100%	75%	100%	100%	75%	100%
75%	50%	100%	100%	100%	100%	100%	100%	100%	100%[1]	100%[2]	100%[2]	75%	75%	75%	75%	100%	75%	75%	75%
105	187	154	187	220	440	660	154	187	220	440	660	154	187	220	440	187	220	440	440
75.6	105	75.6	105	154	264	440	75.6	105	154	264	440	75.6	105	154	220	105	154	264	330
52.5	84	63	84	143	220	396	63	84	143	220	396	63	94.5	105	176	105	143	220	286
40	63	52.5	63	105	187	330	52.5	63	105	187	330	52.5	73.5	105	143	84	105	187	220
7.7	13.6	40	52.5	84	154	176	40	52.5	84	154	176	40	46	52.5	63	63	88.2	105	132
7	6	5	5	5	5	5	6	6	6	6	6	10	9	8	7	15	10	8	8
A		A					B (400 A)[3] - A (630 A)					B (630A - 800A)[5] - A (1000A)				B[7]			
IEC 60947-2		IEC 60947-2					IEC 60947-2					IEC 60947-2				IEC 60947-2			
■		■					■					■				■			
–		■					■					■				■			
F-P		F-P-W					F-P-W					F-W[4]				F-W			
25000		20000					20000					20000				10000			
240		240					120					120				60			
8000		8000 (250 A) - 6000 (320 A)					7000 (400 A) - 5000 (630 A)					7000 (630A) - 5000 (800A) - 4000 (1000A)				2000 (S-H-L versions) - 3000 (V version)			
120		120					60					60				60			

[1] 75% for T5 630
[2] 50% for T5 630
[3] Icw = 5 kA
[4] W version is not available on T6 1000 A
[5] Icw = 7.6 kA (630 A) - 10 kA (800 A)
[6] Only for T7 800/1000/1250 A
[7] Icw = 20 kA (S,H,L versions) - 15 kA (V version)

Notes: in the plug-in version of T2,T3,T5 630 and in the withdrawable version of T5 630 the maximum rated current available is derated by 10% at 40 °C

2 General characteristics

SACE Emax air circuit-breakers

Common data

Voltages		
Rated operational voltage Ue	[V]	690 ~
Rated insulation voltage Ui	[V]	1000
Rated impulse withstand voltage Uimp	[kV]	12
Service temperature	[°C]	-25....+70
Storage temperature	[°C]	-40....+70
Frequency f	[Hz]	50 - 60
Number of poles		3 - 4
Version		Fixed -Withdrawable

Performance levels		
Currents: rated uninterrupted current (at 40 °C) Iu		[A]
		[A]
		[A]
		[A]
		[A]
		[A]
		[A]
Neutral pole current-carrying capacity for 4-pole CBs		[%Iu]
Rated ultimate breaking capacity under short-circuit **Icu**		
220/230/380/400/415 V ~		[kA]
440 V ~		[kA]
500/525 V ~		[kA]
660/690 V ~		[kA]
Rated service breaking capacity under short-circuit **Ics**		
220/230/380/400/415 V ~		[kA]
440 V ~		[kA]
500/525 V ~		[kA]
660/690 V ~		[kA]
Rated short-time withstand current **Icw**	(1s)	[kA]
	(3s)	[kA]
Rated making capacity under short-circuit (peak value) **Icm**		
220/230/380/400/415 V ~		[kA]
440 V ~		[kA]
500/525 V ~		[kA]
660/690 V ~		[kA]
Utilisation category (according to IEC 60947-2)		
Isolation behaviour (according to IEC 60947-2)		
Overcurrent protection		
Electronic releases for AC applications		
Operating times		
Closing time (max)		[ms]
Breaking time for I<Icw (max) (1)		[ms]
Breaking time for I>Icw (max)		[ms]

(1) Without intentional delays
(2) Performance at 600 V is 100 kA

SACE Emax air circuit-breakers		**X1**			**E1 B-N**		
Rated uninterrupted current (at 40 °C) **Iu**	[A]	800	1250	1600	800	1000-1250	1600
Mechanical life with regular ordinary maintenance	[No. operations x 1000]	12.5	12.5	12.5	25	25	25
Operation frequency	[Operations/hour]	60	60	60	60	60	60
Electrical life (440 V ~)	[No. operations x 1000]	6	4	3	10	10	10
(690 V ~)	[No. operations x 1000]	3	2	1	10	8	8
Operation frequency	[Operations/hour]	30	30	30	30	30	30

2 General characteristics

X1			E1		E2				E3					E4			E6	
B	N	L	B	N	B	N	S	L	N	S	H	V	L	S	H	V	H	V
630	**630**	**630**	**800**	**800**	**1600**	**1000**	**800**	**1250**	**2500**	**1000**	**800**	**800**	**2000**	**4000**	**3200**	**3200**	**4000**	**3200**
800	**800**	**800**	**1000**	**1000**	**2000**	**1250**	**1000**	**1600**	**3200**	**1250**	**1000**	**1250**	**2500**		**4000**	**4000**	**5000**	**4000**
1000	**1000**	**1000**	**1250**	**1250**		**1600**	**1250**			**1600**	**1250**	**1600**					**6300**	**5000**
1250	**1250**	**1250**	**1600**	**1600**		**2000**	**1600**			**2000**	**1600**	**2000**						**6300**
1600	**1600**						**2000**			**2500**	**2000**	**2500**						
										3200	**2500**	**3200**						
											3200							
100	100	100	100	100	100	100	100	100	100	100	100	100	100	50	50	50	50	50
42	65	150	42	50	42	65	85	130	65	75	100	130	130	75	100	150	100	150
42	65	130	42	50	42	65	85	110	65	75	100	130	110	75	100	150	100	150
42	50	100	42	50	42	55	65	85	65	75	100	100	85	75	100	130	100	130
42	50	60	42	50	42	55	65	85	65	75	85 (2)	100	85	75	85 (2)	100	100	100
42	50	150	42	50	42	65	85	130	65	75	85	100	130	75	100	150	100	125
42	50	130	42	50	42	65	85	110	65	75	85	100	110	75	100	150	100	125
42	42	100	42	50	42	55	65	65	65	75	85	85	65	75	100	130	100	100
42	42	45	42	50	42	55	65	65	65	75	85	85	65	75	85	100	100	100
42	42	15	42	50	42	55	65	10	65	75	75	85	15	75	100	100	100	100
			36	36	42	42	50	–	65	65	65	65	–	75	75	75	85	85
88.2	143	330	88.2	105	88.2	143	187	286	143	165	220	286	286	165	220	330	220	330
88.2	143	286	88.2	105	88.2	143	187	242	143	165	220	286	242	165	220	330	220	330
88.2	121	220	88.2	105	88.2	121	143	187	143	165	187	220	187	165	220	286	220	286
88.2	121	132	88.2	105	88.2	121	143	187	143	165	187	220	187	165	187	220	220	220
B	B	A	B	B	B	B	B	A	B	B	B	B	A	B	B	B	B	B
■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
30	30	12	30	30	30	30	30	12	30	30	30	30	12	30	30	30	30	30

E2 B-N-S				E2 L		E3 N-S-H-V						E3 L		E4 S-H-V		E6 H-V			
800	1000-1250	1600	2000	1250	1600	800	1000-1250	1600	2000	2500	3200	2000	2500	3200	4000	3200	4000	5000	6300
25	25	25	25	20	20	20	20	20	20	20	20	15	15	15	15	12	12	12	12
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
15	15	12	10	4	3	12	12	10	9	8	6	2	1.8	7	5	5	4	3	2
15	15	10	8	3	2	12	12	10	9	7	5	1.5	1.3	7	4	5	4	2	1.5
30	30	30	30	20	20	20	20	20	20	20	20	20	20	10	10	10	10	10	10

2 General characteristics

SACE Emax air circuit-breakers with full-size neutral conductor

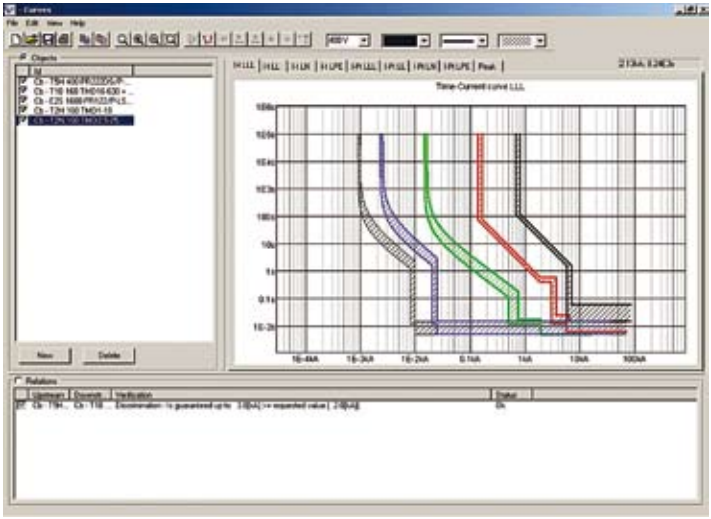
			E4S/f	E4H/f	E6H/f
Rated uninterrupted current (at 40 °C) Iu		[A]	**4000**	**3200**	**4000**
		[A]		**4000**	**5000**
					6300
Number of poles			4	4	4
Rated operational voltage **Ue**		[V ~]	690	690	690
Rated ultimate short-circuit breaking capacity **Icu**					
	220/230/380/400/415 V ~	[kA]	80	100	100
	440 V ~	[kA]	80	100	100
	500/525 V ~	[kA]	75	100	100
	660/690 V ~	[kA]	75	100	100
Rated service short-circuit breaking capacity **Ics**					
	220/230/380/400/415 V ~	[kA]	80	100	100
	440 V ~	[kA]	80	100	100
	500/525 V ~	[kA]	75	100	100
	660/690 V ~	[kA]	75	100	100
Rated short-time withstand current **Icw**					
	(1s)	[kA]	75	85	100
	(3s)	[kA]	75	75	85
Rated short-circuit making capacity **Icm**					
	220/230/380/400/415 V ~	[kA]	176	220	220
	440 V ~	[kA]	176	220	220
	500/525 V ~	[kA]	165	220	220
	660/690 V ~	[kA]	165	220	220
Utilization category (in accordance with IEC 60947-2)			B	B	B
Isolation behavior (in accordance with IEC 60947-2)			■	■	■
Overall dimensions					
	Fixed: H = 418 mm - D = 302 mm L	[mm]	746	746	1034
	Withdrawable: H = 461 - D = 396.5 mm L	[mm]	774	774	1062
Weight (circuit-breaker complete with releases and CT, not including accessories)					
	Fixed	[kg]	120	120	165
	Withdrawable (including fixed part)	[kg]	170	170	250

2.2 Characteristic curves and the software “Curves”

2.2.1 Curves 1.0

The software “Curves”, which can be downloaded from our web site http://bol.it.abb.com, is a tool dedicated to who works in the electrical engineering field.
This program allows the visualization of :

- I-t LLL: tripping characteristics for three-phase faults;
- I-t LL: tripping characteristics for two-phase faults;
- I-t LN: tripping characteristics for single-phase faults;
- I-t LPE: tripping characteristics for phase-to-earth faults;
- I-I^2t LLL: specific let-through energy for three-phase faults;
- I-I^2t LL: specific let-through energy for two-phase faults;
- I-I^2t LN: specific let-through energy for single-phase faults;
- I-I^2t LPE: specific let-through energy for phase-to-earth faults;
- Peak: current limitation curve;
- Cable and fuse characteristic curves.



Besides, other program features are the verifications of cable protection, of human beings’ protection and of discrimination. The algorithms for the verification of the cable protection are described in the international standards. The algorithms for the verification of discrimination are implemented in accordance with the guidelines provided in ABB SACE Technical Application Papers, specifically “QT1: Low voltage selectivity with ABB circuit-breakers” (QT1 from now on). The software “Curves” displays tripping and limiting characteristics according to the catalogues.

2 General characteristics

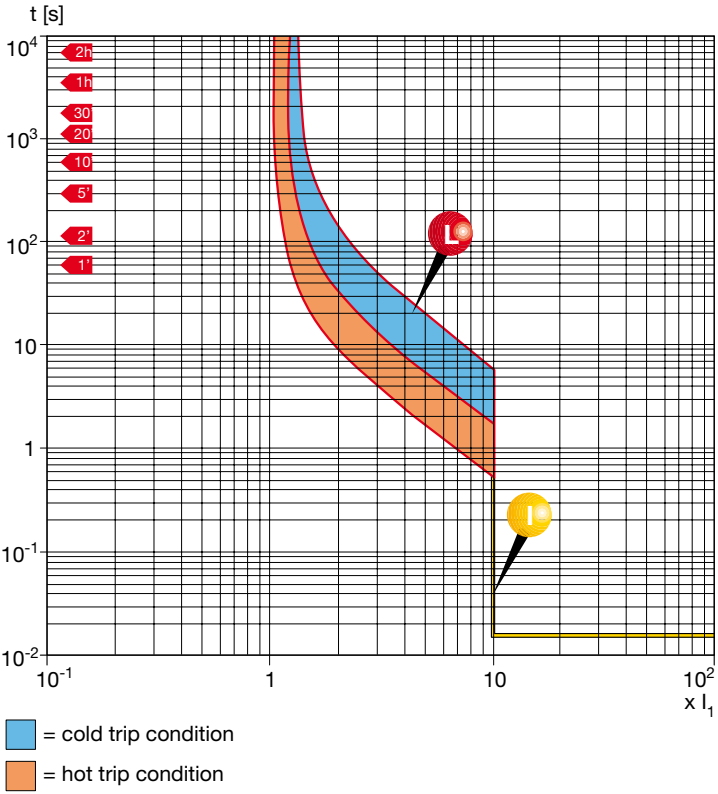
2.2.2 Trip curves of thermomagnetic and magnetic only releases

The overload protection function must not trip the circuit-breaker in 2 hours for current values which are lower than 1.05 times the set current, and must trip within 2 hours for current values which are lower than 1.3 times the set current.
By “cold trip conditions” it is meant that the overload occurs when the circuit-breaker has not reached the normal working temperature (no current flows through the circuit-breaker before the anomalous condition occurs); on the contrary “hot trip conditions” refers to the circuit-breaker having reached the normal working temperature with the rated current flowing through, before the overload current occurs. For this reason “cold trip conditions” times are always greater than “hot trip conditions” times.
The protection function against short-circuit is represented in the time-current curve by a vertical line, corresponding to the rated value of the trip threshold I3. In accordance with the Standard IEC 60947-2, the real value of this threshold is within the range 0.8·I3 and 1.2·I3. The trip time of this protection varies according to the electrical characteristics of the fault and the presence of other devices: it is not possible to represent the envelope of all the possible situations in a sufficiently clear way in this curve; therefore it is better to use a single straight line, parallel to the current axis.
All the information relevant to this trip area and useful for the sizing and coordination of the plant are represented in the limitation curve and in the curves for the specific let-through energy of the circuit-breaker under short-circuit conditions.

The following pages show some examples reporting the settings of thermomagnetic releases.
To simplify the reading of these examples, the tolerance of the protection functions has not been considered.
For a proper setting it is necessary to consider the tolerances referred to the type of thermomagnetic release used; for these information please refer to the technical catalogues.

2 General characteristics

The following figure shows the time-current tripping curve of a circuit-breaker equipped with thermomagnetic release:



2 General characteristics

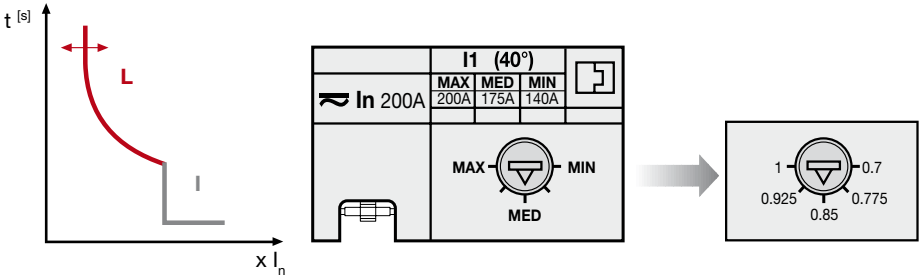
Overload protection (L)
To set correctly the function L of the release is necessary to know the load current (Ib) and divide it for the rated current of the thermomagnetic releases, taking the setting available higher or equal to the value obtained.

$$\text{Setting}_{L} = \frac{I_b}{I_n}$$

Besides, in case of protection of a cable, it is necessary to comply with the following relation :
Ib < I1 < Iz where Iz is the conductor carrying capacity and I1 is the current set on the overload protection.

Example:
XT4N 250 TMA 200 with thermomagnetic release TMA. (with function L adjustable from 0.7 to 1 x In)
Ib=170A

$$\text{Setting}_{L} = \frac{I_b}{I_n} = \frac{170}{200} = 0.85$$



2 General characteristics

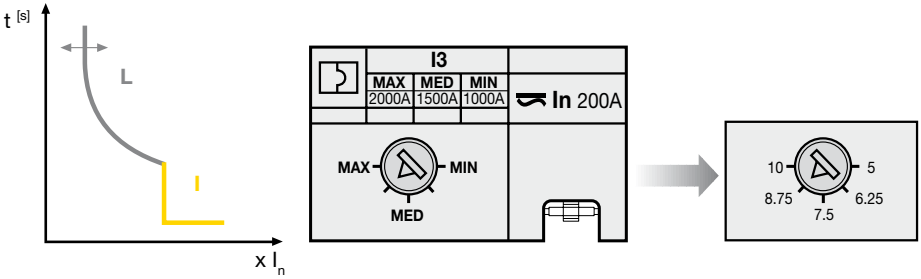
Short-circuit instantaneous protection (I)
To set the magnetic function of the release is necessary to know the minimum value of the short-circuit current that we can have in the plant.
The I3 thresold shall comply with following condition:
I3 ≤ Ikmin
$I3=setting_I \times In$
To detect the setting it is necessary to divide the Ikmin by the rated current of the releases and take the setting value immediately lower.

$$\text{Setting}_I = \frac{Ik\,min}{In}$$

Example:
XT4N 250 TMA 200 with thermomagnetic release TMA with instantaneous function adjustable from 5 (=1000A) to 10 (=2000A).
Ikmin=1800 A

$$\text{Setting}_I = \frac{Ik\,min}{In} = \frac{1800}{200} = 9$$

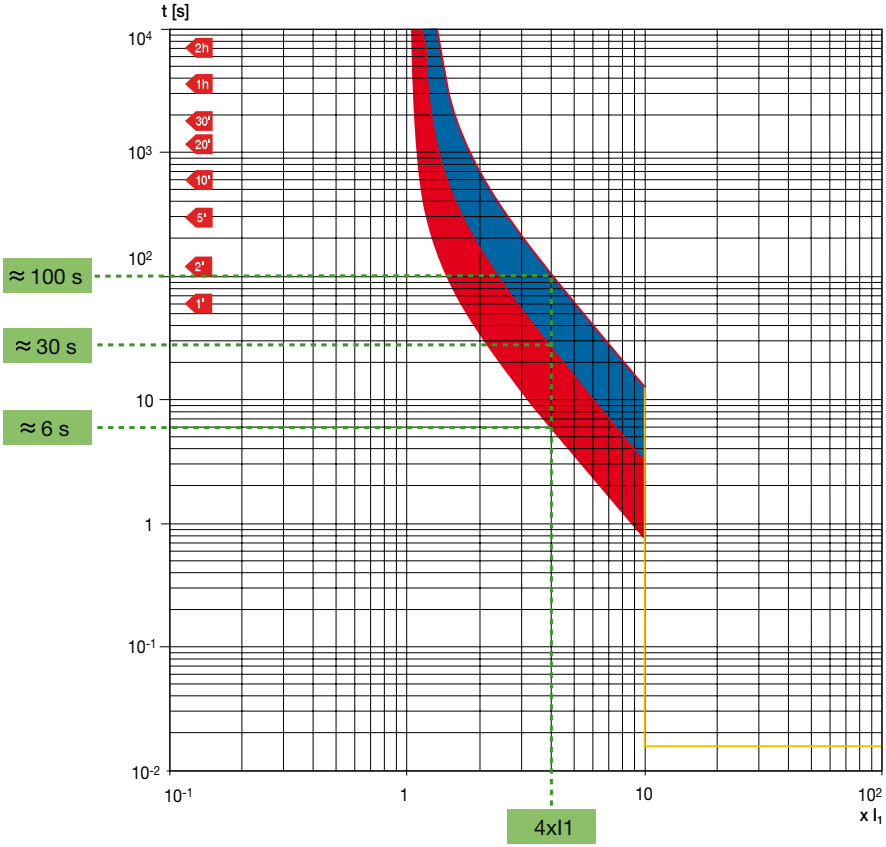
It is possible to choose: ≅ 8.75 :
I3=8.75x200=1750 ≤ 1800 A



2 General characteristics

Example of thermomagnetic release setting
Consider a circuit-breaker type XT2 160 In 160 and, using the trimmer for the thermal regulation, select the current threshold, for example at 144 A; the magnetic trip threshold, fixed at 10xIn, is equal to 1600 A.
Note that, according to the conditions under which the overload occurs, that is either with the circuit-breaker at full working temperature or not, the trip of the thermal release varies considerably. For example, for an overload current of 600 A, the trip time is between 6 and 30 s for hot trip, and between 30 and 100 s for cold trip.
For fault current values higher than 1600 A, the circuit-breaker trips instantaneously through magnetic protection.

XT2 160 - In 160 Time-current curves



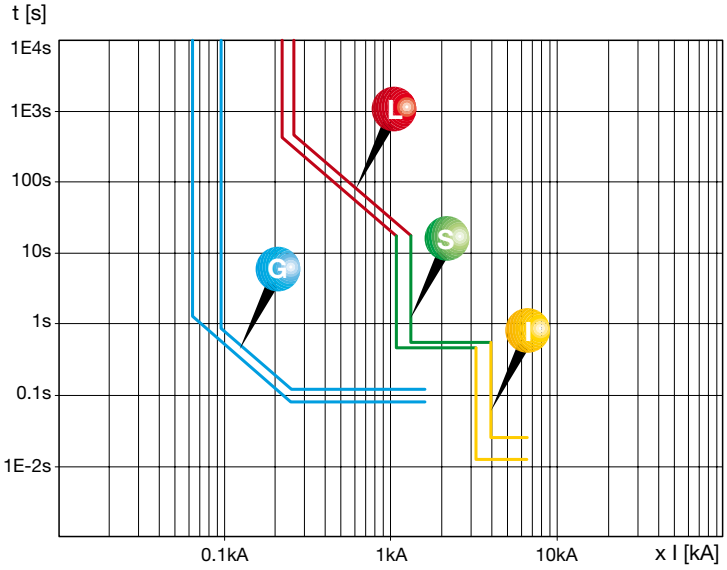
2 General characteristics

2.2.3 The functions of electronic releases

In the following pages the protection functions of the electronic releases for both moulded-case as well as air circuit breakers are reported; as regards the availability of the protection functions with the different releases, reference shall be made to the table on page 43.
The examples shown in these pages show how it is possible to set the electronic release by means of the dip-switch on the front of the circuit-breaker; this operation can be carried out also through the controls viewing the LED display (for the releases PR122-PR123-PR332-PR333) or electronically through the test unit PR 010T or with SD-TESTBUS 2.

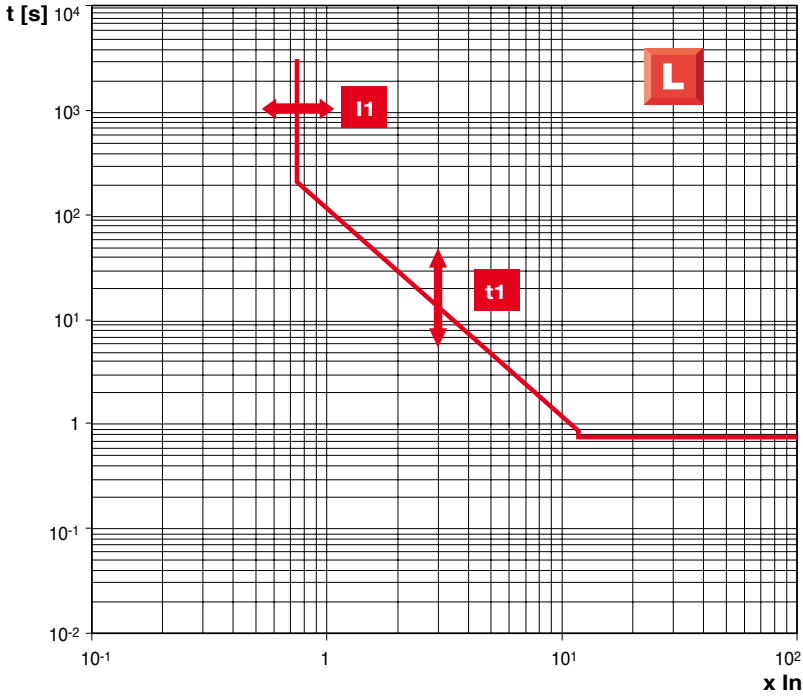
To simplify the reading of the examples, the tolerance of the protection functions has not been considered. For a correct setting it is necessary to take into consideration the tolerances relevant to the different protection functions referred to the electronic trip unit used; for this information please consult the technical catalogue.

The figure below shows the time-current tripping curve of a circuit-breaker equipped with an electronic release having the protection functions LSIG which are described in the following pages:



2 General characteristics

Overload protection (L function)



The application field of this protection function refers to all the installations which can be subject to overloads - usually of low value but of long duration - which are dangerous for the life of apparatus and cables.
These currents usually occur in a sound circuit, where the line results to be overloaded (this event is more likely than a real fault).
The trip curve of this protection (which cannot be excluded) is defined by a current threshold I1 and by a trip time t1. More exactly :

- I1 represents the current value beyond which the protection function commands the opening of the circuit-breaker according to an inverse time trip characteristic, where the time-current connection is given by the relation
  I^2t = constant (constant specific let-through energy);
- t1 represents the trip time of the protection, in seconds, corresponding to a well defined multiple of I1 and it is used to identify a defined curve among those made available by the trip unit.

As regards the settings available please consult the technical catalogues.

2 General characteristics

To set properly L threshold, it is necessary to know the current required by the load (Ib), divide it by the In of the trip unit and take the setting immediately higher than or equal to the value obtained :

$$\text{Setting}_{L} = \frac{I_b}{I_n}$$

Besides, in case of cable protection, the following relation shall be observed Ib < I1 < Iz where Iz is the conductor carrying capacity and I1 is the current value set for the overload protection.

Example :
XT2N 160, trip unit type Ekip LSI In=100, function L (I1=0.4 at 1 x In with step 0.02) through manual setting.
Ib= 85A

$$\text{Setting}_{L} = \frac{I_b}{I_n} = \frac{85}{100} = 0.85$$

I1=0.86 is chosen.

Through the manual setting, the dip-switches shall be positioned so that a coefficient equal to 0.86 is obtained; this coefficient multiplied by the rated current of the trip unit gives the required current value. The figure below shows the correct combination of dip-switches to obtain the required multiplying factor:
I1= 100 x (0.4*+0.02+0.04+0.08+0,32) = 86A
The trip time of L function for an overload current varies according to the type of curve used.
As regards the release considered in the example, the available curves are 4 and each of them is characterized by the passage by a characteristic multiple (3xI1) to which a different trip time (t1=3s, 12s, 36s, 60s) corresponds; since these are curves with I^2t=const, it is possible to identify multiples different from 3xI1 after the setting of t1.
Being a curve with I^2t constant, the condition
$(3xI1)^2$ x t1 =const =I^2t
must be always verified.

(*) 0.4 is the fixed value, which cannot be excluded

2 General characteristics

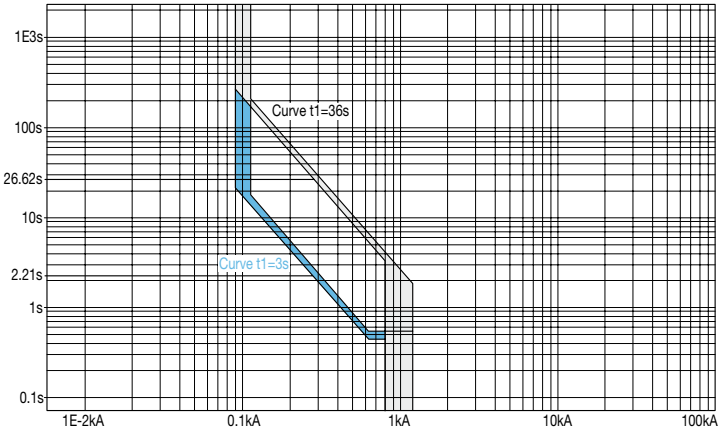
where the expression I^2t represents the product of a generic fault current to the square and the time necessary to the protection to extinguish it.

Assuming an overload current of 300A (Iol) and having set t1 at 3s, the following results :

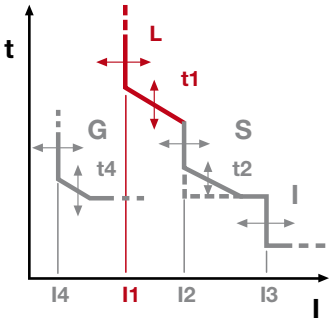
$$(3xI1)^2 \times t1 = Iol^2 \times t \longrightarrow t = \frac{(3x86)^2 \times 3}{(300)^2} = 2.21s$$

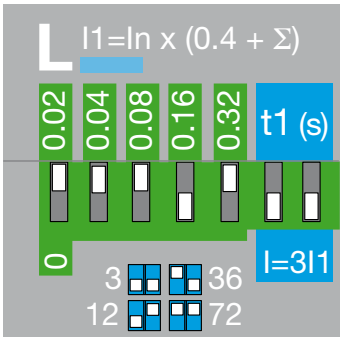
At the same overload level (Iol)=300A, if t1 had been set at 36s, the trip time would have been :

$$(3xI1)^2 \times t1 = Iol^2 \times t \longrightarrow t = \frac{(3x86)^2 \times 36}{(300)^2} = 26.62s$$



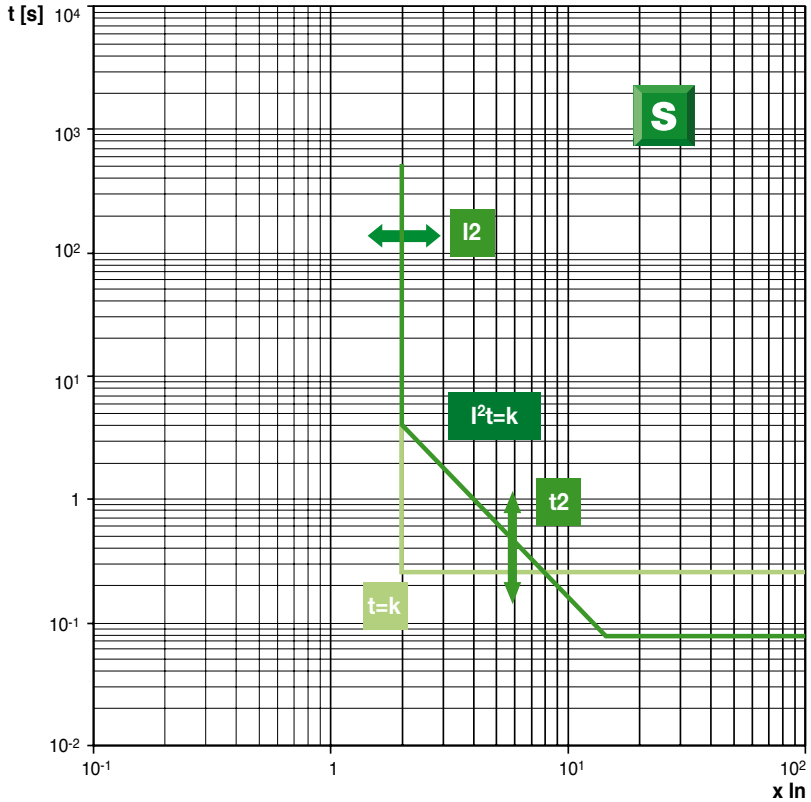
The time t1 shall be chosen keeping into consideration any co-ordination with cables or other devices either on the supply or the load side of the circuit-breaker under consideration.





2 General characteristics

Short-circuit protection with time delay (function S)



This protection function is used to introduce a trip time-delay in case of short-circuit. S function is necessary when time-current discrimination is required so that the tripping is delayed more and more by approaching the supply sources.
The trip curve of this protection (which can be excluded) is defined by a current threshold I2 and by a trip time t2. In details :

- I2 represents the current value beyond which the protection function commands the opening of the circuit-breaker, according to one of the following tripping characteristics:
  - with inverse time delay, where the link time-current is given by the relation $I^2t = k$ (constant let-through energy)
  - with definite time, where the trip time is given by the relation t=k (constant time); in this case the tripping time is equal for any value of current higher than I2;
- t2 represents the trip time of the protection, in seconds, in correspondence with:
  - a well defined multiple of In for the tripping curve at $I^2t = k$;
  - I2 for the tripping curve at t = k.

As regards the availability of the settings with the different trip units, please refer to the technical catalogues.

2 General characteristics

In order to adjust properly the function S of a circuit-breaker equipped with an electronic trip unit it is necessary to divide the Ikmin value (the lowest short-circuit current among all the available ones) by the In value of the trip unit and then to take the setting value immediately lower.

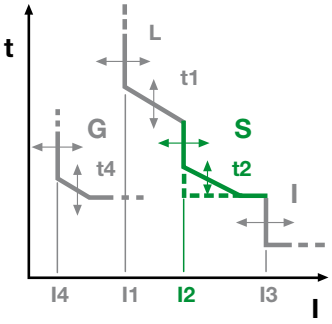
$$\text{Setting}_S = \frac{Ik\,min}{In}$$

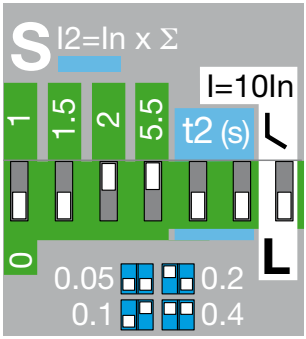
Example :
XT4N 250 with trip unit Ekip LSIG In 250
function S (I2=1-1.5-2-2.5-3-3.5-4.5-5.5-6.5-7-7.5-8-8.5-9-10 x In)
Ikmin=900A

$$\text{Setting}_S = \frac{Ik\,min}{In} = \frac{2000}{250} = 8$$

then, the value 7.5 is to be chosen.
As in the previous example, the figure shows the correct positioning of the dip switches so that the required multiplying factor can be obtained:
I2 = 250 x (2+5.5) = 1875 A < 2000 A

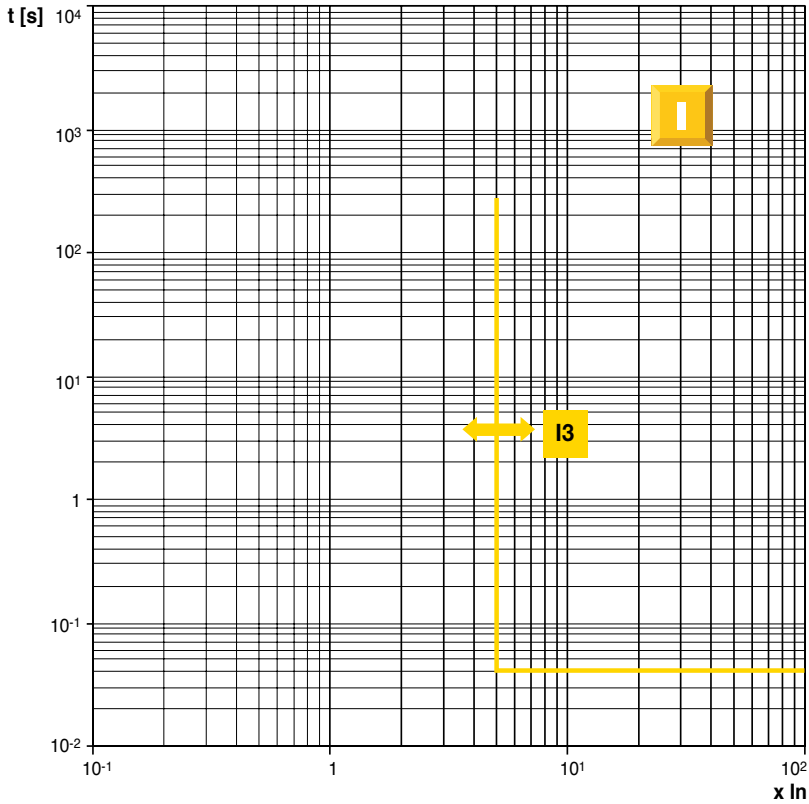
The time delay t2 of function S changes according to the selected characteristic: either t=constant or I^2t=constant.
By selecting t2=const, in case of short-circuit, all the overcurrents higher or equal to I2 (in this case 1875 A) shall be extinguished within the set time t2;
instead, by selecting the characteristic curve with I^2t=const, the same considerations made for the determination of the trip time t1 are valid, taking into account the proper thresholds I2.





2 General characteristics

Short-circuit instantaneous protection (I function)



This function allows to have instantaneous protection in case of short-circuit. This protection is active for fault currents exceeding the set threshold I3; the trip time (instantaneous) cannot be set.
Function I can be excluded; the term “excludible” means that the trip threshold of the current is increased in comparison with the maximum threshold which can be adjusted through standard settings.
In order to set properly the threshold I, it is necessary to know the lowest short-circuit current of those which can occur at the installation point.
The threshold I3 shall comply with the following relation:
$I3 \leq Imin$
$I3 = setting_I \times In$

As regards the availability of the settings with the different trip units, please refer to the technical catalogues.

2 General characteristics

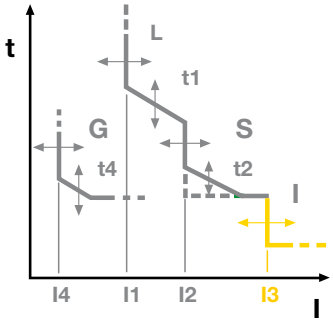
To determine the value to be set, the Ikmin value shall be divided by the In value and the setting value immediately lower shall be taken:

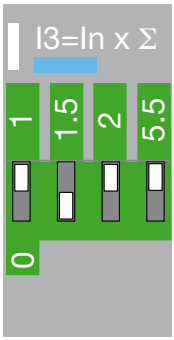
$$\text{Setting}_{I} = \frac{I_{kmin}}{I_n}$$

Example:
XT4N 160 with trip unit Ekip LSIG In100
function I (I3=1-1.5-2-2.5-3-3.5-4.5-5.5-6.5-7-7.5-8-8.5-9-10 x In)
Ikmin=900 A

$$\text{Setting}_{I} = \frac{I_{kmin}}{I_n} = \frac{900}{100} = 9$$

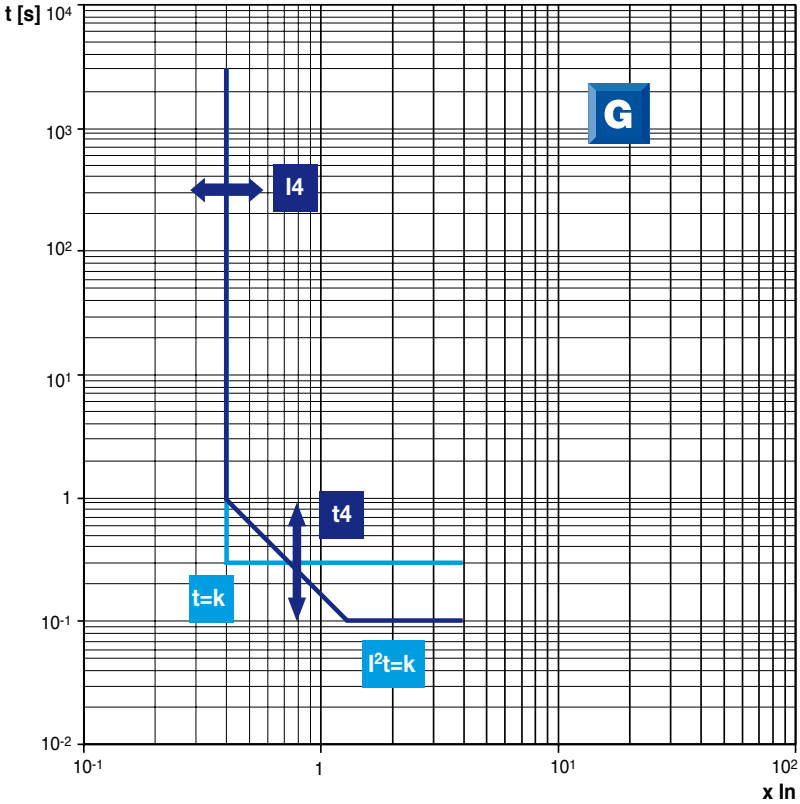
8.5 is to be chosen.
As in the previous example, the figure shows the correct positioning of the dip switches so that the required multiplying factor can be obtained:
I3 = 100 x (1+2+5.5) = 850 A < 900





2 General characteristics

Earth fault protection (function G)



Protection G can assess the vectorial sum of the currents flowing through the live conductors (the three phases and the neutral).
In a sound circuit, this sum is equal to zero, but in the presence of an earth fault, a part of the fault current returns to the source through the protective conductor and/or the earth, without affecting the live conductors. The trip curve of this protection (which can be excluded) is defined by a current threshold I4 and by a trip time t4. More precisely:

- I4 represents the current value beyond which the protection function commands the opening of the circuit-breaker, according to one of the following tripping characteristics:
  - with inverse time delay, where the link time-current is given by the relation $I^2t = k$ (constant let-through energy)
  - with definite time, where the trip time is given by the relation t=k(constant time); in this case the tripping time is equal for any value of current higher than I4;
- t4 represents the trip time of the protection, in seconds, in correspondence with:
  - a well defined multiple of In for the tripping curve at $I^2t = k$;
  - I4 for the tripping curve at t = k.

As regards the availability of the settings with the different trip units, please refer to the technical catalogues.

2 General characteristics

In order to set properly the current I4 and the time t4 of the function G, it is necessary to comply with the requirements reported in the installation Standard (see Chapter 4 of Part 2 - “Protection of human beings”).

Example:
XT4N 250 with trip unit Ekip LSIG In 250
function G (I4=0.2-0.25-0.45-0.55-0.75-0.8-1 x In)
Ik_{PE}=120 A
distribution system: TN-S.
In TN systems, a bolted fault to ground on the LV side usually generates a current with a value analogous to that of a short-circuit and the fault current flowing through the phase and/or the protection conductor (or the conductors) does not affect the earthing system at all.
The relation concerning TN-S distribution systems Zs x Ia ≤ Uo can be expressed as follows:

$$Ia \leq \frac{Uo}{Zs} = Ik_{LPE}$$

where:

- Uo is the voltage phase-to-PE;
- Zs is the fault ring impedance;
- Ia is the trip current within the time delay established by the Standard (see Chapter 4 of Part 2 - “Protection of human beings”).
- Ik_{LPE}= is the fault current phase-to-PE

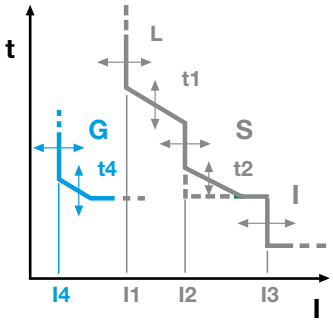
Therefore, it is possible to affirm that the protection against indirect contacts is verified if the trip current Ia is lower than the fault current phase-PE ($Ik|_{PE}$) which is present in correspondence with the exposed conductive part to be protected.
Then:

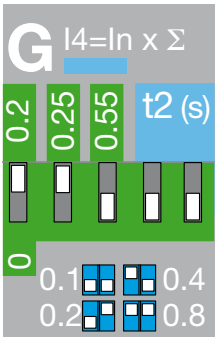
$$\text{Setting } G = \frac{Ik_{PE}}{I_n} = \frac{120}{250} = 0.48$$

the setting 0.45 is selected.

2 General characteristics

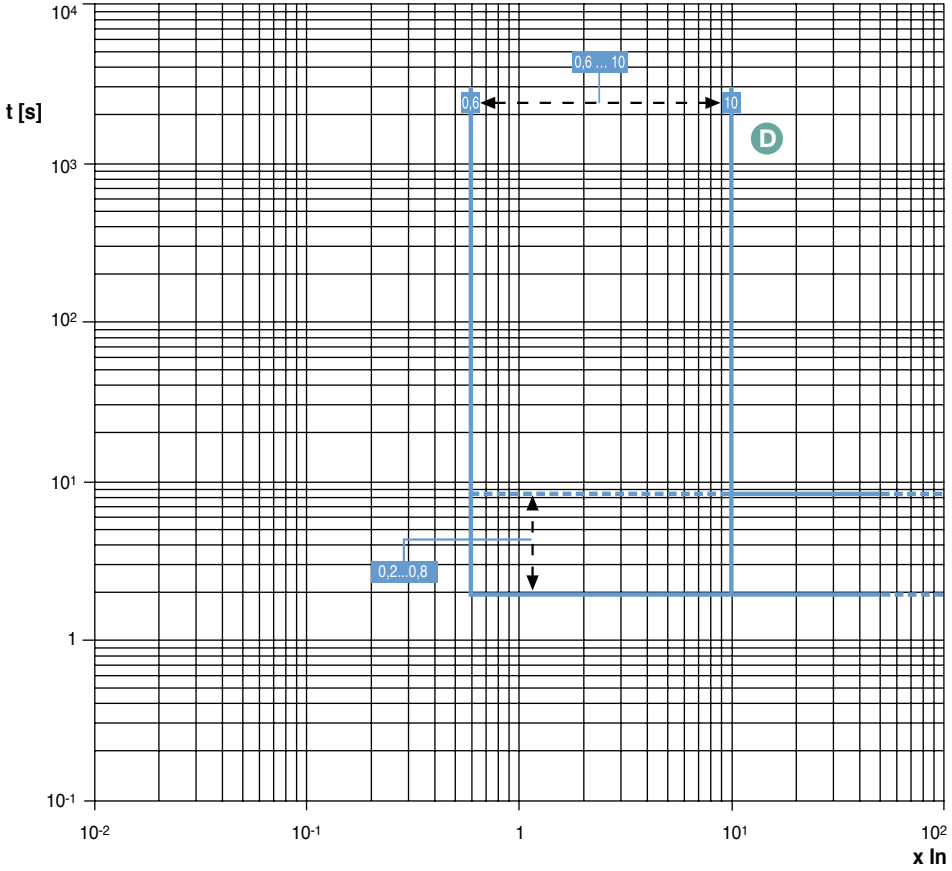
As in the previous example, the figure shows the correct positioning of the dip switches so that the required multiplying factor can be obtained:
I4 = 250 x (0.2+0.25) = 112,5 A < 120 A
The trip time t4 shall be chosen according to the provisions of the installation standards; with the trip unit under consideration, the available curves which define t4 are with I^2t constant; therefore, in order to define the trip time it is necessary to apply the same considerations made for the determination of the trip time t1, but taking into account the proper thresholds I4 and the relevant characteristic curves (t4).
Assuming to use a release with trip time t4=constant, when the set threshold I4 is reached and exceeded, the circuit-breaker shall trip within the set time t4.





2 General characteristics

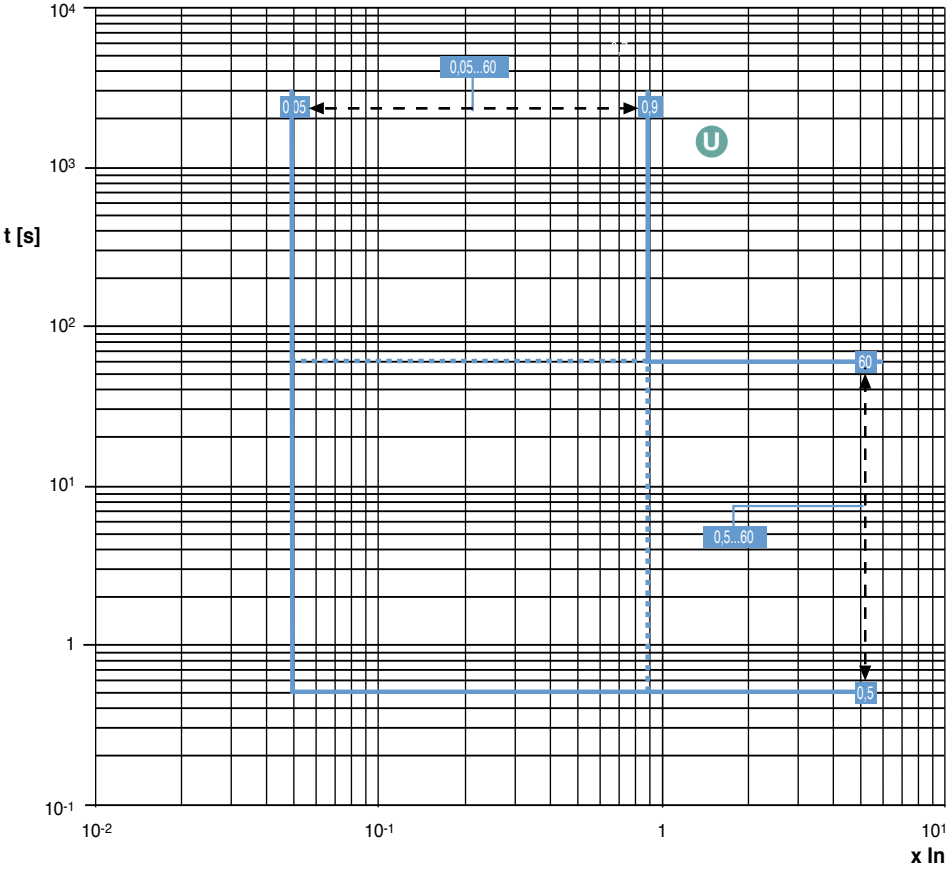
Protection against directional short-circuit with adjustable time-delay (function D)



This protection is very similar to function S with definite time. It allows to identify, besides the intensity, also the direction of the fault current and consequently to understand whether the fault is either on the supply or on the load side of the circuit-breaker, thus excluding only the part of the installation affected by the fault. Its use is particularly suitable in the ring distribution systems and in the installations with more supply lines in parallel.
The adjustable current thresholds are in a range from 0.6 to 10xIn and the trip times can be set within a range from 0.2 to 0.8 seconds.
Function D can be excluded.

2 General characteristics

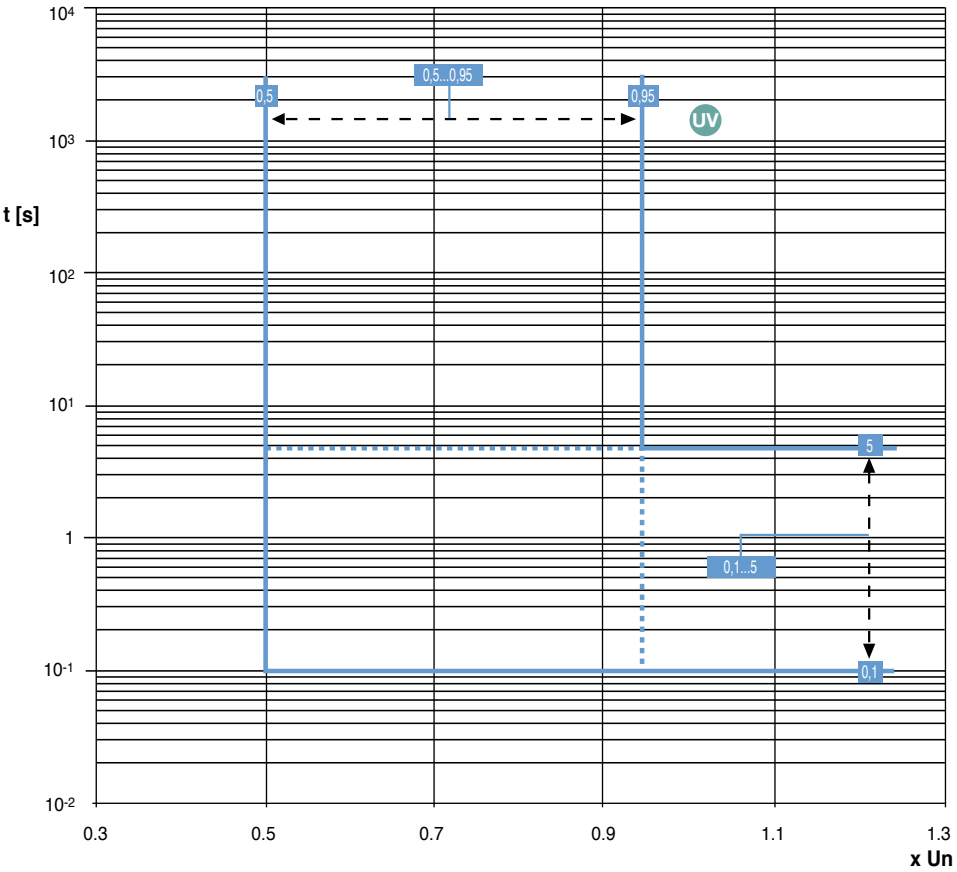
Protection against unbalanced phase (function U)



This protection makes the circuit-breaker open when an unbalanced phase current exceeding the set threshold is detected.
The possible settings are 5% to 90% of the rated current, and the trip times can be set in the range from 0.5 to 60 s.
The protection function U is used above all in the installations with the presence of rotary machines, where an unbalanced phase might cause unwanted effects on the same machines. Function U can be excluded.

2 General characteristics

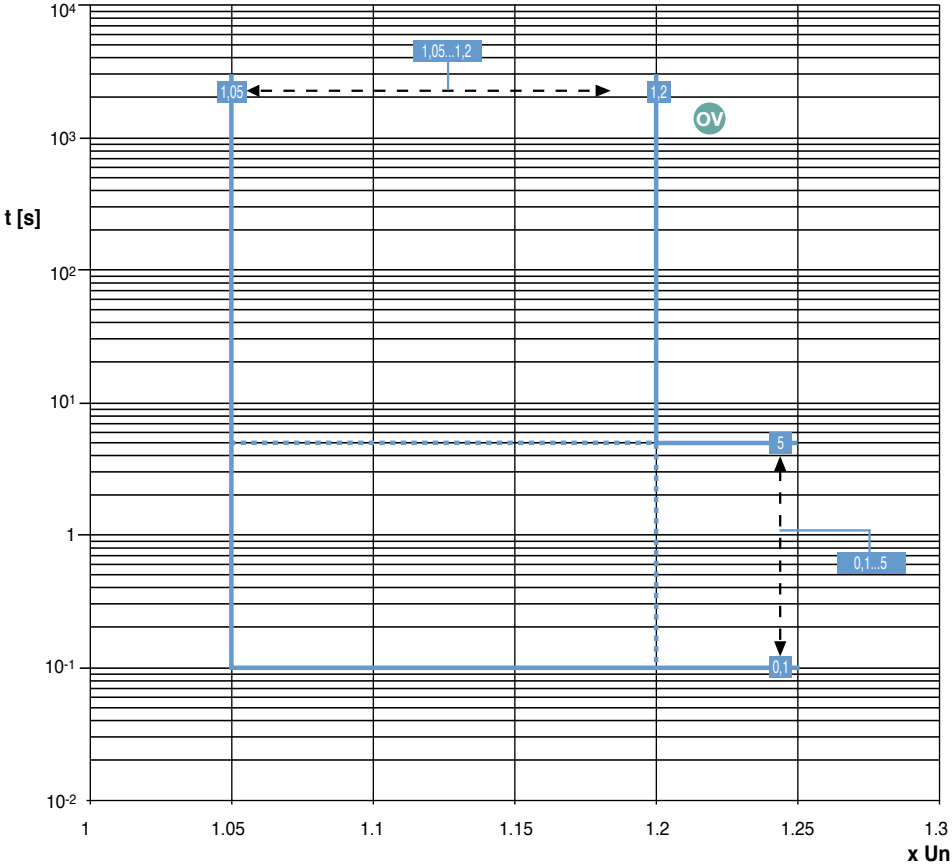
Protection against undervoltage (function UV)



This protection trips after the adjusted time (t8) has elapsed when the phase voltage decreases below the set threshold U8.
The voltage threshold can be set in the range from 0.5 to 0.95xUn and the time threshold from 0.1 to 5 s.
Function UV can be excluded.

2 General characteristics

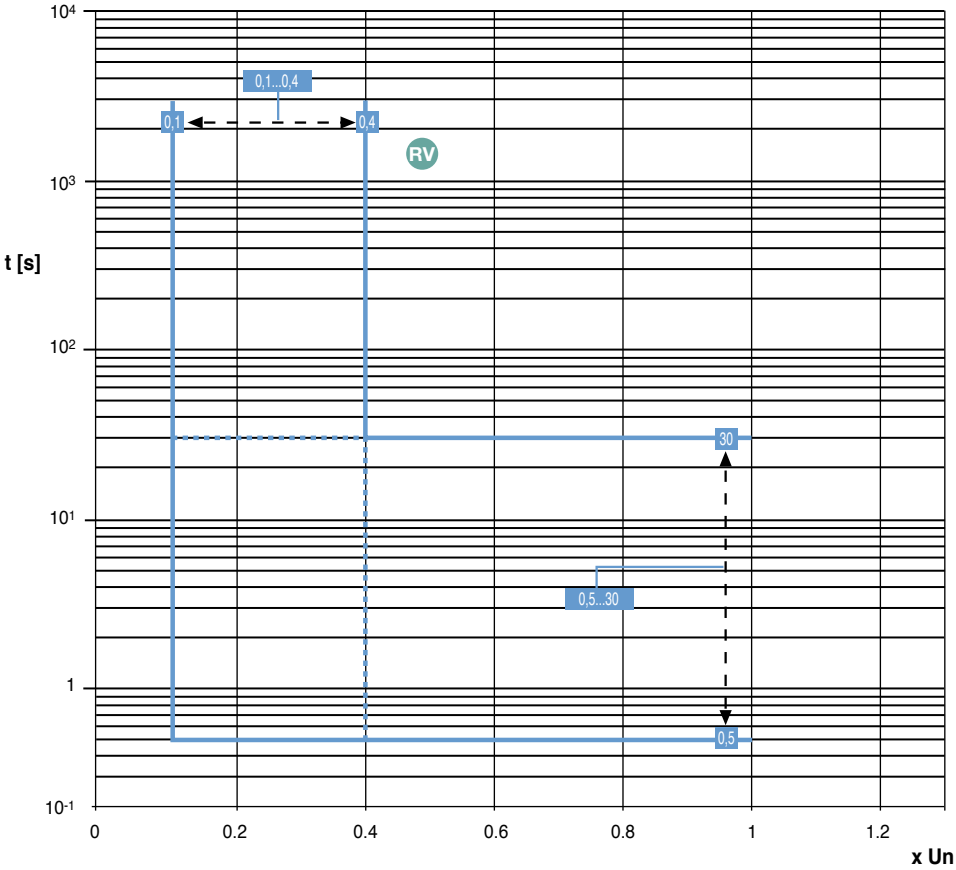
Protection against overvoltage (function OV)



This protection trips after the set time (t9) has elapsed, when the phase voltage exceeds the set threshold U9.
The voltage threshold can be set in the range from 1.05 to 1.2xUn and the time threshold from 0.1 to 5 s.
Function OV can be excluded.

2 General characteristics

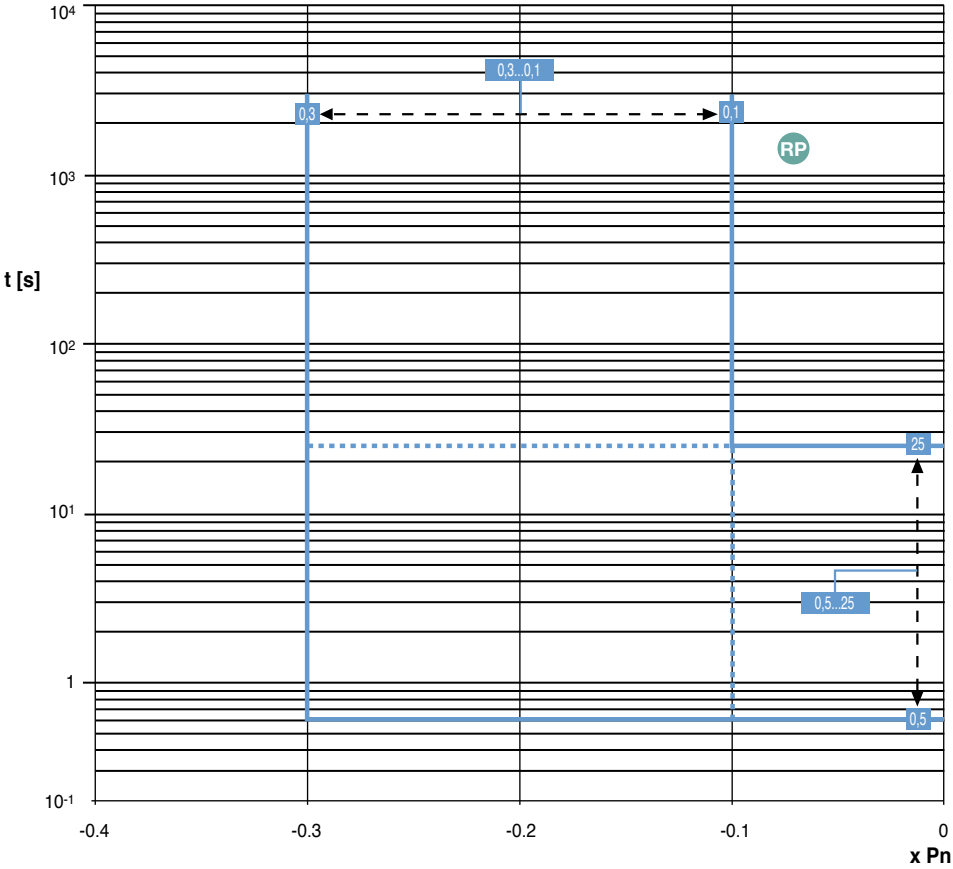
Protection against residual voltage (function RV)



The protection against residual voltage allows to detect the faults which cause the movements of the star centre in case of system with isolated neutral.
This protection trips after the set time when the residual voltage exceeds the threshold U10.
This threshold can be set in a range from 0.1 to 0.4xUn and the time threshold from 0.5s to 30s.
Function RV can be excluded.

2 General characteristics

Protection against reversal of power (function RP)



The protection against reversal of power is particularly suitable for protection of large rotary machines (e.g. motors).
Under certain conditions a motor may generate power instead of absorbing it. When the total reverse active power (sum of the power of the three phases) exceeds the set power threshold P11, the protection function trips after the set time-delay t11 causing the circuit-breaker opening

2 General characteristics

Protection against minimum frequency (function UF)

This protection intervenes by generating an alarm or making the circuit-breaker open after the adjusted time-delay (t9) when the frequency varies below the set threshold f12.
It is used above all for installations supplied by generators and co-generation plants.

Protection against maximum frequency (function OF)

This protection intervenes by generating an alarm or making the circuit-breaker open after the adjusted time-delay (t10) when the frequency exceeds the set threshold f13.
It is used above all for installations supplied by generators and co-generation plants.

Protection against overtemperature (function OT)

This protection allows signaling of the presence of anomalous temperatures which might cause malfunctioning of the electronic components of the trip unit.
If the temperature reaches the first threshold, (70°C), the trip unit shall advise the operator through the lightening up of the “warning” led; should the temperature reach the second threshold (85°C), besides the lightening up of the “warning” and “alarm” leds, the circuit-breaker would be tripped (by enabling the proper parameter).

Overload protection with curves according to IEC60255-3

This protection function against overload finds its application in the co-ordination with MV releases and fuses.
In fact it is possible to obtain a co-ordination among the tripping curves of the circuit-breakers by getting nearer to the slopes of the tripping curves of MV releases or fuses, so that time-current selectivity between LV and MV is obtained. Besides being defined by a current threshold I1 and by a trip time t1, the curves according to Std. IEC 60255 are defined by the parameters “K” and “a” which determine their slope.
The parameters are the following:

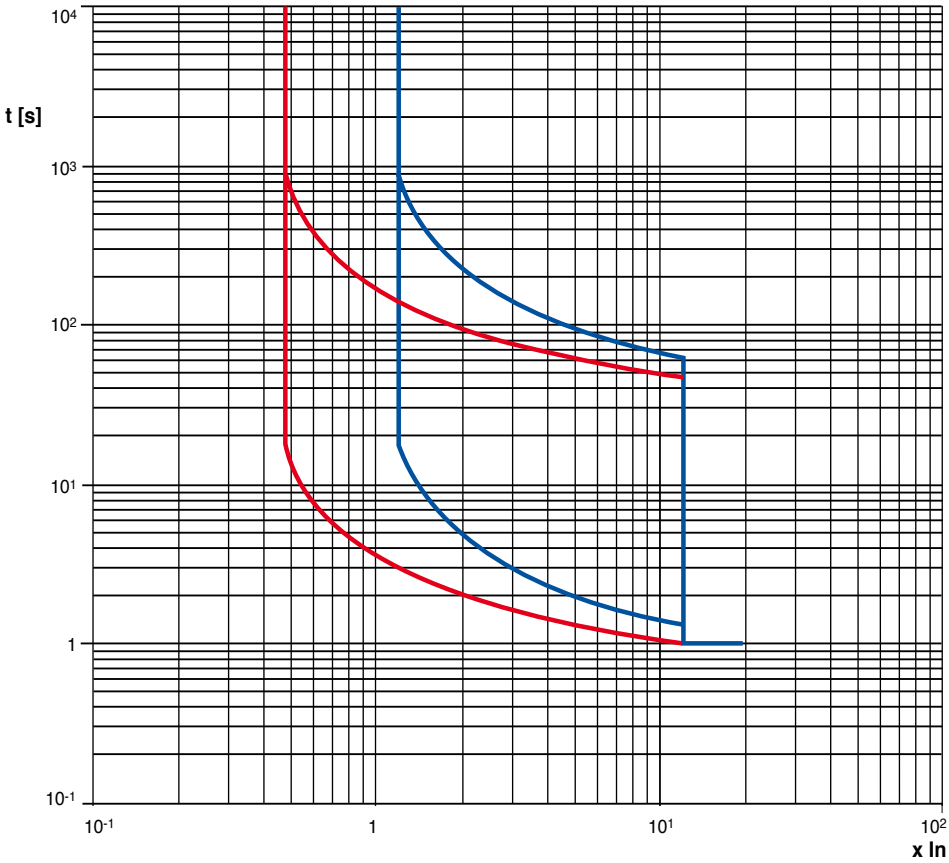
	Curve typology		
Parameters	**A**	**B**	**C**
K	0.14	13.5	80.0
a	0.02	1.0	2.0

The curve L complying with Std. IEC 60255-3 is available both for the electronic trip units type PR332-PR333 for T7 and X1 series circuit-breakers, as well as for the electronic trip units type PR122-PR123 for Emax series circuit-breakers.

2 General characteristics

Curve A

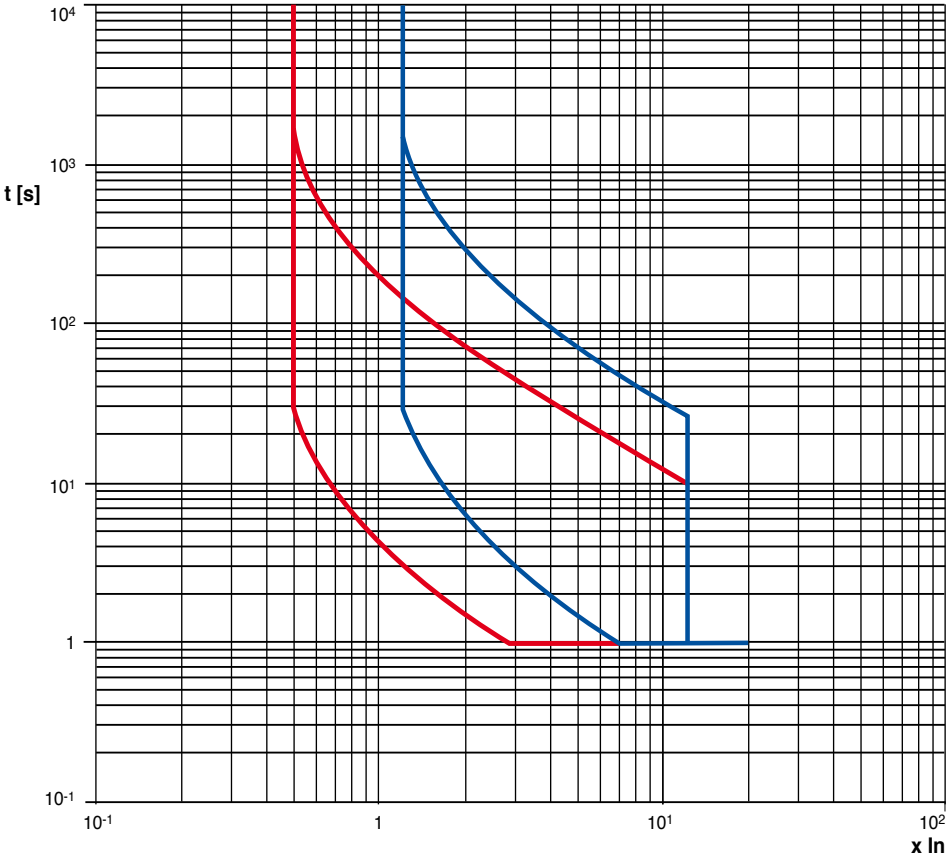
k=0.14 alfa=0.02



2 General characteristics

Curve B

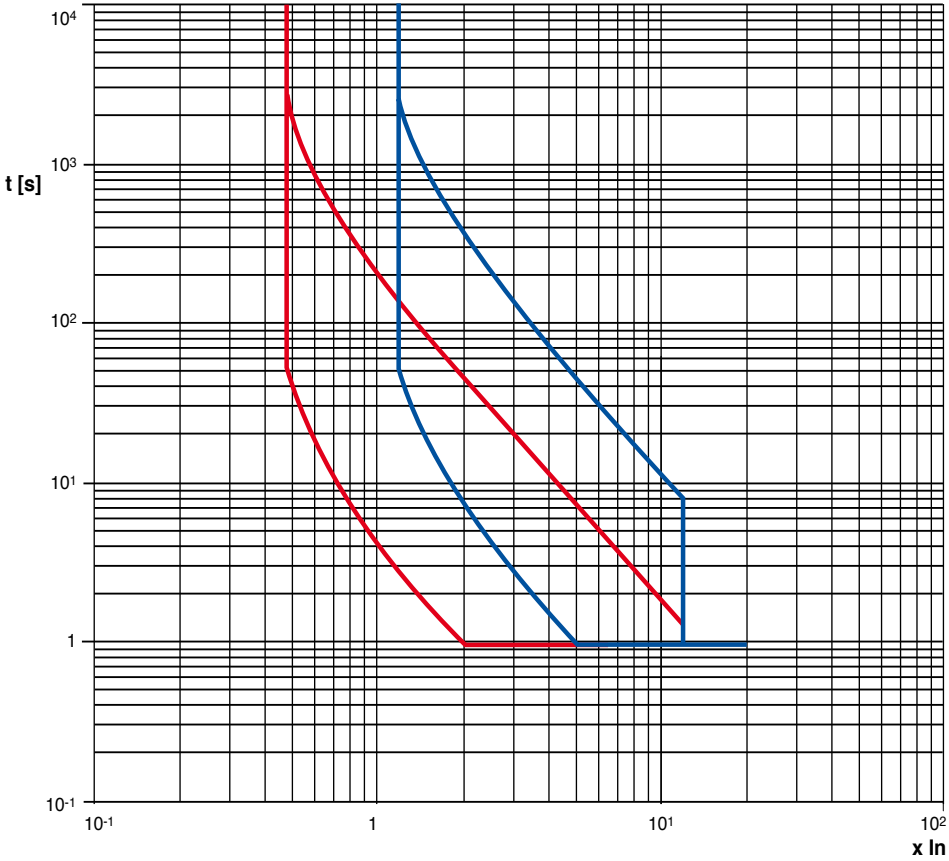
k=13.5 alfa=1



2 General characteristics

Curve C

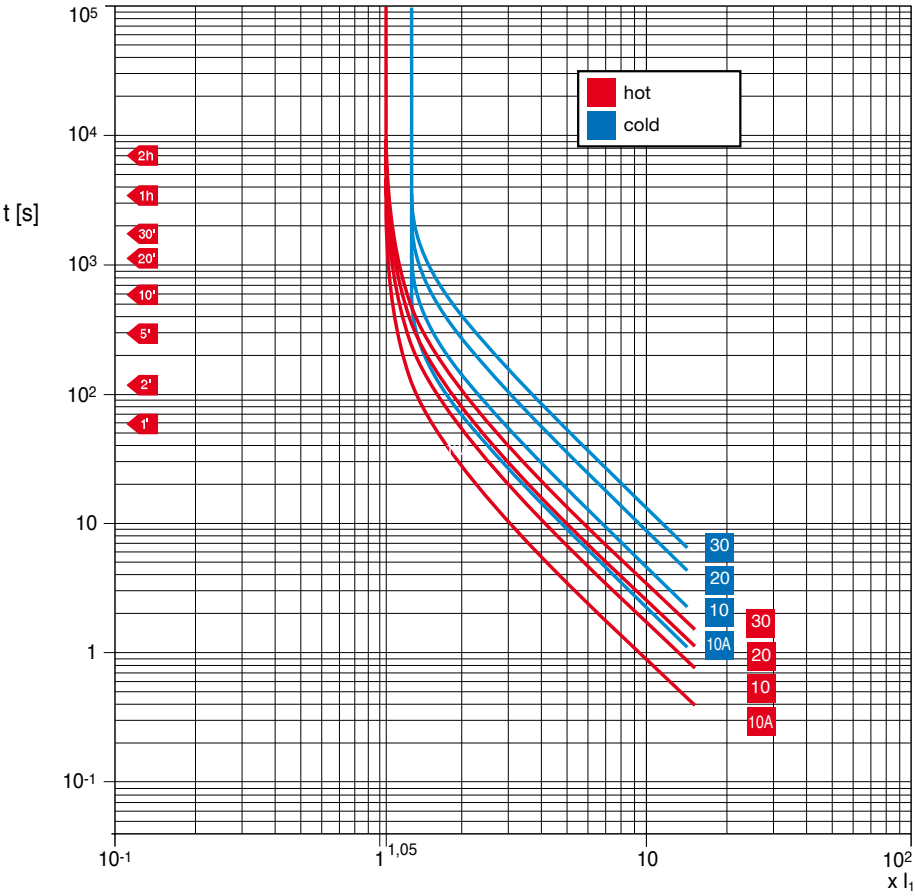
k=80 alfa=2



2 General characteristics

Motor protection

L: motor protection function against overload according to the indications and classes defined by the Std. IEC 60947-4-1

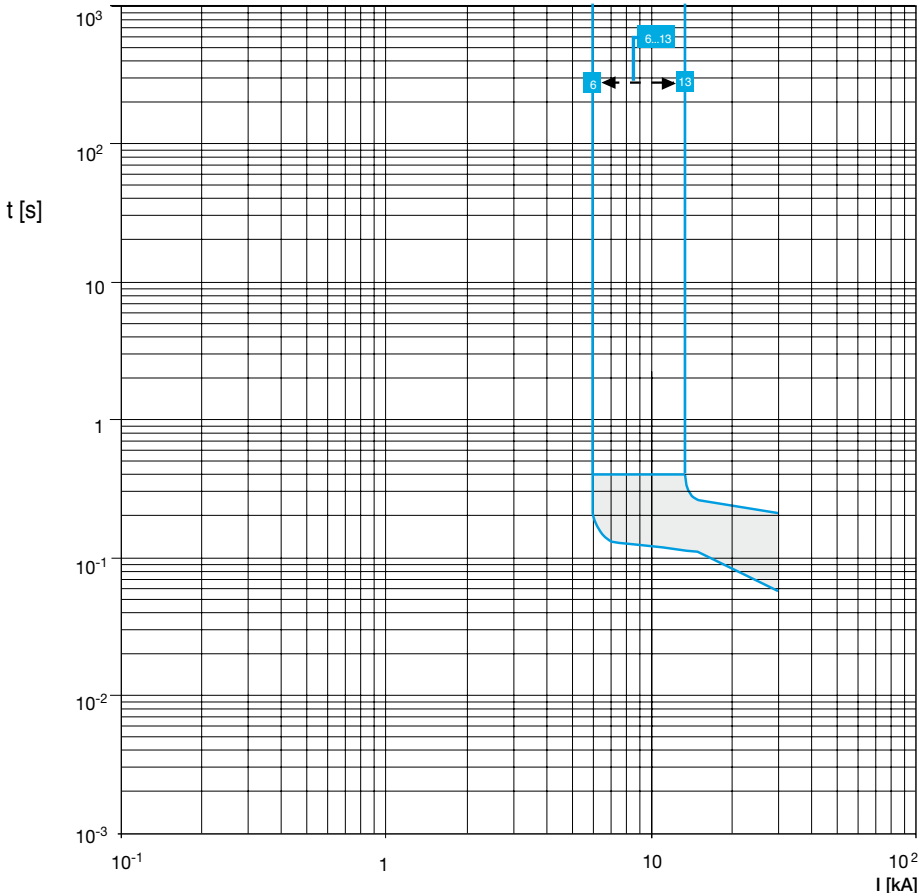


Function L implemented on MP and Ekip M trip units protects the motor against overloads, according to the indications and the classes defined by the Std. IEC 60947-4-1. The protection is based on a pre-defined thermal model, which by simulating the copper and iron overtemperatures inside motors, allows to safeguard properly the motor itself. The trip time-delay is set by selecting the trip class defined in the above mentioned Standard.
The function is temperature-compensated and sensitive to the lack of phase. Function L, which cannot be excluded, can be set manually from a minimum of 0.4 to a maximum of 1x In. Besides, it is necessary to select the starting class of the motor, which determines the trip time with a current equal to 7.2xIe in compliance with the prescriptions of item 4.7.3 of the Std. IEC 60947-4-1 4.7.3. For further details see Chapter 2.3 of Part 2.

2 General characteristics

Motor protection

I: protection against short-circuit with instantaneous trip

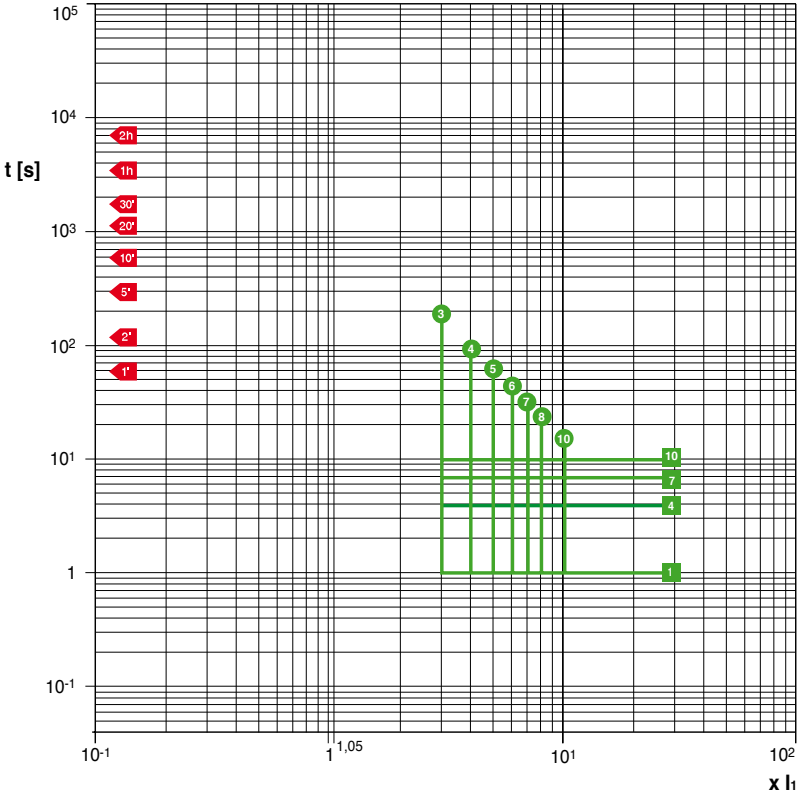


This protection function trips in case of phase-to-phase short-circuit. It is enough that one phase only exceeds the set threshold to cause the instantaneous opening of the circuit-breaker.
The trip current can be set up to 13 times the rated current of the trip unit.

2 General characteristics

Motor protection

R: Protection against rotor block

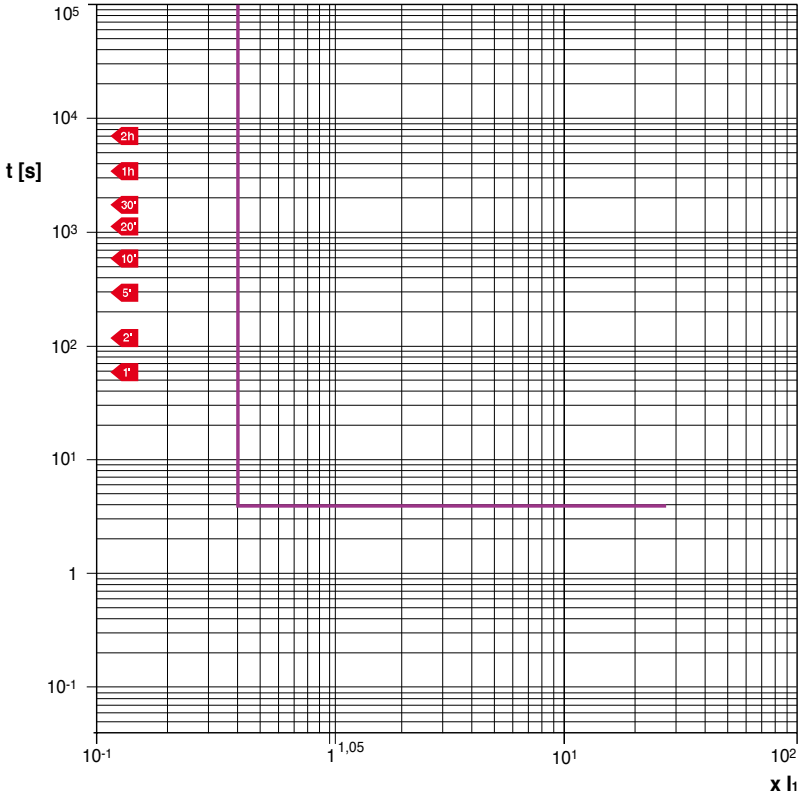


Function R protects the motor against possible rotor block during operation. Protection R has the characteristics of protecting the motor in two different ways, according to whether the fault is present at start-up or whether it occurs during normal service of an already active plant.
In the former case, protection R is linked to protection L for time selection as well: in the presence of a fault during the start-up, protection R is inhibited for a time equal to the time set according to the trip class. Once this time has been exceeded, protection R becomes active causing a trip after the set time t5. In the latter case, protection R is already active and the protection tripping time shall be equal to the set value t5. This protection intervenes when at least one of the phase current exceeds the established value and remains over that threshold for the fixed time t5.

2 General characteristics

Motor protection

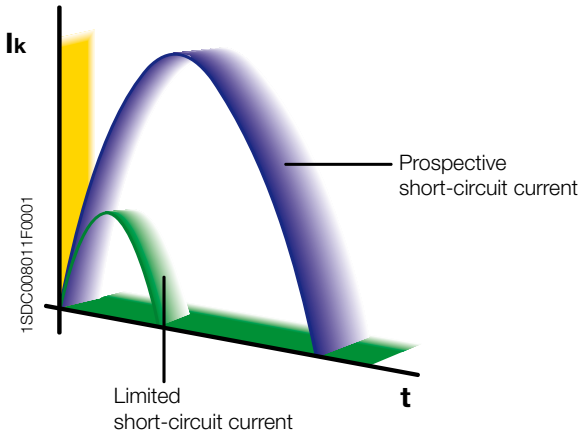
U: Protection against phase unbalance



Function U can be used in those cases where a particularly accurate control is needed as regards phase lack/unbalance. This protection intervenes if the r.m.s. value of one or two currents drop below the level equal to 0.4 times the current I1 set for protection L and remain below it for longer than 4 seconds.
This protection can be excluded.

2.3 Limitation curves

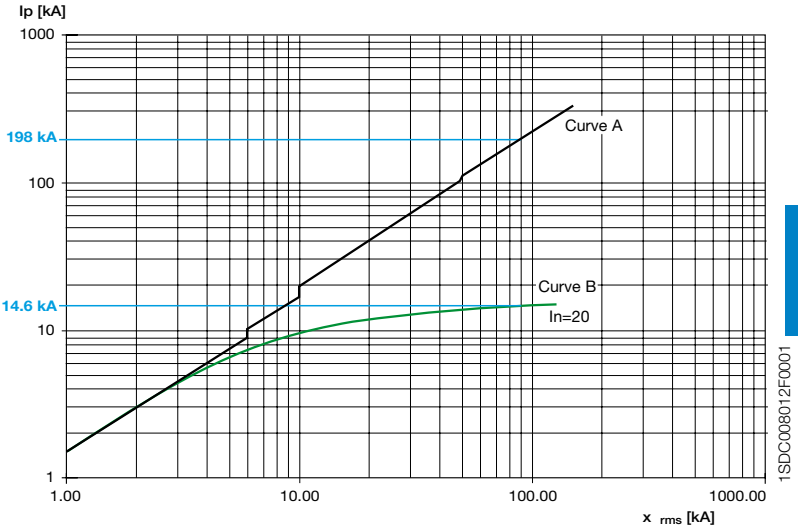
A circuit-breaker in which the opening of the contacts occurs after the passage of the peak of the short-circuit current, or in which the trip occurs with the natural passage to zero, allows the system components to be subjected to high stresses, of both thermal and dynamic type. To reduce these stresses, current-limiting circuit-breakers have been designed (see Chapter 1.2 “Main definitions”), which are able to start the opening operation before the short-circuit current has reached its first peak, and to quickly extinguish the arc between the contacts; the following diagram shows the shape of the waves of both the prospective short-circuit current as well as of the limited short-circuit current.



The following diagram shows the limit curve for Tmax XT2L160, In160 circuit-breaker. The x-axis shows the effective values of the symmetrical prospective short-circuit current, while the y-axis shows the relative peak value. The limiting effect can be evaluated by comparing, at equal values of symmetrical fault current, the peak value corresponding to the prospective short-circuit current (curve A) with the limited peak value (curve B).

2 General characteristics

Circuit-breaker XT2L160 with thermomagnetic release In 20 at 400 V, for a fault current of 90 kA, limits the short-circuit peak to 14.6 kA only, with a remarkable reduction compared with the peak value in the absence of limitation (198 kA).



Considering that the electro-dynamic stresses and the consequent mechanical stresses are closely connected to the current peak, the use of current limiting circuit-breakers allows optimum dimensioning of the components in an electrical plant. Besides, current limitation may also be used to obtain back-up protection between two circuit-breakers in series.

2 General characteristics

In addition to the advantages in terms of design, the use of current-limiting circuit-breakers allows, for the cases detailed by Standard IEC 61439-1, the avoidance of short-circuit withstand verifications for switchboards. Clause 8.2.3.1 of the Standard “Circuits of ASSEMBLIES which are exempted from the verification of the short-circuit withstand strength” states that:

“A verification of the short-circuit withstand strength is not required in the following cases…

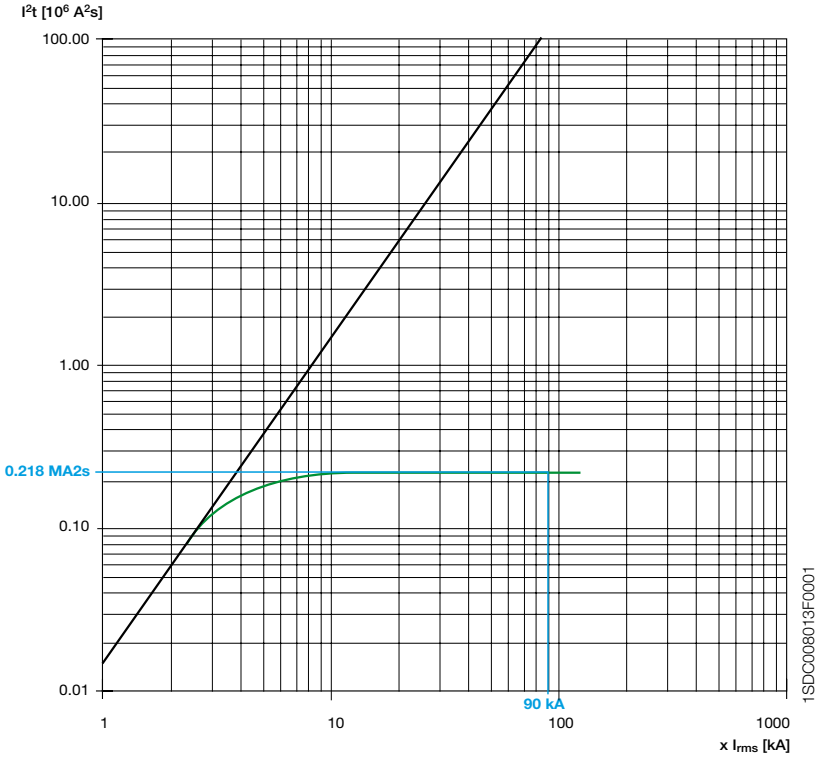
For ASSEMBLIES protected by current-limiting devices having a cut-off current not exceeding 17 kA at the maximum allowable prospective short-circuit current at the terminals of the incoming circuit of the ASSEMBLY...”

The example in the previous page included among those considered by the Standard: if the circuit-breaker was used as a main breaker in a switchboard to be installed in a point of the plant where the prospective short-circuit current is 90 kA, it would not be necessary to carry out the verification of short-circuit withstand.

2.4 Specific let-through energy curves

In case of short-circuit, the parts of a plant affected by a fault are subjected to thermal stresses which are proportional both to the square of the fault current as well as to the time required by the protection device to break the current. The energy let through by the protection device during the trip is termed “specific let-through energy” (I^2t), measured in A^2s. The knowledge of the value of the specific let-through energy in various fault conditions is fundamental for the dimensioning and the protection of the various parts of the installation.
The effect of limitation and the reduced trip times influence the value of the specific let-through energy. For those current values for which the tripping of the circuit-breaker is regulated by the timing of the release, the value of the specific let-through energy is obtained by multiplying the square of the effective fault current by the time required for the protection device to trip; in other cases the value of the specific let-through energy may be obtained from the following diagrams.

The following is an example of the reading from a diagram of the specific let-through energy curve for a circuit-breaker type XT2L 160 In 20 at 400 V.
The x-axis shows the symmetrical prospective short-circuit current, while the y-axis shows the specific let-through energy values, expressed in MA^2s.
Corresponding to a short-circuit current equal to 90 kA, the circuit-breaker lets through a value of I^2t equal to 0.218 MA^2s.



2.5 Temperature derating

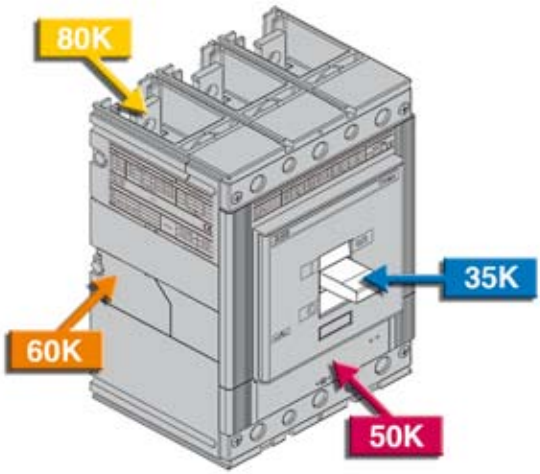
Standard IEC 60947-2 states that the temperature rise limits for circuit-breakers working at rated current must be within the limits given in the following table:

Table 1 - Temperature rise limits for terminals and accessible parts

Description of part*		Temperature rise limits K
- Terminal for external connections		80
- Manual operating means:	metallic	25
	non metallic	35
- Parts intended to be touched but not hand-held:	metallic	40
	non metallic	50
- Parts which need not be touched for normal operation:	metallic	50
	non metallic	60

* No value is specified for parts other than those listed but no damage should be caused to adjacent parts of insulating materials.

These values are valid for a maximum reference ambient temperature of 40°C, as stated in Standard IEC 60947-1, clause 6.1.1.



2 General characteristics

Whenever the ambient temperature is other than 40°C, the value of the current which can be carried continuously by the circuit-breaker is given in the following tables:

SACE Tmax XT circuit-breakers with thermomagnetic release

		30 °C		40 °C		50 °C		60 °C		70 °C	
	In [A]	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
XT1	16	12	17	11,2	16	11	15	10	14	9	13
	20	15	21	14	20	13	19	12	18	11	16
	25	18	26	17,5	25	16	23	15	22	14	20
	32	24	34	22,4	32	21	30	20	28	18	26
	40	29	42	28	40	27	38	25	35	23	33
	50	37	53	35	50	33	47	31	44	28	41
	63	46	66	44,1	63	41	59	39	55	36	51
	80	59	84	56	80	53	75	49	70	46	65
	100	74	105	70	100	66	94	61	88	57	81
	125	92	131	87,5	125	82	117	77	109	71	102
	160	118	168	112	160	105	150	98	140	91	130
XT2	1,6	1,2	1,7	1,1	1,6	1,1	1,5	1	1,4	0,9	1,3
	2	1,5	2,2	1,4	2	1,3	1,9	1,2	1,7	1,1	1,6
	2,5	1,8	2,6	1,8	2,5	1,6	2,3	1,5	2,2	1,4	2
	3	2,5	3,5	2,1	3	2	2,8	1,8	2,6	1,6	2,3
	4	2,9	4,2	2,8	4	2,6	3,7	2,5	3,5	2,2	3,2
	6,3	4,6	6,6	4,4	6,3	4,1	5,9	3,9	5,5	3,6	5,1
	8	5,9	8,4	5,6	8	5,3	7,5	4,9	7	4,6	6,5
	10	7,4	10,5	7	10	6,5	9,3	6,1	8,7	5,7	8,1
	12,5	9,2	13,2	8,8	12,5	8,2	11,7	7,6	10,9	7,1	10,1
	16	11,9	17	11,2	16	10,5	15	9,8	14	9,1	13
	20	14,7	21	14	20	13,3	19	11,9	17	11,2	16
	32	23,8	34	22,4	32	21	30	19,6	28	18,2	26
	40	29,4	42	28	40	25,9	37	24,5	35	22,4	32
	50	37,1	53	35	50	32,9	47	30,1	43	28	40
	63	46,2	66	44,1	63	41,3	59	38,5	55	35,7	51
	80	58,8	84	56	80	52,5	75	49	70	45,5	65
	100	73,5	105	70	100	65,1	93	60,9	87	56,7	81
	125	92,4	132	87,5	125	81,9	117	76,3	109	70,7	101
	160	117,6	168	112	160	105	150	97,3	139	90,3	129

2 General characteristics

		30 °C		40 °C		50 °C		60 °C		70 °C	
	In [A]	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
XT3	63	46	66	44	63	41	59	39	55	36	51
	80	59	84	56	80	53	75	48	69	45	64
	100	74	105	70	100	65	93	61	87	56	80
	125	92	132	88	125	81	116	76	108	70	100
	160	118	168	112	160	104	149	97	139	90	129
	200	148	211	140	200	130	186	121	173	113	161
	250	184	263	175	250	163	233	151	216	141	201
XT4	16	12	17	11	16	10	14	9	13	8	12
	20	16	23	14	20	12	17	11	15	9	13
	25	19	27	18	25	16	23	15	21	13	19
	32	25	36	22	32	19	27	17	24	15	21
	40	30	43	28	40	26	37	24	34	21	30
	50	38	54	35	50	32	46	29	42	27	39
	63	47	67	44	63	41	58	37	53	33	48
	80	60	86	56	80	52	74	46	66	41	58
	100	74	106	70	100	67	95	60	85	53	75
	125	94	134	88	125	81	115	74	105	67	95
	160	118	168	112	160	105	150	96	137	91	130
	200	147	210	140	200	133	190	123	175	112	160
	225	168	241	158	225	146	208	133	190	119	170
	250	183	262	175	250	168	240	161	230	154	220

2 General characteristics

Tmax T circuit-breakers with thermomagnetic release

		10 °C		20 °C		30 °C		40 °C		50 °C		60 °C		70 °C	
	In [A]	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
T1	16	13	18	12	18	12	17	11	16	11	15	10	14	9	13
	20	16	23	15	22	15	21	14	20	13	19	12	18	11	16
	25	20	29	19	28	18	26	18	25	16	23	15	22	14	20
	32	26	37	25	35	24	34	22	32	21	30	20	28	18	26
	40	32	46	31	44	29	42	28	40	26	38	25	35	23	33
	50	40	58	39	55	37	53	35	50	33	47	31	44	28	41
	63	51	72	49	69	46	66	44	63	41	59	39	55	36	51
	80	64	92	62	88	59	84	56	80	53	75	49	70	46	65
	100	81	115	77	110	74	105	70	100	66	94	61	88	57	81
	125	101	144	96	138	92	131	88	125	82	117	77	109	71	102
	160	129	184	123	176	118	168	112	160	105	150	98	140	91	130
T2	1,6	1,3	1,8	1,2	1,8	1,2	1,7	1,1	1,6	1	1,5	1	1,4	0,9	1,3
	2	1,6	2,3	1,5	2,2	1,5	2,1	1,4	2	1,3	1,9	1,2	1,7	1,1	1,6
	2,5	2	2,9	1,9	2,8	1,8	2,6	1,8	2,5	1,6	2,3	1,5	2,2	1,4	2
	3,2	2,6	3,7	2,5	3,5	2,4	3,4	2,2	3,2	2,1	3	1,9	2,8	1,8	2,6
	4	3,2	4,6	3,1	4,4	2,9	4,2	2,8	4	2,6	3,7	2,4	3,5	2,3	3,2
	5	4	5,7	3,9	5,5	3,7	5,3	3,5	5	3,3	4,7	3	4,3	2,8	4
	6,3	5,1	7,2	4,9	6,9	4,6	6,6	4,4	6,3	4,1	5,9	3,8	5,5	3,6	5,1
	8	6,4	9,2	6,2	8,8	5,9	8,4	5,6	8	5,2	7,5	4,9	7	4,5	6,5
	10	8	11,5	7,7	11	7,4	10,5	7	10	6,5	9,3	6,1	8,7	5,6	8,1
	12,5	10,1	14,4	9,6	13,8	9,2	13,2	8,8	12,5	8,2	11,7	7,6	10,9	7,1	10,1
	16	13	18	12	18	12	17	11	16	10	15	10	14	9	13
	20	16	23	15	22	15	21	14	20	13	19	12	17	11	16
	25	20	29	19	28	18	26	18	25	16	23	15	22	14	20
	32	26	37	25	35	24	34	22	32	21	30	19	28	18	26
	40	32	46	31	44	29	42	28	40	26	37	24	35	23	32
	50	40	57	39	55	37	53	35	50	33	47	30	43	28	40
	63	51	72	49	69	46	66	44	63	41	59	38	55	36	51
	80	64	92	62	88	59	84	56	80	52	75	49	70	45	65
	100	80	115	77	110	74	105	70	100	65	93	61	87	56	81
	125	101	144	96	138	92	132	88	125	82	117	76	109	71	101
	160	129	184	123	178	118	168	112	160	105	150	97	139	90	129

2 General characteristics

		10 °C		20 °C		30 °C		40 °C		50 °C		60 °C		70 °C	
	In [A]	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
T3	63	51	72	49	69	46	66	44	63	41	59	38	55	35	51
	80	64	92	62	88	59	84	56	80	52	75	48	69	45	64
	100	80	115	77	110	74	105	70	100	65	93	61	87	56	80
	125	101	144	96	138	92	132	88	125	82	116	76	108	70	100
	160	129	184	123	176	118	168	112	160	104	149	97	139	90	129
	200	161	230	154	220	147	211	140	200	130	186	121	173	112	161
	250	201	287	193	278	184	263	175	250	163	233	152	216	141	201
T4	20	19	27	18	24	16	23	14	20	12	17	10	15	8	13
	32	26	43	24	39	22	36	19	32	16	27	14	24	11	21
	50	37	62	35	58	33	54	30	50	27	46	25	42	22	39
	80	59	98	55	92	52	86	48	80	44	74	40	66	32	58
	100	83	118	80	113	74	106	70	100	66	95	59	85	49	75
	125	103	145	100	140	94	134	88	125	80	115	73	105	63	95
	160	130	185	124	176	118	168	112	160	106	150	100	104	90	130
	200	162	230	155	220	147	210	140	200	133	190	122	175	107	160
	250	200	285	193	275	183	262	175	250	168	240	160	230	150	220
T5	320	260	368	245	350	234	335	224	320	212	305	200	285	182	263
	400	325	465	310	442	295	420	280	400	265	380	250	355	230	325
	500	435	620	405	580	380	540	350	500	315	450	280	400	240	345
T6	630	520	740	493	705	462	660	441	630	405	580	380	540	350	500
	800	685	965	640	905	605	855	560	800	520	740	470	670	420	610

Examples:

Selection of a moulded-case circuit-breaker, with thermomagnetic release, for a load current of 160 A, at an ambient temperature of 60°C. From the table referring to SACE Tmax XT3, it can be seen that the most suitable breaker is the XT3 In 200, which can be set from 121 A to 173 A.