

IEEE Guide on Interactions Between Power System Disturbances and Surge-Protective Devices

Sponsor

**Surge-Protective Devices Committee
of the
IEEE Power Engineering Society**

Approved June 14, 1995

IEEE Standards Board

Abstract: Information is provided to users and manufacturers of surge-protective devices (SPDs) about the interactions that may occur between SPDs and power system disturbances. This guide applies to SPDs manufactured to be connected to 50 or 60 Hz ac power circuits rated at 100–1000 V rms. The effects and side effects of the presence and operation of SPDs on the quality of power available to the connected loads are described. The interaction between multiple SPDs on the same circuit is also described.

Keywords: harmonics, noise, power system disturbance, surge-protective device (SPD), swell, voltage sag, voltage surge

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

Copyright © 1995 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 1995. Printed in the United States of America.

ISBN 1-55937-566-3

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

IEEE Standards documents may involve the use of patented technology. Their approval by the Institute of Electrical and Electronics Engineers does not mean that using such technology for the purpose of conforming to such standards is authorized by the patent owner. It is the obligation of the user of such technology to obtain all necessary permissions.

Introduction

(This introduction is not a part of IEEE Std C62.48-1995, IEEE Guide on Interactions Between Power System Disturbances and Surge-Protective Devices).

The purpose of this guide is to provide users and manufacturers of surge-protective devices (SPDs) with an understanding of the nature of power system disturbances and SPDs, and of the interactions that may occur between them and between SPDs. Given this understanding, users may be able to take steps to either prevent or mitigate adverse effects of such interactions.

The growth of interest in low-voltage SPDs parallels the increasing number of applications of highly sophisticated electronic equipment that may be exposed and susceptible to surge voltages. Users of SPDs may sometimes be under the impression, or may be led to believe the misconception, that by installing an SPD in their facility or within their equipment, they will provide total immunity to any and all power system disturbances. In reality, SPDs will respond to and affect some power system disturbances but not others. The effects that SPDs will have on power system disturbances are often less than desired. SPDs installed at various locations in the wiring systems as well as in equipment may interact with those wiring systems and with each other. In this scenario, the effect of any given SPD is imprecise and predictable only within wide limits.

The SPDs discussed herein are intended to limit transient overvoltages that can appear in low-voltage ac power systems having service voltages of 1000 V or less.

The present document is one member of the IEEE C62 family that deals with power system surges and surge protection. IEEE Std C62.41-1991 characterizes and provides information on surge voltages in low-voltage ac power circuits. Other C62 documents describe performance characteristics of SPDs, recommend standard test protocols for verifying SPD performance, and provide SPD applications guidance.

Suggestions for improvements to this guide will be welcomed. They should be sent to the Secretary, IEEE Standards Board, Institute of Electrical and Electronic Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

At the time this standard was completed, the Working Group on Surge Characterization in Low-Voltage Circuits had the following membership:

Hans J. Steinhoff, *Chair*

George J. Bagnall
Francis P. Drake
Barry Epstein
Frank Fiederlein

H. Ed Foelker
Ernie Gallo
François D. Martzloff
Kurt A. Meindorfer

Richard Odenberg
Alan W. Rebeck
Dennis P. Symanski
Donald M. Worden

Other individuals who have contributed review and comments are as follows:

Chrysanthos Chrysanthou
Robert J. Davidson
Michael Fluegeman
James Forte

Gary L. Goedde
Pete A. Goodwin
Joseph L. Koepfinger
Michael Parente
Pete Richman

Louis Schulman
Ronald B. Standler
Matt Wakeham
Bernie I. Wolff

The following persons were on the balloting committee:

George J. Bagnall
Charles L. Ballentine
James J. Burke
Michel De Nigris
Cliff C. Erven
H. E. Foelker
Gilbert L. Gaibrois
George S. Haralampu
John A. Hetrick
David W. Hutchins

Bengt Johnnerfelt
Stanley S. Kershaw
Joseph L. Koepfinger
Gerald E. Lee
Jeff Mackevich
François D. Martzloff
R. D. Melchior
E. H. Morrow, Jr.
Richard Odenberg
Joseph C. Osterhout
Michael Parente

William T. Rhodes
Ronald B. Standler
Hans J. Steinhoff
Keith B. Stump
Dennis P. Symanski
E. R. Taylor
Arnold Vitols
Steven G. Whisenant
Jonathan J. Woodworth
Donald M. Worden

At the time this standard was published, it was under consideration for approval as an American National Standard. The Accredited Standards Committee on Surge Arresters, C62, had the following members at the time this document was sent to letter ballot:

Joseph L. Koepfinger, Chair

John A. Gauthier, Secretary

Organization Represented

Name of Representative

Alliance for Telecommunications Industry Solutions.....	C. Chrysanthou
Association of American Railroads	Wayne Etter
Bonneville Power Administration	G. E. Lee
Canadian Standards Association (Liaison)	D. M. Smith
Electric Light and Power.....	R. A. Jones H. E. Foelker W. A. Maguire J. W. Wilson M. C. Mingoia (<i>Alt.</i>) F. Martinez
Institute of Electrical and Electronics Engineers	J. L. Koepfinger J. J. Burke G. L. Gaibrois W. H. Kapp S. S. Kershaw, Jr. C. Hansell (<i>Alt.</i>) Edgar Taylor (<i>Alt.</i>)
National Electrical Manufacturers Association	Dennis W. Lenk Bernhard Wolff D. Worden Larry Bock J. Woodworth
National Institute of Standards and Technology	F. D. Martzloff
Rural Electrification Administration	George J. Bagnall
Underwriters Laboratories	P. Notarian Larry Williams (<i>Alt.</i>)
Members-at-Large.....	J. Osterhout B. Panesar R. B. Standler

When the IEEE Standards Board approved this standard on June 14, 1995, it had the following membership:

E. G. “Al” Kiener, *Chair*

Donald C. Loughry, *Vice Chair*

Andrew G. Salem, *Secretary*

Gilles A. Baril
Clyde R. Camp
Joseph A. Cannatelli
Stephen L. Diamond
Harold E. Epstein
Donald C. Fleckenstein
Jay Forster*
Donald N. Heirman

Richard J. Holleman
Jim Isaak
Ben C. Johnson
Sonny Kasturi
Lorraine C. Kevra
Ivor N. Knight
Joseph L. Koepfinger*
D. N. “Jim” Logothetis
L. Bruce McClung

Marco W. Migliaro
Mary Lou Padgett
John W. Pope
Arthur K. Reilly
Gary S. Robinson
Ingo Rusch
Chee Kiow Tan
Leonard L. Tripp

*Member Emeritus

Also included are the following nonvoting IEEE Standards Board liaisons:

Satish K. Aggarwal
Richard B. Engelman
Robert E. Hebner
Chester C. Taylor

Paula M. Kelty
IEEE Standards Project Editor

Contents

CLAUSE	PAGE
1. Overview.....	1
1.1 Scope.....	1
1.2 Purpose.....	1
2. References.....	2
3. Definitions.....	2
4. Power system disturbances	3
4.1 Surges.....	4
4.2 Swells.....	5
4.3 Temporary overvoltages (TOVs).....	5
4.4 Notches	5
4.5 Sags.....	6
4.6 Temporary undervoltages	6
4.7 Harmonics	6
4.8 Noise	7
5. Interactions of power system disturbances and SPDs.....	8
5.1 Response to voltage surges	8
5.2 Response to swells	10
5.3 Response to TOVs	10
5.4 Response to notches.....	10
5.5 Response to sags	10
5.6 Response to temporary undervoltages	10
5.7 Response to harmonics	10
5.8 Response to noise.....	11
6. Side effects.....	11
6.1 Benefits for downstream and upstream loads	11
6.2 Partial loss of power with voltage-switching devices.....	11
6.3 Surge current introduction into a facility	12
6.4 Voltage oscillations caused by SPDs.....	12
6.5 Effects of inductance between SPDs	12
6.6 SPD failure-mode effects on power systems	12
6.7 Effects of SPD peripheral components on power systems	13
ANNEXES	
Annex A Description of environment	14
Annex B Bibliography.....	17

IEEE Guide on Interactions Between Power System Disturbances and Surge-Protective Devices

1. Overview

1.1 Scope

This guide applies to surge-protective devices (SPDs) manufactured to be connected to 50 or 60 Hz ac power circuits rated at 100–1000 V rms.

This guide describes the effects on SPDs of power system disturbances occurring in these low-voltage ac power circuits. The disturbances are not limited to surges. The effects and side effects of the presence and operation of SPDs on the quality of power available to the connected loads are described. The interaction between multiple SPDs on the same circuit is also described.

This guide will discuss both voltage and current surges. The current surges discussed in this guide are the result of voltage surges. Current surges that are solely the result of load changes and do not result in voltage increases, such as a short circuit, are not discussed in this guide.

An SPD is a device whose primary purpose is to provide surge protection. Devices discussed in this guide contain at least one nonlinear component for diverting surge current and/or dissipating surge energy, such as a metal oxide varistor (MOV), silicon avalanche diode (SAD), thyristor, or spark gap. Uninterruptible power supplies, ferroresonators, motor-generators, and filters containing only inductive and/or capacitive components are not considered SPDs in this guide.

1.2 Purpose

The purpose of this document is to provide information on the interactions between power system disturbances and SPDs that is not readily available in other standards. This document provides summary information on power system disturbances that affect or may affect SPDs. The description of the interactions is intended to educate the potential user of such SPDs as to what he or she can expect from such devices.