

TECHNICAL SPECIFICATION



Power transformers – **STANDARD PREVIEW**
Part 23: DC magnetic bias suppression devices
(standards.iteh.ai)

IEC TS 60076-23:2018

<https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC STANDARD PREVIEW
(standards.iteh.ai)

TECHNICAL SPECIFICATION



Power transformers –
Part 23: DC magnetic bias suppression devices

STANDARD PREVIEW
(standards.iteh.ai)

<https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.180

ISBN 978-2-8322-5228-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

| | |
|---|----|
| FOREWORD..... | 5 |
| INTRODUCTION..... | 7 |
| 1 Scope..... | 8 |
| 2 Normative references | 8 |
| 3 Terms and definitions | 8 |
| 4 Service conditions | 9 |
| 4.1 General..... | 9 |
| 4.2 Seismic conditions | 10 |
| 4.3 Unusual conditions..... | 10 |
| 5 Selection principle | 10 |
| 5.1 Classification and features of the devices | 10 |
| 5.2 Selection principle for DC current-limiting devices..... | 10 |
| 5.3 Selection principle for the DC current- blocking device..... | 11 |
| 5.4 Calculation and verification | 11 |
| 6 DC current-limiting device..... | 11 |
| 6.1 Functional requirements..... | 11 |
| 6.1.1 General | 11 |
| 6.1.2 Resistance | 11 |
| 6.1.3 Overvoltage protection..... | 12 |
| 6.1.4 Structure | 12 |
| 6.2 Ability to withstand effects of short-circuit current | 12 |
| 6.2.1 Ability to withstand thermal effects of short-circuit current | 12 |
| 6.2.2 Ability to withstand dynamic effects of short-circuit current | 12 |
| 6.3 Temperature rise | 13 |
| 6.3.1 Metal chip resistors | 13 |
| 6.3.2 Dry-type non-inductive epoxy-resin insulated resistors | 13 |
| 6.3.3 Other types of resistors | 13 |
| 6.4 Insulation level..... | 13 |
| 7 DC current-blocking device..... | 13 |
| 7.1 Functional requirements..... | 13 |
| 7.1.1 General | 13 |
| 7.1.2 Capacitance | 13 |
| 7.1.3 Bypass switches | 14 |
| 7.1.4 Function of device | 14 |
| 7.1.5 Structure | 14 |
| 7.2 Ability to withstand effects of short-circuit current | 15 |
| 7.2.1 Ability to withstand thermal effects of short-circuit current | 15 |
| 7.2.2 Ability to withstand dynamic effects of short-circuit current | 15 |
| 7.3 Temperature rise | 15 |
| 7.4 Insulation level..... | 15 |
| 8 Tests | 15 |
| 8.1 Test classification | 15 |
| 8.2 Routine tests..... | 16 |
| 8.2.1 General | 16 |
| 8.2.2 Visual inspection | 16 |
| 8.2.3 DC resistance measurement..... | 16 |

| | | |
|-----------------------|---|----|
| 8.2.4 | Capacitance measurement | 16 |
| 8.2.5 | Insulation resistance measurement..... | 16 |
| 8.2.6 | Withstand voltage test | 16 |
| 8.2.7 | Gap discharge test | 17 |
| 8.2.8 | Function check of DC current- blocking devices..... | 17 |
| 8.3 | Type tests | 17 |
| 8.3.1 | General | 17 |
| 8.3.2 | Temperature rise test of DC current-limiting device | 17 |
| 8.3.3 | Thermal stability test | 18 |
| 8.3.4 | Dynamic stability test..... | 18 |
| 8.3.5 | Lightning impulse test..... | 18 |
| 8.3.6 | Ingress protection test | 18 |
| 9 | Packing, transportation and storage requirements | 18 |
| 10 | Nameplate specification..... | 18 |
| 11 | Technical documentation requirements..... | 19 |
| Annex A (informative) | Generation mechanism of DC bias current of power transformers caused by HVDC system | 20 |
| Annex B (informative) | Examples of harmful effects of DC bias current | 21 |
| Annex C (informative) | DC current-limiting device | 24 |
| Annex D (informative) | DC current-blocking device | 25 |
| Annex E (informative) | Information needed to calculate the DC bias current of transformers | 26 |
| E.1 | General..... | 26 |
| E.2 | Information of grounding electrode of HVDC system | 26 |
| E.3 | Parameters of equipment in substations and converter stations | 26 |
| E.4 | Parameters of power transmission lines | 26 |
| Annex F (informative) | Methods of calculation of DC bias current..... | 27 |
| F.1 | Method based on modelling of underground electric field | 27 |
| F.2 | Method based on calculation model of resistor network with equivalent voltage sources..... | 28 |
| Annex G (informative) | Application examples | 30 |
| Figure A.1 | – Schematic diagram of DC flowing path in the monopole ground return mode | 20 |
| Figure A.2 | – Resistance network and ground electric field distribution | 20 |
| Figure B.1 | –Mechanism of DC bias | 21 |
| Figure B.2 | – Damage to transformer | 23 |
| Figure C.1 | – Electrical schematic diagram of DC current-limiting device | 24 |
| Figure D.1 | – Electrical schematic diagram of DC current-blocking device | 25 |
| Figure F.1 | – Schematic diagram of modelling for DC bias current calculation..... | 28 |
| Figure F.2 | – Ground potential around the grounding electrode of HVDC system | 28 |
| Figure F.3 | – Schematic diagram for calculation of DC bias current based on the equivalent voltage source | 29 |
| Table 1 | – Test items | 15 |
| Table 2 | – Rated insulation level (kV)..... | 16 |
| Table B.1 | – Test results of DC bias influence on DC system | 22 |

Table B.2 – Vibration data of transformer (mm/s)..... 23
Table F.1 – The resistivity and thickness of layered soil..... 27
Table G.1 – Test data of DC current, noise and vibration 30
Table G.2 – Test data 31

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[IEC TS 60076-23:2018](https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018)

<https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER TRANSFORMERS –

Part 23: DC magnetic bias suppression devices

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 60076-23, which is a technical specification, has been prepared by IEC technical committee 14: Power transformers.

The text of this technical specification is based on the following documents:

| | |
|---------------|------------------|
| Enquiry draft | Report on voting |
| 14/924/DTS | 14/943/RVDTS |

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

iTeh STANDARD PREVIEW
(standards.iteh.ai)

A bilingual version of this publication may be issued at a later date.

[IEC TS 60076-23:2018](#)

<https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018>

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

In some cases, abnormal direct current (DC) is introduced into the AC power network and has adverse effects upon neutral grounded power apparatuses such as power transformers.

- Case 1

Direct current flows into the AC power network through grounded neutral points of transformers when an HVDC transmission system operates in monopole ground return mode or in bipolar unbalanced mode.

- Case 2

Quasi-DC is induced in the AC power network by geo-magnetically induced current (GIC) during the period of a solar magnetic storm.

- Case 3

Electric traction locomotives and some large capacity power electronic equipment may cause DC current in AC power network.

DC current flowing through transformer windings may cause DC magnetic bias of the transformers, presenting a safety risk for both the transformers and the power system. The mechanism and harmful effects of DC bias are shown in Annex A and Annex B.

Two techniques for suppressing the transformer DC bias current are presented in this document, respectively to limit or block the transformer bias current produced by the HVDC transmission system.

The two techniques can also be used to suppress transformer DC bias caused by GIC, electric traction locomotives and some large capacity power electronic equipment. However, these issues are not included in this document due to their complexity.

This document defines the technical requirements for the two types of DC current suppression devices that are connected to neutral points of power transformers and converter transformers.

POWER TRANSFORMERS –

Part 23: DC magnetic bias suppression devices

1 Scope

This document specifies requirements for devices for the suppression of DC magnetic bias of power transformers and converter transformers. It includes requirements for service conditions, structures, testing, packing, transport and storage.

The devices are connected to neutral points of power transformers and converter transformers to suppress DC bias current in the case an HVDC system is operated in monopole ground return mode or bipolar unbalanced mode. In the case of dedicated metallic return HVDC system, the devices are useful to mitigate DC stray current flowing through power transformers and converter transformers during transient conditions such as DC line fault.

This document applies to DC magnetic bias suppression devices for operation at frequencies of 50 Hz and 60 Hz on power systems having voltages above 110 kV.

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.

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-3-3, *Environmental testing – Part 3-3: Guidance – Seismic test methods for equipments*

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 60137, *Insulated bushings for alternating voltages above 1000 V*

IEC 60168, *Tests on indoor and outdoor post insulators of ceramic material of glass for systems with nominal voltages greater than 1000V*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61071, *Capacitors for power electronics*

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

DC magnetic bias suppression device

electric device connected between the transformer neutral point and the earth to limit or to block the DC bias current flowing through the transformer windings

3.2

DC current-limiting device

electric device connected between the transformer neutral point and the earth to limit the DC bias current flowing through the transformer windings

Note 1 to entry: It normally consists of a resistor and a protection gap. For more information, see Annex C.

3.3

DC current- blocking device

electric device connected between the transformer neutral point and the earth to block the DC bias current flowing through the transformer windings

Note 1 to entry: It normally consists of a capacitor, a mechanical bypass switch, a high speed bypass switch, AC and DC sensors, and control devices. For more information, see Annex D.

3.4

mechanical bypass switch (standards.iteh.ai)

mechanical switch connected in parallel to the capacitor in DC current-blocking device for the purpose of bypassing the capacitor persistently

<https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018>

3.5

high speed bypass switch

high speed switch connected in parallel to the capacitor in DC current-blocking device for the purpose of bypassing the capacitor quickly

3.6

DC bias current

DC current flowing through transformer windings which causes drift of the excitation characteristic curve of transformer

4 Service conditions

4.1 General

This document gives detailed requirements for the DC current-limiting or blocking devices under the following conditions.

a) Altitude

Height above sea-level not exceeding 1 000 m (3 300 ft).

b) Climate conditions

- Maximum ambient temperature: +40 °C.
- Minimum ambient temperature: –25 °C.
- Maximum daily temperature difference: 25 °C.
- Maximum relative outdoor humidity: 90 % at 40 °C.

- Maximum wind speed: 35 m/s.
- Ice thickness: 10 mm.
- Sunshine intensity: $\leq 1\,000\text{ W/m}^2$ (wind speed of 0,5 m/s).

4.2 Seismic conditions

Devices for operation under seismic conditions shall be qualified in accordance with IEC 60068-3-3, subject to agreement between the manufacturer and the purchaser.

4.3 Unusual conditions

Any unusual service conditions, which can lead to special consideration in the design of the device, shall be stated in the inquiry and order. These can be factors such as high altitude, extreme high or low temperatures, tropical humidity, severe contamination. They can also concern conditions for shipment, storage and installation, such as weight or space limitation.

5 Selection principle

5.1 Classification and features of the devices

DC magnetic bias suppression devices can be installed at the neutral points of the transformers to suppress the DC bias current. These devices are divided into two categories: DC current-limiting devices and DC current-blocking devices.

Resistor-type DC current-limiting devices limit the DC current flowing through transformer windings by increasing the resistance between neutral points of transformers and earth, without completely blocking the DC current. The installation of such a device at one substation has little effect on the DC current flowing through transformer windings in other substations.

<https://standards.iteh.ai/catalog/standards/sist/a7ddaa2e-2bdc-4e28-bd44-cd770a39d63d/iec-ts-60076-23-2018>

Capacitor-type DC current-blocking devices completely block the DC current from flowing through the transformer windings when connected between neutral points of transformers and earth. The installation of such a device changes the distribution of DC current flowing in the earth and through transformer windings in other substations.

5.2 Selection principle for DC current-limiting devices

To determine the resistance, capacity and other electrical properties of the DC current limiting devices, several factors shall be taken into consideration. These factors include the tolerance of the transformers to magnetic bias current, the short-circuit current level of the grid, the insulation level of the neutral points, and the simulation result of the effect of installing current-limiting devices.

In addition to selecting the appropriate resistance, the protection configuration of transformers shall be assessed, to verify their compatibility with the resistor type DC current-limiting devices.

Normally, no relay protection is required for DC current-limiting devices. However, an overvoltage protection unit shall be included.

In the case where both short-circuit current and DC bias current need to be suppressed, the serially connected reactor and resistor shall be used as the current-limiting component of the device.