



IEEE Guide for the Protection of Shunt Reactors

IEEE Power Engineering Society

Sponsored by the
Power System Relaying Committee



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20 April 2007

IEEE Std C37.109™-2006
(Revision of
IEEE Std C37.109-1988)

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IEEE Guide for the Protection of Shunt Reactors

Sponsor

**Power System Relaying Committee
of the
IEEE Power Engineering Society**

Approved 6 December 2006

IEEE-SA Standards Board

Abstract: A comprehensive guide to the methods and configurations for the protection of power system shunt reactors is provided in this guide. The protection of oil-immersed reactors equipped with auxiliary power windings, improved turn-to-turn protection, and use of digital (microprocessor-based) protection for shunt reactors are included.

Keywords: air-core, auxiliary power winding, circuit switcher, dry-type reactors, microprocessor-based relays, neutral reactor, oil-immersed, pole disagreement, protection, protective relay, reactance, resonance, series-compensated, shunt reactors, turn-to-turn, voltage-unbalance relaying

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Print: ISBN 0-7381-5322-2 SH95617
PDF: ISBN 0-7381-5323-0 SS95617

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Introduction

This introduction is not part of IEEE Std C37.109-2006, IEEE Guide for the Protection of Shunt Reactors.

This guide covers protection of shunt reactors used typically to compensate for capacitive shunt reactance of transmission lines. A survey of shunt reactor protection, conducted in 1979 by the Shunt Reactor Protection Working Group of the IEEE Power System Relaying Committee [B16],^a was used as a reference to determine common circuit arrangements and protective relaying schemes for this guide. This revision includes additional equipment arrangements and provides more detail to selected protective schemes.

Other arrangements or special applications of reactors such as harmonic filter banks, static var compensation (SVC), high-voltage direct current (HVDC), or current-limiting reactors are not specifically addressed; however, the protective methods described in this guide are usually applicable to this equipment.

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^a The numbers in brackets correspond to those of the bibliography in Annex A.

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~~An American National Standard~~

IEEE Guide for the Protection of Shunt Reactors

1. ~~Introduction~~ Overview

1.1 Scope

This guide includes description of acceptable protective relay practices applied to power system shunt reactors. The guide covers protection for dry-type (air-core) and oil-immersed type reactors used on power system buses and lines. Also included in this guide are the protection of oil-immersed reactors equipped with auxiliary power windings, improved turn-to-turn fault protection, and use of digital (microprocessor-based) relays for shunt reactor protection.

1.2 Purpose

The purpose of this guide is to provide users of shunt reactors acceptable methods and configurations for the protection of power system shunt reactors.

~~This guide covers protection of shunt reactors used typically to compensate for capacitive shunt reactance of transmission lines. A survey of shunt reactor protection, conducted in 1979 by the Shunt Reactor Protection Working Group of the IEEE Power System Relaying Committee, was used as a reference to determine the more common circuit arrangements and protective relaying schemes presently in use.~~

~~Other arrangements or special applications of reactors such as harmonic filter banks, static var compensation (SVC), high voltage direct current (HVDC), or current limiting reactors are not specifically addressed; however, the protective methods described in this guide are usually applicable to this equipment~~

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 or corrigenda) applies.

~~This guide shall be used in conjunction with the following publications:~~

~~¹ANSI/IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, or the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.~~

IEEE Std C37.015™-1993, IEEE Application Guide for Shunt Reactor Switching.^{1,2}

~~ANSI/IEEE Std C62.11-1987, C62.22™, Standard Guide for the Application of Metal-Oxide Surge Arresters for AC Power Circuits~~ Alternating- Current Systems.

3. Definitions

For definitions of terms used in this guide, see *The Authoritative Dictionary of IEEE Standards Terms* [B8]³ and IEEE Std C37.100™-1992 [B10].

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

4. Use of reactors

Shunt reactors can be used to provide inductive reactance to compensate for the effects of high charging current of long transmission lines and pipe-type cables. For light load conditions, this charging current can produce more leading reactive ~~kVA~~ power than the system can absorb without with the consequent risk of instability or excessively high voltages at the line terminals (Ferranti effect).

5. Reactor construction and characteristics

The two general types of construction used for shunt reactors are dry-type and oil-immersed. The construction features of each type, along with variations in design, are discussed in 5.1 and 5.2.

5.1 Dry type

Dry-type shunt reactors generally are limited to voltages through 34.5 138 kV and ~~are usually can be directly connected to a transmission line or~~ applied on the tertiary of a transformer that is connected to the transmission line being compensated. The reactors are of the air-core (coreless) type, open to the atmosphere, suitable for indoor or outdoor application. Natural convection of ambient air is generally used for cooling the unit by arranging the windings so as to permit free circulation of air between layers and turns.

The layers and turns are supported mechanically by bracing members or supports made from materials such as ceramics, glass polyester, and concrete. The reactors are constructed as single-phase units and are mounted on base insulators or insulating pedestals that provide the insulation to ground and the support for the reactor.

Since the dry-type shunt reactor has no housing or shielding, a high-intensity external magnetic field is produced when the reactor is energized. Care is thus required in specifying the clearances and arrangement of the reactor units, mounting pad, station structure, and any metal enclosure around the reactor or in the proximity of the reactor. A closed metallic loop in the vicinity of the reactor can produce losses, heating, and arcing at poor joints; therefore, it is important to avoid these loops or to maintain sufficient separation distances. The magnitude of current induced in the loop, which is responsible for extra losses and heating, is dependent on the orientation of the loop with respect to the reactor, impedance of the loop, size of the loop, and distance of the loop from the reactor. Another consideration is the effect of the magnetic fields on the impedance deviation between phases. Methods of minimizing the deviations include adequate separation or arranging the reactors in an equilateral-triangle physical configuration. Deviation from impedance values for reactors will result in a deviation from the actual rating in megavars. The deviation issue as it applies to relaying is discussed in 7.4.3. The reactor manufacturer can provide guidance regarding appropriate clearances or recommendations to minimize stray heating, losses, and impedance deviations.

~~Shielding may be required when it is not possible to arrange dry-type units in an equilateral triangle configuration isolated from external magnetic influences. This shielding is required to limit the impedance deviation between phases.~~