



IEEE

IEC/IEEE 60076-16

Edition 2.0 2018-09
REDLINE VERSION

INTERNATIONAL STANDARD



**Power transformers –
Part 16: Transformers for wind turbine applications**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.180; 29.180

ISBN 978-2-8322-6094-4

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POWER TRANSFORMERS –**Part 16: Transformers for wind turbine applications****FOREWORD**

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International Standard IEC/IEEE 60076-16 has been prepared by IEC technical committee 14: Power transformers, in cooperation with Performance Characteristics Subcommittee of the IEEE Power and Energy Society ¹, under the IEC/IEEE Dual Logo Agreement between IEC and IEEE.

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- 2) thermal correction of the effective cooling medium has been introduced;
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This publication is published as an IEC/IEEE Dual Logo standard.

The text of this standard is based on the following IEC documents:

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A list of all parts in the IEC/IEEE 60076 series, published under the general title *Power transformers*, can be found on the IEC website.

¹ A list of IEEE participants can be found at the following URL: <https://standards.ieee.org/project/60076-16.html>

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

~~This part of IEC 60076 is intended to specify the additional requirements for the transformers for installation in wind turbine applications.~~

~~Wind turbines use generator step-up transformers to connect the turbines to a network. These transformers can be installed in the nacelle or in the tower or outside close to the wind turbine.~~

~~This standard covers transformers for wind turbine applications or wind farms where the constraints on transformers exceed the requirement of the present IEC 60076 series. The constraints are not often known or recognized by the transformer manufacturers, wind turbine manufacturers and operators and as a result the level of reliability of these transformers can be lower than those used for conventional applications.~~

~~The transformers for wind turbine applications are not included in the present list of IEC 60076 standard series.~~

~~The purpose of this standard is help to obtain the same level of reliability as transformers for more common applications.~~

~~This standard deals particularly with the effects of repeated high frequency transient over-voltages, electrical, environmental, thermal, loading, installation and maintenance conditions that are specific for wind turbines or wind farms.~~

~~On site measurements, investigations and observations in wind turbines have detected risks for some different kind of installations:~~

- ~~— repeated high frequency transient over or under voltages in the range of kHz;~~
- ~~— over and under frequency due to turbine control;~~
- ~~— values of over voltage;~~
- ~~— over voltage or under voltage coming from LV side;~~
- ~~— high level of transient over voltages due to switching;~~
- ~~— presence of partial discharge around the transformer;~~
- ~~— harmonic contents current and voltage;~~
- ~~— overloading under ambient conditions;~~
- ~~— fast transient overload;~~
- ~~— clearances not in compliance with the minimum prescribed;~~
- ~~— installation conditions and connections;~~
- ~~— restricted conditions of cooling;~~
- ~~— water droplets;~~
- ~~— humidity levels that exceed the maximum permissible values;~~
- ~~— salt and dust pollution and extreme climatic conditions;~~
- ~~— high levels of vibration;~~
- ~~— mechanical stresses.~~

~~Therefore it is necessary to take into account in the design of the transformer the constraints of this application, or to define some protective devices to protect the transformer. Additional or improved routine, type or special tests for these transformers have to be specified to be in compliance with the constraints on the network.~~

POWER TRANSFORMERS –

Part 16: Transformers for wind turbine applications

1 Scope

This part of IEC 60076 applies to dry-type and liquid-immersed transformers for ~~rated power 100 kVA up to 10 000 kVA for~~ wind turbine step-up applications having a winding with highest voltage for equipment up to and including ~~36 72,5 kV and at least one winding operating at a voltage greater than 1,1 kV~~. This document applies to the transformer used to connect the wind turbine generator to the wind farm power collection system or adjacent distribution network and not the transformer used to connect several wind turbines to a distribution or transmission network.

Transformers covered by this document comply with the relevant requirements prescribed in the IEC 60076 standards or IEEE C57 standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1 IEC references

IEC 60076-1:~~2011~~, *Power transformers – Part 1: General*

IEC 60076-2:~~2011~~, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3:~~2000~~, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-5:~~2006~~, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-7:~~2005~~, *Power transformers – Part 7: Loading guide for mineral-oil-immersed power transformers*

~~IEC 60076-8:1997, Power transformers – Application guide~~

IEC 60076-11:~~2004~~, *Power transformers – Part 11: Dry-type transformers*

IEC 60076-12:~~2008~~, *Power transformers – Part 12: Loading guide for dry-type power transformers*

~~IEC 60076-13:2006, Power transformers – Part 13: Self-protected liquid-filled transformers~~

IEC 60076-14, *Power transformers – Part 14: Liquid-immersed power transformers using high-temperature insulating materials*

~~IEC 61100, Classification of insulating liquids according to fire-point and net calorific value~~

IEC 61378-1:~~2014~~, *Converter transformers – Part 1: Transformers for industrial applications*

~~IEC 61378-3:2006, *Converter transformers – Part 3: Application guide*~~

~~IEC 61400-1:2005, *Wind turbines – Part 1: Design requirements*~~

2.2 IEEE references

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

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

IEEE Std C57.12.80™, *IEEE Standard Terminology for Power and Distribution Transformers*

IEEE Std C57.91™, *IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators*

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

IEEE Std C57.110™, *IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents*

IEEE Std C57.154™, *IEEE Standard for the Design, Testing, and Application of Liquid-Immersed Distribution, Power, and Regulating Transformers Using High-Temperature Insulation Systems and Operating at Elevated Temperatures*

ANSI C84.1, *Electric Power Systems and Equipment – Voltage Ratings (60 Hz)*

2.3 ISO references

ISO 12944 (all parts), *Paints and varnishes – Corrosion protection of steel structures by protective paint systems*

ISO 12944-4, *Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 4: Types of surface and surface preparation*

2.4 CENELEC references

EN 50588-1:2015, *Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV – Part 1: General requirements*



IEEE

IEC/IEEE 60076-16

Edition 2.0 2018-09

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