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IEEE Guide on Transformers for Application in Distributed Photovoltaic (DPV) Power Generation Systems

IEEE Power and Energy Society

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IEEE Std C57.159™-2016

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Abstract: General and specific recommendations on specification, design, and application of liquid-immersed and dry-type transformers in distributed photovoltaic (DPV) power generation systems for commercial, industrial, and utility systems are provided in this guide.

Keywords: distributed power generation, electrostatic shield, harmonics, IEEE C57.159™, impedance, inverter, photovoltaic, PV, transformer, winding connection diagram

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Introduction

This introduction is not part of IEEE Std C57.159-2016, IEEE Guide on Transformers for Application in Distributed Photovoltaic (DPV) Power Generation Systems.

Transformers addressed in this guide are for the application in distributed photovoltaic (DPV) power generation systems and generally belong to Class I transformers per IEEE Std C57.12.00 and Category I and II transformers per IEEE Std C57.12.00 and IEEE Std C57.12.01. The guide focuses mainly on the inverter transformers of the DPV power generation systems that are connected to the inverters supplying ac voltage and current to the primary (LV) winding of the transformer.

Presently known nominal voltage of these transformers is up to 36 kV and rated power is up to 4000 kVA. Transformers for DPV systems are gradually increasing in their numbers in the field due to the recent increased focus on renewable energy sources. These transformers are primarily used as step-up transformers but can be used as step-down transformers as well. Transformers for DPV systems have a number of specific issues (requirements and constraints) that affect transformer design and application.

This IEEE guide provides information to support specification, design, and application of these transformers by:

— Explaining concerns and differences of DPV system application and providing specific operation and construction techniques to address these concerns and differences.

— Summarizing these considerations for the engineer specifying the transformer.

— Explaining specifics of transformers working with inverters in this application.

— Providing timely state-of-the-art guidance while critical technical details of these power systems are still evolving.

— Increasing awareness of the constraints of this application aiming at increasing reliability of DPV system transformers.

— Having a single document listing all issues related to the application and reference to the relevant existing standards and guides.

— Avoiding pitfalls and failures as has happened in other new distributed power generation systems applications.

— The words “should” and “may” in this document refer to matters that are recommended or permissive but not mandatory.

Describing and addressing the special needs of the DPV power generation systems, the guide will ensure that the transformers for these systems are effective and reliable and will fulfill a need of the solar energy’s growing place in the renewable energy generation systems.

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Contents

1. Overview 10
   1.1 Scope 10
   1.2 Purpose 10

2. Normative references 11

3. Definitions 12

4. Specifics of DPV power generation systems in relation to a transformer application 12
   4.1 Typical DPV power generation systems and DPV system inverter transformers 12
   4.2 Ambient temperature, weather, and mode of operation—Effect on the system, inverter, and transformer 15
   4.3 Technical specifics of the DPV power generation systems 16

5. Transformer parameters selection and transformer design 18
   5.1 General design considerations and recommendations 18
   5.2 Loading, loss evaluation, and efficiency 22
   5.3 Power quality consideration 23
   5.4 Voltage and insulation coordination 25
   5.5 Other design consideration 26
   5.6 Technical requirements of auxiliary transformers 29

6. Transformer general requirements, construction, and protection 29
   6.1 Transformer type 29
   6.2 Design consideration 30
   6.3 Construction consideration 30
   6.4 Recommended accessories and gauges placement 31
   6.5 Arc flash aspects and protection 31

7. Transformer test, installation, and commissioning 32
   7.1 Testing 32
   7.2 Installation and commissioning 32

8. Transformer maintenance, diagnostic, and monitoring 33

9. Transformer specification 33

Annex A (informative) Bibliography 34

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1. Overview

1.1 Scope

This guide provides general and specific recommendations on application of step-up and step-down liquid-immersed and dry-type transformers in distributed photovoltaic (DPV) power generation systems for commercial, industrial, and utility systems.

The guide focuses mainly on the inverter transformers of the DPV power generation systems that are connected to the inverters supplying ac voltage and current to the primary (LV) winding of the transformer. Some specifics attributed to the auxiliary power transformers in these systems are also discussed.

Transformers covered in this guide comply with the relevant requirements defined in the IEEE Std C57.12.00 for liquid-immersed and IEEE Std C57.12.01 for dry-type transformers.[1]

1.2 Purpose

This document supports a harmonized approach to specification, design, and use of the transformers described in the scope of the guide as a component of a DPV power generation system.

[1]Information on references can be found in Clause 2.

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The guide supports currently evolving industry of DPV power generation by providing guidance on specification, design, and application of transformers for these systems. This guide also intends to help avoid potential problems caused by improperly defined, missed, and/or misinterpreted points of consideration. Further, it is addressing constraints that are important for the correct specification, efficient design, and reliable application of transformers in DPV power generation 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 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.

Accredited Standards Committee C2-2012, National Electrical Safety Code® (NESC®).[2,3]

ANSI C57.12.55, American National Standard for Transformer-Used in Unit Installation, Including Unit Substation—Conformance Standard.

IEEE Std C57.12.00™, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.[4,5]

IEEE Std C57.12.01™, IEEE Standard for General Requirements for Dry-Type Distribution and Power Transformers.

IEEE Std C57.12.52™, IEEE Standard for Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, With High Voltage 601 to 34500 Volts, Low Voltage 208Y/120 to 4160 Volts—General Requirements.

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

IEEE Std C57.12.91™, IEEE Standard Test Code for Dry-Type Distribution and Power Transformers.

IEEE Std C57.18.10™, IEEE Standard Practices Requirements for Semiconductor Power Rectifier Transformers.

IEEE Std C57.91™, IEEE Guide for Loading Mineral-Oil-Immersed Transformers.

IEEE Std C57.93™, IEEE Guide for Installation of Liquid-Immersed Power Transformers.

IEEE Std C57.94™, IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.

IEEE Std C57.96™, IEEE Guide for Loading Dry-Type Distribution and Power Transformers.

IEEE Std C57.110™, IEEE Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Current.

IEEE Std C57.129™, IEEE Standard for General Requirements and Test Code for Oil-Immersed HVDC Converter Transformers.

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