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Date: 16 May 2025

Origin: International

Latest date for receipt of comments: 25 June 2025

Project No. 2021/00323

Responsible committee: W/- Miscellaneous Standards

Interested committees:

Title: BS EN IEC 60909-0 Short-circuit currents in three-phase a.c. systems

Part 0: Calculation of currents

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

PROJECT NUMBER: IEC 60909-0 ED3	
DATE OF CIRCULATION: 2025-05-02	CLOSING DATE FOR VOTING: 2025-07-25
SUPERSEDES DOCUMENTS: 73/192A/RR	

IEC TC 73 : SHORT-CIRCUIT CURRENTS	
SECRETARIAT: Norway	SECRETARY: Mr Lars Jakob Paulsen
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 8, TC 17, TC 18, TC 64, TC 88, TC 99, TC 121	HORIZONTAL FUNCTION(S):
ASPECTS CONCERNED: Safety	
☒ SUBMITTED FOR CENELEC PARALLEL VOTING Attention IEC-CENELEC parallel voting The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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TITLE: Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents

PROPOSED STABILITY DATE: 2028
NOTE FROM TC/SC OFFICERS: Maintenance projects was approved by National Committees and documented in 73/191/RQ The Secretariat has decided to finish ED 3 within the allocated project time. CDV as the next step is the only way to achieve this. Note that MT1 will start work on ED 4 as soon as ED 3 is published. Technical comments outside the scope of the current ED 3 will be handled in the next revision.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SHORT-CIRCUIT CURRENTS IN THREE-PHASE AC SYSTEMS

Part 0: Calculation of currents

FOREWORD

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- 10) Main aim of the IEC 60909-0 standard is calculation of maximum and minimum short-circuit currents of bolted short circuits (see 5.2.4). Calculation results may serve as input for further evaluations such as calculation of arcing current as described in e.g. IEEE 1584.

International Standard IEC 60909-0 has been prepared by IEC technical committee 73: Short-circuit currents. It is an International Standard.

This third edition cancels and replaces the second edition published in 2016. This edition constitutes a technical revision.

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

- a) Restructuring and complementing of the chapters, especially restructuring and updating of chapter 6.
- b) Restructuring of subscripts

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

CDV	Report on voting
73/xxx/CDV	73/xxx/RVC

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

The language used for the development of this International standard is English

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60909 series, published under the general title *Short-circuit currents in three-phase a.c. systems*, can be found on the IEC website.

This part of IEC 60909 is to be read in conjunction with the following International Standards and Technical Reports:

- IEC TR 60909-1:2002, *Short-circuit currents in three-phase a.c. systems – Part 1: Factors for the calculation of short-circuit currents according to IEC 60909-0*
- IEC TR 60909-2:2008, *Short-circuit currents in three-phase a.c. systems – Part 2: Data of electrical equipment for short-circuit current calculations*
- IEC 60909-3:2009, *Short-circuit currents in three-phase a.c. systems – Part 3: Currents during two separate simultaneous line-to-earth short circuits and partial short-circuit currents flowing through earth*
- IEC TR 60909-4:2021, *Short-circuit currents in three-phase a.c. systems – Part 4: Examples for the calculation of short-circuit currents*

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

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

SHORT-CIRCUIT CURRENTS IN THREE-PHASE AC SYSTEMS

Part 0: Calculation of currents

1 Scope

This part of IEC 60909 is applicable to the calculation of short-circuit currents

- in low-voltage three-phase AC systems, and
 - in high-voltage three-phase AC systems,
- operating at a nominal frequency of 50 Hz or 60 Hz.

Systems at highest voltages of 550 kV and above with long transmission lines need special consideration.

This part of IEC 60909 establishes a general, practicable and concise procedure leading to results which are generally of acceptable accuracy. For this calculation method, an equivalent voltage source at the short-circuit location is introduced. This does not exclude the use of special methods, for example the superposition method, adjusted to particular circumstances, if they give at least the same precision. The superposition method gives the short-circuit current related to the one load flow presupposed. This method, therefore, does not necessarily lead to the maximum resp. minimum short-circuit current.

This part of IEC 60909 deals with the calculation of short-circuit currents in the case of balanced or unbalanced short circuits.

A single line-to-earth fault occurring in networks with isolated or resonant earthing of the neutral point is beyond the scope of this part of IEC 60909.

For currents during two separate simultaneous single-phase line-to-earth short circuits in an isolated neutral system or a resonance earthed neutral system, see IEC 60909-3.

Short-circuit currents and short-circuit impedances may also be determined by system tests, by measurement on a network analyser, or numerical simulations with electromagnetic programs. In existing low-voltage systems it is possible to determine the short-circuit impedance on the basis of measurements at the location of the prospective short circuit considered.

The calculation of the short-circuit impedance is in general based on the rated data of the electrical equipment and the topological arrangement of the system and has the advantage of being possible both for existing systems and for systems at the planning stage.

In general, two types of short-circuit currents, which differ in their magnitude, are considered:

- the maximum short-circuit current which determines the capacity or rating of electrical equipment; and
- the minimum short-circuit current which can be a basis, for example, for the selection of fuses, for the setting of protective devices, and for checking the run-up of motors.

NOTE The current in a three-phase short circuit is assumed to be made simultaneously in all poles. Investigations of non-simultaneous short circuits, which may lead to higher aperiodic components of short-circuit currents, are beyond the scope of this part of IEC 60909.

This part of IEC 60909 does not cover short-circuit currents deliberately created under controlled conditions (short-circuit testing stations).

This part of IEC 60909 does not deal with the calculation of short-circuit currents in installations on board ships and aeroplanes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038:2009, *IEC standard voltages*

IEC 60050-131, *International Electrotechnical Vocabulary – Part 131: Circuit theory* (available at: www.electropedia.org)

IEC TR 60909-1:2002, *Short-circuit currents in three-phase a.c. systems – Part 1: Factors for the calculation of short-circuit currents according to IEC 60909-0*

IEC TR 60909-2:2008, *Short-circuit currents in three-phase a.c. systems – Data of electrical equipment for short-circuit current calculations*

IEC 60909-3:2009, *Short-circuit currents in three-phase a.c. systems – Part 3: Currents during two separate simultaneous line-to-earth short circuits and partial short-circuit currents flowing through earth*

IEC TR 60909-4:2021, *Short-circuit currents in three-phase a.c. systems – Part 4: Examples for the calculation of short-circuit currents*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-131 and the following apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>

- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

short circuit

accidental or intentional conductive path between two or more conductive parts (e.g. three-phase short circuit) forcing the electric potential differences between these conductive parts to be equal or close to zero

[SOURCE: IEC 151-12-04 modified - (e.g. three-phase short circuit) added]

3.1.1

line-to-line short circuit, two-phase short circuit

accidental or intentional conductive path between two line conductors with or without earth connection

3.1.2**line-to-earth short circuit, single-phase short circuit**

accidental or intentional conductive path in a solidly earthed neutral system or an impedance earthed neutral system between a line conductor and local earth

3.2**short-circuit current**

over-current resulting from a short circuit in an electric system

Note 1 to entry: It is necessary to distinguish between the short-circuit current at the short-circuit location and partial short-circuit currents in the network branches (see Figure 2) at any point of the network.

3.3**prospective short-circuit current**

current that would flow if the short circuit were replaced by an ideal connection of negligible impedance without any change of the supply

Note 1 to entry: The current in a three-phase short circuit is assumed to be made simultaneously in all poles. Investigations of non-simultaneous short circuits, which may lead to higher aperiodic components of short-circuit current, are beyond the scope of this part of IEC 60909.

3.4**symmetrical short-circuit current**

rms value of the AC symmetrical component of a prospective short-circuit current (see 3.3), the aperiodic component of current, if any, being neglected

3.4.1**initial symmetrical short-circuit current**

$$I_k''$$

rms value of the total AC symmetrical components of a prospective short-circuit current (see 3.3), applicable at the instant of short circuit if the impedance remains at zero-time value

Note 1 to entry: see Figure 1

Note 2 to entry: The total initial short-circuit current is the sum of the short-circuit currents, caused by voltage and current sources (see 3.4.2 and 3.4.3).

3.4.2**initial symmetrical short-circuit current (voltage source)**

$$I_{kVS}''$$

rms value of the AC symmetrical components of a prospective short-circuit current (see 3.3), caused by a voltage source, applicable at the instant of short circuit if the impedance remains at zero-time value

3.4.3**initial symmetrical short-circuit current (current source)**

$$I_{kCS}''$$

rms value of the AC symmetrical components of a prospective short-circuit current (see 3.3), caused by a current source, applicable at the instant of short circuit if the impedance remains at zero-time value

3.5**initial symmetrical short-circuit power**

$$S_k''$$

fictitious value determined as a product of the initial symmetrical short-circuit current I_k'' (see 3.4.1), the nominal system voltage U_n (see 3.12) and the factor $\sqrt{3}$: $S_k'' = \sqrt{3} \cdot U_n \cdot I_k''$

326 Note 1 to entry: The initial symmetrical short-circuit power S_k'' is not used for the calculation procedure in this part
 327 of IEC 60909.

328 **3.6**
 329 **decaying (aperiodic) component of short-circuit current or DC component**

330 i_{DC}
 331 mean value between the top and bottom envelope of a short-circuit current decaying from an
 332 initial value to zero according to Figure 1

333 **3.7**
 334 **peak short-circuit current**

335 i_p
 336 maximum possible instantaneous value of the prospective short-circuit current

337 Note 1 to entry: see Figure 1

338 Note 2 to entry: Sequential short circuits are not considered.

339 **3.8**
 340 **symmetrical short-circuit breaking current**

341 I_b
 342 rms value of an integral cycle of the symmetrical AC component of the prospective short-circuit
 343 current at the instant of contact separation of the first pole to open of a switching device

344 **3.9**
 345 **steady-state short-circuit current**

346 I_k
 347 rms value of the short-circuit current which remains after the decay of the transient phenomena

348 Note 1 to entry: see Figure 1

349 **3.10**
 350 **symmetrical locked-rotor current**

351 I_{LR}
 352 symmetrical rms current of an asynchronous machine with locked rotor fed with rated voltage
 353 U_{rA} at rated frequency

354 **3.11**
 355 **equivalent electric circuit**

356 model to describe the behaviour of a circuit by means of a network of ideal elements

357 **3.12**
 358 **nominal system voltage**

359 U_n
 360 voltage (line-to-line) by which a system is designated, and to which certain operating
 361 characteristics are referred

362 Note 1 to entry: Values are given in IEC 60038.

363 **3.13**
 364 **equivalent voltage source**

365 $cU_n / \sqrt{3}$
 366 voltage of an ideal source applied at the short-circuit location for calculating the short-circuit
 367 current according to 5.2.2

368 Note 1 to entry: This is the only active voltage of the network.

3.14**voltage factor** c

ratio between the equivalent voltage source and the nominal system voltage U_n divided by $\sqrt{3}$

Note 1 to entry: The values are given in Table 1.

Note 2 to entry: The introduction of a voltage factor c is necessary for various reasons. These are: voltage variations depending on time and place, changing of transformer taps, neglecting loads and capacitances by calculations according to 5.2.4, the subtransient behaviour of generators and motors.

3.15**far-from-generator short circuit**

short circuit during which the magnitude of the symmetrical AC component of the prospective short-circuit current remains essentially constant

Note 1 to entry: see Figure 1a

3.16**near-to-generator short circuit**

short circuit during which the magnitude of the symmetrical AC component of the prospective short-circuit current decreases

Note 1 to entry: see Figure 1b

Note 2 to entry: A near-to-generator short circuit can be assumed if at least one synchronous machine contributes a prospective initial symmetrical short-circuit current which is more than twice the machine's rated current, or a short circuit to which asynchronous motors contribute more than 5 % of the initial symmetrical short-circuit current without motors.

3.17**short-circuit impedances at the short-circuit location F****3.17.1****positive-sequence short-circuit impedance** $\underline{Z}_{(1)}$

<three-phase AC system> impedance of the positive-sequence system as viewed from the short-circuit location

Note 1 to entry: See 5.2.5.

3.17.2**short-circuit impedance** $\underline{Z}_k$

<three-phase AC system> abbreviated expression for the positive-sequence short-circuit impedance $\underline{Z}_{(1)}$ according to 3.17.1 for the calculation of three-phase short-circuit currents

3.17.3**negative-sequence short-circuit impedance** $\underline{Z}_{(2)}$

<three-phase AC system> impedance of the negative-sequence system as viewed from the short-circuit location

Note 1 to entry: See 5.2.5.

3.17.4**zero-sequence short-circuit impedance** $\underline{Z}_{(0)}$

<three-phase AC system> impedance of the zero-sequence system as viewed from the short-circuit location

415 Note 1 to entry: It includes three times the neutral-to-earth impedance $\underline{Z}_E$.

416 **3.18** 417 **impedances of electrical equipment**

418 **3.18.1** 419 **positive-sequence impedance**

420 $\underline{Z}_{(1)}$

421 <electrical equipment> ratio of the line-to-neutral voltage to the short-circuit current of the
422 corresponding line conductor of electrical equipment when fed by a symmetrical positive-
423 sequence system of voltages

424 Note 1 to entry: See Clause 6 and IEC TR 60909-4.

425 Note 2 to entry: The index of symbol $\underline{Z}_{(1)}$ may be omitted if there is no possibility of confusion with the negative-
426 sequence and the zero-sequence impedances.

427 **3.18.2** 428 **negative-sequence impedance**

429 $\underline{Z}_{(2)}$

430 <electrical equipment> ratio of the line-to-neutral voltage to the short-circuit current of the
431 corresponding line conductor of electrical equipment when fed by a symmetrical negative-
432 sequence system of voltages

433 Note 1 to entry: See Clause 6 and IEC TR 60909-4.

434 **3.18.3** 435 **zero-sequence impedance**

436 $\underline{Z}_{(0)}$

437 <electrical equipment> ratio of the line-to-earth voltage to the short-circuit current of one line
438 conductor of electrical equipment when fed by an AC voltage source, if the three paralleled line
439 conductors are used for the outgoing current and a fourth line and/or earth as a joint return

440 Note 1 to entry: See Clause 6 and IEC TR 60909-4.

441 **3.19** 442 **subtransient reactance**

443 X_d''

444 effective reactance of a synchronous machine at the moment of short circuit

445 Note 1 to entry: For the calculation of short-circuit currents the saturated value of X_d'' is taken.

446 **3.20** 447 **minimum time delay**

448 $t_{\min}$

449 shortest time between the beginning of the short-circuit current and the contact separation of
450 the first pole to open of the switching device

451 Note 1 to entry: The time $t_{\min}$ is the sum of the shortest possible operating time of a protective relay and the shortest
452 opening time of a circuit-breaker. It does not take into account adjustable time delays of tripping devices.

453 **3.21** 454 **thermal equivalent short-circuit current**

455 I_{th}

456 the rms value of a current having the same thermal effect and the same duration as the actual
457 short-circuit current, which may contain a DC component and may subside in time

3.22**Short-circuit current (current source) of full size converters****3.22.1****source current for three phase short circuits**

$$I_{kPC}$$

<source current, three phase> rms value of the source current of a power station unit with full size converter and current regulation in case of three-phase short circuit at the high-voltage side of the step-up transformer

3.22.2**source current for line-to-line short circuits**

$$I_{(1)k2PC}$$

<source current, two phase> rms value of the source current (positive-sequence system) of a power station with full size converter and current regulation in case of a line-to-line short circuit or a line-to-line short circuit with earth connection at the high-voltage side of the step-up transformer

3.22.3**source current for line-to-earth short circuits**

$$I_{(1)k1PC}$$

<source current, single phase> rms value of the source current (positive-sequence system) of a power station with full size converter and current regulation in case of a line-to-earth short-circuit at the high-voltage side of the step-up transformer

3.23**impedance of the nodal impedances matrix**

$$\underline{Z}_{(1)ii}, \underline{Z}_{(2)ii}, \underline{Z}_{(0)ii}$$

<self-impedance> diagonal elements of the positive-sequence, or negative-sequence or zero-sequence nodal impedances matrix for the short-circuit location i

3.24**impedance of the nodal impedances matrix**

$$\underline{Z}_{(1)ij}$$

<mutual impedance > elements of the positive-sequence nodal impedances matrix, where i is the node of the short circuit and j the node where the high-voltage side of a power station unit with full size converter is connected

4 Symbols, subscripts and superscripts**4.1 General**

The formulas given in this standard are written without specifying units. The symbols represent physical quantities possessing both numerical values and dimensions that are independent of units, provided a consistent unit system is chosen, for example the international system of units (SI). Symbols of complex quantities are underlined, for example $\underline{Z} = R + jX$.

4.2 Symbols

$\underline{a}$ Complex operator $\underline{a} = e^{j2\pi/3}$

A Initial value of the DC component i_{DC}

c Voltage factor

$cU_n / \sqrt{3}$ Equivalent voltage source (rms)

501	f	Frequency (50 Hz or 60 Hz)
502	f_c	Equivalent frequency to calculate the peak short-circuit current
503	I_b	Symmetrical short-circuit breaking current (rms)
504	i_{DC}	Aperiodic or DC component of short-circuit current
505	I_k	Steady-state short-circuit current (rms)
506	I_{kCE}	Steady-state short-circuit current of a generator with compound excitation
507	I_{LR}	Symmetrical locked-rotor current of an asynchronous generator or motor
508	i_p	Peak short-circuit current
509	I_r	Rated current of electrical equipment
510	I_{th}	Thermal equivalent short-circuit current
511	I_k''	Initial symmetrical short-circuit current (rms)
512	I_{kCS}''	Initial symmetrical short-circuit current (rms) caused by current sources
513	I_{kVS}''	Initial symmetrical short-circuit current (rms) caused by voltage sources
514	K	Correction factor for impedances
515	m	Factor for the heat effect of the DC component
516	n	Factor for the heat effect of the AC component
517	p	Pair of poles of an asynchronous machine
518	p_S	Range of synchronous generator voltage regulation
519	P_{krT}	Total loss in transformer windings at rated current
520	P_{rA}	Rated mechanical power of an asynchronous machine ($P_{rA} = S_{rA} \cos(\varphi_{rA}) \eta_{rA}$)
521	p_T	Range of transformer voltage adjustment
522	q	Factor for the calculation of breaking current of asynchronous machines
523	q_n	Nominal cross-section
524	r_{rT}	Relative resistance of a transformer at rated transformation ratio in per unit
525	R resp. r	Resistance, absolute respectively relative value
526	S_r	Rated apparent power of electrical equipment
527	T_k	Duration of the short-circuit current
528	t_{min}	Minimum time delay
529	t_r	Rated transformation ratio (tap-changer in main position); $t_r \geq 1$
530	u_{kr}	Rated short-circuit voltage of a transformer in per unit
531	$U_{(1)}, U_{(2)}, U_{(0)}$	Positive-, negative-, zero-sequence voltage
532	U_m	Highest voltage for equipment, line-to-line (rms)
533	U_n	Nominal system voltage, line-to-line (rms)
534	U_r	Rated voltage, line-to-line (rms)

535	X_d'' resp. X_q''	Saturated subtransient reactance of a synchronous machine, direct axis
536		respectively quadrature axis
537	X resp. x	Reactance, absolute respectively relative value
538	X_d resp. X_q	Synchronous reactance, direct axis respectively quadrature axis
539	x_d	Unsaturated synchronous reactance, relative value
540	X_{dCE}	Fictitious reactance of a generator with compound excitation in the case of
541		steady-state short circuit at the terminals (poles)
542	x_{dsat}	Saturated synchronous reactance, relative value, reciprocal of the saturated no-
543		load short-circuit ratio
544	x_{rT}	Relative reactance of a transformer at rated transformation ratio in per unit
545	Z resp. z	Impedance, absolute respectively relative value
546	$Z_{(0)}$	Zero-sequence short-circuit impedance
547	$Z_{(1)}$	Positive-sequence short-circuit impedance
548	$Z_{(2)}$	Negative-sequence short-circuit impedance
549	Z_k	Short-circuit impedance of a three-phase AC system at the short-circuit location
550	ϑ_e	Conductor temperature at the end of the short circuit
551	α, β	Factors for the calculation of short-circuit currents, if one conductor is interrupted
552	η_{rA}	Efficiency of asynchronous machines
553	φ	Phase angle
554	κ	Factor for the calculation of the peak short-circuit current
555	λ	Factor for the calculation of the steady-state short-circuit current
556	μ	Factor for the calculation of the symmetrical short-circuit breaking current
557	μ_0	Absolute permeability of vacuum, $\mu_0 = 4\pi \times 10^{-4} \text{ H/km}$
558	ρ	Resistivity
559	01	Positive-sequence neutral reference
560	02	Negative-sequence neutral reference
561	00	Zero-sequence neutral reference

562 4.3 Subscripts

563	(1)	Positive-sequence component
564	(2)	Negative-sequence component
565	(0)	Zero-sequence component
566	A	Asynchronous machine
567	AC	Alternating current
568	AG	Asynchronous generator
569	AM	Asynchronous motor or group of asynchronous motors
570	AM0	Without asynchronous motors
571	asym	Asymmetrical
572	B	Busbar

573	c	Equivalent frequency
574	C	Converter
575	CE	Generator with compound excitation
576	CS	Current source
577	DC	Direct current
578	E	Earth
579	f	Fictitious
580	F	Short-circuit location
581	HV	High-voltage, high-voltage side of a transformer
582	k or k3	Three-phase short circuit (see Figure 2a)
583	K	Corrected impedances with the impedance correction factors
584	k1	Line-to-earth short circuit, line-to-neutral short circuit (see Figure 2d)
585	k2	Line-to-line short circuit (see Figure 2b)
586	k2EL2	Line-to-line short circuit with earth connection (see Figure 2c)
587	k2EL3	Line-to-line short circuit with earth connection (see Figure 2c)
588	kE2E	Line-to-line short circuit with earth connection (see Figure 2c)
589	L	Line
590	L1, L2, L3	Line conductors of a three-phase AC system
591	LV	Low-voltage, low-voltage side of a transformer
592	max	Maximum
593	min	Minimum
594	MV	Medium-voltage, medium-voltage side of a transformer
595	N	Network
596	n	Nominal value
597	PA	Power station with asynchronous generator
598	PC	Power station with full size converter
599	PD	Power station with doubly fed asynchronous generator
600	PP	Power plant
601	PPA	Power plant with asynchronous generator
602	PPC	Power plant with full size converter
603	PPD	Power station with doubly fed asynchronous generator
604	PS	Power station with synchronous generator
605	Q	Feeder connection point
606	r	Rated value
607	R	Reactor
608	res	Resulting
609	S	Synchronous machine
610	SG	Synchronous generator
611	SM	Synchronous motor
612	SPH	Synchronous condenser (phase-shifting machine)
613	t	Transformed value
614	th	Thermal
615	T	Transformer

616	UT	Unit transformer
617	VS	Voltage source
618	Σ AM	Sum of parallel asynchronous motors

619 4.4 Superscripts

620	b	Before the short circuit
621	"	Subtransient
622	'	Transient or per unit length
623		

624 5 Characteristics of short-circuit currents: calculating method

625 5.1 General

626 A complete calculation of short-circuit currents should give the currents as a function of time at
 627 the short-circuit location from the initiation of the short circuit until the steady-state current has
 628 been reached. (see Figure 1a and Figure 1b), depending on the instantaneous value of the
 629 voltage at the short-circuit location at the moment of the short circuit occurrence.

630 In general, a distinction is made between far-from-generator and near-to-generator short
 631 circuits (see also 3.15 and 3.16).

632 The AC component of the near-to-generator short-circuit current decays with time. An example
 633 is shown in Figure 1b). It could happen that the decaying short-circuit current reaches zero for
 634 the first time some cycles after the short circuit took place. This is possible if the DC time
 635 constant of e.g. a synchronous generator or doubly fed asynchronous generator is considerably
 636 larger than the subtransient time constant. This phenomenon is not dealt with in this standard.

637 The decaying aperiodic DC component of the short-circuit current i_{DC} can be calculated
 638 according to Formula (69).

639 In most practical cases a determination of the short-circuit current as a function of time is not
 640 necessary. Depending on the usage of the results, it is mostly sufficient to know the rms value
 641 of the symmetrical AC component I_k'' and the peak value i_p . The maximum peak short-circuit
 642 current results if the short circuit occurs at the zero crossing of the voltage at the short-circuit
 643 location. Its value depends on the direct-current time constant of the network and the decay of
 644 the symmetrical AC component.

645 When calculating single-fed or multiple-fed short-circuit currents in systems supplied by
 646 generators, power-station units, power plants and motors for near-to-generator and/or near-to-
 647 motor short circuits, see Figure 8 and Figure 9, it is of interest to know not only the initial
 648 symmetrical short-circuit current I_k'' and the peak short-circuit current i_p , but also the
 649 symmetrical short-circuit breaking current I_b and the steady-state short-circuit current I_k . In
 650 this case, the symmetrical short-circuit breaking current I_b is smaller than the initial symmetrical
 651 short-circuit current I_k'' . Normally, the steady-state short-circuit current I_k is smaller than the
 652 symmetrical short-circuit breaking current I_b .

653

654 NOTE Schematic diagram with fundamental oscillation and DC component. In real networks the short-circuit current
 655 can deviate from the current shape of Figure 1a and Figure 1b.

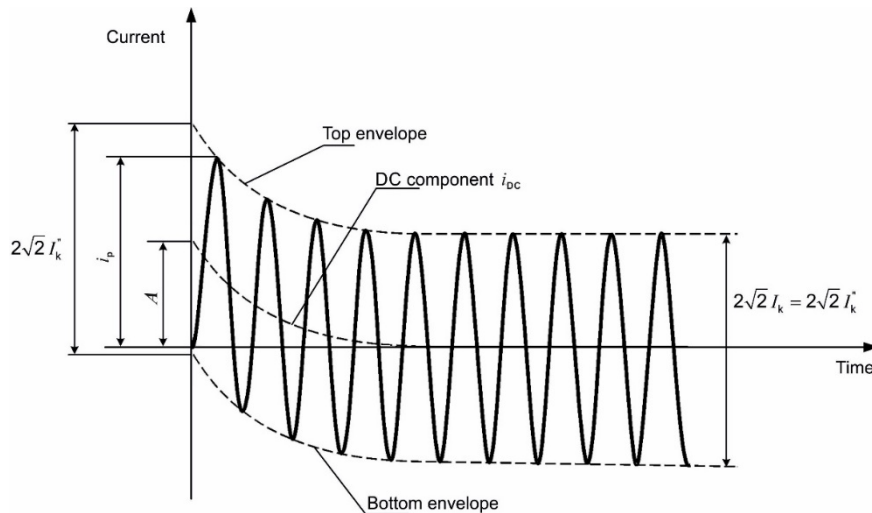


Figure 1a – Short-circuit current of a far-from-generator short circuit with constant AC component and decaying DC component

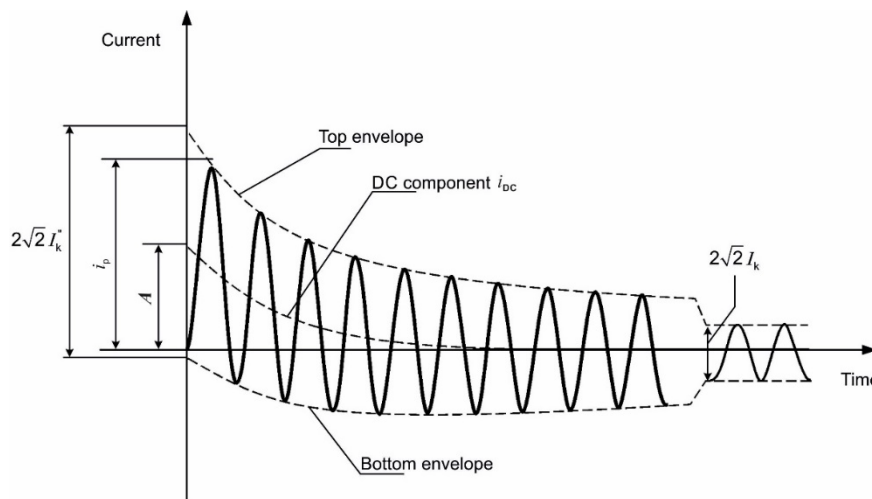


Figure 1b – Short-circuit current of a near-to-generator short circuit with decaying AC and DC component

I_k'' initial symmetrical short-circuit current

i_p peak short-circuit current

I_k steady-state short-circuit current

i_{DC} DC component of short-circuit current

A initial value of the DC component i_{DC}

Figure 1 – Short-circuit current (schematic diagram)

5.2 Method of calculation

5.2.1 General

The basis of the short-circuit current calculation is the superposition of the effects of different sources that determine the total short-circuit current at the short-circuit location. These sources are:

- Equivalent voltage source at the short-circuit location (5.2.2).

b) Installations modelled as current sources (5.2.3).

In the application of the superposition, it is assumed that the steady-state values of the voltages and currents before short circuit are neglected. Figure 3 shows the basic principle of the superposition of the different sources for an exemplary network. Figure 3a represents a three-phase short circuit at the location F, fed by a network and a power station with full size converter. In Figure 3b the network fed only by the equivalent voltage source at the short-circuit location is investigated, in Figure 3c the network with the installations with full size converters modelled as current sources is shown. The partial short-circuit currents at the short-circuit location F of these two networks are added for calculating the short-circuit current at the short-circuit location F of Figure 3a.

The assumptions used for the two calculations are described in 5.2.4.

For short circuits as shown in Figure 2, the short-circuit currents can be calculated by the application of symmetrical components (see 5.2.5). Figure 2 illustrates the short circuits covered by this standard: Three phase (Figure 2a), line-to-line (Figure 2b), line-to-line with earth connection (Figure 2c), and line-to-earth (Figure 2d).

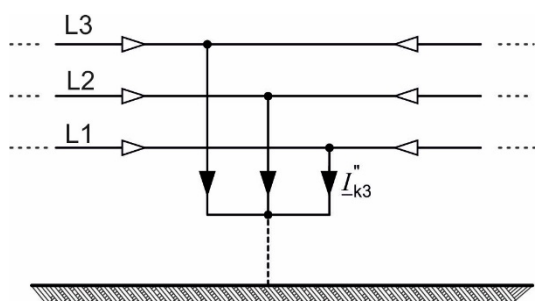


Figure 2a – Three-phase short circuit

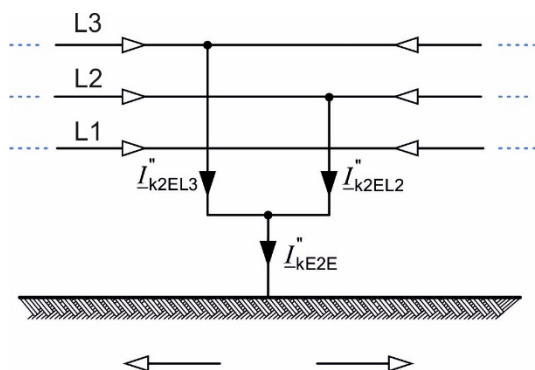


Figure 2c – Line-to-line short circuit with earth connection

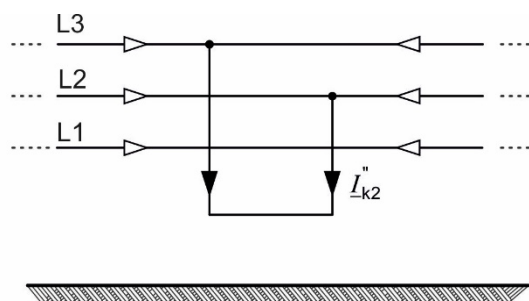


Figure 2b – Line-to-line short circuit

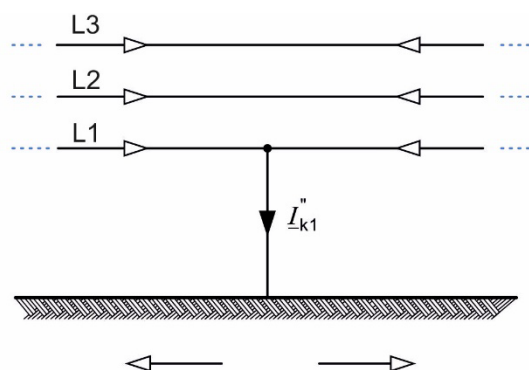


Figure 2d – Line-to-earth short circuit

Short-circuit current

Partial short-circuit currents
in conductors and earth return

Figure 2 – Characterization of short circuits and their currents

The impedances of equipment in upstream or downstream networks of the positive, negative and zero-sequence are to be transformed by the square of the rated transformation ratio t_r . Voltages and currents are to be transformed by the rated transformation ratio t_r . If there are several transformers with slightly differing rated transformation ratios (t_{rT1} , t_{rT2} , ... t_{rTn}) in between two systems, the arithmetic mean value can be used.