



IEEE Recommended Practice for On-load Capacity Switching Distribution Transformers

IEEE Power and Energy Society

Developed by the
Transformers Committee

IEEE Std C57.12.210™-2024

STANDARDS

IEEE Recommended Practice for On-load Capacity Switching Distribution Transformers

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Transformers Committee
of the
IEEE Power and Energy Society

Approved 26 September 2024

IEEE SA Standards Board

Abstract: Guidance and references are provided by this recommended practice for the design, manufacture, testing and selection of oil-immersed on-load capacity switching distribution transformers with rated frequency of 50 Hz/60 Hz, voltages of 10 kV or below, and rated capacity of 750 kVA and below. On-load capacity switching distribution transformers are transformers with two rated capacities and equipped with additional components to control the operating capacity for energy saving purposes.

Keywords: capacity switching, distribution transformer, energy efficiency, IEEE C57.12.210™, on-load switching, technical requirements, testing requirements

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

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PDF: ISBN 979-8-8557-1655-9 STD27607
Print: ISBN 979-8-8557-1656-6 STDPD27607

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Participants

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Jinli Wang, Chair
Dongwei Wang, Vice Chair
Yongxiang Cai, Secretary

Organization Represented	Name of Representative
Beijing Brile Intelligent Technology Group Co., Ltd.	Dongwei Wang
China Southern Power Grid Company Ltd.	Yu Fu
North China Electric Power University	Ke Jia
Schneider Electric (China) Co., Ltd.	Xiaoqiang Lei
Shandong Electrical Engineering & Equipment Group Co., Ltd.	Fei Chen
State Grid Corporation of China	Jinli Wang
Tianjin University	Tao Han

The Working Group gratefully acknowledges the contributions of the following participants. Without their assistance and dedication, this standard would not have been completed.

Wanxing Sheng	Hong Gu	Tianming Zhang
Wenyuan Ma	Tao Han	Qipeng Song
Zhenbang Ma	Chunyu Song	Yanbo Che
Caixia Wei	Xiaobing Xiao	Hengfu Fang
	Bin Yang	

The following members of the entity Standards Association balloting group voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

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Stephen Dukes	Joseph L. Koepfinger*	Lei Wang
Doug Edwards	Howard Li	F. Keith Waters
J. Travis Griffith	Xiaohui Liu	Sha Wei
Guido R. Hiertz	John Haiying Lu	Philip B. Winston
Ronald W. Hotchkiss	Kevin W. Lu	Don Wright
	Hiroshi Mano	

Introduction

This introduction is not part of IEEE Std C57.12.210–2024, IEEE Recommended Practice for On-load Capacity Switching Distribution Transformers.

The on-load capacity switching distribution transformers are transformers with two rated capacities and equipped with additional components to control the operating capacity. It is suitable to be used in areas with distinct seasonal/peak-valley power consumption differences, significant load fluctuation, relatively concentrated annual load peak, and low annual average load rate. It can help reduce light and no-load losses of distribution transformers. This recommended practice provides the structure, technical requirements, functional requirements, performance requirements, test requirements, and case study of the on-load capacity switching distribution transformer, intended to provide guidance and references for the design, manufacture, testing, and selection of this kind of product based on engineering experiences.

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IEEE Recommended Practice for On-load Capacity Switching Distribution Transformers

1. Overview

1.1 Scope

This recommended practice provides guidance and references for the design, manufacture, testing and selection of oil-immersed on-load capacity switching distribution transformers with rated frequency of 50 Hz/60 Hz, voltages of 10 kV or below, and rated capacity of 750 kVA and below. On-load capacity switching distribution transformers are transformers with two rated capacities and equipped with additional components to control the operating capacity for energy saving purposes.

1.2 Purpose

This document provides technical and test requirements and terminologies for on-load capacity switching distribution transformers. This includes the technical parameters of the transformers corresponding to the rated capacity, functional and performance requirements of the on-load capacity switching tap-changer and controllers, test classification, items and methods.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6,7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

⁶The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

1.4 Application background

Energy-saving and emission reduction are the global consensus to deal with the energy and environmental crisis. With an increasing weight of electric power consumption in terminal energy consumption, the electricity sector plays a central role in energy saving. As the core link connecting the bulk power system and consumers, the safe and cost-effective power supply of distribution networks is crucial to guarantee the national economy and people's livelihood and contribute to tackling energy and environmental issues.

The distribution transformer is the terminal transformer delivering power to users directly, having a wide distribution and large quantity. The distribution transformer is equipment with relatively high losses in the power system, accounting for about 50% of the total grid losses, possessing great potential for energy saving.

The losses of the power transformer include no-load losses and variable losses. The no-load losses are not determined by the serving load size, but the rated capacity of the transformer. The selection of transformer capacity needs to balance economic efficiency and safe operation to help prevent burning accidents during peak time.

The load of distribution networks, such as agricultural production, household use, and electric heating, has distinct characteristics of large peak and valley difference, low annual average load rate, and periodic change. During peak times, such as cooling and heating seasons, the distribution transformer usually operates in a heavy overload state, with a high risk of burning accidents. During the light load period, such as the slack season of agricultural production and midnight, the distribution transformer operates on light or no-load, and the no-load losses take a high proportion of the total losses.

The on-load capacity switching distribution transformer (OLCSDT) is developed to excavate the energy-saving potential and improve the safe and economic operation of distribution transformers. The OLCSDT can provide adequate reserve capacity for peak hours, while significantly reducing the no/light-load losses, reactive current, and thus the line losses of the distribution network in valley hours.

The OLCSDT has two rated capacities. It can detect the load change and automatically switch the rated capacity accordingly, without interrupting the power supply. When the control unit detects the transformer operating with light or no-load, it will switch to the small capacity mode to reduce operation losses. When the load rate exceeds the critical point of economic operation under the small capacity mode, the transformer will switch to the large capacity mode to help ensure safe operation. The OLCSDT applies to the area with distinct seasonal electricity consumption, significant load fluctuation, relatively concentrated annual load peak, and low annual average load rate.

In addition, the OLCSDT can also be used as the step-up transformers for distributed photovoltaic (PV) power stations connected to medium voltage distribution networks. It can help to adapt to the PV output fluctuation by switching the rated capacities, reducing the tripping-off of PV, or transformer burning, and facilitating the efficient utilization of distributed energy resources. So far, OLCSDT has been deployed in more than 20 provinces and cities in China, and countries such as Ethiopia, Malaysia, Indonesia, etc. [Annex A](#) provides some cases study for different application scenarios.

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 explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC 60076-1, Power Transformers—Part 1: General.⁸

IEC 60076-2, Power Transformers—Part 2: Temperature rise for Liquid-Immersed Transformers.

IEC 60076-3, Power Transformers—Part 3: Insulation Levels, Dielectric Tests and External Clearances in Air.

IEC 60076-5, Power Transformers—Part 5: Ability to Withstand Short Circuit.

IEC 60076-7, Power Transformers—Part 7: Loading Guide for Mineral-oil-immersed Power Transformers.

IEC 60076-10-1, Power Transformers—Part 10–1: Determination of Sound Levels—Application Guide.

IEC 60076-21, Power transformers—Part 21: Standard requirements, terminology, and test code for step-voltage regulators.

IEC 60076-24, Power transformers—Part 24: Specification of voltage regulating distribution transformers (VRDT).

IEC 60529, Degrees of Protection Provided by Enclosures (IP Code).

IEC/IEEE 60488-1, International Standard—Higher Performance Protocol for the Standard Digital Interface for Programmable Instrumentation—Part 1: General.^{9,10}

IEC TS 60076-20, Power Transformers—Part 20: Energy Efficiency.

IEEE Std C37.108™, IEEE Guide for Protection of Secondary Network Systems.

IEEE Std C57.12.00™, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

IEEE Std C57.12.90™, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.

IEEE Std C57.15™-2017, IEEE Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators.

IEEE Std C57.131™-2012, IEEE Standard Requirements for Tap Changers.

IEEE Std 1815™, IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3).

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3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹¹

on-load capacity switching controller: A control device capable of automatically detecting and distinguishing the load condition of the transformer under excitation or on load, automatically switching rated capacity of the transformer, and transmitting the operation data.

on-load capacity switching distribution transformer: A distribution transformer with large and small rated capacity and capable of automatically switching capacity according to an operating load under excitation or on load.

NOTE—In theory, on-load capacity switching distribution transformer has a variety of capacity allocation ratios, but in practice, the most widely used and mature transformers are the type with 3:1 ratio. The capacities switching is realized by changing between the Delta-Y connection of high-voltage windings and the series-parallel connection of low voltage windings.¹²

on-load capacity switching tap-changer: A switching device inside the on-load capacity switching transformer that is capable of simultaneously changing the connection mode between high-voltage winding and low-voltage winding under excitation or on load.

3.2 Acronyms and abbreviations

CDM	code division multiplexing
CDMA	code division multiple access
EV	electric vehicle
HV	high voltage
LV	low voltage
OLCSC	on-load capacity switching controller
OLCSDT	on-load capacity switching distribution transformer
OLCSTC	on-load capacity switching tap-changer

4. Structure

4.1 Structure and principle

OLCSDT mainly contains the transformer unit, the on-load capacity switching tap-changer (OLCSTC), and the on-load capacity switching controller (OLCSC). The transformer unit mainly contains high-voltage (HV) and low-voltage (LV) winding coils. The structure of OLCSDT is shown in Figure 1.

¹¹IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

¹²Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.