Electrical installation handbook
Volume 1

Protection and control devices

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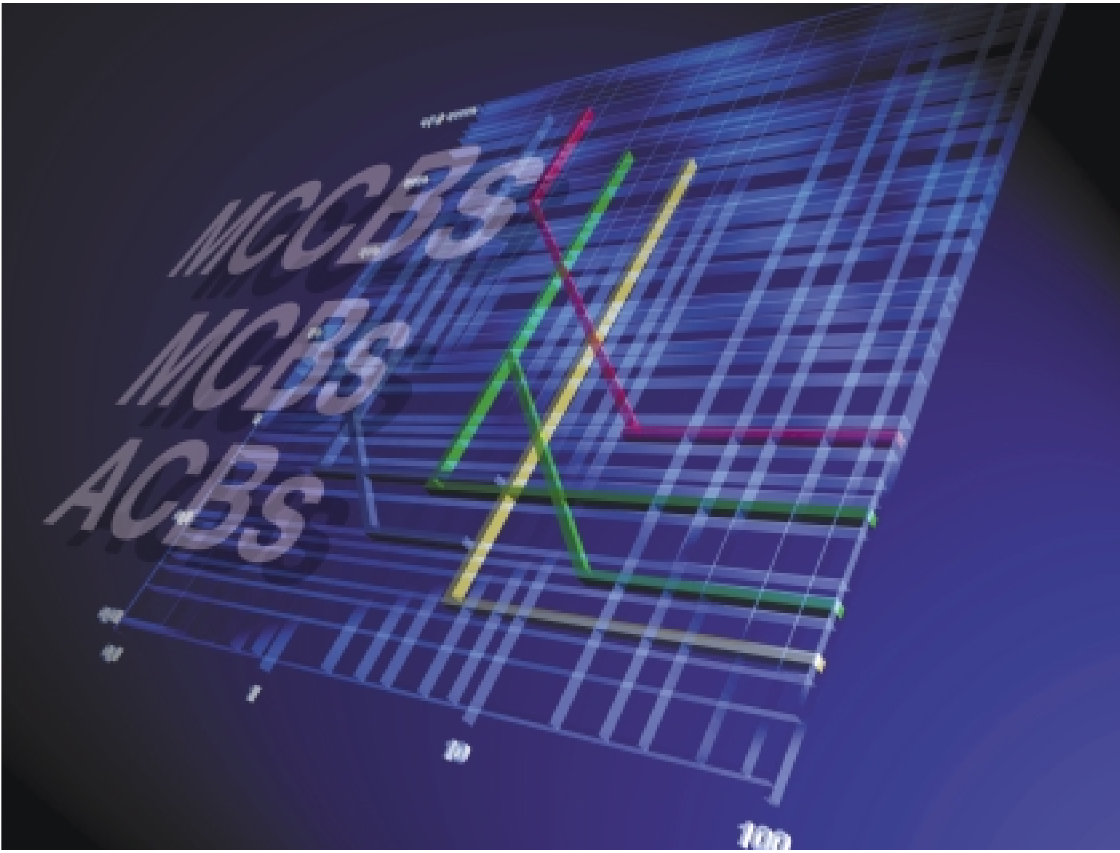

ABB SACE

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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 22 countries (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland, United Kingdom) and cooperates with 13 affiliates (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania, Poland, Romania, Slovenia, Turkey, Ukraine) 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 73/23/CEE – 93/68/CEE

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 89/336/EEC (“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.

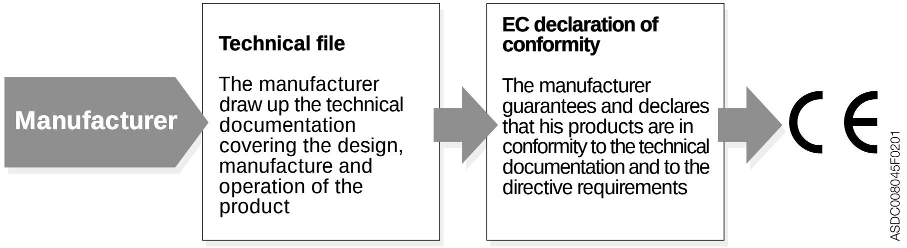
1 Standards

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 73/23/EEC on electrical equipment designed for use within particular voltage range:



Manufacturer

Technical file

The manufacturer draw up the technical documentation covering the design, manufacture and operation of the product

EC declaration of conformity

The manufacturer guarantees and declares that his products are in conformity to the technical documentation and to the directive requirements

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.

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1 Standards

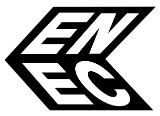
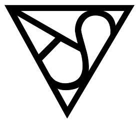
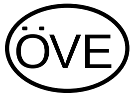
ABB SACE circuit-breakers (Isomax-Tmax-Emax) are approved by the following shipping registers:

• **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

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COUNTRY	Symbol	Mark designation	Applicability/Organization
AUSTRIA		ÖVE Identification Thread	Cables
BELGIUM	CEBEC	CEBEC Mark	Installation materials and electrical appliances
BELGIUM	△ CEBEC	CEBEC Mark	Conduits and ducts, conductors and flexible cords
BELGIUM	CEBEC *	Certification of Conformity	Installation material and electrical appliances (in case there are no equivalent national standards or criteria)
CANADA	CSA ®	CSA Mark	Electrical and non-electrical products. This mark guarantees compliance with CSA (Canadian Standard Association)
CHINA		CCEE Mark	Great Wall Mark Commission for Certification of Electrical Equipment
Czech Republic	E C	EZU' Mark	Electrotechnical Testing Institute
Slovakia Republic	E S	EVPU' Mark	Electrotechnical Research and Design Institute

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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

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COUNTRY	Symbol	Mark designation	Applicability/Organization
GERMANY	VDE	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▷	VDE Cable Mark	For cables, insulated cords, installation conduits and ducts
GERMANY	VDE GS geprüfte Sicherheit	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	MEEI	Hungarian Institute for Testing and Certification of Electrical Equipment
JAPAN	JIS GIAPPONE	JIS Mark	Mark which guarantees compliance with the relevant Japanese Industrial Standard(s).
IRELAND	IIRS IRLANDA	IIRS Mark	Electrical equipment
IRELAND	MARK OF CONFORMITY I.I.R.S.	IIRS Mark	Electrical equipment

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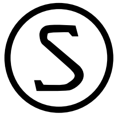
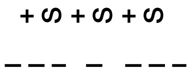
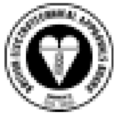
COUNTRY	Symbol	Mark designation	Applicability/Organization
ITALY		IMQ Mark	Mark to be affixed on electrical material for non-skilled users; it certifies compliance with the European Standard(s).
NORWAY	N	Norwegian Approval Mark	Mandatory safety approval for low voltage material and equipment
NETHERLANDS	KEMA KEUR KEMA KEUR KEMA-KEUR	KEMA-KEUR	General for all equipment
POLAND	B	KWE	Electrical products
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)
SPAIN	AENOR N Producto Certificado	AENOR	Asociación Española de Normalización y Certificación. (Spanish Standardization and Certification Association)

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
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
UNITED KINGDOM		BEAB Safety Mark	Compliance with the “British Standards” for household appliances

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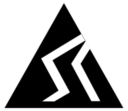
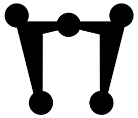
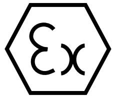
COUNTRY	Symbol	Mark designation	Applicability/Organization
UNITED KINGDOM		BSI Safety Mark	Compliance with the “British Standards”
UNITED KINGDOM		BEAB Kitemark	Compliance with the relevant “British Standards” regarding safety and performances
U.S.A.		UNDERWRITERS LABORATORIES Mark	Electrical and non-electrical products
U.S.A.		UNDERWRITERS LABORATORIES Mark	Electrical and non-electrical products
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		Mark	Cables
CENELEC	⬛🟥🟨	Harmonization Mark	Certification mark providing assurance that the harmonized cable complies with the relevant harmonized CENELEC Standards – identification thread

1 Standards

COUNTRY	Symbol	Mark designation	Applicability/Organization
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.

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1 Standards

1.2 IEC Standards for electrical installation

STANDARD	YEAR	TITLE
IEC 60027-1	1992	Letter symbols to be used in electrical technology - Part 1: General
IEC 60034-1	1999	Rotating electrical machines - Part 1: Rating and performance
IEC 60617-DB-12M	2001	Graphical symbols for diagrams - 12-month subscription to online database comprising parts 2 to 11 of IEC 60617
IEC 61082-1	1991	Preparation of documents used in electrotechnology - Part 1: General requirements
IEC 61082-2	1993	Preparation of documents used in electrotechnology - Part 2: Function-oriented diagrams
IEC 61082-3	1993	Preparation of documents used in electrotechnology - Part 3: Connection diagrams, tables and lists
IEC 61082-4	1996	Preparation of documents used in electrotechnology - Part 4: Location and installation documents
IEC 60038	1983	IEC standard voltages
IEC 60664-1	2000	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 60781	1989	Application guide for calculation of short-circuit currents in low-voltage radial systems
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	2000	Power transformers - Part 5: Ability to withstand short circuit
IEC/TR 60616	1978	Terminal and tapping markings for power transformers
IEC 60726	1982	Dry-type power transformers
IEC 60445	1999	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system

1 Standards

STANDARD	YEAR	TITLE
IEC 60073	1996	Basic and safety principles for man-machine interface, marking and identification – Coding for indication devices and actuators
IEC 60446	1999	Basic and safety principles for man-machine interface, marking and identification - Identification of conductors by colours or numerals
IEC 60447	1993	Man-machine-interface (MMI) - Actuating principles
IEC 60947-1	2001	Low-voltage switchgear and controlgear - Part 1: General rules
IEC 60947-2	2001	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers
IEC 60947-3	2001	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
IEC 60947-4-1	2000	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters
IEC 60947-4-2	2002	Low-voltage switchgear and controlgear - Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters
IEC 60947-4-3	1999	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	2000	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 60947-5-2	1999	Low-voltage switchgear and controlgear - Part 5-2: Control circuit devices and switching elements – Proximity switches
IEC 60947-5-3	1999	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	1996	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	1997	Low-voltage switchgear and controlgear - Part 5-5: Control circuit devices and switching elements - Electrical emergency stop device with mechanical latching function

1 Standards

STANDARD	YEAR	TITLE
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	1998	Low-voltage switchgear and controlgear - Part 6-1: Multiple function equipment – Automatic transfer switching equipment
IEC 60947-6-2	1999	Low-voltage switchgear and controlgear - Part 6-2: Multiple function equipment - Control and protective switching devices (or equipment) (CPS)
IEC 60947-7-1	1999	Low-voltage switchgear and controlgear - Part 7: Ancillary equipment - Section 1: Terminal blocks
IEC 60947-7-2	1995	Low-voltage switchgear and controlgear - Part 7: Ancillary equipment - Section 2: Protective conductor terminal blocks for copper conductors
IEC 60439-1	1999	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies
IEC 60439-2	2000	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	1999	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 60439-5	1999	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 61095	2000	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

STANDARD	YEAR	TITLE
IEC 60890	1987	A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear
IEC 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	1994	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
IEC 60092-302	1997	Electrical installations in ships - Part 302: Low-voltage switchgear and controlgear assemblies
IEC 60092-350	2001	Electrical installations in ships - Part 350: Shipboard power cables - General construction and test requirements
IEC 60092-352	1997	Electrical installations in ships - Part 352: Choice and installation of cables for low-voltage power systems
IEC 60364-5-52	2001	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
	1998	Part 1: General requirements
	1997	Part 2: Test methods
	1997	Part 3: Non-sheathed cables for fixed wiring
	1997	Part 4: Sheathed cables for fixed wiring
	1998	Part 5: Flexible cables (cords)
	2001	Part 6: Lift cables and cables for flexible connections
	1995	Part 7: Flexible cables screened and unscreened with two or more conductors
IEC 60228	1978	Conductors of insulated cables
IEC 60245		Rubber insulated cables - Rated voltages up to and including 450/750 V
	1998	Part 1: General requirements
	1998	Part 2: Test methods
	1994	Part 3: Heat resistant silicone insulated cables

STANDARD	YEAR	TITLE
	1994	Part 5: Lift cables
	1994	Part 6: Arc welding electrode cables
	1994	Part 7: Heat resistant ethylene-vinyl acetate rubber insulated cables
	1998	Part 8: Cords for applications requiring high flexibility
IEC 60309-2	1999	Plugs, socket-outlets and couplers for industrial purposes - Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
IEC 61008-1	1996	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
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	1996	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	1989	General requirements for enclosures for accessories for household and similar fixed electrical installations
IEC 60669-2-1	2000	Switches for household and similar fixed electrical installations - Part 2-1: Particular requirements – Electronic switches
IEC 60669-2-2	2000	Switches for household and similar fixed electrical installations - Part 2: Particular requirements – Section 2: Remote-control switches (RCS)
IEC 606692-3	1997	Switches for household and similar fixed electrical installations - Part 2-3: Particular requirements – Time-delay switches (TDS)

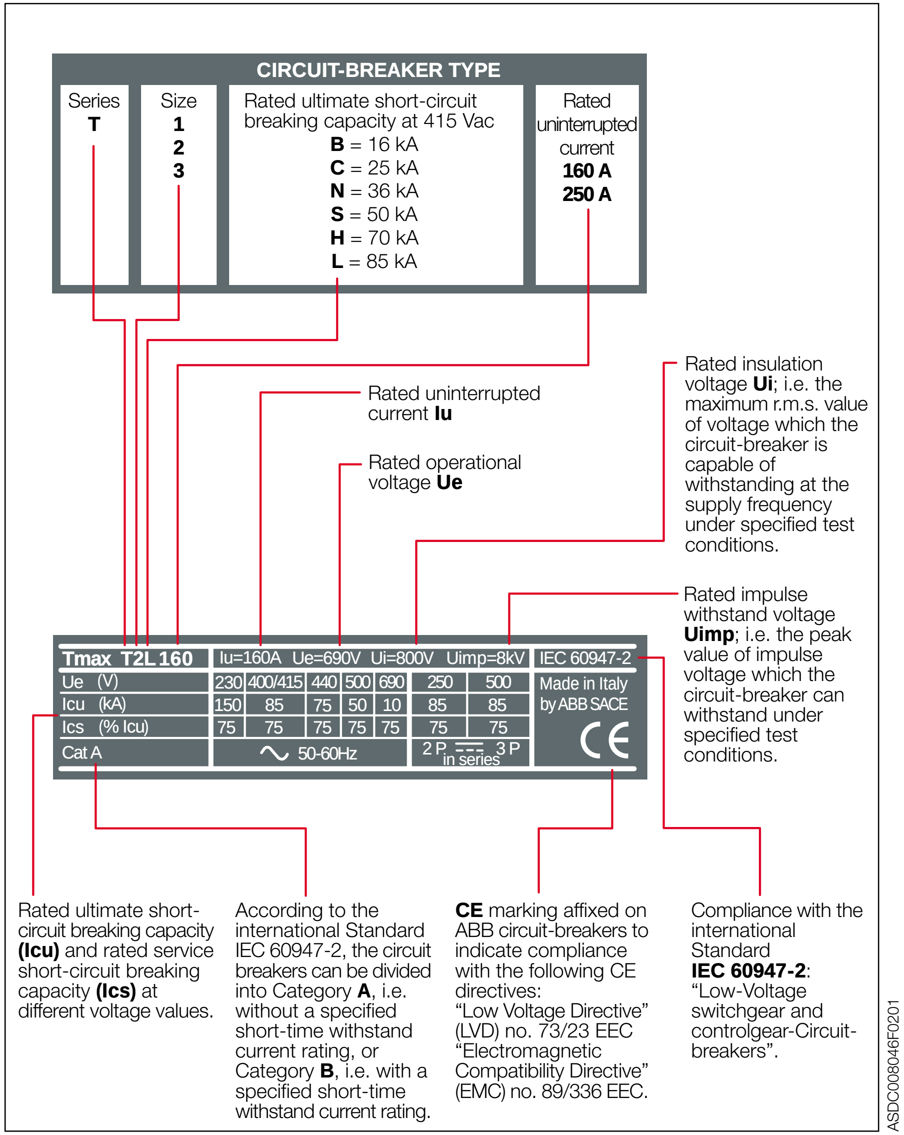
STANDARD	YEAR	TITLE
IEC 60079-10	1995	Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas
IEC 60079-14	1996	Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)
IEC 60079-17	1996	Electrical apparatus for explosive gas atmospheres - Part 17: Inspection and maintenance of electrical installations in hazardous areas (other than mines)
IEC 60269-1	1998	Low-voltage fuses - Part 1: General requirements
IEC 60269-2	1986	Low-voltage fuses. Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application)
IEC 60269-3-1	2000	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
IEC 60127-1/10		Miniature fuses -
	1999	Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links
	1989	Part 2: Cartridge fuse-links
	1988	Part 3: Sub-miniature fuse-links
	1996	Part 4: Universal Modular Fuse-Links (UMF)
	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
IEC 60730-2-7	1990	Automatic electrical controls for household and similar use. Part 2: Particular requirements for timers and time switches
IEC 60364-1	2001	Electrical installations of buildings - Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364-4	2001	Electrical installations of buildings - Part 4: Protection for safety
IEC 60364-5	2001…2002	Electrical installations of buildings - Part 5: Selection and erection of electrical equipment
IEC 60364-6	2001	Electrical installations of buildings - Part 6: Verification
IEC 60364-7	1983…2002	Electrical installations of buildings. Part 7: Requirements for special installations or locations
IEC 60529	2001	Degrees of protection provided by enclosures (IP Code)

STANDARD	YEAR	TITLE
IEC 61032	1997	Protection of persons and equipment by enclosures - Probes for verification
IEC 61000-1-1	1992	Electromagnetic compatibility (EMC) - Part 1: General - Section 1: Application and interpretation of fundamental definitions and terms
IEC 61000-1-2	2001	Electromagnetic compatibility (EMC) - Part 1-2: General - Methodology for the achievement of the functional safety of electrical and electronic equipment with regard to electromagnetic phenomena
IEC 61000-1-3	2002	Electromagnetic compatibility (EMC) - Part 1-3: General - The effects of high-altitude EMP (HEMP) on civil equipment and systems

2 Protection and control devices

2.1 Circuit-breaker nameplates

Moulded-case circuit-breaker: Tmax



Rated uninterrupted current **Iu**

Rated operational voltage **Ue**

Rated insulation voltage **Ui**; i.e. the maximum r.m.s. value of voltage which the circuit-breaker is capable of withstanding at the supply frequency under specified test conditions.

Rated impulse withstand voltage **Uimp**; i.e. the peak value of impulse voltage which the circuit-breaker can withstand under specified test conditions.

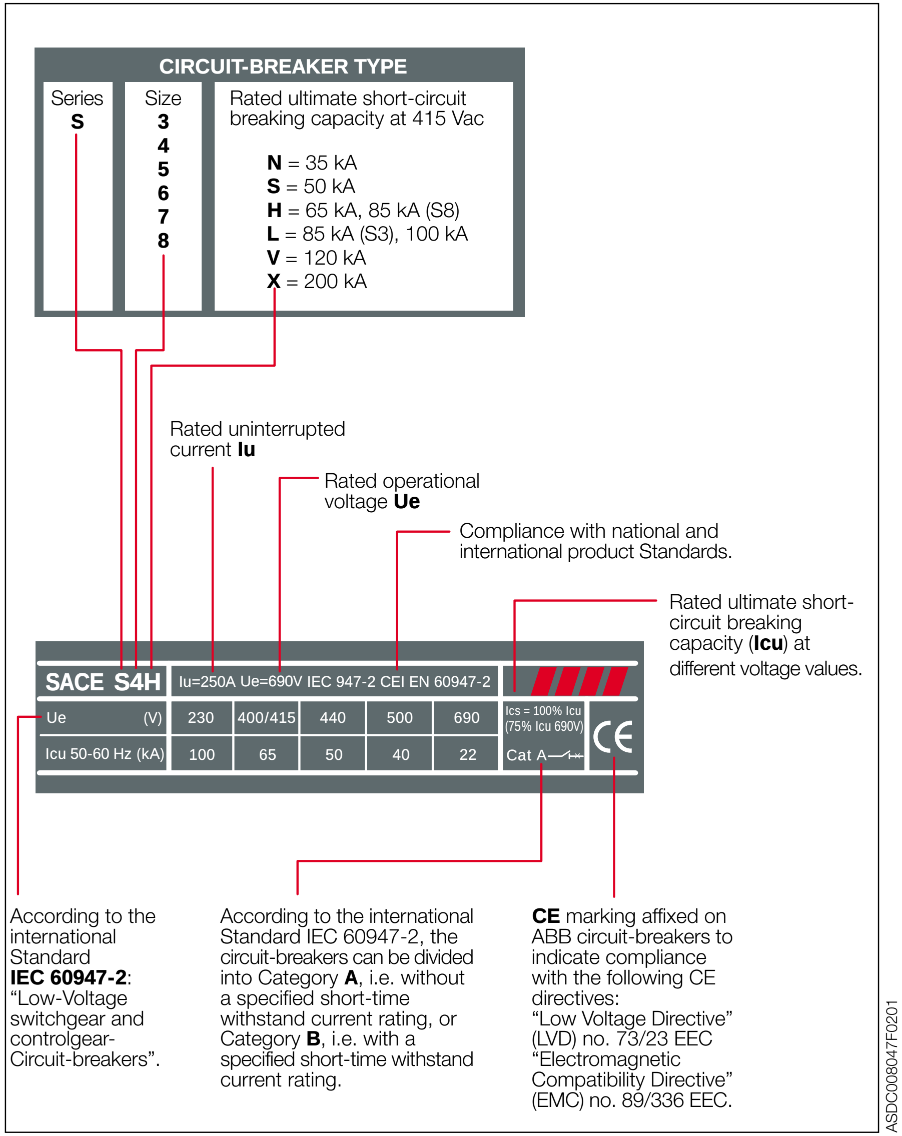
Rated ultimate short-circuit breaking capacity **(Icu)** and rated service short-circuit breaking capacity **(Ics)** at different voltage values.

According to the international Standard IEC 60947-2, the circuit breakers can be divided into Category **A**, i.e. without a specified short-time withstand current rating, or Category **B**, i.e. with a specified short-time withstand current rating.

CE marking affixed on ABB circuit-breakers to indicate compliance with the following CE directives:
“Low Voltage Directive” (LVD) no. 73/23 EEC
“Electromagnetic Compatibility Directive” (EMC) no. 89/336 EEC.

Compliance with the international Standard **IEC 60947-2**: “Low-Voltage switchgear and controlgear-Circuit-breakers”.

Moulded-case circuit-breaker: Isomax



Rated uninterrupted current **Iu**

Rated operational voltage **Ue**

Compliance with national and international product Standards.

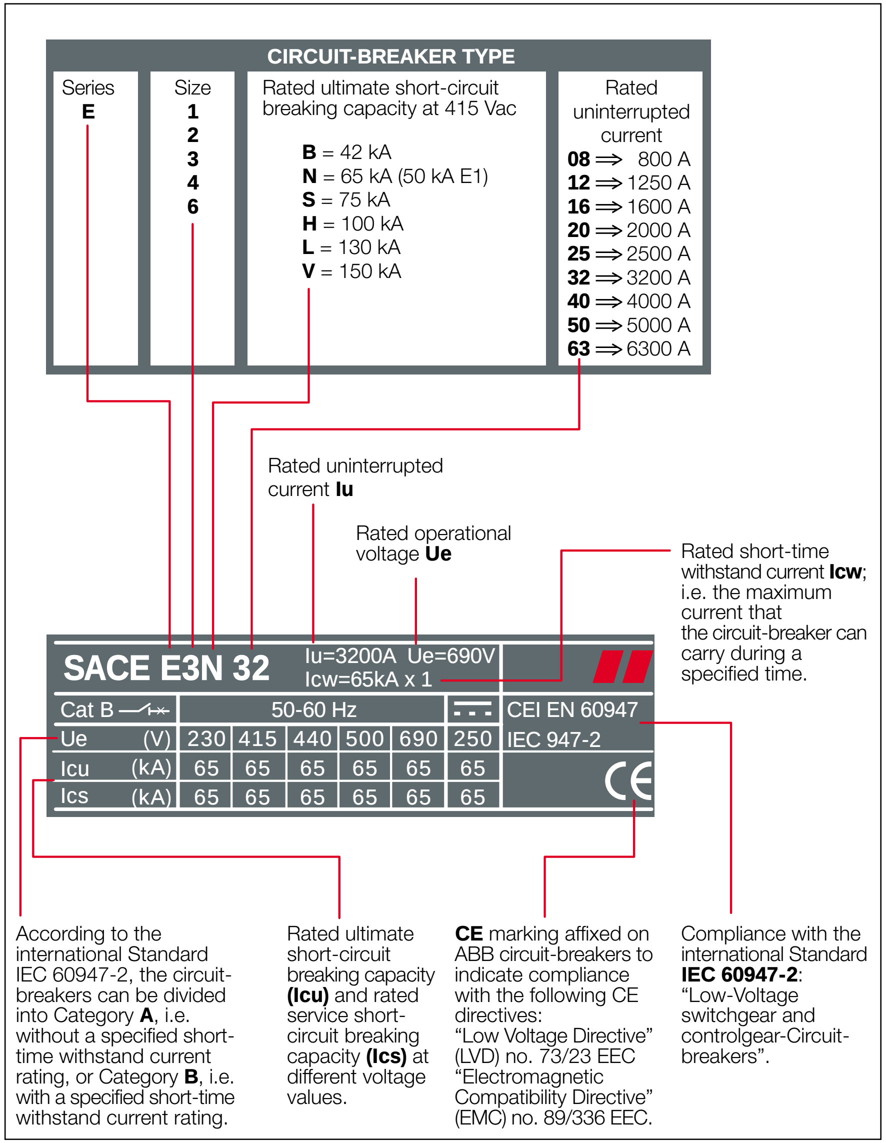
Rated ultimate short-circuit breaking capacity (**Icu**) at different voltage values.

According to the international Standard **IEC 60947-2**: “Low-Voltage switchgear and controlgear-Circuit-breakers”.

According to the international Standard IEC 60947-2, the circuit-breakers can be divided into Category **A**, i.e. without a specified short-time withstand current rating, or Category **B**, i.e. with a specified short-time withstand current rating.

CE marking affixed on ABB circuit-breakers to indicate compliance with the following CE directives:
“Low Voltage Directive” (LVD) no. 73/23 EEC
“Electromagnetic Compatibility Directive” (EMC) no. 89/336 EEC.

Air circuit-breaker: Emax



Rated short-time withstand current **Icw**; i.e. the maximum current that the circuit-breaker can carry during a specified time.

According to the international Standard IEC 60947-2, the circuit-breakers can be divided into Category **A**, i.e. without a specified short-time withstand current rating, or Category **B**, i.e. with a specified short-time withstand current rating.

Rated ultimate short-circuit breaking capacity **(Icu)** and rated service short-circuit breaking capacity **(Ics)** at different voltage values.

CE marking affixed on ABB circuit-breakers to indicate compliance with the following CE directives: "Low Voltage Directive" (LVD) no. 73/23 EEC "Electromagnetic Compatibility Directive" (EMC) no. 89/336 EEC.

Compliance with the international Standard **IEC 60947-2**: "Low-Voltage switchgear and controlgear-Circuit-breakers".

2.2 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.

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_u)

The rated uninterrupted current of an equipment is a value of current, stated by the manufacturer, which the equipment can carry in uninterrupted duty.

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

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.

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 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. 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

2.3 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.

2.3.1 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 available rated currents and the relevant magnetic settings.

Circuit-Breaker			R1	R1,6	R2	R2,5	R3	R3,2	R4	R5	R6,3	R8	R10	R11	R12,5	R16	R20	R25	R32	R40	R50	R52	R63	R80	R100	R125	R160	R200	R250	R320	R400	R500	R630	R800
	Magnetic type	Thermal [A]	0,7÷1	1,1÷1,6	1,4÷2	1,8÷2,5	MO	2,2÷3,2	2,8÷4	3,5÷5	4,4÷6,3	5,6÷8	7÷10	MO	8,8÷12,5	11÷16	14÷20	18÷25	22÷32	28÷40	35÷50	MO	44÷63	56÷80	70÷100	88÷125	112÷160	140÷200	175÷250	224÷320	280÷400	350÷500	441÷630	560÷800
T1	10 x I_n	**I3 [A]**														500	500	500	500	500	500		630	800	1000	1250	1600							
T2	10 x I_n		10	16	20	25		32	40	50	63	80	100		500	500	500	500	500	500	500		630	800	1000	1250	1600							
	(6÷12) x I_n MO*					15÷30				33÷60				67÷132			120÷240		192÷384			314÷624		480÷960	600÷1200									
T3	10 x I_n																						630	800	1000	1250	1600	2000	2500					
	(6÷12) x I_n MO*																								600÷1200	750÷1500	960÷1920	1200÷2400						
S3	3 x I_n																								300	375	480	600	750					
	5 x I_n																		300		300			400	500	630	800	1000	1250					
	10 x I_n																		500		500			800	1000	1250	1600	2000	2500					
	5 x I_n MO*																				300			400	500	630	800	1000	1250					
	10 x I_n MO*																				500			800	1000	1250	1600	2000	2500					
	(4÷12) x I_n MO*						12÷36			20÷60			40÷120					100÷300			200÷600				400÷1200	500÷1500	640÷1920	800÷2400						
S5	2,5 x I_n																													800	700	1250		
	(5÷10) x I_n																													1600÷3200	2000÷4000	2500÷5000		
S6	2,5 x I_n																																1580	2000
	(5÷10) x I_n																																3150÷6300	4000÷8000

*Note: MO Magnetic only

2 Protection and control devices

For example, a circuit-breaker type T2, with rated current In equal to 2.5 A, is available in two versions:

- thermomagnetic with adjustable thermal current I_1 from 1.8 up to 2.5 A and fixed magnetic current I_3 equal to 25 A;
- magnetic only (MO) with adjustable magnetic current I_3 from 15 to 30 A.

2.3.2 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%.

2 Protection and control devices

Besides the standard protection functions, releases provide:

- measurements of the main characteristics of the plant: voltage, frequency, power, energy and harmonics (PR112-PR113);
- serial communication with remote control for a complete management of the plant (PR212-PR112-PR113, equipped with dialogue unit).

CURRENT TRANSFORMER SIZE

Circuit-Breaker	Rated Current (Iu)	R10	R25	R63	R100	R160	R200	R250	R320	R400	R630	R800	R1000	R1250	R1600	R2000	R2500	R3200
T2	160	■	■	■	■	■												
S4	160				■	■												
	250						■	■										
S5	400								■	■								
	630										■							
S6	630								■	■	■							
	800											■						
S7	1250												■	■				
	1600														■			
S8	2000														■	■		
	2500																■	
	3200																	■

		R10	R25	R63	R100	R160	R200	R250	R320	R400	R630	R800	R1000	R1250	R1600	R2000	R2500	R3200
L Function	PR221	4÷10	10÷25	25.2÷63	40÷100	64÷160												
	PR211/PR212				40÷100	64÷160		100÷250	128÷320	160÷400	252÷630	320÷800	400÷1000	500÷1250	640÷1600	800÷2000	1000÷2500	1280÷3200
	PR212MP				40÷100	64÷160	80÷200		128÷320	160÷400	252÷630		400÷1000					
S Function	PR221 (1)	10÷100	25÷250	63÷630	100÷1000	160÷1600												
	PR211/PR212				100÷1000	160÷1600		250÷2500	320÷3200	400÷4000	630÷6300	800÷8000	1000÷10000	1250÷12500	1600÷16000	2000÷20000	2500÷25000	3200÷32000
I Function	PR221 (1)	10÷100	25÷250	63÷630	100÷1000	160÷1600												
	PR211/PR212				150÷1200	240÷1920		375÷3000	480÷3840	600÷4800	945÷7560	1200÷9600	1500÷12000	1875÷15000	2400÷19200	3000÷24000	3750÷30000	4800÷38400
	PR212MP				600÷1300	960÷2080	1200÷2600		1920÷4160	2400÷5200	3780÷8190		6000÷13000					

(1) S function is in alternative to I function

2 Protection and control devices

CURRENT TRANSFORMER SIZE

Circuit-Breaker	Rated Current (Iu)	R250	R400	R800	R1000	R1250	R1600	R2000	R2500	R3200	R4000	R5000	R6300
E1B	800	■	■	■									
E1N	1250	■	■	■	■	■							
E2B	1600	■	■	■	■	■	■						
	2000	■	■	■	■	■	■	■					
E2N	1250	■	■	■	■	■							
	1600	■	■	■	■	■	■						
	2000	■	■	■	■	■	■	■					
E2L	1250	■	■	■	■	■							
	1600	■	■	■	■	■	■						
E3N	2500	■	■	■	■	■	■	■	■				
	3200	■	■	■	■	■	■	■	■	■			
E3S	1250	■	■	■	■	■							
E3H	1600	■	■	■	■	■	■						
	2000	■	■	■	■	■	■	■					
	2500	■	■	■	■	■	■	■	■				
	3200	■	■	■	■	■	■	■	■	■			
E3L	2000	■	■	■	■	■	■	■					
	2500	■	■	■	■	■	■	■	■				
E4S	4000							■		■	■		
E4H	3200							■		■			
	4000							■		■	■		
E4S/f	4000							■		■	■		
E6H	5000									■	■	■	
	6300									■	■	■	■
E6H/f	5000									■	■	■	
	6300									■	■	■	■
E6V	3200									■			
	4000									■	■		
	5000									■	■	■	
	6300									■	■	■	■

		R250	**R400**	**R800**	**R1000**	**R1250**	**R1600**	**R2000**	**R2500**	**R3200**	**R4000**	**R5000**	**R6300**
L Function	PR111 PR112/PR113	100÷250	160÷400	320÷800	400÷1000	500÷1250	640÷1600	800÷2000	1000÷2500	1280÷3200	1600÷4000	2000÷5000	2520÷6300
S	PR111	250÷2500	400÷4000	800÷8000	1000÷10000	1250÷12500	1600÷16000	2000÷20000	2500÷25000	3200÷32000	4000÷40000	5000÷50000	6300÷63000
Function	PR112/PR113	150÷2500	240÷4000	480÷8000	600÷10000	750÷12500	960÷16000	1200÷20000	1500÷25000	1920÷32000	2400÷40000	3000÷50000	3780÷63000
I	PR111	375÷3000	600÷4800	1200÷9600	1500÷12000	1875÷15000	2400÷19200	3000÷24000	3750÷30000	4800÷38400	6000÷48000	7500÷60000	9450÷75600
Function	PR112/PR113	375÷3750	600÷6000	1200÷12000	1500÷15000	1875÷18750	2400÷24000	3000÷30000	3750÷37500	4800÷48000	6000÷60000	7500÷75000	9450÷94500

2 Protection and control devices

2.3.2.1 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.

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.

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 opposite to normal operation.

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.

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

SERIES	RELEASE	VERSION			SIZE
Tmax	PR221DS	LS / LI			T2
Isomax	PR211/P	I	LI		S4÷S7
	PR212/P	LSI	LSIG		S4÷S8
	PR212/MP	LRIU			S4÷S7
Emax	PR111/P	LI	LSI	LSIG	E1÷E6
	PR112/P	LSI	LSIG		E1÷E6
	PR113/P	LSIG – D – UV - OV – RV - U - RP			E1÷E6

The settings and curves of the single protection functions are reported in the chapter 3.2.2

2.3.3 RESIDUAL CURRENT DEVICES

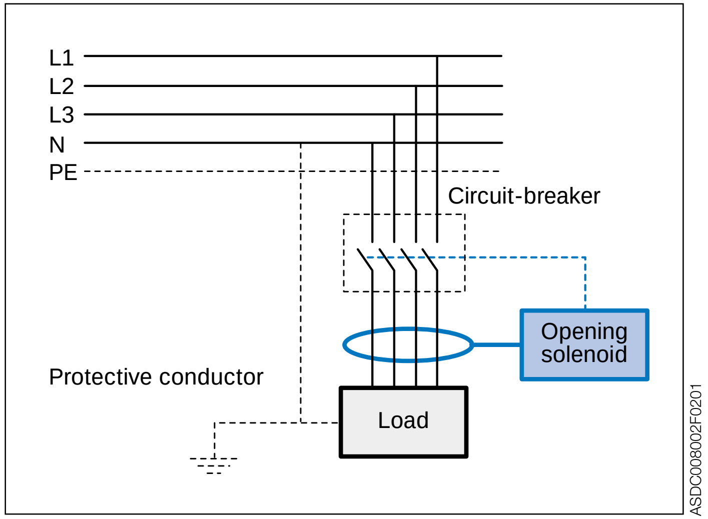
The residual current releases are associated with the circuit-breaker in order to obtain two main functions in a single device:
- protection against overloads and short-circuits;
- protection against indirect contacts (presence of voltage on exposed conductive parts due to loss of insulation).

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 in 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.

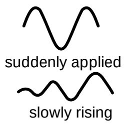
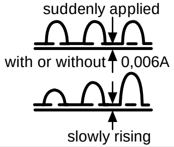
Generic distribution system (IT, TT, TN)



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.

2 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.

	Form of residual current	Correct functioning of residual current devices type AC	A
Sinusoidal ac	 suddenly applied slowly rising	+	+
Pulsating dc	 suddenly applied with or without 0,006A slowly rising		+

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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.

The following table shows the main characteristics of ABB SACE residual current devices; they can be mounted both on circuit-breakers as well as on switch disconnectors (in case of fault currents to earth lower than the apparatus breaking capacity), are type A devices and they do not need auxiliary supply since they are self-supplied.

2 Protection and control devices

		RC211	**RC212**	**RC221**	**RC222**
Primary service voltage	[V]	220 ÷ 500	50 ÷ 500	85 ÷ 500	85 ÷ 500
Rated service current	[A]	Up to 250	Up to 250	Up to 250	Up to 250
Rated residual current trip $I_{\Delta n}$	[A]	0.03-0.1-0.3	0.03-0.1-0.3-0.5-3	0.03-0.1-0.3-0.5-1-3	0.03-0.05-0.1-0.3-0.5-1-3-5-10
Time limit for non-trip (at $2xI_{\Delta n}$)	[s]	Instantaneous	Inst.-0.1-0.25 0.5-1-1.5	instantaneous	Inst. -0.1-0.2-1-0.3-0.5-1-2-3
Tolerance over Trip times	[%]		± 20		± 20
Suitable for circuit-breaker type		S3, S3D	S3, S3D	T1, T2, T3, T1D, T3D	T1, T2, T3, T1D, T3D

Note: for detailed information, please consult the relevant technical catalogues.

ABB SACE moulded-case circuit-breakers series Isomax[1] and Tmax and air circuit-breakers series Emax[1] can be combined with the switchboard residual current relay type RCQ, type A, with separate toroid (to be installed externally on the line conductors).

[1] up to 2000 A rated currents

			RCQ
Power supply voltage	ac	[V]	80 ÷ 500
	dc	[V]	48÷125
Trip threshold adjustements $I_{\Delta n}$			
1st range of adjustements		[A]	0.03 – 0.05 - 0.1 - 0.3 – 0.5
2nd range of adjustements		[A]	1 – 3 – 5 – 10 - 30
Trip time adjustement		[s]	0 - 0.1 - 0.2 - 0.3 - 0.5 - 0.7 - 1 - 2 - 3 - 5
Tolerance over Trip times		[%]	± 20

Note: for detailed information, please consult the relevant technical catalogues.

The versions with adjustable trip times allow to obtain a residual current protection system coordinated from a discrimination point of view, from the main switchboard up to the ultimate load.

3.1 Electrical characteristics of circuit-breakers

Tmax moulded-case circuit-breaker

			T1 1P	T1			T2				T3	
Rated uninterrupted current, **Iu**		[A]	160	160			160				250	
Poles		No.	1	3/4			3/4				3/4	
Rated operational voltage, **Ue**	(ac) 50-60 Hz	[V]	240	690			690				690	
	(dc)	[V]	125	500			500				500	
Rated impulse withstand voltage, **Uimp**		[kV]	8	8			8				8	
Rated insulation voltage, **Ui**		[V]	500	800			800				800	
Voltage test at industrial frequency for 1 min.		[V]	3000	3000			3000				3000	
Rated ultimate short-circuit breaking capacity, **Icu**			**B**	**B**	**C**	**N**	**N**	**S**	**H**	**L**	**N**	**S**
(ac) 50-60 Hz 220 / 230 V		[kA]	25 (3)	25	40	50	65	85	100	120	50	85
(ac) 50-60 Hz 380 / 415 V		**[kA]**	**-**	**16**	**25**	**36**	**36**	**50**	**70**	**85**	**36**	**50**
(ac) 50-60 Hz 440 V		[kA]	-	10	15	22	30	45	55	75	25	40
(ac) 50-60 Hz 500 V		[kA]	-	8	10	15	25	30	36	50	20	30
(ac) 50-60 Hz 690 V		[kA]	-	3	4	6	6	7	8	10	5	8
(dc) 250 V - 2 poles in series		[kA]	25 (at 125 V)	16	25	36	36	50	70	85	36	50
(dc) 250 V - 3 poles in series		[kA]	-	20	30	40	40	55	85	100	40	55
(dc) 500 V - 3 poles in series		[kA]	-	16	25	36	36	50	70	85	36	50
Rated short-circuit service breaking capacity, **Ics**												
(ac) 50-60 Hz 220 / 230 V		[%Icu]	75%	100%	75%	75%	100%	100%	100%	100%	75%	50%
(ac) 50-60 Hz 380 / 415 V (1)		[%Icu]	-	100%	100%	50% (25 kA)	100%	100%	100%	75% (70 kA)	75%	50% (27 kA)
(ac) 50-60 Hz 440 V		[%Icu]	-	100%	75%	50%	100%	100%	100%	75%	75%	50%
(ac) 50-60 Hz 500 V		[%Icu]	-	100%	75%	50%	100%	100%	100%	75%	75%	50%
(ac) 50-60 Hz 690 V		[%Icu]	-	100%	75%	50%	100%	100%	100%	75%	75%	50%
Rated short-circuit making capacity, **Icm**												
(ac 50-60 Hz 220 / 230 V		[kA]	52.5	52,5	84	105	143	187	220	264	105	187
(ac) 50-60 Hz 380 / 415 V		[kA]	-	32	52.5	75.6	75.6	105	154	187	75.6	105
(ac) 50-60 Hz 440 V		[kA]	-	17	30	46.2	63	94.5	121	165	52.5	84
(ac) 50-60 Hz 500 V		[kA]	-	13.6	17	30	52.5	63	75.6	105	40	63
(ac) 50-60 Hz 690 V		[kA]	-	4.3	5.9	9.2	9.2	11.9	13.6	17	7.7	13.6
Breaking time		[ms]	7	7	6	5	3	3	3	3	7	6
Utilization category			A	A			A				A	
Isolation behaviour			■	■			■				■	
Reference Standards			IEC 60947-2	IEC 60947-2			IEC 60947-2				IEC 60947-2	
Releases: thermomagnetic	TMD (adj.)		■	■			■					
	TMF (fixed)		■	-			-				-	
magnetic only	MA		-	-			■ (MF up to R12.5 A)				■	
microprocessor-based	PR221DS-LS		-	-			■				-	
	PR221DS-I		-	-			■				-	
Versions			F	F			F - P (2)				F - P (2)	
Terminals F - P		FC Cu	FC Cu - EF - FC CuAl	F - FC Cu - FC CuAl - EF -			F-FC Cu-FC CuAl-EF-ES- 95 mm^2				ES - R - FC CuAl 185 mm^2 R - FC CuAl 240 mm^2	
Fixing on DIN rail			-	DIN EN 50022			DIN EN 50022				DIN EN 50022	
Mechanical life		[No. Operations]	25000	25000			25000				25000	
		[No. operations per hour]	240	240			240				120	
Electrical life at 415 V		[No. Operations]	8000	8000			8000				8000	
		[No. operations per hour]	120	120			120				120	
Basic dimensions, fixed version	3 poles	L [mm]	25.4 (1 pole)	76			90				105	
	4 poles	L [mm]	-	102			120				140	
		H [mm]	130	130			130				150	
		P [mm]	70	70			70				70	
Weight fixed version	3/4 poles	[kg]	0.4 (1 pole)	0.9 / 1.2			1.1 / 1.5				2.1 / 3	
plug-in version	3/4 poles	[kg]	-	-			1.5 / 1.9				2.7 / 3.7	

(1) The data in brackets indicates the absolute value [kA] of the rated short-circuit breaking capacity, Ics.

(2) In the plug-in version, the maximum setting is derated by 10% at 40 °C.

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

3 General characteristics

SACE Isomax moulded-case circuit-breakers

			S3			S4		
Rated uninterrupted current, **Iu**		[A]	**160 - 250**			**160 - 250**		
Poles		No.	3-4			3-4		
Rated operational voltage, **Ue**	(ac) 50-60Hz	[V]	690			690		
	(dc)	[V]	750			-		
Rated impulse withstand voltage, **Uimp**		[kV]	8			8		
Rated insulation voltage, **Ui**		[V]	800			800		
Test voltage at industrial frequency for 1 min.		[V]	3000			3000		
Rated ultimate short-circuit breaking capacity, **Icu**			**N**	**H**	**L**	**N**	**H**	**L**
(ac) 50-60 Hz 220/230 V	[kA]		65	100	170	65	100	200
(ac) 50-60 Hz 380/415 V	**[kA]**		**35** (1)	**65**	**85**	**35** (1)	**65**	**100**
(ac) 50-60 Hz 440 V		[kA]	30	50	65	30	50	80
(ac)) 50-60 Hz 500 V		[kA]	25	40	50	25	40	65
(ac)) 50-60 Hz 690 V		[kA]	14	18	20 (5)	18	22	30
(dc) 250 V - 2 poles in series	[kA]		35	65	85	-	-	-
(dc) 500 V - 2 poles in series	[kA]		35	50	65	-	-	-
(dc) 500 V - 3 poles in series	[kA]		-	-	-	-	-	-
(dc) 750 V - 3 poles in series	[kA]		20	35	50	-	-	-
Rated short-circuit service breaking capacity, **Ics** (2)		[%Icu]	100%	75%	75%	100%	100%	75%
Rated short-circuit making capacity (415 V) **Icm**		[kA]	74	143	187	74	143	220
Opening time (415V at Icu)		[ms]	8	7	6	8	7	6
Rated short-time withstand current for 1 s, **Icw**		[kA]						
Utilization category (EN 60947-2)			A			A		
Isolation behaviour			■			■		
IEC 60947-2, EN 60947-2			■			■		
Releases: thermomagnetic	T fixed, M fixed 5 In							
	T fixed, M fixed 10 In							
	T adjustable, M fixed 3 In		■	■				
	T adjustable, M fixed 5 In		■	■	■			
	T adjustable, M fixed 10 In		■	■	■			
	T adjustable, M adjustable							
magnetic only	M fixed		■	■	■			
with microprocessor	PR211/P (I-LI)					■	■	■
	PR212/P (LSI-LSIG)					■	■	■
Interchangeability						■		
Versions			F - P - W			F - P - W		
Terminals	fixed		F- EF - ES - FC FC CuAl - RC - R			F - EF - ES - FC FC CuAl - RC - R		
	plug-in		EF - FC - R			EF - FC - R		
	withdrawable (3)		EF - FC - R			EF - FC - R		
Fixing on DIN rail			DIN EN 50023			DIN EN 50023		
Mechanical life	[No. operations / operations per hours]		25000/120			20000/120		
Electrical life (at 415 V)	[No. operations / operations per hours]		10000(160A)-8000 (250A)/120			10000(160A)-8000(250A)/120		
Basic dimensions, fixed	3/4 poles	L [mm]	105/140			105/140		
		D [mm]	103.5			103.5		
		H [mm]	170			254		
Weights fixed	3/4 poles	[kg]	2.6 / 3.5			4 / 5.3		
plug-in	3/4 poles	[kg]	3.1 / 4.1			4.5 / 5.9		
withdrawable	3/4 poles	[kg]	3.5 / 4.5			4. 9 / 6.3		

(1) All the versions with Icu=35kA are certified at 36kA

(2) For S3 N/H/L, S4 N/H/L, S5 N/H, and S6 N/S/H circuit-breakers the performance percentage of Ics at 690V is reduced by 25%.

(3) The withdrawable version circuit-breakers must be fitted with the front flange for the lever operating mechanism or with its alternative accessories, such as the rotary handle or the motor operator

(4) For the S5 circuit-breaker, the plug-in version is only available for the version with 400 A rated current

(5) The SACE S3 circuit-breaker with breaking capacity L at 690 V can only be supplied from above

3 General characteristics

			S5			S6				S7			S8	
Rated uninterrupted current, **Iu**		[A]	**400 - 630**			**630 - 800**				**1250 - 1600**			**2000 - 2500 - 3200**	
Poles		No.	3-4			3-4				3-4			3-4	
Rated operational voltage, **Ue**	(ac) 50-60Hz	[V]	690			690				690			690	
	(dc)	[V]	750			750				-			-	
Rated impulse withstand voltage, **Uimp**		[kV]	8			8				8			8	
Rated insulation voltage, **Ui**		[V]	800			800				800			690	
Test voltage at industrial frequency for 1 min.		[V]	3000			3000				3000			2500	
Rated ultimate short-circuit breaking capacity, **Icu**			**N**	**H**	**L**	**N**	**S**	**H**	**L**	**S**	**H**	**L**	**H**	**V**
(ac) 50-60 Hz 220/230 V	[kA]		65	100	200	65	85	100	200	85	100	200	85	120
(ac) 50-60 Hz 380/415 V	**[kA]**		**35** (1)	**65**	**100**	**35** (1)	**50**	**65**	**100**	**50**	**65**	**100**	85	120
(ac) 50-60 Hz 440 V		[kA]	30	50	80	30	45	50	80	40	55	80	70	100
(ac)) 50-60 Hz 500 V		[kA]	25	40	65	25	35	40	65	35	45	70	50	70
(ac)) 50-60 Hz 690 V		[kA]	20	25	30	20	22	25	30	20	25	35	40	50
(dc) 250 V - 2 poles in series	[kA]		35	65	100	35	50	65	100	-	-	-	-	-
(dc) 500 V - 2 poles in series	[kA]		35	50	65	20	35	50	65	-	-	-	-	-
(dc) 500 V - 3 poles in series	[kA]		-	-	-	-	-	-	-	-	-	-	-	-
(dc) 750 V - 3 poles in series	[kA]		20	35	50	16	20	35	50	-	-	-	-	-
Rated short-circuit service breaking capacity, **Ics** (2)		[%Icu]	100%	100%	75%	100%	100%	100%	75%	100%	75%	50%	50%	50%
Rated short-circuit making capacity (415 V) **Icm**		[kA]	74	143	220	74	105	143	220	105	143	220	187	264
Opening time (415V at Icu)		[ms]	8	7	6	10	9	8	7	22	22	22	20	20
Rated short-time withstand current for 1 s, **Icw**		[kA]	5 (400A)			7,6 (630A) - 10 (800A)				15 (1250A) - 20 (1600A)			35	
Utilization category (EN 60947-2)			B (400A) - A (630A)			B				B			B	
Isolation behaviour			■			■				■				
IEC 60947-2, EN 60947-2			■			■				■				
Releases: thermomagnetic	T fixed, M fixed 5 In													
	T fixed, M fixed 10 In													
	T adjustable, M fixed 3 In													
	T adjustable, M fixed 5 In													
	T adjustable, M fixed 10 In													
	T adjustable, M adjustable		■	■	■	■	■	■	■					
magnetic only	M fixed													
with microprocessor	PR211/P (I-LI)		■	■	■	■	■	■	■	■	■	■		
	PR212/P (LSI-LSIG)		■	■	■	■	■	■	■	■	■	■		
Interchangeability			■			■				■				
Versions			F - P (400) - W			F - W				F - W			F	
Terminals	fixed		F - EF(400A) - ES - FC FC CuAl (400A)-RC (400A)-R			F - EF - ES - FC CuAl RC - R				F - EF - ES - FC CuAl (1250A) HR - VR			F (2000-2500A) - VR	
	plug-in		EF - FC - R			-				-			-	
	withdrawable (3)		EF(400A) - ES - FC (400A)R - VR (630A)			EF - HR - VR				EF - HR - VR			-	
Fixing on DIN rail			DIN EN 50023			-				-			-	
Mechanical life	[No. operations / operations per hours]		20000/120			20000/120				10000/120			10000/20	
Electrical life (at 415 V)	[No. operations / operations per hours]		7000(400A)-5000(630A)/60			7000(630A)-5000(800A)/60				7000(1250A)-5000(1600A)/20			2500(2500A)/20-1500(3200A)/10	
Basic dimensions, fixed	3/4 poles	L [mm]	140/184			210/280				210/280			406/556	
		D [mm]	103.5			103.5				138.5			242	
		H [mm]	254			268				406			400	
Weights fixed	3/4 poles	[kg]	5 / 7			9.5 / 12				17 / 22			57/76	
plug-in	3/4 poles	[kg]	6.1 / 8.4			-				-			-	
withdrawable	3/4 poles	[kg]	6.4 / 8.7			12.1 / 15.1				21.8 / 29.2			-	

KEY TO VERSIONS
F = Fixed
P = Plug-in
W = Withdrawable

KEY TO TERMINALS
F = Front
EF = Extended front
ES = Extended spreaded front
FC = Front for copper cables
FC CuAl = Front for copper or aluminium cables
R = Rear threaded
RC = Rear for copper or aluminium cables
HR = Rear horizontal flat bar
VR = Rear vertical flat bar

3 General characteristics

SACE Isomax current-limiting circuit-breakers

			SACE Isomax S3X	**SACE Isomax S4X**	**SACE Isomax S6X**
Rated uninterrupted current, **Iu**		[A]	**125-200**	**250**	**400-630**
Poles		No.	3-4	3-4	3-4
Rated operational voltage, **Ue** (ac) 50-60Hz		[V]	690	690	690
Rated impulse withstand voltage, **Uimp**		[kV]	8	8	8
Rated insulation voltage, **Ui**		[V]	800	800	800
Test voltage at industrial frequency for 1 min.			3000	3000	3000
Rated ultimate short-circuit breaking capacity, **Icu**			**X**	**X**	**X**
	(ac) 50-60 Hz 220/230 V	[kA]	300	300	300
	(ac) 50-60 Hz 380/415 V	**[kA]**	**200**	**200**	**200**
	(ac) 50-60 Hz 440 V	[kA]	180	180	180
	(ac) 50-60 Hz 500 V	[kA]	150	150	150
	(ac) 50-60 Hz 690 V	[kA]	**75** (2)(3)	**75**	**75**
Rated service short-circuit breaking capacity, **Ics** (1)		[%Icu]	100%	100%	100%
Rated short-circuit making capacity (415 V) **Icm**		[kA]	440	440	440
Opening time (415V at Icu)		[ms]	3,5	3,5	3,5
Utilization category (EN 60947-2)			A	A	A
Isolation behaviour			■	■	■
IEC 60947-2, EN 60947-2			■	■	■
Releases:	thermomagnetic - T adjustable, M fixed 10 In		■		
	with microprocessor PR211/P (I-LI)			■	■
	with microprocessor PR212/P (LSI-LSIG)			■	■
Interchangeability				■	■
Versions			F-P-W	F-P-W	F-W
Terminals	fixed		F - EF - ES - FC - FC CuAl - RC - R	F - EF - ES - FC - FC CuAl - RC - R	F - EF - ES - FC CuAl - RC - R
	plug-in		EF - R	EF - R	-
	withdrawable		EF - R	EF - R	EF - HR - VR
Fixing on DIN rail			DIN EN 50023	DIN EN 50023	-
Mechanical life		[No. operations / operation per hours]	25000/120	20000/120	20000/120
Electrical life (at 415 V)		[No. operations / operation per hours]	10000(125A)-8000(200A) / 120	800 / 120	7000(630A)-5000(800A)/60
Basic dimensions, fixed	L (3/4 poles)	[mm]	105/140	105/140	210/280
	D	[mm]	103.5	103.5	103.5
	H	[mm]	255	339	268
Weights, 3/4 poles	fixed	[kg]	3.6 / 4.8	5 / 7	9.5 / 12
	plug-in	[kg]	6.3 / 8.7	8.2 / 10.7	-
	withdrawable	[kg]	7.1 / 9.5	9 / 11.5	12.1 / 15.1

(1) The value of Ics at 500V and 690V for S3X, S4X and S6X is reduced by 25%

(2) For S3X with R32 setting: Icu (690V) = 50 kA and Ics = 100% Icu
Icu (500V) = 75 kA and Ics = 100% Icu

(3) S3X at 690V can only be supplied from above

KEY TO VERSIONS
F = Fixed
P = Plug-in
W = Withdrawable

KEY TO TERMINALS
F = Front
EF = Extended front
ES = Extended spreaded front
FC = Front for copper cables
FC CuAl = Front for copper or aluminium cables
R = Rear threaded
RC = Rear for copper or aluminium cables
HR = Rear horizontal flat bar
VR = Rear vertical flat bar

3 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
Test voltage at industrial frequency for 1 minut	[V]	3500 ~
Service temperature	[°C]	-25....+70
Storage temperature	[°C]	-40....+70
Frequency f	[Hz]	50 - 60
Number of poles		3 - 4
Version		Fixed -Withdrawable

			E1		E2			E3				E4		E6	
Performance levels			B	N	B	N	L	N	S	H	L	S	H	H	V
Currents															
Rated uninterrupted current (at 40 °C) Iu		[A]	**800**	**800**	**1600**	**1250**	**1250**	**2500**	**1250**	**1250**	**2000**	**4000**	**3200**	**5000**	**3200**
		[A]	**1250**	**1250**	**2000**	**1600**	**1600**	**3200**	**1600**	**1600**	**2500**		**4000**	**6300**	**4000**
		[A]				**2000**			**2000**	**2000**					**5000**
		[A]							**2500**	**2500**					**6300**
		[A]							**3200**	**3200**					
Neutral pole capacity for four-pole circuit-breakers		[%Iu]	100	100	100	100	100	100	100	100	100	50	50	50	50
Rated ultimate short-circuit breaking capacity **Icu**															
220/230/380/400/415 V ~		[kA]	42	50	42	65	130	65	75	100	130	75	100	100	150
440 V ~		[kA]	42	50	42	65	110	65	75	100	110	75	100	100	150
500/660/690 V ~		[kA]	36	36	42	55	85	65	75	85 (2)	85	75	85 (2)(3)	100	100
Rated duty short-circuit breaking capacity **Ics**															
220/230/380/400/415 V ~		[kA]	42	50	42	65	130	65	75	85	130	75	100	100	125
440 V ~		[kA]	42	50	42	65	110	65	75	85	110	75	100	100	125
500/660/690 V ~		[kA]	36	36	42	55	65	65	75	85	65	75	85 (3)	100	100
Rated short-time withstand current **Icw**	(1s)	[kA]	36	50	42	55	10	65	75	75	15	75	100	100	100
	(3s)		36	36	42	42	–	65	65	65	–	75	75	85	85
Rated short-circuit making capacity **Icm**															
220/230/380/400/415 V ~		[kA]	88.2	105	88.2	143	286	143	165	220	286	165	220	220	330
440 V ~		[kA]	88.2	105	88.2	143	242	143	165	220	242	165	220	220	330
500/660/690 V ~		[kA]	75.6	75.6	88.2	121	187	143	165	187	187	165	187	220	220
Application category (in accordance with IEC 60947-2)			B	B	B	B	A	B	B	B	A	B	B	B	B
Isolation behavior (in accordance with IEC 60947-2)			■	■	■	■	■	■	■	■	■	■	■	■	■
Overcurrent protection															
Microprocessor-based releases for AC applications			■	■	■	■	■	■	■	■	■	■	■	■	■
Operating times															
Closing time (max)		[ms]	80	80	80	80	80	80	80	80	80	80	80	80	80
Break time for I<Icw (max) (1)		[ms]	70	70	70	70	70	70	70	70	70	70	70	70	70
Break time for I>Icw (max)		[ms]	30	30	30	30	12	30	30	30	12	30	30	30	30
Overall dimensions															
Fixed: H = 418 mm - D = 302 mm L (3/4 poles)		[mm]	296/386		296/386			404/530				566/656		782/908	
Withdrawable: H = 461 mm - D = 396.5 mm L (3/4 poles)		[mm]	324/414		324/414			432/558				594/684		810/936	
Weights (circuit-breaker complete with releases and CT, not including accessories)															
Fixed 3/4 poles		[kg]	45/54	45/54	50/61	50/61	52/63	66/80	66/80	66/80	72/83	97/117	97/117	140/160	140/160
Withdrawable 3/4 poles (including fixed part)		[kg]	70/82	70/82	78/93	78/93	80/95	104/125	104/125	104/125	110/127	147/165	147/165	210/240	210/240

(1) Without intentional delays
(2) Performance at 600 V is 100 kA
(3) Performance at 500 V is 100 kA

SACE Emax air circuit-breakers			**E1 B-N**		**E2 B-N**			**E2 L**		**E3 N-S-H**					**E3 L**		**E4 S-H**		**E6 H-V**			
Rated uninterrupted current (a 40 °C) **Iu**		[A]	800	1250	1250	1600	2000	1250	1600	1250	1600	2000	2500	3200	2000	2500	3200	4000	3200	4000	5000	6300
Mechanical life																						
with regular routine maintenance		[Operations x 1000]	25	25	25	25	25	20	20	20	20	20	20	20	15	15	15	15	12	12	12	12
Frequency		[Operations per hour]	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Electrical life	(440 V ~)	[Operations x 1000]	10	10	15	12	10	4	3	12	10	9	8	6	2	1.8	7	5	5	4	3	2
	(690 V ~)	[Operations x 1000]	10	8	15	10	8	3	2	12	10	9	7	5	1.5	1.3	7	4	5	4	2	1.5
Frequency		[Operations per hour]	30	30	30	30	30	20	20	20	20	20	20	20	20	20	10	10	10	10	10	10

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

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

3.2 Trip curves

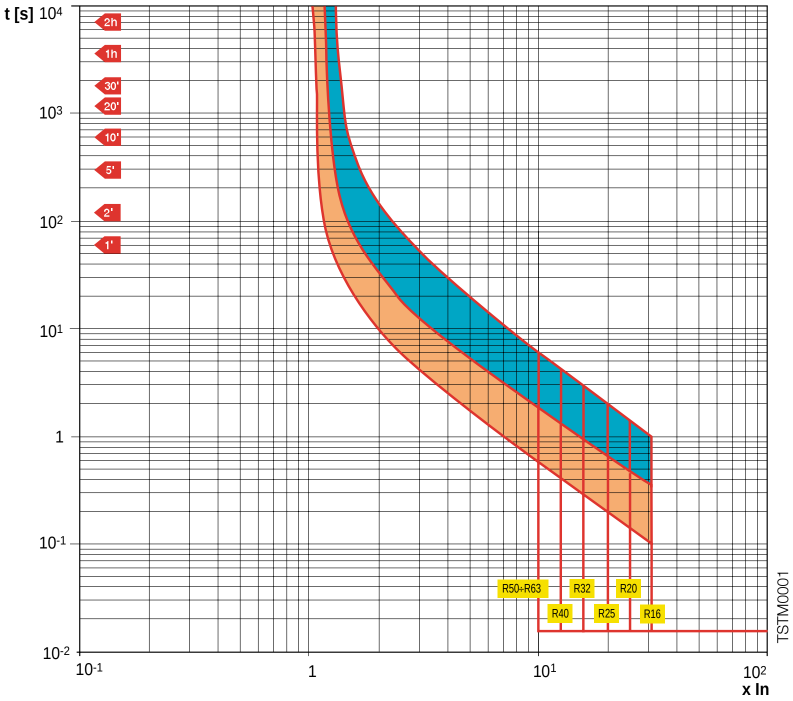
3.2.1 Thermomagnetic release trip curves

The overload protection function must not trip the breaker in 2 hours for current values which are lower than 1.05 times the set current, and must trip within 1.3 times the set current. By "cold trip conditions", it is meant that the overload occurs when the circuit-breaker has not reached normal working temperature (no current flows through the circuit-breaker before the anomalous condition occurs); on the contrary by "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.

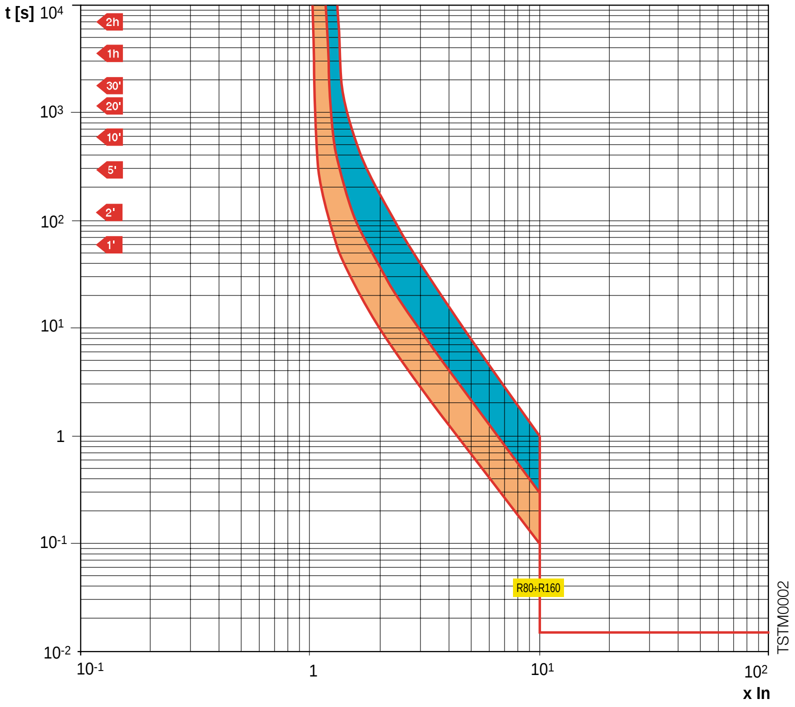
Trip curve
thermomagnetic
release

Tmax T1 160 TMD R16-R63



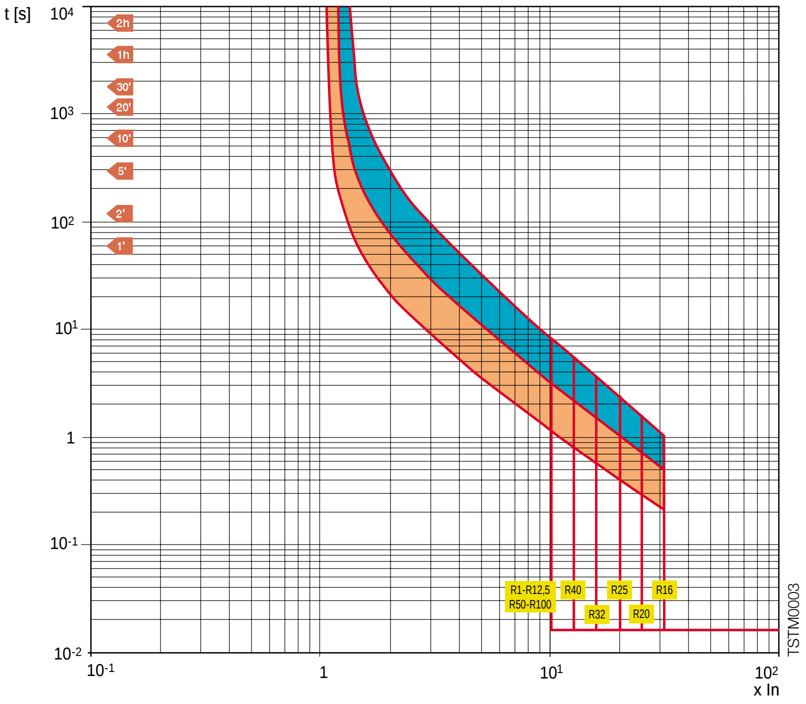
Trip curve
thermomagnetic
release

Tmax T1 160 TMD R80-R160



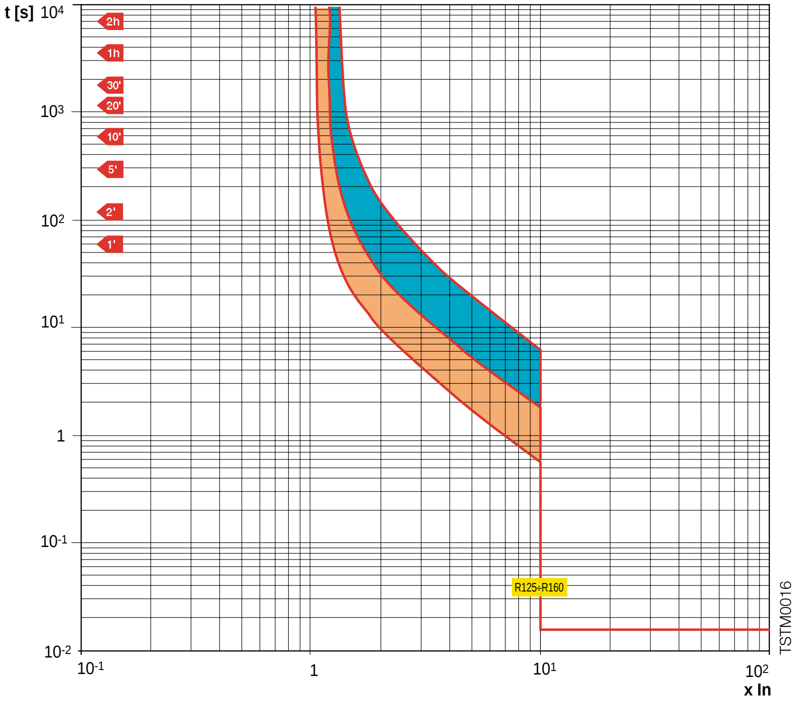
Trip curve
thermomagnetic
release

Tmax T2 160 TMD R1-R100



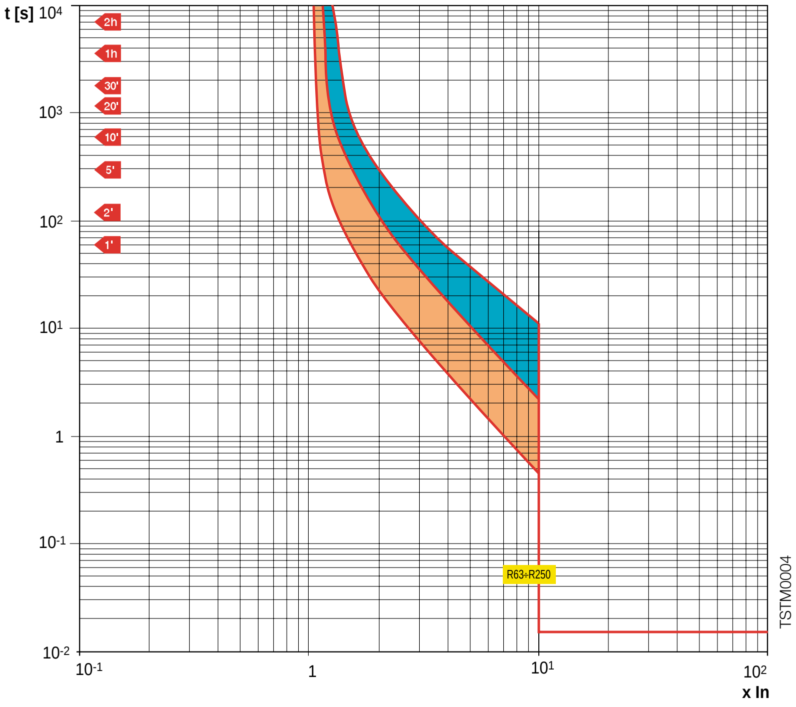
Trip curve
thermomagnetic
release

Tmax T2 160 TMD R125-R160



Trip curve
thermomagnetic
release

Tmax T3 250 TMD R63-R250

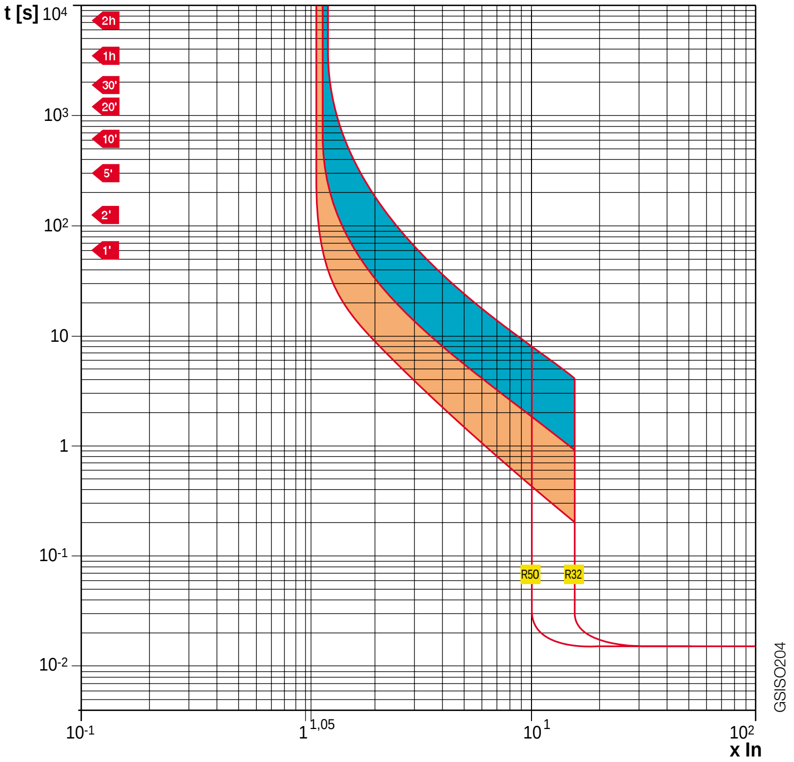


3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S3 160

$I_3 = 10 \times In$



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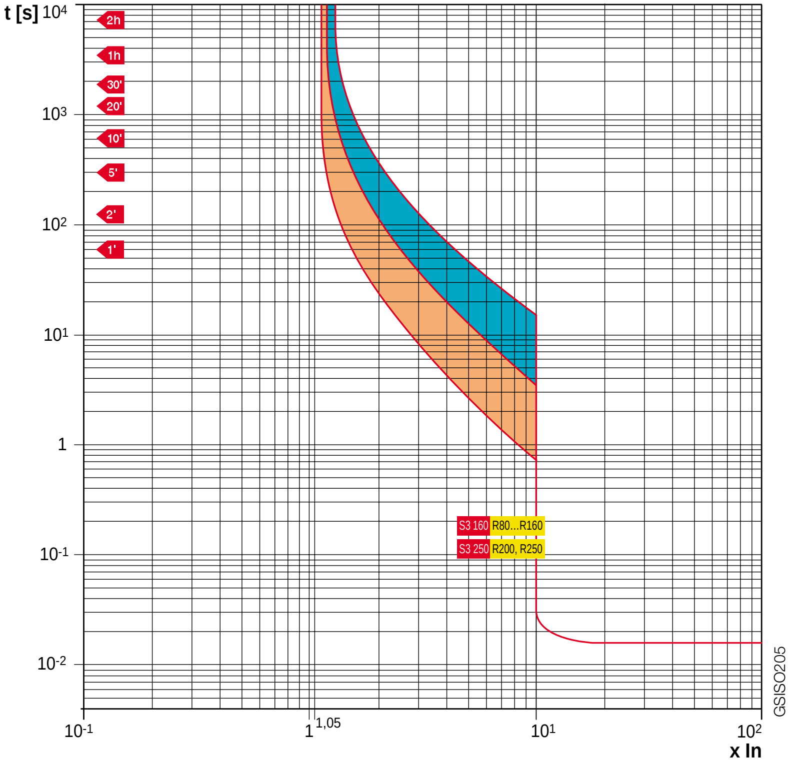
3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S3 160 – S3 250

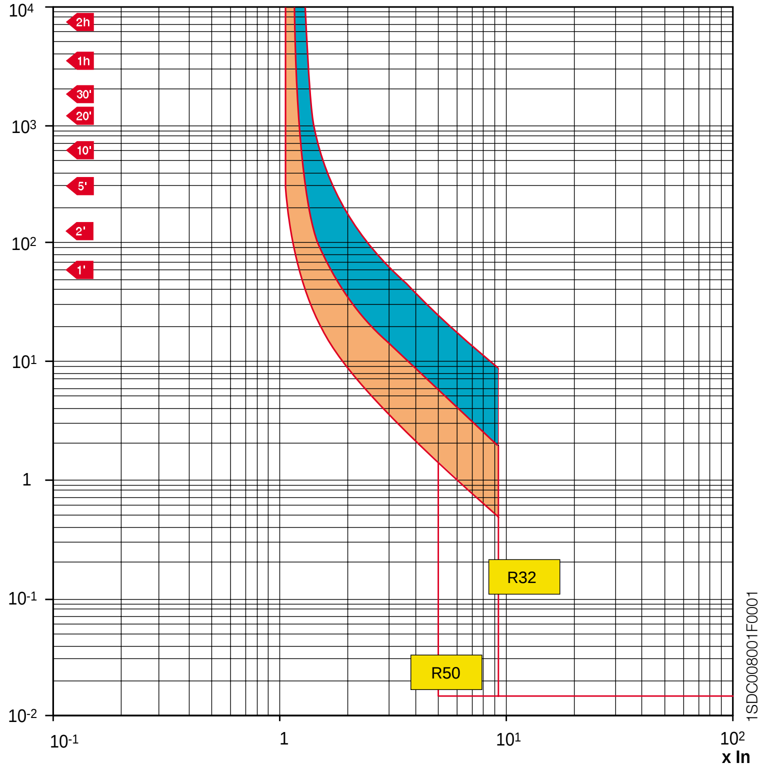
$I_3 = 10 \times In$



3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S3 160 I3 = 5 x In



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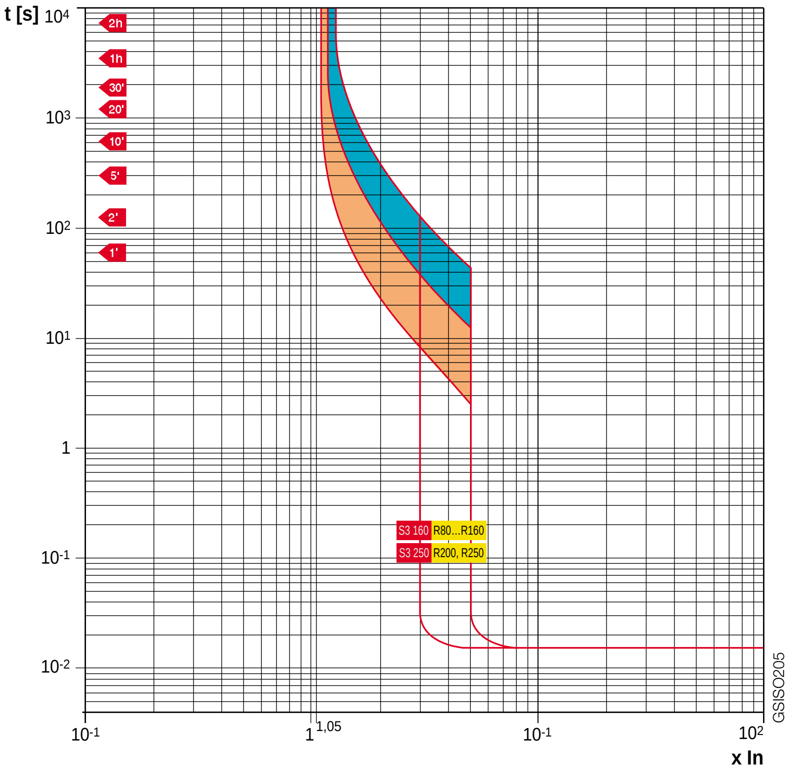
3 General characteristics

Trip curve
thermomagnetic
release

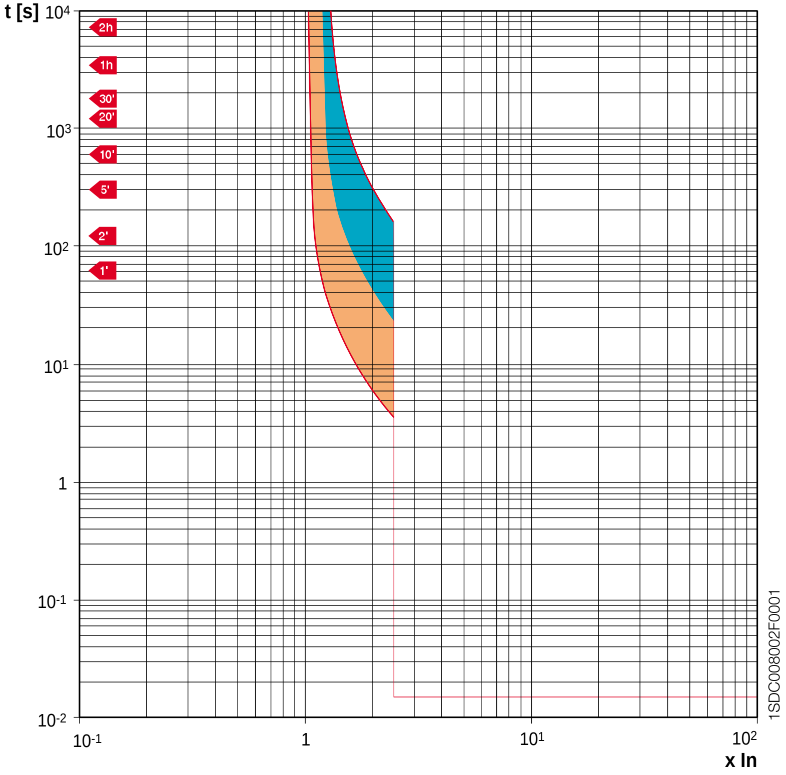
SACE Isomax S3 160 – S3 250 I3 = 3 x In I3 = 5 x In



3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S5 400 (R320-400) – S5 630 (R500) I3 = 2.5 In



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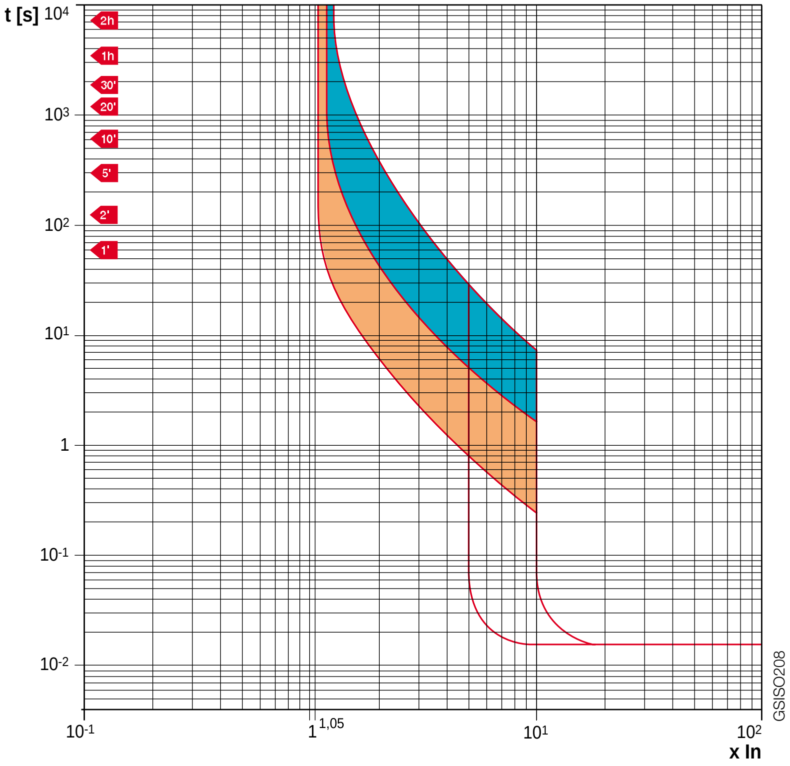
3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S5 400 (R320-400) – S5 630 (R500) I3 = 5÷10 In

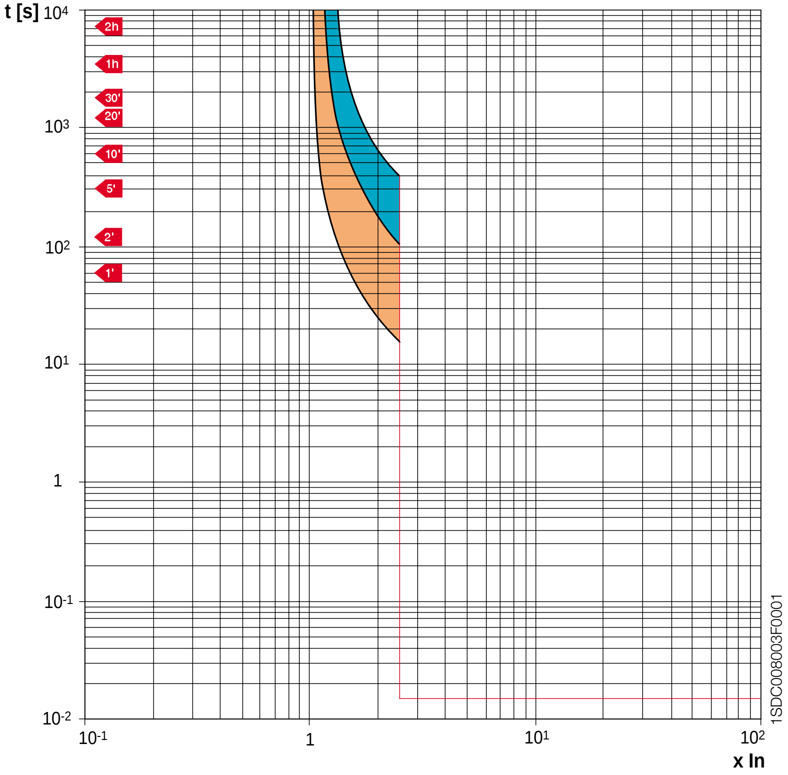


3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S6 630 (R630)

I_3 = 2.5 In



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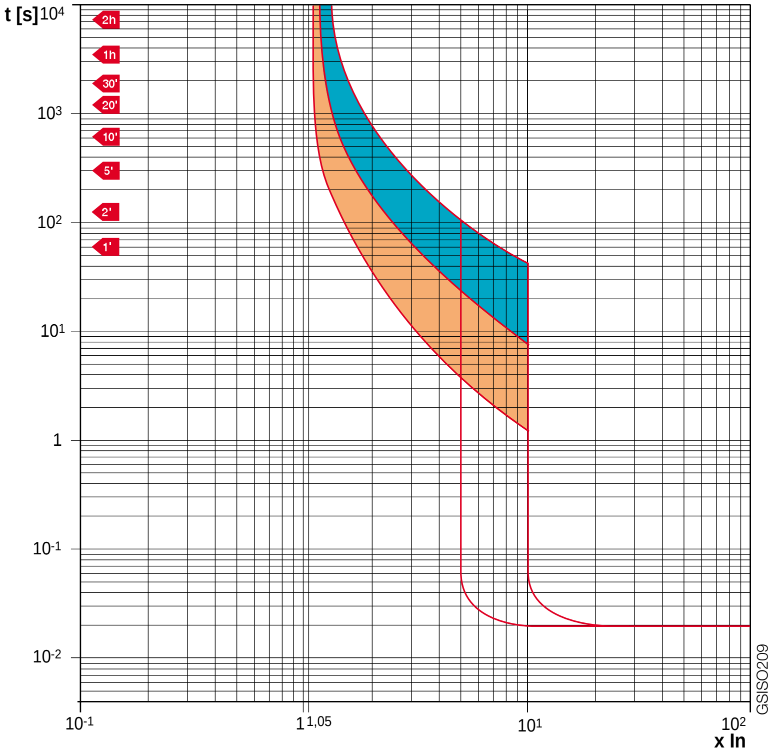
3 General characteristics

Trip curve
thermomagnetic
release

Trip curve SACE Isomax S6 630 (R630)

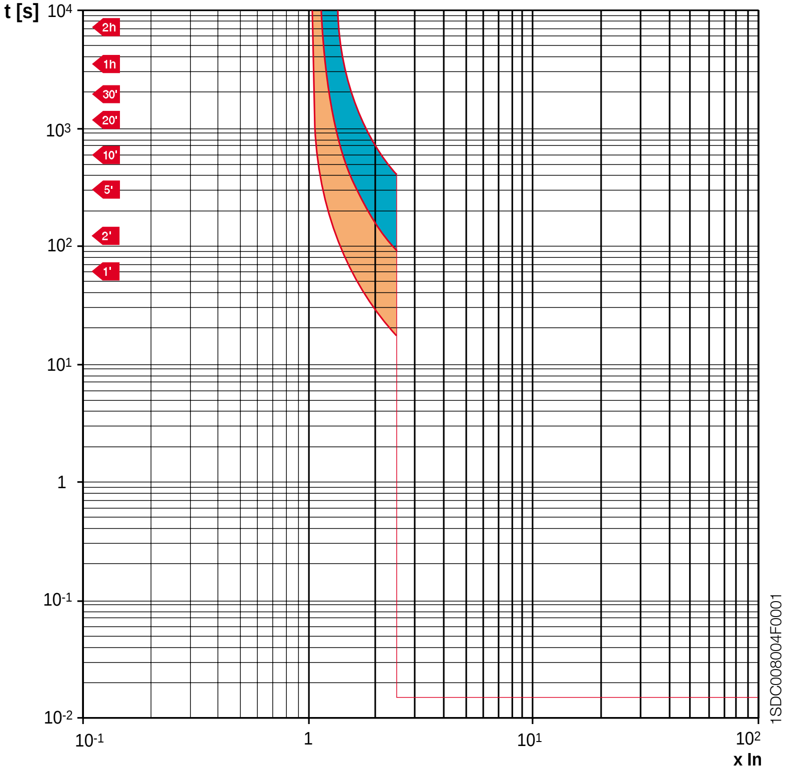
I_3 = 5÷10 In



3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S6 800 (R800) I3 = 2.5 In



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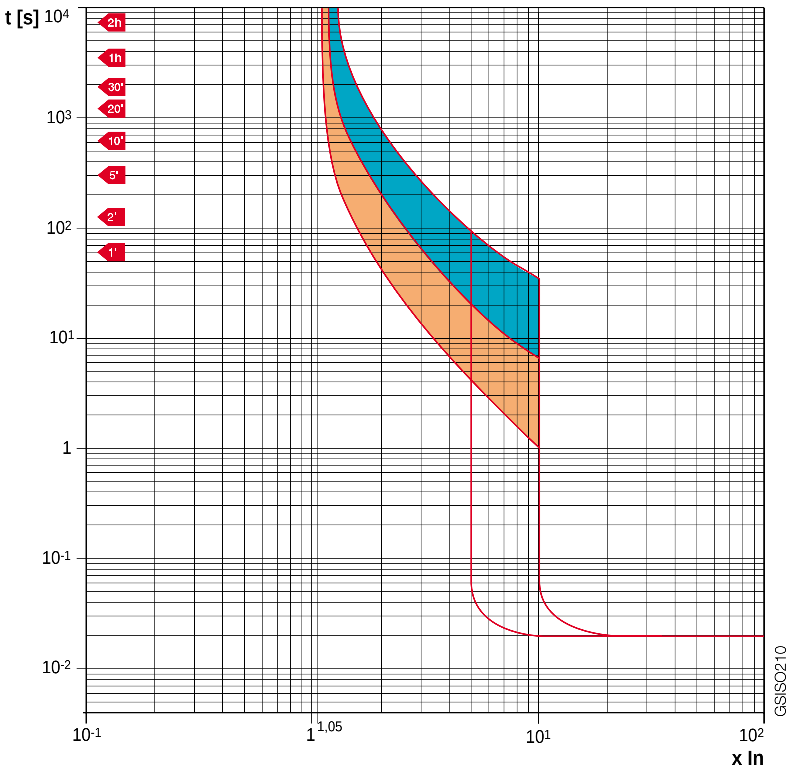
3 General characteristics

Trip curve
thermomagnetic
release

SACE Isomax S6 800 (R800) I3 = 5÷10 In

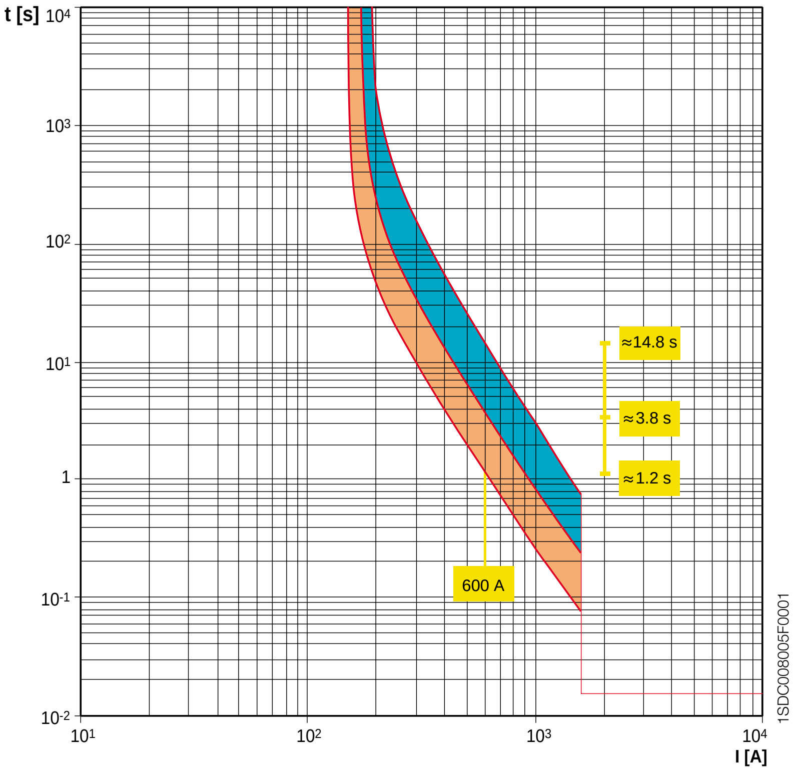


3 General characteristics

Example of thermomagnetic release setting

Consider a circuit-breaker type T1 160 R160 and select, using the trimmer for thermal regulation, the current threshold, for example at 144 A; the magnetic trip threshold, fixed at 10·In, 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 1.2 and 3.8 s for hot trip, and between 3.8 and 14.8 s for cold trip.
For fault current values higher than 1600 A, the circuit-breaker trips instantaneously through magnetic protection.

T1 160 - R160 Time-Current curves

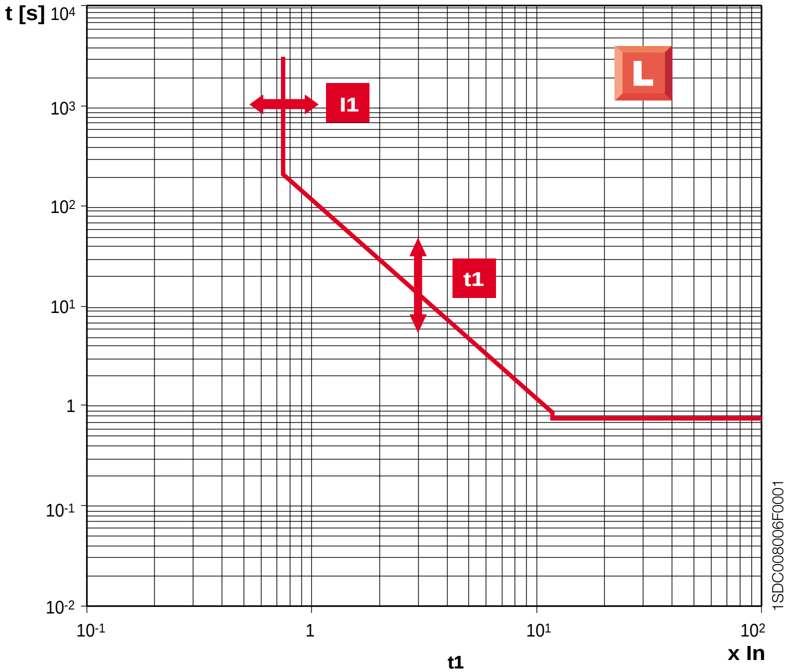


3 General characteristics

3.2.2 Trip curves of electronic releases

Introduction
The following figures show the curves of the single protection functions available in the electronic releases. The setting ranges and resolution are referred to setting operations to be carried out locally.

L FUNCTION



	I1	t1
PR221	(0.4 – 0.44 – 0.48 – 0.52 – 0.56 – 0.6 – 0.64 – 0.68 – 0.72 – 0.76 – 0.8 – 0.84 – 0.88 - 0.92 – 0.96 – 1) x In	A= 3s; B= 6s (@ 6 x I1)
PR211	(0.4 – 0.5 – 0.6 – 0.7 – 0.8 – 0.9 – 0.95 – 1) x In	A= 3s; B= 6s; C= 12s; D= 18s (@ 6 x I1)
PR212	(0.4 – 0.5 – 0.55 – 0.6 – 0.65 – 0.7 – 0.75 – 0.8 – 0.85 – 0.875 – 0.9 – 0.925 – 0.95 - 0.975 – 1) x In	A= 3s; B= 6s; C= 12s; D= 18s (@ 6 x I1)
PR111	(0.4 – 0.5 – 0.6 – 0.7 – 0.8 – 0.9 – 0.95 – 1) x In	A= 3s; B= 6s; C= 12s; D= 18s (@ 6 x I1)
PR112 PR113	(0.4 … 1) x In with step 0.01 x In	3 … 144s with step 3s (@ 3 x I1)

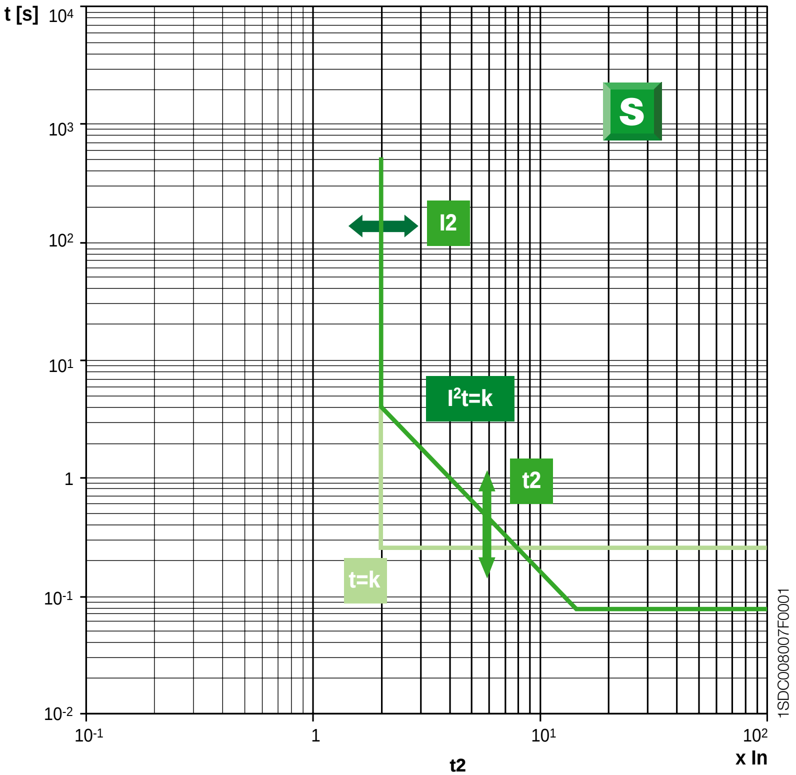
Here below the tolerances:

	I1	t1
PR221 PR211 PR212	1.05÷1.3 x I1	± 10 % (up to 2 x In) ± 20 % (over 2 x In)
PR111	1.1÷1.2 x I1	± 10 % (up to 3 x In) ± 20 % (over 3 x In)
PR112 PR113	1.1÷1.2 x I1	± 10 % (up to 4 x In) ± 20 % (over 4 x In)

3 General characteristics

S FUNCTION

$(I^2t=k, t=k)$



	I2	t2
PR221	(1 – 1.5 – 2 – 2.5 – 3 – 3.5 – 4.5 – 5.5 – 6.5 – 7 – 7.5 – 8 – 8.5 – 9 – 10 – OFF) x In	B= 0.1s; C= 0.25s (@ 8 x I2)
PR211 PR212 PR111	(1 – 2 – 3 – 4 – 6 – 8 – 10 – OFF) x In	A= 0.05s; B= 0.1s; C= 0.25s; D= 0.5s (@ 8 x I2)
PR112 PR113	(0.6 … 10 – OFF) x In with step 0.1 x In	0.05 … 0.75s with step 0.01s (@ 10 x I2)

Here below the tolerances:

	I2	t2
PR221	± 10 % (up to 2 x In) ± 20 % (over 2 x In)	± 20 %
PR211 PR212	± 10 %	± 20 %
PR111	± 10 %	± 20 % ($I^2t=k$) the better between ± 20 % and ± 50 ms (t=k)
PR112 PR113	± 7 % (up to 4 x In) ± 10 % (over 4 x In)	the better between ± 10 % and ± 50 ms (up to 4 x In, with t=k) the better between ± 15 % and ± 50 ms (over 4 x In, with t=k) ± 15 % (up to 4 x In, with $I^2t=k$) ± 20 % (over 4 x In, with $I^2t=k$)

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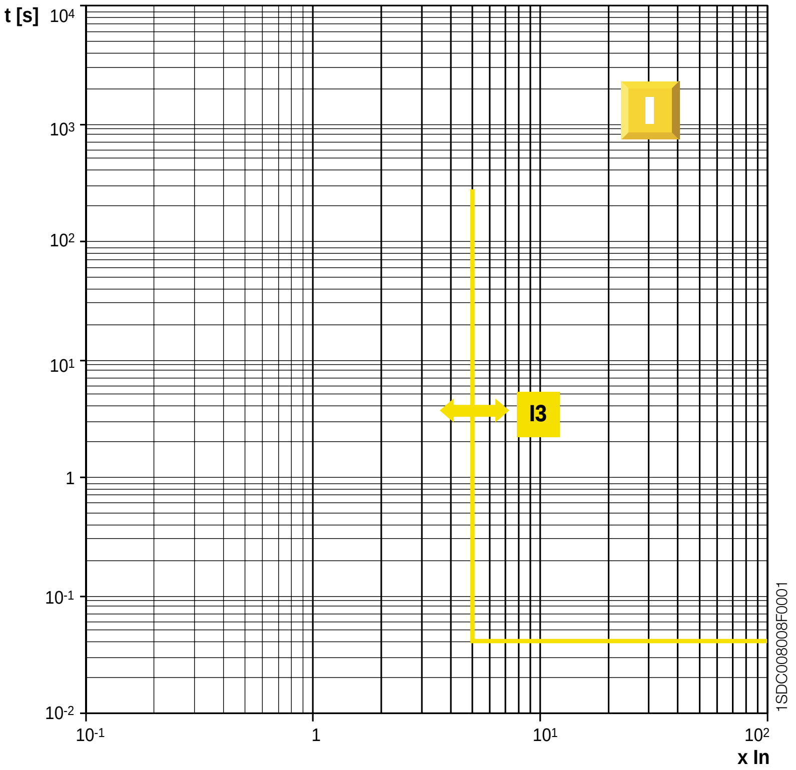
3 General characteristics

I FUNCTION



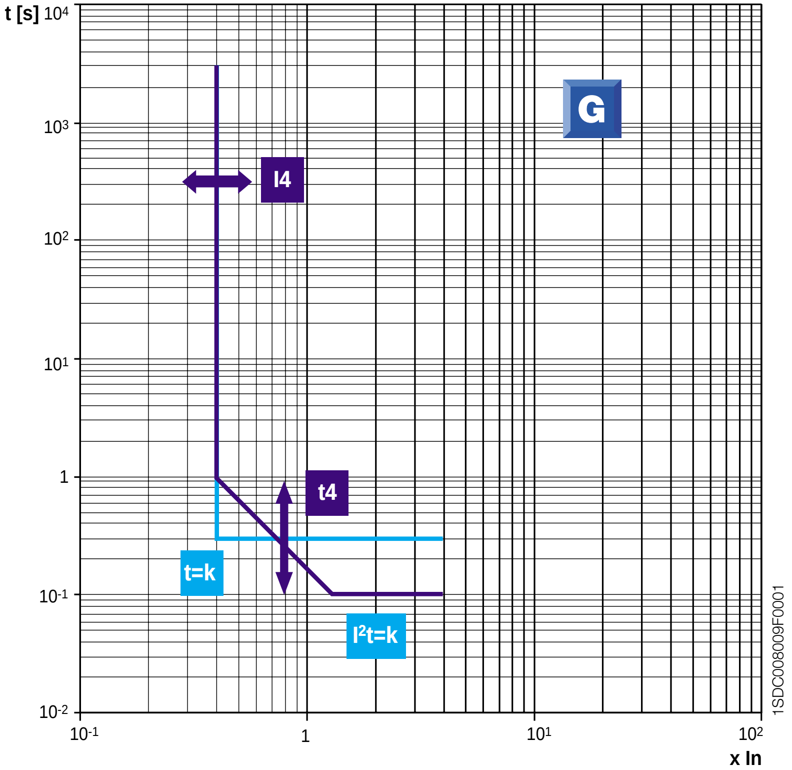
	I3
PR221	(1 – 1.5 – 2 – 2.5 – 3 – 3.5 – 4.5 – 5.5 – 6.5 – 7 – 7.5 – 8 – 8.5 – 9 – 10 – OFF) x In
PR211 PR212 PR111	(1.5 – 2 – 4 – 6 – 8 – 10 – 12 – OFF) x In
PR112 PR113	(1.5 … 15 – OFF) x In with step 0.1 x In

Here below the tolerances:

	I3	**Tripping time:**
PR221 PR211 PR212	± 20 %	≤ 15 ms
PR111	± 20 %	35 ms up to 3 x In 30 ms over 3 x In
PR112 PR113	± 10 % up to 4 x In ± 15 % over 4 x In	≤ 25 ms

3 General characteristics

G FUNCTION ($I^2t=k$, t=k)



	I4	t4
PR212 PR111 (1)	(0.2 – 0.3 – 0.4 – 0.6 – 0.8 – 0.9 – 1 – OFF) x In	A= 0.1s; B= 0.2s; C= 0.4s; D= 0.8s (@ 4 x I4)
PR112 PR113	(0.2 … 1 – OFF) x In with step 0.02 x In	0.1 … 1s with step 0.05s (@ 4 x I4)

(1) only with $I^2t=k$ characteristic

Here below the tolerances:

	I4	t4
PR212	± 20 %	± 20 %
PR111 (1)	± 10 %	± 20 %
PR112	± 10 %	± 20 % ($I^2t=k$) the better between ± 10 % and ± 50 ms (t=k) up to 4 x In
PR113	± 7 % up to 4 x In	± 15 % ($I^2t=k$) the better between ± 10 % and ± 50 ms (t=k) up to 4 x In

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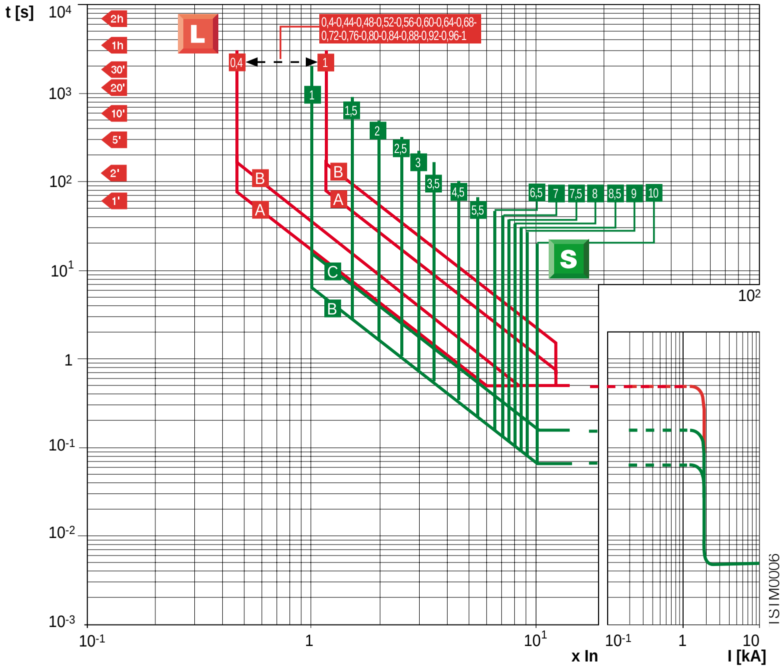
3 General characteristics

PR221DS

Trip curve
electronic releases

Tmax T2 160
LS function

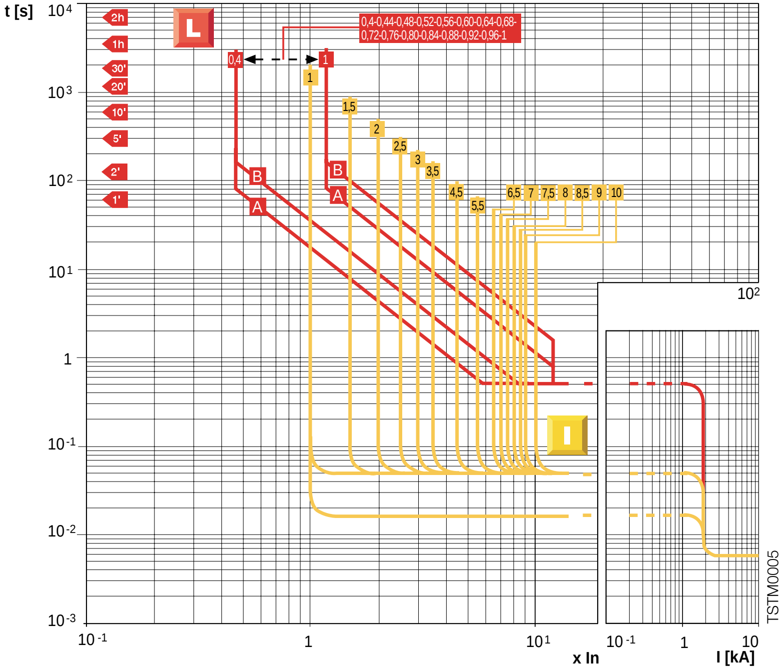


3 General characteristics

PR221DS

Trip curve
electronic releases

Tmax T2 160
LI function



Note: for PR221DS-I releases, please consider the curves relevant to I function only.

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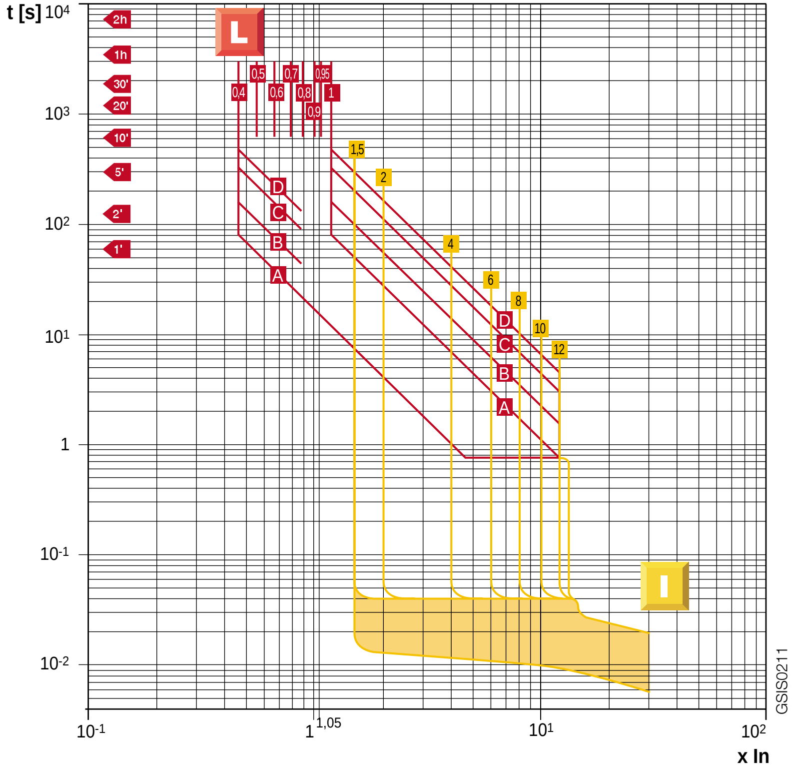
3 General characteristics

PR211/P

Trip curve
electronic releases

SACE Isomax S4-S5-S6-S7
LI function



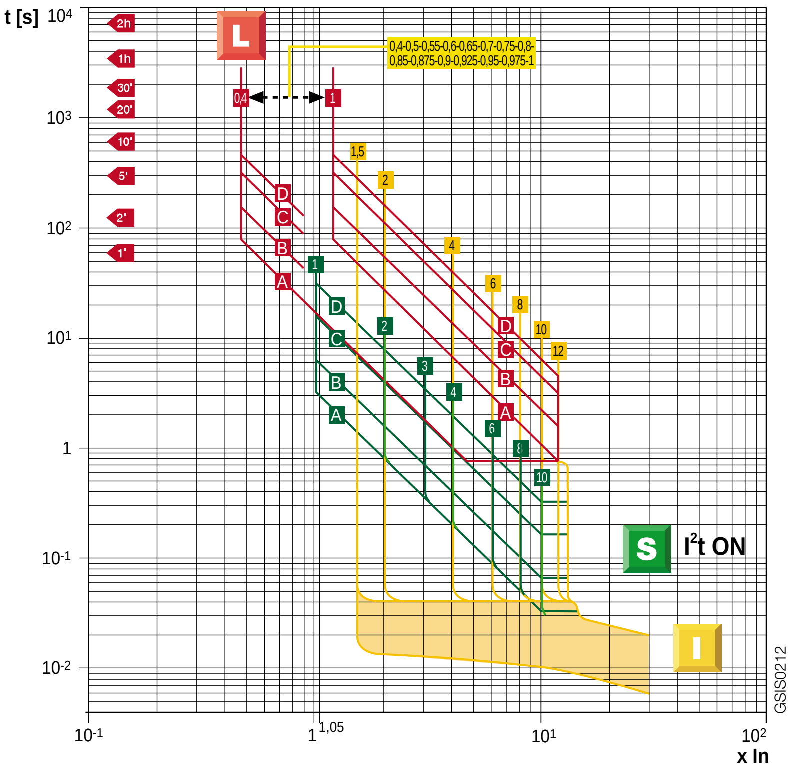
Note: for PR211/P-I releases, consider the curves relevant to function I only.

3 General characteristics

PR212/P

Trip curve
electronic releases

SACE Isomax S4-S5-S6-S7-S8
LSI function, S inverse short delay (I^2t = constant)



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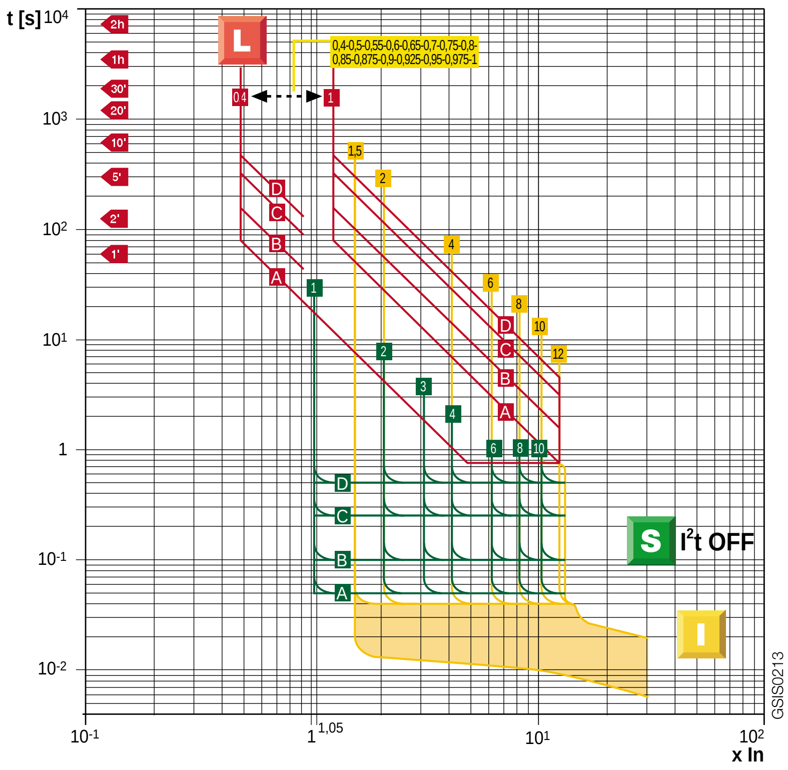
3 General characteristics

PR212/P

Trip curve
electronic releases

SACE Isomax S4-S5-S6-S7 -S8
LSI Function, S independent time delay (t = constant)

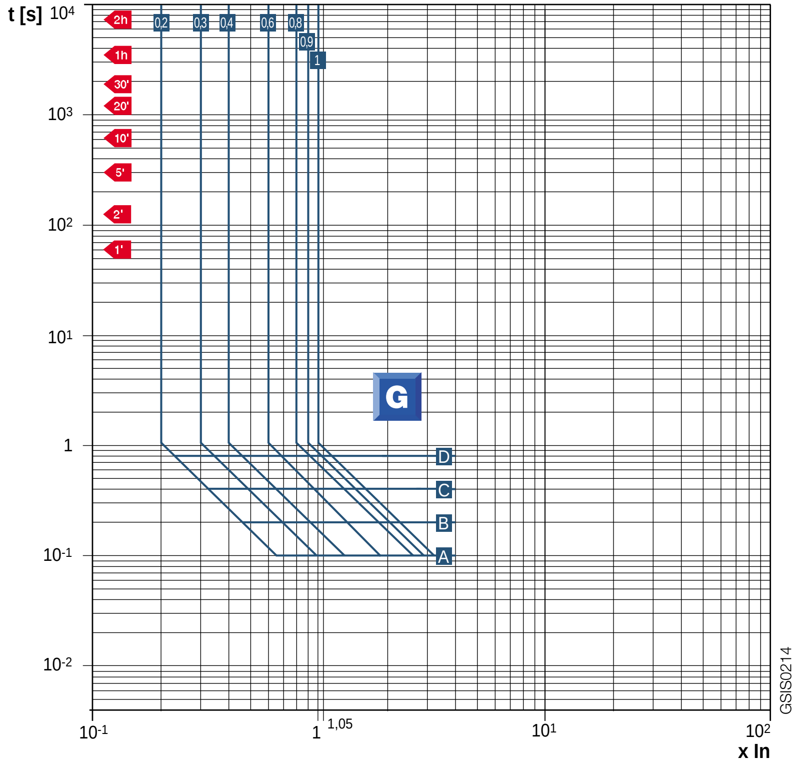


3 General characteristics

PR212/P

Trip curve
electronic releases

SACE Isomax S4-S5-S6-S7-S8
G function



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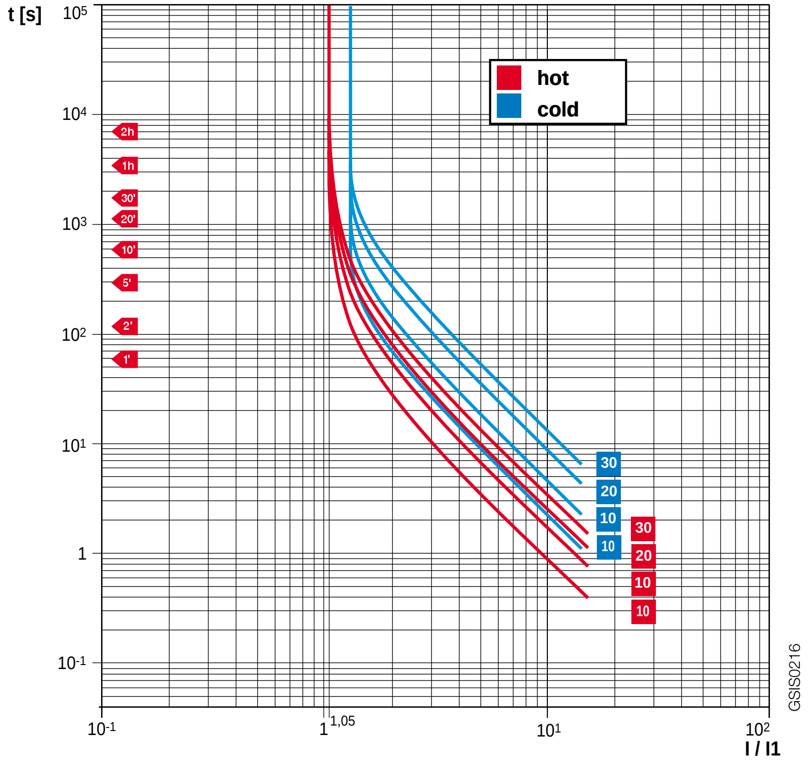
3 General characteristics

PR212/MP

Trip curve
electronic releases

SACE Isomax S4-S5-S6-S7
L function (hot and cold trip)



	I1	t1
PR212/MP	(0.4 ÷ 1) x In with step 0.01 x In	4 – 8 – 16 – 24 s

Here the tolerances

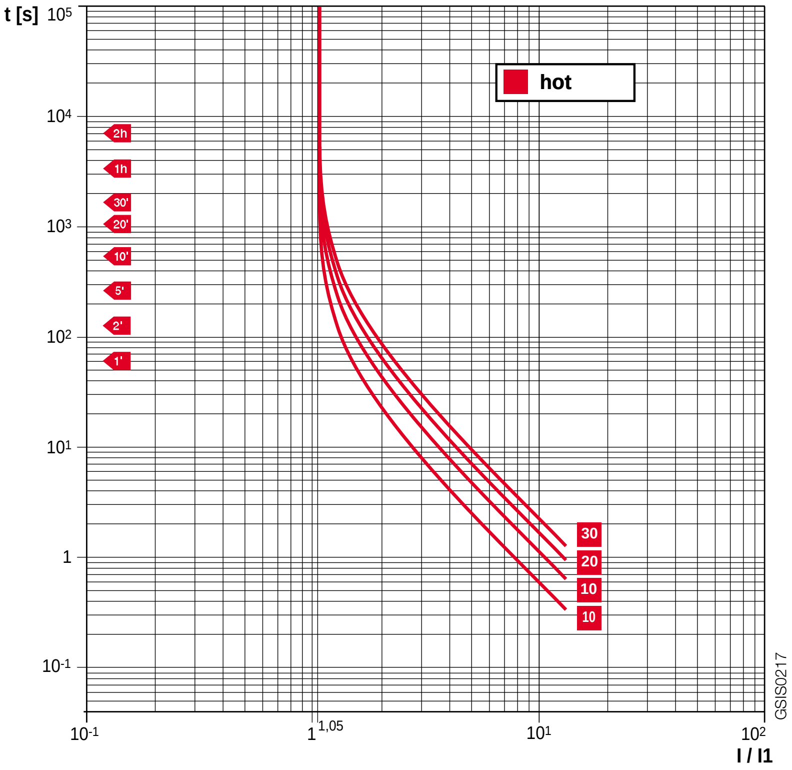
	I1	t1
PR212/MP	According to IEC 60947-4-1	According to IEC 60947-4-1

3 General characteristics

PR212/MP

Trip curve
electronic releases

S4-S5-S6-S7 SACE Isomax
L function (hot trip with one or two phases supplied)



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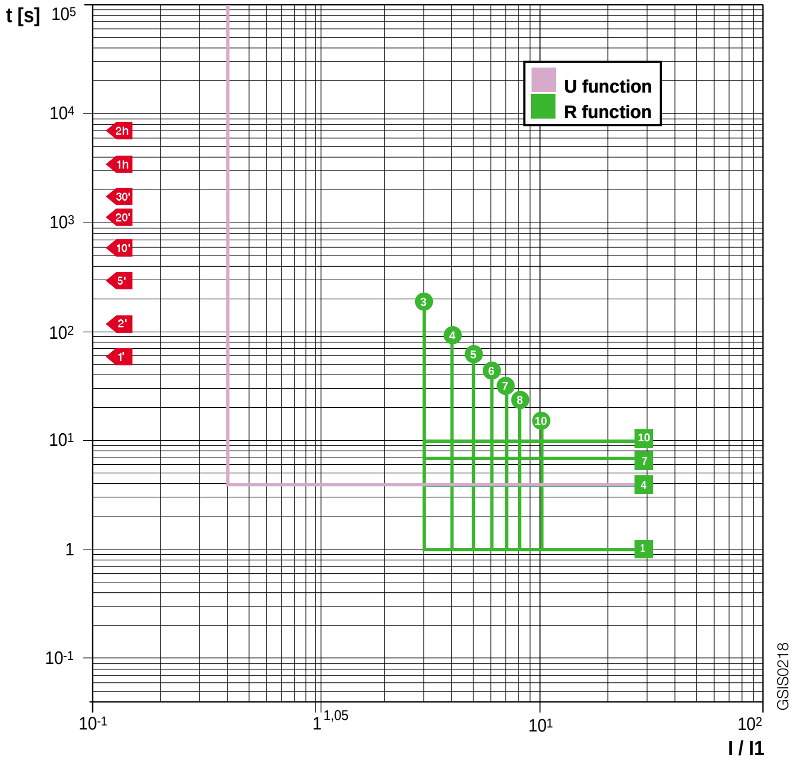
3 General characteristics

PR212/MP

Trip curve
electronic releases

S4-S5-S6-S7 SACE Isomax
R, U function



R	**I5**	**t5**
PR212/MP	(3 - 4- 5 - 6 - 7 - 8 - 10 - OFF) x I1	1 – 4 – 7 – 10 s
U	**I6**	**t6**
PR212/MP	0.4 x I1	4 s

Here the tolerances

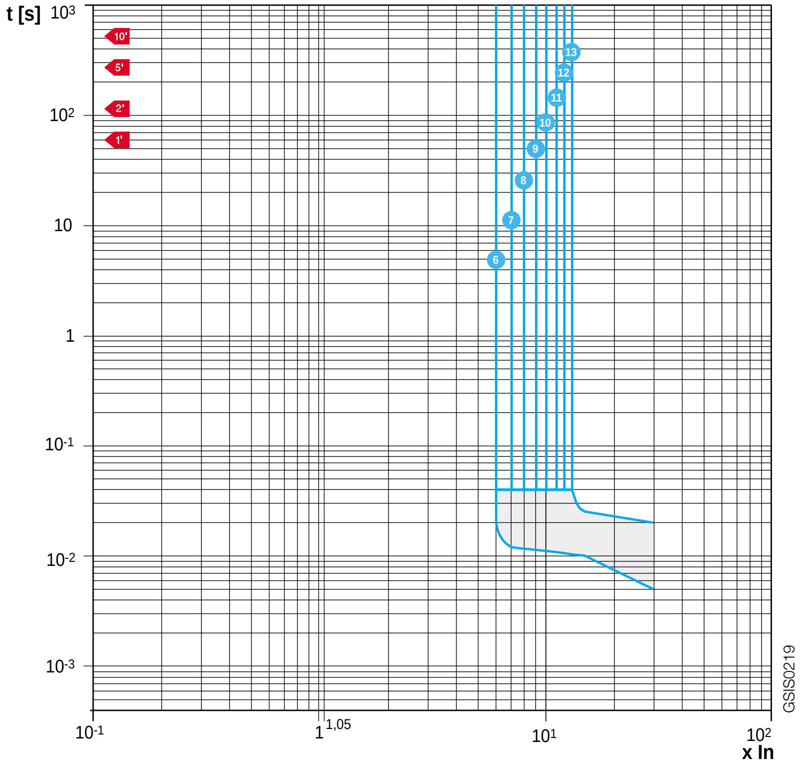
R	**I5**	**t5**
PR212/MP	± 10 %	± 20 %
U	**I6**	**t6**
PR212/MP	± 20 %	± 20 %

3 General characteristics

PR212/MP

Trip curve
electronic releases

S4-S5-S6-S7 SACE Isomax
I function



	I3
PR212/MP	(6 - 7- 8 - 9 - 10 - 11 - 12 - 13 - OFF) x In

The tolerances are according to IEC 60947-4-1.

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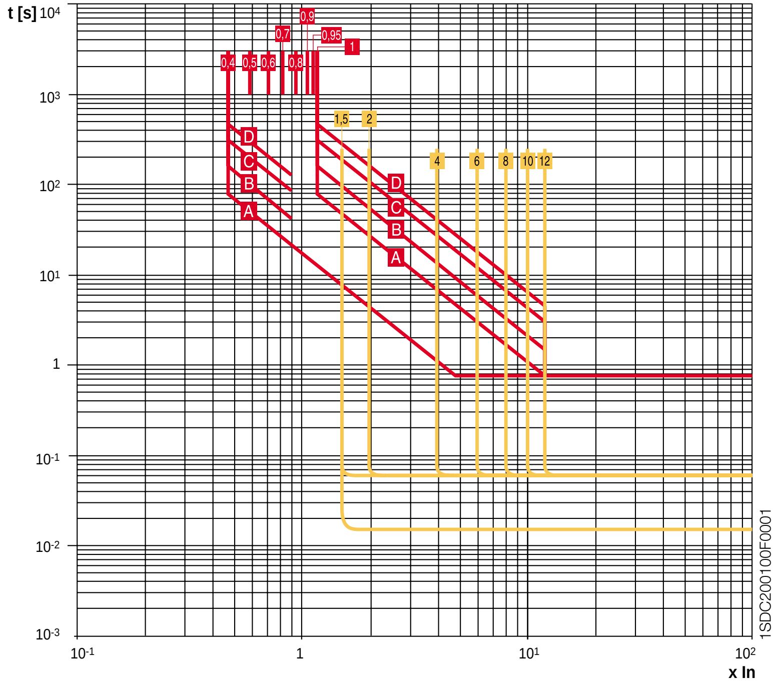
3 General characteristics

PR111/P

Trip curve
electronic releases

SACE Emax
LI function

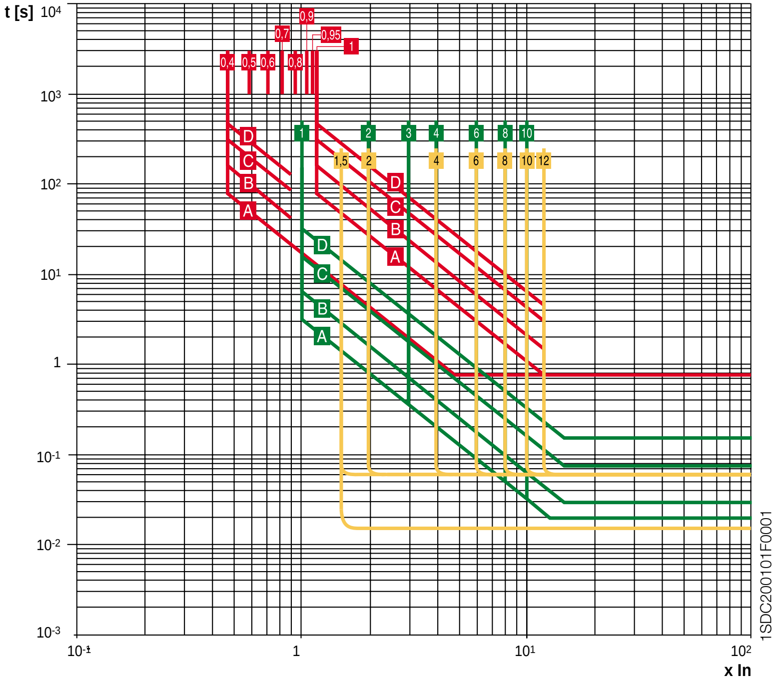


3 General characteristics

PR111/P

Trip curve
electronic releases

SACE Emax
LSI function, S inverse short time delay (I^2t = const. ON)

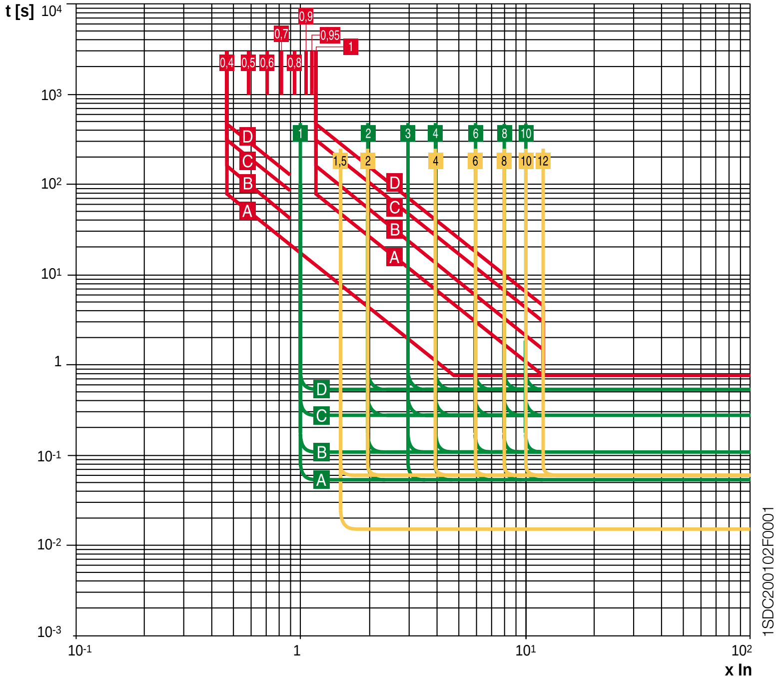


3 General characteristics

PR111/P

Trip curve
electronic releases

SACE Emax
LSI function, S independent time delay (I^2t = cost.OFF)

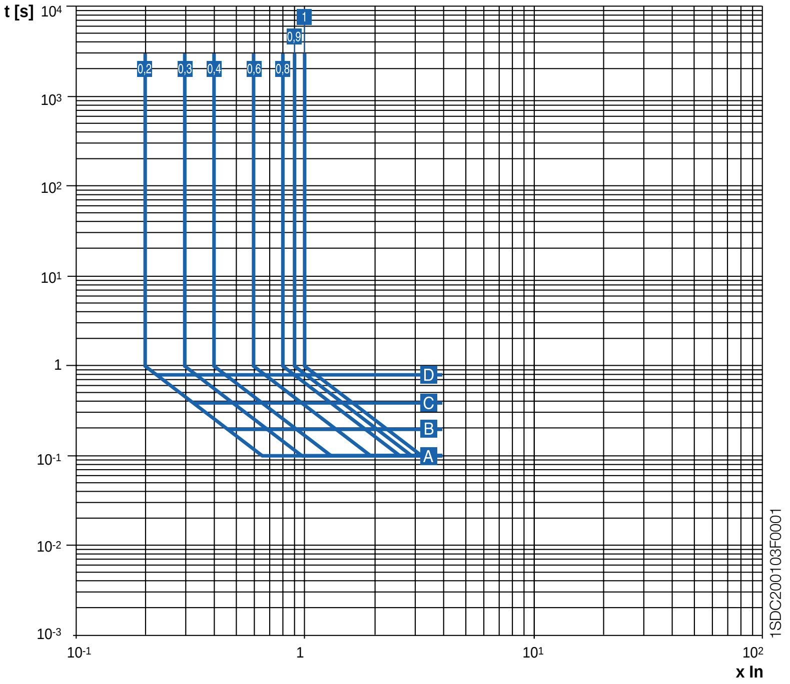


3 General characteristics

PR111/P

Trip curve
electronic releases

SACE Emax
G function



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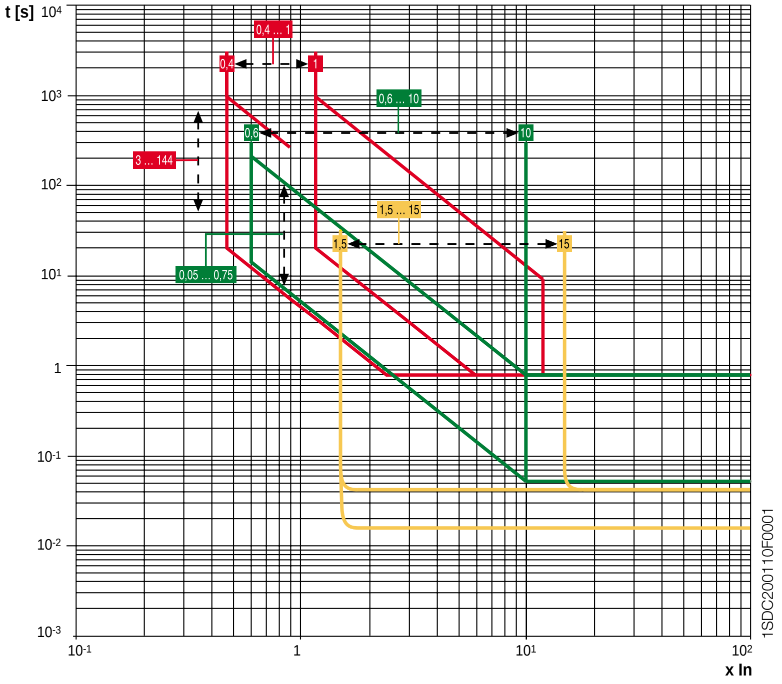
3 General characteristics

PR112/P-PR113/P

Trip curve
electronic releases

SACE Emax
LSI function, S inverse short time delay (I^2t = cost. ON)

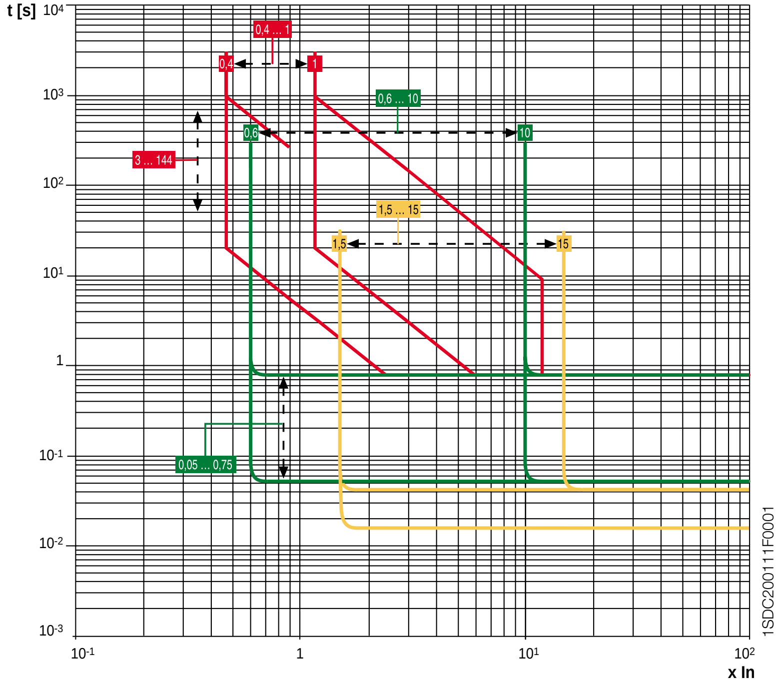


3 General characteristics

PR112/P – PR113/P

Trip curve
electronic releases

SACE Emax
LSI function, S independent time delay (I^2t = constant OFF)

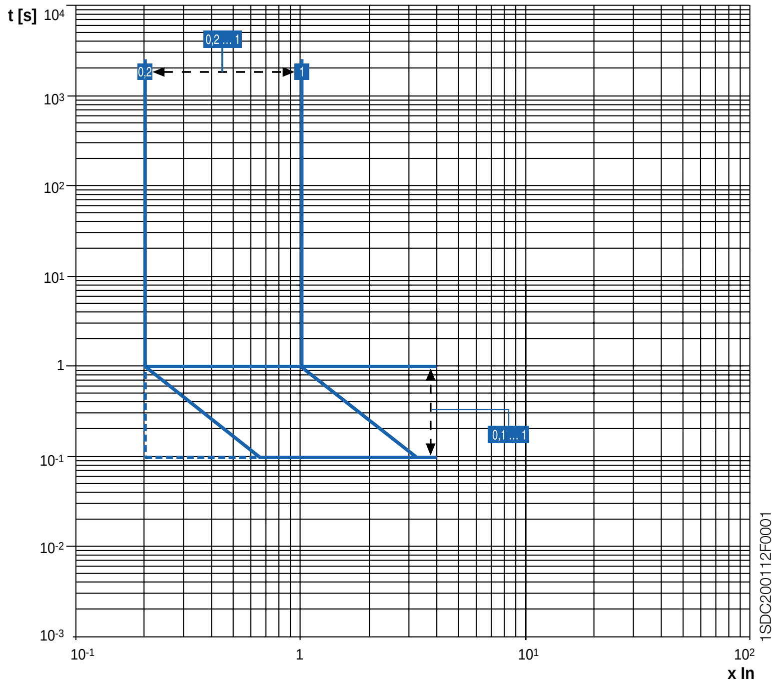


3 General characteristics

PR112/P – PR113/P

Trip curve
electronic releases

SACE Emax
G function



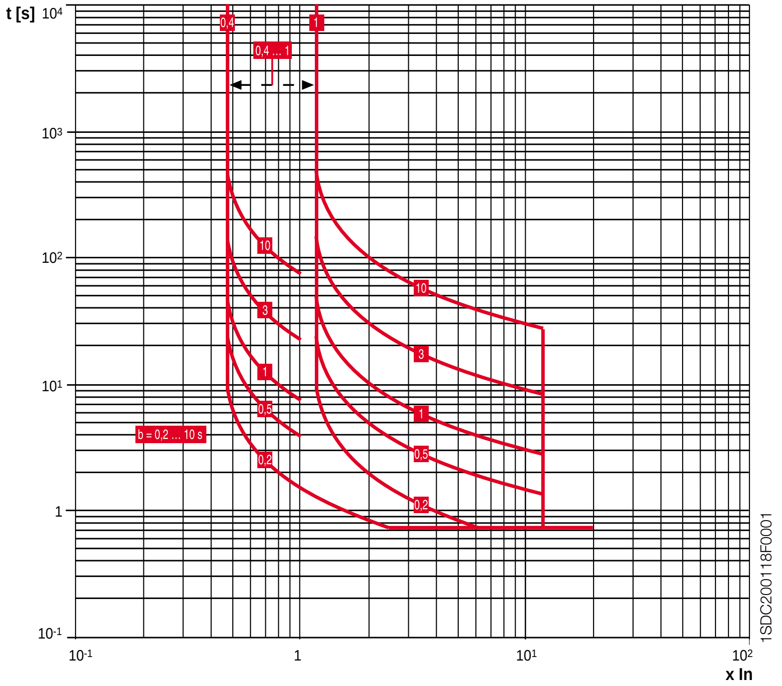
3 General characteristics

PR113/P release – Function L in compliance with Std. IEC 60255-3

The following three curves refer to the protection function L complying with Std. IEC 60255-3 and integrate the standard one; they are applicable in coordination with fuses and MV circuit- breakers.

Trip curve
electronic releases

L function, Normal Inverse Curve



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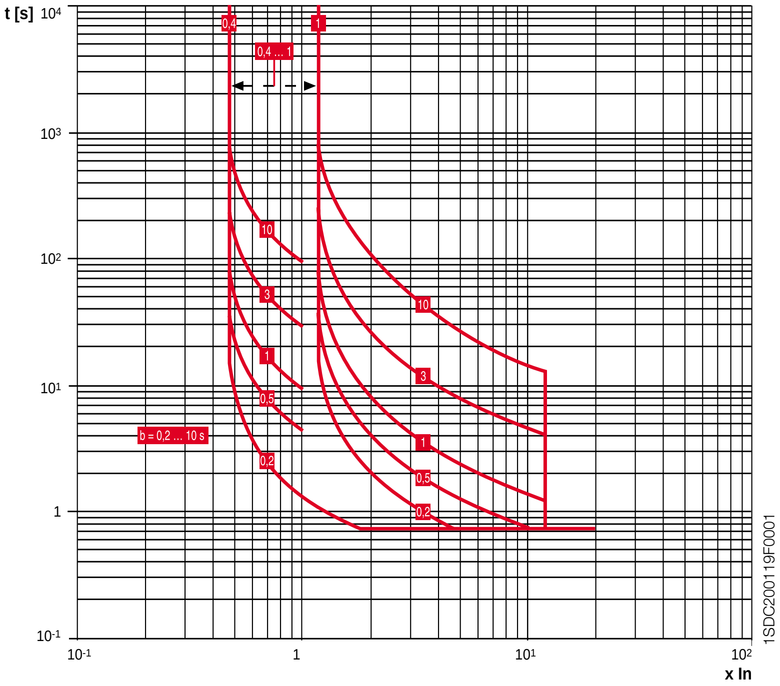
3 General characteristics

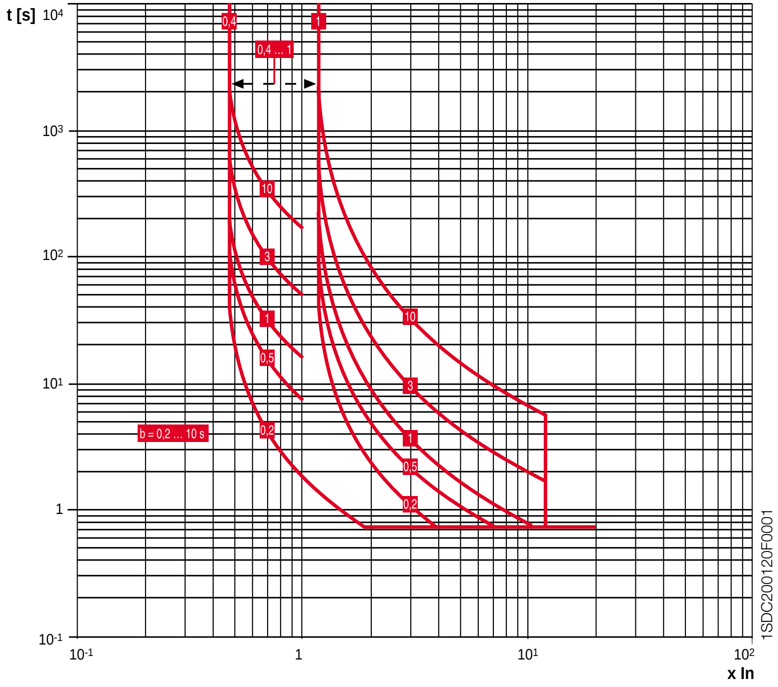
Trip curve
electronic releases

L function, Very Inverse Curve



Trip curve
electronic releases

L function, Extremely Inverse Curve



	I1	t1
PR113	(0.4 ÷ 1) x In with step 0.01 x In	b = 0.2 ÷ 10 with step 0.1 s

Here below the tolerances:

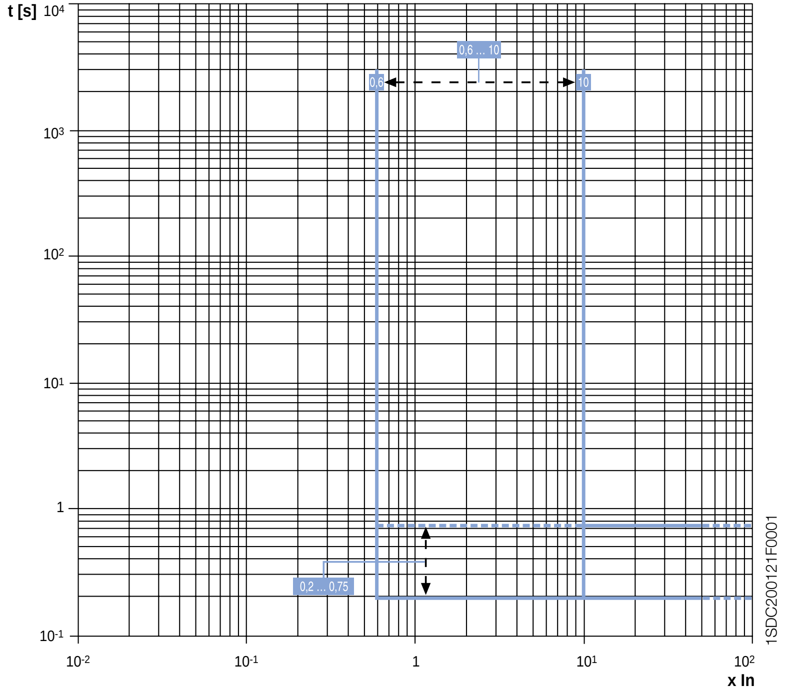
PR113	1.1÷1.25 x I1	± 30 % (2 ÷ 5) x In ± 20 % over 5 x In

PR113/P release – Other protection functions

The following curves refer to the particular protection functions provided for PR113/P.

Trip curve
electronic releases

D function, Directional Short Circuit Protection



	I7	t7
PR113	(0.6 … 10 – OFF) x In with step 0.1 x In	0.2 … 0.75s with step 0.01s

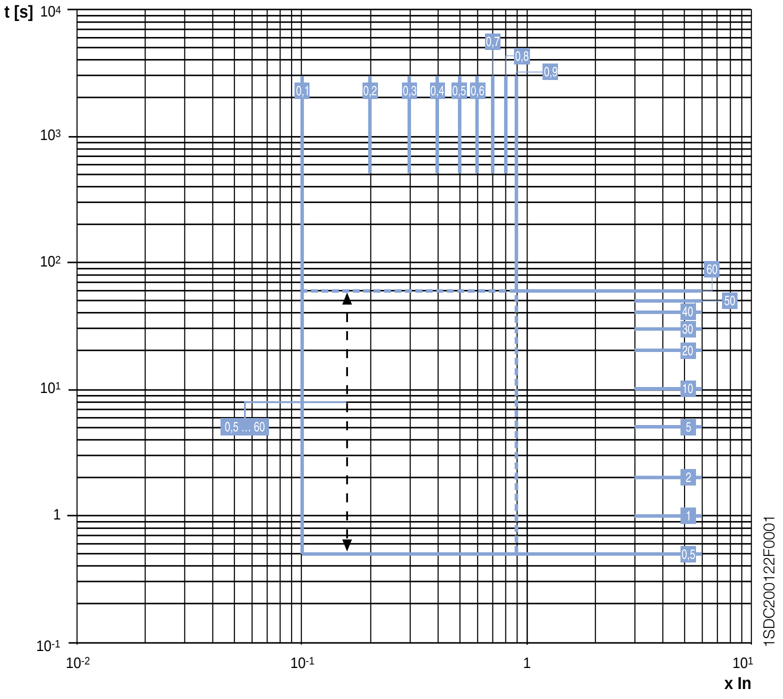
Here below the tolerances:

	I7	t7
PR113	± 10 %	± 20 %

3 General characteristics

Trip curve
electronic releases

U function, Phase Unbalance Protection



	I6	t6
PR113	(10% … 90% – OFF) with step 10%	0.5 … 60s with step 0.5s

Here below the tolerances:

	I6	t6
PR113	± 10 %	± 20 %

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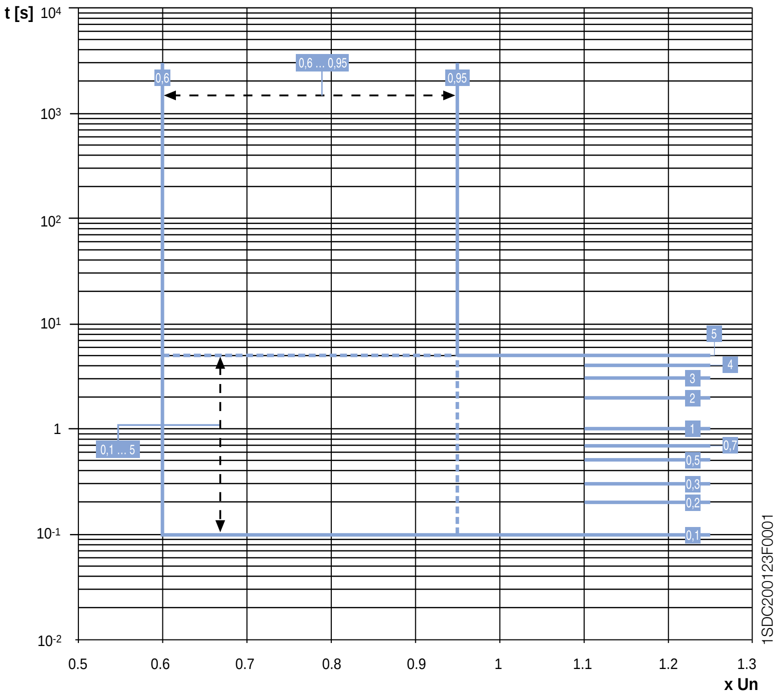
3 General characteristics

Trip curve
electronic releases

UV function, Undervoltage Protection



	I6	t6
PR113	(0.6 … 0.95 – OFF) x Un with step 0.01 x Un	0.1 … 5s with step 0.1s

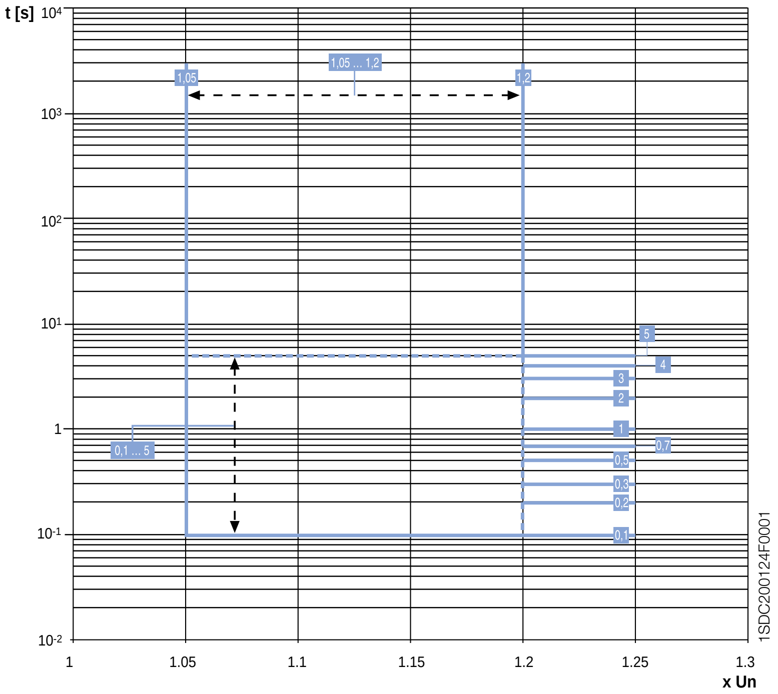
Here below the tolerances:

	I6	t6
PR113	± 5 %	± 20 %

3 General characteristics

Trip curve
electronic releases

OV function, Overvoltage Protection



	I9	t9
PR113	(1.05 … 1.2 – OFF) x Un with step 0.01 x Un	0.1 … 5s with step 0.1s

Here below the tolerances:

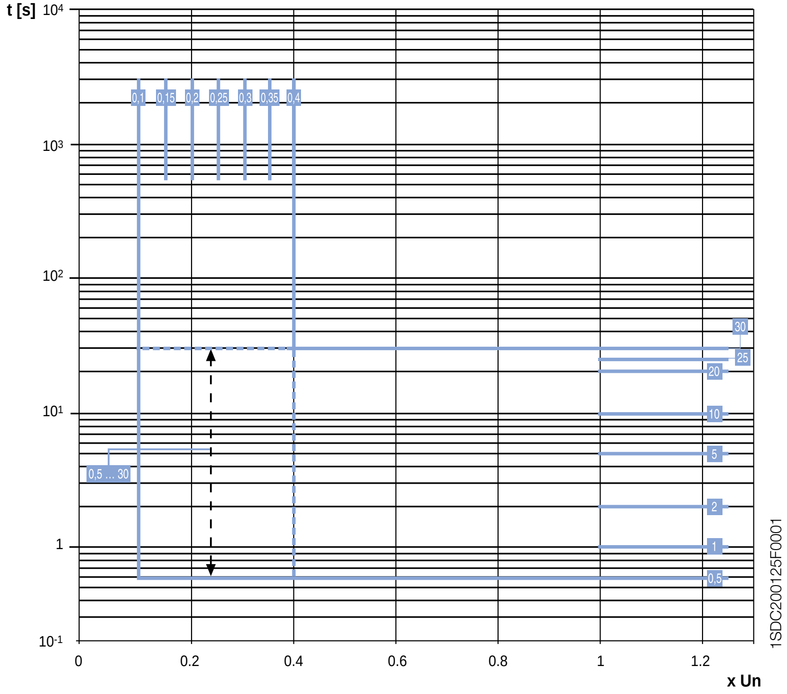
	I9	t9
PR113	± 5 %	± 20 %

---

3 General characteristics

Trip curve
electronic releases

RV function, Residual Voltage Protection



	I10	t10
PR113	(0.1 … 0.4 – OFF) x Un with step 0.05 x Un	0.5 … 30s with step 0.5s

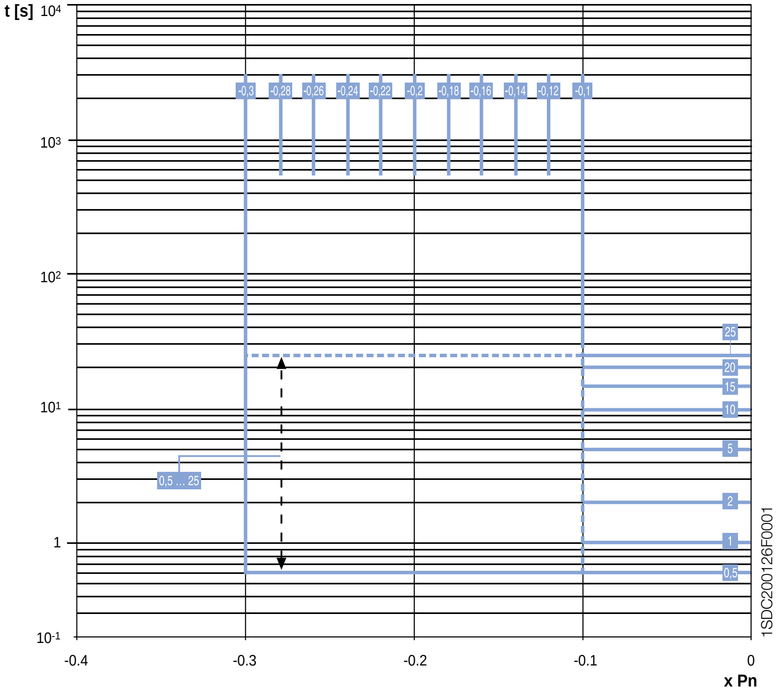
Here below the tolerances:

	I10	t10
PR113	± 5 %	± 20 %

3 General characteristics

Trip curve
electronic releases

RP function, Reverse Power Protection



	P11	t11
PR113	(-0.3 … -0.1 – OFF) x Pn with step 0.02 x Pn	0.1 … 25s with step 0.1s

Here below the tolerances:

	P11	t11
PR113	± 10 %	± 20 %

3 General characteristics

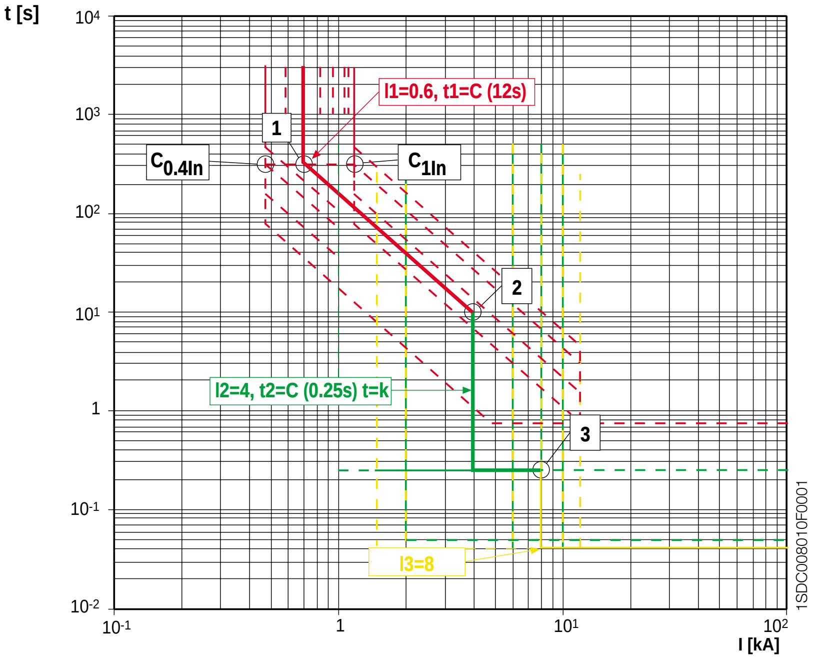
Example of electronic release setting

Considering a circuit-breaker type E1B1250 fitted with a PR111/P LSI release and with TA of 1000 A, it is supposed that for the system requirements, the protection functions are regulated according to the following settings:

L	I1=0.6	t1=C
S	I2=4	t2=C (t=k)
I	I3=8	

The trip curve of the release is represented in the following figure (continuous lines): it can be seen that:

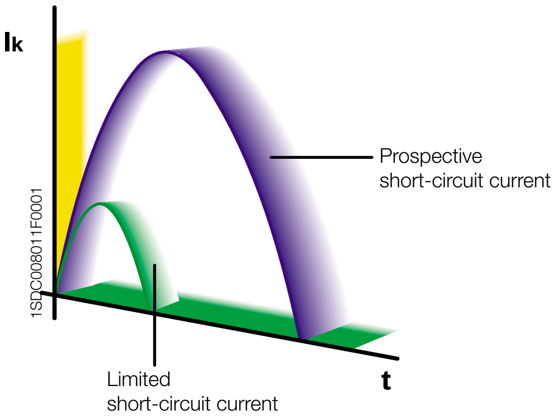
- for function L, the curve is represented by the mean value between the tolerances given by the Standard (the overload protection function must not trip for current values lower than 1.05·In, and must trip within 1.3·In), therefore corresponding to 1.175·In (around 700 A);
- graphically, point **1** is obtained at the intersection of the vertical part of function L and the horizontal segment ($C_{0.4In}$-C_{1In}) which connects the points relevant to the same t1, taken from the curves with setting 0.4·In and 1·In;
- corresponding to point **2** (4000 A), the function S takes the place of function L, as the trip time of function S is lower than the trip time of function L;
- in the same way as for point **2**, for point **3** (8000 A) and beyond, function S is substituted by function I.



3 General characteristics

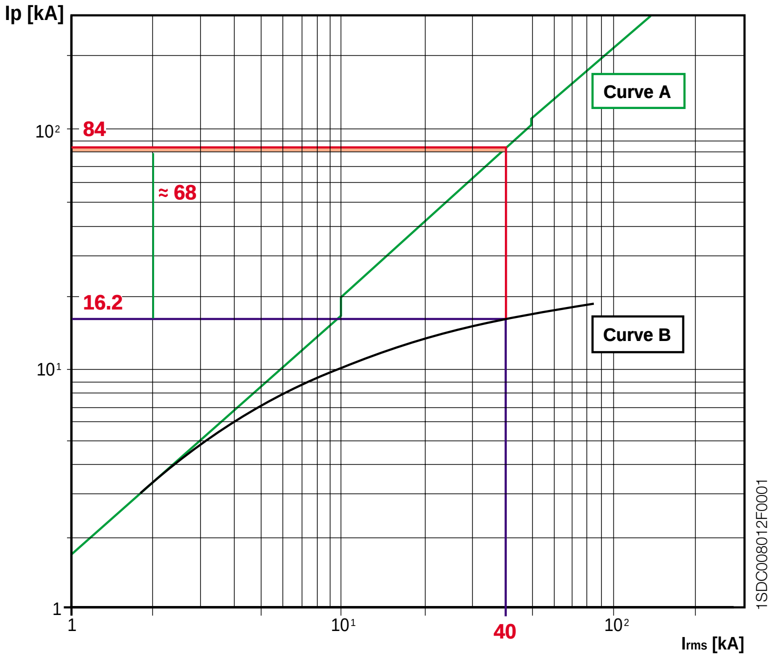
3.3 Limitation curves

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 2.2 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 T2L160, R160 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).

Circuit-breaker T2L160 with thermomagnetic release R160 at 400 V, for a fault current of 40 kA, limits the short-circuit peak to 16.2 kA only, with a reduction of about 68 kA compared with the peak value in the absence of limitation (84 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.

In addition to the advantages in terms of design, the use of current-limiting circuit-breakers allows, for the cases detailed by Standard IEC 60439-1, 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.

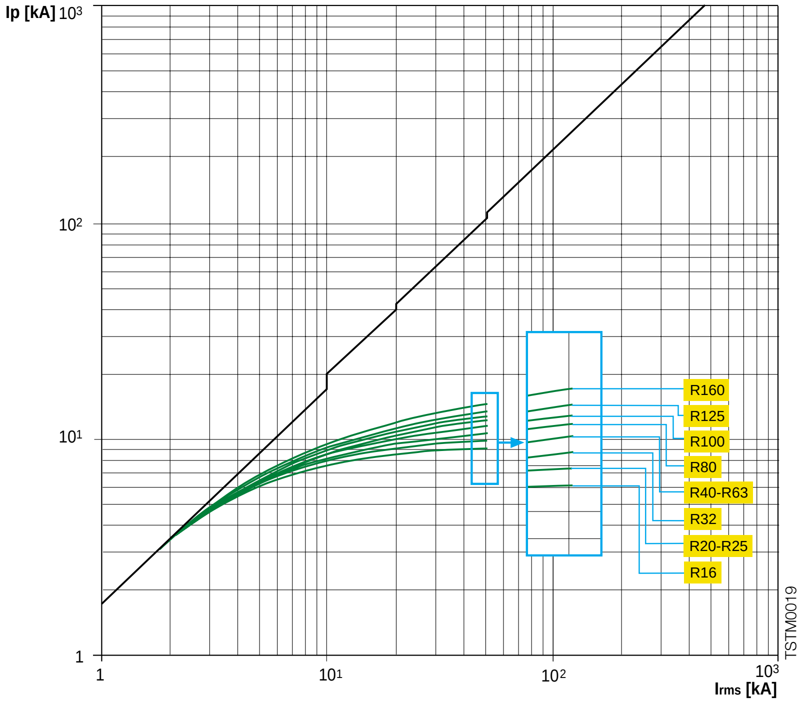
...”

The example above is 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 40 kA, it would not be necessary to carry out the verification of short-circuit withstand.

3 General characteristics

Limitation curves

Tmax T1 160 – 230V



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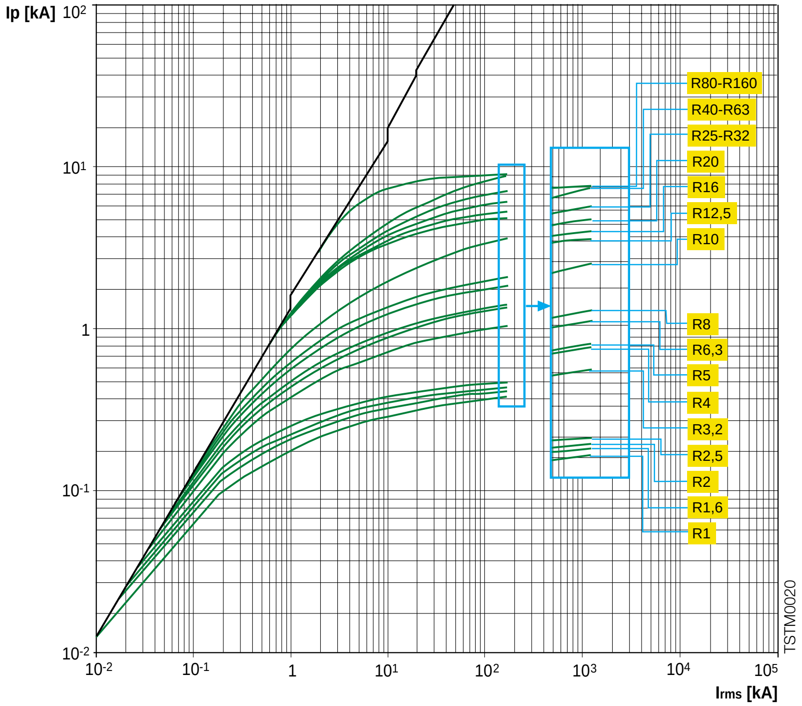
3 General characteristics

Limitation curves

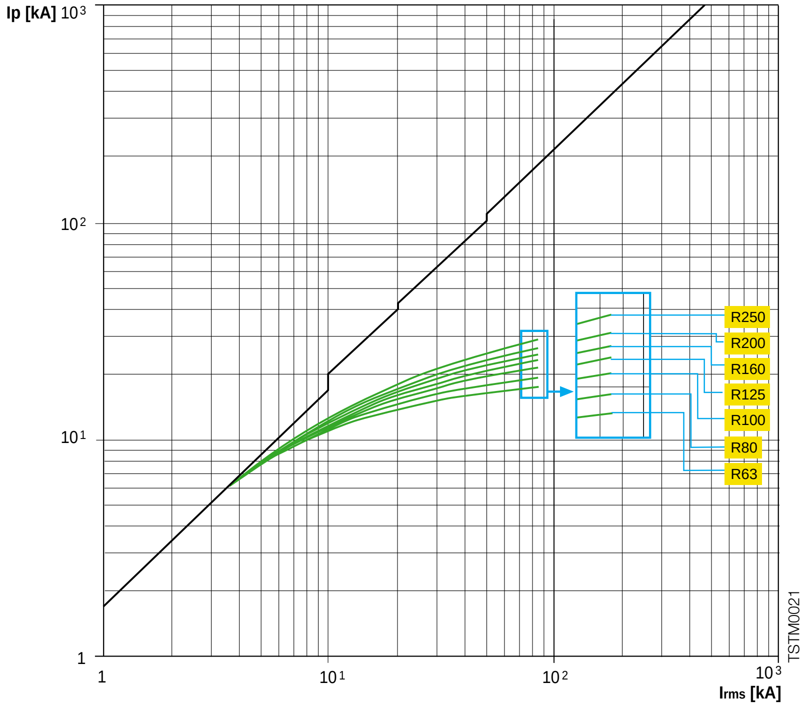
Tmax T2 160 – 230V



3 General characteristics

Limitation curves

Tmax T3 250 – 230V



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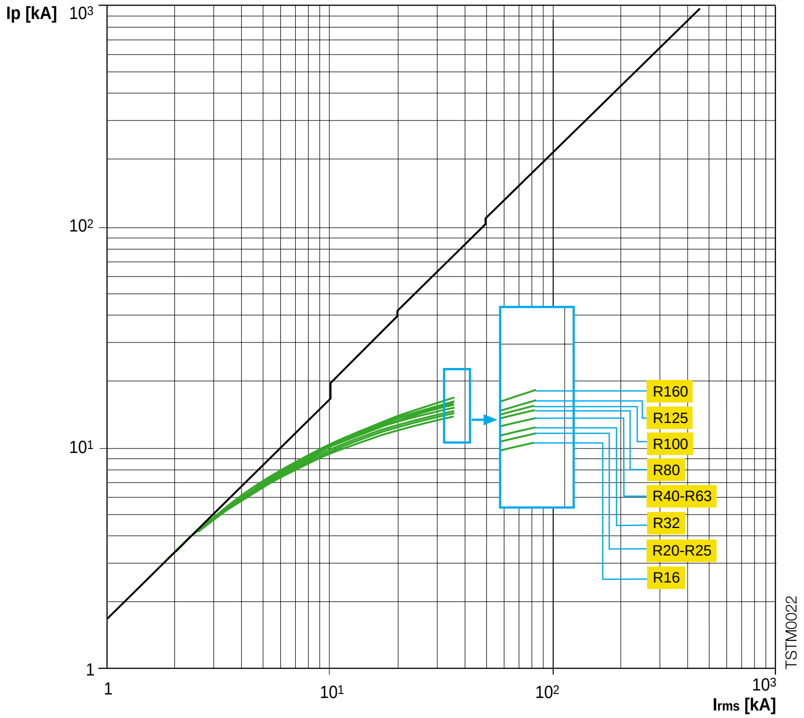
3 General characteristics

Limitation curves

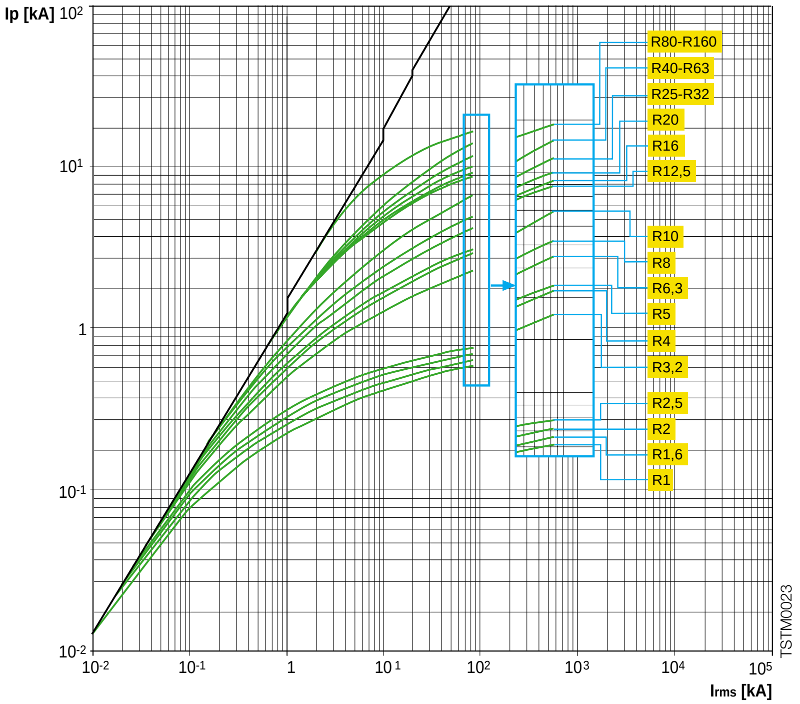
Tmax T1 160 – 400-440V



3 General characteristics

Limitation curves

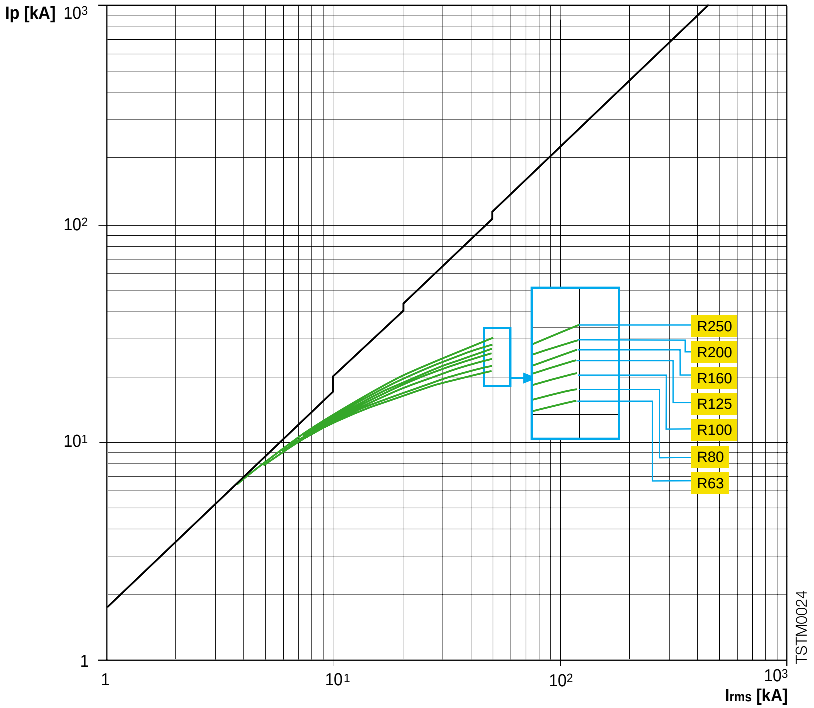
Tmax T2 160 – 400-440V



3 General characteristics

Limitation curves

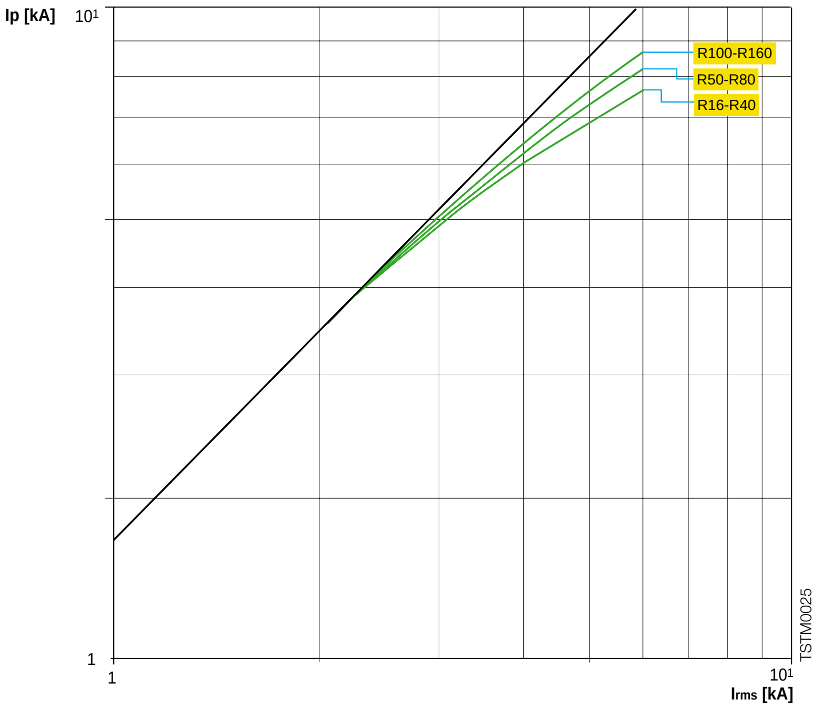
Tmax T3 250 – 400-440V



3 General characteristics

Limitation curves

Tmax T1 160 – 690V



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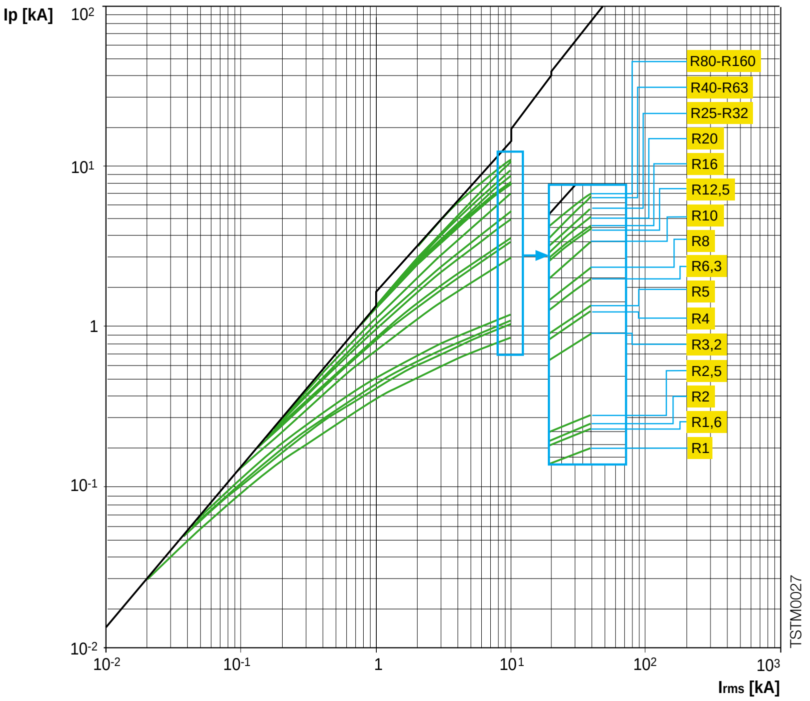
3 General characteristics

Limitation curves

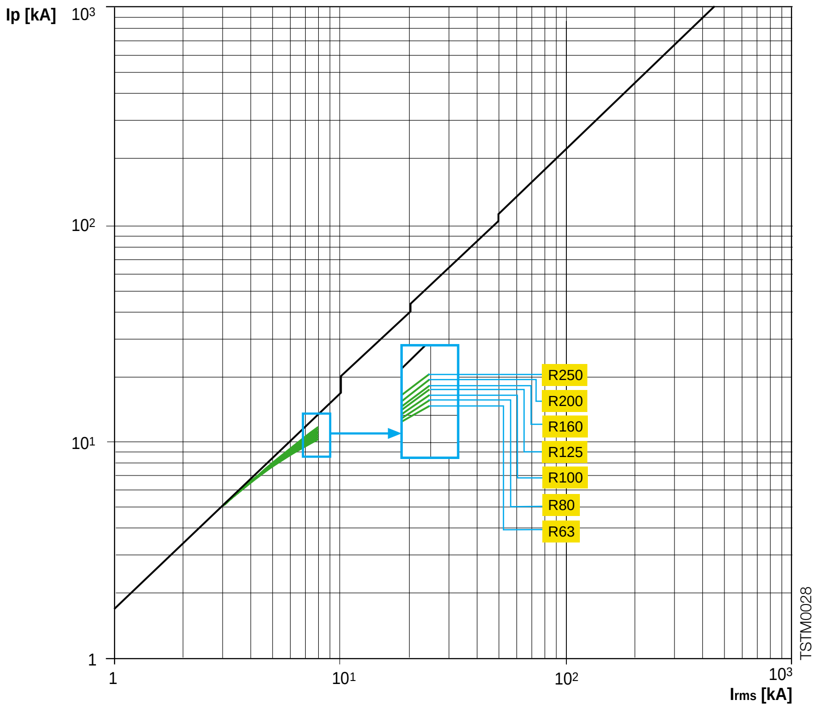
Tmax T2 160 – 690V



3 General characteristics

Limitation curves

Tmax T3 250 – 690V



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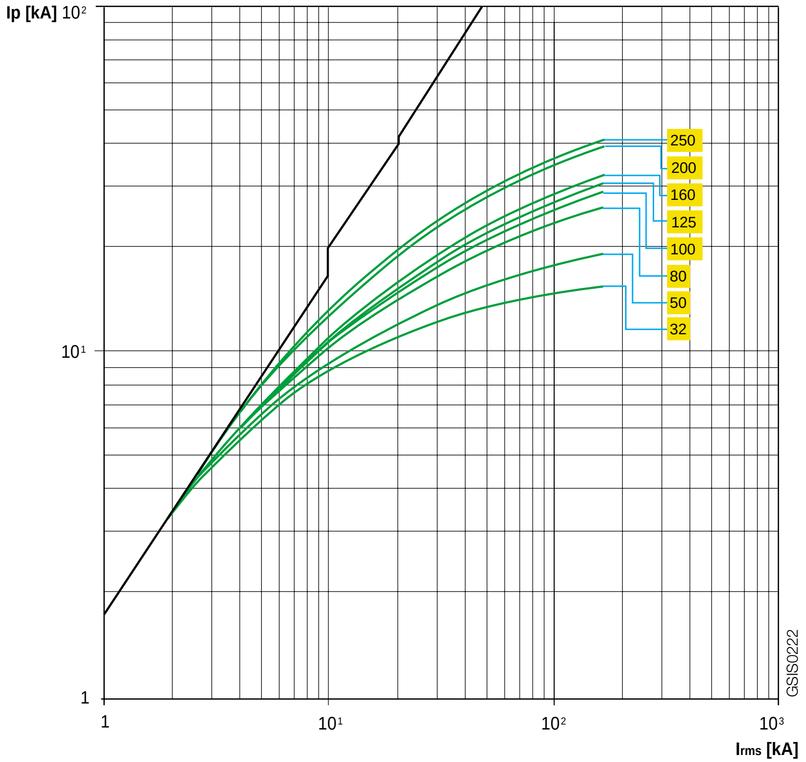
3 General characteristics

Limitation curves

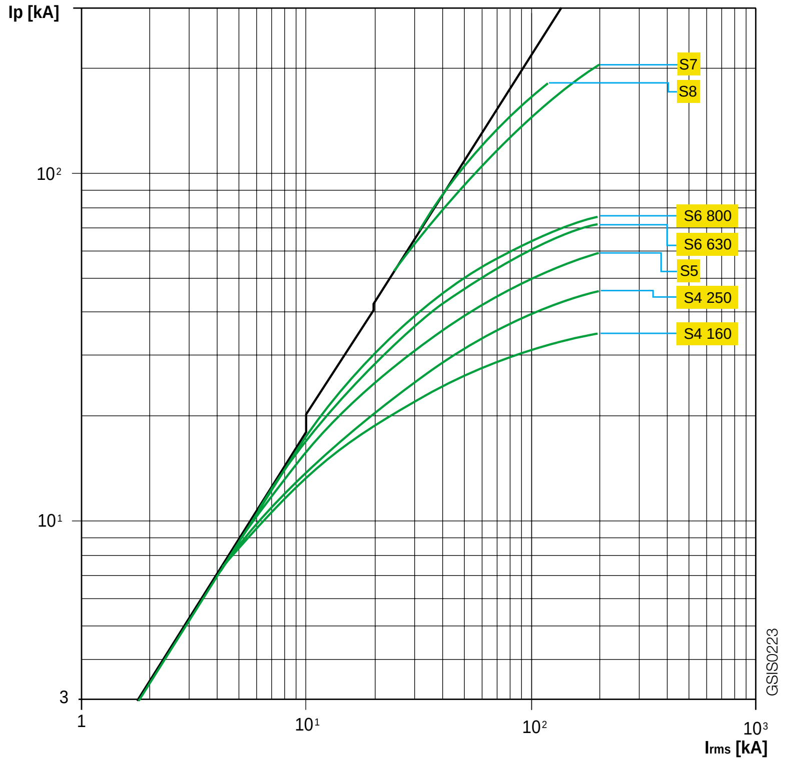
Sace Isomax S3 160 – S3 250 – 230V



3 General characteristics

Limitation curves

SACE Isomax S4 160 – S4 250 – S5 – S6 630 – S6 800 – S7 – S8 – 230V



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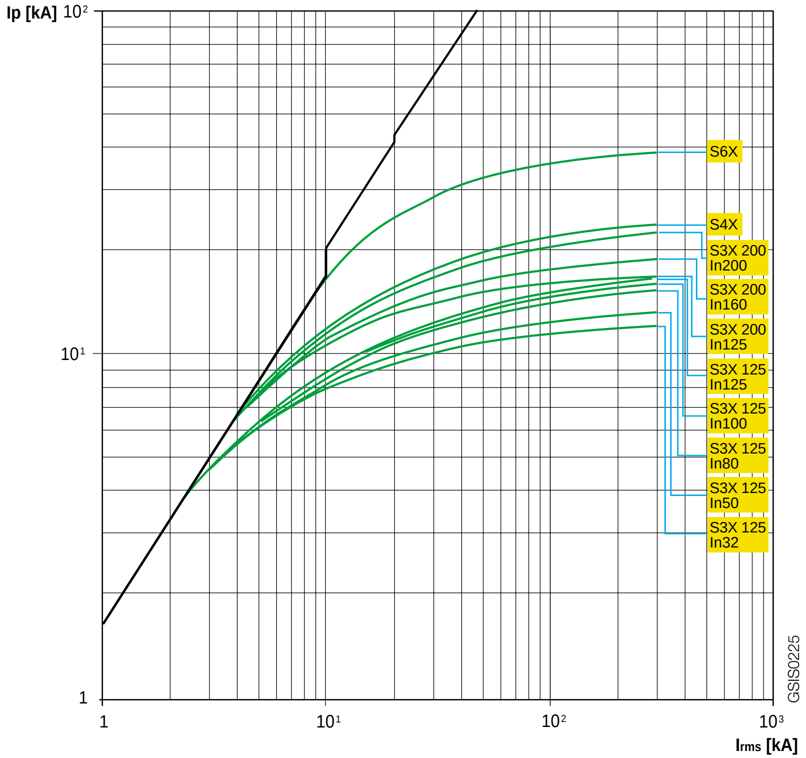
3 General characteristics

Limitation curves

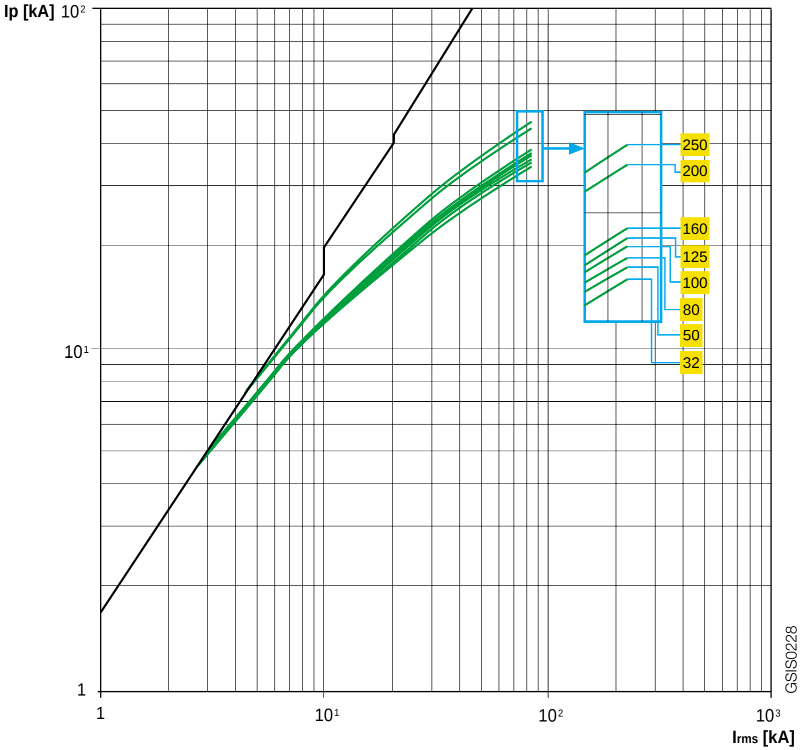
SACE Isomax S3X 125 – S3X 200 – S4X – S6X – 230V



3 General characteristics

Limitation curves

SACE Isomax S3 160 – S3 250 – 400-440V



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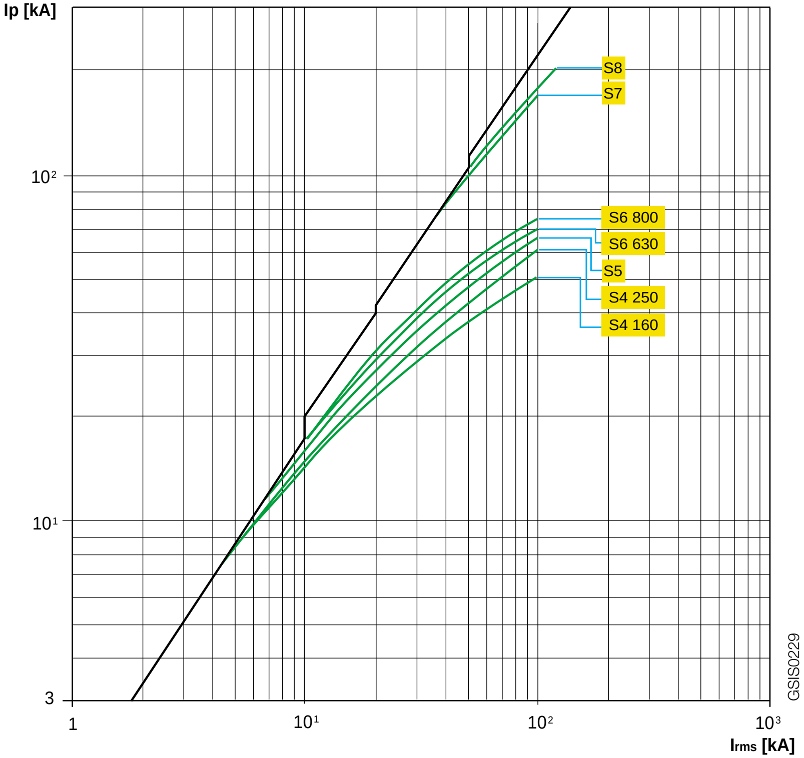
3 General characteristics

Limitation curves

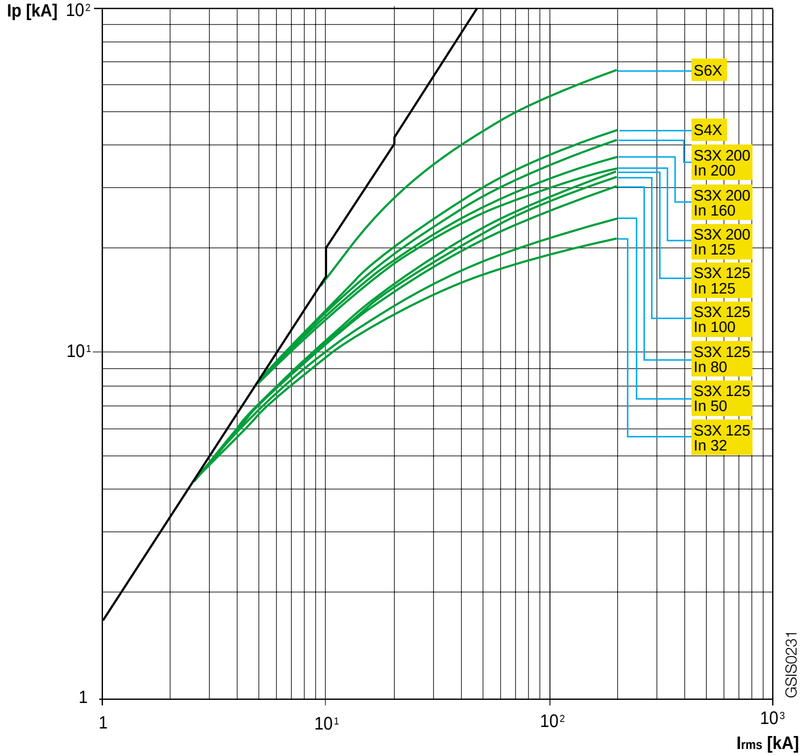
SACE Isomax S4 160 – S4 250 – S5 – S6 630 – S6 800 – S7 – S8 – 400 - 440V



3 General characteristics

Limitation curves

SACE Isomax S3X 125 – S3X 200 – S4X – S6X – 400-440V



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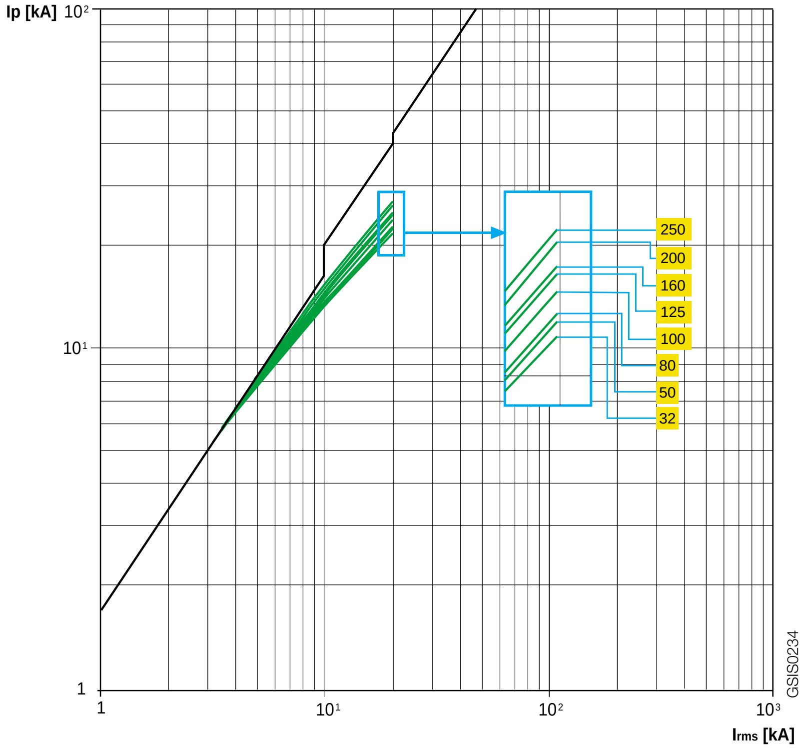
3 General characteristics

Limitation curves

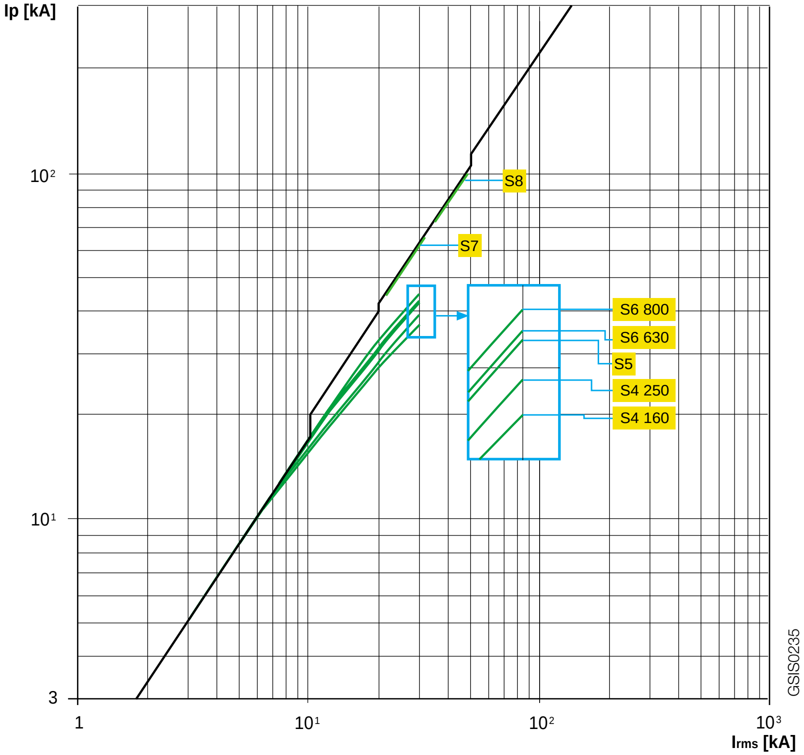
SACE Isomax S3 160 – S3 250 – 690V



3 General characteristics

Limitation curves

SACE Isomax S4 160 – S4 250 – S5 – S6 630 – S6 800 – S7 – S8 – 690V



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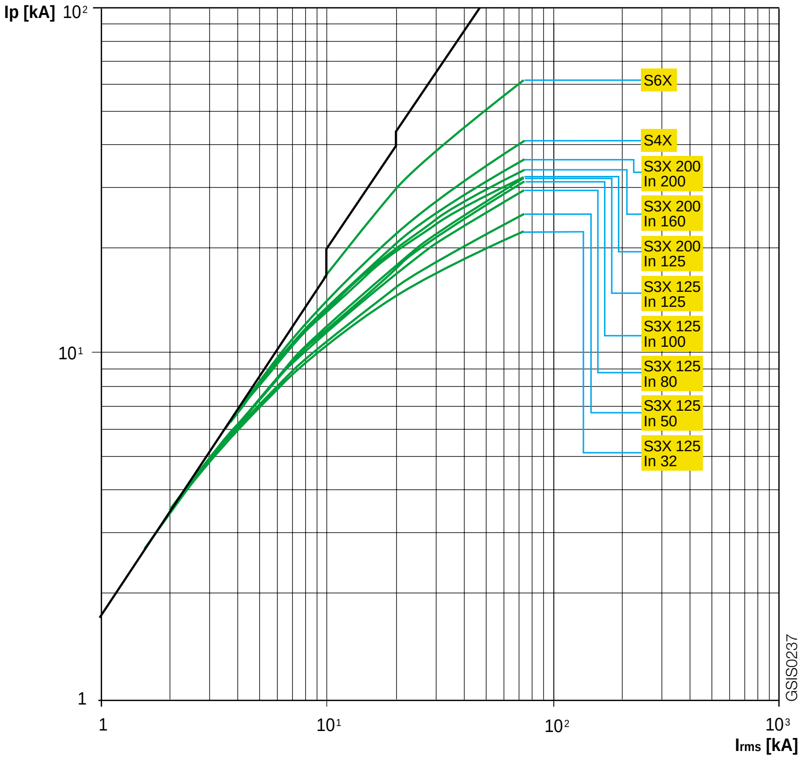
3 General characteristics

Limitation curves

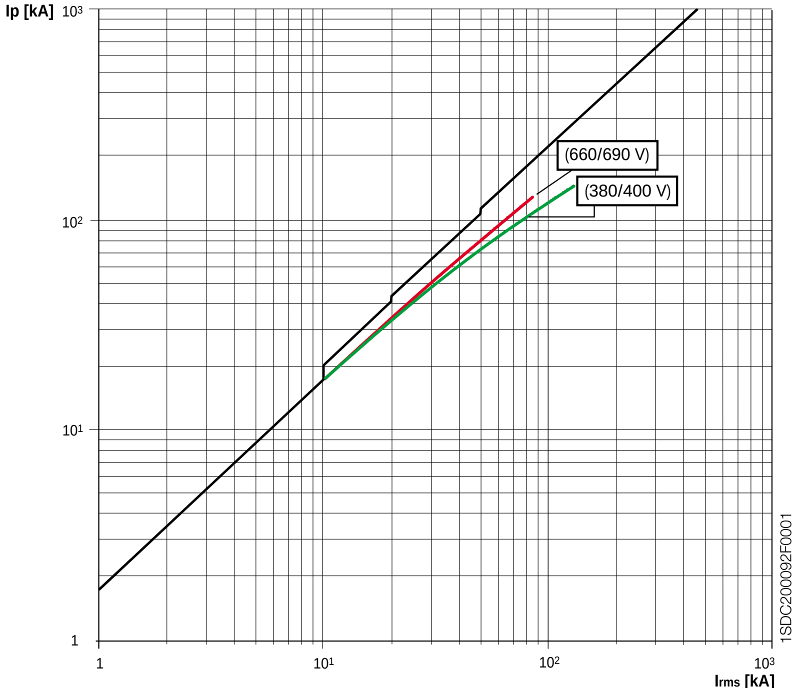
SACE Isomax S3X 125 – S3X 200 – S4X – S6X – 690V



3 General characteristics

Limitation curves

Emax E2L 660/690 V-380/400V



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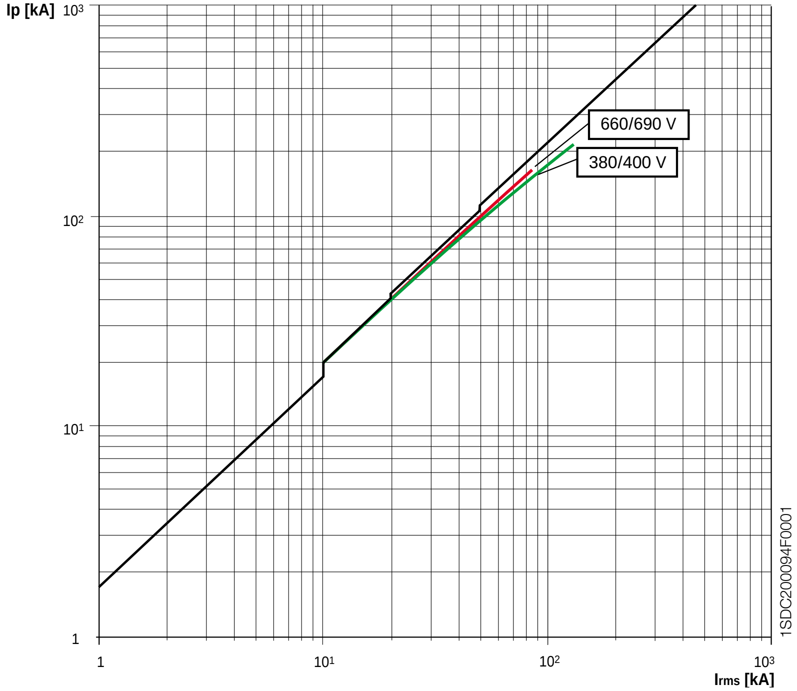
3 General characteristics

Limitation curves

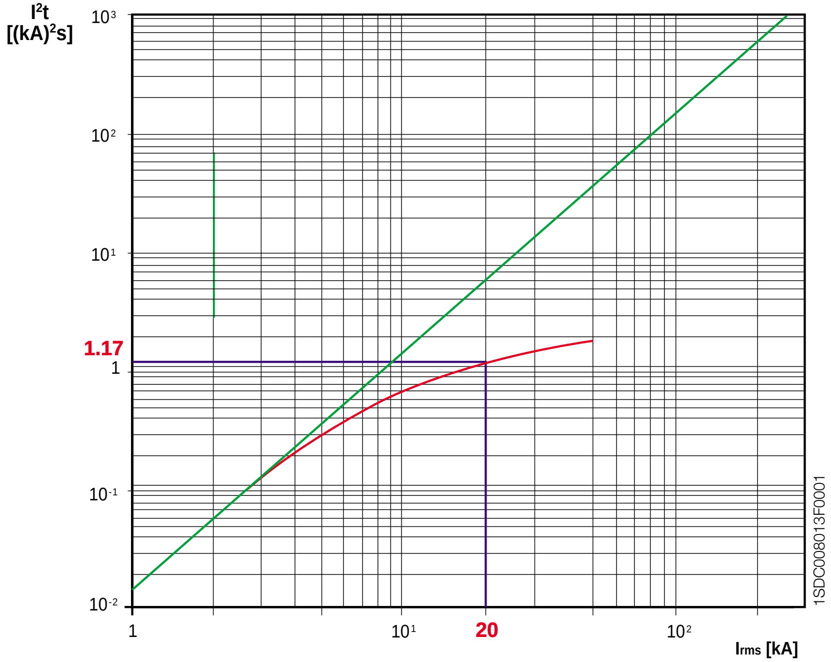
Emax E3L 660/690V-380/400V



3.4 Specific let-through energy curves

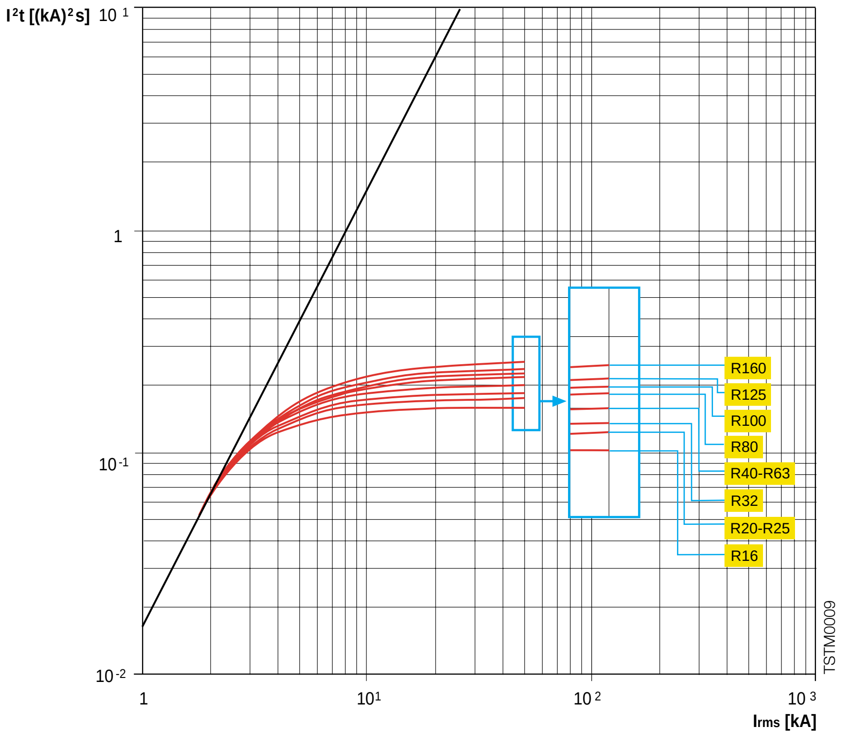
In case of short-circuit, the parts of a plant affected by a fault are subjected to thermal stresses which are proportional both to the square of the fault current as well as to the time required by the protection device to break the current. The energy let through by the protection device during the 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 T3S 250 R160 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 $(kA)^2s$.
Corresponding to a short-circuit current equal to 20 kA, the circuit-breaker lets through a value of I^2t equal to 1.17 $(kA)^2s$ (1170000 A^2s).



Specific let-through energy curves

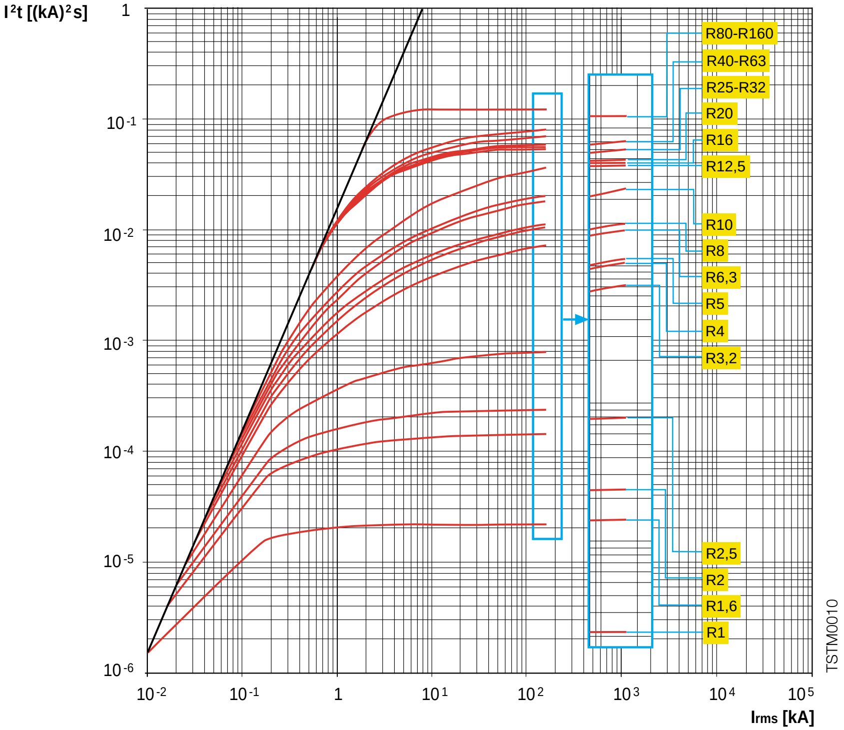
Tmax T1 160 – 230V



3 General characteristics

Specific let-through energy curves

Tmax T2 160 – 230V



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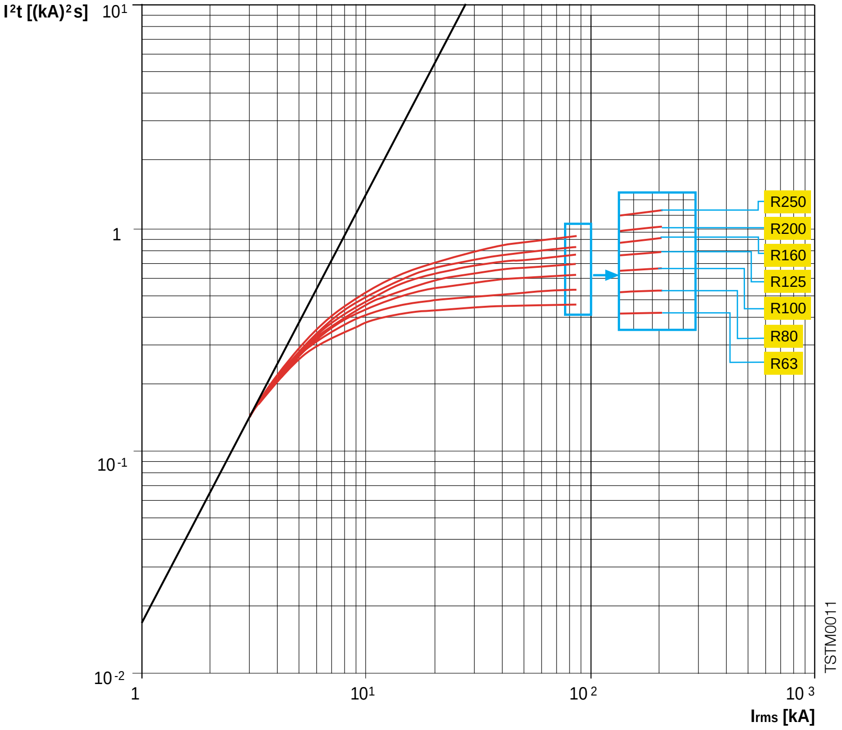
3 General characteristics

Specific let-through energy curves

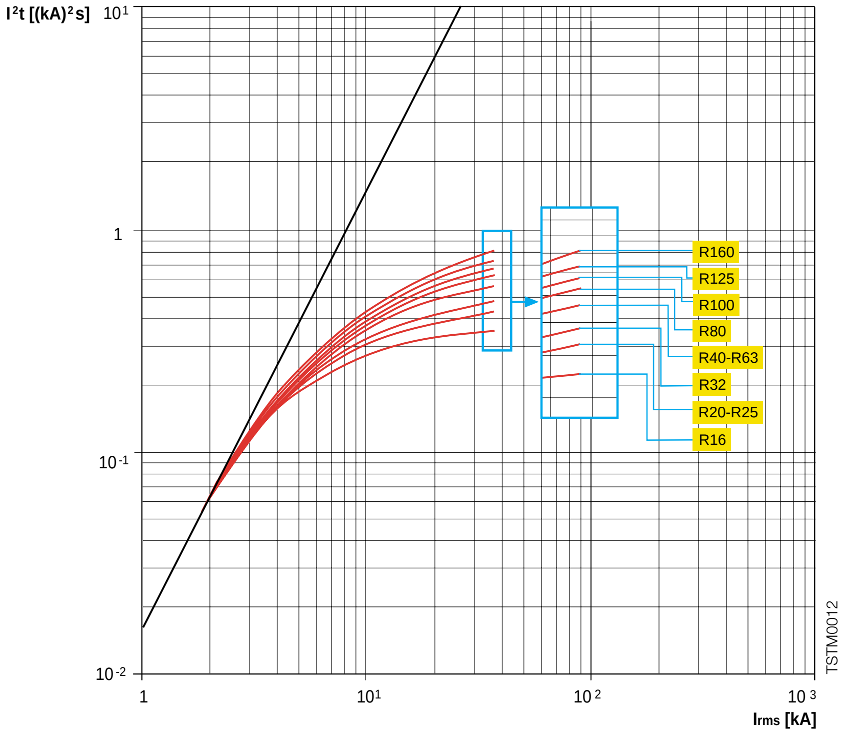
Tmax T3 250 – 230V



3 General characteristics

Specific let-through energy curves

Tmax T1 160 – 400-440V



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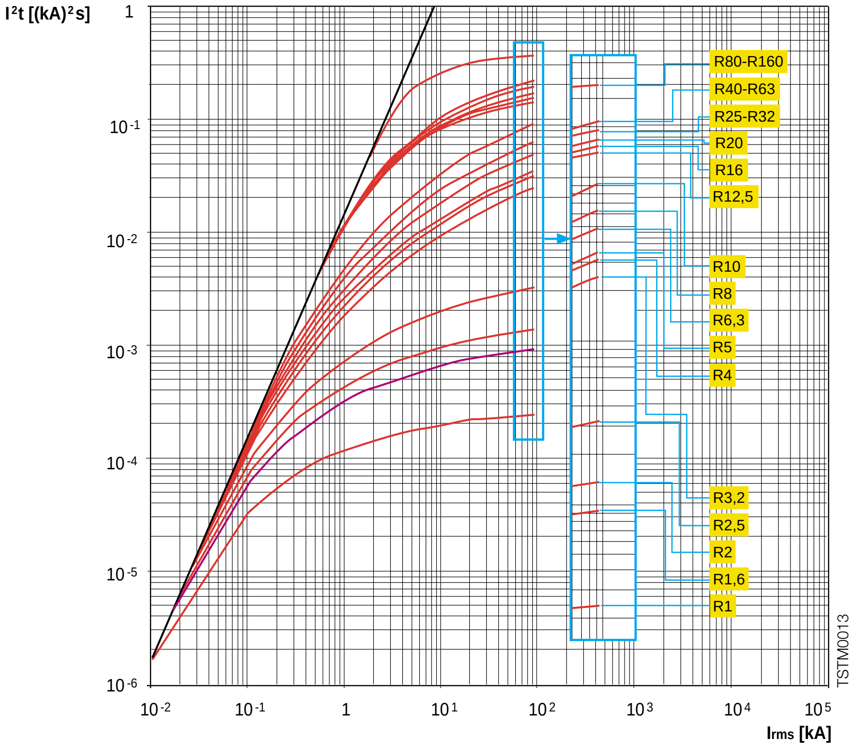
3 General characteristics

Specific let-through energy curves

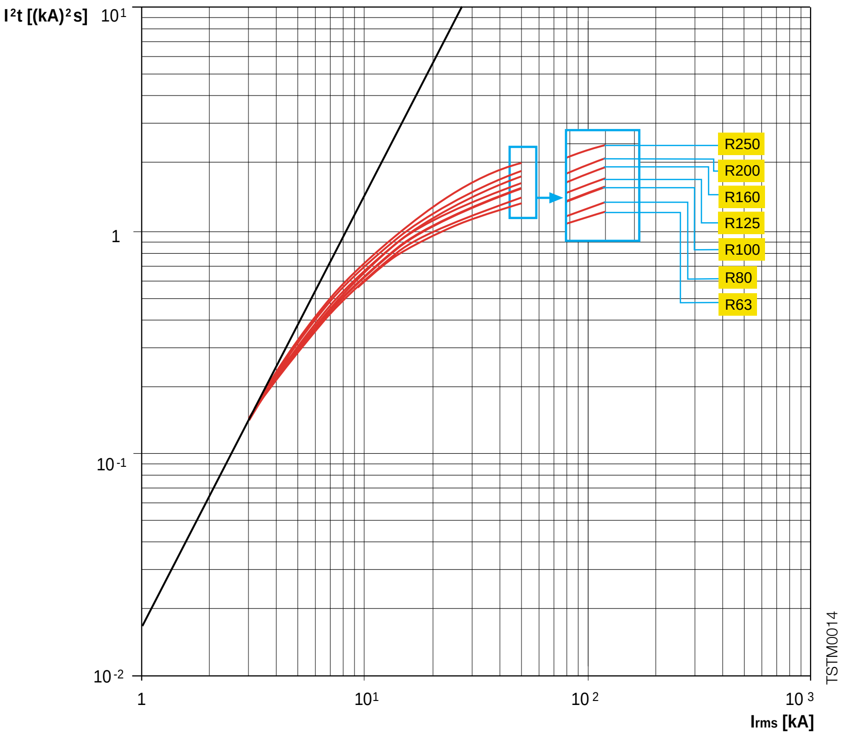
Tmax T2 160 – 400-440V



3 General characteristics

Specific let-through energy curves

Tmax T3 250 – 400-440V



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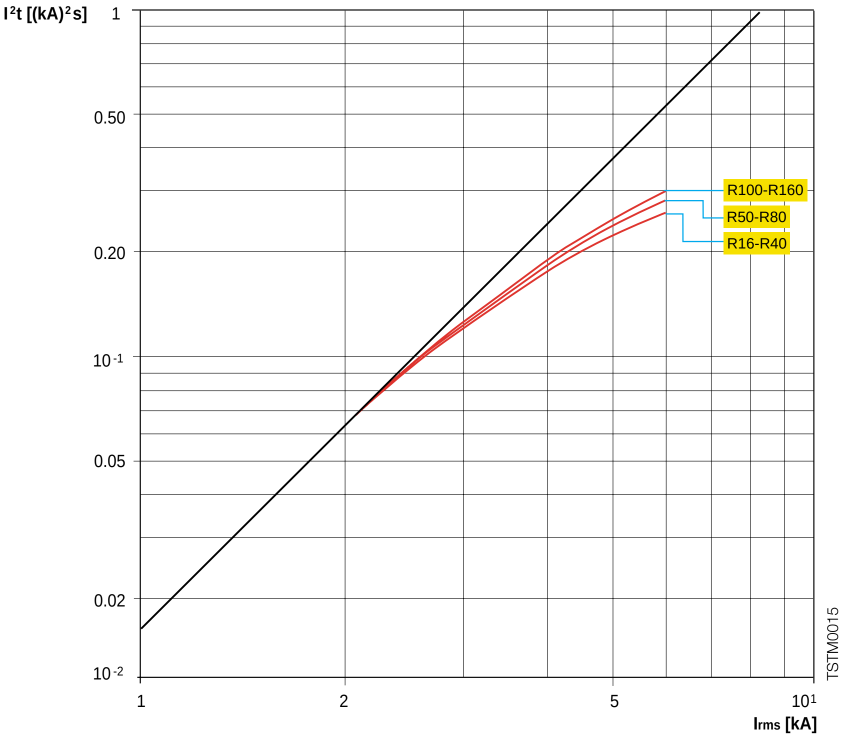
3 General characteristics

Specific let-through energy curves

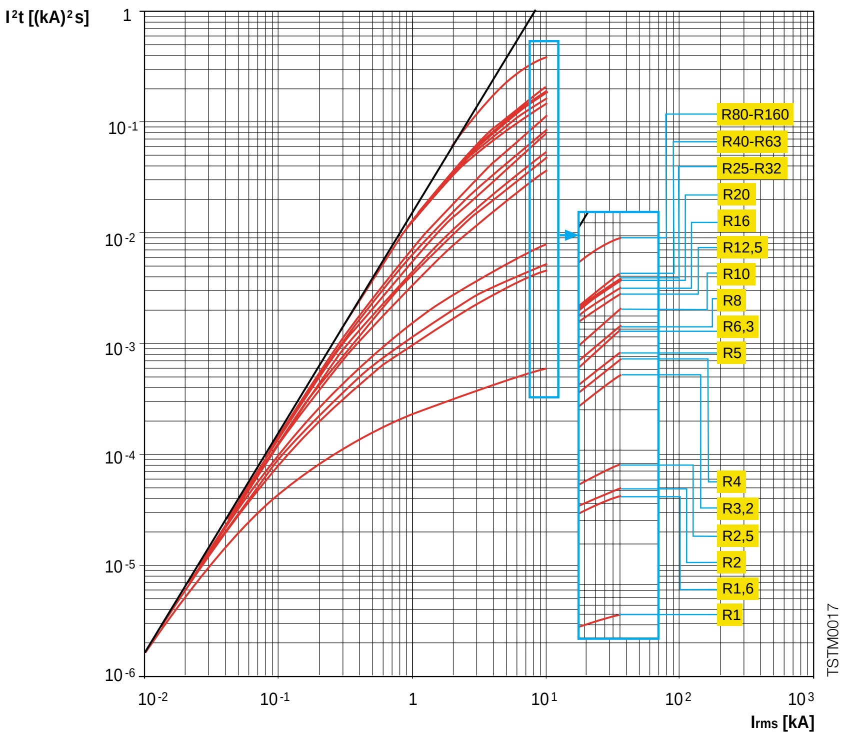
Tmax T1 160 – 690V



3 General characteristics

Specific let-through
energy curves

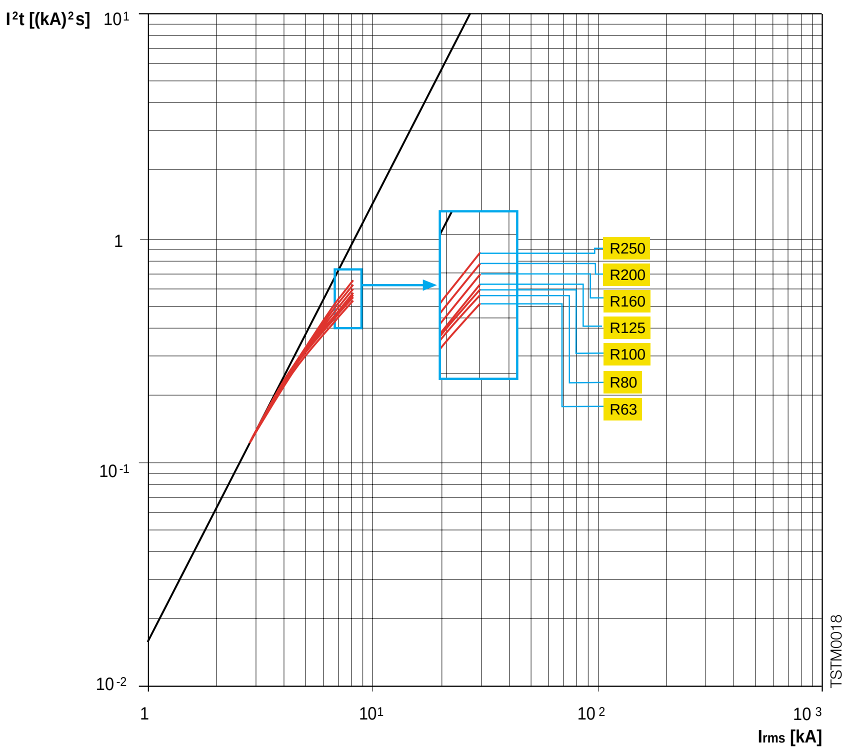
Tmax T2 160 – 690V



3 General characteristics

Specific let-through
energy curves

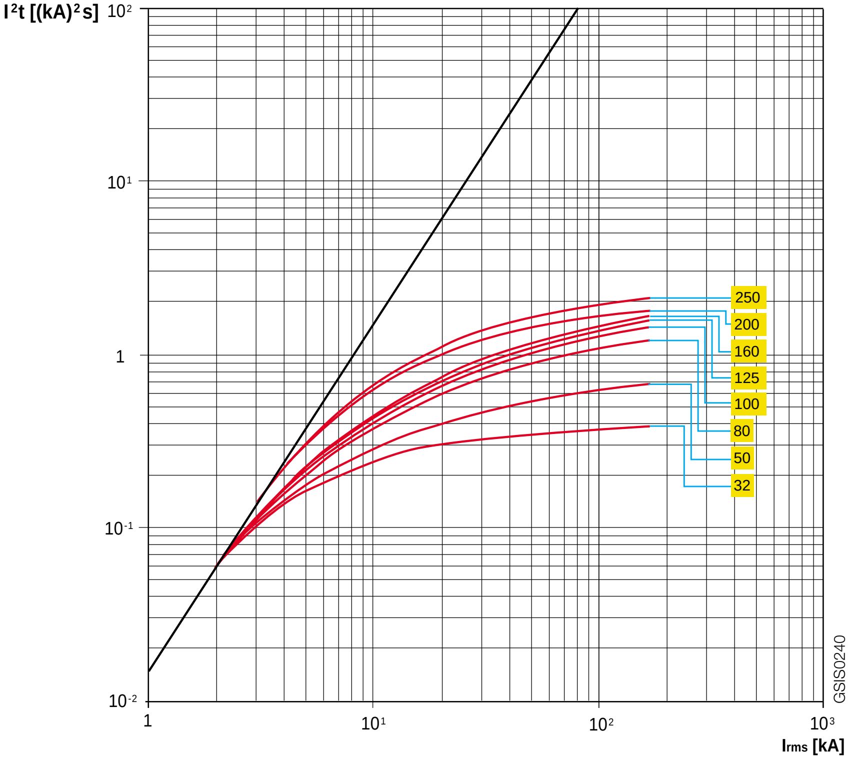
Tmax T3 250 – 690V



3 General characteristics

Specific let-through energy curves

SACE Isomax S3 160 – S3 250 – 230V



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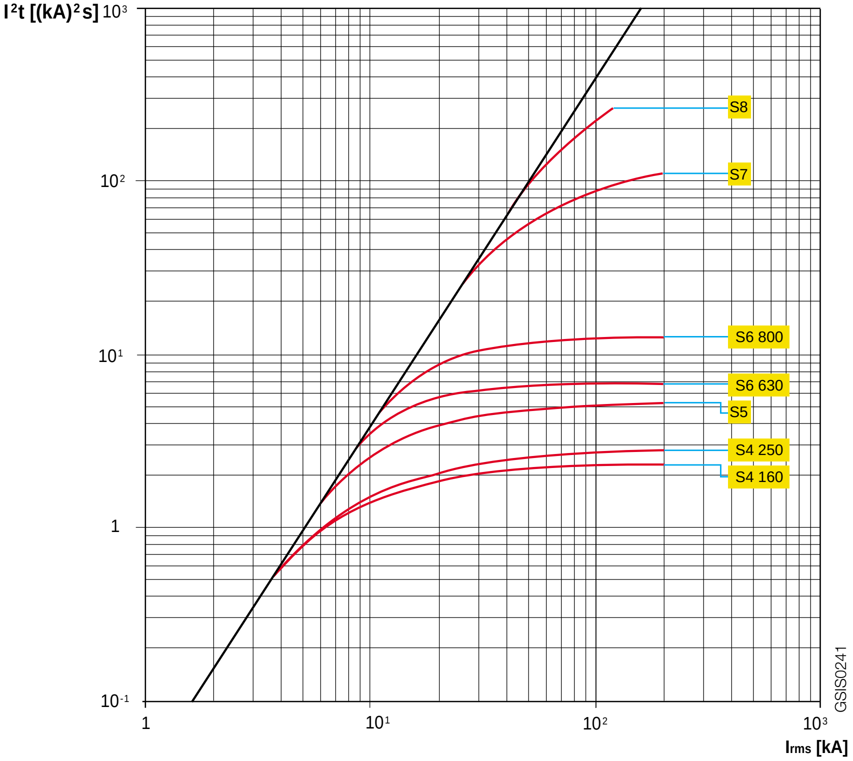
3 General characteristics

Specific let-through energy curves

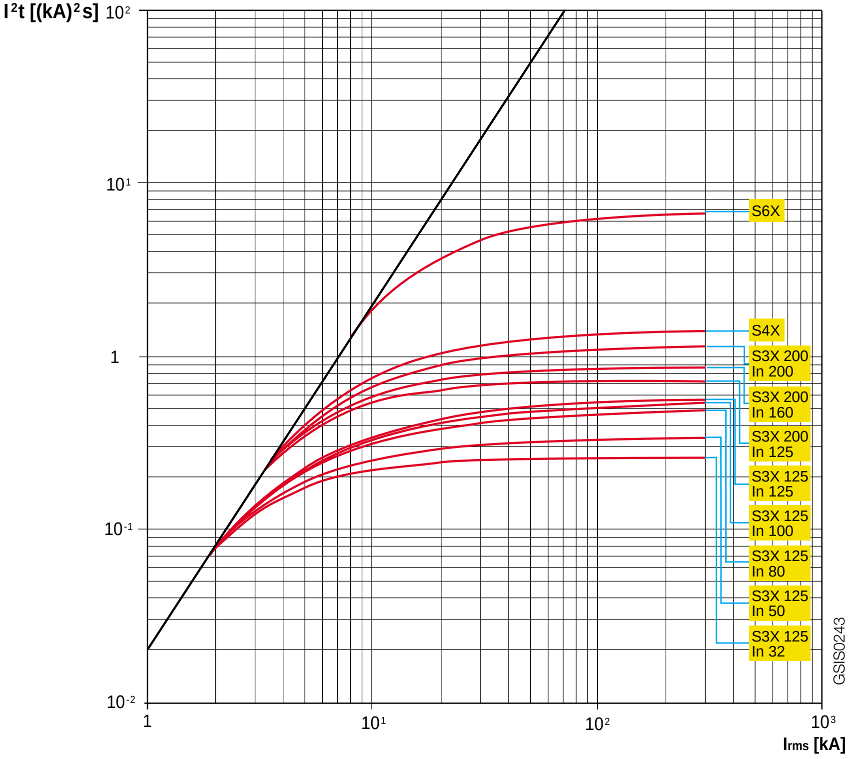
SACE Isomax S4 160 – S4 250 – S5 – S6 630 – S6 800 – S7 – S8 – 230V



3 General characteristics

Specific let-through
energy curves

SACE Isomax S3X 125 – S3X 200 – S4X – S6X – 230V



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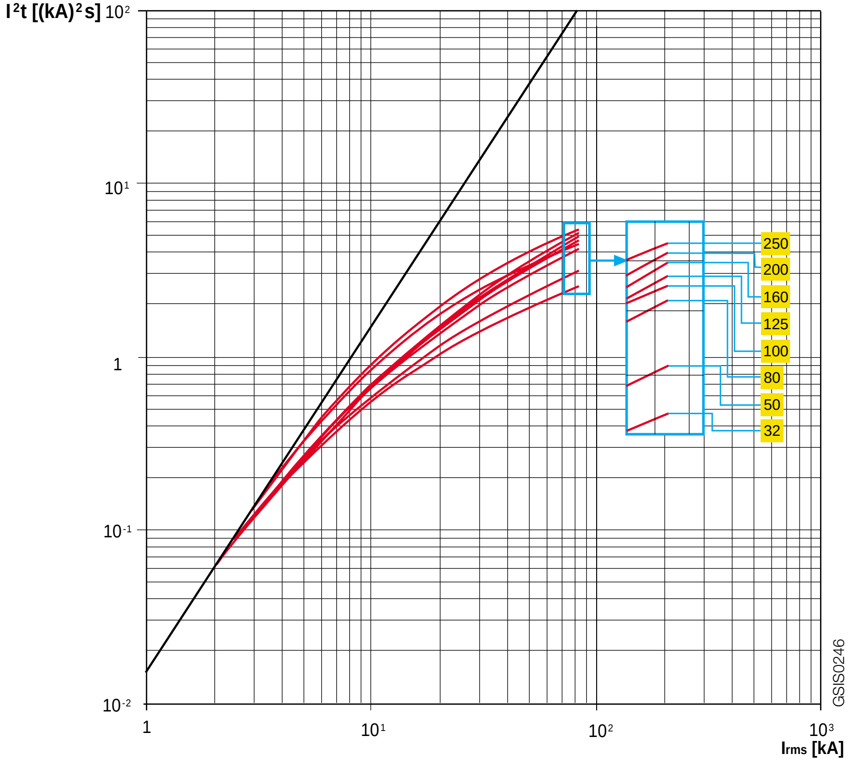
3 General characteristics

Specific let-through
energy curves

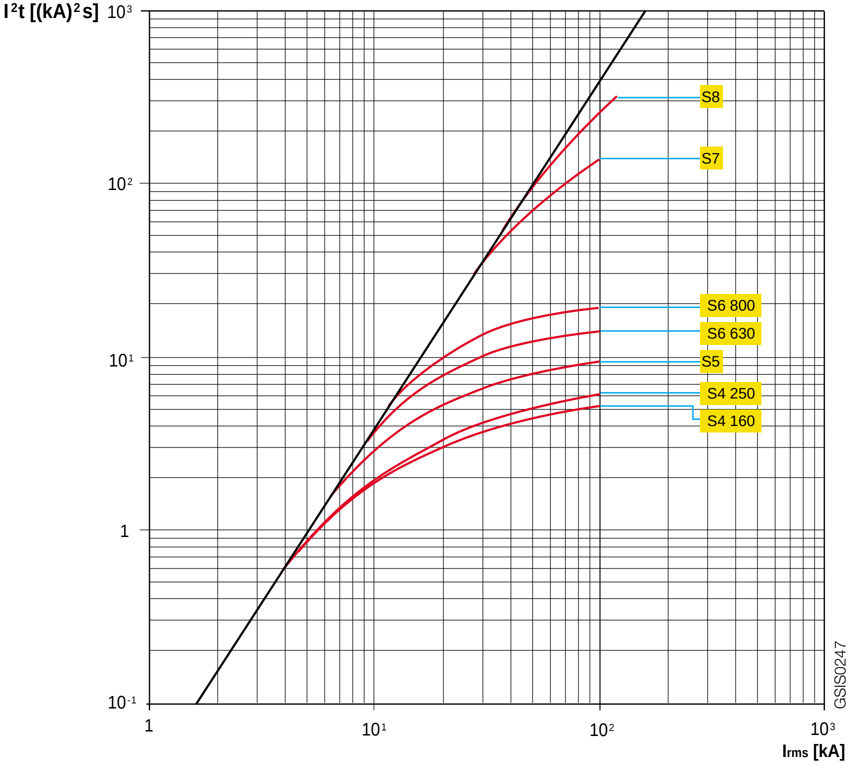
SACE Isomax S3 160 – S3 250 – 400-440V



3 General characteristics

Specific let-through energy curves

SACE Isomax S4 160 – S4 250 – S5 – S6 630 – S6 800 – S7 – S8 – 400-440V



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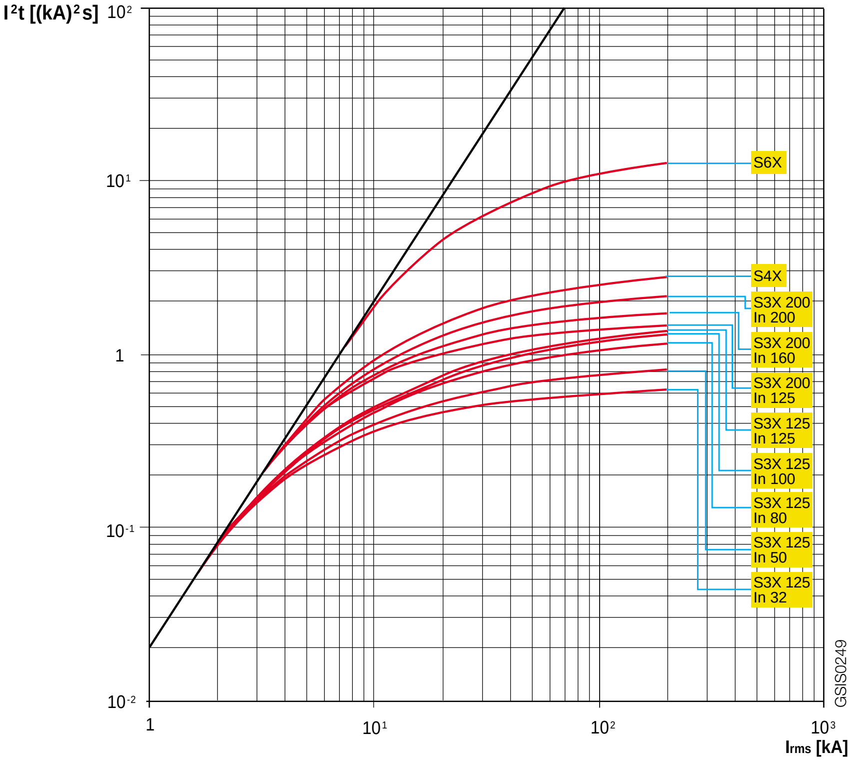
3 General characteristics

Specific let-through energy curves

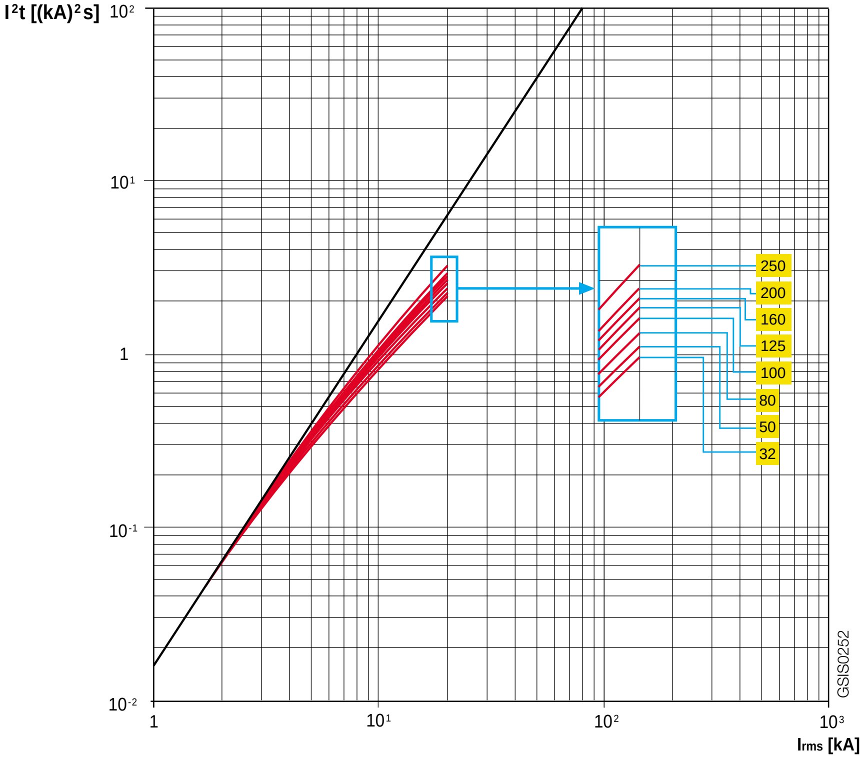
SACE Isomax S3X 125 – S3X 200 – S4X – S6X – 400-440V



3 General characteristics

Specific let-through energy curves

SACE Isomax S3 160 – S3 250 – 690V



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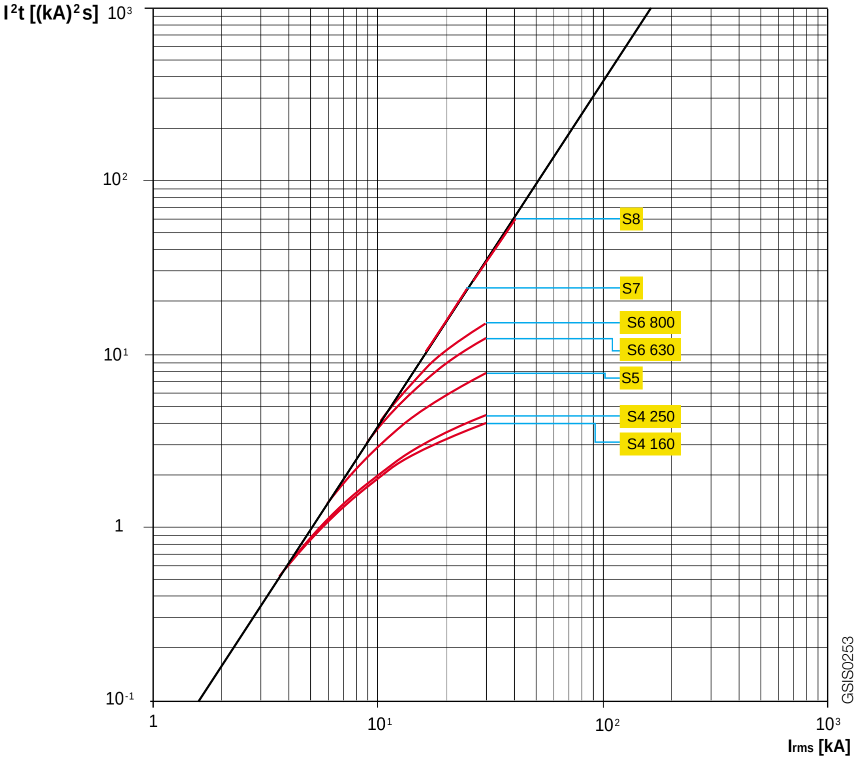
3 General characteristics

Specific let-through energy curves

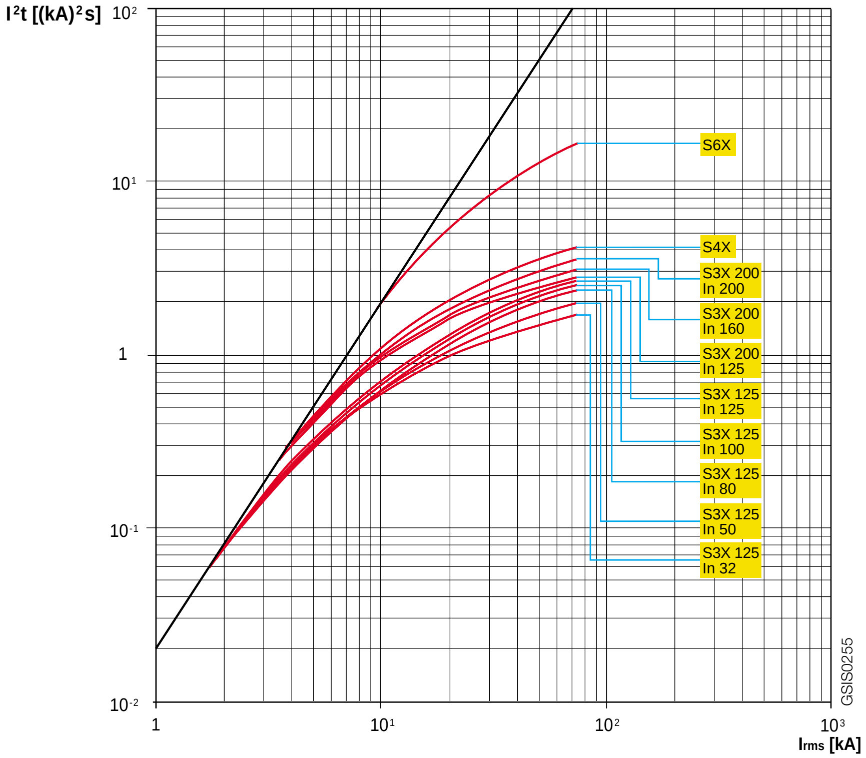
SACE Isomax S4 160 – S4 250 – S5 – S6 630 – S6 800 – S7 – S8 – 690V



3 General characteristics

Specific let-through
energy curves

SACE Isomax S3X 125 – S3X 200 – S4X – S6X – 690V



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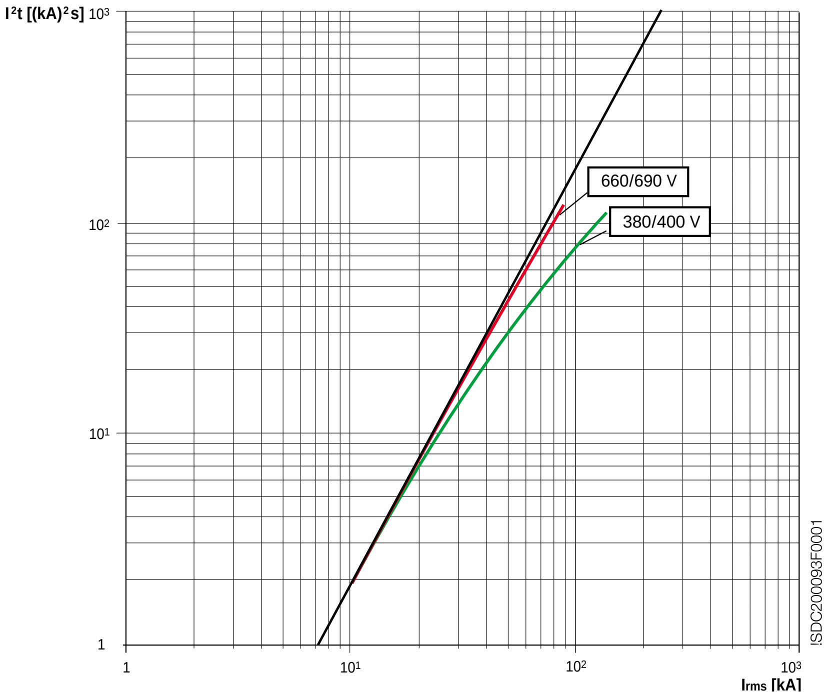
3 General characteristics

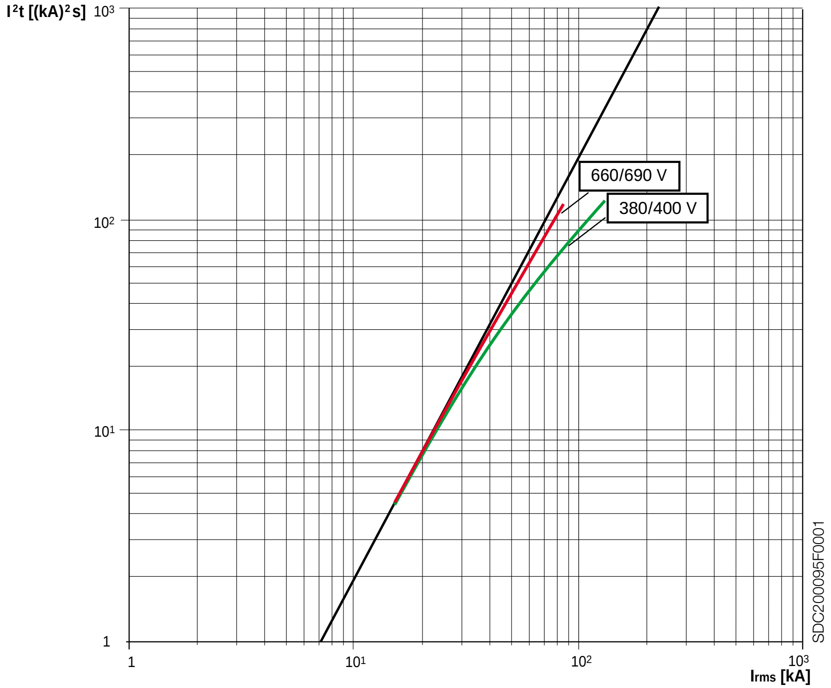
Specific let-through
energy curves

EMAX E2L 660/690V-380/400V



Specific let-through energy curves

EMAX E3L 660/690V-380/400



3.5 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.
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:

Circuit-breakers with thermomagnetic release

Tmax T1 and T1 1P (*)

	10 °C		**20 °C**		**30 °C**		**40 °C**		**50 °C**		**60 °C**		**70 °C**	
TMD	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
R16	13	18	12	18	12	17	11	16	11	15	10	14	9	13
R20	16	23	15	22	15	21	14	20	13	19	12	18	11	16
R25	20	29	19	28	18	26	18	25	16	23	15	22	14	20
R32	26	37	25	35	24	34	22	32	21	30	20	28	18	26
R40	32	46	31	44	29	42	28	40	26	38	25	35	23	33
R50	40	58	39	55	37	53	35	50	33	47	31	44	28	41
R63	51	72	49	69	46	66	44	63	41	59	39	55	36	51
R80	64	92	62	88	59	84	56	80	53	75	49	70	46	65
R100	81	115	77	110	74	105	70	100	66	94	61	88	57	81
R125	101	144	96	138	92	131	88	125	82	117	77	109	71	102
R160	129	184	123	176	118	168	112	160	105	150	98	140	91	130

(*) For the T1 1P circuit-breaker (fitted with TMF fixed thermomagnetic release), only consider the column corresponding to the maximum adjustment of the TMD releases.

3 General characteristics

Tmax T2

	10 °C		20 °C		30 °C		40 °C		50 °C		60 °C		70 °C	
TMD	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
R1	0.8	1.1	0.8	1.1	0.7	1.1	0.7	1.0	0.7	0.9	0.6	0.9	0.6	0.8
R1.6	1.3	1.8	1.2	1.8	1.2	1.7	1.1	1.6	1.0	1.5	1.0	1.4	0.9	1.3
R2	1.6	2.3	1.5	2.2	1.5	2.1	1.4	2.0	1.3	1.9	1.2	1.7	1.1	1.6
R2.5	2.0	2.9	1.9	2.8	1.8	2.6	1.8	2.5	1.6	2.3	1.5	2.2	1.4	2.0
R3.2	2.6	3.7	2.5	3.5	2.4	3.4	2.2	3.2	2.1	3.0	1.9	2.8	1.8	2.6
R4	3.2	4.6	3.1	4.4	2.9	4.2	2.8	4.0	2.6	3.7	2.4	3.5	2.3	3.2
R5	4.0	5.7	3.9	5.5	3.7	5.3	3.5	5.0	3.3	4.7	3.0	4.3	2.8	4.0
R6.3	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
R8	6.4	9.2	6.2	8.8	5.9	8.4	5.6	8.0	5.2	7.5	4.9	7.0	4.5	6.5
R10	8.0	11.5	7.7	11.0	7.4	10.5	7.0	10.0	6.5	9.3	6.1	8.7	5.6	8.1
R12.5	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
R16	13	18	12	18	12	17	11	16	10	15	10	14	9	13
R20	16	23	15	22	15	21	14	20	13	19	12	17	11	16
R25	20	29	19	28	18	26	18	25	16	23	15	22	14	20
R32	26	37	25	35	24	34	22	32	21	30	19	28	18	26
R40	32	46	31	44	29	42	28	40	26	37	24	35	23	32
R50	40	57	39	55	37	53	35	50	33	47	30	43	28	40
R63	51	72	49	69	46	66	44	63	41	59	38	55	36	51
R80	64	92	62	88	59	84	56	80	52	75	49	70	45	65
R100	80	115	77	110	74	105	70	100	65	93	61	87	56	81
R125	101	144	96	138	92	132	88	125	82	117	76	109	71	101
R160	129	184	123	178	118	168	112	160	105	150	97	139	90	129

Tmax T3

TMD	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
R63	51	72	49	69	46	66	44	63	41	59	38	55	35	51
R80	64	92	62	88	59	84	56	80	52	75	48	69	45	64
R100	80	115	77	110	74	105	70	100	65	93	61	87	56	80
R125	101	144	96	138	92	132	88	125	82	116	76	108	70	100
R160	129	184	123	176	118	168	112	160	104	149	97	139	90	129
R200	161	230	154	220	147	211	140	200	130	186	121	173	112	161
R250	201	287	193	278	184	263	175	250	163	233	152	216	141	201

3 General characteristics

SACE Isomax S3

	10 °C		20 °C		30 °C		40 °C		50 °C		60 °C		70 °C	
TMD	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
R 32	26	43	24	39	22	36	19	32	16	27	14	24	11	21
R 50	37	62	35	58	33	54	30	50	27	46	25	42	22	39
R 80	59	98	55	92	52	86	48	80	44	74	40	66	32	58
R 100	83	118	80	113	74	106	70	100	66	95	59	85	49	75
R 125	103	145	100	140	94	134	88	125	80	115	73	105	63	95
R 160	130	185	124	176	118	168	112	160	106	150	100	104	90	130
R 200	162	230	155	220	147	210	140	200	133	190	122	175	107	160
R 250	200	285	193	275	183	262	175	250	168	240	160	230	150	220

SACE Isomax S5 400/630

TMD	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
R 320	260	368	245	350	234	335	224	320	212	305	200	285	182	263
R 400	325	465	310	442	295	420	280	400	265	380	250	355	230	325
R 500	435	620	405	580	380	540	350	500	315	450	280	400	240	345

SACE Isomax S6 630/800

TMD	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
R 630	520	740	493	705	462	660	441	630	405	580	380	540	350	500
R 800	685	965	640	905	605	855	560	800	520	740	470	670	420	610

3 General characteristics

Circuit-breakers with electronic release

Tmax T2 160

	up to 40 °C		50 °C		60 °C		70 °C	
Terminals	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
F	**160**	1	153.6	0.96	140.8	0.88	128	0.8
EF	**160**	1	153.6	0.96	140.8	0.88	128	0.8
ES	**160**	1	153.6	0.96	140.8	0.88	128	0.8
FC Cu	**160**	1	153.6	0.96	140.8	0.88	128	0.8
FC Cu	**160**	1	153.6	0.96	140.8	0.88	128	0.8
R	**160**	1	153.6	0.96	140.8	0.88	128	0.8

SACE Isomax S4 160

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**160**	1	160	1	160	1	160	1
Front for cables	**160**	1	160	1	160	1	160	1
Rear for cables	**160**	1	160	1	160	1	152	0.95
Rear threaded	**160**	1	160	1	160	1	152	0.95
Plug-in - Withdrawable								
Front flat bar	**160**	1	160	1	160	1	152	0.95
Front for cables	**160**	1	160	1	160	1	152	0.95
Rear for cables	**160**	1	160	1	160	1	144	0.9
Rear threaded	**160**	1	160	1	160	1	144	0.9

SACE Isomax S4 250

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**250**	1	250	1	250	1	237.5	0.95
Front for cables	**250**	1	250	1	250	1	237.5	0.95
Rear for cables	**250**	1	250	1	250	1	225	0.9
Rear threaded	**250**	1	250	1	250	1	225	0.9
Plug-in - Withdrawable								
Front flat bar	**250**	1	250	1	250	1	225	0.9
Front for cables	**250**	1	250	1	250	1	225	0.9
Rear for cables	**250**	1	250	1	250	1	200	0.8
Rear threaded	**250**	1	250	1	250	1	200	0.8

SACE Isomax S5 400

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**400**	1	400	1	400	1	380	0.95
Front for cables	**400**	1	400	1	400	1	380	0.9
Rear for cables	**400**	1	400	1	400	1	360	0.9
Rear threaded	**400**	1	400	1	400	1	320	0.8
Plug-in - Withdrawable								
Front flat bar	**400**	1	400	1	400	1	380	0.95
Front for cables	**400**	1	400	1	380	0.95	360	0.9
Rear for cables	**400**	1	400	1	380	0.95	360	0.9
Rear threaded	**400**	1	380	0.95	360	0.9	320	0.8

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3 General characteristics

SACE Isomax S5 630

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**630**	1	598.5	0.95	567	0.9	504	0.8
Front for cables	**630**	1	567	0.9	504	0.8	441	0.7
Rear threaded	**630**	1	504	0.8	441	0.7	378	0.6
Plug-in - Withdrawable								
Front flat bar	**630**	1	504	0.8	441	0.7	378	0.6
Rear flat bar	**630**	1	567	0.9	504	0.8	441	0.7
Rear threaded	**630**	1	441	0.7	378	0.6	315	0.5

SACE Isomax S6 630

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**630**	1	630	1	630	1	598.5	0.95
Front for cables	**630**	1	630	1	598.5	0.95	567	0.9
Rear for cables	**630**	1	630	1	598.5	0.95	567	0.9
Rear threaded	**630**	1	630	1	567	0.9	504	0.8
Plug-in - Withdrawable								
Front flat bar	**630**	1	630	1	598.5	0.95	567	0.9
Rear vertical flat bar	**630**	1	630	1	598.5	0.95	567	0.9
Rear horizontal flat bar	**630**	1	598.5	0.95	567	0.9	504	0.8

SACE Isomax S6 800

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**800**	1	800	1	800	1	760	0.95
Front for cables	**800**	1	800	1	760	0.95	720	0.9
Rear for cables	**800**	1	800	1	760	0.95	720	0.9
Rear threaded	**800**	1	800	1	720	0.9	640	0.8
Plug-in - Withdrawable								
Front flat bar	**800**	1	800	1	760	0.95	720	0.9
Rear vertical flat bar	**800**	1	800	1	760	0.95	720	0.9
Rear horizontal flat bar	**800**	1	760	0.95	720	0.9	640	0.8

SACE Isomax S7 1250

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**1250**	1	1250	1	1250	1	1187.5	0.95
Rear vertical flat bar	**1250**	1	1250	1	1250	1	1187.5	0.95
Front for cables	**1250**	1	1250	1	1187.5	0.95	1125	0.9
Rear horizontal flat bar	**1250**	1	1250	1	1250	1	1125	0.9
Plug-in - Withdrawable								
Front flat bar	**1250**	1	1250	1	1187.5	0.95	1125	0.9
Rear vertical flat bar	**1250**	1	1250	1	1187.5	0.95	1125	0.9
Rear horizontal flat bar	**1250**	1	1250	1	1125	0.9	1000	0.8

3 General characteristics

SACE Isomax S7 1600

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**1600**	1	1520	0.95	1440	0.9	1280	0.8
Rear vertical flat bar	**1600**	1	1520	0.95	1440	0.9	1280	0.8
Rear horizontal flat bar	**1600**	1	1440	0.9	1280	0.8	1120	0.7
Plug-in - Withdrawable								
Front flat bar	**1600**	1	1440	0.9	1280	0.8	1120	0.7
Rear vertical flat bar	**1600**	1	1440	0.9	1280	0.8	1120	0.7
Rear horizontal flat bar	**1600**	1	1280	0.8	1120	0.7	906	0.6

SACE Isomax S8 2000

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**2000**	1	2000	1	1900	0,95	1715	0,85
Rear vertical flat bar	**2000**	1	2000	1	2000	1	1785	0,9

SACE Isomax S8 2500

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Front flat bar	**2500**	1	2500	1	2270	0,9	2040	0,8
Rear vertical flat bar	**2500**	1	2500	1	2375	0,95	2130	0,85

SACE Isomax S8 3200

	up to 40 °C		50 °C		60 °C		70 °C	
Fixed	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1	I_{max} [A]	I_1
Rear vertical flat bar	**3200**	1	3060	0,95	2780	0,85	2510	0,8

3 General characteristics

Emax E1

Temperature	**E1 800**		**E1 1250**	
[°C]	%	[A]	%	[A]
10	100	800	100	1250
20	100	800	100	1250
30	100	800	100	1250
40	100	800	100	1250
45	100	800	100	1250
50	100	800	100	1250
55	100	800	100	1250
60	100	800	100	1250
65	100	800	99	1240
70	100	800	98	1230

Emax E2

Temperature	**E2 1250**		**E2 1600**		**E2 2000**	
[°C]	%	[A]	%	[A]	%	[A]
10	100	1250	100	1600	100	2000
20	100	1250	100	1600	100	2000
30	100	1250	100	1600	100	2000
40	100	1250	100	1600	100	2000
45	100	1250	100	1600	100	2000
50	100	1250	100	1600	97	1945
55	100	1250	100	1600	94	1885
60	100	1250	98	1570	91	1825
65	100	1250	96	1538	88	1765
70	100	1250	94	1510	85	1705

Emax E3

Temperature	**E3 1250**		**E3 1600**		**E3 2000**		**E3 2500**		**E3 3200**	
[C°]	%	[A]	%	[A]	%	[A]	%	[A]	%	[A]
10	100	1250	100	1600	100	2000	100	2500	100	3200
20	100	1250	100	1600	100	2000	100	2500	100	3200
30	100	1250	100	1600	100	2000	100	2500	100	3200
40	100	1250	100	1600	100	2000	100	2500	100	3200
45	100	1250	100	1600	100	2000	100	2500	100	3200
50	100	1250	100	1600	100	2000	100	2500	97	3090
55	100	1250	100	1600	100	2000	100	2500	93	2975
60	100	1250	100	1600	100	2000	100	2500	89	2860
65	100	1250	100	1600	100	2000	97	2425	86	2745
70	100	1250	100	1600	100	2000	94	2350	82	2630

3 General characteristics

Emax E4

Temperature	**E4 3200**		**E4 4000**	
[°C]	%	[A]	%	[A]
10	100	3200	100	4000
20	100	3200	100	4000
30	100	3200	100	4000
40	100	3200	100	4000
45	100	3200	100	4000
50	100	3200	98	3900
55	100	3200	95	3790
60	100	3200	92	3680
65	98	3120	89	3570
70	95	3040	87	3460

Emax E6

Temperature	**E6 3200**		**E6 4000**		**E6 5000**		**E6 6300**	
[°C]	%	[A]	%	[A]	%	[A]	%	[A]
10	100	3200	100	4000	100	5000	100	6300
20	100	3200	100	4000	100	5000	100	6300
30	100	3200	100	4000	100	5000	100	6300
40	100	3200	100	4000	100	5000	100	6300
45	100	3200	100	4000	100	5000	100	6300
50	100	3200	100	4000	100	5000	100	6300
55	100	3200	100	4000	100	5000	98	6190
60	100	3200	100	4000	98	4910	96	6070
65	100	3200	100	4000	96	4815	94	5850
70	100	3200	100	4000	94	4720	92	5600

3 General characteristics

The following Table shows the rated uninterrupted current in a switchboard with IP 31 degree of protection, for withdrawable air circuit-breakers.

Type	Iu	**Vertical terminals**				**Horizontal and front terminals**			
	[A]	Continuous capacity [A]			Busbars section [mm^2]	Continuous capacity [A]			Busbars section [mm^2]
		35°C	45°C	55°C		35°C	45°C	55°C	
E1B/N 08	800	800	800	800	1x(60x10)	800	800	800	1x(60x10)
E1B/N 12	1250	1250	1250	1250	1x(80x10)	1250	1250	1200	2x(60x8)
E2N 12	1250	1250	1250	1250	1x(60x10)	1250	1250	1250	1x(60x10)
E2B/N 16	1600	1600	1600	1600	2x(60x10)	1600	1600	1530	2x(60x10)
E2B/N 20	2000	2000	2000	1800	3x(60x10)	2000	2000	1750	3x(60x10)
E2L 12	1250	1250	1250	1250	1x(60x10)	1250	1250	1250	1x(60x10)
E2L 16	1600	1600	1600	1500	2x(60x10)	1600	1490	1400	2x(60x10)
E3S/H 12	1250	1250	1250	1250	1x(60x10)	1250	1250	1250	1x(60x10)
E3S/H 16	1600	1600	1600	1600	1x(100x10)	1600	1600	1600	1x(100x10)
E3S/H 20	2000	2000	2000	2000	2x(100x10)	2000	2000	2000	2x(100x10)
E3N/S/H 25	2500	2500	2500	2500	2x(100x10)	2500	2490	2410	2x(100x10)
E3N/S/H 32	3200	3200	3100	2800	3x(100x10)	3000	2880	2650	3x(100x10)
E3L 20	2000	2000	2000	2000	2x(100x10)	2000	2000	1970	2x(100x10)
E3L 25	2500	2500	2390	2250	2x(100x10)	2375	2270	2100	2x(100x10)
E4H 32	3200	3200	3200	3200	3x(100x10)	3200	3200	3020	3x(100x10)
E4S/H 40	4000	4000	3980	3500	4x(100x10)	3600	3510	3150	6x(60x10)
E6V 32	3200	3200	3200	3200	3x(100x10)	3200	3200	3200	3x(100x10)
E6V 40	4000	4000	4000	4000	4x(100x10)	4000	4000	4000	4x(100x10)
E6H/V 50	5000	5000	4850	4600	6x(100x10)	4850	4510	4250	6x(100x10)
E6H/V 63	6300	6000	5700	5250	7x(100x10)	-	-	-	-

Note: the reference temperature is the ambient temperature

Examples:

Selection of a moulded-case circuit-breaker, with thermomagnetic release, for a load current of 180 A, at an ambient temperature of 60°C.
From the table referring to Tmax circuit-breakers (page 137-138), it can be seen that the most suitable breaker is the T3 R250, which can be set from 152 A to 216 A.

Selection of a moulded-case circuit-breaker, with electronic release, in withdrawable version with rear flat horizontal bar terminals, for a load current equal to 570 A, with an ambient temperature of 55 °C.
From the table referring to SACE Isomax circuit-breakers (page 141), it can be seen that the most suitable breaker is the S6 630, which can be set from 252 A to 582.75 A.

Selection of an air circuit-breaker, with electronic release, in withdrawable version with vertical terminals, for a load current of 2700 A, with a temperature outside of the IP31 switchboard of 55 °C.
From the tables referring to the current carrying capacity inside the switchboard for Emax circuit-breakers (see above), it can be seen that the most suitable breaker is the E3 3200, with busbar section 3x(100x10)mm^2, which can be set from 1280 A to 2800 A.

3 General characteristics

The following tables show the maximum settings for L protection (against overload) for electronic releases, according to temperature, version and terminals.

Tmax T2	All terminals	
In ≤ 125A	F	P
≤40	1	1
45		
50		
55		
60		
65		
70		

Tmax T2	All terminals	
In = 160A	F	P
≤40	1	0.88
45	0.96	0.88
50	0.96	0.88
55	0.92	0.88
60	0.88	0.88
65	0.84	0.84
70	0.8	0.8

Isomax S4 In ≤ 160A	Front flat bar Front for cables		Front flat bar Front for cables		Rear for cables Rear threaded		Rear for cables Rear threaded	
	PR211		PR212		PR211		PR212	
	F	P-W	F	P-W	F	P-W	F	P-W
≤40	1	1	1	1	1	1	1	1
45								
50								
55								
60								
65		0.95		0.975	0.95	0.95	0.975	0.95
70				0.95		0.9	0.95	0.9

Isomax S4 In = 250A	Front flat bar Front for cables		Front flat bar Front for cables		Rear for cables Rear threaded		Rear for cables Rear threaded	
	PR211		PR212		PR211		PR212	
	F	P-W	F	P-W	F	P-W	F	P-W
≤40	1	1	1	1	1	1	1	1
45								
50								
55								
60								
65	0.95	0.95	0.975	0.95	0.95	0.9	0.95	0.9
70		0.9	0.95	0.9	0.9	0.8	0.9	0. 8

3 General characteristics

Isomax S5 In ≤ 400A	Front flat bar		Front flat bar		Front for cables Rear for cables		Front for cables Rear for cables		Rear threaded		Rear threaded	
	PR211		PR212		PR211		PR212		PR211		PR212	
	F	P-W	F	P-W	F	P-W	F	P-W	F	P-W	F	P-W
≤40	1	1	1	1	1	1	1	1	1		1	1
45										0,95		0.975
50												0.95
55						0.95		0.975		0,9		0.925
60								0.95				0.9
65	0.95	0.95	0.975	0.975	0.95	0.9	0.95	0.925	0.95	0.85	0.9	0.85
70			0.95	0.95	0.9		0.9	0.9	0.9	0.8	0.8	0.8

Isomax S5 In = 630A	Front flat bar		Front flat bar		Front for cables		Front for cables		Rear threaded		Rear threaded	
	PR211		PR212		PR 211	PR212	PR 211	PR212	PR211		PR212	
	F	W	F	W	F	F	W	W	F	W	F	W
≤40	1	1	1	1	1	1	1	1	1	1	1	1
45	0.95	0.9	0.975	0.9	0.95	0.95	0.95	0.95	0.9	0.8	0.9	0.85
50		0.8	0.95	0.8	0.9	0.9	0.9	0.9	0.8	0.7	0.8	0.7
55	0.9	0.7	0.925	0.75	0.8	0.85	0.8	0.85	0.7	0.6	0.75	0.65
60			0.9	0.7		0.8		0.8			0.7	0.6
65	0.8	0.6	0.85	0.65	0.7	0.75	0.7	0.75	0.6	0.5	0.65	0.55
70			0.8	0.6		0.7		0.7			0.6	0.5

Isomax S6 In ≤ 630A	Front flat bar		Front for cables Rear for cables		Rear threaded		Front flat bar Rear vertical flat bar		Rear horizontal flat bar	
	PR211	PR212	PR211	PR212	PR211	PR212	PR211	PR212	PR211	PR212
	F	F	F	F	F	F	W	W	W	W
≤40	1	1	1	1	1	1	1	1	1	1
45									0.95	0.975
50										0.95
55			0.95	0.975	0.95	0.95	0.95	0.975	0.9	0.925
60				0.95	0.9	0.9		0.95		0.9
65	0.95	0.975	0.9	0.925	0.8	0.85	0.9	0.925	0.8	0.85
70		0.95		0.9		0.8		0.9		0.8

3 General characteristics

Isomax S6 In = 800A	Front flat bar		Front for cables Rear for cables		Rear threaded		Front flat bar Rear vertical flat bar		Rear horizontal flat bar	
	PR211	PR212	PR211	PR212	PR211	PR212	PR211	PR212	PR211	PR212
	F	F	F	F	F	F	W	W	W	W
<40	1	1	1	1	1	1	1	1	1	1
45									0.95	0.975
50										0.95
55			0.95	0.975	0.95	0.95	0.95	0.975	0.9	0.925
60				0.95	0.9	0.9		0.95		0.9
65	0.95	0.975	0.9	0.925	0.8	0.85	0.9	0.925	0.8	0.85
70		0.95		0.9		0.8		0.9		0.8

Isomax S7 In ≤ 1250A	Front flat bar Rear vertical flat bar		Front flat bar Rear vertical flat bar		Front for cables		Rear horizontal flat bar		Rear horizontal flat bar	
	PR211		PR212		PR211	PR212	PR211		PR212	
	F	W	F	W	F	F	F	W	F	W
<40	1	1	1	1	1	1	1	1	1	1
45										
50										
55		0.95		0.975	0.95	0.975		0.95		0.95
60				0.95		0.95		0.9		0.9
65	0.95	0.9	0.975	0.975	0.9	0.925	0.95	0.8	0.95	0.85
70			0.95	0.9		0.9	0.9		0.9	0.8

Isomax S7 In = 1600A	Front flat bar Rear vertical flat bar		Front flat bar Rear vertical flat bar		Rear horizontal flat bar		Rear horizontal flat bar	
	PR211		PR212		PR211		PR212	
	F	W	F	W	F	W	F	W
<40	1	1	1	1	1	1	1	1
45	0.95	0.95	0.975	0.95	0.95	0.9	0.95	0.9
50		0.9	0.95	0.9	0.9	0.8	0.9	0.8
55	0.9	0.8	0.925	0.85	0.8	0.7	0.85	0.75
60			0.9	0.8			0,8	0.7
65	0.95	0.7	0,85	0.75	0.7	0.6	0.75	0.65
70			0.8	0.7			0.7	0.6

Isomax S8 In ≤ 2000A	Front flat bar	Rear vertical flat bar
	PR212	
	F	F
<40	1	1
45		
50		
55		
60	0.95	
65	0.9	0.925
70	0.85	0.875

Isomax S8 In = 2500A	Front flat bar	Rear vertical flat bar
	PR212	
	F	F
<40	1	1
45		
50		
55	0.95	
60	0.9	0.95
65	0.85	0.9
70	0.8	0.85

Isomax S8 In = 3200A	Rear vertical flat bar
	PR212
	F
<40	1
45	
50	0.95
55	0.9
60	0.85
65	0.8
70	0.75

3 General characteristics

Emax E1	800 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60		
65		
70		

Emax E1	1250 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60		
65	0.95	0.99
70		0.98

Emax E2	1250 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60		
65		
70		

Emax E2	1600 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60	0.95	0.98
65		0.96
70	0.9	0.94

Emax E2	2000 A	
	PR111	PR112/PR113
<40	1	1
45		
50	0.95	0.97
55	0.9	0.94
60		0.91
65	0.85	0.88
70		0.85

Emax E3	1250/1600/2000 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60		
65		
70		

Emax E3	2500 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60		
65	0.95	0.97
70	0.9	0.94

Emax E3	3200 A	
	PR111	PR112/PR113
<40	1	1
45		
50	0.95	0.97
55	0.9	0.93
60	0.85	0.89
65		0.86
70	0.8	0.82

Emax E4	3200 A	
	PR111	PR112/PR113
<40	1	1
45		
50		
55		
60		
65	0.95	0.98
70		0.95

Emax E4	4000 A	
	PR111	PR112/PR113
<40	1	1
45		
50	0.95	0.98
55		0.95
60	0.9	0.92
65	0.85	0.89
70		0.87

3 General characteristics

Emax E6	3200/4000 A	
	PR111	PR112/PR113
≤40	1	1
45		
50		
55		
60		
65		
70		

Emax E6	5000 A	
	PR111	PR112/PR113
≤40	1	1
45		
50		
55		
60	0.95	0.98
65		0.96
70	0.9	0.94

Emax E6	6000 A	
	PR111	PR112/PR113
≤40	1	1
45		
50		
55	0.95	0.98
60		0.96
65	0.9	0.94
70		0.92

	Vertical Terminals					
	35 °C		45 °C		55 °C	
	PR111	PR112/PR113	PR111	PR112/PR113	PR111	PR112/PR113
E1B/N 08	1	1	1	1	1	1
E1B/N 12	1	1	1	1	1	1
E2N 12	1	1	1	1	1	1
E2B/N 16	1	1	1	1	1	1
E2B/N 20	1	1	1	1	0.9	0.9
E2L 12	1	1	1	1	1	1
E2L 16	1	1	1	1	0.9	0.93
E3S/H 12	1	1	1	1	1	1
E3S/H 16	1	1	1	1	1	1
E3S/H 20	1	1	1	1	1	1
E3N/S/H 25	1	1	1	1	1	1
E3N/S/H 32	1	1	0.95	0.96	0.8	0.87
E3L 20	1	1	1	1	1	1
E3L 25	1	1	0.95	0.95	0.9	0.9
E4H 32	1	1	1	1	1	1
E4S/H 40	1	1	0.95	0.99	0.8	0.87
E6V 32	1	1	1	1	1	1
E6V 40	1	1	1	1	1	1
E6H/V 50	1	1	0.95	0.97	0.9	0.92
E6H/V 63	0.95	0.95	0.9	0.9	0.8	0.83

3 General characteristics

	Horizontal and front terminals					
	35 °C		45 °C		55 °C	
	PR111	PR112/PR113	PR111	PR112/PR113	PR111	PR112/PR113
E1B/N 08	1	1	1	1	1	1
E1B/N 12	1	1	1	1	0.95	0.96
E2N 12	1	1	1	1	1	1
E2B/N 16	1	1	1	1	0.95	0.95
E2B/N 20	1	1	1	1	0.8	0.87
E2L 12	1	1	1	1	1	1
E2L 16	1	1	0.9	0.93	0.8	0.87
E3S/H 12	1	1	1	1	1	1
E3S/H 16	1	1	1	1	1	1
E3S/H 20	1	1	1	1	1	1
E3N/S/H 25	1	1	0.95	0.99	0.95	0.94
E3N/S/H 32	0.9	0.93	0.9	0.9	0.8	0.82
E3L 20	1	1	1	1	0.95	0.98
E3L 25	0.95	0.95	0.9	0.9	0.8	0.84
E4H 32	1	1	1	1	0.9	0.94
E4S/H 40	0.9	0.9	0.8	0.87	0.7	0.78
E6V 32	1	1	1	1	1	1
E6V 40	1	1	1	1	1	1
E6H/V 50	0.95	0.97	0.9	0.9	0.8	0.85
E6H/V 63	---	---	---	---	---	---

3.6 Altitude derating

For installations carried out at altitudes of more than 2000 m above sea level, the performance of low voltage circuit-breakers is subject to a decline.
Basically there are two main phenomena:

- the reduction of air density causes a lower efficiency in heat transfer. The allowable heating conditions for the various parts of the circuit-breaker can only be followed if the value of the rated uninterrupted current is decreased;
- the rarefaction of the air causes a decrease in dielectric rigidity, so the usual isolation distances become insufficient. This leads to a decrease in the maximum rated voltage at which the device can be used.

The correction factors for the different types of circuit-breakers, both moulded- case and air circuit-breakers, are given in the following table:

Rated operational voltage Ue [V]

Altitude	2000[m]	3000[m]	4000[m]	5000[m]
Tmax*	690	600	500	440
Isomax	690	600	500	440
Emax	690	600	500	440

Rated uninterrupted current Iu [A]

Altitude	2000[m]	3000[m]	4000[m]	5000[m]
Tmax	100%	98%	93%	90%
Isomax	100%	95%	90%	85%
Emax	100%	98%	93%	90%

*Excluding Tmax T1P

3.7 Electrical characteristics of switch disconnectors

A switch disconnector as defined by the standard IEC 60947-3 is a mechanical switching device which, when in the open position, carries out a disconnecting function and ensures an isolating distance (distance between contacts) sufficient to guarantee safety. This safety of disconnection must be guaranteed and verified by the positive operation: the operating lever must always indicate the actual position of the mobile contacts of the device.
The mechanical switching device must be able to make, carry and break currents in normal circuit conditions, including any overload currents in normal service, and to carry, for a specified duration, currents in abnormal circuit conditions, such as, for example, short-circuit conditions.

Switch disconnectors are often used as:

- main sub-switchboard devices;
- switching and disconnecting devices for lines, busbars or load units;
- bus-tie.

The switch disconnector shall ensure that the whole plant or part of it is not live, safely disconnecting from any electrical supply. The use of such a switch disconnector allows, for example, personnel to carry out work on the plant without risks of electrical nature.
Even if the use of a single pole devices side by side is not forbidden, the standards recommend the use of multi-pole devices so as to guarantee the simultaneous isolation of all poles in the circuit.
The specific rated characteristics of switch disconnectors are defined by the standard IEC 60947-3, as detailed below:

- **Icw [kA]**: rated short-time withstand current:
  is the current that a switch is capable of carrying, without damage, in the closed position for a specific duration
- **Icm [kA]**: rated short-circuit making capacity:
  is the maximum peak value of a short-circuit current which the switch disconnector can close without damages. When this value is not given by the manufacturer it must be taken to be at least equal to the peak current corresponding to Icw. It is not possible to define a breaking capacity Icu [kA] since switch disconnectors are not required to break short-circuit currents
- **utilization categories with alternating current AC and with direct current DC:**
  define the kind of the conditions of using which are represented by two letters to indicate the type of circuit in which the device may be installed (AC for alternating current and DC for direct current), with a two digit number for the type of load which must be operated, and an additional letter (A or B) which represents the frequency in the using.
  With reference to the utilization categories, the product standard defines the current values which the switch disconnector must be able to break and make under abnormal conditions.

3 General characteristics

The characteristics of the utilization categories are detailed in Table 1 below. The most demanding category in alternating current is AC23A, for which the device must be capable of connecting a current equal to 10 times the rated current of the device, and of disconnecting a current equal to 8 times the rated current of the device.

From the point of view of construction, the switch disconnector is a very simple device. It is not fitted with devices for overcurrent detection and the consequent automatic interruption of the current. Therefore the switch disconnector cannot be used for automatic protection against overcurrent which may occur in the case of failure, protection must be provided by a coordinated circuit-breaker. The combination of the two devices allows the use of switch disconnectors in systems in which the short-circuit current value is greater than the electrical parameters which define the performance of the disconnector (back-up protection see Chapter 4.4. This is valid only for Isomax and Tmax switch-disconnectors. For the Emax/MS air disconnectors, it must be verified that the values for Icw and Icm are higher to the values for short-circuit in the plant and correspondent peak, respectively.

Table1: Utilization categories

Nature of current	Utilization categories		
	Utilization category		Typical applications
	Frequent operation	Non-frequent operation	
Alternating Current	AC-20A	AC-20B	Connecting and disconnecting under no-load conditions
	AC-21A	AC-21B	Switching of resistive loads including moderate overloads
	AC-22A	AC-22B	Switching of mixed resistive and inductive loads, including moderate overload
	AC-23A	AC-23B	Switching of motor loads or other highly inductive loads
Direct Current	DC-20A	DC-20B	Connecting and disconnecting under no-load conditions
	DC-21A	DC-21B	Switching of resistive loads including moderate overloads
	DC-22A	DC-22B	Switching of mixed resistive and inductive loads, including moderate overload (e.g. shunt motors)
	DC-23A	DC-23B	Switching of highly inductive loads

3 General characteristics

Tables 2, 3 and 4 detail the main characteristics of the disconnectors.

Table 2: Tmax switch disconnectors

			Tmax T1D	Tmax T3D
Conventional thermal current, **In**		[A]	160	250
Rated service current in AC23A category, **Ie**		[A]	125	200
Poles		No.	3/4	3/4
Rated operational voltage, **Ue**	(ac) 50-60 Hz	[V]	690	690
	(dc)	[V]	500	500
Rated impulse withstand voltage, **Uimp**		[kV]	8	8
Rated insulation voltage, **Ui**		[V]	800	800
Test voltage at industrial frequency for 1 minute		[V]	3000	3000
Rated short-circuit making capacity, **Icm**	(min) only switch disconnector	[kA]	2.8	5.3
	(max) with circuit-breaker on supply side	[kA]	187	105
Rated short-time withstand current for 1s, **Icw**		[kA]	2	3.6
Isolation behaviour			■	■
Reference standards			IEC 60947-3	IEC 60947-3
Versions			F	F - P
Terminals			FC Cu - EF - FC CuAl 95 mm^2	F - FC Cu - FC CuAl - EF - ES - R - FC CuAl 240 mm^2
Mechanical life		[No. Operations]	20000	25000
		[No. operations per hours]	120	120
Basic dimensions, fixed	3 poles	L [mm]	76	105
	4 poles	L [mm]	102	140
		H [mm]	130	150
		P [mm]	70	70
Weight fixed	3/4 poles	[kg]	0.9 / 1.2	2.1 / 3
plug-in	3/4 poles	[kg]	-	2.7 / 3.7

3 General characteristics

3 General characteristics

Table 3: SACE Isomax switch disconnectors

			S3D	**S6D**	**S7D**	**S8D**
Conventional thermal current at 60 °C, **In**		[A]	100 / 160 / 250 / 320	400 / 630 / 800	1000 / 1250 / 1600	2000 / 2500 / 3200
Number of poles		Nr.	3/4	3/4	3/4	3/4
Rated operational voltage, **Ue**	(ac) 50-60Hz	[V~]	690	690	690	690
	(dc)	[V–]	750	750	750	750
Rated current, **Iu**		[A]	100-160-250-320	400-630-800	1000-1250-1600	2000-2500-3200
Rated impulse withstand voltage, **Uimp**		[kV]	8	8	8	8
Rated insulation voltage, **Ui**		[V]	800	800	800	800
Test voltage at industrial frequency for 1 min.		[V]	3000	3000	3000	3000
Rated short-circuit making capacity (415 V~), **Icm**		[kA]	10	30	52,5	85
Rated short-time withstand current for 1 s, **Icw**		[kA]	6,5	15	25	40
Isolation behaviour			■	■	■	■
IEC 60947-3			■	■	■	■
Versions			F - P - W	F - W	F - W	F
Terminals	fixed		F - EF - FC FC CuAl - R - RC	F - EF - FC CuAl R - RC	F - EF - FC CuAl (1250A) HR - VR	EF (2500A)-R
	plug-in		F - FC - R	-	-	-
	withdrawable		F - FC - R	F - HR - VR	F - HR - VR	-
Mechanical life	[No. of operations / operation per hour]		25000/120	20000/120	10000/120	10000/20
Basic dimensions, fixed	L (3/4 poles)	[mm]	105/140	210/280	210/280	406/556
	D	[mm]	103,5	103,5	138,5	242
	H	[mm]	170	268	406	400
Weights, fixed	3/4 poles	[kg]	2.6/3.5	9.5/12	17/22	57/76

Table 4: Emax switch disconnectors

			E1B/MS	**E1N/MS**	**E2B/MS**	**E2N/MS**	**E3N/MS**	**E3S/MS**	**E4S/MS**	**E4S/fMS**	**E4H/MS**	**E6H/MS**	**E6H/f MS**
Rated uninterrupted current		[A]	**800**	**800**	**1600**	**1250**	**2500**	**1250**	**4000**	**4000**	**3200**	**5000**	**5000**
(a 40 °C) Iu		[A]	**1250**	**1250**	**2000**	**1600**	**3200**	**1600**			**4000**	**6300**	**6300**
		[A]				**2000**		**2000**					
		[A]						**2500**					
		[A]						**3200**					
Rated operational voltage **Ue**		[V ~]	690	690	690	690	690	690	690	690	690	690	690
		[V –]	250	250	250	250	250	250	250	250	250	250	250
Rated insulation voltage **Ui**		[V ~]	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Rated impulse withstand voltage **Uimp**		[kV]	12	12	12	12	12	12	12	12	12	12	12
Rated short-time withstand current **Icw**	(1s)	[kA]	36	50	42	55	65	75	75	80	100	100	100
	(3s)	[kA]	36	36	42	42	65	65	75	75	75	85	85
Rated short-circuit making capacity (peak value) **Icm**													
220/230/380/400/415/440 V ~		[kA]	75.6	105	88.2	121	143	165	165	176	220	220	220
500/660/690 V ~		[kA]	75.6	75.6	88.2	121	143	165	165	165	187	220	220

4 Protection coordination

4.1 Protection coordination

The design of a system for protecting an electric network is of fundamental importance both to ensure the correct economic and functional operation of the installation as a whole and to reduce to a minimum any problem caused by anomalous operating conditions and/or malfunctions.
The present analysis discusses the coordination between the different devices dedicated to the protection of zones and specific components with a view to:

- guaranteeing safety for people and installation at all times;
- identifying and rapidly excluding only the zone affected by a problem, instead of taking indiscriminate actions and thus reducing the energy available to the rest of the network;
- containing the effects of a malfunction on other intact parts of the network (voltage dips, loss of stability in the rotating machines);
- reducing the stress on components and damage in the affected zone;
- ensuring the continuity of the service with a good quality feeding voltage;
- guaranteeing an adequate back-up in the event of any malfunction of the protective device responsible for opening the circuit;
- providing staff and management systems with the information they need to restore the service as rapidly as possible and with a minimal disturbance to the rest of the network;
- achieving a valid compromise between reliability, simplicity and cost effectiveness.

To be more precise, a valid protection system must be able to:

- understand what has happened and where it has happened, discriminating between situations that are anomalous but tolerable and faults within a given zone of influence, avoiding unnecessary tripping and the consequent unjustified disconnection of a sound part of the system;
- take action as rapidly as possible to contain damage (destruction, accelerated ageing, ...), safeguarding the continuity and stability of the power supply.

The most suitable solution derives from a compromise between these two opposing needs - to identify precisely the fault and to act rapidly - and is defined in function of which of these two requirements takes priority.

Over-current coordination

Influence of the network's electrical parameters (rated current and short-circuit current)

The strategy adopted to coordinate the protective devices depends mainly on the rated current (I_n) and short-circuit current (I_k) values in the considered point of network.
Generally speaking, we can classify the following types of coordination:

- current discrimination;
- time (or time-current) discrimination;
- zone (or logical) discrimination;
- energy discrimination;
- back-up.

4 Protection coordination

Definition of discrimination

The **over-current discrimination** is defined in the Standards as *"coordination of the operating characteristics of two or more over-current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the others do not operate"* (IEC 60947-1, def. 2.5.23);
It is possible to distinguish between:

- **total discrimination** means *"over-current discrimination such that, in the case of two over-current protective devices in series, the protective device on the load side provides protection without tripping the other protective device"* (IEC 60947-2, def. 2.17.2);
- **partial discrimination** means *"over-current discrimination such that, in the case of two over-current protective devices in series, the protective device on the load side provides protection up to a given over-current limit without tripping the other"* (IEC 60947-2, def. 2.17.3); this over-current threshold is called *"discrimination limit current* I_S*"* (IEC 60947-2, def. 2.17.4).

Current discrimination

This type of discrimination is based on the observation that the closer the fault comes to the network's feeder, the greater the short-circuit current will be. We can therefore pinpoint the zone where the fault has occurred simply by calibrating the instantaneous protection of the device upstream to a limit value higher than the fault current which causes the tripping of the device downstream.
We can normally achieve total discrimination only in specific cases where the fault current is not very high (and comparable with the device's rated current) or where a component with high impedance is between the two protective devices (e.g. a transformer, a very long or small cable...) giving rise to a large difference between the short-circuit current values.

This type of coordination is consequently feasible mainly in final distribution networks (with low rated current and short-circuit current values and a high impedance of the connection cables).
The devices' time-current tripping curves are generally used for the study.
This solution is:

- rapid;
- easy to implement;
- and inexpensive.

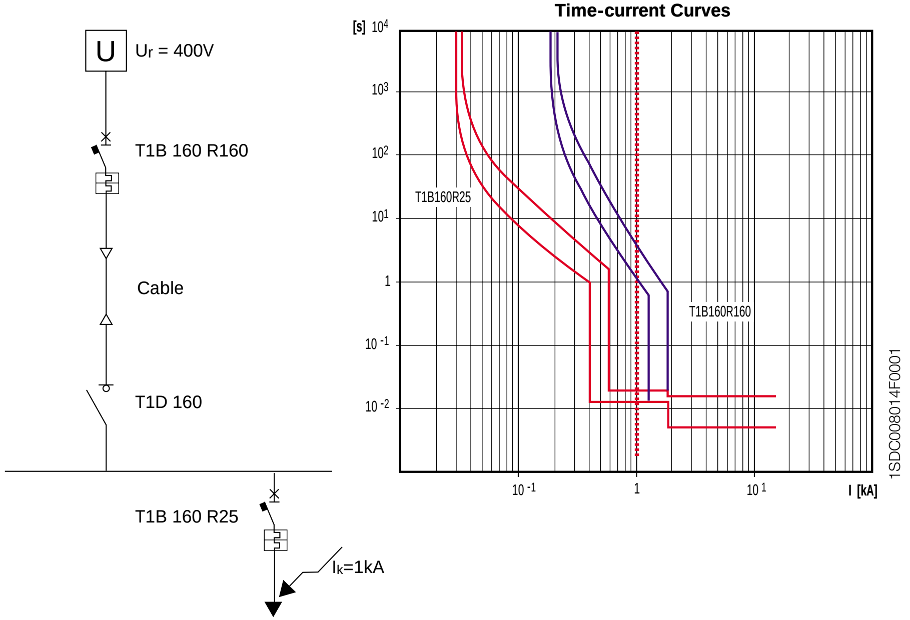
On the other hand:

- the discrimination limits are normally low;
- increasing the discrimination levels causes a rapid growing of the device sizes.

The following example shows a typical application of current discrimination based on the different instantaneous tripping threshold values of the circuit-breakers considered.

4 Protection coordination

With a fault current value at the defined point equal to 1000 A, an adequate coordination is obtained by using the considered circuit-breakers as verified in the tripping curves of the protection devices.
The discrimination limit is given by the minimum magnetic threshold of the circuit-breaker upstream, T1B160 R160.



Time discrimination

This type of discrimination is an evolution from the previous one. The setting strategy is therefore based on progressively increasing the current thresholds and the time delays for tripping the protective devices as we come closer to the power supply source. As in the case of current discrimination, the study is based on a comparison of the time-current tripping curves of the protective devices.

This type of coordination:

- is easy to study and implement;
- is relatively inexpensive;
- enables to achieve even high discrimination levels, depending on the I_{cw} of the upstream device;
- allows a redundancy of the protective functions and can send valid information to the control system,

but has the following disadvantages:

- the tripping times and the energy levels that the protective devices (especially those closer to the sources) let through are high, with obvious problems concerning safety and damage to the components even in zones unaffected by the fault;

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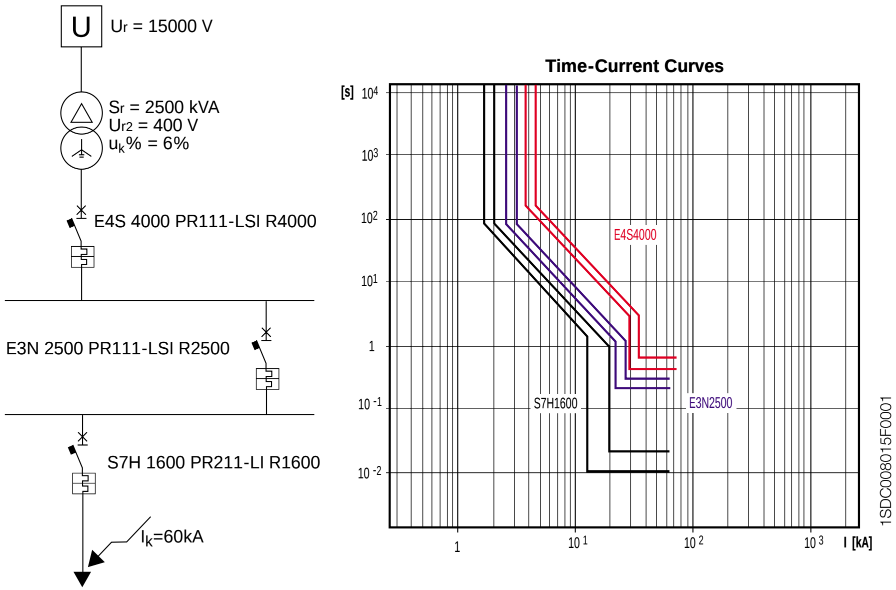
4 Protection coordination

- it enables the use of current-limiting circuit-breakers only at levels hierarchically lower down the chain; the other circuit-breakers have to be capable of withstanding the thermal and electro-dynamic stresses related to the passage of the fault current for the intentional time delay. Selective circuit-breakers, often air type, have to be used for the various levels to guarantee a sufficiently high short-time withstand current;
- the duration of the disturbance induced by the short-circuit current on the power supply voltages in the zones unaffected by the fault can cause problems with electronic and electro-mechanical devices (voltage below the electromagnetic releasing value);
- the number of discrimination levels is limited by the maximum time that the network can stand without loss of stability.

The following example shows a typical application of time discrimination obtained by setting differently the tripping times of the different protection devices.

Electronic release:	L (Long delay)	S (Short delay)	I (IST)
E4S 4000 PR111-LSI R4000	Setting: 0.9 Curve: B	Setting: 8 Curve: D	Off
E3N 2500 PR111-LSI R2500	Setting: 1 Curve: A	Setting: 10 Curve: C	Off
S7H 1600 PR211-LI R1600	Setting: 1 Curve: A		Setting: 10



4 Protection coordination

Zone (or logical) discrimination

This type of coordination is implemented by means of a dialogue between current measuring devices that, when they ascertain that a setting threshold has been exceeded, give the correct identification and disconnection only of the zone affected by the fault.

It is available with the circuit-breakers of Emax series only.

In practice, it can be implemented in two ways:

- the releases send information on the preset current threshold that has been exceeded to the supervisor system and the latter decides which protective device has to trip;
- in the event of current values exceeding its setting threshold, each protective device sends a blocking signal via a direct connection or bus to the protective device higher in the hierarchy (i.e. upstream with respect to the direction of the power flow) and, before it trips, it makes sure that a similar blocking signal has not arrived from the protective device downstream; in this way, only the protective device immediately upstream of the fault trips.

The first mode foresees tripping times of about one second and is used mainly in the case of not particularly high short-circuit currents where a power flow is not uniquely defined.

The second mode enables distinctly shorter tripping times: with respect to a time discrimination coordination, there is no longer any need to increase the intentional time delay progressively as we move closer to the source of the power supply. The maximum delay is in relation to the time necessary to detect any presence of a blocking signal sent from the protective device downstream.

Advantages:

- reduction of the tripping times and increase of the safety level; the tripping times will be around 100 milliseconds;
- reduction of both the damages caused by the fault as well of the disturbances in the power supply network;
- reduction of the thermal and dynamic stresses on the circuit-breakers and on the components of the system;
- large number of discrimination levels;
- redundancy of protections: in case of malfunction of zone discrimination, the tripping is ensured by the settings of the other protection functions of the circuit-breakers. In particular, it is possible to adjust the time-delay protection functions against short-circuit at increasing time values, the closer they are to the network's feeder.

Disadvantages:

- higher costs;
- greater complexity of the system (special components, additional wiring, auxiliary power sources, ...).

This solution is therefore used mainly in systems with high rated current and high short-circuit current values, with precise needs in terms of both safety and continuity of service: in particular, examples of logical discrimination can be often found in primary distribution switchboards, immediately downstream of transformers and generators and in meshed networks.

4 Protection coordination

Energy discrimination

Energy coordination is a particular type of discrimination that exploits the current-limiting characteristics of moulded-case circuit-breakers. It is important to remember that a current-limiting circuit-breaker is *"a circuit-breaker with a break time short enough to prevent the short-circuit current reaching its otherwise attainable peak value"* (IEC 60947-2, def. 2.3).

In practice, ABB SACE moulded-case circuit-breakers of Isomax and Tmax series, under short-circuit conditions, are extremely rapid (tripping times of about some milliseconds) and therefore it is impossible to use the time-current curves for the coordination studies.

The phenomena are mainly dynamic (and therefore proportional to the square of the instantaneous current value) and can be described by using the specific let-through energy curves.

In general, it is necessary to verify that the let-through energy of the circuit-breaker downstream is lower than the energy value needed to complete the opening of the circuit-breaker upstream.

This type of discrimination is certainly more difficult to consider than the previous ones because it depends largely on the interaction between the two devices placed in series and demands access to data often unavailable to the end user. Manufacturers provide tables, rules and calculation programs in which the minimum discrimination limits are given between different combinations of circuit-breakers.

Advantages:

- fast breaking, with tripping times which reduce as the short-circuit current increases;
- reduction of the damages caused by the fault (thermal and dynamic stresses), of the disturbances to the power supply system, of the costs...;
- the discrimination level is no longer limited by the value of the short-time withstand current I_{cw} which the devices can withstand;
- large number of discrimination levels;
- possibility of coordination of different current-limiting devices (fuses, circuit-breakers,..) even if they are positioned in intermediate positions along the chain.

Disadvantage:

- difficulty of coordination between circuit-breakers of similar sizes.

This type of coordination is used above all for secondary and final distribution networks, with rated currents below 1600A.

Back-up protection

The back-up protection is an *"over-current coordination of two over-current protective devices in series where the protective device, generally but not necessarily on the supply side, effects the over-current protection with or without the assistance of the other protective device and prevents any excessive stress on the latter"* (IEC 60947-1, def. 2.5.24).

Besides, IEC 60364-4-43, § 434.5.1 states: *"… A lower breaking capacity is admitted if another protective device having the necessary breaking capacity is installed on the supply side. In that case, characteristics of the devices, must be co-ordinated so that the energy let through by these two devices does not exceed that which can be withstood without damage by the device on the load side and the conductors protected by these devices."*

4 Protection coordination

Advantages:

- cost-saving solution;
- extremely rapid tripping.

Disadvantages:

- extremely low discrimination values;
- low service quality, since at least two circuit-breakers in series have to trip.

Coordination between circuit-breaker and switch disconnector

The switch disconnector

The switch disconnectors derive from the corresponding circuit-breakers, of which they keep the overall dimensions, the fixing systems and the possibility of mounting all the accessories provided for the basic versions. They are devices which can make, carry and break currents under normal service conditions of the circuit.

They can also be used as general circuit-breakers in sub-switchboards, as bus-ties, or to isolate installation parts, such as lines, busbars or groups of loads.

Once the contacts have opened, these switches guarantee isolation thanks to their contacts, which are at the suitable distance to prevent an arc from striking in compliance with the prescriptions of the standards regarding aptitude to isolation.

Protection of switch disconnectors

Each switch disconnector shall be protected by a coordinated device which safeguards it against overcurrents, usually a circuit-breaker able to limit the short-circuit current and the let-through energy values at levels acceptable for the switch-disconnector.

As regards overload protection, the rated current of the circuit-breaker shall be lower than or equal to the size of the disconnector to be protected.

Regarding Isomax and Tmax series switch disconnectors the coordination tables show the circuit-breakers which can protect them against the indicated prospective short-circuit currents values.

Regarding Emax series switch disconnectors it is necessary to verify that the short-circuit current value at the installation point is lower than the short-time withstand current I_{cw} of the disconnector, and that the peak value is lower than the making current value (I_{cm}).

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4 Protection coordination

4.2 Discrimination tables

The tables below give the selectivity values of short-circuit currents (in kA) between pre-selected combinations of circuit-breakers, for voltages from 380 to 415 V. The tables cover the possible combinations of ABB SACE Emax air circuit-breakers series, ABB SACE Isomax and Tmax moulded-case circuit-breakers series and the series of ABB modular circuit-breakers.

The values are obtained following particular rules which, if not respected, may give selectivity values which in some cases may be much lower than those given. Some of these guidelines are generally valid and are indicated below; others refer exclusively to particular types of circuit-breakers and will be subject to notes below the relevant table.

General rules:

- the function I of electronic releases (PR111-PR112-PR113, PR211/P-PR212/P, PR221/DS) of upstream breakers must be excluded (I3 in OFF);
- the magnetic trip of thermomagnetic (TM) or magnetic only (MO) breakers positioned upstream must be ≥ $10 \cdot I_n$ and set to the maximum threshold;
- it is fundamentally important to verify that the settings adopted by the user for the electronic releases of breakers positioned either upstream or downstream do not cause intersections in the time-current curve in the area of overload protection (function L) and in the area of selective short-circuit protection (function S).

It is always advisable to verify the time-current curve in the overload protection area (function L), even when thermomagnetic breakers are used.

Note for the correct reading of the coordination tables:

Tmax @ 415V ac	
Version	Icu [kA]
B	16
C	25
N	36
S	50
H	70
L	85

Isomax @ 415V ac	
Version	Icu [kA]
N	35*
S	50
H	65
L	100 (S3= 85)
X	200

Emax @ 415V ac	
Version	Icu [kA]
B	42
N	65 (E1=50)
S	75
H	100
L	130
V	150

* Versions certified at 36 kA

Discrimination tables MCB-MCB

S290 - S240 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S240	7.5	6	C	T	T
		8	C	T	T
		10	C	5	T
		13	C	4.5	7
		16	C	4.5	7
		20	C	3.5	5
		25	C	3.5	5
		32	C		4.5
		40	C		

S290 - S250 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S250	10	≤ 2	C	T	T
		3	C	T	T
		4	C	T	T
		6	B-C	T	T
		8	B-C	T	T
		10	B-C	5	8
		13	B-C	4.5	7
		16	B-C	4.5	7
		20	B-C	3.5	5
		25	B-C	3.5	5
		32	B-C		4.5
		40	B-C		
		50	B-C		
		63	B-C		

S290 - S250 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S250	10	≤ 2	K	T	T
		3	K	T	T
		4	K	T	T
		6	K	T	T
		8	K	T	T
		10	K	5	8
		16	K	3	5
		20	K	3	7
		25	K		4
		32	K		
		40	K		
		50	K		
		63	K		

S290 - S260 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S260	10	≤ 2	C	T	T
		3	C	T	T
		4	C	T	T
		6	B-C	T	T
		8	B-C	T	T
		10	B-C	5	8
		13	B-C	4.5	7
		16	B-C	4.5	7
		20	B-C	3.5	5
		25	B-C	3.5	5
		32	B-C		4.5
		40	B-C		
		50	B-C		
		63	B-C		

S290 - S270 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S270	15	≤ 2	C	T	T
		3	C	T	T
		4	C	T	T
		6	B-C	10.5	T
		8	B-C	10.5	T
		10	B-C	5	8
		13	B-C	4.5	7
		16	B-C	4.5	7
		20	B-C	3.5	5
		25	B-C	3.5	5
		32	B-C		4.5
		40	B-C		
		50	B-C		
		63	B-C		

S290 - S270 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S270	15	≤ 2	D	T	T
		3	D	T	T
		4	D	T	T
		6	D	10.5	T
		8	D	10.5	T
		10	D	5	8
		16	D	3	5
		20	D	3	5
		25	D	2.5	4
		32	D		4
		40	D		
		50	D		
		63	D		

S290 - S270 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S270	10	≤ 2	Z	T	T
		3	Z	T	T
		4	Z	T	T
		6	Z	T	T
		8	Z	T	T
		10	Z	5	8
		16	Z	4.5	7
		20	Z	3.5	5
		25	Z	3.5	5
		32	Z	3	4.5
		40	Z	3	4.5
		50	Z		3
		63	Z		

S290 - S280 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S280	15	6	B-C	10.5	T
	25	10	B-C	5	8
		13	B-C	4.5	7
		16	B-C	4.5	7
		20	B-C	3.5	5
		25	B-C	3.5	5
	20	32	B-C		4.5
		40	B-C		
	15	50	B-C		
		63	B-C		

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Discrimination tables MCB-MCB

S290 - S280 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S280	15	6	D	10.5	T
	25	10	D	5	8
		16	D	3	5
		20	D	3	5
		25	D	2.5	4
	20	32	D		4
		40	D		
	15	50	D		
		63	D		

S290 - S280 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S280	15	6	K	10.5	T
	25	10	K	5	8
		13	K	3	5
		16	K	3	5
		20	K	3	5
		25	K		4
	20	32	K		
		40	K		
	15	50	K		
		63	K		

S290 - S280 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S280	∞	≤ 2	Z	T	T
	15	3	Z	T	T
		4	Z	T	T
		6	Z	10.5	T
	25	10	Z	5	8
		13	Z	4.5	7
		16	Z	4.5	7
		20	Z	3.5	5
		25	Z	3.5	5
	20	32	Z	3	4.5
		40	Z	3	4.5
	15	50	Z		3
		63	Z		

S290 - S500 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S500	50	6	B-C-D	6	10
		10	B-C-D	6	10
		13	B-C-D	6	10
		16	B-C-D	6	10
		20	B-C-D	6	7.5
		25	B-C-D	4.5	6
		32	B-C-D		6
		40	B-C-D		
		50	B-C-D		
		63	B-C-D		

S290 - S500 @ 400V

			Supply s.	S290	
	I_{cu} [kA]			15	
		I_n [A]		80	100
Load s.			Char.	D	D
S500	50	≤ 5.8	K	T	T
		5.3..8	K	10	T
		7.3..11	K	7.5	T
	30	10..15	K	4.5	10
		14..20	K	4.5	6
		18..26	K		4.5
		23..32	K		
		29..37	K		
		34..41	K		
		38..45	K		

S500 - S240 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n[A]		32	40	50	63
Load s.			Char.	D	D	D	D
S240	7.5	6	C	1.5	2	3	5.5
		8	C	1.5	2	3	5.5
		10	C	1	1.5	2	3
		13	C		1.5	2	3
		16	C			2	3
		20	C				2.5
		25	C				
		32	C				
		40	C				

S500 - S250 @ 400 V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n[A]		32	40	50	63
Load s.			Char.	D	D	D	D
S250	10	≤ 2	C	T	T	T	T
		3	C	3	6	T	T
		4	C	2	3	6	T
		6	B-C	1.5	2	3	5.5
		8	B-C	1.5	2	3	5.5
		10	B-C	1	1.5	2	3
		13	B-C		1.5	2	3
		16	B-C			2	3
		20	B-C				2.5
		25	B-C				
		32	B-C				
		40	B-C				
		50	B-C				
		63	B-C				

S500 - S250 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S250	10	≤ 2	K	T	T	T	T
		3	K	3	6	T	T
		4	K	2	3	6	T
		6	K	1.5	2	3	5.5
		8	K	1.5	2	3	5.5
		10	K		1.5	2	3
		16	K				2
		20	K				
		25	K				
		32	K				
		40	K				
		50	K				
		63	K				

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4 Protection coordination

Discrimination tables MCB-MCB

S500 - S260 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S260	10	≤ 2	C	T	T	T	T
		3	C	3	6	T	T
		4	C	2	3	6	T
		6	B-C	1.5	2	3	5.5
		8	B-C	1.5	2	3	5.5
		10	B-C	1	1.5	2	3
		13	B-C		1.5	2	3
		16	B-C			2	3
		20	B-C				2.5
		25	B-C				
		32	B-C				
		40	B-C				
		50	B-C				
		63	B-C				

S500 - S270 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S270	15	≤ 2	C	T	T	T	T
		3	C	3	6	T	T
		4	C	2	3	6	T
		6	B-C	1.5	2	3	5.5
		8	B-C	1.5	2	3	5.5
		10	B-C	1	1.5	2	3
		13	B-C		1.5	2	3
		16	B-C			2	3
		20	B-C				2.5
		25	B-C				
		32	B-C				
		40	B-C				
		50	B-C				
		63	B-C				

S500 - S270 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S270	15	≤ 2	D	T	T	T	T
		3	D	3	6	T	T
		4	D	2	3	6	T
		6	D	1.5	2	3	5.5
		8	D	1.5	2	3	5.5
		10	D	1	1.5	2	3
		16	D			1.5	2
		20	D				2
		25	D				
		32	D				
		40	D				
		50	D				
		63	D				

S500 - S270 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S270	10	≤ 2	Z	T	T	T	T
		3	Z	3	6	T	T
		4	Z	2	3	6	T
		6	Z	1.5	2	3	5.5
		8	Z	1.5	2	3	5.5
		10	Z	1	1.5	2	3
		16	Z	1	1.5	2	3
		20	Z		1.5	2	2.5
		25	Z			2	2.5
		32	Z				2
		40	Z				
		50	Z				
		63	Z				

4 Protection coordination

S500 - S280 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S280	15	6	B-C	1.5	2	3	5
	25	10	B-C	1	1.5	2	3
		13	B-C		1.5	2	3
		16	B-C			2	3
		20	B-C				2.5
		25	B-C				
	20	32	B-C				
		40	B-C				
	15	50	B-C				
		63	B-C				

S500 - S280 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S280	15	6	D	1.5	2	3	5
	25	10	D	1	1.5	2	3
		16	D			1.5	2
		20	D				2
		25	D				
	20	32	D				
		40	D				
	15	50	D				
		63	D				

S500 - S280 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S280	15	6	K	1.5	2	3	5
	25	10	K		1.5	2	3
		13	K			1.5	2
		16	K				2
		20	K				
		25	K				
	20	32	K				
		40	K				
	15	50	K				
		63	K				

S500 - S280 @ 400V

			Supply s.	S500			
	I_{cu} [kA]			50			
		I_n [A]		32	40	50	63
Load s.			Char.	D	D	D	D
S280	∞	≤ 2	Z	T	T	T	T
	15	3	Z	3	6	T	T
		4	Z	2	3	6	T
		6	Z	1.5	2	3	5.5
	25	10	Z	1	1.5	2	3
		13	Z	1	1.5	2	3
		16	Z	1	1.5	2	3
		20	Z		1.5	2	2.5
		25	Z			2	2.5
	20	32	Z				2
		40	Z				
	15	50	Z				
		63	Z				

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Discrimination tables Tmax-MCB

Tmax T1 - S240 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S240	7.5	C	6	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		C	8		5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		C	10			3	3	3	4.5	T	T	T	T	T
		C	13				3	3	4.5	T	T	T	T	T
		C	16					3	4.5	5	T	T	T	T
		C	20						3	5	6	T	T	T
		C	25							5	6	T	T	T
		C	32								6	T	T	T
		C	40									T	T	T

Tmax T1 - S250 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S250	10	C	≤ 2	T	T	T	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T	T	T	T
		B-C	6	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		B-C	8		5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		B-C	10			3	3	3	4.5	7.5	8.5	T	T	T
		B-C	13				3	3	4.5	7.5	7.5	T	T	T
		B-C	16					3	4.5	5	7.5	T	T	T
		B-C	20						3	5	6	T	T	T
		B-C	25							5	6	T	T	T
		B-C	32								6	7.5	T	T
		B-C	40									7.5	T	T
		B-C	50										7.5	T
		B-C	63											T

Tmax T1 - S250 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S250	10	K	≤ 2	T	T	T	T	T	T	T	T	T	T	T
		K	3	T	T	T	T	T	T	T	T	T	T	T
		K	4	T	T	T	T	T	T	T	T	T	T	T
		K	6	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		K	8		5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		K	10			3	3	3	3	6	8.5	T	T	T
		K	16					3	3	4.5	7.5	T	T	T
		K	20						3	3.5	5.5	6.5	T	T
		K	25							3.5	5.5	6	9.5	T
		K	32								4.5	6	9.5	T
		K	40									5	8	T
		K	50										6	9.5
		K	63											9.5

Tmax T1 - S260 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S260	10	C	≤ 2	T	T	T	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T	T	T	T
		B-C	6	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		B-C	8		5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		B-C	10			3	3	3	4.5	7.5	8.5	T	T	T
		B-C	13				3	3	4.5	7.5	7.5	T	T	T
		B-C	16					3	4.5	5	7.5	T	T	T
		B-C	20						3	5	6	T	T	T
		B-C	25							5	6	T	T	T
		B-C	32								6	7.5	T	T
		B-C	40									7.5	T	T
		B-C	50										7.5	T
		B-C	63											T

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4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T1 - S270 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S270	15	C	≤ 2	T	T	T	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T	T	T	T
		B-C	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
		B-C	8		5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
		B-C	10			3	3	3	4.5	7.5	8.5	T	T	T
		B-C	13				3	3	4.5	7.5	7.5	12	T	T
		B-C	16					3	4.5	5	7.5	12	T	T
		B-C	20						3	5	6	10	T	T
		B-C	25							5	6	10	T	T
		B-C	32								6	7.5	12	T
		B-C	40									7.5	12	T
		B-C	50										7.5	10.5
		B-C	63											10.5

Tmax T1 - S270 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S270	15	D	≤ 2	T	T	T	T	T	T	T	T	T	T	T
		D	3	T	T	T	T	T	T	T	T	T	T	T
		D	4	T	T	T	T	T	T	T	T	T	T	T
		D	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
		D	8		5.5	5.5	5.5	5.5	5.5	10.5	12	T	T	T
		D	10			3	3	3	3	5	8.5	T	T	T
		D	16					2	2	3	5	8	13.5	T
		D	20						2	3	4.5	6.5	11	T
		D	25							2.5	4	6	9.5	T
		D	32								4	6	9.5	T
		D	40									5	8	T
		D	50										5	9.5
		D	63											9.5

4 Protection coordination

Tmax T1 - S270 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S270	10	Z	≤ 2	T	T	T	T	T	T	T	T	T	T	T
		Z	3	T	T	T	T	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T	T	T	T	T
		Z	6	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		Z	8		5.5	5.5	5.5	5.5	5.5	T	T	T	T	T
		Z	10			3	3	3	4.5	8	8.5	T	T	T
		Z	16					3	4.5	5	7.5	T	T	T
		Z	20						3	5	6	T	T	T
		Z	25							5	6	T	T	T
		Z	32								6	7.5	T	T
		Z	40									7.5	T	T
		Z	50										7.5	T
		Z	63											T

Tmax T1 - S280 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S280	15	B-C	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
	25	B-C	10			3	3	3	4.5	7.5	8.5	17*	T	T
		B-C	13				3	3	4.5	7.5	7.5	12	20*	T
		B-C	16					3	4.5	5	7.5	12	20*	T
		B-C	20						3	5	6	10	15	T
		B-C	25							5	6	10	15	T
	20	B-C	32								6	7.5	12	T
		B-C	40									7.5	12	T
	15	B-C	50										7.5	10.5
		B-C	63											10.5

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* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T1 - S280 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S280	15	D	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
	25	D	10			3	3	3	3	5	8.5	17*	T	T
		D	16					2	2	3	5	8	13.5	T
		D	20						2	3	4.5	6.5	11	T
		D	25							2.5	4	6	9.5	T
	20	D	32								4	6	9.5	T
		D	40									5	8	T
	15	D	50										5	9.5
		D	63											9.5

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Tmax T1 - S280 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S280	15	K	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
	25	K	10			3	3	3	3	6	8.5	17*	T	T
		K	13					3	3	5	7.5	10	13.5	T
		K	16					3	3	4.5	7.5	10	13.5	T
		K	20						3	3.5	5.5	6.5	11	T
		K	25							3.5	5.5	6	9.5	T
	20	K	32								4.5	6	9.5	T
		K	40									5	8	T
	15	K	50										6	9.5
		K	63											9.5

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

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Tmax T1 - S280 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S280	∞	Z	≤ 2	T	T	T	T	T	T	T	T	T	T	T
	15	Z	3	T	T	T	T	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T	T	T	T	T
		Z	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
	25	Z	10			3	3	3	4.5	8	8.5	17*	T	T
		Z	13					3	4.5	7.5	7.5	12	20*	T
		Z	16					3	4.5	5	7.5	12	20*	T
		Z	20						3	5	6	10	15	T
		Z	25							5	6	10	15	T
	20	Z	32								6	7.5	12	T
		Z	40									7.5	12	T
	15	Z	50										7.5	10.5
		Z	63											10.5

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Tmax T1 - S500 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S500	50	B-C-D	6	5.5	5.5	5.5	5.5	5.5	5.5	10.5	15	20*	25*	T
		B-C-D	10			4.5	4.5	4.5	4.5	8	10	20*	25*	T
		B-C-D	13				4.5	4.5	4.5	7.5	10	15	25*	T
		B-C-D	16					4.5	4.5	7.5	10	15	25*	T
		B-C-D	20						4.5	7.5	10	15	25*	T
		B-C-D	25							6	10	15	20*	T
		B-C-D	32								7.5	10	20*	T
		B-C-D	40									10	20*	T
		B-C-D	50										15	T
		B-C-D	63											T

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* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T1 - S500 @ 400V

			Supply s.	T1										
			Version	B,C,N										
			Release	TM										
			I_u [A]	160										
Load s.	I_{cu} [kA]	Char.	I_n [A]	16	20	25	32	40	50	63	80	100	125	160
S500	50	K	≤ 5.8	36	36	T	T	T	T	T	T	T	T	T
		K	5.3..8	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
		K	7.3..11			4.5	4.5	4.5	4.5	8	T	T	T	T
	30	K	10..15				4.5	4.5	4.5	7.5	10	15	T	T
		K	14..20					4.5	4.5	7.5	10	15	T	T
		K	18..26						4.5	7.5	10	15	T	T
		K	23..32							6	10	15	20*	T
		K	29..37								7.5	10	20*	T
		K	34..41									10	20*	T
		K	38..45										15	T

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Tmax T2 - S240 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S240	7.5	C	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		C	8			5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		C	10			3*	3	3	3	4.5	T	T	T	T	T		T	T	T	T
		C	13			3*		3	3	4.5	T	T	T	T	T		T	T	T	T
		C	16					3*	3	4.5	5	T	T	T	T			T	T	T
		C	20					3*		3	5	6	T	T	T			T	T	T
		C	25							3*	5	6	T	T	T			T	T	T
		C	32							3*		6	T	T	T			T	T	T
		C	40									5.5*	T	T	T				T	T

* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Tmax T2 - S250 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S250	10	C	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		B-C	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		B-C	8			5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		B-C	10			3*	3	3	3	4.5	7.5	8.5	T	T	T		T	T	T	T
		B-C	13			3*		3	3	4.5	7.5	7.5	T	T	T		T	T	T	T
		B-C	16					3*	3	4.5	5	7.5	T	T	T			T	T	T
		B-C	20					3*		3	5	6	T	T	T			T	T	T
		B-C	25							3*	5	6	T	T	T			T	T	T
		B-C	32							3*		6	7.5	T	T			T	T	T
		B-C	40									5.5*	7.5	T	T				T	T
		B-C	50									3*	5*	7.5	T				T	T
		B-C	63										5*		T					T

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S250 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S250	10	K	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		K	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		K	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		K	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		K	8			5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		K	10			3*	3	3	3	3	6	8.5	T	T	T		T	T	T	T
		K	16					2*	3	3	4.5	7.5	T	T	T			T	T	T
		K	20					2*		3	3.5	5.5	6.5	T	T			T	T	T
		K	25							2*	3.5	5.5	6	9.5	T			T	T	T
		K	32									4.5	6	9.5	T			T	T	T
		K	40									3*	5	8	T				T	T
		K	50									2*	3*	6	9.5				9.5	9.5
		K	63										3*		9.5					9.5

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* Value for the supply side magnetic only circuit-breaker.

Discrimination tables Tmax-MCB

Tmax T2 - S260 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S260	10	C	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		B-C	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		B-C	8			5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		B-C	10			3*	3	3	3	4.5	7.5	8.5	T	T	T		T	T	T	T
		B-C	13			3*		3	3	4.5	7.5	7.5	T	T	T		T	T	T	T
		B-C	16					3*	3	4.5	5	7.5	T	T	T			T	T	T
		B-C	20					3*		3	5	6	T	T	T			T	T	T
		B-C	25							3*	5	6	T	T	T			T	T	T
		B-C	32							3*		6	7.5	T	T			T	T	T
		B-C	40									5.5*	7.5	T	T				T	T
		B-C	50									3*	5*	7.5	T				T	T
		B-C	63										5*		T					T

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S270 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S270	15	C	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		B-C	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
		B-C	8			5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
		B-C	10			3*	3	3	3	4.5	7.5	8.5	T	T	T		T	T	T	T
		B-C	13			3*		3	3	4.5	7.5	7.5	12	T	T		T	T	T	T
		B-C	16					3*	3	4.5	5	7.5	12	T	T			T	T	T
		B-C	20					3*		3	5	6	10	T	T			T	T	T
		B-C	25							3*	5	6	10	T	T			T	T	T
		B-C	32							3*		6	7.5	12	T			T	T	T
		B-C	40									5.5*	7.5	12	T				T	T
		B-C	50									3*	5*	7.5	10.5				10.5	10.5
		B-C	63										5*		10.5					10.5

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S270 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S270	15	D	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		D	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		D	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		D	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
		D	8			5.5	5.5	5.5	5.5	5.5	10.5	12	T	T	T		T	T	T	T
		D	10			3*	3	3	3	3	5	8.5	T	T	T		T	T	T	T
		D	16					2*	2	2	3	5	8	13.5	T			T	T	T
		D	20					2*		2	3	4.5	6.5	11	T			T	T	T
		D	25							2*	2.5	4	6	9.5	T			T	T	T
		D	32									4	6	9.5	T			T	T	T
		D	40									3*	5	8	T				T	T
		D	50									2*	3*	5	9.5				9.5	9.5
		D	63										3*		9.5					9.5

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S270 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S270	10	Z	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		Z	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		Z	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		Z	8			5.5	5.5	5.5	5.5	5.5	T	T	T	T	T		T	T	T	T
		Z	10			3*	3	3	3	4.5	8	8.5	T	T	T		T	T	T	T
		Z	16					3*	3	4.5	5	7.5	T	T	T			T	T	T
		Z	20					3*		3	5	6	T	T	T			T	T	T
		Z	25							3*	5	6	T	T	T			T	T	T
		Z	32							3*		6	7.5	T	T			T	T	T
		Z	40									5.5*	7.5	T	T				T	T
		Z	50									4*	5*	7.5	T				T	T
		Z	63										5*		T					T

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* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T2 - S280 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S280	15	B-C	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
	25	B-C	10			3*	3	3	3	4.5	7.5	8.5	17	T	T		T	T	T	T
		B-C	13			3*		3	3	4.5	7.5	7.5	12	20	T		T	T	T	T
		B-C	16					3*	3	4.5	5	7.5	12	20	T			T	T	T
		B-C	20					3*		3	5	6	10	15	T			T	T	T
		B-C	25							3*	5	6	10	15	T			T	T	T
	20	B-C	32							3*		6	7.5	12	T			T	T	T
		B-C	40									5.5*	7.5	12	T				T	T
	15	B-C	50									3*	5*	7.5	10.5				10.5	10.5
		B-C	63										5*		10.5					10.5

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S280 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S280	15	D	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
	25	D	10			3*	3	3	3	3	5	8.5	17	T	T		T	T	T	T
		D	16					2*	2	2	3	5	8	13.5	T			T	T	T
		D	20					2*		2	3	4.5	6.5	11	T			T	T	T
		D	25							2*	2.5	4	6	9.5	T			T	T	T
	20	D	32									4	6	9.5	T			T	T	T
		D	40									3*	5	8	T				T	T
	15	D	50									2*	3*	5	9.5				9.5	9.5
		D	63										3*		9.5					9.5

* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Tmax T2 - S280 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S280	15	K	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
	25	K	10			3*	3	3	3	3	6	8.5	17	T	T		T	T	T	T
		K	13					2*	3	3	5	7.5	10	13.5	T		T	T	T	T
		K	16					2*	3	3	4.5	7.5	10	13.5	T			T	T	T
		K	20					2*		3	3.5	5.5	6.5	11	T			T	T	T
		K	25							2*	3.5	5.5	6	9.5	T			T	T	T
	20	K	32									4.5	6	9.5	T			T	T	T
		K	40									3*	5	8	T				T	T
	15	K	50									2*	3*	6	9.5				9.5	9.5
		K	63										3*		9.5					9.5

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S280 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S280	∞	Z	≤ 2	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	15	Z	3	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
		Z	6	5.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T		T	T	T	T
	25	Z	10			3*	3	3	3	4.5	8	8.5	17	T	T		T	T	T	T
		Z	13			3*		3	3	4.5	7.5	7.5	12	20	T		T	T	T	T
		Z	16					3*	3	4.5	5	7.5	12	20	T			T	T	T
		Z	20					3*		3	5	6	10	15	T			T	T	T
		Z	25							3*	5	6	10	15	T			T	T	T
	20	Z	32							3*		6	7.5	12	T			T	T	T
		Z	40									5.5*	7.5	12	T				T	T
	15	Z	50									4*	5*	7.5	10.5				10.5	10.5
		Z	63										5*		10.5					10.5

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* Value for the supply side magnetic only circuit-breaker.

Discrimination tables Tmax-MCB

Tmax T2 - S290 @ 400V

			Supply s.	T2	
			Version	N,S,H,L	
			Release	TM,M	EL
			I_u [A]	160	
Load s.	I_{cu} [kA]	Char.	I_n [A]	160	160
S290	15	C-D-K	80		4
		C-D-K	100		4
		C	125		4

Tmax T2 - S500 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S500	50	B-C-D	6	4.5	5.5	5.5	5.5	5.5	5.5	5.5	10.5	15	20	25	36		36	36	36	36
		B-C-D	10			4.5*	4.5	4.5	4.5	4.5	8	10	20	25	36		36	36	36	36
		B-C-D	13			4.5*		4.5	4.5	4.5	7.5	10	15	25	36		36	36	36	36
		B-C-D	16					4.5*	4.5	4.5	7.5	10	15	25	36			36	36	36
		B-C-D	20					4.5*		4.5	7.5	10	15	25	36			36	36	36
		B-C-D	25							4.5*	6	10	15	20	36			36	36	36
		B-C-D	32							4.5*		7.5	10	20	36			36	36	36
		B-C-D	40									5*	10	20	36				36	36
		B-C-D	50									5*	7.5*	15	36				36	36
		B-C-D	63										5*		36					36

* Value for the supply side magnetic only circuit-breaker.

Tmax T2 - S500 @ 400V

			Supply s.	T2																
			Version	N,S,H,L																
			Release	TM,M												EL				
			I_u [A]	160																
Load s.	I_{cu} [kA]	Char.	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160	10	25	63	100	160
S500	50	K	≤ 5.8	36	36	36	36	36	36	36	36	36	36	36	50**	50**	50**	50**	50**	50**
		K	5.3..8	4.5*	5.5	5.5	5.5	5.5	5.5	5.5	10.5	36	36	36	50**		50**	50**	50**	50**
		K	7.3..11			4.5*	4.5	4.5	4.5	4.5	8	36	36	36	50**		50**	50**	50**	50**
	30	K	10..15			4.5*		4.5	4.5	4.5	7.5	10	15	T	T		T	T	T	T
		K	14..20					4.5*	4.5	4.5	7.5	10	15	T	T			T	T	T
		K	18..26					4.5*		4.5	7.5	10	15	T	T			T	T	T
		K	23..32							4.5*	6	10	15	20	T			T	T	T
		K	29..37							4.5*		7.5	10	20	T				T	T
		K	34..41									5*	10	20	T				T	T
		K	38..45									5*	7.5*	15	T				T	T

* Value for the supply side magnetic only circuit-breaker.

** Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Tmax T3 - S240 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S240	7.5	C	6	T	T	T	T	T	T	T
		C	8	T	T	T	T	T	T	T
		C	10	T	T	T	T	T	T	T
		C	13	T	T	T	T	T	T	T
		C	16	5	T	T	T	T	T	T
		C	20	5	6	T	T	T	T	T
		C	25	5	6	T	T	T	T	T
		C	32		6	T	T	T	T	T
		C	40		4	T	T	T	T	T

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4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T3 - S250 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S250	10	C	≤ 2	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T
		B-C	6	T	T	T	T	T	T	T
		B-C	8	T	T	T	T	T	T	T
		B-C	10	7.5	8.5	T	T	T	T	T
		B-C	13	7.5	7.5	T	T	T	T	T
		B-C	16	5	7.5	T	T	T	T	T
		B-C	20	5	6	T	T	T	T	T
		B-C	25	5	6	T	T	T	T	T
		B-C	32		6	7.5	T	T	T	T
		B-C	40			7.5	T	T	T	T
		B-C	50			5*	7.5	T	T	T
		B-C	63			5*	6*	T	T	T

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S250 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S250	10	K	≤ 2	T	T	T	T	T	T	T
		K	3	T	T	T	T	T	T	T
		K	4	T	T	T	T	T	T	T
		K	6	T	T	T	T	T	T	T
		K	8	T	T	T	T	T	T	T
		K	10	6	8.5	T	T	T	T	T
		K	16	4.5	7.5	T	T	T	T	T
		K	20	3.5	5.5	6.5	T	T	T	T
		K	25	3.5	5.5	6	9.5	T	T	T
		K	32		4.5	6	9.5	T	T	T
		K	40			5	8	T	T	T
		K	50			3*	6	9.5	T	T
		K	63			3*	5.5*	9.5	T	T

* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Tmax T3 - S260 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S260	10	C	≤ 2	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T
		B-C	6	T	T	T	T	T	T	T
		B-C	8	T	T	T	T	T	T	T
		B-C	10	7.5	8.5	T	T	T	T	T
		B-C	13	7.5	7.5	T	T	T	T	T
		B-C	16	5	7.5	T	T	T	T	T
		B-C	20	5	6	T	T	T	T	T
		B-C	25	5	6	T	T	T	T	T
		B-C	32		6	7.5	T	T	T	T
		B-C	40			7.5	T	T	T	T
		B-C	50			5*	7.5	T	T	T
		B-C	63			5*	6*	T	T	T

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S270 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S270	15	C	≤ 2	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T
		B-C	6	10.5	T	T	T	T	T	T
		B-C	8	10.5	T	T	T	T	T	T
		B-C	10	7.5	8.5	T	T	T	T	T
		B-C	13	7.5	7.5	12	T	T	T	T
		B-C	16	5	7.5	12	T	T	T	T
		B-C	20	5	6	10	T	T	T	T
		B-C	25	5	6	10	T	T	T	T
		B-C	32		6	7.5	12	T	T	T
		B-C	40			7.5	12	T	T	T
		B-C	50			5*	7.5	10.5	T	T
		B-C	63			5*	6*	10.5	T	T

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* Value for the supply side magnetic only circuit-breaker.

Discrimination tables Tmax-MCB

Tmax T3 - S270 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S270	15	D	≤ 2	T	T	T	T	T	T	T
		D	3	T	T	T	T	T	T	T
		D	4	T	T	T	T	T	T	T
		D	6	10.5	T	T	T	T	T	T
		D	8	10.5	12	T	T	T	T	T
		D	10	5	8.5	T	T	T	T	T
		D	16	3	5	8	13.5	T	T	T
		D	20	3	4.5	6.5	11	T	T	T
		D	25	2.5	4	6	9.5	T	T	T
		D	32		4	6	9.5	T	T	T
		D	40			5	8	T	T	T
		D	50			3*	5	9.5	T	T
		D	63			3*	5*	9.5	T	T

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S270 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S270	10	Z	≤ 2	T	T	T	T	T	T	T
		Z	3	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T
		Z	6	T	T	T	T	T	T	T
		Z	8	T	T	T	T	T	T	T
		Z	10	8	8.5	T	T	T	T	T
		Z	16	5	7.5	T	T	T	T	T
		Z	20	5	6	T	T	T	T	T
		Z	25	5	6	T	T	T	T	T
		Z	32		6	7.5	T	T	T	T
		Z	40			7.5	T	T	T	T
		Z	50			5*	7.5	T	T	T
		Z	63			5*	6*	T	T	T

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S280 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S280	15	B-C	6	10.5	T	T	T	T	T	T
	25	B-C	10	7.5	8.5	17	T	T	T	T
		B-C	13	7.5	7.5	12	20	T	T	T
		B-C	16	5	7.5	12	20	T	T	T
		B-C	20	5	6	8	13.5	T	T	T
		B-C	25	5	6	8	13.5	T	T	T
	20	B-C	32		6	7.5	12	T	T	T
		B-C	40			7.5	12	T	T	T
	15	B-C	50			5*	7.5	10.5	T	T
		B-C	63			5*	6*	10.5	T	T

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S280 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S280	15	D	6	10.5	T	T	T	T	T	T
	25	D	10	5	8.5	17	T	T	T	T
		D	16	3	5	8	13.5	T	T	T
		D	20	3	4.5	6.5	11	T	T	T
		D	25	2.5	4	6	9.5	T	T	T
	20	D	32		4	6	9.5	T	T	T
		D	40			5	8	T	T	T
	15	D	50			3*	5	9.5	T	T
		D	63			3*	5*	9.5	T	T

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* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T3 - S280 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S280	15	K	6	10.5	T	T	T	T	T	T
	25	K	10	6	8.5	17	T	T	T	T
		K	13	5	7.5	10	13.5	T	T	T
		K	16	4.5	7.5	10	13.5	T	T	T
		K	20	3.5	5.5	6.5	11	T	T	T
		K	25	3.5	5.5	6	9.5	T	T	T
	20	K	32		4.5	6	9.5	T	T	T
		K	40			5	8	T	T	T
	15	K	50			3*	6	9.5	T	T
		K	63			3*	5.5*	9.5	T	T

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S280 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S280	∞	Z	≤ 2	T	T	T	T	T	T	T
	15	Z	3	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T
		Z	6	10.5	T	T	T	T	T	T
	25	Z	10	8	8.5	17	T	T	T	T
		Z	13	7.5	7.5	12	20	T	T	T
		Z	16	5	7.5	12	20	T	T	T
		Z	20	5	6	10	15	T	T	T
		Z	25	5	6	10	15	T	T	T
	20	Z	32		6	7.5	12	T	T	T
		Z	40			7.5	12	T	T	T
	15	Z	50			5*	7.5	10.5	T	T
		Z	63			5*	6*	10.5	T	T

* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Tmax T3 - S290 @ 400V

			Supply s.	T3		
			Version	N,S		
			Release	TM,M		
			I_u [A]	250		
Load s.	I_{cu} [kA]	Char.	I_n [A]	160	200	250
S290	15	C-D-K	80	4*	10	15
		C-D-K	100	4*	7.5*	15
		C	125		7.5*	

* Value for the supply side magnetic only circuit-breaker.

Tmax T3 - S500 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S500	50	B-C-D	6	10.5	15	20	25	36	36	36
		B-C-D	10	8	10	20	25	36	36	36
		B-C-D	13	7.5	10	15	25	36	36	36
		B-C-D	16	7.5	10	15	25	36	36	36
		B-C-D	20	7.5	10	15	25	36	36	36
		B-C-D	25	6	10	15	20	36	36	36
		B-C-D	32		7.5	10	20	36	36	36
		B-C-D	40			10	20	36	36	36
		B-C-D	50			7.5*	15	36	36	36
		B-C-D	63			5*	6*	36	36	36

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* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Discrimination tables Tmax-MCB

Tmax T3 - S500 @ 400V

			Supply s.	T3						
			Version	N,S						
			Release	TM,M						
			I_u [A]	250						
Load s.	I_{cu} [kA]	Char.	I_n [A]	63	80	100	125	160	200	250
S500	50	K	≤ 5.8	36	36	36	36	T	T	T
		K	5.3..8	10.5	36	36	36	T	T	T
		K	7.3..11	8	36	36	36	T	T	T
	30	K	10..15	7.5	10	15	T	T	T	T
		K	14..20	7.5	10	15	T	T	T	T
		K	18..26	7.5	10	15	T	T	T	T
		K	23..32	6	10	15	20	T	T	T
		K	29..37		7.5	10	20	T	T	T
		K	34..41			10	20	T	T	T
		K	38..45			7.5*	15	T	T	T

* Value for the supply side magnetic only circuit-breaker.

4 Protection coordination

Discrimination tables Tmax-Tmax

Tmax - Tmax @ 415V

				Supply s.	T1	T2					T3		
				Version	B,C,N	N,S,H,L					N,S		
				Release	TM	TM	EL				TM,M		
			I_u [A]		160	160					250		
Load s.	Version	Release		I_n [A]	160	160	25	63	100	160	160	200	250
T1	B,C,N	TM	160	16	3	3		3	3	3	3	4	5
				20	3	3		3	3	3	3	4	5
				25	3	3		3	3	3	3	4	5
				32	3	3			3	3	3	4	5
				40	3	3			3	3	3	4	5
				50	3	3			3	3	3	4	5
				63	3	3				3	3	4	5
				80						3		4	5
				100									5
				125									
				160									
T2	N,S,H,L	TM	160	1,6..5	T	T	T	T	T	T	T	T	T
				6,3..10	10	10	10	10	10	10	10	15	40
				12,5	3	3		3	3	3	3	4	5
				16	3	3		3	3	3	3	4	5
				20	3	3		3	3	3	3	4	5
				25	3	3		3	3	3	3	4	5
				32	3	3			3	3	3	4	5
				40	3	3			3	3	3	4	5
				50	3	3			3	3	3	4	5
				63	3	3				3	3	4	5
				80						3	3*	4	5
				100								4*	5
				125									
				160									
		EL	160	10..160								3	4
T3	N,S	TM	250	63							3	4	5
				80							3*	4	5
				100								4*	5
				125									
				160..250									

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* Value for the supply side magnetic only circuit-breaker.

Discrimination tables Tmax-Isomax

Tmax - Isomax @ 415V

				Supply s.	T3		
				Version	N,S		
				Release	TM,M		
			I_u [A]		250		
Load s.	Version	Release		I_n [A]	160	200	250
S3	N,H,L	TM	250	32	3	4	5
				50	3	4	5
				80	3*	4	5
				100		4*	5
				125			
				160..250			

* Value for the supply side magnetic only circuit-breaker.

Discrimination tables Isomax-MCB

Isomax S3 - S240 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S240	7.5	C	6	5.5	5.5	T	T	T	T	T	T
		C	8	5.5	5.5	T	T	T	T	T	T
		C	10	3	3	T	T	T	T	T	T
		C	13		3	T	T	T	T	T	T
		C	16		3	T	T	T	T	T	T
		C	20		2.5	5.5	T	T	T	T	T
		C	25			5.5	T	T	T	T	T
		C	32			4.5	7	T	T	T	T
		C	40				7	T	T	T	T

Isomax S3 - S250 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S250	10	C	≤ 2	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T
		B-C	6	5.5	5.5	T	T	T	T	T	T
		B-C	8	5.5	5.5	T	T	T	T	T	T
		B-C	10	3	3	8.5	T	T	T	T	T
		B-C	13		3	7.5	T	T	T	T	T
		B-C	16		3	7.5	T	T	T	T	T
		B-C	20		2.5	5.5	8	T	T	T	T
		B-C	25			5.5	8	T	T	T	T
		B-C	32			4.5	7	T	T	T	T
		B-C	40				7	T	T	T	T
		B-C	50					6	T	T	T
		B-C	63						T	T	T

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Discrimination tables Isomax-MCB

Isomax S3 - S250 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S250	10	K	≤ 2	T	T	T	T	T	T	T	T
		K	3	T	T	T	T	T	T	T	T
		K	4	T	T	T	T	T	T	T	T
		K	6	5.5	5.5	T	T	T	T	T	T
		K	8	5.5	5.5	T	T	T	T	T	T
		K	10		3	8.5	T	T	T	T	T
		K	16			5	8	T	T	T	T
		K	20			4.5	6.5	T	T	T	T
		K	25				6	9.5	T	T	T
		K	32					9.5	T	T	T
		K	40						T	T	T
		K	50							T	T
		K	63								T

Isomax S3 - S260 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S260	10	C	≤ 2	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T
		B-C	6	5.5	5.5	T	T	T	T	T	T
		B-C	8	5.5	5.5	T	T	T	T	T	T
		B-C	10	3	3	8.5	T	T	T	T	T
		B-C	13		3	7.5	T	T	T	T	T
		B-C	16		3	7.5	T	T	T	T	T
		B-C	20		2.5	5.5	8	T	T	T	T
		B-C	25			5.5	8	T	T	T	T
		B-C	32			4.5	7	T	T	T	T
		B-C	40				7	T	T	T	T
		B-C	50					6	T	T	T
		B-C	63						T	T	T

Isomax S3 - S270 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S270	15	C	≤ 2	T	T	T	T	T	T	T	T
		C	3	T	T	T	T	T	T	T	T
		C	4	T	T	T	T	T	T	T	T
		B-C	6	5.5	5.5	T	T	T	T	T	T
		B-C	8	5.5	5.5	T	T	T	T	T	T
		B-C	10	3	3	8.5	T	T	T	T	T
		B-C	13		3	7.5	12	T	T	T	T
		B-C	16		3	7.5	12	T	T	T	T
		B-C	20		2.5	5.5	8	13.5	T	T	T
		B-C	25			5.5	8	13.5	T	T	T
		B-C	32			4.5	7	12	T	T	T
		B-C	40				7	12	T	T	T
		B-C	50					6	10.5	T	T
		B-C	63						10.5	T	T

Isomax S3 - S270 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S270	15	D	≤ 2	T	T	T	T	T	T	T	T
		D	3	T	T	T	T	T	T	T	T
		D	4	T	T	T	T	T	T	T	T
		D	6	5.5	5.5	T	T	T	T	T	T
		D	8	5.5	5.5	T	T	T	T	T	T
		D	10	3	3	8.5	T	T	T	T	T
		D	16		2	5	8	13.5	T	T	T
		D	20		2	4.5	6.5	11	T	T	T
		D	25			4	6	9.5	T	T	T
		D	32			4	6	9.5	T	T	T
		D	40				5	8	T	T	T
		D	50						9.5	T	T
		D	63						9.5	T	T

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Discrimination tables Isomax-MCB

Isomax S3 - S270 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S270	10	Z	≤ 2	T	T	T	T	T	T	T	T
		Z	3	T	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T	T
		Z	6	5.5	5.5	T	T	T	T	T	T
		Z	8	5.5	5.5	T	T	T	T	T	T
		Z	10	3	3	8.5	T	T	T	T	T
		Z	16		3	7.5	T	T	T	T	T
		Z	20		2.5	5.5	8	T	T	T	T
		Z	25		2.5*	5.5	8	T	T	T	T
		Z	32		2*	4.5	7	T	T	T	T
		Z	40			4.5*	7	T	T	T	T
		Z	50			3*	4.5*	6	T	T	T
		Z	63				4.5*	6*	T	T	T

* Value for the supply side magnetic only circuit-breaker.

Isomax S3 - S280 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S280	15	B-C	6	5.5	5.5	T	T	T	T	T	T
	25	B-C	10	3	3	8.5	17	T	T	T	T
		B-C	13		3	7.5	12	20	T	T	T
		B-C	16		3	7.5	12	20	T	T	T
		B-C	20		2.5	5.5	8	13.5	T	T	T
		B-C	25			5.5	8	13.5	T	T	T
	20	B-C	32			4.5	7	12	T	T	T
		B-C	40				7	12	T	T	T
	15	B-C	50					6	10.5	T	T
		B-C	63						10.5	T	T

Isomax S3 - S280 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S280	15	D	6	5.5	5.5	T	T	T	T	T	T
	25	D	10	3	3	8.5	17	T	T	T	T
		D	16		2	5	8	13.5	24.5	T	T
		D	20		2	4.5	6.5	11	22	T	T
		D	25			4	6	9.5	16.5	T	T
	20	D	32			4	6	9.5	16.5	T	T
		D	40				5	8	15	T	T
	15	D	50						9.5	T	T
		D	63						9.5	T	T

Isomax S3 - S280 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S280	15	K	6	5.5	5.5	T	T	T	T	T	T
	25	K	10		3	8.5	17	T	T	T	T
		K	13		2	5	8	13.5	24.5	T	T
		K	16			5	8	13.5	24.5	T	T
		K	20			4.5	6.5	11	22	T	T
		K	25				6	9.5	16.5	T	T
	20	K	32					9.5	16.5	T	T
		K	40						15	T	T
	15	K	50							T	T
		K	63								T

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Discrimination tables Isomax-MCB

Isomax S3 - S280 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S280	∞	Z	≤ 2	T	T	T	T	T	T	T	T
	15	Z	3	T	T	T	T	T	T	T	T
		Z	4	T	T	T	T	T	T	T	T
		Z	6	5.5	5.5	T	T	T	T	T	T
	25	Z	10	3	3	8.5	17	T	T	T	T
		Z	13	3	3	7.5	12	20	T	T	T
		Z	16		3	7.5	12	20	T	T	T
		Z	20		2.5	5.5	8	13.5	T	T	T
		Z	25		2.5*	5.5	8	13.5	T	T	T
	20	Z	32		2*	4.5	7	12	T	T	T
		Z	40			4.5*	7	12	T	T	T
	15	Z	50			3*	4.5*	6	10.5	T	T
		Z	63				4.5*	6*	10.5	T	T

* Value for the supply side magnetic only circuit-breaker.

Isomax S3 - S290 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S290	15	C-D-K	80							9.5	T
		C-D-K	100								14
		C	125								

Isomax S3 - S500 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S500	50	B-C-D	6	4.5	4.5	10	15	35	35	35	35
		B-C-D	10	4.5	4.5	10	15	35	35	35	35
		B-C-D	13		4.5	10	15	35	35	35	35
		B-C-D	16		4.5	10	15	35	35	35	35
		B-C-D	20		4.5	7.5	15	35	35	35	35
		B-C-D	25			7.5	10	20	35	35	35
		B-C-D	32			6	10	20	35	35	35
		B-C-D	40				7.5	15	35	35	35
		B-C-D	50					10	35	35	35
		B-C-D	63						35	35	35

Isomax S3 - S500 @ 400V

			Supply s.	S3							
			Version	N,H,L							
			Release	TM,M							
			I_u [A]	160-250							
Load s.	I_{cu} [kA]	Char.	I_n [A]	32	50	80	100	125	160	200	250
S500	50	K	≤ 5.8	35	35	35	35	35	T	T	T
		K	5.3..8	4.5	4.5	35	35	35	T	T	T
		K	7.3..11		3	25	35	35	T	T	T
	30	K	10..15			10	15	30	T	T	T
		K	14..20			6	10	20	T	T	T
		K	18..26				7.5	15	T	T	T
		K	23..32					15	T	T	T
		K	29..37						20	T	T
		K	34..41						20	T	T
		K	38..45						20	T	T

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Discrimination tables Isomax-MCB

Isomax S4 - S240 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	250		
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S240	7.5	C	6	T	T	T
		C	8	T	T	T
		C	10	T	T	T
		C	13	T	T	T
		C	16	T	T	T
		C	20	T	T	T
		C	25	T	T	T
		C	32	T	T	T
		C	40	T	T	T

Isomax S4 - S250 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	250		
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S250	10	C	≤ 2	T	T	T
		C	3	T	T	T
		C	4	T	T	T
		B-C	6	T	T	T
		B-C	8	T	T	T
		B-C	10	T	T	T
		B-C	13	T	T	T
		B-C	16	T	T	T
		B-C	20	T	T	T
		B-C	25	T	T	T
		B-C	32	T	T	T
		B-C	40	T	T	T
		B-C	50	T	T	T
		B-C	63	T	T	T

Isomax S4 - S250 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S250	10	K	≤ 2	T	T	T
		K	3	T	T	T
		K	4	T	T	T
		K	6	T	T	T
		K	8	T	T	T
		K	10	T	T	T
		K	16	T	T	T
		K	20	T	T	T
		K	25	T	T	T
		K	32	T	T	T
		K	40	T	T	T
		K	50	T	T	T
		K	63	T	T	T

Isomax S4 - S260 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S260	10	C	≤ 2	T	T	T
		C	3	T	T	T
		C	4	T	T	T
		B-C	6	T	T	T
		B-C	8	T	T	T
		B-C	10	T	T	T
		B-C	13	T	T	T
		B-C	16	T	T	T
		B-C	20	T	T	T
		B-C	25	T	T	T
		B-C	32	T	T	T
		B-C	40	T	T	T
		B-C	50	T	T	T
		B-C	63	T	T	T

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Isomax S4 - S270 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S270	15	C	≤ 2	T	T	T
		C	3	T	T	T
		C	4	T	T	T
		B-C	6	T	T	T
		B-C	8	T	T	T
		B-C	10	T	T	T
		B-C	13	T	T	T
		B-C	16	T	T	T
		B-C	20	T	T	T
		B-C	25	T	T	T
		B-C	32	T	T	T
		B-C	40	T	T	T
		B-C	50	T	T	T
		B-C	63	T	T	T

Isomax S4 - S270 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S270	15	D	≤ 2	T	T	T
		D	3	T	T	T
		D	4	T	T	T
		D	6	T	T	T
		D	8	T	T	T
		D	10	T	T	T
		D	16	T	T	T
		D	20	T	T	T
		D	25	T	T	T
		D	32	T	T	T
		D	40	T	T	T
		D	50	T	T	T
		D	63	T	T	T

Isomax S4 - S270 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S270	10	Z	≤ 2	T	T	T
		Z	3	T	T	T
		Z	4	T	T	T
		Z	6	T	T	T
		Z	8	T	T	T
		Z	10	T	T	T
		Z	16	T	T	T
		Z	20	T	T	T
		Z	25	T	T	T
		Z	32	T	T	T
		Z	40	T	T	T
		Z	50	T	T	T
		Z	63	T	T	T

Isomax S4 - S280 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S280	15	B-C	6	T	T	T
	25	B-C	10	T	T	T
		B-C	13	T	T	T
		B-C	16	T	T	T
		B-C	20	T	T	T
		B-C	25	T	T	T
	20	B-C	32	T	T	T
		B-C	40	T	T	T
	15	B-C	50	T	T	T
		B-C	63	T	T	T

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Discrimination tables Isomax-MCB

Isomax S4 - S280 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S280	15	D	6	T	T	T
	25	D	10	T	T	T
		D	16	T	T	T
		D	20	T	T	T
		D	25	T	T	T
	20	D	32	T	T	T
		D	40	T	T	T
	15	D	50	T	T	T
		D	63	T	T	T

Isomax S4 - S280 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S280	15	K	6	T	T	T
	25	K	10	T	T	T
		K	13	T	T	T
		K	16	T	T	T
		K	20	T	T	T
		K	25	T	T	T
	20	K	32	T	T	T
		K	40	T	T	T
	15	K	50	T	T	T
		K	63	T	T	T

Isomax S4 - S280 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S280	∞	Z	≤ 2	T	T	T
	15	Z	3	T	T	T
		Z	4	T	T	T
		Z	6	T	T	T
	25	Z	10	T	T	T
		Z	13	T	T	T
		Z	16	T	T	T
		Z	20	T	T	T
		Z	25	T	T	T
	20	Z	32	T	T	T
		Z	40	T	T	T
	15	Z	50	T	T	T
		Z	63	T	T	T

Isomax S4 - S290 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S290	15	C-D-K	80		14	T
		C-D-K	100		10.5	T
		C	125			T

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Isomax S4 - S500 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S500	50	B-C-D	6	40*	40*	40*
		B-C-D	10	40*	40*	40*
		B-C-D	13	40*	40*	40*
		B-C-D	16	40*	40*	40*
		B-C-D	20	40*	40*	40*
		B-C-D	25	40*	40*	40*
		B-C-D	32	40*	40*	40*
		B-C-D	40	40*	40*	40*
		B-C-D	50	40*	40*	40*
		B-C-D	63	40*	40*	40*

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Isomax S4 - S500 @ 400V

			Supply s.	S4		
			Version	N,H,L		
			Release	EL		
			I_u [A]	160		250
Load s.	I_{cu} [kA]	Char.	I_n [A]	100	160	250
S500	50	K	≤ 5.8	T	T	T
		K	5.3..8	T	T	T
		K	7.3..11	T	T	T
	30	K	10..15	T	T	T
		K	14..20	T	T	T
		K	18..26	T	T	T
		K	23..32	T	T	T
		K	29..37	T	T	T
		K	34..41	T	T	T
		K	38..45	T	T	T

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4 Protection coordination

4 Protection coordination

Discrimination tables Isomax-Tmax

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM								EL			EL				EL		EL			TM							EL			EL		
			I_u [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		I_n [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T1	B	TM	160	16						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				20-25						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				32						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				40-63						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				80						3*	4	5		7	7	T	T	T		T	T	T	T	T						3*	4		7	7	T	T	T
				100						3*	4*	5		7	7	T	T	T		T	T	T	T	T						3*	4*		7	7	T	T	T
				125							4*	5*			7	T	T	T		T	T	T	T	T							4*			7	T	T	T
				160								5*			7	T	T	T		T	T	T	T	T										7	T	T	T

* Value for the supply side magnetic only circuit-breaker.

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			I_u [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		I_n [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T1	C	TM	160	25						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				32						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				40-63						3	4	5	8	8	8	T	T	T		T	T	T	T	T						3	4	8	8	8	T	T	T
				80						3*	4	5		7	7	T	T	T		T	T	T	T	T						3*	4		7	7	T	T	T
				100						3*	4*	5		7	7	24	24	24		T	T	T	T	T						3*	4*		7	7	T	T	T
				125							4*	5*			7	24	24	24		T	T	T	T	T							4*			7	T	T	T
				160								5*			7	24	24	24		T	T	T	T	T										7	T	T	T

1SDC008024F0201

* Value for the supply side magnetic only circuit-breaker.

Discrimination tables Isomax-Tmax

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			I_u [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		I_n [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T1	N	TM	160	32						3	4	5	8	8	8	30	30	30		T	T	T	T	T						3	4	8	8	8	T	T	T
				40-63						3	4	5	8	8	8	30	30	30		T	T	T	T	T						3	4	8	8	8	T	T	T
				80						3*	4	5		7	7	30	30	30		T	T	T	T	T						3*	4*		7	7	T	T	T
				100						3*	4*	5		7	7	24	24	24		T	T	T	T	T						3*	4*		7	7	T	T	T
				125							4*	5*			7	24	24	24		T	T	T	T	T							4*			7	T	T	T
				160								5*			7	24	24	24		T	T	T	T	T										7	T	T	T

* Value for the supply side magnetic only circuit-breaker.

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			I_u [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		I_n [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T2	N	TM	160	1,6-2,5	T	T	T	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
				3,2	10	13	30**	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	10	10	30	T	T	T	T	T	T	T	T	T	T
				4-5	6	7	15	30**	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	6	6	15	30	T	T	T	T	T	T	T	T	T
				6,3	3	4	7	14	20**	T	T	T	T	T	T	T	T	T		T	T	T	T	T	3	3	7	14	20	T	T	T	T	T	T	T	T
				8		3	5	10	15	30**	T	T	T	T	T	T	T	T		T	T	T	T	T			5	10	15	35	T	T	T	T	T	T	T
				10			4	6	8	15	30	T	T	T	T	T	T	T		T	T	T	T	T			4	6	8	15	30	T	T	T	T	T	T
				12,5-16				3	3	6	10	20	T	T	T	T	T	T		T	T	T	T	T				3	3	8	10	T	T	T	T	T	T
				20				3	3	5	10	18	30	30	30	T	T	T		T	T	T	T	T				3	3	6	9	30	30	30	T	T	T
				25-32				3	3	5	10	18	25	25	25	T	T	T		T	T	T	T	T				3	3	5	8	25	25	25	T	T	T
				40-63				3	3	5	7	10	20	20	20	T	T	T		T	T	T	T	T				3	3	5	7	20	20	20	T	T	T
				80							3	5		9	9	T	T	T		T	T	T	T	T						3*	3		10	10	T	T	T
				100							3*	5		9	9	T	T	T		T	T	T	T	T						3*	3*		10	10	T	T	T
				125							3*	5*			9	T	T	T		T	T	T	T	T							3*			10	T	T	T
				160								5*			9	T	T	T		T	T	T	T	T										10	T	T	T
		EL	160	10..160							3	5	9	9	9	T	T	T		T	T	T	T	T						3	3	10	10	10	T	T	T

1SDC008025F0201

* Value for the supply side magnetic only circuit-breaker.
** Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Discrimination tables Isomax-Tmax

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			Iu [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		In [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T2	S	TM	160	1,6-2,5	T	T	T	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
				3,2	10	13	30**	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	10	10	30	T	T	T	T	T	T	T	T	T	T
				4-5	6	7	15	30**	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	6	6	15	30	T	T	T	T	T	T	T	T	T
				6,3	3	4	7	14	20**	T	T	T	T	T	T	T	T	T		T	T	T	T	T	3	3	7	14	20	T	T	T	T	T	T	T	T
				8		3	5	10	15	30**	T	T	T	T	T	T	T	T		T	T	T	T	T			5	10	15	35	T	T	T	T	T	T	T
				10			4	6	8	15	30	T	T	T	T	T	T	T		T	T	T	T	T			4	6	8	15	30	T	T	T	T	T	T
				12,5-16				3	3	6	10	20	40**	40**	40**	T	T	T		T	T	T	T	T				3	3	8	10	40	40	40	T	T	T
				20				3	3	5	10	18	30	30	30	T	T	T		T	T	T	T	T				3	3	6	9	30	30	30	T	T	T
				25-32				3	3	5	10	18	25	25	25	T	T	T		T	T	T	T	T				3	3	5	8	25	25	25	T	T	T
				40-63				3	3	5	7	10	20	20	20	T	T	T		T	T	T	T	T				3	3	5	7	20	20	20	T	T	T
				80							3	5		9	9	T	T	T		T	T	T	T	T						3*	3		10	10	T	T	T
				100							3*	5		9	9	T	T	T		T	T	T	T	T						3*	3*		10	10	T	T	T
				125							3*	5*			9	T	T	T		T	T	T	T	T							3*			10	T	T	T
				160								5*			9	T	T	T		T	T	T	T	T										10	T	T	T
		EL	160	10-160							3	5	9	9	9	T	T	T		T	T	T	T	T						3	3	10	10	10	T	T	T

1SDC008026F0201

* Value for the supply side magnetic only circuit-breaker.

** Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

4 Protection coordination

4 Protection coordination

Discrimination tables Isomax-Tmax

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			I_u [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		I_n [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T2	H	TM	160	1,6-2,5	T	T	T	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
				3,2	10	13	30**	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	10	10	30	T	T	T	T	T	T	T	T	T	T
				4-5	6	7	15	30**	60**	T	T	T	T	T	T	T	T	T		T	T	T	T	T	6	6	15	30	T	T	T	T	T	T	T	T	T
				6,3	3	4	7	14	20**	T	T	T	T	T	T	T	T	T		T	T	T	T	T	3	3	7	14	20	60	T	T	T	T	T	T	T
				8		3	5	10	15	30**	60**	T	T	T	T	T	T	T		T	T	T	T	T			5	10	15	35	T	T	T	T	T	T	T
				10			4	6	8	15	30	50**	T	T	T	T	T	T		T	T	T	T	T			4	6	8	15	30	T	T	T	T	T	T
				12,5-16				3	3	6	10	20	40**	40**	40**	T	T	T		T	T	T	T	T				3	3	8	10	40	40	40	T	T	T
				20				3	3	5	10	18	30	30	30	T	T	T		T	T	T	T	T				3	3	6	9	30	30	30	T	T	T
				25-32				3	3	5	10	18	25	25	25	T	T	T		T	T	T	T	T				3	3	5	8	25	25	25	T	T	T
				40-63				3	3	5	7	10	20	20	20	T	T	T		T	T	T	T	T				3	3	5	7	20	20	20	T	T	T
				80							3	5		9	9	T	T	T		T	T	T	T	T						3*	3		10	10	T	T	T
				100							3*	5		9	9	T	T	T		T	T	T	T	T						3*	3*		10	10	T	T	T
				125							3*	5*			9	T	T	T		T	T	T	T	T							3*			10	T	T	T
				160								5*			9	T	T	T		T	T	T	T	T										10	T	T	T
		EL	160	10-160							3	5	9	9	9	T	T	T		T	T	T	T	T						3	3	10	10	10	T	T	T

1SDC008027F0201

* Value for the supply side magnetic only circuit-breaker.

** Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Discrimination tables Isomax-Tmax

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			Iu [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		In [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T2	L	TM	160	1,6-2,5	T	T	T	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
				3,2	10	13	30**	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	10	10	30	T	T	T	T	T	T	T	T	T	T
				4-5	6	7	15	30**	60**	T	T	T	T	T	T	T	T	T		T	T	T	T	T	6	6	15	30	70	T	T	T	T	T	T	T	T
				6,3	3	4	7	14	20**	T	T	T	T	T	T	T	T	T		T	T	T	T	T	3	3	7	14	20	60	T	T	T	T	T	T	T
				8		3	5	10	15	30**	60**	T	T	T	T	T	T	T		T	T	T	T	T			5	10	15	35	70	T	T	T	T	T	T
				10			4	6	8	15	30	50**	T	T	T	T	T	T		T	T	T	T	T			4	6	8	15	30	T	T	T	T	T	T
				12,5-16				3	3	6	10	20	40**	40**	40**	T	T	T		T	T	T	T	T				3	3	8	10	40	40	40	T	T	T
				20				3	3	5	10	18	30	30	30	T	T	T		T	T	T	T	T				3	3	6	9	30	30	30	T	T	T
				25-32				3	3	5	10	18	25	25	25	T	T	T		T	T	T	T	T				3	3	5	8	25	25	25	T	T	T
				40-63				3	3	5	7	10	20	20	20	T	T	T		T	T	T	T	T				3	3	5	7	20	20	20	T	T	T
				80							3	5		9	9	T	T	T		T	T	T	T	T						3*	3		10	10	T	T	T
				100							3*	5		9	9	T	T	T		T	T	T	T	T						3*	3*		10	10	T	T	T
				125							3*	5*			9	T	T	T		T	T	T	T	T							3*			10	T	T	T
				160								5*			9	T	T	T		T	T	T	T	T										10	T	T	T
		EL	160	10-160							3	5	9	9	9	T	T	T		T	T	T	T	T						3	3	10	10	10	T	T	T

1SDC008028F0201

* Value for the supply side magnetic only circuit-breaker.

** Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Discrimination tables Isomax-Tmax

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			Iu [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		In [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T3	N	TM	250	63							3	4	5	5	5	12	12	12		T	T	T	T	T							3	5	5	5	T	T	T
				80							3	4		5	5	12	12	12		T	T	T	T	T							3		5	5	T	T	T
				100							3*	4		5	5	12	12	12		T	T	T	T	T							3*		5	5	T	T	T
				125							3*	4*			5	12	12	12		T	T	T	T	T							3*			5	T	T	T
				160								4*			5	10	10	10		T	T	T	T	T										5	T	T	T
				200												10	10	10		30	T	T	T	T											32	32	32
				250													10	10		30	T	T	T	T												32	32

* Value for the supply side magnetic only circuit-breaker.

Isomax - Tmax @ 415V

					Circuit-breakers for distribution																				Current-limiting circuit-breakers												
				Supply s.	S3								S4			S5				S6		S7			S3							S4			S6		
				Version	N,H,L								N,H,L			N,H,L				N,S,H,L		S,H,L			X							X			X		
				Release	TM,M								EL			EL				EL		EL			TM,M							EL			EL		
			Iu [A]		160						250		160		250	400		630		630	800	1250		1600	125				125/200	200		250			400		630
Load s.	Version	Release		In [A]	50	63	80	100	125	160	200	250	100	160	250	320	400	630		630	800	1000	1250	1600	32	50	80	100	125	160	200	100	160	250	320	400	630
T3	S	TM	250	63							3	4	5	5	5	12	12	12		T	T	T	T	T							3	5	5	5	T	T	T
				80							3	4		5	5	12	12	12		T	T	T	T	T							3		5	5	T	T	T
				100							3*	4		5	5	12	12	12		40**	T	T	T	T							3*		5	5	42	42	42
				125							3*	4*			5	12	12	12		36**	T	T	T	T							3*			5	38	38	38
				160								4*			5	10	10	10		36**	T	T	T	T										5	38	38	38
				200												10	10	10		30	T	T	T	T											32	32	32
				250													10	10		30	40**	T	T	T												32	32

1SDC008029F0201

* Value for the supply side magnetic only circuit-breaker.

** Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Discrimination tables Isomax-Isomax

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S3	N	TM	160	32	3	3	5	12	12	12	25	30	T	T	T	3	3	5	25	25	25
				50	3	3	5	12	12	12	25	30	T	T	T	3	3	5	25	25	25
				80		3	5	12	12	12	25	30	T	T	T		3	5	25	25	25
				100		3	5	12	12	12	25	30	T	T	T		3	5	25	25	25
				125			5	12	12	12	25	30	T	T	T			5	25	25	25
				160			5	12	12	12	25	30	T	T	T			5	25	25	25
			250	200				12	12	12	25	30	T	T	T				25	25	25
				250					12	12	25	30	T	T	T					25	25

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S3	H	TM	160	32	3	3	5	12	12	12	25	30	T	T	T	3	3	5	25	25	25
				50	3	3	5	12	12	12	25	30	T	T	T	3	3	5	25	25	25
				80		3	5	12	12	12	25	30	T	T	T		3	5	25	25	25
				100		3	5	12	12	12	25	30	T	T	T		3	5	25	25	25
				125			5	12	12	12	25	30	T	T	T			5	25	25	25
				160			5	12	12	12	25	30	T	T	T			5	25	25	25
			250	200				12	12	12	25	30	T	T	T				25	25	25
				250					12	12	25	30	T	T	T					25	25

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S3	L	TM	160	32	3	3	5	12	12	12	25	30	65*	65*	65*	3	3	5	25	25	25
				50	3	3	5	12	12	12	25	30	65*	65*	65*	3	3	5	25	25	25
				80		3	5	12	12	12	25	30	65*	65*	65*		3	5	25	25	25
				100		3	5	12	12	12	25	30	65*	65*	65*		3	5	25	25	25
				125			5	12	12	12	25	30	65*	65*	65*			5	25	25	25
				160			5	12	12	12	25	30	65*	65*	65*			5	25	25	25
			250	200				12	12	12	25	30	65*	65*	65*				25	25	25
				250					12	12	25	30	65*	65*	65*					25	25

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S4	N	EL	160	100				11	11	11	20	25	T	T	T				20	20	20
				160				11	11	11	20	25	T	T	T				20	20	20
			250	250					11	11	20	25	T	T	T					20	20

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S4	H	EL	160	100				11	11	11	20	25	50	50	50				20	20	20
				160				11	11	11	20	25	50	50	50				20	20	20
			250	250					11	11	20	25	50	50	50					20	20

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S4	L	EL	160	100				11	11	11	20	25	50	50	50				20	20	20
				160				11	11	11	20	25	50	50	50				20	20	20
			250	250					11	11	20	25	50	50	50					20	20

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4 Protection coordination

Discrimination tables Isomax-Isomax

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S5	N	EL	400	320							15	20	T	T	T						15
				400							15	20	T	T	T						15
			630	630									T	T	T						

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S5	H	EL	400	320							15	20	50	50	50						15
				400							15	20	50	50	50						15
			630	630									50	50	50						

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S5	L	EL	400	320							15	20	50	50	50						15
				400							15	20	50	50	50						15
			630	630									50	50	50						

4 Protection coordination

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S6	N	EL	630	630									T	T	T						
			800	800									T	T	T						

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S6	S	EL	630	630									40	40	40						
			800	800									40	40	40						

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S6	H	EL	630	630									40	40	40						
			800	800									40	40	40						

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Discrimination tables Isomax-Isomax

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S6	L	EL	630	630									40	40	40						
			800	800									40	40	40						

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S3	X	TM	125	32	4	4	14	T	T	T	T	T	T	T	T	4	4	14	T	T	T
				50	4	4	14	T	T	T	T	T	T	T	T	4	4	14	T	T	T
				80		4	9	50*	50*	50*	T	T	T	T	T		4	9	T	T	T
				100		4	9	50*	50*	50*	T	T	T	T	T		4	9	T	T	T
			125 200	125			9	50*	50*	50*	T	T	T	T	T			9	T	T	T
			200	160				25	25	25	T	T	T	T	T				T	T	T
				200				25	25	25	T	T	T	T	T				T	T	T

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S4	X	EL	250	100				20	20	20	50*	50*	65*	65*	65*				50	50	50
				160				20	20	20	50*	50*	65*	65*	65*				50	50	50
				250					20	20	50*	50*	65*	65*	65*					50	50

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

Isomax - Isomax @ 415V

					Circuit-breakers for distribution											Current-limiting circuit-breakers					
				Supply s.	S4			S5			S6		S7			S4			S6		
				Version	N,H,L			N,H,L			N,S,H,L		S,H,L			X			X		
				Release	EL			EL			EL		EL			EL			EL		
			I_u [A]		160		250	400		630	630	800	1250		1600	250			400		630
Load s.	Version	Release		I_n [A]	100	160	250	320	400	630	630	800	1000	1250	1600	100	160	250	320	400	630
S6	X	EL	400	320									45	45	65*						
				400									45	45	65*						
			630	630									45	45	65*						

* Choose the lowest value among those indicated and the rated ultimate short-circuit current of the supply side circuit-breaker.

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4 Protection coordination

Discrimination tables Emax-MCCBs

Emax - Tmax @ 415V

			Supply s.	E1		E2			E3				E4		E6	
			Version	B	N	B	N	L*	N	S	H	L*	S	H	H	V
			Release	EL		EL			EL				EL		EL	
Load s.	Version	Release	Iu [A]	800 1250	800 1250	1600 2000	1250 1600 2000	1250 1600	2500 3200	1250 1600 2000 2500 3200	1250 1600 2000 2500 3200	2000 2500	4000	3200 4000	5000 6300	3200 4000 5000 6300
T1	B	TM	160	T	T	T	T	T	T	T	T	T	T	T	T	T
	C			T	T	T	T	T	T	T	T	T	T	T	T	T
	N			T	T	T	T	T	T	T	T	T	T	T	T	T
T2	N	TM, EL	160	T	T	T	T	T	T	T	T	T	T	T	T	T
	S			36	T	T	T	T	T	T	T	T	T	T	T	T
	H			36	T	T	55	T	T	T	T	T	T	T	T	T
	L			36	T	T	55	T	T	T	75	T	T	T	T	T
T3	N	TM	250	T	T	T	T	T	T	T	T	T	T	T	T	T
	S			36	T	T	T	T	T	T	T	T	T	T	T	T

* Emax air circuit-breakers with electronic releases PR112/P and PR113/P.

Emax - Isomax @ 415V

			Supply s.	E1		E2			E3				E4		E6	
			Versione	B	N	B	N	L*	N	S	H	L*	S	H	H	V
			Release	EL		EL			EL				EL		EL	
Load s.	Version	Release	Iu [A]	800 1250	800 1250	1600 2000	1250 1600 2000	1250 1600	2500 3200	1250 1600 2000 2500 3200	1250 1600 2000 2500 3200	2000 2500	4000	3200 4000	5000 6300	3200 4000 5000 6300
S3	N	TM	160 250	T	T	T	T	T	T	T	T	T	T	T	T	T
	H			36	T	T	55	T	T	T	T	T	T	T	T	T
	L			36	T	T	55	T	T	T	75	T	T	T	T	T
S4	N	EL	160 250	T	T	T	T	T	T	T	T	T	T	T	T	T
	H			36	T	T	55	T	T	T	T	T	T	T	T	T
	L			36	T	T	55	T	T	T	75	T	T	T	T	T
S5	N	EL	400 630	T	T	T	T	T	T	T	T	T	T	T	T	T
	H			36	T	T	55	T	T	T	T	T	T	T	T	T
	L			36	T	T	55	T	T	T	75	T	T	T	T	T
S6	N	EL	630 800	T	T	T	T	T	T	T	T	T	T	T	T	T
	S			36	T	T	T	T	T	T	T	T	T	T	T	T
	H			36	T	T	55	T	T	T	T	T	T	T	T	T
	L			36	T	T	55	T	T	T	75	T	T	T	T	T
S7	S	EL	1250 1600			T	T		T	T	T	42	T	T	T	T
	H					T	55		T	T	T	42	T	T	T	T
	L					T	55		T	T	75	42	T	T	T	T
S8	H	EL	2000/2500/3200						T	T	75		T	T	T	T
	V								T	T	75		T	T	T	100
S3	X	TM	125/200	36	T	T	55	100	T	T	75	100	T	T	T	100
S4	X	EL	250	36	T	T	55	100	T	T	75	100	T	T	T	100
S6	X	EL	400/630	36	T	T	55	100	T	T	75	100	T	T	T	100

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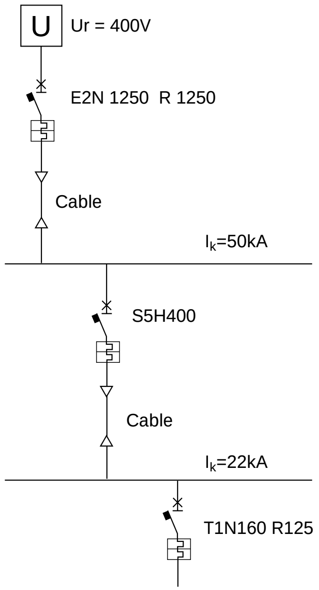
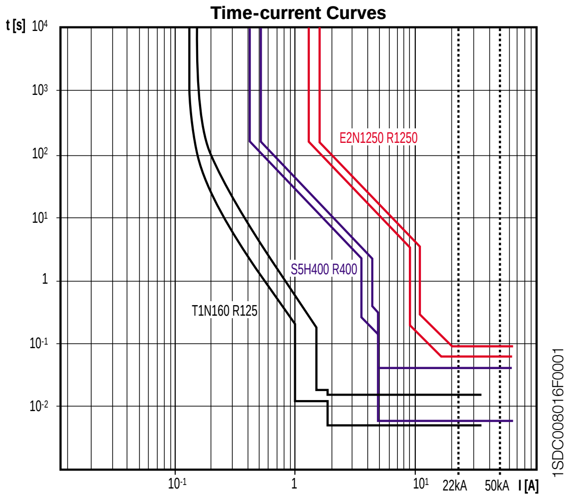
* Emax air circuit-breakers with electronic releases PR112/P and PR113/P.

4 Protection coordination

Example:

From the selectivity table on page 224 it can be seen that breakers E2N1250 and S5H400, correctly set, are selective up to 55 kA (higher than the short-circuit current at the busbar).
From the selectivity table on page 208 it can be seen that, instead, breakers S5H400 e T1N160 R125 are selective up to 24kA (higher than the short-circuit current at the busbar).





From the curves it is evident that between breakers E2N1250 and S5H400 time discrimination exists, while between breakers S5H400 and T1N160 there is energy discrimination.

4 Protection coordination

4.3 Back-up tables

The tables shown give the short-circuit current value (in kA) for which the back-up protection is verified for the chosen circuit-breaker combination, at voltages from 380 up to 415 V. These tables cover all the possible combinations between ABB SACE moulded-case circuit-breakers Isomax and Tmax and those between the above mentioned circuit-breakers and ABB MCBs.

Notes for a correct interpretation of the coordination tables:

Tmax @ 415V ac	
Version	Icu [kA]
B	16
C	25
N	36
S	50
H	70
L	85

Isomax @ 415V ac	
Version	Icu [kA]
N	35*
S	50
H	65
L	100 (S3=85)
X	200

Emax @ 415V ac	
Version	Icu [kA]
B	42
N	65 (E1=50)
S	75
H	100
L	130
V	150

* Versions certified at 36 kA.

Tmax - MCB @ 400V

			Supply s.	T1	T1	T1	T2	T3	T2	T3	T2	T2
	Version			B	C	N			S		H	L
Load s.	Char.	I_n [A]	I_{cu} [kA]	16	25	36			50		70	85
S240	C	6..10	7.5	16	25	30	36	36	36	40	40	40
		13..40						16		16		
S250	B,C,K	6..10	10	16	25	30	36	36	36	40	40	40
		13..63						16		16		
S260	B,C	6..10	10	16	25	30	36	36	36	40	40	40
		13..63						16		16		
S270	B,C,D	6..10	15	16	25	30	36	36	50	40	70	85
		13..63						25		25	60	60
S270	Z	6..10	10	16	25	30	36	36	36	40	40	40
		13..63						16		16		
S280	B,C,D,K,Z	6..10	15			30	36	36	50	40	70	85
		13..25	25					30		30	60	60
		32..40	20		25			25		25		
		50..63	15	16				25		25		
		80, 100	6	16	16	16		16	36	16	36	36
S290	C,D,K	80..125	15	16	25	30	36	30	50	30	70	85

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4 Protection coordination

Isomax - MCB @ 400V

			Supply s.	S3	S4	S3	S4	S3	S4	S3 I_u 125	S3 I_u 200	S4
	Version			N		H		L		X		
Load s.	Char.	I_n [A]	I_{cu}	36		65		85	100	200		
S240	C	6..40	7.5							10		
S250	B,C,K	6..63	10	16	16	16	16	16	16	20	20	20
S260	B,C	6..63	10	16	16	16	16	16	16	20	20	20
S270	B,C,D	6..63	15	25	20	25	20	25	20	25	25	25
S270	Z	6..63	10	16	16	16	16	16	16	20	20	20
S280	B,C,D,K,Z	6..8	15	25	20	25	20	25	20	25	25	25
		10..25	25	30	30	30	30	30	30	35	35	30
		32..40	20	25	25	25	25	25	25	30	25	25
		50..63	15	25	20	25	20	25	20	25	25	25
		80, 100	6	16		16		16		16	16	
S290	C,D,K	80..125	15	25	20	25	20	25	20	25	25	25

Tmax - Tmax @ 415V

		Supply s.	T1	T1	T2	T3	T2	T3	T2	T2
	Version		C	N			S		H	L
Load s.		I_{cu} [kA]	25	36			50		70	85
T1	B	16	25	36	36	36	50	50	70	85
T1	C	25		36	36	36	50	50	70	85
T1	N	36					50	50	70	85
T2							50	50	70	85
T3								50		
T2	S	50								85
T2	H	70								85

Tmax - Isomax @ 415V

		Supply s.	T1	T1	T2	T3	T2	T3	T2	T2
	Version		C	N			S		H	L
Load s.		I_{cu} [kA]	25	36			50		70	85
S3	N	36						50		
S3	H	65								

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4 Protection coordination

Isomax - Tmax @ 415V

		Supply s.	S3	S4	S5	S6	S6	S7	S3	S4	S5	S6	S7	S3	S4	S5	S6	S7	S3 Iu 125	S3 Iu 200	S4	S6
	Version		N				S		H					L					X			
Load s.		I_{cu} [kA]	36				50		65					85	100				200			
T1	B	16	36	30	30	30	36		40	40	40	40		50	50	50	50		130	85	65	50
T1	C	25	36	36	36	36	50	50	65	65	65	65	50	85	85	85	70	50	170	150	130	70
T1	N	36					50	50	65	65	65	65	50	85	100	100	70	50	170	150	130	70
T2							50	50	65	65	65	65	65	85	100	100	85	85	200	200	200	100
T3							50	50	65	65	65	65	50	85	100	100	100	50		200	200	100
T2	S	50							65	65	65	65	65	85	100	100	85	85	200	200	200	130
T3									65	65	65	65		85	100	100	100			200	200	130
T2	H	70												85	100	100	85	85	200	200	200	150
T2	L	85													100	100			200	200	200	150

Isomax - Isomax @ 415V

		Supply s.	S6	S7	S3	S4	S5	S6	S7	S3	S4	S5	S6	S7	S3 Iu 125	S3 Iu 200	S4	S6
	Version		S		H					L					X			
Load s.		I_{cu} [kA]	50		65					85	100				200			
S3	N	36	50	40	65	65	65	65	40	85	100	65	65	40		200	200	100
S4			50	40			65	65	40			65	65	40				100
S5			50	40				65	40				85	40				170
S6				40					40					50				
S6	S	50												85				200
S3	H	65								85	100	100	100			200	200	200
S4												100	100					200
S5													100	85				200
S6														85				200
S3	L	85									100	100	100			200	200	200
S4		100																200
S5																		200
S6																		200

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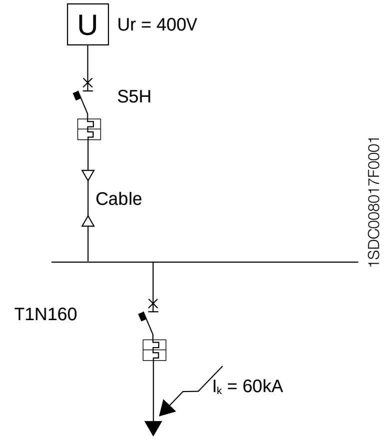
4 Protection coordination

Example:
From the coordination table on page 228 the following conclusion is derived: the circuit-breakers type S5H and T1N are coordinated in back-up protection up to a value of 65 kA (higher than the short-circuit current measured at the installation point), although the maximum breaking capacity of T1N, at 415 V, is 36 kA.



4.4 Coordination tables between circuit-breakers and switch disconnectors

The tables shown give the values of the short-circuit current (in kA) for which back-up protection is verified by the pre-selected combination of circuit-breaker and switch disconnector, for voltages between 380 and 415 V. The tables cover the possible combinations of moulded-case circuit-breakers in the ABB SACE Isomax and Tmax series, with the switch disconnectors detailed above.

Note for the correct reading of the coordination tables:

Tmax @ 415V ac	
Version	Icu [kA]
B	16
C	25
N	36
S	50
H	70
L	85

Isomax @ 415V ac	
Version	Icu [kA]
N	35*
S	50
H	65 (S8 = 85)
L	100 (S3 = 85)
V	120
X	200

* Versions certified at 36 kA

415 V	SWITCH DISCONNECTOR														
	T1D 160	**T3D 250**	**S3D 100**	**S3D 160**	**S3D 250**	**S3D 320**	**S6D 400**	**S6D 630**	**S6D 800**	**S7D 1000**	**S7D 1250**	**S7D 1600**	**S8D 2000**	**S8D 2500**	**S8D 3200**
T1B	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
T1C	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
T1N	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
T2N	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
T2S	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
T2H	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
T2L	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
T3N		36	36	36	36	36	36	36	36	36	36	36	36	36	36
T3S		50	50	50	50	50	50	50	50	50	50	50	50	50	50
S3N		35	35	35	35	35	35	35	35	35	35	35	35	35	35
S3H		35	65	65	65	65	65	65	65	65	65	65	65	65	65
S3L		35	65	65	65	65	85	85	85	85	85	85	85	85	85
S4N			35	35	35	35	35	35	35	35	35	35	35	35	35
S4H			65	65	65	65	65	65	65	65	65	65	65	65	65
S4L			65	65	65	65	100	100	100	100	100	100	100	100	100
S5N							35	35	35	35	35	35	35	35	35
S5H							65	65	65	65	65	65	65	65	65
S5L							100	100	100	100	100	100	100	100	100
S6N							35	35	35	35	35	35	35	35	35
S6S							50	50	50	50	50	50	50	50	50
S6H							65	65	65	65	65	65	65	65	65
S6L							100	100	100	100	100	100	100	100	100
S7S										50	50	50	50	50	50
S7H										65	65	65	65	65	65
S7L										100	100	100	100	100	100
S8H													85	85	85
S8V													120	120	120

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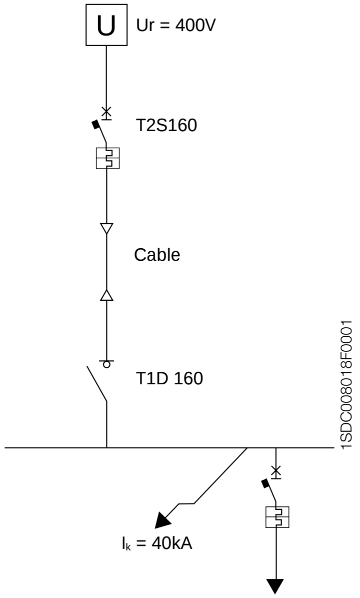
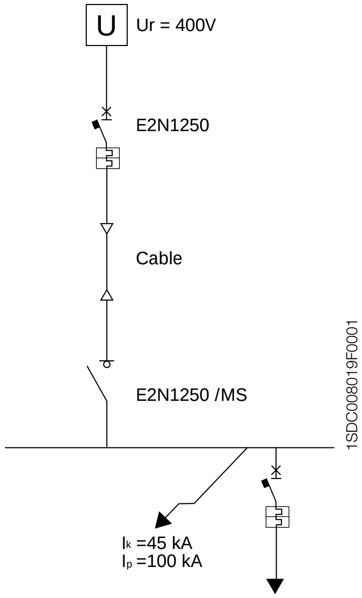
Example:
From the coordination table on page 230-231 it can be seen that circuit-breaker T2S160 is able to protect the switch disconnector T1D160 up to a short-circuit current of 50 kA (higher than the short-circuit current at the installation point). Overload protection is also verified, as the rated current of the breaker is not higher than the size of the disconnector.



Example:
For the correct selection of the components, the disconnector must be protected from overloads by a device with a rated current not greater than the size of the disconnector, while in short-circuit conditions it must be verified that:
$I_{cw} \geq I_k$
$I_{cm} \geq I_p$.
Therefore, with regard to the electrical parameters of the single devices, Emax E2N1250/MS disconnector is selected, and a E2N1250 breaker.
That is:
I_{cw}(E2N /MS) = 55 kA > 45 kA
I_{cm} (E2N /MS) = 121 kA > 100 kA.



5 Special applications

5.1 Direct current networks

Main applications of direct current:

- Emergency supply or auxiliary services.
  The use of direct current is due to the need to employ a back-up energy source which allows the supply of essential services such as protection services, emergency lighting, alarm systems, hospital and industrial services, data-processing centres etc., using accumulator batteries, for example.
- Electrical traction.
  The advantages offered by the use of dc motors in terms of regulation and of single supply lines lead to the widespread use of direct current for railways, underground railways, trams, lifts and public transport in general.
- Particular industrial installations.
  There are some electrolytic process plants and applications which have a particular need for the use of electrical machinery.
  Typical uses of circuit-breakers include the protection of cables, devices and the operation of motors.

Considerations for the interruption of direct current

Direct current presents larger problems than alternating current does in terms of the phenomena associated with the interruption of high currents. Alternating currents have a natural passage to zero of the current every half-cycle, which corresponds to a spontaneous extinguishing of the arc which is formed when the circuit is opened.
This characteristic does not exist in direct currents, and furthermore, in order to extinguish the arc, it is necessary that the current lowers to zero.
The extinguishing time of a direct current, all other conditions being equal, is proportional to the time constant of the circuit T = L/R.
It is necessary that the interruption takes place gradually, without a sudden switching off of the current which could cause large over-voltages. This can be carried out by extending and cooling the arc so as to insert an ever higher resistance into the circuit.
The energetic characteristics which develop in the circuit depend upon the voltage level of the plant and result in the installation of breakers according to connection diagrams in which the poles of the breaker are positioned in series to increase their performance under short-circuit conditions. The breaking capacity of the switching device becomes higher as the number of contacts which open the circuit increases and, therefore, when the arc voltage applied is larger.
This also means that when the supply voltage of the installation rises, so must the number of current switches and therefore the poles in series.

5 Special applications

Calculation of the short-circuit current of an accumulator battery
The short-circuit current at the terminals of an accumulator battery may be supplied by the battery manufacturer, or may be calculated using the following formula:

$$I_k = \frac{U_{Max}}{R_i}$$

where:
- U_{Max} is the maximum flashover voltage (no-load voltage);
- R_i is the internal resistance of the elements forming the battery.

The internal resistance is usually supplied by the manufacturer, but may be calculated from the discharge characteristics obtained through a test such as detailed by IEC 60896 – 1 or IEC 60896 – 2.
For example, a battery of 12.84 V and internal resistance of 0.005 Ω gives a short-circuit current at the terminals of 2568 A.
Under short-circuit conditions the current increases very rapidly in the initial moments, reaches a peak and then decreases with the discharge voltage of the battery. Naturally, this high value of the fault current causes intense heating inside the battery, due to the internal resistance, and may lead to explosion. Therefore it is very important to prevent and / or minimize short-circuit currents in direct currents systems supplied by accumulator batteries.

Criteria for the selection of circuit-breakers

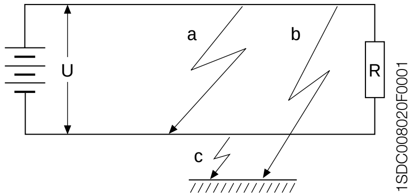
For the correct selection of a circuit-breaker for the protection of a direct current network, the following factors must be considered:
1. the load current, according to which the size of the breaker and the setting for the thermo-magnetic over-current release can be determined;
2. the rated plant voltage, according to which the number of poles to be connected in series is determined, thus the breaking capacity of the device can also be increased;
3. the prospective short-circuit current at the point of installation of the breaker influencing the choice of the breaker;
4. the type of network, more specifically the type of earthing connection.

Note: in case of using of four pole circuit-breakers, the neutral must be at 100%

Direct current network types

Direct current networks may be carried out:
- with both polarities insulated from earth;
- with one polarity connected to earth;
- with median point connected to earth.

Network with both polarities insulated from earth



- Fault a: the fault, without negligible impedance, between the two polarities sets up a short-circuit current to which both polarities contribute to the full voltage, according to which the breaking capacity of the breaker must be selected.
- Fault b: the fault between the polarity and earth has no consequences from the point of view of the function of the installation.
- Fault c: again, this fault between the polarity and earth has no consequences from the point of view of the function of the installation.

In insulated networks it is necessary to install a device capable of signalling the presence of the first earth fault in order to eliminate it. In the worst conditions, when a second earth fault is verified, the breaker may have to interrupt the short-circuit current with the full voltage applied to a single polarity and therefore with a breaking capacity which may not be sufficient.
In networks with both polarities insulated from earth it is appropriate to divide the number of poles of the breaker necessary for interruption on each polarity (positive and negative) in such a way as to obtain separation of the circuit.

The diagrams to be used are as follows:

Diagram A

Three-pole breaker with one pole per polarity

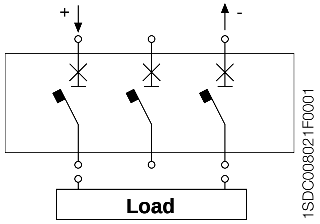


Diagram B

Three-pole breaker with two poles in series for one polarity and one pole for the other polarity (1)

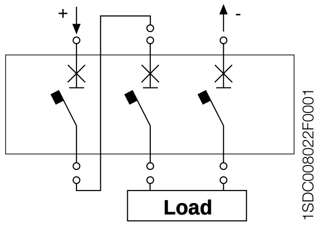


Diagram D

Four-pole breaker with two poles in parallel per polarity

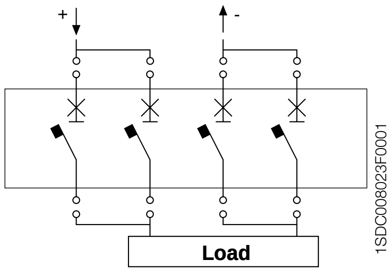
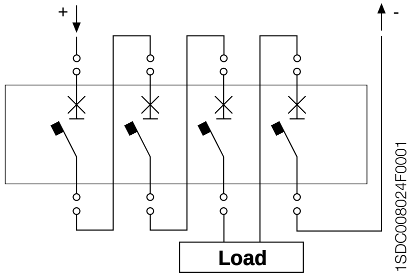


Diagram G

Four-pole breaker with three poles in series on one polarity and one pole on the remaining polarity (1)

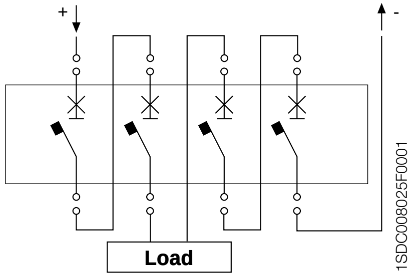


(1) It is not advisable to divide the poles of the breaker unequally as, in this type of network, a second earth fault may lead to the single pole working under fault conditions at full voltage. In these circumstances, it is essential to install a device capable of signalling the earth fault or the loss of insulation of one polarity.

5 Special applications

Diagram H

Four-pole breaker with two poles in series per polarity

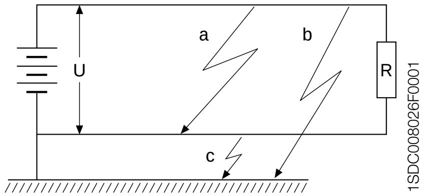


The following table summarises the number of poles to be considered in the selection of the correct breaking capacity

Poles in series for the definition of breaking capacity

	Probability of having second fault	
Diagram	**Zero**	**Not zero**
A	2	1
B	3	1
D	2	1
G	4	1
H	4	2

Network with one polarity connected to earth



- Fault a: the fault between the two polarities sets up a short-circuit current to which both polarities contribute to the full voltage U, according to which the breaking capacity of the breaker is selected.
- Fault b: the fault on the polarity not connected to earth sets up a current which involves the over-current protection according to the resistance of the ground.
- Fault c: the fault between the polarity connected to earth and earth has no consequences from the point of view of the function of the installation.

5 Special applications

In a network with one polarity connected to earth, all the poles of the breaker necessary for protection must be connected in series on the non-earthed polarity. If isolation is required, it is necessary to provide another breaker pole on the earthed polarity.

Diagrams to be used with circuit isolation are as follows:

Diagram A

Three-pole breaker with one pole per polarity

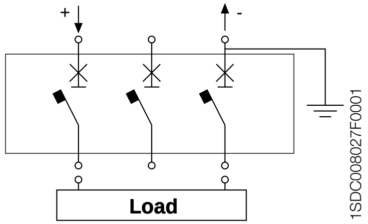


Diagram B

Three-pole breaker with two poles in series on the polarity not connected to earth, and one pole on the remaining polarity

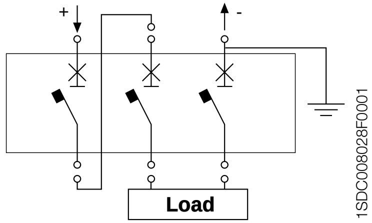
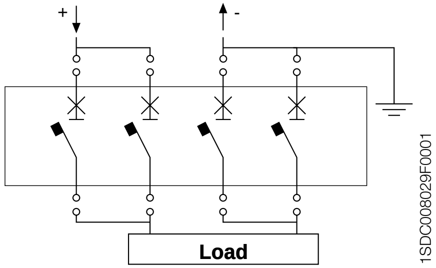


Diagram D

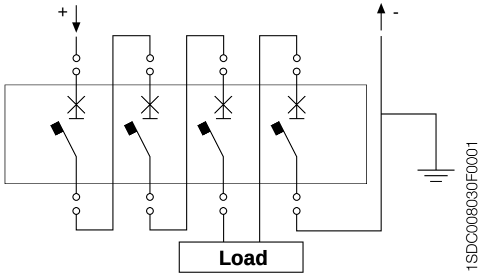
Four-pole breaker with two poles in parallel per polarity



5 Special applications

Diagram G

Four-pole breaker with three poles in series on the polarity not connected to earth, and one pole on the remaining polarity



Diagrams to be used without circuit isolation are as follows:

Diagram C

Three-pole breaker with three poles in series

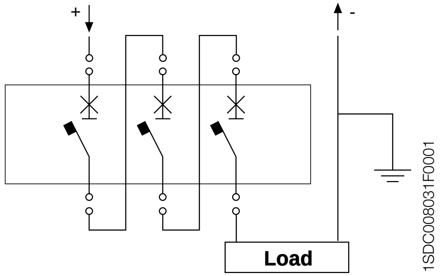
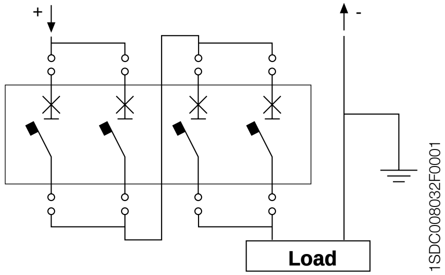


Diagram E

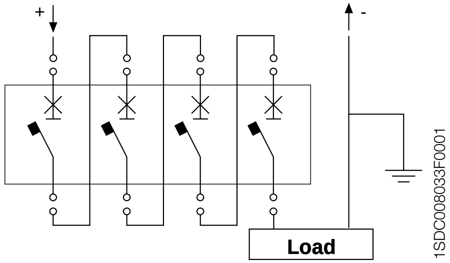
Four-pole breaker with series of two poles in parallel



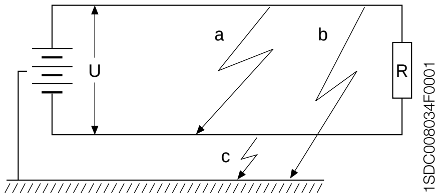
5 Special applications

Diagram F

Four-pole breaker with four poles in series on the polarity not connected to earth



Network with the median point connected to earth



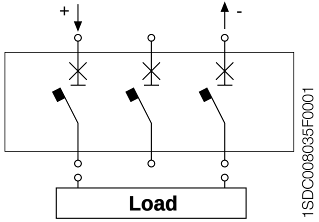
- Fault a: the fault between the two polarities sets up a short-circuit current to which both polarities contribute to the full voltage U, according to which the breaking capacity of the breaker is selected.
- Fault b: the fault between the polarity and earth sets up a short-circuit current less than that of a fault between the two polarities, as it is supplied by a voltage equal to 0.5 U.
- Fault c: the fault in this case is analogous to the previous case, but concerns the negative polarity.

With network with the median point connected to earth the breaker must be inserted on both polarities.

Diagrams to be used are as follows:

Diagram A

Three-pole breaker with one pole per polarity



5 Special applications

Diagram D

Four-pole breaker with two poles in parallel per polarity

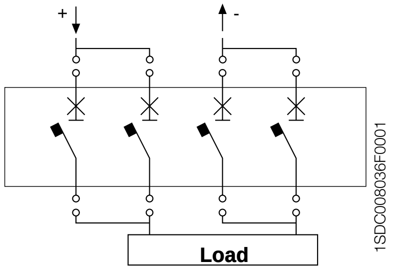
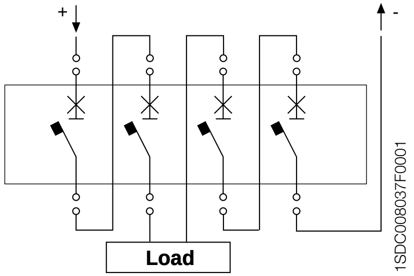


Diagram H

Four-pole breaker with two poles in series per polarity



Use of switching devices in direct current

Parallel connection of breaker poles

According to the number of poles connected in parallel, the coefficients detailed in the following table must be applied:

Table 1: Correction factor for poles connected in parallel

number of poles in parallel	2	3	4 (neutral 100%)
reduction factor of dc carrying capacity	0.9	0.8	0.7
breaker current carrying capacity	1.8xIn	2.4xIn	2.8xIn

The connections which are external from the breaker terminals must be carried out by the user in such a way as to ensure that the connection is perfectly balanced.

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5 Special applications

Example:

Using a SACE Isomax S6N800 R800 circuit-breaker with three poles in parallel, a coefficient equal to 0.8 must be applied, therefore the maximum carrying current will be 0.8·3·800 = 1920 A.

Behaviour of thermal releases

As the functioning of these releases is based on thermal phenomena arising from the flowing of current, they can therefore be used with direct current, their trip characteristics remaining unaltered.

Behaviour of magnetic releases

The values of the trip thresholds of ac magnetic releases, used for direct current, must be multiplied by the following coefficient (k_m), according to the breaker and the connection diagram:

Table 2: k_m coefficient

Circuit-breaker	diagram A	diagram B	diagram C	diagram D	diagram E	diagram F	diagram G	diagram H
S3	1.3	1.15	1.15	-	-	1	1	1
S5	1.1	1	1	1.1	1	1.1	1.1	1.1
S6	1.1	1	1	1.1	1	0.9	0.9	0.9
T1	1.3	1	1	-	-	-	-	-
T2	1.3	1.15	1.15	-	-	-	-	-
T3	1.3	1.15	1.15	-	-	-	-	-

Example

Data:
- Direct current network insulated from earth;
- Rated voltage U_r = 250 V;
- Short-circuit current I_k = 32 kA
- Rated current I_n = 230 A

Using Table 3, it is possible to select the SACE Isomax S3N250 R250 four pole breaker, using the connection shown in diagram H (two poles in series for one polarity and two poles in series for the remaining polarity). In this way an adequate breaking capacity is ensured, even in the case of a second earth fault which would involve only two poles at full network voltage.
From Table 2 corresponding to diagram H, and with breaker Isomax S3, k_m=1; therefore the nominal magnetic trip will occur at 2500 A (taking into account the tolerance, the trip will occur between 2000 A and 3000 A).
In the case of a double earth fault being improbable, or if the first fault can be signalled at an appropriate time, a SACE Isomax S3N250 R250 three pole breaker can be installed, using the connection shown in diagram A (one pole per polarity). In this case, from Table 2 corresponding to diagram A, and with breaker S3, k_m=1.3; therefore the nominal magnetic release will not occur at 2500 A, but at 3250 A (taking account of the tolerance between 2600 A and 3900 A).

5 Special applications

The following table summarizes the breaking capacity of the various circuit-breakers available for direct current. The number of poles to be connected in series to guarantee the breaking capacity is given in brackets.

Table 3: Breaking capacity according to the voltage

Circuit-breaker	Rated current [A]	Breaking capacity [kA]			
		≤ 125 [V][1]	250 [V]	500 [V]	750 [V]
T1B160	16 ÷ 160	16 (1P)	20 (3P) - 16 (2P)	16 (3P)	
T1C160	25 ÷ 160	25 (1P)	30 (3P) - 25 (2P)	25 (3P)	
T1N160	32 ÷ 160	36 (1P)	40 (3P) - 36 (2P)	36 (3P)	
T2N160	1.6 ÷ 160	36 (1P)	40 (3P) - 36 (2P)	36 (3P)	
T2S160	1.6 ÷ 160	50 (1P)	55 (3P) - 50 (2P)	50 (3P)	
T2H160	1.6 ÷ 160	70 (1P)	85 (3P) - 70 (2P)	70 (3P)	
T2L160	1.6 ÷ 160	85 (1P)	100 (3P) - 85 (2P)	85 (3P)	
T3N250	63 ÷ 250	36 (1P)	40 (3P) - 36 (2P)	36 (3P)	
T3S250	63 ÷ 250	50 (1P)	55 (3P) - 50 (2P)	50 (3P)	
S3N160/250	32÷250	35 (1P)	35 (2P)	35 (2P)	20 (3P)
S3H160/250	32÷250	65 (1P)	65 (2P)	50 (2P)	35 (3P)
S3L160/250	32÷250	85 (1P)	85 (2P)	65 (2P)	50 (3P)
S5N400/630	320÷500	35 (1P)	35 (2P)	35 (2P)	20 (3P)
S5H400/630	320÷500	65 (1P)	65 (2P)	50 (2P)	35 (3P)
S5L400/630	320÷500	100 (1P)	100 (2P)	65 (2P)	50 (3P)
S6N630/800	630 – 800	35 (1P)	35 (2P)	20 (2P)	16 (3P)
S6S630/800	630 – 800	50 (1P)	50 (2P)	35 (2P)	20 (3P)
S6H630/800	630 – 800	65 (1P)	65 (2P)	50 (2P)	35 (3P)
S6L630/800	630 – 800	100 (1P)	100 (2P)	65 (2P)	50 (3P)

[1] Minimum allowed voltage 24 Vdc.

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5 Special applications

5.2 Networks at particular frequencies: 400 Hz and 16 2/3 Hz

Standard production breakers can be used with alternating currents with frequencies other than 50/60 Hz (the frequencies to which the rated performance of the device refer, with alternating current) as appropriate derating coefficients are applied.

400 Hz networks

At high frequencies, performance is reclassified to take into account phenomena such as:

- the increase in the skin effect and the increase in the inductive reactance directly proportional to the frequency causes overheating of the conductors or the copper components in the breaker which normally carry current;
- the lengthening of the hysteresis loop and the reduction of the magnetic saturation value with the consequent variation of the forces associated with the magnetic field at a given current value.

In general these phenomena have consequences on the behaviour of both thermo-magnetic releases and the current interrupting parts of the circuit-breaker.

The following tables refer to circuit-breakers with thermomagnetic releases, with a breaking capacity lower than 35 kA. This value is usually more than sufficient for the protection of installations where such a frequency is used, normally characterized by rather low short-circuit currents.
As can be seen from the data shown, the tripping threshold of the thermal element (I_n) decreases as the frequency increases because of the reduced conductivity of the materials and the increase of the associated thermal phenomena; in general, the derating of this performance is generally equal to 10%.
Vice versa, the magnetic threshold (I_3) increases with the increase in frequency: for this reason it is recommended practice to use a $5 \cdot I_n$ version.

Table 1: SACE Isomax performance S2 400Hz

I_n (400Hz) **I_3=5In**

S2N 160		**MIN**	**MED**	**MAX**	**I_3 (50Hz)**	**k_m**	**I_3 (400Hz)**
S2B 160	**R12.5**	8	9.5	11	160	2	320
	R16	10	12	14	160	2	320
	R20	12	15	18	200	2	400
	R25	16	19	22	200	2	400
	R32	20	24.5	29	200	2	400
	R40	25	30.5	36	200	2	400
	R50	31	38	45	250	2	500
	R63	39	48	57	320	2	640
	R80	50	61	72	400	2	800
	R100	63	76.5	90	500	2	1000
	R125	79	96	113	630	2	1260
	R160	100	122	144	800	2	1600

5 Special applications

Table 2: SACE Isomax performance S3 400 Hz

I_n (400Hz) **I_3=5In**

S3N 160		MIN	MED	MAX	I_3 (50Hz)	k_m	I_3 (400Hz)
	R32	20	24.5	29	300	1.7	510
	R50	31	38	45	300	1.7	510
	R80	50	61	72	400	1.7	680
	R100	63	76.5	90	500	1.7	850
	R125	79	96	113	630	1.7	1071
	R160	100	122	144	800	1.7	1360
S3N 250		**MIN**	**MED**	**MAX**	**I_3 (50Hz)**	**K**	**I_3 (400Hz)**
	R200	126	153	180	1000	1.7	1700
	R250	157	191	225	1250	1.7	2125

Table 3: SACE Isomax performance S5 400 Hz

I_n (400Hz) **I_3=5-10In** (set I_3 = 5 In)

S5N 400		MIN	MED	MAX	I_3 (50Hz)	k_m	I_3 (400Hz)
	R320	202	245	288	1600	1.5	2400
	R400	252	306	360	2000	1.5	3000
S5N 630		**MIN**	**MED**	**MAX**	**I_3 (50Hz)**	**K**	**I_3 (400Hz)**
	R500	315	382	450	2500	1.5	3750

Table 4: SACE Isomax performance S6 400 Hz

I_n (400Hz) **I_3=5-10In** (set I_3 = 5 In)

S6N 630		MIN	MED	MAX	I_3 (50Hz)	k_m	I_3 (400Hz)
	R630	397	482	567	3150	1.5	4725
S6N 800		**MIN**	**MED**	**MAX**	**I_3 (50Hz)**	**k_m**	**I_3 (400Hz)**
	R800	504	612	720	4000	1.5	6000

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5 Special applications

16 2/3 Hz networks

Single phase distribution with a frequency of 16 2/3 Hz was developed for electrical traction systems as an alternative to three phase 50 Hz systems, and to direct current systems.
At low frequencies the thermal tripping threshold is not subject to any derating, while the magnetic threshold requires a correction coefficient k_m, as detailed in table 7 and table 10.
The Isomax series and Tmax thermomagnetic moulded-case circuit-breakers are suitable for use with frequencies of 16 2/3 Hz; the electrical performance and the relevant connection diagrams are shown below.

SACE Isomax circuit-breakers

Table 5: Possible connections according to the voltage, the type of distribution and the type of fault

	Neutral not grounded	Neutral grounded*	
		L-N fault	L-E fault
250 V	A1	A2	B2
500 V	A1	A2	B2
750 V	B1	B2, B3	B3
1000 V	C1	C2,C3	C2

* In the case of the only possible faults being L-N or L-E with non-significant impedance, use the diagrams shown. If both faults are possible, use the diagrams valid for LE fault.

Table 6: Breaking capacity [kA]

		250 V	500 V	750 V	1000 V*
	In [A]				
S3N160	32 ÷ 160	35 (2P)	35 (2P)	20 (3P)	-
S3N250	200 ÷ 250	35 (2P)	35 (2P)	20 (3P)	-
S3H160	32 ÷ 160	65 (2P)	50 (2P)	35 (3P)	-
S3H250	200 ÷ 250	65 (2P)	50 (2P)	35 (3P)	-
S3L160	32 ÷ 160	85 (2P)	65 (2P)	50 (3P)	40 (4P)
S3L250	200 ÷ 250	85 (2P)	65 (2P)	50 (3P)	40 (4P)
S5N400	320 ÷ 400	35 (2P)	35 (2P)	20 (3P)	-
S5N630	500	35 (2P)	35 (2P)	20 (3P)	-
S5H400	320 ÷ 400	65 (2P)	50 (2P)	35 (3P)	-
S5H630	500	65 (2P)	50 (2P)	35 (3P)	-
S5L400	320 ÷ 400	100 (2P)	65 (2P)	50 (3P)	40 (4P)
S5L630	500	100 (2P)	65 (2P)	50 (3P)	40 (4P)
S6N630	630	35 (2P)	20 (2P)	16 (3P)	-
S6N800	800	35 (2P)	20 (2P)	16 (3P)	-
S6S630	630	50 (2P)	35 (2P)	20 (3P)	-
S6S800	800	50 (2P)	35 (2P)	20 (3P)	-
S6H630	630	65 (2P)	50 (2P)	35 (3P)	-
S6H800	800	65 (2P)	50 (2P)	35 (3P)	-
S6L630	630	100 (2P)	65 (2P)	50 (3P)	40 (4P)
S6L800	800	100 (2P)	65 (2P)	50 (3P)	50 (4P)

* 1000V version circuit-breakers in dc, with neutral at 100%.

5 Special applications

Table 7: k_m factor

	Diagram A	Diagram B	Diagram C
S3	0.9	0.9	0.9
S5	0.9	0.9	0.9
S6	0.9	0.9	0.9

Tmax circuit-breakers

Table 8: Possible connections according to the voltage, the type of distribution and the type of fault

		Neutral not grounded L-N fault	Neutral grounded* L-E fault
250 V	A1, B1	A2, B2, B3	B2, B3
500 V	B1	B2, B3	B3
750 V	C1	C2, C3	C2

* In the case of the only possible faults being L-N or L-E with non-significant impedance, use the diagrams shown. If both faults are possible, use the diagrams valid for L-E fault.

Table 9: Breaking capacity [kA]

	In [A]	250 V	500 V	750 V*
T1B160	16 ÷160	16 (2P) 20 (3P)	16 (3P)	-
T1C160	25 ÷ 160	25 (2P) 30 (3P)	25 (3P)	-
T1N160	32 ÷ 160	36 (2P) 40 (3P)	36 (3P)	-
T2N160	1.6 ÷ 160	36 (2P) 40 (3P)	36 (3P)	-
T2S160	1.6 ÷ 160	50 (2P) 55 (3P)	50 (3P)	-
T2H160	1.6 ÷ 160	70 (2P) 85 (3P)	70 (3P)	-
T2L160	1.6 ÷ 160	85 (2P) 100 (3P)	85 (3P)	50 (4P)
T3N250	63 ÷ 250	36 (2P) 40 (3P)	36 (3P)	-
T3S250	63 ÷ 250	50 (2P) 55 (3P)	50 (3P)	-

* circuit-breakers with neutral at 100%

Table 10: k_m factor

	Diagram A	Diagram B	Diagram C
T1	1	1	
T2	0.9	0.9	0.9
T3	0.9	0.9	

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5 Special applications

Connection diagrams

Diagram A1

Configuration with two poles in series (without neutral connected to earth)
- Interruption for phase to neutral fault: 2 poles in series
- Interruption for phase to earth fault: not considered

(The installation method must be such as to make the probability of a second earth fault negligible)

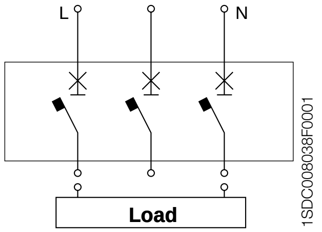


Diagram A2

Configuration with two poles in series (with neutral connected to earth)
- Interruption for phase to neutral fault: 2 poles in series
- Interruption for phase to earth fault: single pole (same capacity as two poles in series, but limited to 125V)

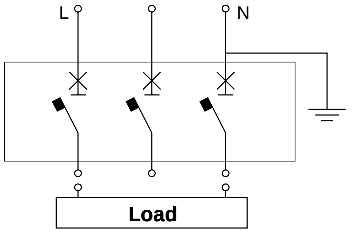


Diagram B1

Configuration with three poles in series (without neutral connected to earth)
- Interruption for phase to neutral fault: 3 poles in series
- Interruption for phase to earth fault: not considered

(The installation method must be such as to make the probability of a second earth fault negligible)

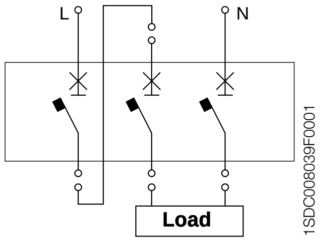


Diagram B2

Configuration with three poles in series (with neutral connected to earth and interrupted)
- Interruption for phase to neutral fault: 3 poles in series
- Interruption for phase to earth fault: 2 poles in series

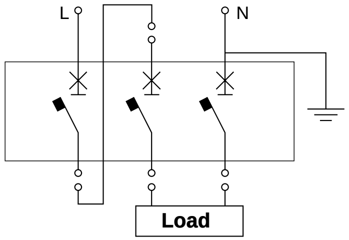


Diagram B3

Configuration with three poles in series (with neutral connected to earth but not interrupted)
- Interruption for phase to neutral fault: 3 poles in series
- Interruption for phase to earth fault: 3 poles in series

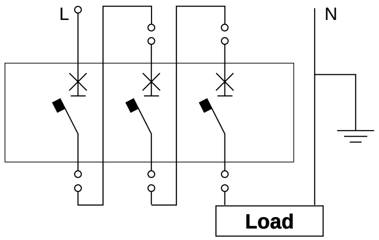


Diagram C1

Configuration with four poles in series (without neutral connected to earth)
- Interruption for phase to neutral fault: 4 poles in series
- Interruption for phase to earth fault: not considered

(The installation method must be such as to make the probability of a second earth fault negligible)

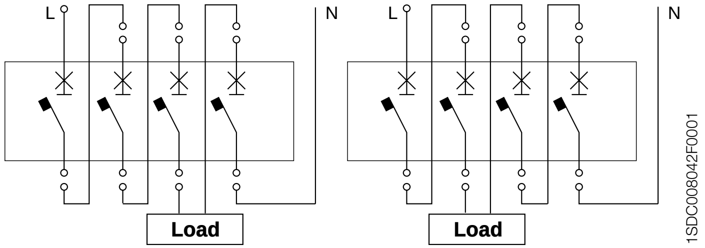


Diagram C2

Configuration with four poles in series, on one polarity (with neutral connected to earth and not interrupted)
- Interruption for phase to neutral fault: 4 poles in series
- Interruption for phase to earth fault: 4 poles in series

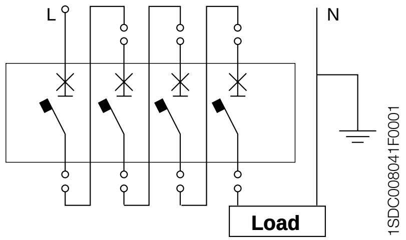
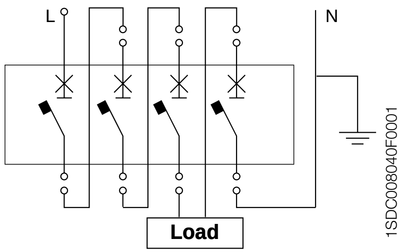


Diagram C3

Interruption with four poles in series (with neutral connected to earth and interrupted)
- Interruption for phase to neutral fault: 4 poles in series
- Interruption for phase to earth fault: 3 poles in series



5 Special applications

Example:

Network data:
Rated voltage 250 V
Rated frequency 16 2/3 Hz
Load current 120 A
Phase to neutral short-circuit current 45 kA
Neutral connected to earth

Assuming that the probability of a phase to earth fault is negligible, Table 8 shows that connections A2, B2 or B3 may be used.
Therefore it is possible to choose a Tmax T2S160 R125 circuit-breaker, which with the connection according to diagram A2 (two poles in series) has a breaking capacity of 50 kA, while according to diagrams B2 or B3 (three poles in series) the breaking capacity is 55 kA. To determine the magnetic trip, see factor k_m in Table 10. The magnetic threshold will be:
I_3= 1250·0.9 = 1125 A
whichever diagram is used.
If it is possible to have an earth fault with non significant impedance, the diagrams to be considered (Table 8) are only B2 or B3. In particular, in diagram B2 it can be seen that only 2 poles are working in series, the breaking capacity will be 50 kA (Table 9), while with diagram B3, with 3 poles working in series, the breaking capacity is 55 kA.

5.3 1000 Vdc and 1000 Vac networks

The SACE Isomax and Emax /E 1000 V circuit-breakers are particularly suitable for use in installations in mines, petrochemical plants and services connected to electrical traction (tunnel lighting).

1000 Vdc Moulded case circuit-breakers

General Characteristics

The range of Isomax S moulded-case circuit-breakers for use in installations with rated voltage up to 1000 V direct current comply with international standard IEC 60947-2. The range is fitted with adjustable thermomagnetic releases and is suitable for all installation requirements, having a range of available settings from 32 A to 800 A. The four-pole version circuit-breakers allow high performance levels to be reached thanks to the series connection of the poles in series.
The circuit-breakers in the SACE Isomax S 1000 V range maintain the same dimensions and fixing points as standard circuit-breakers.
The range of 1000 V circuit-breakers provides:
- insulated plates between the phases to guarantee adequate insulation;
- insulated rear panel to guarantee insulation from any metallic surface onto which the circuit-breaker may be fixed.

These circuit-breakers can also be fitted with the range of Isomax S standard accessories, with the exception of mechanical interlocks.
In particular it is possible to use conversion kits for removable and withdrawable moving parts and various terminal kits.

5 Special applications

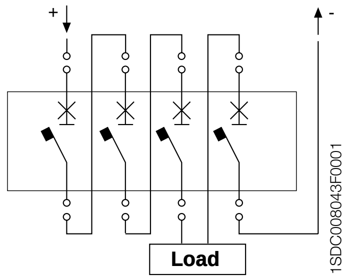
1000 V dc Moulded-case circuit-breakers		**S3**	**S5**	**S6**	**S6**
Rated uninterrupted current, **Iu**	[A]	**160-250**	**400**	**630**	**800**
Poles	Nr.	4	4	4	4
Rated operational voltage, **Ue**	[V –]	1000	1000	1000	1000
Rated impulse withstand voltage, **Uimp**	[kV]	8	8	8	8
Rated insulation voltage, **Ui**	[V]	1000	1000	1000	1000
Test voltage at industrial frequency for 1 min.	[V]	3000	3000	3000	3000
Ultimate rated short-circuit breaking capacity, **Icu**		**L**	**L**	**L**	**L**
(4 poles in series)	[kA]	40	40	40	50
Rated short-circuit making capacity $\mathbf{I_{cm}}$	[kA]	40	40	40	50
Opening time	[ms]	25	35	45	50
Rated short-time withstand current for 1 s, Icw	[kA]	–	5	7.6	10
Utilisation category (EN 60947-2)		A	B	B	B
Isolation behaviour		■	■	■	■
IEC 60947-2, EN 60947-2		■	■	■	■
Thermomagnetic releases, T adjustable - M fixed	10 Ith	■	–	–	–
Thermomagnetic releases, T adjustable - M adjustable		–	■	■	■
Versions		F	F	F	F
Terminals		F	F	F	F
Fixing on DIN rail		DIN EN 50023	DIN EN 50023	–	–
Mechanical life	[No. operations / operations per hours]	25000/120	20000/120	20000/120	20000/120
Basic dimensions, fixed	L [mm]	140	184	280	280
	D [mm]	103.5	103.5	103.5	103.5
	H [mm]	170	254	268	268
Weights, fixed	[kg]	3.5	7	12	12

Connection diagrams

Possible connection diagrams with reference to the type of distribution system in which they can be used follow.

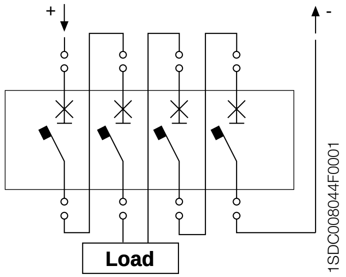
Networks insulated from earth

The following diagrams can be used (the polarity may be inverted).



A) 3+1 poles in series (1000 Vdc)

5 Special applications

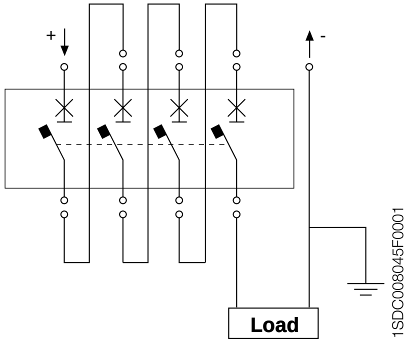


B) 2+2 poles in series (1000 Vdc)

It is assumed that the risk of a double earth fault in which the first fault is downstream of the breaker on one polarity and the second is upstream of the same switching device on the opposite polarity is null.
In this condition the fault current, which can reach high values, effects only some of the 4 poles necessary to ensure the breaking capacity.
It is possible to prevent the possibility of a double earth fault by installing a device which signals the loss of insulation and identifies the position of the first earth fault, allowing it to be eliminated quickly.

Networks with one polarity connected to earth

As the polarity connected to earth does not have to be interrupted (in the example it is assumed that the polarity connected to earth is negative, although the following is also valid with the polarity inverted), the diagram which shows the connection of 4 poles in series on the polarity not connected to earth may be used.

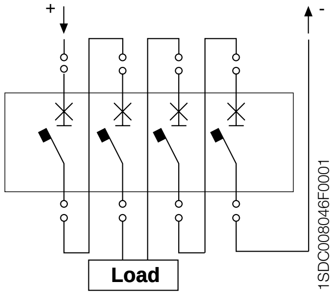


C) 4 poles in series (1000 Vdc)

5 Special applications

Network with median point of the supply source connected to earth

In the presence of an earth fault of positive or negative polarity, the poles involved in the fault work at U/2 (500 V); the following diagram must be used:



D) 2+2 poles in series (1000 Vdc)

Correction factors for tripping thresholds

With regard to overload protection, no correction factors need to be applied. However, for the magnetic threshold values in use with 1000 Vdc with the previously described applicable diagrams, refer to the corresponding values for alternating current, multiplied by the correction factors given in the following table:

Circuit-breaker	k_m
S3L	1
S5L	1.1
S6L	0.9

Circuit-breakers with thermomagnetic release for direct current

	R32 (1)	**R50** (1)	**R80** (1)	**R100** (1)	**R125** (1)	**R160** (1)	**R200** (1)	**R250** (1)	**R400** (2)	**R630** (2)	**R800** (2)
S3L 160	🟥	🟥	🟥	🟥	🟥	🟥	–	–	–	–	–
S3L 250	–	–	–	–	–	–	🟥	🟥	–	–	–
S5L 400	–	–	–	–	–	–	–	–	🟥	–	–
S6L 630	–	–	–	–	–	–	–	–	–	🟥	–
S6L 800	–	–	–	–	–	–	–	–	–	–	🟥
I_3 dc (10xI_n) [A]	500	500	800	1000	1250	1600	2000	2500	–	–	–
I_3 dc (5-10xI_n) [A]									2000-4000	3150-6300	4000-8000

(1) Thermal threshold adjustable from 0.7 and 1 x In; fixed magnetic threshold
(2) Thermal threshold adjustable from 0.7 and 1 x In; magnetic threshold adjustable between 5 and 10 x In.

5 Special applications

Example

To ensure the protection of a user supplied with a network having the following characteristics:

Rated voltage U_r = 1000 Vdc
Short-circuit current I_k = 18 kA
Rated current I_b = 520 A
Network with both polarities insulated from earth.

From the table of available settings, the circuit-breaker to be used is:
S6L630 R630 four-pole I_{cu}@1000 Vdc = 40 kA
Thermal trip threshold adjustable from (0.7-1) x I_n therefore from 441 A to 630 A to be set at 0.85.
Magnetic trip threshold adjustable from (5-10) x I_n which with correction factor k_m = 0.9 gives the following adjustment range: 2835 A to 5670 A. The magnetic threshold will be adjusted according to any conductors to be protected.
The connection of the poles must be as described in diagrams A or B.
A device which signals any first earth fault must be present.
With the same system data, if the network is carried out with a polarity connected to earth, the circuit-breaker must be connected as described in diagram C.

5 Special applications

1000 Vdc air switch disconnectors

The air switch disconnectors derived from the Emax air breakers are identified by the standard range code together with the code “/E MS”.
These comply with the international Standard IEC 60947-3 and are especially suitable for use as bus-ties or principle isolators in direct current installations, for example in electrical traction applications.
The overall dimensions and the fixing points remain unaltered from those of standard breakers, and they can be fitted with various terminal kits and all the accessories for the Emax range; they are available in both withdrawable and fixed versions, and in three-pole version (up to 750 Vdc) and four-pole (up to 1000 Vdc).
The withdrawable breakers are assembled with special version fixed parts for applications of 750/1000 Vdc.
The range covers all installation requirements up to 1000 Vdc / 3200 A or up to 750 Vdc / 4000 A.
A breaking capacity equal to the rated short-time withstand current is attributed to these breakers when they are associated with a suitable external relay.

The following table shows the available versions and their relative electrical performance:

			E1B/E MS		E2N/E MS		E3H/E MS		E4H/E MS
Rated uninterrupted current (at 40 °C) Iu		[A]	**800**		**1250**		**1250**		**3200**
		[A]	**1250**		**1600**		**1600**		**4000**
		[A]			**2000**		**2000**		
		[A]					**2500**		
		[A]					**3200**		
Number of poles			3	4	3	4	3	4	3
Rated operational voltage **Ue**		[V]	750	1000	750	1000	750	1000	750
Rated insulation voltage **Ui**		[V]	1000	1000	1000	1000	1000	1000	1000
Rated impulse withstand voltage **Uimp**		[kV]	12	12	12	12	12	12	12
Rated short-time withstand current **Icw** (1s)		[kA]	20	20	25	25	40	40	65
Rated making capacity **Icm**	750 V dc	[kA]	20	20	25	25	40	40	65
	1000 V dc		–	20	–	25	–	40	–

5 Special applications

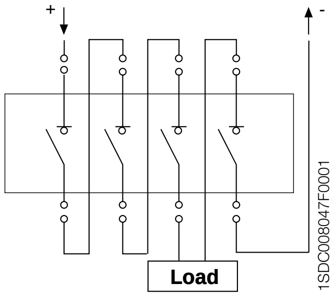
Connection diagrams

Connection diagrams to be used according to the type of distribution system follow.

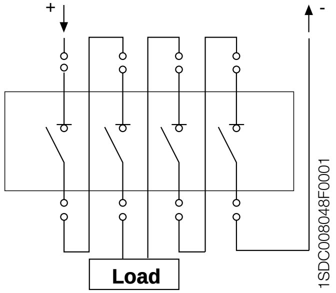
The risk of a double earth fault on different poles is assumed to be zero, that is, the fault current involves only one part of the breaker poles.

Networks insulated from earth

The following diagrams may be used (the polarity may be inverted).

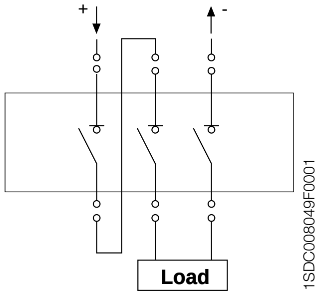


E) 3+1 poles in series (1000 Vdc)



F) 2+2 poles in series (1000 Vdc)

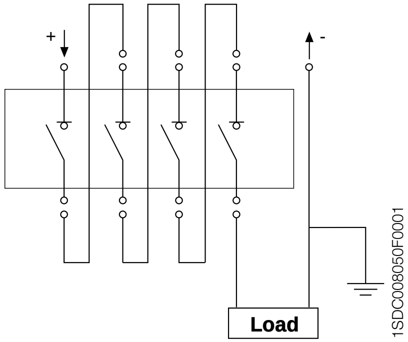
5 Special applications



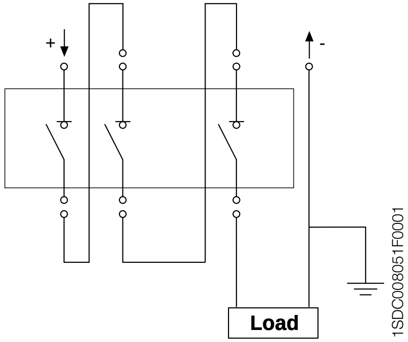
G) 2+1 poles in series (750 Vdc)

Networks with one polarity connected to earth

The polarity connected to earth does not have to be interrupted (in the examples it is assumed that the polarity connected to earth is negative):



H) 4 poles in series (1000 Vdc)



I) 3 poles in series (750 Vdc)

Network with median point of the supply source connected to earth

Only four-pole breakers may be used as in the configuration shown in diagram F).

5 Special applications

1000 Vac moulded-case circuit-breakers

General Characteristics

The circuit-breakers in the Isomax S 1000 V range comply with the international Standard IEC 60947-2.

These circuit-breakers can be fitted with thermo-magnetic releases (for the smaller sizes) and with SACE PR211 electronic releases (in version LI) or PR212 (in versions LSI and LSIG). All installation requirements can be met with a range of available settings from 32 A to 800 A and with breaking capacity up to 30 kA at 1000 Vac.

The circuit-breakers in the SACE Isomax S 1000 V range maintain the same dimensions and fixing points as standard 690 V circuit-breakers. Standard supply provides:

- insulated plates between the phases to guarantee adequate insulation;
- insulated rear panel to guarantee insulation from any metallic surface onto which the circuit-breaker may be fixed.

5 Special applications

These circuit-breakers can also be fitted with all the accessories in the SACE Isomax S standard range, with the exception of:
- residual current relays RC211 and RC212 (it is possible to use the SACE RCQ switchboard relay);
- mechanical interlocks.

In particular it is possible to use conversion kits for removable and withdrawable moving parts and various terminal kits.

The circuit-breakers in the SACE Isomax S 1000 V range can be supplied via the upper terminals only.

The following table shows the electrical characteristics of the range:

1000 Vac moulded-case circuit-breakers		**S3**	**S3X**	**S4**	**S4X**	**S5**	**S6**	**S6X**
Rated uninterrupted current, **Iu**	[A]	**160**	125	160-250	250	400	630-800	630
Poles	Nr.	3	3	3	3	3	3	3
Rated operational voltage, **Ue** (ac) 50-60Hz	[V]	1000	1000	1000	1000	1000	1000	1000
Rated impulse withstand voltage, **Uimp**	[kV]	8	8	8	8	8	8	8
Rated insulation voltage, **Ui**	[V]	1000	1000	1000	1000	1000	1000	1000
Test voltage at industrial frequency for 1 min.	[V]	3000	3000	3000	3000	3000	3000	3000
Rated ultimate short-circuit breaking capacity,		**L**	**X**	**L**	**X**	**L**	**L**	**X**
Icu (ac) 50-60 Hz 1000 V	[kA]	6	30	8	30	8	12	30
Rated short-circuit making capacity **Icm**	[kA]	9.2	63	13.6	63	13.6	24	63
Opening time	[ms]	20	10	30	20	30	30	25
Rated short-time withstand current for 1 s, **Icw**	[kA]					5	7.6 (630A)-10 (800A)	
Utilisation category (EN 60947-2)		A	A	A	A	B	B	A
Isolation behaviour		■	■	■	■	■	■	■
IEC 60947-2, EN 60947-2		■	■	■	■	■	■	■
Thermomagnetic releases T adjustable, M fixed 10 In		■	■					
PR211/P (LI only) electronic releases				■	■	■	■	■
PR212/P (LSI-LSIG) electronic releases				■	■	■	■	■
Versions		F	F	F	F	F	F	F
Terminals		F	F	F	F	F	F	F
Fixing on DIN rail		DIN EN 50023	DIN EN 50023	DIN EN 50023	DIN EN 50023	DIN EN 50023	–	–
Mechanical life	[No. operations / operations per hours]	25000/120	25000/120	20000/120	20000/120	20000/120	20000/120	20000/120
Dimensions	L [mm]	105	105	105	105	140	210	210
	D [mm]	103.5	103.5	103.5	103.5	103.5	103.5	103.5
	H [mm]	170	255	254	254	254	268	406
Weights	[kg]	2.6	3.6	4	4	5	9.5	15

5 Special applications

The followimg tables show the available releases.

Circuit-breakers with electronic release for alternating current

	In100	In250	In400	In630	In800
S4L 160	■	–	–	–	–
S4L 250	–	■	–	–	–
S4X 250	–	■	–	–	–
S5L 400	–	–	■	–	–
S6L 630	–	–	–	■	–
S6X 630	–	–	–	■	–
S6L 800	–	–	–	–	■
I_3 (1.5 …12 x In) [A]	150…1200	375…3000	600 ... 4800	945…7560	1200…9600

Circuit-breakers with thermomagnetic release for alternating current

(thermal threshold adjustable from 0.7 to 1 x In; fixed magnetic threshold)

	R32	R50	R80	R100	R125	R160
S3L 160	■	■	■	■	■	■
S3X 125	■	■	■	■	■	–
I_3 ac (10x I_n) [A]	500	500	800	1000	1250	1600

1000 Vac Air circuit-breakers and switch disconnectors

For 1000 V alternating current installations, the following devices are available:

- **Circuit-breakers** in compliance with Standard IEC 60947-2.
  The special version breakers up to 1000 Vac are identified by the standard range code together with the suffix "/E", and are derived from the correspondent Emax standard breakers and retain the same versions, accessories and overall dimensions.
  The Emax range of breakers is available in both withdrawable and fixed versions with three and four poles, and can be fitted with accessories and equipped with the full range of electronic releases and microprocessors (PR111-PR112-PR113).
- **Switch disconnectors** in compliance with Standard IEC 60947-3.
  These breakers are identified by the code of the standard range, from which they are derived, together with the suffix "/E MS". Three-pole and four-pole versions are available in both withdrawable and fixed versions with the same dimensions, accessory characteristics and installation as the standard switch disconnectors.

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5 Special applications

The following tables show the electrical characteristics of the devices:

Air circuit-breakers

		E2B/E		E2N/E			E3H/E					E4H/E	
Rated uninterrupted current (at 40 °C) Iu	[A]	**1600**	**2000**	**1250**	**1600**	**2000**	**1250**	**1600**	**2000**	**2500**	**3200**	**3200**	**4000**
Rated operational voltage **Ue**	[V~]	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Rated ultimate short-circuit breaking capacity **Icu**	[kA]	20	20	30	30	30	50	50	50	50	50	65	65
Rated duty short-circuit breaking capacity **Ics**	[kA]	20	20	30	30	30	50	50	50	50	50	65	65
Rated short-time withstand current **Icw** (1s)	[kA]	20	20	30	30	30	50	50	50	50	50	65	65

Air switch disconnectors

		E2B/E MS	E2N/E MS	E3H/E MS	E4H/E MS
Rated uninterrupted current (at 40 °C) Iu	[A]	**1600**	**1250**	**1250**	**3200**
	[A]	**2000**	**1600**	**1600**	**4000**
	[A]		**2000**	**2000**	
	[A]			**2500**	
	[A]			**3200**	
Number of poles		3/4	3/4	3/4	3/4
Rated operational voltage **Ue**	[V]	1000	1000	1000	1000
Rated insulation voltage **Ui**	[V]	1000	1000	1000	1000
Rated impulse withstand voltage **Uimp**	[kV]	12	12	12	12
Rated short-time withstand current **Icw** (1s)	[kA]	20	30	50	65
Rated making capacity **Icm** 1000 Vac (peak value)	[kA]	40	63	105	143

5.4 Automatic Transfer Switches

In the electrical plants, where a high reliability is required from the power supply source because the operation cycle cannot be interrupted and the risk of a lack of power supply is unacceptable, an emergency line supply is indispensable to avoid the loss of large quantities of data, damages to working processes, plant stops etc.

For these reasons, transfer switch devices are used mainly for:

- power supply of hotels and airports;
- surgical rooms and primary services in hospitals;
- power supply of UPS groups;
- databanks, telecommunication systems, PC rooms;
- power supply of industrial lines for continuous processes.

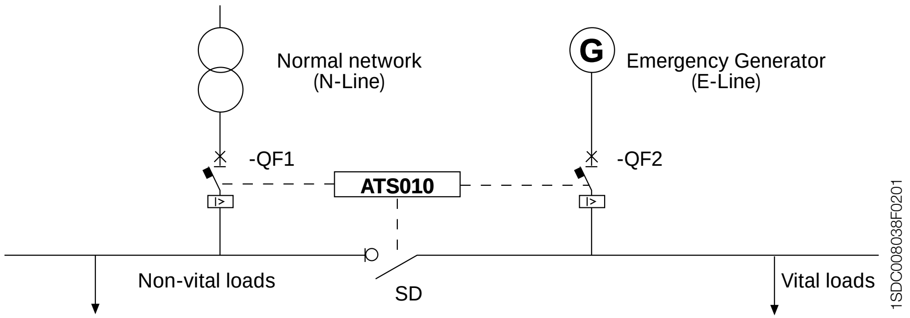
ATS010 is the solution offered by ABB: it is an automatic transfer switch system with micro-processor based technology which allows switching of the supply from the normal line (N-Line) to the emergency line (E-Line) in case any of the following anomalies occurs on the main network:

- overvoltages and voltage dips;
- lack of one of the phases;
- asymmetries in the phase cycle;
- frequency values out of the setting range.

Then, when the network standard parameters are recovered, the system switches again the power supply to the main network (N-Line).

ATS010 is used in systems with two distinct supply lines connected to the same busbar system and functioning independently (“island condition”): the first one is used as normal supply line, the second is used for emergency power supply from a generator system. It is also possible to provide the system with a device to disconnect the non-priority loads when the network is supplied from the E-Line.

The following scheme shows a plant having a safety auxiliary power supply:



ATS010 device is interfaced by means of appropriate terminals:

- with the protection circuit-breakers of the N-Line and of the E-Line, motorized and mechanically interlocked, to detect their status and send opening and closing commands according to the set time delays;
- with the control card of the Gen set to control its status and send start and stop commands;
- with any further signals coming from the plant in order to block the switching logic;
- with the N-Line to detect any possible anomaly and with the E-Line to verify the voltage presence;
- with an additional device to disconnect non-priority loads;
- with an auxiliary power supply at 24 Vdc ± 20% (or 48 Vdc ± 10%). This supply source shall be present also in case of lack of voltage on both lines (N-Line and E-Line).

The circuit-breakers used to switch from the N-line to the E-line shall have all the necessary accessories and shall be properly interlocked in order to guarantee the correct working of the plant. The following accessories are required:

Moulded-case circuit-breakers SACE Isomax (S3÷S7):

- motor operator;
- trip signaling contact;
- open/closed signaling contacts;
- racked-in signaling contact in case of plug-in or withdrawable circuit-breakers;
- mechanical interlock between two circuit-breakers.

Air circuit-breakers Emax:

- charging spring motor;
- shunt opening release;
- shunt closing release;
- trip signaling contact;
- open/closed signaling contacts;
- racked-in signaling contact in case of withdrawable circuit-breakers;
- mechanical interlock between two circuit-breakers.

Switching strategies

According to the application where ATS010 device is used, two different switching strategies can be chosen.

Strategy 1: this strategy is used when an auxiliary supply source is available for the supply of the motor operators of the circuit-breakers; the switching sequence is as follows:

- normal line anomaly detection;
- normal line circuit-breaker opening and Gen Set starting;
- waiting for presence of Gen Set voltage and emergency circuit-breaker closing.

For example, strategy 1 is used for systems in which a redundant 110 V auxiliary power supply is available (MV/LV substations); the plant is designed so that the auxiliary voltage is always present even when neither the normal line nor the Gen Set are active. In this case, the auxiliary power supply can be used to feed the motor operators and/or the shunt opening and closing releases of the circuit-breakers. ATS010 operates the circuit-breakers regardless of the presence of the network and of the Gen Set.

Strategy 2: this strategy is absolutely necessary when the power supply for the auxiliary accessories of the circuit-breakers is directly derived from the network and the Gen Set, since a safety auxiliary power supply is not available; in this case, before operating the circuit-breakers, ATS010 waits for availability of normal line or emergency line voltage: normal line or Gen Set. The switching sequence is as follows:
- normal line anomaly detection;
- Gen Set starting;
- waiting for presence of Gen Set voltage and normal line circuit-breaker opening;
- Gen Set circuit-breaker closing.

Note: in both strategies, it is necessary to provide an auxiliary power supply for ATS010.

Operating modes

By using the front selector it is possible to choose one of the following six operating modes:

TEST:
This operating mode is useful to test the Gen Set start and therefore to test the emergency line power supply status without disconnecting normal line power supply.

AUTOMATIC:
The transfer switch logic is ON and checks both the circuit-breakers as well as the generator. In case of normal line anomalies, the transfer switch procedure begins from normal to emergency line and viceversa when normal line voltage become available again.

MANUAL:
The MANUAL mode offers a choice between the following possibilities:

1. Normal ON

The emergency line circuit-breaker is forced to open and the normal line circuit-breaker is forced to close; the Gen Set is stopped and the transfer switch logic is disabled.
This selector position guarantees that the emergency line is not closed and that the Gen Set is not running; this position is useful when the user wants to carry out maintenance on the emergency line or on the Gen Set (in these cases it is advisable to install mechanical lock in open position for the emergency line circuit-breaker).

2. Normal – Emergency OFF (maintenance)

Both circuit-breakers (N-Line and E-Line) are forced in open position. It is useful when all loads are to be disconnected from the power supply sources, for example to carry out maintenance on the plant (in these cases, it is advisable to mechanically lock both circuit-breakers in the open position).

3. Gen Set START

The START command of the Gen Set has been activated through the proper output. The circuit-breakers are not operated and the transfer switch logic is disabled.
When emergency line voltage is present and switching is enabled, it is possible to switch the selector to ‘Emergency ON’ position in order to force supply from the emergency line.

4. Emergency ON

Power supply is forced from the emergency line. Before switching to this position, ‘Gen-Set START’ operating mode is activated and shall be present until switching is enabled as previously described.

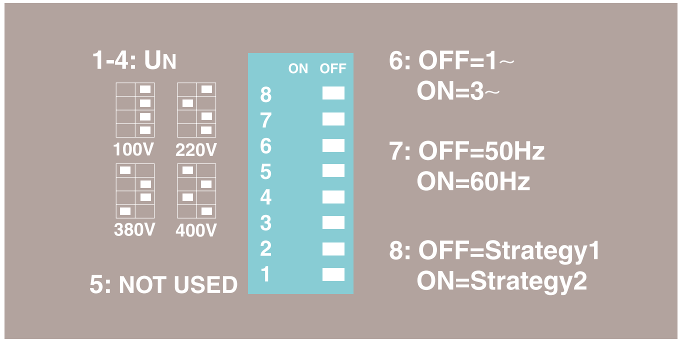
5 Special applications

Setting of parameters

All the parameters for the functioning of ATS010 can be simply adjusted through dip-switches or trimmers.

Rated voltage for three-phase or single-phase plant
The following parameters of the N-Line can be set through dip-switches:
- network rated voltage value (from 100 V up to 500 V);
- power supply type (three-phase or single-phase);
- frequency value (50 Hz or 60 Hz);
- type of strategy.

Note: Voltages higher than 500 V can be reached by using VTs (voltage transformers); in this case the setting of the voltage value shall consider the transformation ratio.



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The figure below shows all the possible voltage values which can be set by the dip-switches from 1 to 4.

		ON	OFF
100V	4		■
	3		■
	2		■
	1		■

		ON	OFF
115V	4		■
	3		■
	2		■
	1	■	

		ON	OFF
120V	4		■
	3		■
	2	■	
	1		■

		ON	OFF
208V	4		■
	3		■
	2	■	
	1	■	

5 Special applications

		ON	OFF
220V	4		■
	3	■	
	2		■
	1		■

		ON	OFF
230V	4		■
	3	■	
	2		■
	1	■	

		ON	OFF
240V	4		■
	3	■	
	2	■	
	1		■

		ON	OFF
277V	4		■
	3	■	
	2	■	
	1	■	

		ON	OFF
347V	4	■	
	3		■
	2		■
	1		■

		ON	OFF
380V	4	■	
	3		■
	2		■
	1	■	

		ON	OFF
400V	4	■	
	3		■
	2	■	
	1		■

		ON	OFF
415V	4	■	
	3		■
	2	■	
	1	■	

		ON	OFF
440V	4	■	
	3	■	
	2		■
	1		■

		ON	OFF
480V	4	■	
	3	■	
	2		■
	1	■	

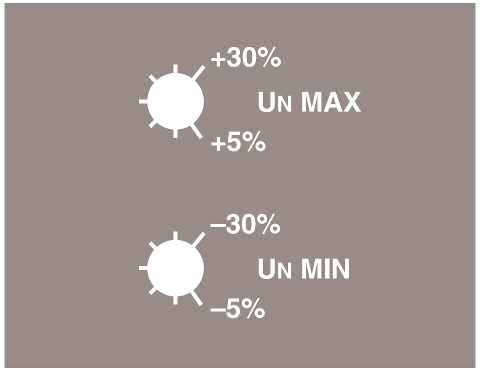
		ON	OFF
500V	4	■	
	3	■	
	2	■	
	1		■

Note: the black square shows the dip-switch position.

5 Special applications

Overvoltage threshold

According to the load characteristics, it is possible to set the voltage range outside which the N-Line supply cannot be accepted and switching to the E-Line is necessary.



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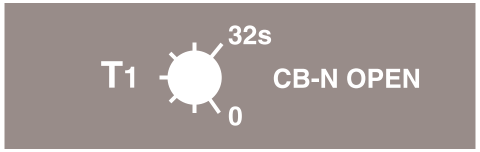
Transfer switch delay configuration

Transfer switch delays can be set through special trimmers. Setting times and relevant purposes are reported below:

T1 = 0 ÷ 32 s CB-N open

Delay time from net anomaly detection to N-Line CB opening. It is used to avoid transfer switching in case of short voltage dips.



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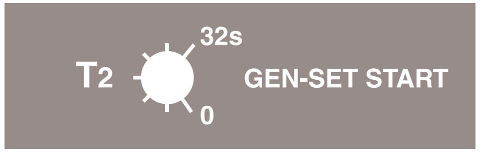
T2 = 0 ÷ 32 s GEN-SET START

Delay time from net anomaly detection to Gen set start command. It is used to prevent from transfer switching in case of short voltage dips.



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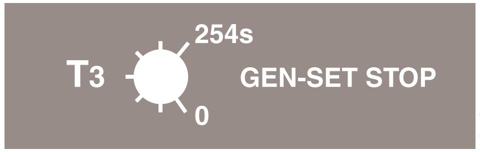
5 Special applications

T3= 0 ÷ 254 s GEN-SET STOP

Delay time from N-Line return to Gen set stop command. It is used when the Generator needs a cooling time after the disconnection of the load (opening of the E-Line circuit-breaker).



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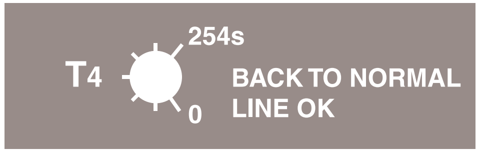
T4= 0 ÷ 254 s BACK TO NORMAL LINE OK

Delay time necessary for N-Line voltage to establish, before inverse switching procedure is started.



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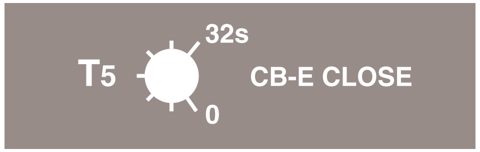
T5 = 0 ÷ 32 s CB-E CLOSE

Delay time for E-Line CB closing command, after the generator voltage presence signal is ON. This delay allows the E-Line voltage to establish before transfer switching is started.



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5 Special applications

Check on the plant and on the circuit-breakers

ATS010 can be used in plants with the following characteristics:
- the Gen set shall function independently (“island” condition);
- rated voltage and frequency of the plants are included within the given ranges;
- ATS010 supply is guaranteed even if N-Line and E-Line voltages are missing.

The two circuit-breakers controlled by ATS are to be:
- mechanically interlocked;
- of the prescribed type and size;
- equipped with the prescribed accessories.

References Standards

EN 50178 (1997): ”Electronic equipment for use in power installations”
Compliance with “Low Voltage Directive” (LVD) no. 73/23/EEC and “Electromagnetic Compatibility Directive” (EMC) no. 89/336/EEC.
Electromagnetic compatibility: EN 50081-2, EN 50082-2
Environmental conditions: IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-3.

ATS010 - main technical characteristics

Rated power supply voltage (galvanically isolated from the ground)	24 Vdc ± 20% 48 Vdc ± 10% (maximum ripple ± 5%)
Maximum power consumption	5 W @ 24 Vdc 10 W @ 48 Vdc
Rated power (N-Line voltage present and CBs not operated)	1,8 W @ 24 Vdc 4,5 W @ 48 Vdc
Operating temperature	-25 °C…+70 °C
Maximum humidity	90 % without condensation
Storing temperature	-20 °C…..+80 °C
Degree of protection	IP54 (front panel)
Dimensions (H x W x D)	144 x 144 x 85
Weight [kg]	0,8

Normal line voltage sensor

Normal line rated voltage	100…500 Vac with direct connection Over 500 Vac with external voltage transformers
Rated frequency	50 Hz / 60 Hz
Impulse withstand voltage on L1, L2, L3 inputs	6 kV

Motor operators - shunt opening/closing releases

Isomax S3-S4-S5-S6-S7	Up to 250 Vac From 48 Vdc to 110 Vdc
Emax	Up to 250 Vac From 24 Vdc to 110 Vdc

6 Switchboards

6.1 Electrical switchboards

The switchboard is a combination of one or more low voltage switching, protection and other devices assembled in one or more enclosure so as to satisfy the requirements regarding safety and to allow the functions for which it was designed to be carried out.
A switchboard consists of a container, termed enclosure by the relevant Standards (which has the function of support and mechanical protection of the components contained within), and the electrical equipment, which consists of devices, internal connections and input and output terminals for connection with the system.

The reference Standard is IEC 60439-1 published in 1999, titled “Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies”, approved by CENELEC code number EN 60439-1,

Supplementary calculation guides are:

IEC 60890 “A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear“.

IEC 61117 “A method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)”.

IEC 60865-1 “Short-circuit currents - Calculation of effects - Part 1: Definitions and calculation methods”.

Standard IEC 60439-1 sets out the requirements relating to the construction, safety and maintainability of electrical switchboards, and identifies the nominal characteristics, the operational environmental conditions, the mechanical and electrical requirements and the performance regulations.
The type-tests and individual tests are defined, as well as the method of their execution and the criteria necessary for the evaluation of the results.

Standard IEC 60439-1 distinguishes between the two types of switchboard: TTA (type-tested assemblies) and PTTA (partially type-tested assemblies).
By “type-tested assemblies” (TTA), it is meant a low voltage switchgear and controlgear assemblies conforming to an established type or system without deviations likely to significantly influence the performance from the typical assembly verified to be in accordance with the Standard prescriptions.
TTA switchboards are assemblies derived directly from a prototype designed in all details and subjected to type-tests; as the type-tests are very complex, switchboards designed by a manufacturer with a sound technical and financial basis are referred to. Nevertheless, TTA assemblies can be mounted by a panel builder or installer who follows the manufacturer’s instructions; deviations from the prototype are only allowed if they do not significantly change the performance compared with the type-tested equipment.

6 Switchboards

By "partially type-tested assemblies" (PTTA), it is meant a low voltage and controlgear assembly, tested only with a part of the type-tests; some tests may be substituted by extrapolation which are calculations based on experimental results obtained from assemblies which have passed the type-tests. Verifications through simplified measurements or calculations, allowed as an alternative to type tests, concern heating, short circuit withstand and insulation.

Standard IEC 60439-1 states that some steps of assembly may take place outside the factory of the manufacturer, provided the assembly is performed in accordance with the manufacturer's instructions.
The installer may use commercial assembly kits to realize a suitable switchboard configuration.
The same Standard specifies a division of responsibility between the manufacturer and the assembler in Table 7: "List of verifications and tests to be performed on TTA and PTTA" in which the type-tests and individual tests to be carried out on the assembly are detailed.
The type-tests verify the compliance of the prototype with the requirements of the Standard, and are generally under the responsibility of the manufacturer, who must also supply instructions for the production and assembly of the switchboard. The assembler has responsibility for the selection and assembly of components in accordance with the instructions supplied and must confirm compliance with the Standards through the previously stated checks in the case of switchboards that deviate from a tested prototype. Routine tests must also be carried out on every example produced.

The distinction between TTA and PTTA switchgear and controlgear assemblies has no relevance to the declaration of conformity with Standard IEC 60439-1, in so far as the switchboard must comply with this Standard.

6 Switchboards

List of verifications and tests to be performed on TTA and PTTA

No.	Characteristics to be checked	Sub-clauses	TTA	PTTA
1	Temperature-rise limits	8.2.1	Verification of temperature-rise limits by test (type test)	Verification of temperature-rise limits by test or extrapolation
2	Dielectric properties	8.2.2	Verification of dielectric properties by test (type test)	Verification of dielectric properties by test according to 8.2.2 or 8.3.2, or verification of insulation resistance according to 8.3.4 (see Nos. 9 and 11)
3	Short-circuit withstand strength	8.2.3	Verification of the short-circuit withstand strength by test (type test)	Verification of the short-circuit withstand strength by test or by extrapolation from similar type-tested arrangements
4	Effectiveness of the protective circuit	8.2.4		
	Effective connection between the exposed conductive parts of the ASSEMBLY and the protective circuit	8.2.4.1	Verification of the effective connection between the exposed conductive parts of the ASSEMBLY and the protective circuit by inspection or by resistance measurement (type test)	Verification of the effective connection between the exposed conductive parts of the ASSEMBLY and the protective circuit by inspection or by resistance measurement
	Short-circuit withstand strength of the protective circuit	8.2.4.2	Verification of the short-circuit withstand strength of the protective circuit by test (type test)	Verification of the short-circuit withstand strength of the protective circuit by test or appropriate design and arrangement of the protective conductor (see 7.4.3.1.1, last paragraph)
5	Clearances and creepage distances	8.2.5	Verification of the clearances and creepage distances (type test)	Verification of clearances and creepage distances
6	Mechanical operation	8.2.6	Verification of mechanical operation (type test)	Verification of mechanical operation
7	Degree of protection	8.2.7	Verification of the degree of protection (type test)	Verification of the degree of protection
8	Wiring, electrical operation	8.3.1	Inspection of the ASSEMBLY including inspection of wiring and, if necessary, electrical operation test (routine test)	Inspection of the ASSEMBLY including inspection of wiring and, if necessary, electrical operation test
9	Insulation	8.3.2	Dielectric test (routine test)	Dielectric test or verification of insulation resistance according to 8.3.4 (see Nos. 2 and 11)
10	Protective measures	8.3.3	Checking of protective measures and of the electrical continuity of the protective circuits (routine test)	Checking of protective measures
10	Insulation resistance	8.3.4		Verification of insulation resistance unless test according to 8.2.2 or 8.3.2 has been made (see Nos. 2 and 9)

6 Switchboards

Degrees of protection

The degree of protection IP indicates a level of protection provided by the assembly against access to or contact with live parts, against ingress of solid foreign bodies and against the ingress of liquid. The IP code is the system used for the identification of the degree of protection, in compliance with the requirements of Standard IEC 60529. Unless otherwise specified by the manufacturer, the degree of protection applies to the complete switchboard, assembled and installed for normal use (with door closed).
The manufacturer shall also state the degree of protection applicable to particular configurations which may arise in service, such as the degree of protection with the door open or with devices removed or withdrawn.

Elements ofthe IP Code and their meanings

Element	Numerials or letters	Meaning for the protection of equipment	Meaning for the protection of persons	Ref.
Code letters	**IP**			
First characteristic numeral		Against ingress of the solid foreign objects	Against access to hazardous parts with	Cl.5
	0	(non-protected)	(non-protected)	
	1	≥ 50 mm diameter	back of hand	
	2	≥ 12.5 mm diameter	finger	
	3	≥ 2.5 mm diameter	tool	
	4	≥ 1.0 mm diameter	wire	
	5	dust-protected	wire	
	6	dust-tight	wire	
Second characteristic numeral		Against ingress of water with harmful effects		Cl.6
	0	(non-protected)		
	1	vertically dripping		
	2	dripping (15° tilted)		
	3	spraying		
	4	splashing		
	5	jetting		
	6	powerful jetting		
	7	temporary immersion		
	8	continuous immersion		
Additional letter (optional)			Against access to hazardous parts with	Cl.7
	A		back of hand	
	B		finger	
	C		tool	
	D		wire	
Supplementary letter (optional		Supplemetary information specific to:		Cl.8
	A	Hight voltage apparatus		
	B	Motion during water test		
	C	Stationary during water test		
	D	Weather conditions		

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6 Switchboards

Form of separation and classification of switchboards

Forms of internal separation

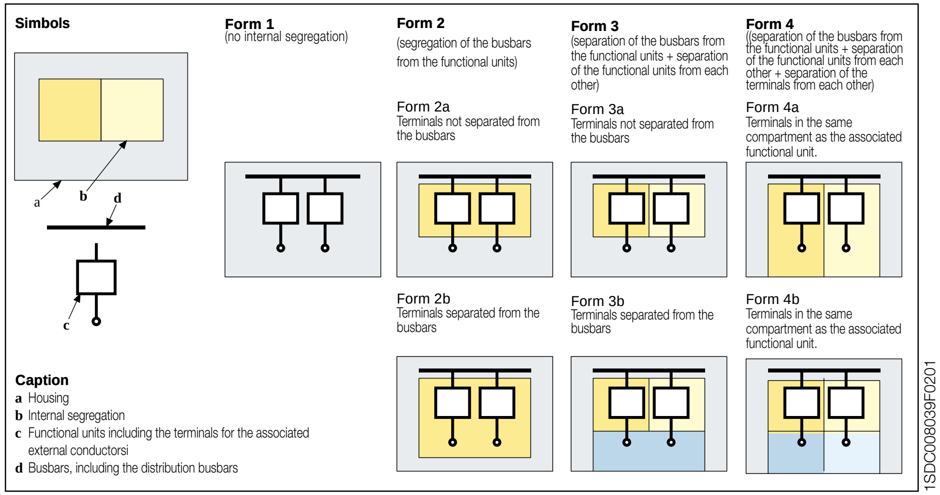
By form of separation it is meant the type of subdivision provided within the switchboard. Separation by means of barriers or partitions (metallic or insulating) may have the function to:

- provide protection against direct contact (at least IPXXB) in the case of access to a part of the switchboard which is not live, with respect to the rest of the switchboard which remains live;
- reduce the risk of starting or propagating an internal arc;
- impede the passage of solid bodies between different parts of the switchboard (degree of protection of at least IP2X).

A partition is a separation element between two parts, while a barrier protects the operator from direct contact and from arcing effects from any interruption devices in the normal access direction.
The following table from Standard IEC 60439-1 highlights typical forms of separation which can be obtained using barriers or partitions:

Main criteria	Subcriteria	Form
No separation		Form 1
Separation of busbars from the functional units	Terminals for external conductors not separated from busbars	Form 2a
	Terminals for external conductors separated from busbars	Form 2b
Separation of busbars from the functional units and separation of all functional units from one another. Separation of the terminals for external conductors from the functional units, but not from each other	Terminals for external conductors not separated from busbars	Form 3a
	Terminals for external conductors separated from busbars	Form 3b
Separation of busbars from the functional units and separation of all functional units from one another, including the terminals for external conductors which are an integral part of the functional unit	Terminals for external conductors in the same compartment as the associated functional unit	Form 4a
	Terminals for external conductors not in the same compartment as the associated functional unit, but in individual, separate, enclosed protected spaces or compartments	Form 4b

6 Switchboards



Caption

a Housing

b Internal segregation

c Functional units including the terminals for the associated external conductorsi

d Busbars, including the distribution busbars

Classification

Different classifications of electrical switchboard exist, depending on a range of factors.

Based on construction type, Standard IEC 60439-1 firstly distinguishes between open and enclosed assemblies.
A switchboard is enclosed when it comprises protective panels on all sides, providing a degree of protection against direct contact of at least IPXXB. Switchboards used in normal environments must be enclosed.

Open switchboards, with or without front covering, which have the live parts accessible. These switchboards may only be used in electrical plants.

With regard to external design, switchboards are divided into the following categories:

- **Cubicle-type assembly**
  Used for large scale control and distribution equipment; multi-cubicle-type assembly can be obtained by placing cubicles side by side.

6 Switchboards

- **Desk-type assembly**
  Used for the control of machinery or complex systems in the mechanical, iron and steel, and chemical industries.

- **Box-type assembly**
  Characterized by wall mounting, either mounted on a wall or flush-fitting; these switchboards are generally used for distribution at department or zone level in industrial environments and in the tertiary sector.

- **Multi-box-type assembly**
  Each box, generally protected and flanged, contains a functional unit which may be an automatic circuit-breaker, a starter, a socket complete with locking switch or circuit-breaker.

With regard to the intended function, switchboards may be divided into the following types:

- **Main distribution boards**
  Main distribution boards are generally installed immediately downstream of MV/LV transformers, or of generators; they are also termed power centres. Main distribution boards comprise one or more incoming units, busbar connectors, and a relatively smaller number of output units.

- **Secondary distribution boards**
  Secondary distribution boards include a wide range of switchboards for the distribution of power, and are equipped with a single input unit and numerous output units.

- **Motor operation boards**
  Motor control boards are designed for the control and centralised protection of motors: therefore they comprise the relative coordinated devices for operation and protection, and auxiliary control and signalling devices.

- **Control, measurement and protection boards**
  Control, measurement and protection boards generally consist of desks containing mainly equipment for the control, monitoring and measurement of industrial processes and systems.

- **Machine-side boards**
  Machine-side boards are functionally similar to the above; their role is to provide an interface between the machine with the power supply and the operator.

- **Assemblies for construction sites (ASC)**
  Assemblies for construction sites may be of different sizes, from a simple plug and socket assembly to true distribution boards with enclosures of metal or insulating material. They are generally mobile or, in any case, transportable.

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Method of temperature rise assessment by extrapolation for partially tested assemblies (PTTA)

For PTTA assemblies, the temperature rise can be determined by laboratory tests or calculations, which can be carried out in accordance with Standard IEC 60890. The formulae and coefficients given in this Standard are deduced from measurements taken from numerous switchboards, and the validity of the method has been checked by comparison with the test results.
This method does not cover the whole range of low voltage switchgear and controlgear assemblies since it has been developed under precise hypotheses which limit the applications; this can however be correct, suited and integrated with other calculation procedures which can be demonstrated to have a technical basis.
Standard IEC 60890 serves to determine the temperature rise of the air inside the switchboard caused by the energy dissipated by the devices and conductors installed within the switchboard.
To calculate the temperature rise of the air inside an enclosure, once the requirements of the Standard have been met, the following must be considered:

- Dimensions of the enclosure.
- Type of installation:
    - enclosure open to air on all sides;
    - wall-mounted enclosure;
    - enclosure designed for mounting in extremities;
    - enclosure in an internal position in a multi-compartment switchboard;
    - any ventilation openings, and their dimensions.
    - number of horizontal internal separators;
    - power losses from the effective current flowing through any device and conductor installed within the switchboard or compartment.

The Standard allows the calculation of temperature rise of the air at mid-height and at the highest point of the switchboard. Once the values are calculated, it must be evaluated if the switchboard can comply with the requirements relating to the set limits at certain points within the same switchboard.
The appendix B explains the calculation method described in the Standard.
ABB supplies the client with calculation software which allows the temperature rise inside the switchboard to be calculated quickly.

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6.2 MNS switchboards

MNS systems are suitable for applications in all fields concerning the generation, distribution and use of electrical energy; e. g., they can be used as:
- main and sub-distribution boards;
- motor power supply of MCCs (Motor Control Centres);
- automation switchboards.

The MNS system is a framework construction with maintenance-free bolted connections which can be equipped as required with standardized components and can be adapted to any application. The consistent application of the modular principle both in electrical and mechanical design permits optional selection of the structural design, interior arrangement and degree of protection according to the operating and environmental conditions.

The design and material used for the MNS system largely prevent the occurrence of electric arcs, or provide for arc extinguishing within a short time. The MNS System complies with the requirements laid down in VDE0660 Part 500 as well as IEC 61641 and has furthermore been subjected to extensive accidental arc tests by an independent institute.

The MNS system offers the user many alternative solutions and notable advantages in comparison with conventional-type installations:
- compact, space-saving design;
- back-to-back arrangement;
- optimized energy distribution in the cubicles;
- easy project and detail engineering through standardized components;
- comprehensive range of standardized modules;
- various design levels depending on operating and environmental conditions;
- easy combination of the different equipment systems, such as fixed and withdrawable modules in a single cubicle;
- possibility of arc-proof design (standard design with fixed module design);
- possibility of earthquake-, vibration- and shock-proof design;
- easy assembly without special tools;
- easy conversion and retrofit;
- largely maintenance-free;
- high operational reliability;
- high safety for human beings.

The basic elements of the frame are C-sections with holes at 25 mm intervals in compliance with Standard DIN 43660. All frame parts are secured maintenance-free with tapping screws or ESLOK screws. Based on the basic grid size of 25 mm, frames can be constructed for the various cubicle types without any special tools. Single or multi-cubicle switchgear assemblies for front or front and rear operations are possible.
Different designs are available, depending on the enclosure required:
- single equipment compartment door;
- double equipment compartment door;
- equipment and cable compartment door;
- module doors and/or withdrawable module covers and cable compartment door.

The bottom side of the cubicle can be provided with floor plates. With the aid of flanged plates, cable ducts can be provided to suit all requirements. Doors and cladding can be provided with one or more ventilation opening, roof plates can be provided with metallic grid (IP 30 – IP40) or with ventilation chimney (IP 40, 41, 42).

6 Switchboards

Depending on the requirements, a frame structure can be subdivided into the following compartments (functional areas):
- equipment compartment;
- busbar compartment;
- cable compartment.

The equipment compartment holds the equipment modules, the busbar compartment contains the busbars and distribution bars, the cable compartment houses the incoming and outgoing cables (optionally from above and from below) with the wiring required for connecting the modules as well as the supporting devices (cable mounting rails, cable connection parts, parallel connections, wiring ducts, etc.). The functional compartments of a cubicle as well as the cubicles themselves can be separated by partitions. Horizontal partitions with or without ventilation openings can also be inserted between the compartments.

All incoming/outgoing feeder and bus coupler cubicles include one switching device. These devices can be fixed-mounted switch disconnectors, fixed-mounted or withdrawable air or moulded case circuit-breakers.

This type of cubicles is subdivided into equipment and busbar compartments; their size (H x W) is 2200 mm x 400 mm / 1200 mm x 600 mm, and the depth depends on the dimensions of the switchgear used.

Cubicles with air circuit-breakers up to 2000 A can be built in the reduced dimensioned version (W = 400 mm).

It is possible to interconnect cubicles to form optimal delivery units with a maximum width of 3000 mm.

6.3 ArTu distribution switchboards

The range of ABB SACE ArTu distribution switchboards provides a complete and integrated offer of switchboards and kit systems for constructing primary and secondary low voltage distribution switchboards.

With a single range of accessories and starting from simple assembly kits, the ArTu switchboards make it possible to assembly a wide range of configurations mounting modular, moulded-case and air circuit-breakers, with any internal separation up to Form 4.

ABB SACE offers a series of standardized kits, consisting of pre-drilled plates and panels for the installation of the whole range of circuit-breakers type System pro M, Isomax, Tmax and Emax E1, E2, E3 without the need of additional drilling operations or adaptations.

Special consideration has been given to cabling requirements, providing special seats to fix the plastic cabling duct horizontally and vertically.

Standardization of the components is extended to internal separation of the switchboard: in ArTu switchboards, separation is easily carried out and it does not require either construction of “made-to-measure” switchboards or any additional sheet cutting, bending or drilling work.

ArTu switchboards are characterized by the following features:
- integrated range of modular metalwork structures up to 3200 A with common accessories;
- possibility of fulfilling all application requirements in terms of installation (wall-mounting, floor-mounting, monoblock and cabinet kits) and degree of protection (IP31, IP41, IP43, IP65);
- structure made of hot-galvanized sheet;

6 Switchboards

- maximum integration with modular devices and ABB SACE moulded-case and air circuit-breakers;
- minimum switchboard assembly times thanks to the simplicity of the kits, the standardization of the small assembly items, the self-supporting elements and the presence of clear reference points for assembly of the plates and panels;
- separations in kits up to Form 4.

The range of ArTu switchboards includes three versions, which can be equipped with the same accessories.

ArTu L series

ArTu L series consists of a range of modular switchboard kits, with a capacity of 24 modules per row and degree of protection IP31 (without door) or IP43 (basic version with door). These switchboards can be wall- or floor-mounted:
- wall-mounted ArTu L series, with heights of 600, 800, 1000 and 1200 mm, depth 200 mm, width 700 mm. Both System pro M modular devices and moulded-case circuit-breakers Tmax T1-T2-T3 are housed inside this switchboard series;
- floor-mounted ArTu L series, with heights of 1400, 1600, 1800 and 2000 mm, depth 240 mm, width 700 mm. System pro M modular devices, moulded-case circuit-breakers type Tmax T1-T2-T3 and Isomax S3, S4 and S5 (fixed version with front terminals) are housed inside this switchboard series.

ArTu M series

ArTu M series consists of a modular range of monoblock switchboards for wall-mounted (with depths of 150 and 200 mm with IP65 degree of protection) or floor-mounted (with depth of 250 mm and IP31 or IP65 degrees of protection) installations, in which it is possible to mount System pro M modular devices and Tmax T1-T2-T3 moulded-case circuit-breakers on a DIN rail. The possibility of installing S3 circuit-breakers (200 mm depth) is foreseen only in the wall-mounted M versions, whereas ArTu M series of floor-mounted switchboards can be equipped with S3…S6 circuit-breakers, together with the Tmax series.

ArTu K series

ArTu K series consists of a range of modular switchboard kits for floor-mounted installation with four different depths (250, 350, 600 and 800 mm) and with degree of protection IP31 (without front door), IP41 (with front door and ventilated side panels) or IP65 (with front door and blind side panels), in which it is possible to mount System pro M modular devices, the whole range of moulded-case circuit–breakers Tmax and Isomax, and Emax circuit-breakers E1, E2 and E3.

ArTu switchboards have three functional widths:
- 400 mm, for the installation of moulded-case circuit-breakers up to 400 A (S5);
- 600 mm, which is the basic dimension for the installation of all the apparatus;
- 800 mm, for the creation of the side cable container within the structure of the floor-mounted switchboard or for the use of panels with the same width.

The available internal space varies in height from 600 mm (wall-mounted L series) to 2000 mm (floor-mounted M series and K series), thus offering a possible solution for the most varied application requirements.

Annex A: Calculation tools

A.1 Slide rules

These slide rules represent a valid instrument for a quick and approximate dimensioning of electrical plants.
All the given information is connected to some general reference conditions; the calculation methods and the data reported are gathered from the IEC Standards in force and from plant engineering practice. The instruction manual enclosed with the slide rules offers different examples and tables showing the correction coefficients necessary to extend the general reference conditions to those actually required.

These two-sided slide rules are available in four different colors, easily identified by subject:
- yellow slide rule: cable sizing;
- orange slide rule: cable verification and protection;
- green slide rule: protection coordination;
- blue slide rule: motor and transformer protection.

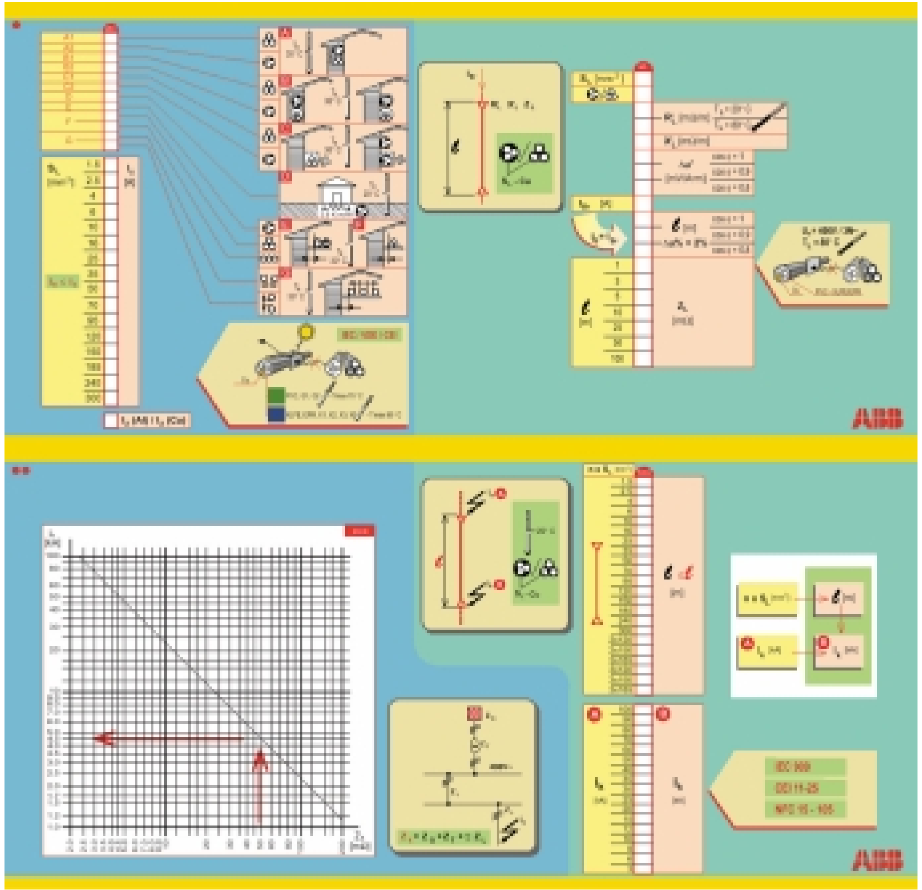
ABB also offers a slide rule for contactor choice.

Annex A: Calculation tools

Yellow slide rule: cable sizing

Side ●
Definition of the current carrying capacity, impedance and voltage drop of cables.

Side ● ●
Calculation of the short-circuit current for three-phase fault on the load side of a cable line with known cross section and length.
In addition, a diagram for the calculation of the short-circuit current on the load side of elements with known impedance.



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Calculation tools

Orange slide rule: cable verification and protection

Side ●
Verification of cable protection against indirect contact and short-circuit with ABB SACE MCCBs (moulded-case circuit-breakers).

Side ● ●
Verification of cable protection against indirect contact and short-circuit with ABB MCBs (modular circuit-breakers).

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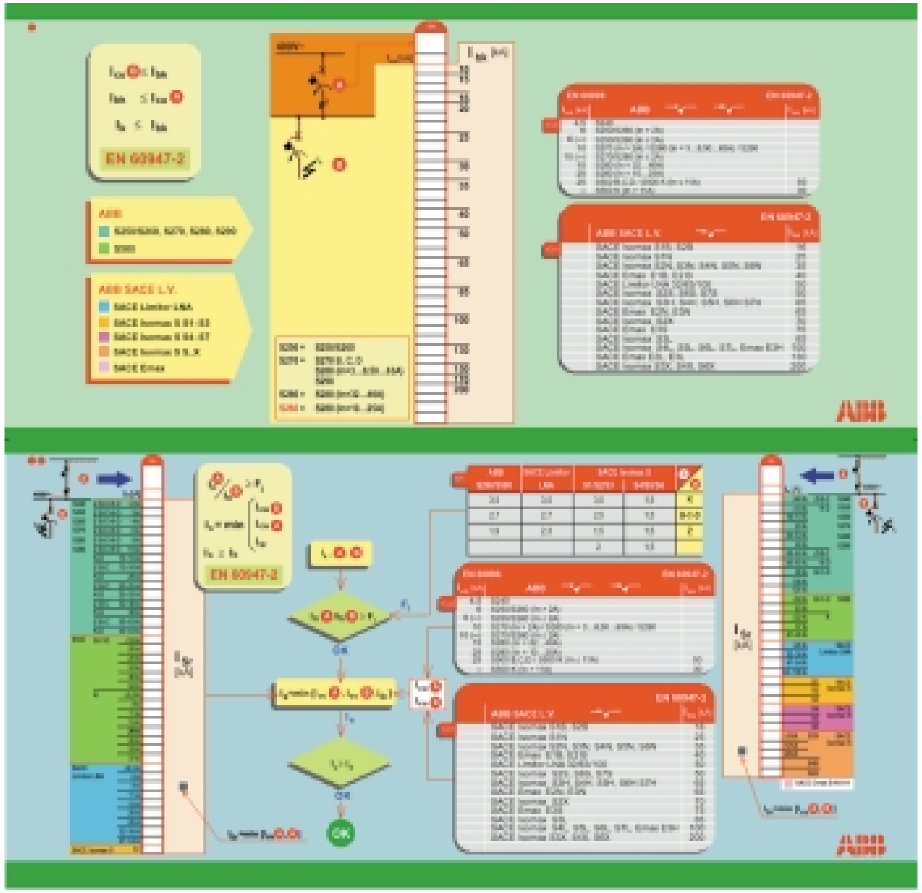
Calculation tools

Green slide rule: protection coordination

Side ●
Selection of the circuit-breakers when back-up protection is provided.

Side ● ●
Definition of the discrimination limit current for the combination of two circuit-breakers in series.



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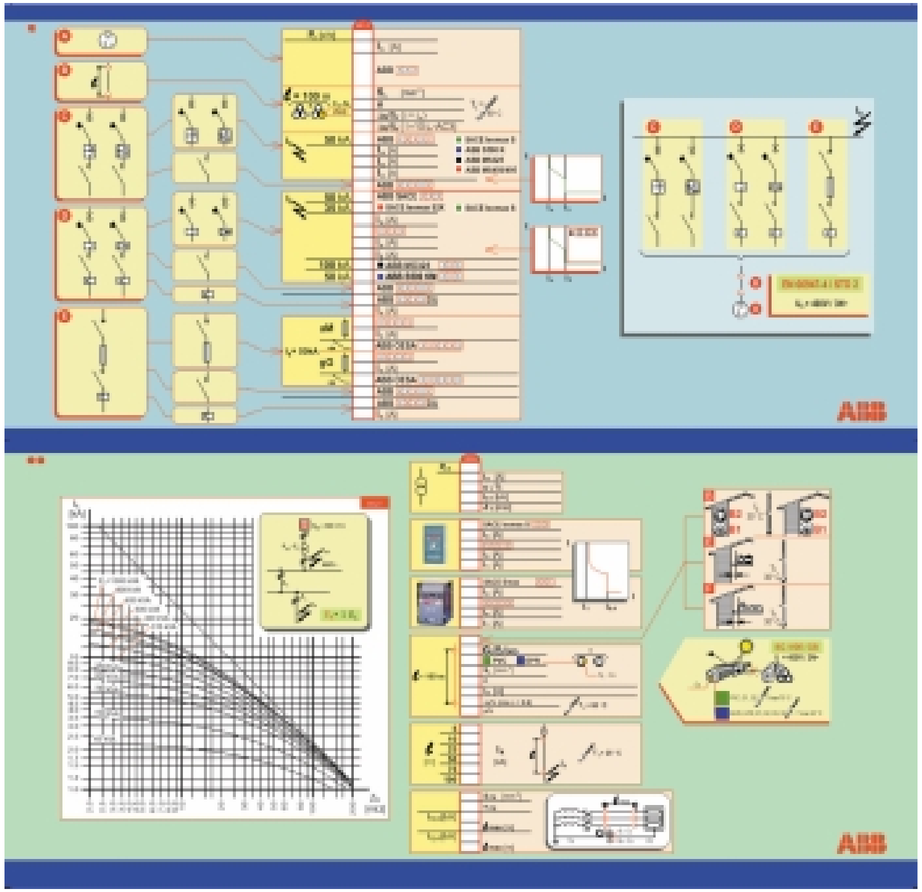
Calculation tools

Blue slide rule: motor and transformer protection

Side ●
Selection and coordination of the protection devices for the motor starter, DOL start-up (coordination type 2 in compliance with the Standard IEC 60947-4-1).

Side ● ●
Sizing of a transformer feeder.
In addition, a diagram for the calculation of the short-circuit current on the load side of transformers with known rated power.



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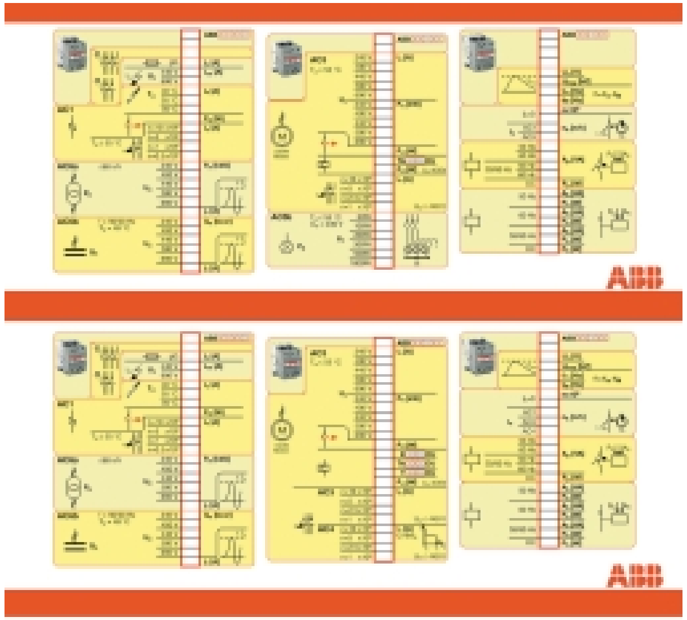
Calculation tools

Contactor slide rule

This slide rule allows a quick selection of the contactor suitable for the plant requirements.
In particular, according to the selected contactor, the slide rule can determine:
- the device for protection against short-circuit;
- rated operational current, power loss and maximum number of operations for resistive load switching (category AC-1);
- thermal release and number of operations for motor switching in utilization categories AC-3 and AC-4;
- number of incandescent lamps (category AC-5b) to be switched;
- maximum power and maximum peak current of the transformer (category AC-6a) to be switched;
- maximum power and maximum peak current of the capacitor bank (category AC-6b) to be switched;
- characteristic data, such as rated voltage and rated impulse withstand voltage, controlled frequency range, coil consumption (holding and pull-in values), etc.;
- Y/Δ and DOL coordination with fuses and circuit-breakers.



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Annex A: Calculation tools

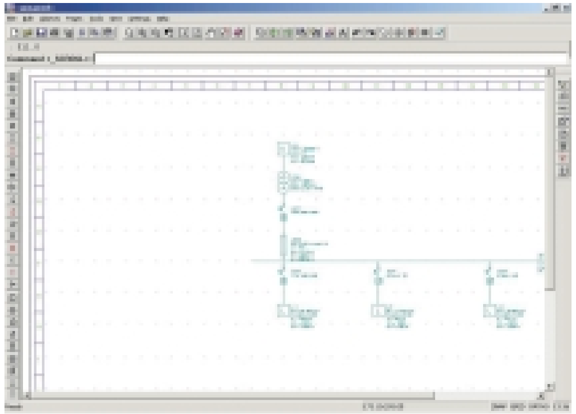
A.2 DOCWin

DOCWin is a software for the dimensioning of electrical networks, with low or medium voltage supply.
Networks can be completely calculated through simple operations starting from the definition of the single-line diagram and thanks to the drawing functions provided by an integrated CAD software.

Drawing and definition of networks

Creation of the single-line diagram, with no limits to the network complexity. Meshed networks can also be managed.

- The diagram can be divided into many pages.
- The program controls the coherence of drawings in real time.
- It is possible to enter and modify the data of the objects which form the network by using a table.
- It is possible to define different network configurations by specifying the status (open/closed) of the operating and protective devices.



Supplies

- There are no pre-defined limits: the software manages MV and LV power supplies and generators, MV/LV and LV/LV transformers, with two or three windings, with or without voltage regulator, according to the requirements.

Network calculation

- Load Flow calculation using the Newton-Raphson method. The software can manage networks with multiple slacks and unbalances due to single- or two-phase loads. Magnitude and phase shift of the node voltage and of the branch current are completely defined for each point of the network, for both MV as well as LV.
- Calculation of the active and reactive power required by each single power source.

Annex A: Calculation tools

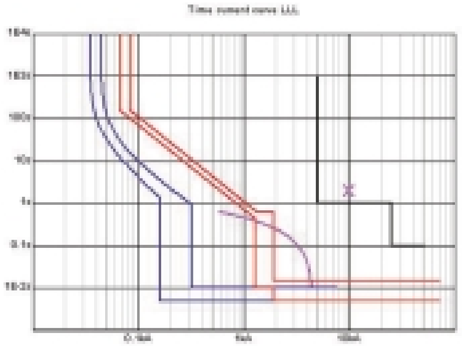
- Management of local (motors) and centralized power factor correction with capacitor banks.
- Management of the demand factor for each single node of the network and of the utilization factor on the loads.
- Short-circuit current calculation for three-phase, phase-to-phase, phase-to-neutral, phase-to-ground faults. The calculation is also carried out for MV sections, in compliance with the Standards IEC 60909-0, IEC 61363-1 (naval installations) or with the method of symmetric components, taking into account also the time-variance contribution of rotary machines (generators and motors).
- Calculation of switchboard overtemperature in compliance with Standard IEC 60890. The power dissipated by the single apparatus is automatically derived by the data files of the software, and can be considered as a function of the rated current or of the load current.

Cable line sizing

- Cable line sizing according to thermal criteria in compliance with the following Standards: CEI 64-8 (tables CEI UNEL 35024-35026), IEC 60364, VDE 298-4, NFC 15-100, IEC 60092 (naval installations) and IEC 60890.
- Possibility of setting, as additional calculation criterion, the economic criteria stated in the Standard IEC 60827-3-2.
- Possibility of setting, as additional calculation criterion, the maximum allowed voltage drop.
- Automatic sizing of busbar trunking system.
- Sizing and check on the dynamic withstand of busbars in compliance with the Standard IEC 60865.

Curves and verifications

- Representation of:
- time / current curves (I-t),
- current / let-through energy curves (I-I^2t),
- current limiting curves (peak): visual check of the effects of the settings on the trip characteristics of protection devices.

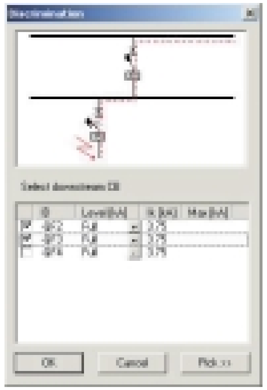


Calculation tools

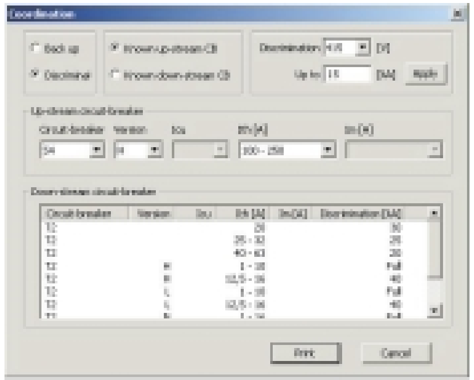
- Representation of the curves of circuit-breakers, cables, transformers, motors and generators.
- Possibility of entering the curve of the utility and of the MV components point by point, to verify the tripping discrimination of protection devices.
- Verification of the maximum voltage drop at each load.
- Verification of the protection devices, with control over the setting parameters of the adjustable releases (both thermomagnetic as well as electronic).

Selection of operating and protection devices

- Automatic selection of protection devices (circuit-breakers and fuses)
- Automatic selection of operating devices (contactors and switch disconnectors)
- Discrimination and back-up managed as selection criteria, with discrimination level adjustable for each circuit-breaker combination.

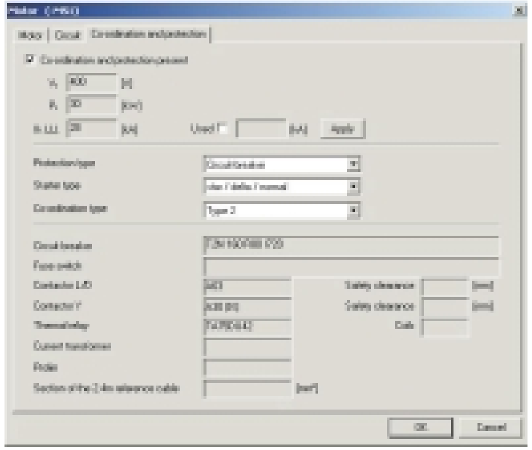


- Discrimination and back-up verification also through quick access to coordination tables.



Calculation tools

- Motor coordination management through quick access to ABB tables.



Printouts

- Single-line diagram, curves and reports of the single components of the network can be printed by any printer supported by the hardware configuration.
- All information can be exported in the most common formats of data exchange.
- All print modes can be customized.

Annex B: Temperature rise evaluation according to IEC 60890

The calculation method suggested in the Standard IEC 60890 makes it possible to evaluate the temperature rise inside an assembly (PTTA); this method is applicable only if the following conditions are met:

- there is an approximately even distribution of power losses inside the enclosure;
- the installed equipment is arranged in a way that air circulation is only slightly impeded;
- the equipment installed is designed for direct current or alternating current up to and including 60 Hz with the total of supply currents not exceeding 3150 A;
- conductors carrying high currents and structural parts are arranged in a way that eddy-current losses are negligible;
- for enclosures with ventilating openings, the cross-section of the air outlet openings is at least 1.1 times the cross-section of the air inlet openings;
- there are no more than three horizontal partitions in the PTTA or a section of it;
- where enclosures with external ventilation openings have compartments, the surface of the ventilation openings in each horizontal partition shall be at least 50% of the horizontal cross section of the compartment.

The data necessary for the calculation are:

- dimensions of the enclosure: height, width, depth;
- the type of installation of the enclosure (see Tab. 8);
- presence of ventilation openings;
- number of internal horizontal partitions;
- the power loss of the equipment installed in the enclosure (see Tab. 13, 14, 15);
- the power loss of the conductors inside the enclosure, equal to the sum of the power loss of every conductor, according to Table 1, 2, 3.

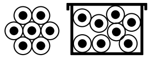
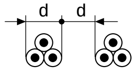
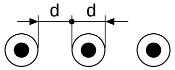
For equipment and conductors not fully loaded, it is possible to evaluate the power loss as:

$$P = P_n \left(\frac{I}{I_r}\right)^2 \quad (1)$$

where:
P is the actual power loss;
P_n is the rated power loss (at I_r);
I is the actual current;
I_r is the rated current.

Annex B: Temperature rise evaluation according to IEC 60890

Table 1: operating current and power losses of insulated conductors

Cross-section (Cu)	**Maximum permissible conductor temperature 70 °C**											
	 1)											
	Air temperature inside the enclosure around the conductors											
	35 °C		55 °C		35 °C		55 °C		35 °C		55 °C	
	operating current	**power losses 2)**	**operating current**	**power losses 2)**	**operating current**	**power losses 2)**	**operating current**	**power losses 2)**	**operating current**	**power losses 2)**	**operating current**	**power losses 2)**
mm^2	A	W/m	A	W/m	A	W/m	A	W/m	A	W/m	A	W/m
1.5	12	2.1	8	0.9	12	2.1	8	0.9	12	2.1	8	0.9
2.5	17	2.5	11	1.1	20	3.5	12	1.3	20	3.5	12	1.3
4	22	2.6	14	1.1	25	3.4	18	1.8	25	3.4	20	2.2
6	28	2.8	18	1.2	32	3.7	23	1.9	32	3.7	25	2.3
10	38	3.0	25	1.3	48	4.8	31	2.0	50	5.2	32	2.1
16	52	3.7	34	1.6	64	5.6	42	2.4	65	5.8	50	3.4
25					85	6.3	55	2.6	85	6.3	65	3.7
35					104	7.5	67	3.1	115	7.9	85	5.0
50					130	7.9	85	3.4	150	10.5	115	6.2
70					161	8.4	105	3.6	175	9.9	149	7.2
95					192	8.7	125	3.7	225	11.9	175	7.2
120					226	9.6	147	4.1	250	11.7	210	8.3
150					275	11.7	167	4.3	275	11.7	239	8.8
185					295	10.9	191	4.6	350	15.4	273	9.4
240					347	12.0	225	5.0	400	15.9	322	10.3
300					400	13.2	260	5.6	460	17.5	371	11.4

Conductors for auxiliary circuits

					Diam.
0.12	2.6	1.2	1.7	0.5	0.4
0.14	2.9	1.3	1.9	0.6	-
0.20	3.2	1.1	2.1	0.5	-
0.22	3.6	1.3	2.3	0.5	0.5
0.30	4.4	1.4	2.9	0.6	0.6
0.34	4.7	1.4	3.1	0.6	0.6
0.50	6.4	1.8	4.2	0.8	0.8
0.56		1.6		0.7	-
0.75	8.2	1.9	5.4	0.8	1.0
1.00	9.3	1.8	6.1	0.8	-

1) Any arrangement desired with the values specified referring to six cores in a multi-core bundle with a simultaneous load 100%

2) single length

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Annex B: Temperature rise evaluation according to IEC 60890

Table 2: operating current and power losses of bare conductors, in vertical arrangement without direct connections to apparatus

Width x Thickness	Cross-section (Cu)	Maximum permissible conductor temperature 85 °C															
		Air temperature inside the enclosure around the conductors 35 °C								Air temperature inside the enclosure around the conductors 55 °C							
		50 Hz to 60 Hz ac				dc and ac to 16 2/3 Hz				50 Hz to 60 Hz ac				dc and ac to 16 2/3 Hz			
		operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)
mm x mm	mm ^{2}	A*	W/m	A**	W/m	A*	W/m	A**	W/m	A*	W/m	A**	W/m	A*	W/m	A**	W/m
12 x 2	23.5	144	19.5	242	27.5	144	19.5	242	27.5	105	10.4	177	14.7	105	10.4	177	14.7
15 x 2	29.5	170	21.7	282	29.9	170	21.7	282	29.9	124	11.6	206	16.0	124	11.6	206	16.0
15 x 3	44.5	215	23.1	375	35.2	215	23.1	375	35.2	157	12.3	274	18.8	157	12.3	274	18.8
20 x 2	39.5	215	26.1	351	34.8	215	26.1	354	35.4	157	13.9	256	18.5	157	12.3	258	18.8
20 x 3	59.5	271	27.6	463	40.2	271	27.6	463	40.2	198	14.7	338	21.4	198	14.7	338	21.4
20 x 5	99.1	364	29.9	665	49.8	364	29.9	668	50.3	266	16.0	485	26.5	266	16.0	487	26.7
20 x 10	199	568	36.9	1097	69.2	569	36.7	1107	69.6	414	19.6	800	36.8	415	19.5	807	37.0
25 x 5	124	435	34.1	779	55.4	435	34.1	78	55.6	317	18.1	568	29.5	317	18.1	572	29.5
30 x 5	149	504	38.4	894	60.6	505	38.2	899	60.7	368	20.5	652	32.3	369	20.4	656	32.3
30 x 10	299	762	44.4	1410	77.9	770	44.8	1436	77.8	556	27.7	1028	41.4	562	23.9	1048	41.5
40 x 5	199	641	47.0	1112	72.5	644	47.0	1128	72.3	468	25.0	811	38.5	469	24.9	586	38.5
40 x 10	399	951	52.7	1716	88.9	968	52.6	1796	90.5	694	28.1	1251	47.3	706	28.0	1310	48.1
50 x 5	249	775	55.7	1322	82.9	782	55.4	1357	83.4	566	29.7	964	44.1	570	29.4	989	44.3
50 x 10	499	1133	60.9	2008	102.9	1164	61.4	2141	103.8	826	32.3	1465	54.8	849	32.7	1562	55.3
60 x 5	299	915	64.1	1530	94.2	926	64.7	1583	94.6	667	34.1	1116	50.1	675	34.4	1154	50.3
60 x 10	599	1310	68.5	2288	116.2	1357	69.5	2487	117.8	955	36.4	1668	62.0	989	36.9	1814	62.7
80 x 5	399	1170	80.7	1929	116.4	1200	80.8	2035	116.1	858	42.9	1407	61.9	875	42.9	1484	61.8
80 x 10	799	1649	85.0	2806	138.7	1742	85.1	3165	140.4	1203	45.3	2047	73.8	1271	45.3	1756	74.8
100 x 5	499	1436	100.1	2301	137.0	1476	98.7	2407	121.2	1048	53.3	1678	72.9	1077	52.5	1756	69.8
100 x 10	999	1982	101.7	3298	164.2	2128	102.6	3844	169.9	1445	54.0	2406	84.4	1552	54.6	2803	90.4
120 x 10	1200	2314	115.5	3804	187.3	2514	115.9	4509	189.9	1688	61.5	2774	99.6	1833	61.6	3288	101.0

*) one conductor per phase **) two conductors per phase 1) single length

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Annex B: Temperature rise evaluation according to IEC 60890

Table 3: operating current and power losses of bare conductors used as connections between apparatus and busbars

Width x Thickness	Cross-section (Cu)	Maximum permissible conductor temperature 65 °C							
		Air temperature inside the enclosure around the conductors 35 °C				Air temperature inside the enclosure around the conductors 55 °C			
		50 Hz to 60 Hz ac and dc				50 Hz to 60 Hz ac and dc			
		operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)	operating current	power losses 1)
mm x mm	mm ^{2}	A*	W/m	A**	W/m	A*	W/m	A**	W/m
12 x 2	23.5	82	5.9	130	7.4	69	4.2	105	4.9
15 x 2	29.5	96	6.4	150	7.8	88	5.4	124	5.4
15 x 3	44.5	124	7.1	202	9.5	102	4.8	162	6.1
20 x 2	39.5	115	6.9	184	8.9	93	4.5	172	7.7
20 x 3	59.5	152	8.0	249	10.8	125	5.4	198	6.8
20 x 5	99.1	218	9.9	348	12.7	174	6.3	284	8.4
20 x 10	199	348	12.8	648	22.3	284	8.6	532	15.0
25 x 5	124	253	10.7	413	14.2	204	7.0	338	9.5
30 x 5	149	288	11.6	492	16.9	233	7.6	402	11.3
30 x 10	299	482	17.2	960	32.7	402	11.5	780	21.6
40 x 5	199	348	12.8	648	22.3	284	8.6	532	15.0
40 x 10	399	648	22.7	1245	41.9	532	15.3	1032	28.8
50 x 5	249	413	14.7	805	27.9	338	9.8	655	18,5
50 x 10	499	805	28.5	1560	53.5	660	19.2	1280	36.0
60 x 5	299	492	17.2	960	32.7	402	11.5	780	21.6
60 x 10	599	960	34.1	1848	63.2	780	22.5	1524	43.0
80 x 5	399	648	22.7	1256	42.6	532	15.3	1032	28.8
80 x 10	799	1256	45.8	2432	85.8	1032	30.9	1920	53.5
100 x 5	499	805	29.2	1560	54.8	660	19.6	1280	36.9
100 x 10	999	1560	58.4	2680	86.2	1280	39.3	2180	57.0
120 x 10	1200	1848	68.3	2928	85.7	1524	46.5	2400	57.6

*) one conductor per phase **) two conductors per phase 1) single length

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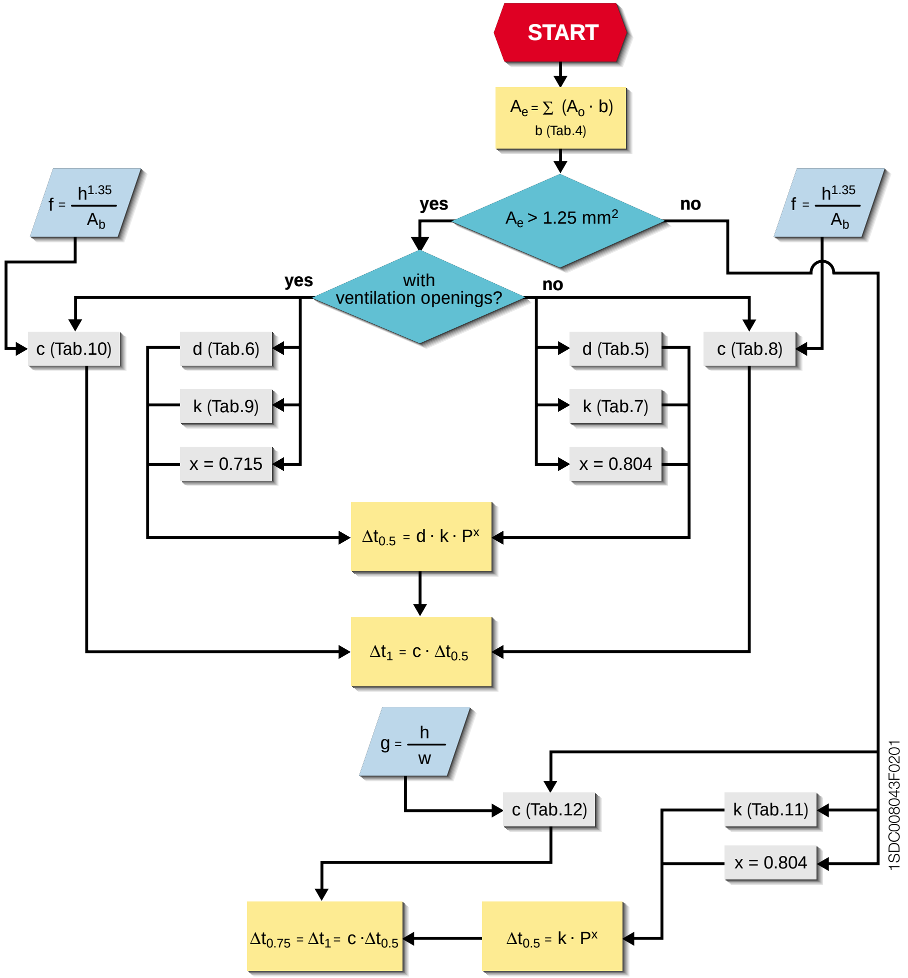
Annex B: Temperature rise evaluation according to IEC 60890

For enclosures without vertical partitions or individual sections with an effective cooling surface larger than 11.5 m^2 or with a width larger than 1.5 m, it is possible to evaluate the temperature rise dividing the enclosure into fictitious parts, considering the power loss equally distributed.

The following diagram shows the procedure to evaluate the temperature rise.



Annex B: Temperature rise evaluation according to IEC 60890

Table 4: Surface factor *b* according to the type of installation

Type of installation	Surface factor *b*
Exposed top surface	1.4
Covered top surface, e.g. of built-in enclosures	0.7
Exposed side faces, e.g. front, rear and side walls	0.9
Covered side faces, e.g. rear side of wall-mounted enclosures	0.5
Side faces of central enclosures	0.5
Floor surface	Not taken into account

Fictitious side faces of sections which have been introduced only for calculation purposes are not taken into account

Table 5: Factor *d* for enclosures without ventilation openings and with an effective cooling surface $A_e > 1.25$ m^2

Number of horizontal partitions *n*	Factor *d*
0	1
1	1.05
2	1.15
3	1.3

Table 6: Factor *d* for enclosures with ventilation openings and with an effective cooling surface $A_e > 1.25$ m^2

Number of horizontal partitions *n*	Factor *d*
0	1
1	1.05
2	1.1
3	1.15

Table 7: Enclosure constant *k* for enclosures without ventilation openings, with an effective cooling surface $A_e > 1.25$ m^2

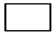
A_e [m^2]	k	A_e [m^2]	k
1.25	0.524	6.5	0.135
1.5	0.45	7	0.13
2	0.35	7.5	0.125
2.5	0.275	8	0.12
3	0.225	8.5	0.115
3.5	0.2	9	0.11
4	0.185	9.5	0.105
4.5	0.17	10	0.1
5	0.16	10.5	0.095
5.5	0.15	11	0.09
6	0.14	11.5	0.085

Annex B: Temperature rise evaluation according to IEC 60890

Table 8: Temperature distribution factor *c* for enclosures without ventilation openings, with an effective cooling surface $A_e > 1.25\ m^2$

$f = \frac{h^{1.35}}{A_b}$	Type of installation 1	2	3	4	5
0.6	1.225	1.21	1.19	1.17	1.113
1	1.24	1.225	1.21	1.185	1.14
1.5	1.265	1.245	1.23	1.21	1.17
2	1.285	1.27	1.25	1.23	1.19
2.5	1.31	1.29	1.275	1.25	1.21
3	1.325	1.31	1.295	1.27	1.23
3.5	1.35	1.33	1.315	1.29	1.255
4	1.37	1.355	1.34	1.32	1.275
4.5	1.395	1.375	1.36	1.34	1.295
5	1.415	1.395	1.38	1.36	1.32
5.5	1.435	1.415	1.4	1.38	1.34
6	1.45	1.435	1.42	1.395	1.355
6.5	1.47	1.45	1.435	1.41	1.37
7	1.48	1.47	1.45	1.43	1.39
7.5	1.495	1.48	1.465	1.44	1.4
8	1.51	1.49	1.475	1.455	1.415
8.5	1.52	1.505	1.49	1.47	1.43
9	1.535	1.52	1.5	1.48	1.44
9.5	1.55	1.53	1.515	1.49	1.455
10	1.56	1.54	1.52	1.5	1.47
10.5	1.57	1.55	1.535	1.51	1.475
11	1.575	1.565	1.549	1.52	1.485
11.5	1.585	1.57	1.55	1.525	1.49
12	1.59	1.58	1.56	1.535	1.5
12.5	1.6	1.585	1.57	1.54	1.51

where h is the height of the enclosure, and A_b is the area of the base.
For "Type of installation":

Type of installation n°		
1	Separate enclosure, detached on all sides	
2	First or last enclosure, detached type	
3	Separate enclosure for wall-mounting	
	Central enclosure, detached type	
4	First or last enclosure, wall-mounting type	
	Central enclosure for wall-mounting and with covered top surface	
5	Central enclosure, wall-mounting type	

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Annex B: Temperature rise evaluation according to IEC 60890

Table 9: Enclosure constant *k* for enclosures with ventilation openings and an effective cooling surface $A_e > 1.25\ m^2$

Ventilation opening in cm²	A_e [m²] 1	1.5	2	2.5	3	4	5	6	7	8	10	12	14
50	0.36	0.33	0.3	0.28	0.26	0.24	0.22	0.208	0.194	0.18	0.165	0.145	0.135
100	0.293	0.27	0.25	0.233	0.22	0.203	0.187	0.175	0.165	0.153	0.14	0.128	0.119
150	0.247	0.227	0.21	0.198	0.187	0.173	0.16	0.15	0.143	0.135	0.123	0.114	0.107
200	0.213	0.196	0.184	0.174	0.164	0.152	0.143	0.135	0.127	0.12	0.11	0.103	0.097
250	0.19	0.175	0.165	0.155	0.147	0.138	0.13	0.121	0.116	0.11	0.1	0.095	0.09
300	0.17	0.157	0.148	0.14	0.133	0.125	0.118	0.115	0.106	0.1	0.093	0.088	0.084
350	0.152	0.141	0.135	0.128	0.121	0.115	0.109	0.103	0.098	0.093	0.087	0.082	0.079
400	0.138	0.129	0.121	0.117	0.11	0.106	0.1	0.096	0.091	0.088	0.081	0.078	0.075
450	0.126	0.119	0.111	0.108	0.103	0.099	0.094	0.09	0.086	0.083	0.078	0.074	0.07
500	0.116	0.11	0.104	0.1	0.096	0.092	0.088	0.085	0.082	0.078	0.073	0.07	0.067
550	0.107	0.102	0.097	0.093	0.09	0.087	0.083	0.08	0.078	0.075	0.07	0.068	0.065
600	0.1	0.095	0.09	0.088	0.085	0.082	0.079	0.076	0.073	0.07	0.067	0.065	0.063
650	0.094	0.09	0.086	0.083	0.08	0.077	0.075	0.072	0.07	0.068	0.065	0.063	0.061
700	0.089	0.085	0.08	0.078	0.076	0.074	0.072	0.07	0.068	0.066	0.064	0.062	0.06

Table 10: Temperature distribution factor *c* for enclosures with ventilation openings and an effective cooling surface $A_e > 1.25\ m^2$

Ventilation opening in cm²	$f = \frac{h^{1.35}}{A_b}$ 1.5	2	3	4	5	6	7	8	9	10
50	1.3	1.35	1.43	1.5	1.57	1.63	1.68	1.74	1.78	1.83
100	1.41	1.46	1.55	1.62	1.68	1.74	1.79	1.84	1.88	1.92
150	1.5	1.55	1.63	1.69	1.75	1.8	1.85	1.9	1.94	1.97
200	1.56	1.61	1.67	1.75	1.8	1.85	1.9	1.94	1.97	2.01
250	1.61	1.65	1.73	1.78	1.84	1.88	1.93	1.97	2.01	2.04
300	1.65	1.69	1.75	1.82	1.86	1.92	1.96	2	2.03	2.06
350	1.68	1.72	1.78	1.85	1.9	1.94	1.97	2.02	2.05	2.08
400	1.71	1.75	1.81	1.87	1.92	1.96	2	2.04	2.07	2.1
450	1.74	1.77	1.83	1.88	1.94	1.97	2.02	2.05	2.08	2.12
500	1.76	1.79	1.85	1.9	1.95	1.99	2.04	2.06	2.1	2.13
550	1.77	1.82	1.88	1.93	1.97	2.01	2.05	2.08	2.11	2.14
600	1.8	1.83	1.88	1.94	1.98	2.02	2.06	2.09	2.12	2.15
650	1.81	1.85	1.9	1.95	1.99	2.04	2.07	2.1	2.14	2.17
700	1.83	1.87	1.92	1.96	2	2.05	2.08	2.12	2.15	2.18

Annex B: Temperature rise evaluation according to IEC 60890

Table 11: Enclosure constant *k* for enclosures without ventilation openings and with an effective cooling surface $A_e \le 1.25\ m^2$

A_e [m^2]	k	A_e [m^2]	k
0.08	3.973	0.65	0.848
0.09	3.643	0.7	0.803
0.1	3.371	0.75	0.764
0.15	2.5	0.8	0.728
0.2	2.022	0.85	0.696
0.25	1.716	0.9	0.668
0.3	1.5	0.95	0.641
0.35	1.339	1	0.618
0.4	1.213	1.05	0.596
0.45	1.113	1.1	0.576
0.5	1.029	1.15	0.557
0.55	0.960	1.2	0.540
0.6	0.9	1.25	0.524

Table 12: Temperature distribution factor *c* for enclosures without ventilation openings and with an effective cooling surface $A_e \le 1.25\ m^2$

g	c	g	c
0	1	1.5	1.231
0.1	1.02	1.6	1.237
0.2	1.04	1.7	1.24
0.3	1.06	1.8	1.244
0.4	1.078	1.9	1.246
0.5	1.097	2	1.249
0.6	1.118	2.1	1.251
0.7	1.137	2.2	1.253
0.8	1.156	2.3	1.254
0.9	1.174	2.4	1.255
1	1.188	2.5	1.256
1.1	1.2	2.6	1.257
1.2	1.21	2.7	1.258
1.3	1.22	2.8	1.259
1.4	1.226		

where g is the ratio of the height and the width of the enclosure.

Annex B: Temperature rise evaluation according to IEC 60890

Table 13: Tmax power losses

Total (3/4 poles) power loss in W		T1 1P	T1	T2		T3	
Setting	I_n [A]	F	F	F	P	F	P
R1	1			4.5	5.1		
R1,6	1.6			6.3	7.5		
R2	2			7.5	8.7		
R2,5	2.5			7.8	9.0		
R3,2	3.2			8.7	10.2		
R4	4			7.8	9.0		
R5	5			8.7	10.5		
R6,3	6.3			10.5	12.3		
R8	8			8.1	9.6		
R10	10			9.3	10.8		
R12,5	12.5			3.3	3.9		
R16	16	1.5	4.5	4.2	4.8		
R20	20	1.8	5.4	5.1	6.0		
R25	25	2.0	6.0	6.9	8.4		
R32	32	2.1	6.3	8.1	9.6		
R40	40	2.6	7.8	11.7	13.8		
R50	50	3.7	11.1	12.9	15.0		
R63	63	4.3	12.9	15.3	18.0	12.9	15.3
R80	80	4.8	14.4	18.3	21.6	14.4	17.4
R100	100	7.0	21.0	25.5	30.0	16.8	20.4
R125	125	10.7	32.1	36.0	44.1	19.8	23.7
R160	160	15	45.0	51.0	60.0	23.7	28.5
R200	200					39.6	47.4
R250	250					53.4	64.2
In=10	10			1.5	1.8		
In=25	25			3.0	3.6		
In=63	63			10.5	12.0		
In=100	100			24.0	27.6		
In=160	160			51.0	60.0		

Annex B: Temperature rise evaluation according to IEC 60890

Table 14: SACE Isomax power losses

Total (3/4 poles) power loss in W		S3		S3X		S4		S4X		S5		S6		S6X		S7		S8
Setting	Iu [A]	F	P-W	F	P-W	F	P-W	F	P-W	F	P-W	F	W	F	W	F	W	F
R32	32	12	13	7.9	9.7													
R50	50	16	18	12.3	15.2													
R80	80	18	21	19.7	24.2													
R100	100	21	25	24.6	30.3													
R125	125	20	26	30.8	37.8													
R160	160	30	40	30.7	37.2													
R200	200	36	46	48	58													
R250	250	50	65															
R320	320									60	90							
R400	400									65	96							
R500	500									120	150							
R630	630											92	117					
R800	800											93	119					
In=100	100					5	8	9.6	12									
In=160	160					15	22	24.6	30.7									
In=250	250					40	55	60	75									
In=320	320									45	65							
In=400	400									60	90			80.4	101			
In=630	630									170	200	90	115	126.6	151.6			
In=800	800											96	125					
In=1000	1000															102	140	
In=1250	1250															160	220	
In=1600	1600															260	360	
In=2000	2000																	200
In=2500	2500																	315
In=3200	3200																	500

Annex B: Temperature rise evaluation according to IEC 60890

Table 15: Emax power losses

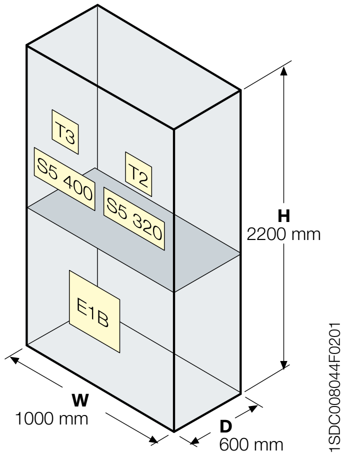
Total (3/4 poles)	E1B-N		E2B-N		E2L		E3N-S-H		E3L		E4S-H		E6H-V	
power loss in W	F	W	F	W	F	W	F	W	F	W	F	W	F	W
In=250	6	9	3	5	4	7	2	4	3	5				
In=400	16	24	7	13	11	17	6	9	9	13				
In=800	65	95	29	54	43	68	25	38	34	53				
In=1000	96	147	45	84	67	106	38	59	54	83				
In=1250	150	230	70	130	105	165	60	90	84	129				
In=1600			115	215	170	265	85	150	138	211				
In=2000			180	330			130	225	215	330	92	166		
In=2500							205	350	335	515				
In=3200							330	570			235	425	170	290
In=4000											360	660	265	445
In=5000													415	700
In=6300													650	1100

Example

Single separate enclosure for wall-mounting, without ventilation openings and with one internal horizontal partition.

Data:
Enclosure height: 2200 mm
Enclosure width: 1000 mm
Enclosure depth: 600 mm

Installed equipment:
E1B1250, In1250 (withdrawable)
S5N400, In400 (withdrawable)
S5N400, In320 (fixed)
T3N250, R250 (fixed)
T2N160, In100 (fixed)
Total conductor power loss = 200 W



According to table 13, considering the circuit-breakers fully loaded:

	Power loss [W]
T3N250, R250	53.4
T2N160, In=100	24

According to table 14 considering the circuit-breakers fully loaded:

	Power loss [W]
S5N400, In=400	96
S5N400, In=320	60

Annex B: Temperature rise evaluation according to IEC 60890

According to Table 15, considering that the load current is lower than the rated current:

I=400+320+250+100=1070 A

P_n (@1250 A)=230 W

	Power loss [W]
E1B1250, In1250	$230 \cdot \left(\frac{1070}{1250}\right)^2 = 168.5$

Then the total power loss of the equipment installed is:

P = 601.9 W

The effective cooling surface A_e is:

	Dimensions (mxm)	A_o (m²)	b factor	A_o x b (m²)
Top	1x0.6	0.6	1.4	0.84
Front	2.2x1	2.2	0.9	1.98
Rear	2.2x1	2.2	0.5	1.1
Left-hand side	2.2x0.6	1.32	0.9	1.188
Right-hand side	2.2x0.6	1.32	0.9	1.188
			$A_e = \sum (A_o \cdot b)$	6.296

From Table 5, d = 1.05 (one horizontal partition, without ventilation)

From Table 7, k = 0.137 (value interpolated)

Since *x* = 0.804, the temperature rise at half the height of the enclosure is:

$$\Delta t_{0.5} = d \cdot k \cdot P^x = 1.05 \cdot 0.137 \cdot 601.9^{0.804} = 24.70 \text{ K}$$

For the evaluation of the temperature rise at the top of the enclosure, it is necessary to determine the ***c*** factor, using the ***f*** factor:

$$f = \frac{h^{1.35}}{A_b} = \frac{2.2^{1.35}}{1 . 0.6} = 4.832$$

From Table 8, column 3 (separate enclosure for wall-mounting), c = 1.373 (value interpolated)

$$\Delta t_1 = c \cdot \Delta t_{0.5} = 1.373 \cdot 24.70 = 33.91\text{K}$$

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ABB SACE S.p.A.
L.V. Breakers
Via Baioni, 35
24123 Bergamo - Italy
Tel.: +39 035.395.111 - Telefax: +39 035.395.306-433

http://www.abb:com