TECHNICAL REPORT

IEC TR 62066

First edition
2002-06

Surge overvoltages and surge protection in low-voltage a.c. power systems – General basic information

Surtensions de choc et protection contre la foudre dans les réseaux à basse tension – Informations générales fondamentales

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CONTENTS

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SURGE OVERVOLTAGES AND SURGE PROTECTION IN LOW-VOLTAGE AC POWER SYSTEMS – GENERAL BASIC INFORMATION

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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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 62066, which is a technical report, has been prepared by Technical Committee 64: Electrical installations and protection against electric shock.

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

Enquiry draft	Report on voting
64/1125/CDV	64/1163/RVC

Full information on the voting for the approval of this technical report 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 3.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

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- withdrawn;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

This document, which is purely informative, is not to be regarded as an International Standard.

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

SURGE OVERVOLTAGES AND SURGE PROTECTION IN LOW-VOLTAGE AC POWER SYSTEMS – GENERAL BASIC INFORMATION

1 Scope

IEC 62066 is a technical report that presents a general overview on the different kinds of surge overvoltages that can occur on low-voltage installations. Typical surge magnitude and duration as well as frequency of occurrence are described. Information on overvoltages resulting from interactions between power system and communications system is also provided.

Additionally, general guidelines are given concerning surge protection means and systems on the basis of availability and risk considerations, including interactions and the need for coordination and consideration of temporary overvoltages in the selection of surge-protective devices.

2 Reference documents

IEC 60364-4-44:2001, *Electrical installations of buildings – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*
Amendment 1 (2000)

IEC/TR 61000-2-5:1995, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 5: Classification of electromagnetic environments.* Basic EMC publication

IEC 61000-4-1:2000, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Overview of IEC 61000-4 series*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test.* Basic EMC publication

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*
Amendment 1 (2000)

IEC/TR 61000-5-2:1997, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

IEC 61024-1:1990, *Protection of structures against lightning – Part 1: General principles*

IEC 61024-1-1:1993, *Protection of structures against lightning – Part 1: General principles – Section 1: Guide A – Selection of protection levels for lightning protection systems*

IEC 61312-1:1995, *Protection against lightning electromagnetic impulse – Part 1: General principles*

IEC/TS 61312-3:2000, *Protection against lightning electromagnetic impulse – Part 3: Requirements of surge protective devices (SPDs)*

IEC 61643-1:1998, *Surge protective devices connected to low-voltage power distribution systems – Part 1: Performance requirements and testing methods*

IEC 61643-12:2002, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*

IEC 61662:1995, *Assessment of the risk of damage due to lightning*
Amendment 1 (1996)

IEC 61663-2:2001, *Lightning protection – Telecommunications lines – Part 2: Lines using metallic conductors*

ITU-T K.20, *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents*

ITU-T K.21, *Resistibility of telecommunication equipment installed in customers' premises to overvoltages and overcurrents*

IEEE 1036:1992, *Guide for application of shunt power capacitors*

NOTE Other documents are listed in the bibliography, which includes documents that were used in developing the present report, documents cited in support of a recommendation, and documents suggested as further reading for information.

3 Definitions

For the purposes of this technical report, the terms and definitions given in other relevant IEC publications (see clause 2) apply, as well as the definitions listed below.

3.1
combination wave
waveform delivered by a generator that applies a 1,2/50 voltage impulse across an open circuit and an 8/20 current impulse into a short circuit. The voltage, current amplitude and waveforms that are delivered to the SPD are determined by the generator and the impedance of the SPD to which the surge is applied. The ratio of peak open-circuit voltage to peak short-circuit current is 2 Ω; this is defined as the fictive impedance Z_f. The short-circuit current is symbolized by I_{sc}. The open-circuit voltage is symbolized by U_{oc}

NOTE For the purposes of this technical report, the combination wave delivered by a surge generator in accordance with definition 3.24 of IEC 61643-1 may be applied to equipment other than an SPD.

3.2
combined multi-port SPD
surge-protective device integrating in a single package the means for providing surge protection at two or more ports of an equipment connected to different systems, such as a power system and a communications system

NOTE In addition to providing surge protection for each port, the device may also provide means to avoid shifting of the reference potentials between the equipment ports.

3.3
coordination of SPDs (cascade)
selection of characteristics for two or more SPDs to be connected across the same conductors of a system but separated by some decoupling impedance such that, given the parameters of the impedance and of the impinging surge, this selection will ensure that the energy deposited in each of the SPDs is commensurate with its rating

3.4
direct stroke
stroke impacting the structure of interest

3.5
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equi-potentiality

NOTE In typical installations, the equipotential bonding is provided for safety at the power frequency. At surge current frequencies, the length of the bonding conductors inescapably introduces some difference in potentials.

3.6
facility
physical entity (for example, a hospital, factory, machinery, etc.) that is built, constructed, installed or established to perform some particular function or to serve or facilitate some particular end

3.7
lightning flash to earth
electrical discharge of atmospheric origin between cloud and earth consisting of one or more strokes

NOTE For the purpose of this technical report, flash to earth can be understood not only as the earth (soil) but also as a flash to a structure, a power system, etc., as opposed to a cloud-to-cloud event.

3.8
lightning protection system (LPS)
complete system used to protect a space against the effects of lightning. It consists of both external and internal lightning protection systems

NOTE In particular cases, an LPS may consist of an external LPS or an internal LPS only.

3.9
near flash
flash striking in the vicinity of the structure of interest

3.10
point of strike
point where a lightning stroke contacts the earth, a structure, or an LPS

3.11
prospective overvoltage
theoretical overvoltage that would appear on the conductors of a power supply system or user installation before flashover of basic insulation or operation of voltage-limiting devices

3.12
SPD disconnector
internal or external device required for disconnecting an SPD from the system in the event of SPD failure. It is intended to prevent a persistent fault on the system and may give visible indication of the SPD failure

3.13
steepness factor
ratio for a current impulse, of the front-of wave slope defined for the interval between 10 % and 90 % of the crest value, to the slope defined for the interval between 10 % and 30 % of the crest value

3.14
stroke (lightning)
single electrical discharge in a lightning flash to earth

3.15
surge overvoltage
temporary or transient voltage occurring in the system, resulting from a surge current due to an atmospheric discharge, an induction phenomenon, switching, or a fault in the system itself

3.16
surge protective device (SPD)
device that is intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear component

3.17
surge reference equalizer
device used for connecting equipment to external systems whereby all conductors connected to the protected load are routed, physically and electrically, through a single enclosure with a shared reference point between the input and output ports of each system

NOTE Sharing the reference point may be accomplished within the device either by a direct bond or through a suitable device, such as an SPD which maintains isolation during normal conditions but provides an effective bond during the occurrence of a surge in one or both systems.

3.18
temporary overvoltage (TOV)
oscillatory overvoltage at power frequency at a given location, of relatively long duration and which is undamped or weakly damped

NOTE Temporary overvoltages usually originate from switching operations or faults (for example, sudden load rejection, single-phase faults) and/or from non-linearities (ferro-resonance effects, harmonics).

3.19
thermal runaway
operational condition when the sustained power loss of an SPD exceeds the thermal dissipation of the housing and connections, leading to a cumulative increase in the temperature of the internal elements culminating in failure

4 Overvoltages in low-voltage systems

Overvoltages in low-voltage systems result from several types of events or mechanisms and may be classified in four categories. The scope of this technical report is limited to low-voltage a.c. power systems, focussing on the first two categories but also giving guidelines for the third category shown below. A significant fourth category of overvoltages can occur from interactions of the a.c. power system with other systems, such as communications system, so that this fourth category is also relevant to the subject of this technical report.

a) Lightning overvoltages

Lightning overvoltages are the result of a direct flash to or near the power system, structures (with or without lightning protection system) or to the soil. Distant lightning flashes can also induce overvoltages in the circuits of an installation. These overvoltages are the subject of clause 5, where the various coupling mechanisms are described.

b) Switching overvoltages

Switching overvoltages are the result of intentional actions on the power system, such as load, inductor or capacitor switching in the transmission or distribution systems by the utility, or in the low-voltage system by end-user operations. They can also be the result of unintentional events such as power system faults and their elimination. Both are the subject of clause 6.

c) Temporary overvoltages

Temporary overvoltages occur in power systems, as the result of a wide range of system conditions, both normal operation and abnormal conditions. Both are the subject of clause 7. Their occurrence is relevant to the selection of suitable surge-protective devices.

d) System interaction overvoltages

Overvoltages can occur between different systems, such as power and communications, during the flow of surge currents in one of the systems. These are briefly described in clause 8.

Clauses 5, 6, 7, and 8 referenced above present an overview of these overvoltages and causes, without discussion of consequences, need for mitigation, or risk analysis. These related topics are discussed in subsequent clauses.

5 Lightning overvoltages

5.1 General

Lightning is a natural and unavoidable event which affects low-voltage systems (power systems as well as signal/communication systems) through several mechanisms. The obvious interaction is a flash to the power system, but other coupling mechanisms can also produce overvoltages (see figure 1). To better understand the diversity of mechanisms, this subclause first presents a summary of the basic parameters of a lightning stroke between a cloud and any object at the ground level. Figure 2 gives examples of lightning flashes to a typical complex electrical system.

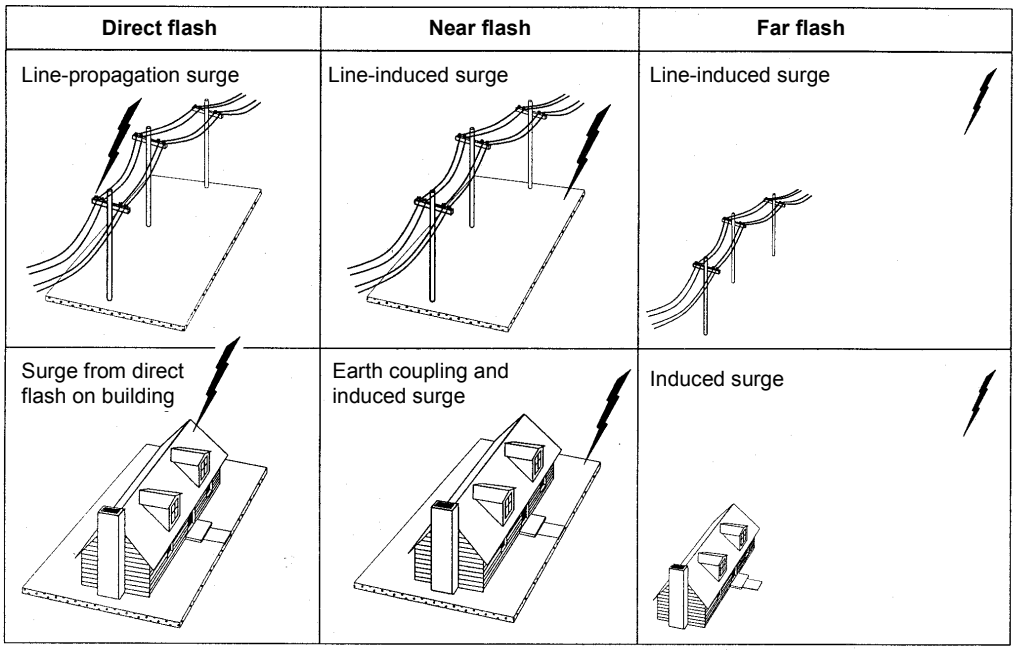

Figure 1 – Examples of lightning flash coupling mechanisms