TECHNICAL SPECIFICATION

IEC TS 61934

First edition
2006-04

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

Reference number
IEC/TS 61934:2006(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/online_news/ justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

TECHNICAL SPECIFICATION

IEC TS 61934

First edition
2006-04

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

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE S

For price, see current catalogue

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.

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 61934, which is a technical specification, has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems[1].

[1] Provisional title.

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

Enquiry draft	Report on voting
112/13/DTS	112/25/RVC

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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

1 Scope

This Technical Specification is applicable to the off-line electrical measurement of partial discharges (PD) that occur in electrical insulation systems (EIS) when stressed by repetitive voltage impulses having a rise time of 50 µs or less.

Typical applications are EIS belonging to apparatus driven by power electronics, such as motors.

NOTE 1 Use of this document with specific products may require specification of additional procedures.

NOTE 2 Those described in the TS are emerging technologies, so that experience and cautions, as well as certain preconditions, are needed to apply this TS.

Excluded are

– methods based on optical or ultrasonic PD detection,

– fields of application for PD measurements when stressed by non-repetitive impulse voltages.

2 Normative references

The following referenced documents are indispensable for the application 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 60270:2000, *High voltage test techniques – Partial discharge measurements*

IEC 62068-1:2003, *Electrical insulation systems – Electrical stresses produced by repetitive impulses – Part 1: General method of evaluation of electrical endurance*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply, some of which are taken from IEC 60270 and IEC 62068-1.

3.1
repetitive voltage impulses
impulses that occur when switching of power electronic devices at a carrier or driven frequency

3.2
partial discharge
PD
electric discharge that only partially bridges the insulation between conductors

[IEC 60270:2000, Definition 3.1, modified]

3.3
partial discharge pulse
PD pulse
current or voltage pulse at the terminal of the object under test that results from a partial discharge occurring within the object under test

NOTE The pulse is measured using suitable detector circuits, which have been introduced into the test circuit for the purpose of the test.

A detector in accordance with the provisions of this technical specification produces a current or a voltage signal at its output related to the PD pulse at its input.

[IEC 60270:2000, Definition 3.2, modified]

3.4
repetitive partial discharge inception voltage
RPDIV
minimum peak-to-peak voltage at which partial discharges occur with a repetition rate of 1 or more PD pulses per every 2 voltage impulses

NOTE This 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.

3.5
repetitive partial discharge extinction voltage
RPDEV
maximum peak-to-peak voltage at which partial discharges occur with a repetition rate of less than 1 PD pulse per 2 voltage impulses

NOTE This 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 PD have been detected.

3.6
impulse voltage polarity
polarity of the applied impulse voltage, with respect to earth

[IEC 62068-1:2003, Definition 3.10]

3.7
unipolar impulse
repetitive voltage impulse, the polarity of which is either positive or negative

[IEC 62068-1:2003, Definition 3.8, modified]

NOTE The magnitude of the oscillation of the opposite polarity has to be less than 20 %.

3.8
bipolar impulse
repetitive voltage impulse, the polarity of which changes

[IEC 62068-1:2003, Definition 3.9, modified]

3.9
impulse voltage repetition rate
inverse of the average time between successive impulses of the same polarity, whether unipolar or bipolar

[IEC 62068-1:2003, Definition 3.11, modified]

3.10
PD pulse repetition rate
inverse of the average time between successive PD pulses of the same polarity

[IEC 62068-1:2003, Definition 3.11, modified]

3.11
impulse rise time
time for the voltage impulse to go from 0 % to 100 %

NOTE Unless otherwise stated, this is estimated as 1,25 times the time for the voltage to rise from 10 % to 90 %.

[IEC 62068-1:2003, Definition 3.12, modified]

3.12
rate of impulse voltage rise
impulse voltage magnitude divided by the rise time, defined in 3.11

3.13
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 Unless otherwise specified, the upper and lower values are fixed at 90 % and 10 % of the pulse magnitude.

3.14
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

3.15
impulse duty cycle
ratio, for a given time interval, of the impulse width to the total time

3.16
peak partial discharge magnitude
largest magnitude of any quantity related to PD pulses permitted in a test object at a specified voltage following a specified conditioning and test

[IEC 60270:2000, Definition 3.4 modified]

NOTE For impulse voltage tests, the peak magnitude of the PD pulse is the largest repeatedly occurring PD magnitude.

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 should normally 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, the detector circuit shall be of the ultra-wide band (UWB) type (see 4.6. of IEC 60270, i.e. >400 kHz), where the operating detection range is such that the exciting impulse voltage is strongly suppressed while the PD pulse is not significantly suppressed. IEC 60270 does not suggest specific ultra-wide band detection methods. For the purposes of this technical specification, specific detection methods are required. Types of couplers other than conventional capacitors are permitted in this document.

4.2 Measurement quantities

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

RPDIV and RPDEV may depend on PD measurement sensitivity and measurement circuit noise, so that normalization as indicated in Clause 7 is needed. Moreover, they depend on the test object and the pulse deformation from the discharge to the measurement point.

In this technical specification, PD readings are reported in units of mV. In any case, a sensitivity evaluation of the measuring system is necessary and should be carried out according to Clause 7.

4.3 Test objects

4.3.1 General

Test objects behave predominantly as inductive, capacitive or distributed equivalent impedances according to the voltage supply frequency content. For some test objects, whether they are predominantly inductive, capacitive or distributed may depend on the PD detection frequency range (not only on the voltage supply frequency). Test objects with distributed behaviour have transmission line characteristics which may cause attenuation and distortion of the PD pulses as the pulses propagate through the test object.

4.3.2 Inductive test objects

Types of inductive test objects may include

- stator and rotor windings;
- transformer windings;
- motorettes and formettes (see IEC 60034).

4.3.3 Capacitive test objects

Types of capacitive test objects may include

- twisted pairs of winding wire;
- capacitors;
- packaging of switching devices;
- power electronic modules and substrates;
- isolated heat sinks;
- mainwall insulation models in stator coils and bars;
- printed circuit boards;
- optocouplers.

4.3.4 Distributed test objects

The following test objects may have distributed equivalent impedance properties:

- cables;
- busbars;
- stator and rotor windings;
- transformer windings;
- turn insulation of stator and rotor windings.

4.4 Effect of testing conditions

4.4.1 General

PD pulses can occur during the rise time of a voltage impulse or the remaining period of the impulse. PD depends on the testing conditions, including supply voltage impulse, environmental factors, as well as from ageing extent. For this reason, comparative evaluations should be carried out using test circuits and generators having the same characteristics (see IEC 62068-1), and comparable environmental conditions. Measurement of PD quantities at different times during the service life of a test object can be used as a diagnostic technique to assess the degree of ageing of the insulation system and form the basis of condition-based maintenance procedures.

4.4.2 Effect of impulse voltage supply

The RPDIV, RPDEV and, in general, PD-associated quantities will depend upon specific features of the impulse waveform, for example the impulse rise time, the impulse decay time, the impulse repetition rate and the number of oscillations in the impulse. For the purpose of comparison between different insulating materials or design solutions, partial discharge measurements can be performed using standardized voltage supply waveforms (see IEC 62068-1). The appropriate impulse waveform can depend on the type of test object and the type of application. The specification of the impulse supply should include, amongst other factors,

- impulse rise time;
- impulse voltage polarity;
- impulse voltage repetition rate;
- impulse width;
- impulse duty cycle.

4.4.3 Effect of environmental factors

RPDIV, RPDEV and, in general, PD-associated quantities may be affected by the following factors:

- humidity;
- temperature;
- degree of contamination of the test object;
- atmospheric pressure;
- type of gas.

4.4.4 Effect of testing conditions and ageing

RPDIV, RPDEV and PD-associated quantities may be affected by

- previous voltage applications as well as the time between voltage applications,
- operation time or time under stress of the test object.

In addition, they may vary as ageing of the electrical insulation occurs, that is, during operation of the EIS.

5 PD detection methods

5.1 General

Any PD pulse detection system, where the test object is excited by voltage impulses, requires strong suppression of the residual voltage impulse, measured by the PD detection circuit, and negligible suppression of the PD pulse. The PD pulse shall have a magnitude after processing by the detection system that is greater than the residual transmitted voltage impulse. The amount of impulse voltage suppression required will be dependent on the test voltage and the rise time of the impulse.

As the impulse voltage increases in amplitude, greater suppression is required in order to ensure that important PD pulse magnitudes are higher than the residual transmitted voltage impulse on the output of the detector. Similarly, as the rise time of the applied impulse voltage becomes shorter, the suppression should be greater, due to the increased overlap of frequency spectra of supply impulse and PD pulse (see Annex A). PD pulse coupling devices shall be designed in order to ensure that important PD pulse magnitudes are higher than the residual transmitted voltage impulse on the output of the detector.

Annex A provides indications on the voltage impulse suppression action required by the coupling device. Suggestions for the amount of supply voltage impulse suppression needed as a function of impulse magnitude and rise time are given.

Examples of PD pulses extracted from a supply voltage impulse through filtering techniques are reported in Annex B.

5.2 PD pulse coupling and detection devices

5.2.1 Introductory remarks

PD current or voltage pulses in a test object can be detected either by means of high voltage capacitors, high frequency current transformers (HFCT) or electromagnetic couplers (e.g. antennas). The detectors, in conjunction with the rest of the measuring system, must be able to suppress the impulse voltage to a magnitude less than that expected from the PD pulse (using e.g. appropriate filters). The following circuits are applicable for PD pulse detection.

NOTE Since the voltage impulses and PD pulses contain high-frequency components, short, non-inductive earthing of the supply, the test object and the PD detector is required.

5.2.2 Coupling capacitor with multipole filter

A coupling capacitor with a voltage rating exceeding the expected applied impulse voltage, together with a filter that strongly attenuates the test voltage impulses, can be used. The filter should have at least three poles and special measures to inhibit cross coupling of the input signal to the output. The filter can be designed using passive or active filtering technology. The coupling capacitor is connected to the test object high-voltage terminal (Figure 1). Annex A shows a schematic example of filter behaviour. Figure 2 reports an example of frequency spectra of PD pulse and impulse voltage before and after filtering for an 8th order filter.

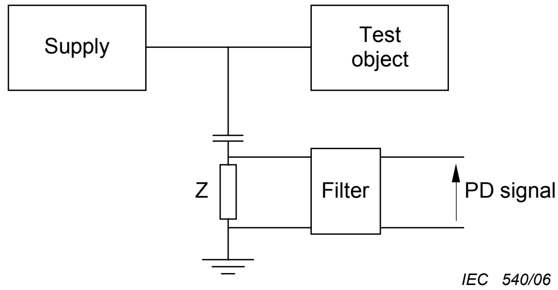


Figure 1 – Coupling capacitor with multipole filter

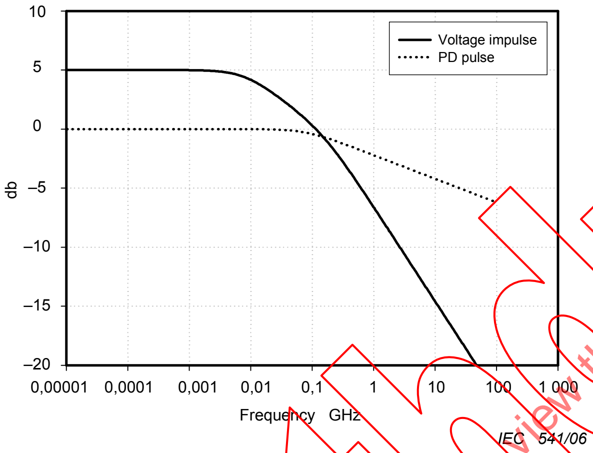


Figure 2a – Example of voltage impulse and PD pulse frequency spectra before filtering

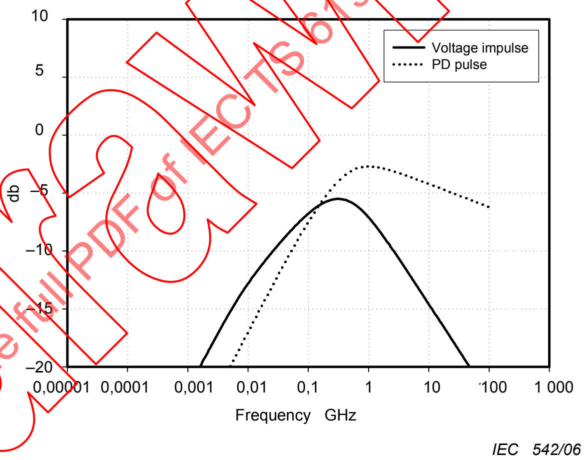


Figure 2b – Example of voltage impulse and PD pulse frequency spectra after filtering

NOTE Voltage rise time 50 ns, PD pulse rise time 2 ns, 8th order filter with filter cut-off frequency equal to 500 MHz.

Figure 2 – Example of voltage impulse and PD pulse frequency spectra before and after filtering

5.2.3 HFCT with multipole filter

An HFCT, together with a filter, can be used to detect PD pulses while suppressing the impulse voltage. Note that HFCTs may have a very wide range of upper cut-off frequencies that may affect the performance of this method. The HFCT should have higher cut-off frequency than voltage impulse frequency. The filter should have at least three poles and special measures to inhibit cross coupling of the input signal to the output. The filter can be implemented using passive or active filtering technology. The HFCT can be placed over the high-voltage cable between the impulse supply and the test object (Figure 3). In this case, the HFCT should have sufficient electrical insulation to ensure that breakdown between the cable and the HFCT does not occur. Alternatively, the HFCT can be connected between the test object and earth (Figure 4). Only mains voltage insulation is then required. The latter arrangement is effective, in general, only if the metallic enclosure of the test object can be isolated from earth. Annex A shows a schematic example of filter behaviour.

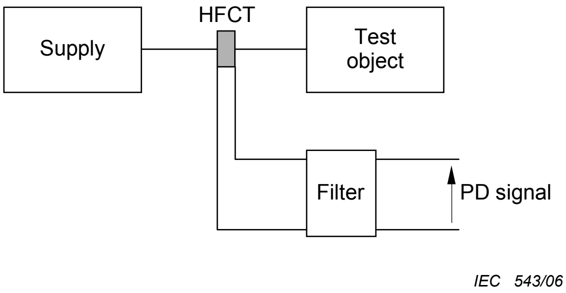


Figure 3 – HFCT with multipole filter

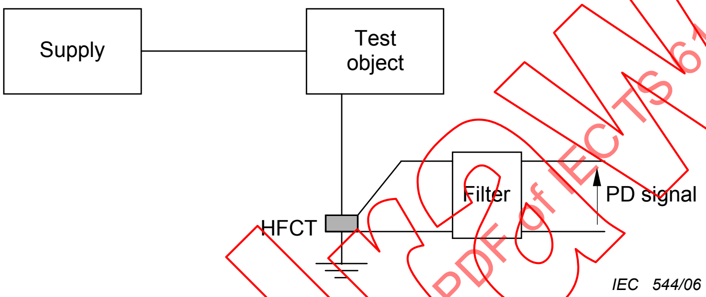


Figure 4 – HFCT between test object and earth with multipole filter

5.2.4 Electromagnetic couplers

Antenna type couplers can be used to separate impulses from the supply from PD originating in the test object (Figure 5).

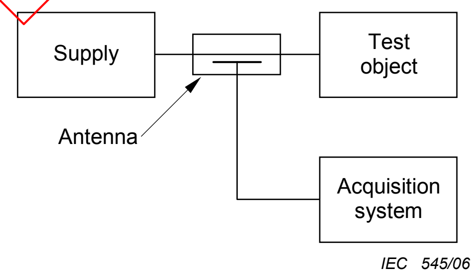


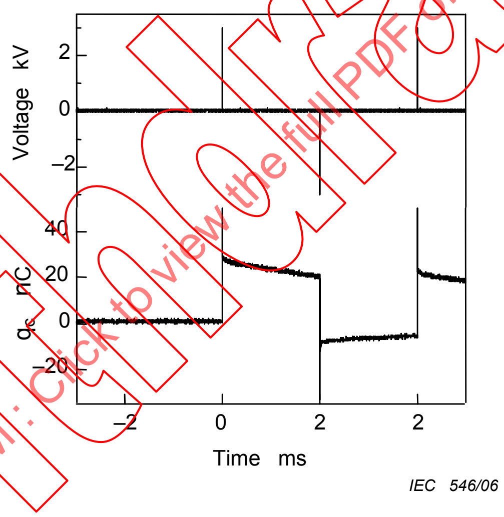
Figure 5 – Circuit using an electromagnetic coupler (for example an antenna) to suppress impulses from the supply

5.2.5 Charge measurements

For simple, unearthed capacitive test objects, such as twisted pairs (with equivalent capacitance C_s), it is possible to measure PD charge using both a detection capacitor with a capacitance C_d ($C_d >> C_s$) in series with the test object and a voltage detector with high input impedance R.

Charge is built on the detecting capacitor through the charging current due to impulse voltage rise. When impulse voltage decays to zero, capacitor charge is cancelled out by that of opposite charge. Consequently, without PD, the voltage of the detecting capacitor shows the same shape of the applied impulse voltage, with amplitude scaled by the ratio C_s/C_d. Once PD occurs during the impulse voltage, the PD charge decays to zero with the time constant RCd, where R is the impedance of the measuring system. When the time constant is selected long enough with respect to the impulse voltage duration, a charge decay can be observed after a single shot of impulse voltage. Figure 6 shows an experimental example of impulse voltage and accumulated charge for a twisted pair sample. The charge measurement is meaningful as a PD detection tool only if the voltage impulses are bipolar and identical for both polarities. The sensitivity of PD measurement depends on the background noise in the same way as for conventional PD measurement.

A scheme of the test circuit is shown in Figure 7.



NOTE Peak impulse voltage magnitude = 2,3 kV, impulse voltage frequency = 500 Hz.

Figure 6 – Example of waveforms of repetitive bipolar impulse voltage and charge accumulation for on twisted-pair sample

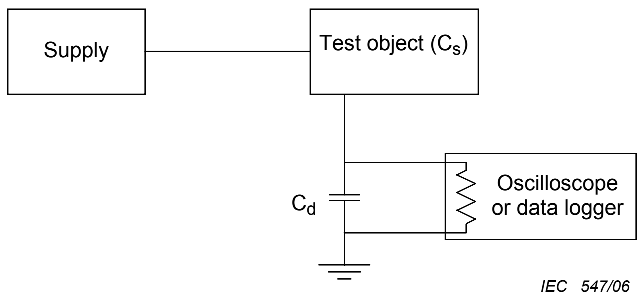


Figure 7 – Charge measurements

5.3 Source-controlled gating techniques

An alternative method to suppress the impulse voltage is to gate the PD signal electronically (from any of the above detectors) so that the signal is blocked from being displayed or registered for the duration of the initial portion of the short rse time of the impulse (Figure 8). With this method, any PD occurring during the initial part of the impulse rise time will not be detected. Hence, only PD occurring after the supply voltage commutation transient will be recorded.

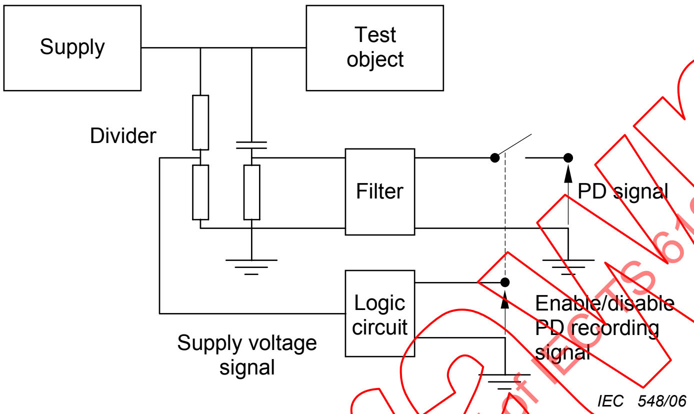


Figure 8 – Example of PD detection using electronic source-controlled gating (other PD coupling devices can be used)

6 Display methods

The results of a PD test are the RPDIV and RPDEV. In addition, the PD pulse repetition rate and the largest peak PD pulse magnitude at a specified test voltage as well as the test conditions should be measured. It should be pointed out that PD magnitude is only a relative measure of PD activity, seeing that PD pulses are attenuated and distorted when they travel from the source to the measurement point.

The PD signal output from the coupler and detection system can be recorded on a digital oscilloscope or pulse magnitude analyser. For oscillographic display, the PD output is normally displayed on one channel, while a reduced magnitude version of the applied impulse voltage is recorded on another channel (Annex A). The magnitudes of the PD pulses as well as the temporal position in which they occur with respect to the impulse voltage are recorded. Note that the retrigger rate of most oscilloscopes is limited to <50 per second, so that the majority of PD and voltage impulses may not be displayed.

Electronic pulse magnitude analysers can be used to measure the magnitude of the PD pulses and their repetition rate (see 4.4 of IEC 60270:2000).

7 Sensitivity of PD measurement

The RPDIV and RPDEV, as well as, in general, PD-associated quantities, depend on the sensitivity of the measuring system to PD and how well the PD pulses can be distinguished from other electrical interference or noise (such as the residual signal from the voltage impulse itself). Thus the sensitivity of the PD measuring system shall be assessed and recorded. The sensitivity is measured in mV.

NOTE 1 The PD is not measured in pC, since the procedure of IEC 60270 cannot be used for UWB PD detection systems (integration of the pulse current to yield the apparent charge cannot be performed as indicated in IEC 60270).

PD sensitivity and effect of noise may be assessed in steps, as follows:

Step 1: Sensitivity measurement

Measure the PD detector output with a suitable electronic impulse generator (which can be a low-voltage generator) connected to a capacitor having capacitance close to the test object. The impulse should have a rise time that is less than 1/*f*, where *f* is the upper frequency limit of the detection system. For example, if the upper cut-off frequency of the PD measurement system is 100 MHz, the electronic generator impulse rise time should be less than 10 ns. Measure the minimum impulse voltage at which the PD detector shows a detectable signal. This is, in mV, the sensitivity of the PD testing device.

Step 2: Background noise measurement

Connect the electronic pulse generator in parallel with the test object and the voltage impulse supply. The voltage impulse supply is not energized. Measure the output of the PD detector for the input voltage measured in step 1. Noise from the environment is thus measured, but interference from switching devices in the voltage impulse supply is excluded.

Step 3: Testing device noise measurement

If possible, replace the test object with a PD-free capacitance that has about the same high frequency capacitance as the test object. With the electronic pulse generator removed from the circuit, and the test object replaced with an equivalent high frequency PD free capacitance, energize the voltage impulse supply to the expected maximum test voltage. On the output of the PD detector, measure the magnitude of the interference from the voltage impulse supply in mV.

The maximum PD sensitivity in mV is the magnitude of the lowest amplitude detected pulses (in mV) from Step 1, while the minimum noise level (in mV) from either the environment (Step 2) or the interference from the impulse voltage supply (Step 3) is the highest measured under Step 2 or 3. Both noise and sensitivity levels shall be reported in the test report.

NOTE 2 Step 3 may not be feasible if appropriate capacitors are not available. In such cases, reference should be made to the results of Step 2.

For test objects having distributed equivalent impedance, such as motor and transformer windings, propagation effects of PD pulses may cause strong attenuation of the high-frequency components, thus only PD close to the measurement point may be observed.

8 Test circuits

Typical test circuits are shown in Figures 1 to 8. The impulse supply should be as physically close to the test object as possible, in order to prevent attenuation and dispersion of the applied impulse due to the equivalent transmission parameters of the connecting leads. Earth loops should be avoided.

The PD detector should be as close as possible to the test object, Since the PD is measured with a UWB detection system, earthing of the test object should be made directly to the impulse voltage supply, with leads as short as possible and with low inductance.

NOTE It is recommended that lead lengths should not exceed 1 m.

9 Test procedures

The background noise and detection limits shall first be measured using the procedures set out in Clause 7.

The RPDIV shall be measured using a stepwise procedure. The rate of voltage increase, and whether the increase will be in steps or linear, needs to be established. An example is to apply a voltage equal to 50 % of the expected RPDIV to the test object and to increase the voltage in 5 % steps every minute until RPDIV is detected. If required, the impulse voltage is then raised to the highest impulse voltage magnitude specified for the test. The maximum PD pulse magnitude at the peak impulse test voltage is then measured. The maximum impulse test voltage is then gradually reduced to a value at which partial discharges in the test arrangement display an average repetition rate less than 1 PD pulse for every 2 impulses (this value is the RPDEV). The PDIV measurement may be preceded by a conditioning procedure, if appropriate.

10 Test report

The following quantities should be reported typically:

- RPDIV, RPDEV;
- partial discharge pulse repetition rate;
- peak partial discharge magnitude;
- background noise level;
- sensitivity level of the measurement system (see Clause 7);
- maximum (peak-to-peak) test impulse voltage level;
- ambient temperature and humidity;
- operation time or time under stress of the test object;
- state of cleanliness of the test object (e.g. no cleaning, factory clean);
- the specifications of the impulse voltage reported in 4.4.2.

Annex A
(informative)

Indications on the voltage impulse suppression action required by the coupling device

A schematic example of the possible overlap of voltage impulse and PD pulse frequency spectra is shown in Figure A.1. The steeper the voltage impulse, the larger the overlap area between the two spectra. The cut-off frequency for an optimal voltage impulse suppression coupling device is indicated in Figure A.1. The action of a filter is displayed in Figure A.2. Impulse voltage and PD pulse magnitude are damped by the filter transfer function, $H(f)$ (being f frequency). The filter cut-off frequency should be selected in such a way that, after filtering, the PD signal magnitude prevails on voltage impulse magnitude within the bandwidth of the PD detector. A broadband PD detector is generally required for this purpose.

Suggestions regarding the extent of impulse voltage attenuation, as a function of voltage magnitude and rise time, are reported in Figure A.3. Note that attenuation depends on voltage impulse magnitude and rise time.

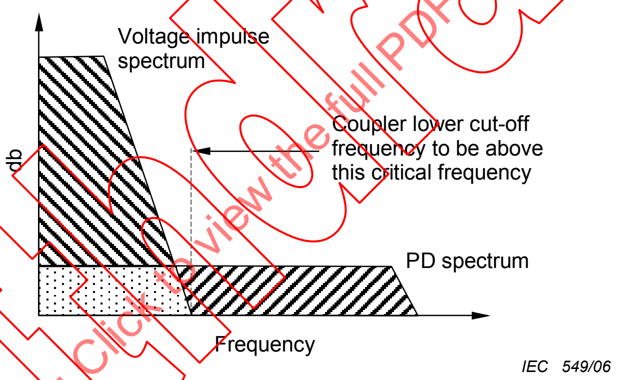


Figure A.1 – Schematic example of overlap between voltage impulse and PD pulse spectra (dotted area)

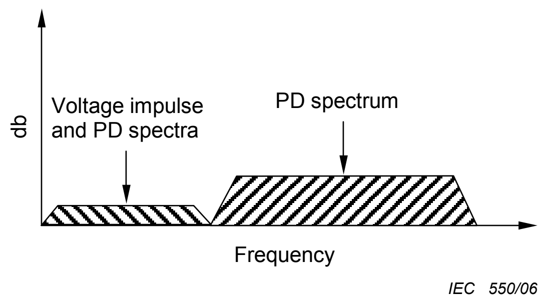


Figure A.2 – Schematic example of voltage impulse and PD pulse spectra after filtering