

TECHNICAL SPECIFICATION



Electrical insulating materials and systems – Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses

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

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

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Measurement of partial discharge pulses during repetitive, short rise-time voltage impulses and comparison with power frequency	9
4.1 Measurement frequency.....	9
4.2 Measurement quantities	9
4.3 Test objects	10
4.3.1 General	10
4.3.2 Inductive test objects	10
4.3.3 Capacitive test objects.....	10
4.3.4 Distributed impedance test objects	10
4.4 Voltage impulse generators.....	10
4.4.1 General	10
4.4.2 Voltage impulse waveforms	11
4.5 Effect of testing conditions	11
4.5.1 General	11
4.5.2 Effect of environmental factors	12
4.5.3 Effect of testing conditions and ageing	12
5 PD detection methods	12
5.1 General.....	12
5.2 PD pulse coupling and detection devices	12
5.2.1 Introductory remarks	12
5.2.2 Coupling capacitor with multipole filter	13
5.2.3 HFCT with multipole filter.....	14
5.2.4 Electromagnetic couplers.....	15
5.2.5 Electromagnetic UHF antennae	15
6 Measuring instruments	16
7 Sensitivity check of the PD measuring equipment and high voltage source generator.....	16
7.1 General.....	16
7.2 Test diagram for sensitivity check	16
7.3 PD detection sensitivity check.....	17
7.4 Background noise check	17
7.5 Detection system and HVIG noise check.....	17
7.6 Sensitivity report.....	17
8 Test procedure for increasing and decreasing the repetitive impulse voltage magnitude	18
9 Test report.....	19
Annex A (informative) Voltage impulse suppression required by the coupling device	20
Annex B (informative) PD pulses extracted from a supply voltage impulse through filtering techniques.....	22
Annex C (informative) Results of round-robin tests of RPDIV measurement.....	24
Annex D (informative) Examples of noise levels of practical PD detectors.....	26

Bibliography.....	27
Figure 1 – Coupling capacitor with multipole filter	13
Figure 2 – Example of voltage impulse and ideal PD pulse frequency spectra before and after filtering.....	14
Figure 3 – HFCT between supply and test object with multipole filter	14
Figure 4 – HFCT between test object and earth with multipole filter	15
Figure 5 – Circuit using an electromagnetic coupler (e.g. an antenna) to suppress impulses from the test supply.....	15
Figure 6 – Circuit using an electromagnetic UHF antenna	16
Figure 7 – Test diagram for sensitivity check	17
Figure 8 – Example of relation between the outputs of LVPG and PD detector.....	18
Figure 9 – Example of increasing and decreasing the impulse voltage magnitude	19
Figure A.1 – Example of overlap between voltage impulse and PD pulse spectra (dotted area).....	20
Figure A.2 – Example of voltage impulse and PD pulse spectra after filtering	20
Figure A.3 – Example of impulse voltage damping as a function of impulse voltage magnitude and rise time.....	21
Figure B.1 – Power supply waveform and recorded signal using an antenna during supply voltage commutation.....	22
Figure B.2 – Signal detected by an antenna from the record of Figure B.1, using a filtering technique (400 MHz high-pass filter)	23
Figure B.3 – Characteristic of the filter used to pass from Figure B.1 to Figure B.2	23
Figure C.1 – Sequence of negative voltage impulses used for RRT	24
Figure C.2 – PD pulses corresponding to voltage impulses	25
Figure C.3 – Dependence of normalized RPDIV on 100 data (NRPDIV/100) on relative humidity	25
Table 1 – Example of parameter values of impulse voltage waveform without load	11
Table D.1 – Examples of bandwidths and noise levels for practical PD sensors	26

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL INSULATING MATERIALS AND SYSTEMS –
ELECTRICAL MEASUREMENT OF PARTIAL DISCHARGES (PD)
UNDER SHORT RISE TIME AND REPETITIVE VOLTAGE IMPULSES**

FOREWORD

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IEC TS 61934 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is a Technical Specification.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) background information on the progress being made in the field of power electronics including the introduction of wide band gap semiconductor devices has been added to the Introduction;
- b) voltage impulse generators; the parameter values of the voltage impulse waveform have been modified to reflect application of wide band gap semiconductor devices.
- c) PD detection methods; charge-based measurements are not described in this third edition nor are source-controlled gating techniques to suppress external noise.

- d) Since the previous edition in 2011, there have been significant technical advances in this field as evidenced by several hundreds of publications. Consequently, the Bibliography in the 2011 edition has been deleted in this third edition.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
112/578/DTS	112/610/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

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INTRODUCTION

Power electronics has been developed along with both control theory and semiconductor technology. Switching is one of the essential features of power electronics control. For higher efficiency and smoother operation, switching times of devices such as an insulated-gate bipolar transistor (IGBT) tend to be shorter than microseconds. The introduction of wide band gap devices, such as those based on silicon carbide, can result in transients with rise times of the order of a few tens of nanoseconds. Such a short rise time can cause transient overvoltage impulses or surges in systems. When the voltage impulses reach the breakdown strength of an air gap, partial discharge (PD) can occur. In addition, the impulses are repetitive from power electronics modulation such as pulse width modulation (PWM). Since PD can cause degradation of electrical insulation parts in the system, it is one of the most important parameters to be measured.

The first edition of IEC TS 61934 was issued in April 2006. Because of rapid development in this field, the revision activity for the latest information was approved by TC 112 at their Berlin meeting in September 2006. The second edition of IEC TS 61934 was published in 2011. Owing to further advances in this area, a revision of the second edition was commenced formally in 2019 and has resulted in this third edition.

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ELECTRICAL INSULATING MATERIALS AND SYSTEMS – ELECTRICAL MEASUREMENT OF PARTIAL DISCHARGES (PD) UNDER SHORT RISE TIME AND REPETITIVE VOLTAGE IMPULSES

1 Scope

This document is applicable to the off-line electrical measurement of partial discharges (PDs) that occur in electrical insulation systems (EISs) when stressed by repetitive voltage impulses generated from power electronics devices.

Typical applications are EISs belonging to apparatus driven by power electronics, such as motors, inductive reactors, wind turbine generators and the power electronics modules themselves.

NOTE Use of this document with specific products can require the application of additional procedures.

Excluded from the scope of this document are

- methods based on optical or ultrasonic PD detection,
- fields of application for PD measurements when stressed by non-repetitive impulse voltages such as lightning impulse or switching impulses from switchgear.

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.

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IEC 60270, *High-voltage test techniques – Partial discharge measurements*

3 Terms and definitions

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

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

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

3.1

repetitive voltage impulse

voltage impulse which is used as test voltage for the evaluation of switching surges from power electronics devices with a carrier or driven frequency

3.2

partial discharge

PD

localized electric discharge that only partially bridges the insulation between conductors and which can or cannot occur adjacent to a conductor

3.3

partial discharge pulse

current pulse in an object under test that results from a partial discharge occurring within the object under test

Note 1 to entry: The pulse is measured using suitable detector circuits, which have been introduced into the test circuit for the purpose of the test.

Note 2 to entry: A detector in accordance with the provisions of this document produces a current or a voltage signal at its output related to the PD pulse at its input.

[SOURCE: IEC 60270, 3.2, modified – “or voltage” has been deleted, the second part of the definition has been included in Note 1 to entry and Note 2 to entry has been revised.]

3.4

RPDIV

repetitive partial discharge inception voltage

minimum peak-to-peak impulse voltage at which more than five PD pulses occur on ten voltage impulses of the same polarity

Note 1 to entry: The RPDIV is a mean value for the specified test time and a test arrangement where the voltage applied to the test object is gradually increased from a value at which no partial discharges can be detected. Further explanation is mentioned in 8.

3.5

RPDEV

repetitive partial discharge extinction voltage

maximum peak-to-peak impulse voltage at which less than five PD pulses occur on ten voltage impulses of the same polarity

Note 1 to entry: The RPDEV is a mean value for a specified test time and a test arrangement where the voltage applied to the test object gradually decreases from a voltage at which PDs have been detected. Further explanation is mentioned in Clause 8.

3.6

impulse voltage polarity

polarity of the applied impulse voltage with respect to earth

3.7

unipolar impulse

repetitive voltage impulse, the polarity of which is either positive or negative

[SOURCE: IEC 62068:2013, 3.11, modified – “repetitive” has been added.]

3.8

bipolar impulse

repetitive voltage impulse, the polarity of which changes from positive to negative or vice versa

3.9

impulse voltage repetition rate

inverse of the average time between successive impulses of the same polarity, whether unipolar or bipolar

3.10

impulse rise time

time for the voltage to rise from 10 % to 90 %

3.11

impulse decay time

time interval between the instants at which the instantaneous value of an impulse decreases from a specified upper value to a specified lower value

Note 1 to entry: Unless otherwise specified, the upper and lower values are fixed at 90 % and 10 % of the impulse magnitude.

3.12

impulse width

interval of time between the first and last instants at which the instantaneous value of an impulse reaches a specified fraction of impulse magnitude or a specified threshold

3.13

impulse duty cycle

ratio, for a given time interval, of the impulse width to the total time

3.14

peak partial discharge magnitude

largest magnitude of any quantity related to PD pulses observed in a test object at a specified voltage following a specified conditioning and test

Note 1 to entry: For impulse voltage tests, the peak magnitude of the PD pulse is the largest repeatedly occurring PD magnitude.

[SOURCE: IEC 60270, 3.4, modified – In the term “largest repeatedly occurring” has been replaced with “peak”, the definition has been revised and the Note to entry has been added.]

4 Measurement of partial discharge pulses during repetitive, short rise-time voltage impulses and comparison with power frequency

4.1 Measurement frequency

IEC 60270 describes the methods employed to measure the electrical pulses associated with PD in test objects excited by DC and alternating voltages up to 400 Hz. The methods used to measure PD pulses when the test object is subjected to supply voltage impulses shall be modified from the standard narrow-band and wide-band frequency methods described in IEC 60270.

To measure the PD during repetitive short rise time voltage impulses, it is necessary to avoid the induced current of the impulse voltage. One technique is current or electromagnetic wave measurement at ultra-high frequency, that is, higher than the frequency components associated with the impulse. Ultra-wide band (UWB) detection is often used with a high-pass filter for the suppression of the relatively lower frequency components of the impulse voltage. In principle, narrow-band measurement in the ultra-high frequency (UHF: 300 MHz to 3 GHz) region is also effective for the suppression of the impulse voltage. Partial discharge measurement methods in this frequency range are described in IEC TS 62478.

NOTE Measurements in accordance with IEC TS 62478 cannot be calibrated in relation to apparent charge in pC, so a direct value-based comparison to measurements in accordance with IEC 60270 is not possible.

4.2 Measurement quantities

Measured quantities concern the RPDIV, the RPDEV, the peak partial discharge magnitude and partial discharge pulse repetition rate.

The RPDIV and RPDEV can depend on PD measurement sensitivity and measurement circuit noise, therefore normalization, as indicated in Clause 7, is necessary. Moreover, they depend on the test object and the pulse deformation from the discharge site to the measurement point.

In this document, and consistent with IEC TS 62478, PD readings are reported in units of mV. In all cases, a sensitivity evaluation of the measuring system is necessary and shall be carried out according to Clause 7.