



# IEEE Guide for Protecting Power Transformers

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**IEEE Power Engineering Society**

Sponsored by the  
Power System Relaying Committee

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# **IEEE Guide for Protecting Power Transformers**

Sponsor

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

Approved 31 January 2008

**IEEE-SA Standards Board**

**Abstract:** This guide is intended to provide protection engineers and other readers with guidelines for protecting three-phase power transformers of more than 5 MVA rated capacity and operating at voltages exceeding 10 kV. In some cases, a user may apply the techniques described in this guide for protecting transformers of less than 5 MVA ratings or operating at voltages less than 10 kV. Information to assist protection engineers in applying properly relays and other devices to protect transformers used in transmission and distribution systems is provided in this guide. General philosophy, practical applications, and economic considerations involved in power transformer protection are discussed. Emphasis is placed on practical applications. Types of faults in transformers are described. Technical problems with the protection systems, including the behavior of current transformers during system faults, are discussed. Associated problems, such as fault clearing and reenergization, are discussed as well.

**Keywords:** analysis of dissolved gases in transformer oil, application of multifunction relays for transformer protection, differential protection, failures of transformers, overcurrent protection, protection of phase-shifting transformers, protection of transformers, volts-per-hertz protection

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## Introduction

This introduction is not part of IEEE Std C37.91-2008, IEEE Guide for Protecting Power Transformers.

This document is a revision of IEEE Std C37.91™-2000, IEEE Guide for Protective Relay Applications to Power Transformers. This guide is intended to provide aid in the effective application of relays and other devices for the protection of power transformers.

In this revision, several areas have been improved. Most notably:

- Several clauses have been revised.
- Differential protection has been augmented to include the techniques used in numerical relays. Techniques now being used in numerical relays, such as harmonic restraint and harmonic blocking, wave shape recognition, low-current detection, and direct-current blocking methods, are included.
- An example of the relay blocking logic is included.
- New figures have been included to reflect the practice of connecting all current transformers (CTs) in wye configuration when numerical relays are used.
- The possibility of CT saturation when faults occur outside the protection zone of differential relays and the current does not flow through the differential zone is explained.
- Protection of transformers for faults in the grounded wye-connected windings has been expanded to include the use of restricted earth-fault relays.
- The practice of remote tripping of circuit breakers to protect transformers used to tap transmission and subtransmission lines is explained.
- The clause on gas analysis has been revised to bring it in line with the current practices. The use of rate of change of total dissolved combustible gases is incorporated.
- New annexes have been created. Annex B lists the transformer failure statistics collected by the Canadian Electrical Association. Annex C outlines the procedure for setting relays for protecting three transformers. The first transformer is a step-up transformer, the second transformer is a network autotransformer, and the third transformer is used for supplying energy to a distribution system. Annex D describes the need for monitoring current on the high-voltage and low-voltage windings, when automatic tap changing is used, for determining the hot-spot temperature of a transformer. Annex E outlines the methods that are used in differential relays for compensating for the phase shift in delta-wye transformers.

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Michael Thompson  
Demetrios A. Tziouvaras  
Joe T. Uchiyama  
Don K. Ware  
Murty Yalla  
Tony Yip  
Richard Young

The Working Group thanks the balloters, especially those who provided comments that have definitely helped in improving the usefulness of this guide. The Working Group is especially grateful to Jefferey Benach, Gary Hoffman, and Peter Meyer for their written contributions provided for this guide.

The following members of the individual balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

William J. Ackerman  
Steven Alexanderson  
Stan Arnot  
Gary E. Arntson  
Ali Al Awazi  
Peter Balma  
Paul Barnhart  
David C. Beach  
Philip Beaumont  
Thomas R. Beckwith  
Jeffrey D. Benach  
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## 1. Overview

This guide is intended to provide protection engineers and other readers with guidelines for protecting three-phase power transformers of more than 5 MVA rated capacity and operating at voltages exceeding 10 kV. In some cases, a user may apply the techniques described in this guide for protecting transformers of less than 5 MVA ratings or operating at voltages less than 10 kV.

### 1.1 Scope

The scope of this guide includes general philosophy, practical applications, and economic considerations involved in power transformer protection.

Emphasis is placed on practical applications. General philosophy and economic considerations in protecting transformers are reviewed. Types of faults in transformers are described. Technical problems with the protection systems, including the behavior of current transformers (CTs) during system faults, are discussed. Associated problems, such as fault clearing and reenergization, are discussed as well.

### 1.2 Purpose

The purpose of this guide is to provide protection engineers with information that helps them to properly apply relays and other devices to protect transformers used in transmission and distribution systems.

## 2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is