IEC/TR 60909-2

Edition 2.0 2008-11

TECHNICAL REPORT

Short-circuit currents in three-phase a.c. systems – Part 2: Data of electrical equipment for short-circuit current calculations

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE X

ICS 17.220.01; 29.240.20

ISBN 978-2-88910-327-0

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 4
1 General 6
1.1 Scope and object 6
1.2 Normative references 6
2 Data for electrical equipment 6
2.1 General 6
2.2 Data of typical synchronous machines 7
2.3 Data of typical two-winding, three-winding and auto-transformers 10
2.4 Data of typical overhead lines, single and double circuits 14
2.5 Data of typical high-voltage, medium-voltage and low-voltage cables 20
2.6 Data of typical asynchronous motors 35
2.7 Busbars 38
Annex A (informative) Information from National Committees 42
Bibliography 43

Figure 1 – Subtransient reactance of synchronous machines 50 Hz and 60 Hz (Turbogenerators, salient pole generators, motors SM and condensers SC) 8
Figure 2 – Rated Voltage U_{rG} and rated power factor $\cos\varphi_{rG}$ of synchronous machines (Turbo generators, salient pole generators, motors and condensers 50 Hz and 60 Hz) 9
Figure 3 – Unsaturated and saturated synchronous reactance of two-pole turbo generators 50 Hz and 60 Hz (relative values) 9
Figure 4 – Three-winding transformer (No. 6 of Table 3). 12
Figure 5 – Rated short-circuit voltage u_{kr} of unit transformers in power stations (ST) with or without on-load tap-changer 13
Figure 6 – Rated short-circuit voltages u_{kr} of network transformers 14
Figure 7 – Positive-sequence reactance $X'_{(1)} = X'_L$ of low-voltage and medium-voltage overhead lines 50 Hz, Cu or Al, with one circuit according to Equation (15) of IEC 60909-0 16
Figure 8 – Positive-sequence reactance $X'_{(1)} = X'_L$ of overhead lines 50 Hz (60 Hz-values converted to 50 Hz) 19
Figure 9 – Type of overhead lines 20
Figure 10 – Single-core cable 64 kV / 110 kV with lead sheath [4] 23
Figure 11 – Reduction factor depending on the inducing current for cables with one lead sheath and two overlapping steel tapes, f = 50 Hz [3] 35
Figure 12 – Reduction factor depending on the inducing current for cables with three lead sheaths and two overlapping steel tapes, f = 50 Hz [3] 35
Figure 13 – Ratio I_{LR}/I_{rM} of low-voltage and medium-voltage asynchronous motors, 50 Hz and 60 Hz 37
Figure 14 – Product $\cos\varphi_{rM}$ x η_{rM} of low-voltage and medium-voltage motors, 50 Hz and 60 Hz 38
Figure 15 – Geometric mean distance g_{L1L1} = g_{L2L2} = g_{L3L3} of the main conductors 39
Figure 16 – Factor α and β for the calculation of $X'_{(1)}$ given in Equation (34) 40

Table 1 – Actual data of typical synchronous generators, motors and condensers 7
Table 2 – Actual data of typical two-winding transformers (NT: network; ST: power station) 10
Table 3 – Actual data of typical three-winding transformers 11
Table 4 – Actual data of typical autotransformers with and without tertiary winding 12
Table 5 – Actual data of typical overhead lines 50 Hz and 60 Hz 18
Table 6 – Actual data of typical electric cables 21
Table 7 – Equations for the positive-sequence and the zero-sequence impedance of cables 22
Table 8 – Single-core cables 64/110 kV, 2XK2Y, 3×1×240 ... 1 200 rm, Cu with lead sheath 24
Table 9 – 10-kV-cables N2XS2Y 25
Table 10 – 20-kV-cables N2XS2Y 26
Table 11 – Positive-sequence and zero-sequence impedance of four low-voltage single-core cables NYY 4×1× q_{n}... (Case No. 2a in Table 7) 27
Table 12 – Low-voltage cable NYY 29
Table 13 – Low-voltage cable NYY with three and a half copper conductors 30
Table 14 – Low-voltage cable NYCWY with four copper conductors 32
Table 15 – Low-voltage cable NYCWY 33
Table 16 – Actual data of typical asynchronous motors 36
Table 17 – Actual data of distribution busbars 38
Table 18 – Example for the calculation of $X'_{(1)}$ for busbars using Figures 15 and 16 41
Table A.1 – Information received from National Committees 42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SHORT-CIRCUIT CURRENTS IN THREE-PHASE AC SYSTEMS –

Part 2: Data of electrical equipment for short-circuit current calculations

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 60909-2, which is a technical report, has been prepared by IEC technical committee 73: Short-circuit currents.

This technical report is to be read in conjunction with IEC 60909-0 and IEC 60909-3.

This second edition cancels and replaces the first edition published in 1992. This edition constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

- Subclause 2.5 gives equations and examples for the calculation of the positive-, the negative and the zero-sequence impedances and reduction factors for high-, medium and low-voltage cables with sheaths and shields earthed at both ends.
- Subclause 2.7 gives equations and figures for the calculation of the positive-sequence impedances of busbar configurations.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
73/142/DTR	73/145/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

A bilingual version of this publication may be issued at a later date.

SHORT-CIRCUIT CURRENTS IN THREE-PHASE AC SYSTEMS –

Part 2: Data of electrical equipment for short-circuit current calculations

1 General

1.1 Scope and object

This part of IEC 60909 comprises data of electrical equipment collected from different countries to be used when necessary for the calculation of short-circuit currents in accordance with IEC 60909-0.

Generally, electrical equipment data are given by the manufacturers on the name plate or by the electricity supplier.

In some cases, however, the data may not be available. The data in this report may be applied for calculating short-circuit currents in low-voltage networks if they are in accordance with typical equipment employed in the user's country. The collected data and their evaluation may be used for medium- or high-voltage planning purposes and also for comparison with data given by manufacturers or electricity suppliers. For overhead lines and cables the electrical data may in some cases also be calculated from the physical dimensions and the material following the equations given in this report.

Thus this technical report is an addition to IEC 60909-0. It does not, however, change the basis for the standardized calculation procedure given in IEC 60909-0 and IEC 60909-3.

1.2 Normative references

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

IEC 60909-0:2001, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

IEC 60909-3:-[1], *Short-circuit currents in three-phase a.c. systems – Part 3: Currents du-ring two separate simultaneous line-to-earth short-circuit currents and partial short-circuit currents flowing through earth*

[1] To be published.