OSM/IN DECISION

Standard:	EN 61643 series EN 50539 series	**Sub clause:**	General instruction for residual voltage measurements	**Sheet N°:**	OSM/IN 288
Subject:	residual voltage measurements	**Key words:**	- residual voltage - limiting voltage - protection level - measurement techniques	**Meeting N°:** **Inquiry:**	28 (2018) OSM/IN(Inq)163_ 2018

Question: How shall the measurements for the determination of the residual voltage and measured limiting voltage be conducted to ensure comparable test results?

Proposal: To minimize the induced voltage and to give guidance to the test labs, it was agreed by OSM IN members to adopt the here below procedure which was developed by CLC TC37A WG1 at its meeting, on 28th February and 1st of March 2018 in Prague and which will be included as annex in the future edition of the EN/IEC 61643-1 standards.

Explanatory Notes:
Due to repetitive discussions between manufacturers, test labs and certification bodies the document and future

Background
Caused by different test results of identical SPDs in different test labs during the residual voltage measurement according to EN 61643, a test set-up to minimize the variation in test results of identical SPDs is created.
Practical experiences show that different test labs use different routings of the measurement lines and therefore create different loop sizes between the measurement lines and the device under test (DUT) that is applied with 8/20 current impulses and between the two measurement lines. Such loop also exists by using voltage probes. The loop size depends on the size of probe.
Technically it is known that the magnetic field of the 8/20 current induces a voltage into the loop between the two measurement lines. This voltage is added to the voltage drop between the terminals of DUT where the measurement lines are connected to. This induced voltage is proportional to the loop size and the peak value of the 8/20 current impulse and may have values of several 10 V up to some kV.
To minimize the induced voltage and to give guidance to the test labs the attached proposal of an interpretation sheet is given.

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Tests set-up to measure the residual voltage with 8/20 current impulses according to EN 61643 series

Informative annex

1 **Introduction**

Residual voltages measurements are very sensitive measurements due to the fact that they are carried out at high frequencies in presence of magnetic fields which may strongly interfere with the results of these measurements to such an extent that different measurements from one measurement to another one, or between different testing entities may not be comparable. This annex intends to provide guidelines on testing techniques for making correct residual voltages measurements to limit these deviations and discrepancies.

1 General

According to the induction law, an alternating magnetic field induces a voltage into a conductor loop. The induced voltage depends on the loop size and the frequency and the amount of magnetic field. The intensity of a magnetic field decreases with increasing distance to its source.

The residual voltage according to EN 61643 series is measured with 8/20 current impulses. The magnetic field generated by this 8/20 current impulse induces a voltage into the loop build up by the voltage measurement lines that are connected to the device under test. This voltage is added to the voltage drop between the two points where the measurement lines are connected to. This induced voltage depends on and is proportional to the size of the loop build by the voltage measurement lines and to the peak value of the 8/20 current impulse and may have values of several 10 V up to some kV. The wave shape of the induced voltage follows the derivative di/dt of the 8/20 current impulse and reaches its maximum at the beginning of the 8/20 current impulse. A zero crossing and therefore 0 V occurs at crest value of the 8/20 current impulse. A typical waveshape of the induced voltage is shown in Figure 1.

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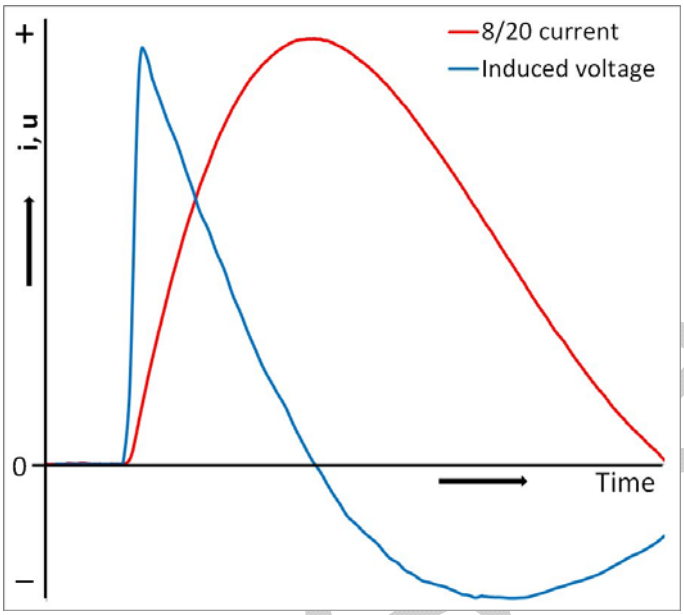

Figure 1 – 8/20 current impulse and induced voltage

In general, the test procedure to measure the residual voltage with 8/20 current impulses according to EN 61643 series requires the connection of the voltage measuring system as close as possible to the SPD. This is caused by the fact that a voltage drop occurs along the length of a conductor when a current flows through. This voltage drop also influences the measured voltage between the two points where the measurement lines are connected to.

To show the influence of the loop size of the voltage measurement lines and the voltage drop of the conductors to the test sample when the 8/20 current impulse flows, three test arrangements are assumed.

Test arrangement A is given in Figure 2 and shows a large loop size of the voltage measurement lines that are connected far from the test sample.

Test arrangement B is given in Figure 3 and shows a smaller loop size of the voltage measurement lines that are connected directly to the test sample.

Test arrangement C is given in Figure 4 and shows a loop size as small as possible of the voltage measurement lines that are twisted and connected directly to the test sample.

Figure 5 shows the measured voltage time behaviour of the test arrangements A, B and C during 8/20 current application when the device under test is a voltage limiting SPD.

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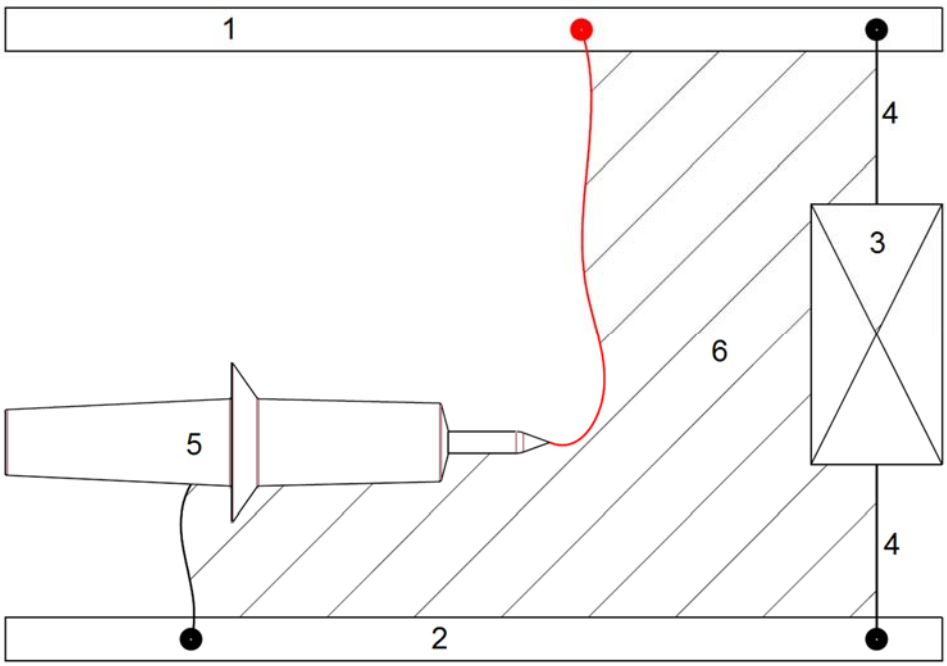

Key: 1 HV output terminal of impulse current generator
2 Ground terminal of impulse current generator
3 Device under test (SPD)
4 Conductor to connect the SPD to the impulse current generator
5 Voltage probe
6 Loop area created by the voltage measurement lines

Figure 2 – Test arrangement A

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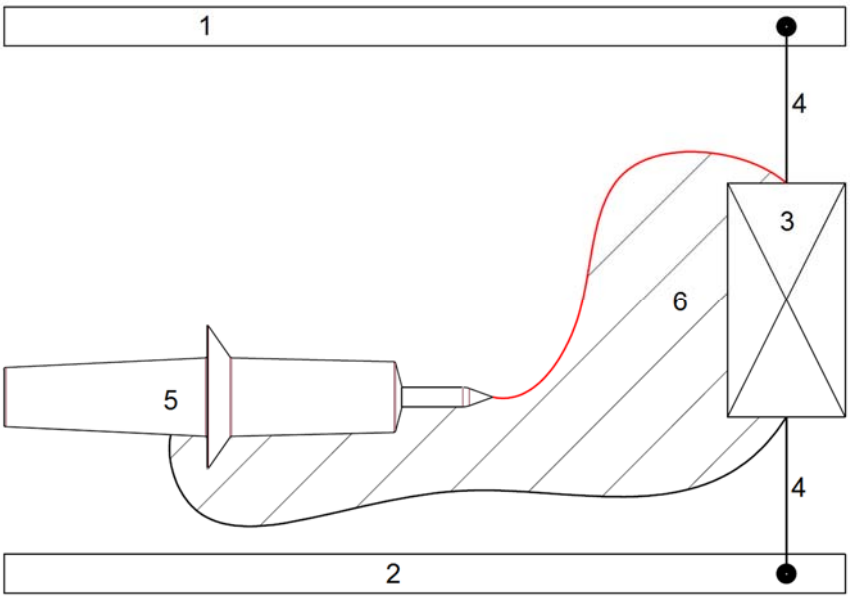

Key: 1 HV output terminal of impulse current generator
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4 Conductor to connect the SPD to the impulse current generator
5 Voltage probe
6 Loop area created by the voltage measurement lines

Figure 3 – Test arrangement B

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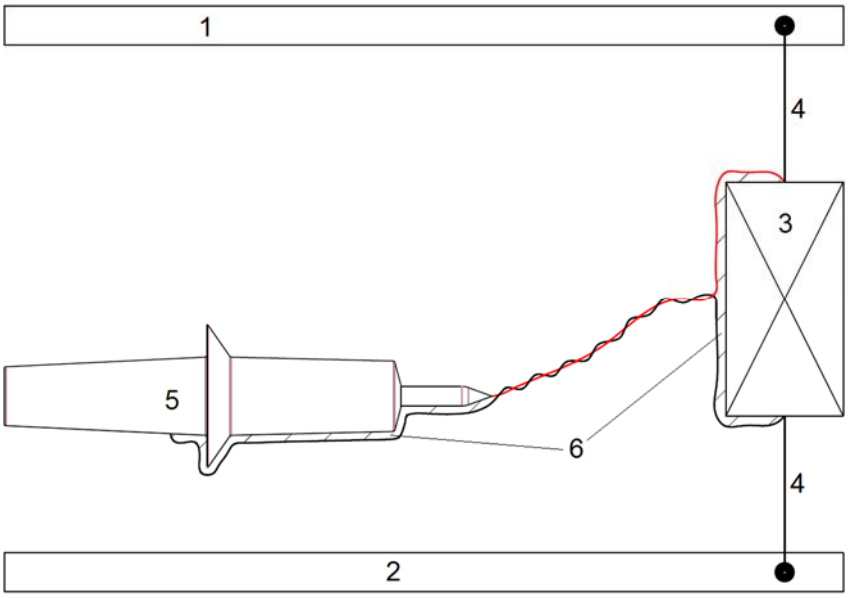

Key: 1 HV output terminal of impulse current generator
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Figure 4 – Test arrangement C

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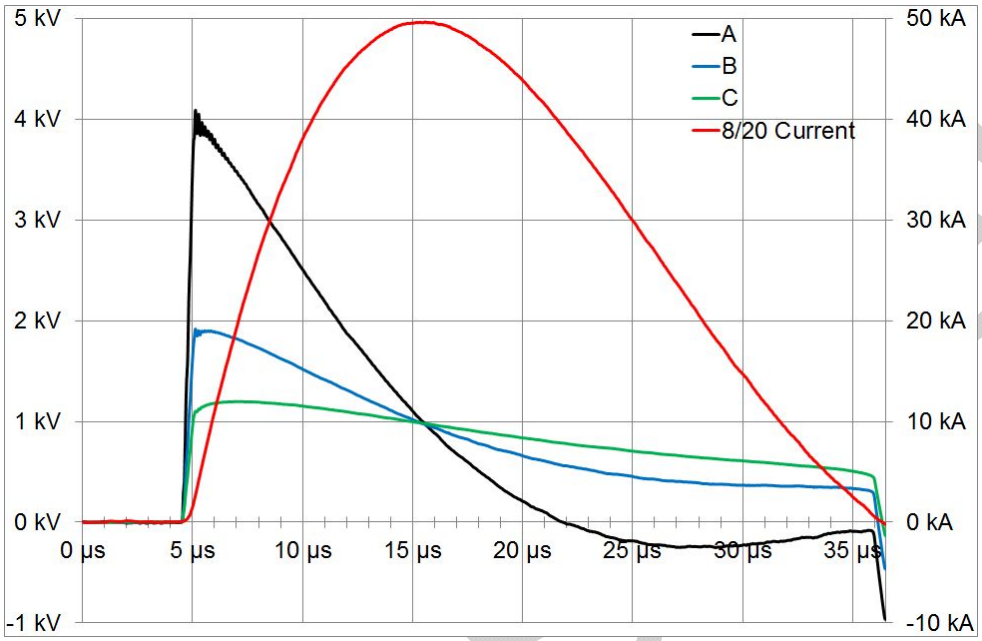

Figure 5 – measured voltages of test arrangements A, B and C during 8/20 current application

2 Guidance for the test arrangement

The following guidance for a test arrangement to measure the residual voltage with 8/20 current impulses according to EN 61643 series may be applied

- if it is unknown or it is assumed, that the influence of the magnetic field of the 8/20 current or the loop size of the measurement lines is too big, or
- if the measured residual voltage exceeds the voltage protection level U_p of a SPD defined by the manufacturer, or
- if agreed or required by the manufacturer of the SPD.

The following two alternate test arrangements are proposed. Depending on the equipment available and as required by the manufacturer of the SPD one of these methods could be chosen.

In addition, the use of differential probes and/or a scope with isolated inputs should be considered.

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3.1 Method 1: Voltage probe placed at a certain distance

If the design of the SPD and/or the size of the voltage probe does not allow to connect the voltage probes very close to the device under test (DUT) without creating a large loop area, the following test setup may be appropriate to minimize the loop build up by the measurement lines and the SPD itself.

The measurement lines connecting the voltage probe to the DUT should be as small as possible. Their insulation should be as small as possible but thick enough to withstand, when twisted together, the expected residual voltage. The measuring lines should be routed along the shortest distance between the terminals of DUT onto the housing of DUT. From half of the shortest distance between the terminals of DUT, the measurement lines should be twisted with a twist rate of at least 30 twists per meter and routed at around 90° +/-10° away from the axis created by the DUT and its conductors to the impulse current generator.

The shortest distance between the terminals of DUT onto its housing may vary depending on the mode of protection under test. A typical example of a SPD having a single mode of protection is given in **Figure 6**. Two typical examples of a multipole SPD are given in Figure 8 and Figure 9.

Figure 7 shows a wrong routing of the measurement lines, where the loop between the measurement lines and the DUT is too large.

The voltage probe should be placed in a distance of 200 mm minimum up to 500 mm maximum away from the DUT.

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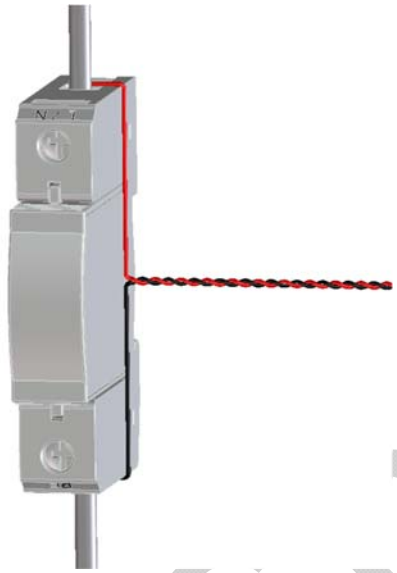

Figure 6 – Routing of the measurement lines of a SPD having a single mode of protection

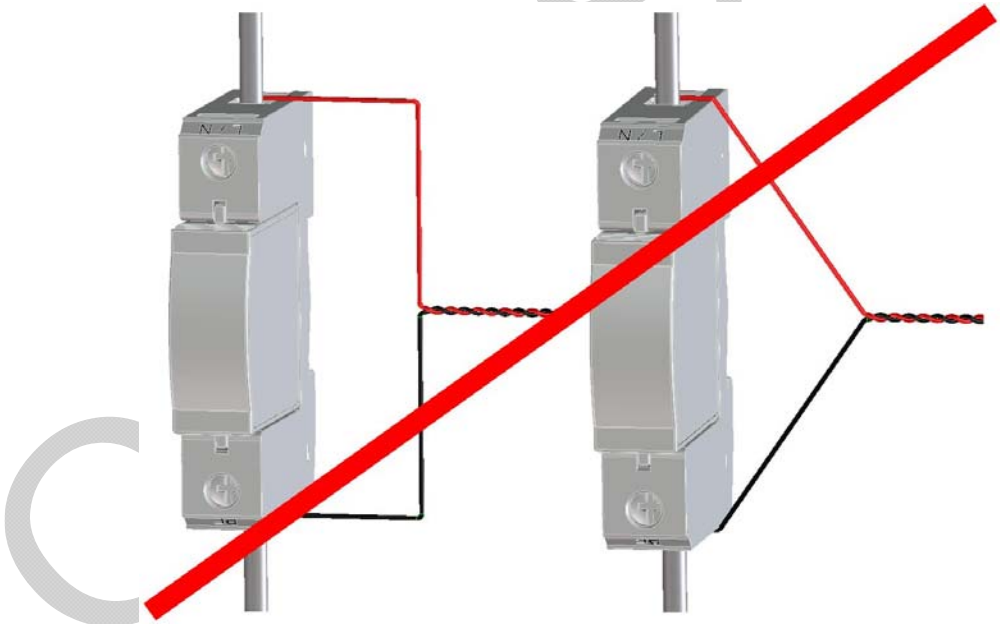

Figure 7 – Wrong routings of the measurement lines

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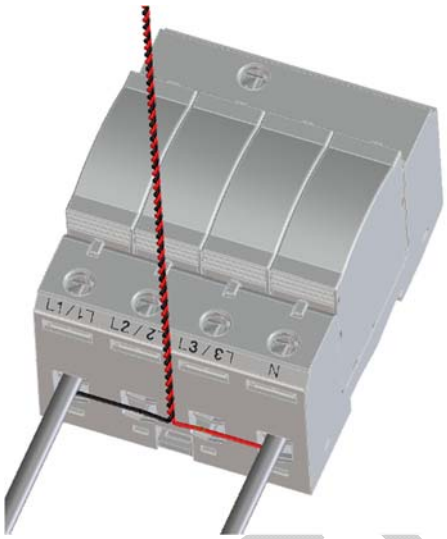

Figure 8 – Routing of the measurement lines of a multipole SPD, example 1

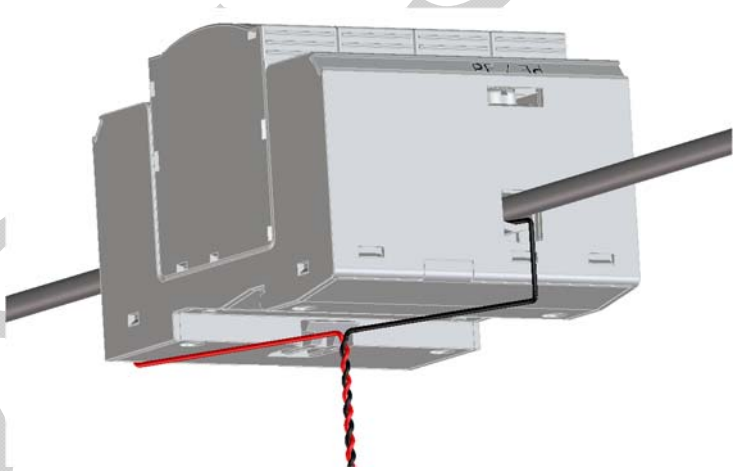

Figure 9 – Routing of the measurement lines of a multipole SPD, example 2

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3.2 Method 2: Minimized loop of measurement lines

If the design of the SPD and the size of the voltage probe allows to connect the voltage probe directly or via short measurement lines placed close to the DUT the following test setup may be appropriate to minimize the loop build by the measurement lines and the SPD itself.

The voltage probe (with reduced dimensions) is placed as close as possible to the SPD. The voltage probe is either connected directly to the DUT or via a separate connecting wire which is as straight and as short as possible. It should be considered that the connecting wire itself is not part of the test circuit for the impulse current and no impulse flows through it.

To minimize the loop size even further, the ground connection wire 5 (connected to 4 on the ground side) should be twisted around the body of the voltage probe.

If possible, the voltage probe should be positioned in parallel to the impulse current flow through the SPD Therefore the design of the SPD (one-pole/ multipole) and the corresponding flow of surge current should to be considered.

Figure 10 shows an example for the application of method 2 to a SPD having a single mode of protection.

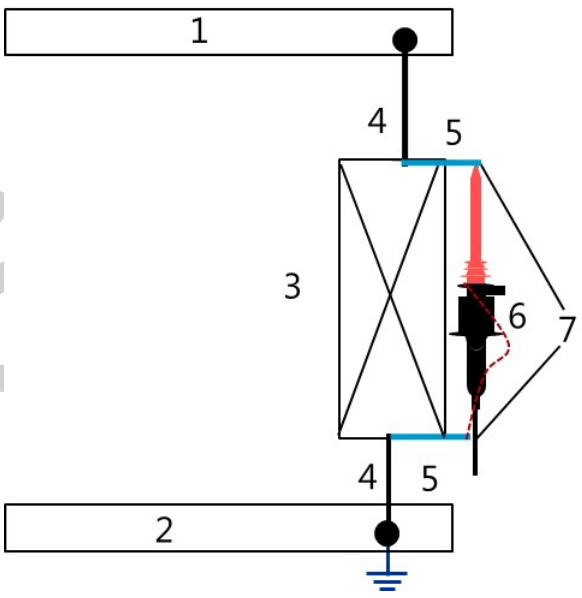

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Figure 10 – Example for the application of method 2 at a SPD having a single mode of protection