

Application guide for calculation of short-circuit currents in low-voltage radial systems

(Implementation of CENELEC
HD 581 S1)

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National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee. It is identical with IEC 781:1989 *Application guide for calculation of short-circuit currents in low-voltage radial systems*, published by the International Electrotechnical Commission (IEC). This standard also implements Harmonization Document HD 581 S1:1991 which was published by the European Committee for Electrotechnical Standardization (CENELEC).

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the HD title page, pages 2 to 32, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

Application guide for calculation of short-circuit currents in low-voltage radial systems

(IEC 781:1989)

Guide d'application pour le calcul des
courants de court-circuit dans les réseaux à
basse tension radiaux
(CEI 781:1989)

Berechnung von Kurzschlußströmen in
unvermaschten Drehstrom-
Niederspannungsstrahlennetzen;
Anwendungsleitfaden
(IEC 781:1989)

This Harmonization Document was approved by CENELEC on 1991-03-15. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

Up-to-date lists and bibliographical references concerning such national implementation may be obtained on application to the Central Secretariat or to any CENELEC member.

This Harmonization Document exists in three official versions (English, French, German).

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 781:1989 could be accepted without textual changes, has shown that no CENELEC common modifications were necessary for the acceptance as Harmonization Document.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as HD 581 S1 on 15 March 1991.

The following dates were fixed:

- latest date of announcement of the HD at national level (doa) 1991-09-01
- latest date of publication of a harmonized national standard (dop) 1992-03-01
- latest date of withdrawal of conflicting national standards (dow) 1992-03-01

Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative.

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1 Scope

This application guide specifies a standardized procedure developed from IEC Publication 909 for the calculation of short-circuit currents in three-phase a.c. systems operating at nominal frequency (50 or 60 Hz) when the short circuit occurs in low-voltage radial systems and when the simplifying conditions given in Clause 3 are met.

In order to facilitate application by non-specialist engineers, an example calculated using the recommended forms is included.

2 Object

It is the object of this application guide to present a practical method to be used when calculating short-circuit currents in low-voltage networks. The method corresponds strictly with IEC Publication 909 and leads to conservative results with sufficient accuracy.

Two short-circuit currents which differ in magnitude are to be calculated:

- the *maximum* short-circuit current which causes the maximum thermal and electromagnetic effects on electrical equipment and determines the required capacity or rating;
- the *minimum* short-circuit current which may be a basis for the adjustment of protective devices.

3 General calculation methods and calculation assumptions

The calculation of short-circuit currents according to this application guide is based on the following conditions:

- The short circuit is far-from-generator and is supplied at *one* point by an electricity supply network.
- The low-voltage network considered is unmeshed.
- The values of the source voltage and the impedances of all electrical equipment are assumed to be constant.
- Contact resistances and fault impedances are not taken into account.
- The short circuit is simultaneous in all poles, if multiphase.
- Short-circuit currents are not calculated for internal faults in one of several parallel cables.
- For the duration of the short circuit there is no change in the circuits involved. The number of phases involved remains the same e.g. a three-phase short circuit remains three-phase during the time of the short circuit.
- Line capacitances and parallel admittances of passive elements are disregarded.
- Double earth faults at different locations are disregarded.
- The conditions for disregarding the influence of motors, given in Sub-clause 7.3, must be met. If not, see IEC Publication 909.
- Transformer tap-changers are assumed to be in the main position.
- According to Sub-clause 4.10.2: $Z_{(1)} = Z_{(2)}$.

For more detailed information see IEC Publication 909.

4 Definitions

For the purpose of this application guide, the following definitions apply. Reference is made to the International Electrotechnical Vocabulary (IEV) [IEC Publication 50] when applicable.

4.1

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 (IEV 151-03-41)

4.2

far-from-generator short circuit

a short circuit during which the magnitude of the symmetrical a.c. component of the prospective short-circuit current remains essentially constant

4.3

short-circuit current

an over-current resulting from a short circuit due to a fault or an incorrect connection in an electric circuit (IEV 441-11-07)

NOTE It is necessary to distinguish between the short-circuit current at the short-circuit location and in the network branches.

4.4

prospective (available) short-circuit current

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

4.5

initial symmetrical short-circuit current I_k''

the r.m.s. value of the a.c. symmetrical component of a prospective (available) short-circuit current applicable at the instant of short circuit if the impedance remains at zero-time value (see Figure 1)

4.6

peak short-circuit current i_p

the maximum possible instantaneous value of the prospective (available) short-circuit current

NOTE The magnitude of the peak short-circuit current varies in accordance with the moment at which the short circuit occurs. The calculation of the peak three-phase short-circuit current i_p applies for that phase-conductor and that moment in which the greatest possible short-circuit current exists.

4.7

symmetrical short-circuit breaking current I_b

the r.m.s. value of an integral cycle of the symmetrical a.c. component of the prospective short-circuit current at the instant of contact separation of the first pole of a switching device

4.8

steady-state short-circuit current I_k

the r.m.s. value of the short-circuit current which remains after the decay of the transient phenomena (see Figure 1)

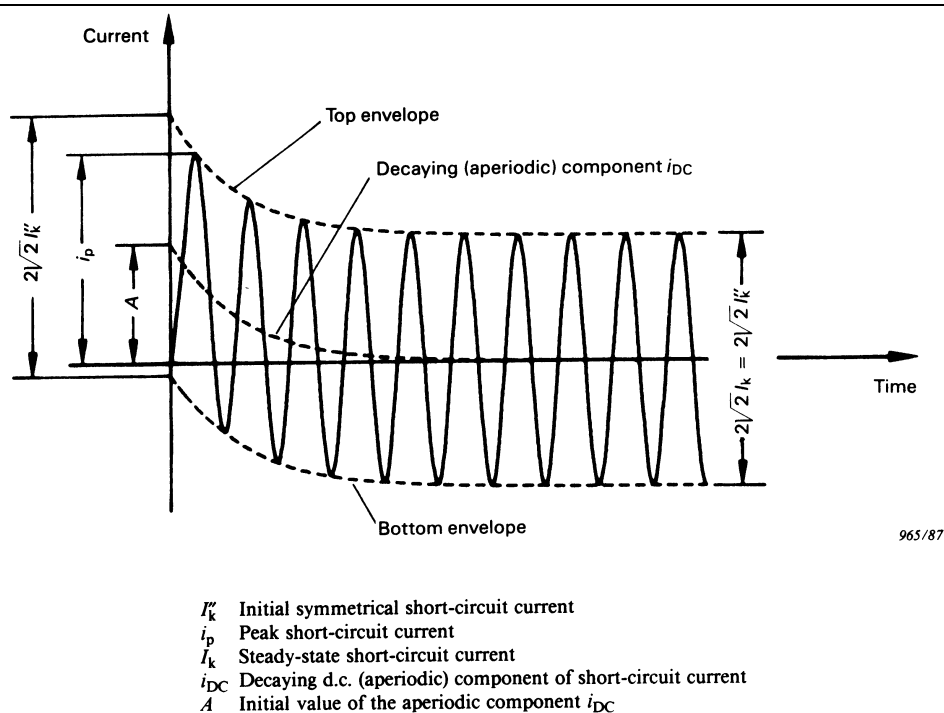


Figure 1 — Short-circuit current of a far-from-generator short circuit (schematic diagram)

4.9

nominal system voltage U_n

voltage (line-to-line) by which a system is designated and to which certain operating characteristics are referred. Values are listed in IEC Publication 38

4.10 Short-circuit impedances of electrical equipment

4.10.1

positive-sequence short-circuit impedance $\underline{Z}_{(1)}$ of electrical equipment

the ratio of the line-to-neutral voltage to the short-circuit current of the corresponding phase of an electrical equipment when fed by a symmetrical positive-sequence system of voltages

NOTE Index of symbol $\underline{Z}_{(1)}$ may be omitted if there is no possibility of confusion with the negative-sequence and the zero-sequence short-circuit impedances.

4.10.2

negative-sequence short-circuit impedance $\underline{Z}_{(2)}$ of electrical equipment

the ratio of the line-to-neutral voltage to the short-circuit current of the corresponding phase of an electrical equipment when fed by a symmetrical negative-sequence system of voltages

NOTE In this application guide, covering far-from-generator short circuits, it is assumed that $\underline{Z}_{(2)} = \underline{Z}_{(1)}$ in all cases.

4.10.3

zero-sequence short-circuit impedance $\underline{Z}_{(0)}$ of electrical equipment

the ratio of the line-to-earth voltage to the short-circuit current of one phase of an electrical equipment when fed by an a.c. voltage source, if the three paralleled phase conductors are used for the outgoing current and a fourth line and/or earth is joint return

4.11 Short-circuit impedances at the short-circuit location F

4.11.1

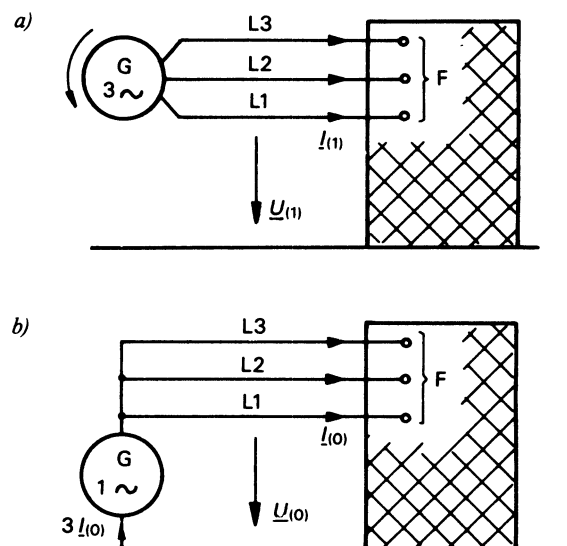
positive-sequence short-circuit impedance $\underline{Z}_{(1)}$ of a three-phase a.c. system

the impedance of the positive-sequence system as viewed from the short-circuit location [see Figure 2a)]

4.11.2

zero-sequence short-circuit impedance $\underline{Z}_{(0)}$ of a three-phase a.c. system

the impedance of the zero-sequence system as viewed from the short-circuit location [see Figure 2b)]. It includes three times the neutral-to-earth impedance $3\underline{Z}_{NE}$



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a) Positive-sequence short-circuit impedance:

$$\underline{Z}_{(1)} = \underline{U}_{(1)} / \underline{I}_{(1)}$$

b) Zero-sequence short-circuit impedance:

$$\underline{Z}_{(0)} = \underline{U}_{(0)} / \underline{I}_{(0)}$$

Figure 2 — Short-circuit impedance of a three-phase a.c. system at the short-circuit location F

4.12 voltage source

an active element which can be represented by an ideal voltage source independent of all currents and voltages in the circuit, in series with a passive circuit element (IEV 131-01-37)

4.13 equivalent voltage source $cU_n / \sqrt{3}$

the voltage of an ideal source applied at the short-circuit location in the positive-sequence network as the only active voltage of the system for calculating the short-circuit current according to Clause 9

4.14 voltage factor c

the ratio between the equivalent voltage source and the nominal system voltage U_n divided by $\sqrt{3}$. For values see Table I

NOTE The introduction of a voltage factor c is necessary for various reasons. These are:

- voltage variations depending on time and place,
- changing of transformer tapings,
- neglecting loads and capacitances by calculations according to Clause 9.

5 Symbols, subscripts and superscripts

Symbols of complex quantities are underlined, for example: $\underline{Z} = R + jX$.

All equations are written without units specified. The symbols represent quantities possessing both numerical values and dimensions that are independent of units, provided that a consistent unit system is chosen, for example the International System of Units (SI).