

IEEE Std C37.90.1™-2002
(Revision of IEEE Std C37.90.1-1989)

IEEE Standards

C37.90.1™

IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Power Engineering Society

Sponsored by the
Power System Relaying Committee



Published by
The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

31 May 2002

Print: SH94987
PDF: SS94987

*Recognized as an
American National Standard (ANSI)*

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1 August 2002
American National Standards Institute

Approved 21 March 2002
IEEE-SA Standards Board

Abstract: *Two types of design tests for relays and relay systems that relate to the immunity of this equipment to repetitive electrical transients are specified. Test generator characteristics, test waveforms, selection of equipment terminals on which tests are to be conducted, test procedures, criteria for acceptance, and documentation of test results are described. This standard has been harmonized with IEC standards where consensus could be reached.*

Keywords: *fast transient test, oscillatory test, relay, relay systems, surge withstand capability*

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*Print: ISBN 0-7381-3255-1 SH94987
PDF: ISBN 0-7381-3256-X SS94987*

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Introduction

(This introduction is not part of IEEE Std C37.90.1-2002, IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.)

Assurance is needed that electronic relays and relay systems will operate satisfactorily when installed in the harsh environment of a substation or switchyard. Standard surge tests will provide assurance that the relays and relay systems will withstand a specified surge level. The use of proper grounding and shielding techniques when installing the equipment will attenuate the actual surge level impinging on the equipment. However, even with proper grounding and shielding, surges may reach the equipment that are above the test levels specified in this standard. In such cases, the addition by the user of surge suppression devices external to the relay system may be required.

The first standard document to specify an SWC test was ANSI/IEEE Std C37.90a™-1974/IEEE Std 472™-1974 (redesignated ANSI/IEEE Std C37.90.1-1974), IEEE Guide for Surge Withstand Capability (SWC) Tests.

Experience with ANSI/IEEE Std C37.90.1-1974 was good, and in 1978 the guide was incorporated as section 9 of ANSI/IEEE Std C37.90™-1978, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus. This meant that the oscillatory SWC test became a required test for relays and relay systems containing semiconducting devices.

From the beginning, it was realized that the oscillatory SWC test had limitations and did not adequately represent all conducted transients that may be experienced in substation environments. The need for a complementary test was recognized and the general type of test required was identified. The problem then became one of a search for a circuit that would produce a repeatable, controllable output. During the search, the IEC *showering arc* test was studied as well as a number of other tests proposed by various organizations. These were not chosen because they were not repeatable or controllable.

The combination of the fast transient SWC test and the oscillatory SWC test ensure that relays and relay systems will function at a level of immunity in the presence of conducted transients that occur in substations. The fast transient test was therefore incorporated into ANSI/IEEE Std C37.90.1-1989, because it is stable, easy to control, and can be performed in a minimum time and at a reasonable cost.

A working group was later assembled to harmonize ANSI/IEEE Std C37.90.1-1989 with corresponding IEC standards and to make the standard more understandable through clarifications and improvements to the document. This working group made extensive revisions such that one set of tests are necessary to reach closer harmonization with the corresponding IEC standards.

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IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

1. Overview

1.1 Scope

This standard specifies design tests for relays and relay systems that relate to the immunity of this equipment to repetitive electrical transients. Two types of tests are specified. The oscillatory and fast transient SWC tests are defined as distinct tests. However, it is not intended to prohibit a combined test, provided all requirements of the individual SWC tests are met.

The application of SWC tests to equipment other than relays and relay systems is the responsibility of those specifying the testing.

1.2 Purpose

The purpose of this standard is to establish a common and reproducible basis for evaluating the performance of relays and relay systems when subjected to repetitive transients on supply, signal, control, and communication lines or connections. This standard is to establish that an evaluation is performed during both normal (non-tripped) and abnormal (tripped) relay operating conditions.

2. References

This standard shall be used in conjunction with the following publications. If the following publications are superseded by an approved revision, the revision shall apply.

ANSI C93.5-1997, American National Standard Requirements for Single Function Power-Line Carrier Transmitter/Receiver Equipment.¹

¹ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

IEEE Std C37.100™-1992 (Reaff 2001), IEEE Standard Definitions for Power Switchgear.²

3. Definitions

Certain terms, defined below, are used in surge testing and to identify parts of a relay system. Other terms used are defined elsewhere, for example in *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B4] or IEEE Std C37.100-1992.³

3.1 calibration: The adjustment of a device to have the designed operating characteristics, and the subsequent marking of the positions of the adjusting means, or the making of adjustments necessary to bring operating characteristics into substantial agreement with standardized scales or marking.

3.2 common (longitudinal)-mode voltage: The voltage common to all conductors of a group as measured between that group at a given location and an arbitrary reference (usually earth).

3.3 communications interface equipment: A portion of a relay system that transmits or receives information from a communications system; e.g., audio tone equipment or carrier transmitter-receiver included as an integral part of the relay system.

3.4 communications system: Any system that transfers protection or other data to or from the relay interface to or from another location.

3.5 current circuit: An input circuit to which is applied a voltage or a current that is a measure of primary current. Current inputs less than 100 mA shall be treated as a signal circuit. (See: **signal circuit**)

3.6 digital data circuit: Any circuit that transfers data in a digitally encoded form that is essential for the proper operation of the relay system.

3.7 input circuit: Circuits with the primary intended function of sensing logical state data, such as circuit breaker position or interlocking commands between relays.

3.8 measuring unit: Any analog or digital device that analyzes input currents or voltages or both to produce an output to the relay logic.

3.9 normal tolerance: Accuracy of the equipment, specified by the manufacturer as a numeric or percentage *plus or minus* variation. Tolerances may be general or specific to a given application.

3.10 output circuit: A circuit from a relay system that exercises direct or indirect control of power apparatus such as tripping or closing of a power circuit breaker.

3.11 output: Outputs convey a state of the equipment under test. They may include: electrical outputs such as contacts or trip pulses, mechanical outputs such as targets, visual outputs such as indicating lights or LEDs, audio outputs such as bells or buzzers, message outputs in digital or analog form, protective communication signals, and data communication signals in analog or digital form.

3.12 power supply circuit: An input circuit to a relay system that supplies power for the functioning of the relay system.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

³The numbers in brackets correspond to those of the bibliography in Annex F.

3.13 relay interface equipment: An assembly that connects a relay system to other equipment, i.e., carrier equipment or instrument transformers. This assembly does not need to be located in the vicinity of the rest of the relay system.

3.14 relay logic: A logic network that coordinates the output of measuring units and other inputs to energize output circuits when prescribed conditions and sequences have been met.

3.15 relay system: An assembly usually consisting of current and voltage circuits, measuring units, logic, and power supplies to provide a specific relay scheme, such as line, transformer, bus, or generator protection. A relay system may include connections to other systems, such as data logging, alarm, communications, or other relay systems.

3.16 signal circuit: Any circuit other than a power supply circuit or an output circuit whose maximum voltage is less than 50 V and maximum current is less than 100 mA.

3.17 surge ground: The point of external connection to the relay system reference or common bus for surge protection.

3.18 transverse (differential)-mode voltage: The voltage between two conductors of a circuit at a given location.

3.19 voltage circuit: An input circuit to which is applied a voltage or a current that is a measure of primary voltage. Voltage inputs less than 50 V shall be treated as signal circuits. (See: **signal circuit**)

4. Test wave shapes

4.1 Oscillatory waveform (see Figure 1)

The test voltage parameters for an open circuit generator condition at the generator terminals shall be

- a) **Waveform envelope:** A damped oscillatory wave, with the envelope decaying to 50% of peak value between the third and sixth periods.
- b) **Frequency:** 1 MHz (tolerance $\pm 10\%$)
- c) **Rise time of first peak:** 75 ns (tolerance $\pm 20\%$), as measured between 10% and 90% of the peak value.
- d) **Test voltage magnitude:** Initial crest of 2.5 kV for common mode tests and for transverse tests (tolerance $+ 0 / - 10\%$).
- e) **Repetition rate:** 6–10 bursts per period of the power system frequency. Bursts shall be nonsynchronous with the power system frequency.
- f) **Duration:** 2 seconds (tolerance $+ 10\% / - 0\%$). For relays with an operating time greater than 2 seconds, it is recommended that the test be carried out with a minimum time setting. In such cases, the period of application of the test signal shall be at least as long as the operating time of the relay under test.
- g) **Source impedance:** 200 Ω resistive at 1 MHz (tolerance $\pm 20\%$).

4.2 Fast transient test waveform (see Figure 2)

The test voltage parameters for an open circuit generator condition at the generator terminals shall be

- a) **Waveform polarity:** Positive and negative
- b) **Rise time:** 5 ns (tolerance $\pm 30\%$)
- c) **Magnitude:** 4 kV crest value (tolerance $\pm 10\%$)
- d) **Pulse duration:** 50 ns (tolerance $\pm 30\%$) (50% value)
- e) **Repetition rate:** The waveform consists of bursts of pulses that repeat periodically.
 - 1) *Burst duration:* 15 ms (tolerance $\pm 20\%$)
 - 2) *Repetition rate during bursts:* 2.5 kHz (tolerance $\pm 20\%$)
 - 3) *Burst period:* 300 ms (tolerance $\pm 20\%$)
- f) **Duration:** Not less than 1 minute, each polarity
- g) **Source impedance:** 50 Ω (tolerance $\pm 20\%$) between 1 MHz and 100 MHz

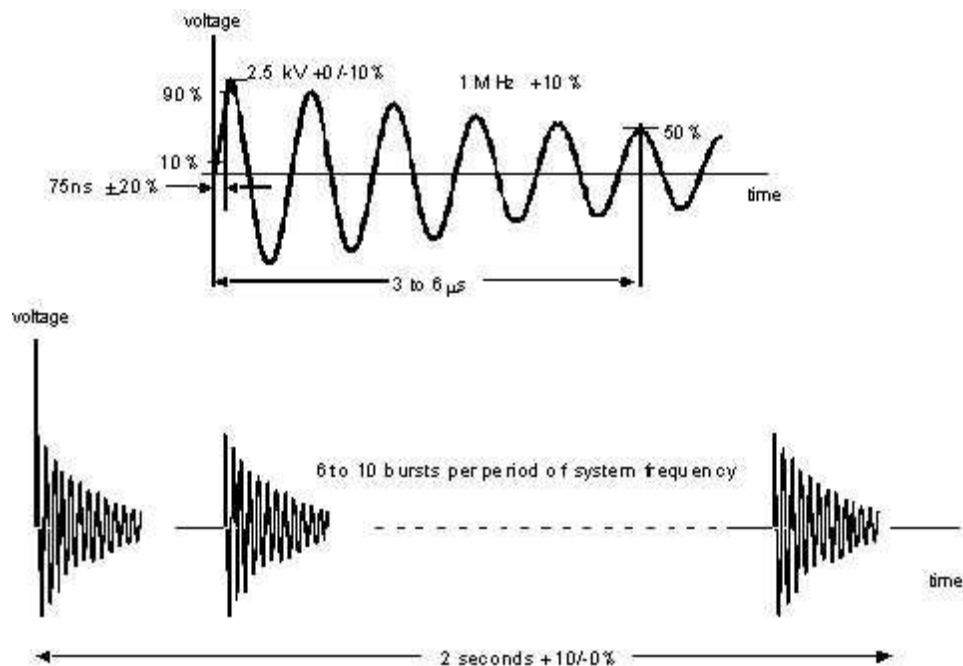


Figure 1—Oscillatory test waveform