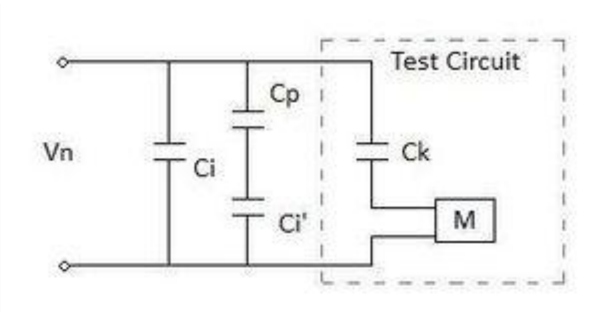
Partial Discharge

A partial discharge, as defined by IEC 60270, is a "localised electrical discharges that only partially bridges the insulation between conductors and which can or cannot occur adjacent to conductors". In other words, it is a partial breakdown in the insulation between two active conductors.

Partial discharges can occur in any location where the local electrical field strength is sufficient to breakdown that portion of the dielectric material (whether it be a deteriorated piece of insulation or an air cavity). The discharges generally appear as pulses with a typical duration of less than 1us. While very short in duration, the energy present in the discharge can interact with the surrounding dielectric material resulting in further insulation degradation and eventually if left unchecked, insulation failure.

Partial Discharge Testing

Partial discharge testing can detect the presence and location of partial discharge activity in electrical equipment. Suppose a piece of electrical equipment has a small air cavity in its insulation due to prolonged degradation and the cavity is subject to partial discharge. We want to test for partial discharge and so we connect a set of coupling capacitors in parallel to measure the charges caused by the partial discharge.



Partial discharge equivalent circuit with test circuit

The figure right shows a simplified equivalent circuit combined with a typical test circuit (as suggested in IEC 60270). The circuit elements are as follows:

- Vn is the voltage source
- Ci is the capacitance of the insulation system
- Cp is the capacitance of an air cavity in the insulation due to degradation
- Ci' is the capacitance of the rest of the insulation around the air cavity
- Ck is the capacitance of the coupling capacitor
- M is the measuring system hooked up in series

At some inception volage, the electromagnetic field is strong enough to bridge the air cavity in the insulation and a partial discharge occurs. After the breakdown of the air gap, the rest of the insulation around the cavity (Ci) now sees the full voltage Vn and therefore the charge across Ci' increases.

This extra charge must be provided by all of the parallel capacitances around it (e.g. in this model Ci and Ck) or the voltage source (though it is usually too slow to react). So in a typical situation, the capacitances Ci and Ck discharge a short pulse into Ci' to provide the extra charge. However doing so reduces the voltage across all the capacitances and the voltage source Vn reacts by charging all of the capacitances in the system (including the air cavity) back to the normal voltage Vn.

Partial discharge testing is done by directly measuring the short pulse discharged into Ci' by the coupling capacitor Ck. In the equivalent circuit, the measuring system is represented by a single box M, but in practice, this includes the coupling device, connecting cables, measuring device, etc.

Now it's clear that any pulse measured by the measuring system **is not** the actual partial discharge, but an **apparent charge** caused by the real partial discharge (i.e. because the coupling capacitor Ck has to help provide the extra charge for Ci'). It's not possible to directly measure the partial discharge, but the apparent charges can be used to infer the level of partial discharge activity in the insulation system.

Test Circuit Calibration

Because only the apparent charges can be measured, it is important that the test circuit is properly calibrated. During calibration, a pulse of known magnitude is delivered into the system to simulate a partial discharge. The measuring system is then monitored to ensure that the test pulses are captured. The calibration process is done so that pulses with magnitudes of interest (i.e. that will damage the system) are reliably captured. A scaling factor can also be inferred based on the calibration tests.

References

- [1] IEC 60270 (2000) "High Voltage Test Techniques - Partial Discharge Measurements"
- [2] IEEE 400 (2001) "IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems"
- [3] IEEE 1434 (2000) "IEEE Trial-Use Guide to the Measurement of Partial Discharges in Rotating Machinery"

Source:

http://www.openelectrical.org/wiki/index.php?title=Partial_Discharge

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