Istók Róbert: Test of High Voltage Capacitors

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Abstract: This paper present three measurement types which are using in case of high voltage capacitors tests. One of measurement is the partial discharge test. This is used for capacitors insulating testing. The measurement system used during the test, should measure up to 200kV. Because the measurement system is sensitive to background electromagnetic noises, it is very important that the measurements have to be done in a poor electromagnetic noise environment. The second measurement is the capacitance measurement test, which should be done together with the third measurement type, which is the dissipation factor test. This kind of tests are used for testing the quality of the electrical insulation of capacitors. The dielectric losses of the capacitor insulation should be influenced by polarization, conduction and surface currents too. The upper range of the measurement system is 200kV too.

Keywords: coupling capacitor, partial discharge, schering bridge, dielectric polarization, dielectric losses

1. Introduction

The high voltage capacitors have a wide range of application, as power factor correction, harmonics rejection, [1]. Another field where the capacitors are used is the photovoltaic systems, where the DC-link capacitors absorb the high DC current pulses. In some situations the high voltage capacitors should be used for high freuqency noise emission filtration too. For example this kind of capacitors should be placed on the top of the locomotive to filter the high frequency signals used for communication throught the power supply lines. Another spacial use of high voltage capacitors is the high voltage laboratories, where these capacitors should be used as coupling capacitors for partial discharges measurements or in capacitive voltage dividers.

2. Test methods of high voltage capacitors

2.1 Partial Discharge Measurements

The partial discharge (PD) is a dielectric breakdown and appear in small portion of a dielectrics materials. The partial discharge appear when the electric field is higher than the dielectric strength in a given point of insulation material [2]. In figure 1 is presented an example of two energized solid dielectrics. In figure 1a is presented an energized solid dielectric whitout any deffect. The electric field lines are paralel, and homogen. In figure 1b, in the middle of the solid dielectric material there is a void filled with air. It is well know that the permittivity of the air is lower, this is the reason why the electric field strength is higher in that place of the dielectric material. If the energizing voltage is enough higher, there will appear the partial discharge inside of void.

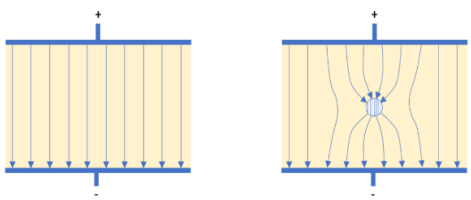

Figure 1a Figure 1b

Figure 1 Two energized solid dielectrics [3]

In figure 2 is presented the measurement system used at Óbuda University. It contains next:

- voltage regulator from 0V to 400V
- step up tranfomator up to 200kV
- Coupling capacitor 200kV 1nF
- PD detector and measureng impedance

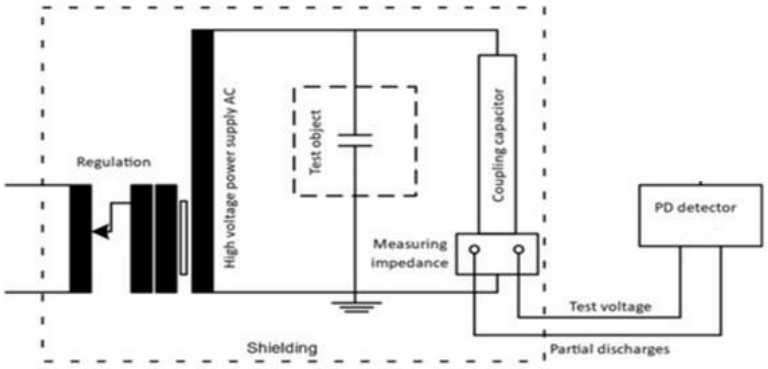

Figure 2 Partial discharge measurement system

The measurement system is located in a shielded room, because it is very sensitive to electromagnetic noises. The maximum current in the system is 0,5A. Over this current the power supply is switched off automatically. Because the PD source is not accesible directly for the measurement system, there have to be done a calibration. The calibrator is a source of know impulses and should be connected in paralel with the test object. The PD detector measure the effect of these pulses, and the calibration is done. In figure 3 should be seen the measurement results of the calibration. In this case there was used a 20pC puls. Another information from the figre is that the backgroung noise is under 1pC. The background noises are coming in the measurement system throughth power supply. In figure 4 is presented the measurement results of a 1nF 50kV capacitor. It should be seen that there is not any partial discharge inside of capacitor. In figure 5 is presented a measurement result of same type capacitor, where are partial discharges inside of capacitor. These capacitors are filled with oils. Some times the partial discahrges appear inside of capacitors because in the oil remains air bubles.

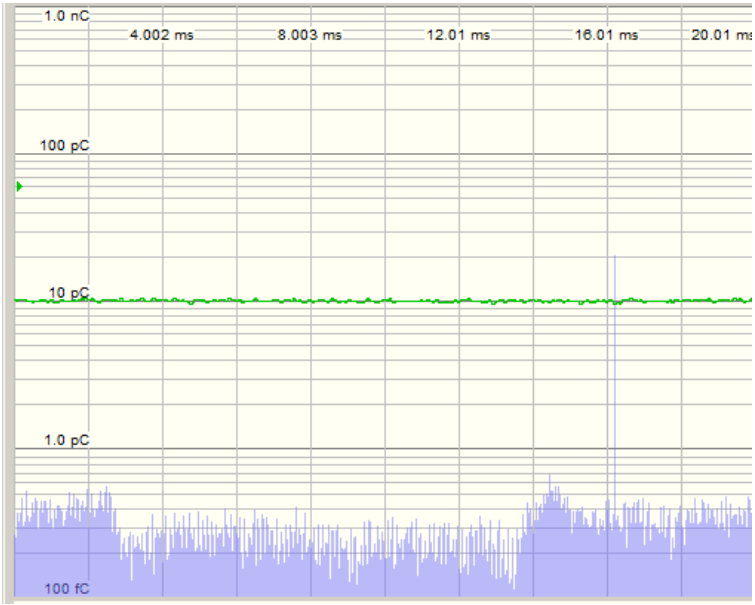

Figure 3 Calibration of partial discharge measurement system

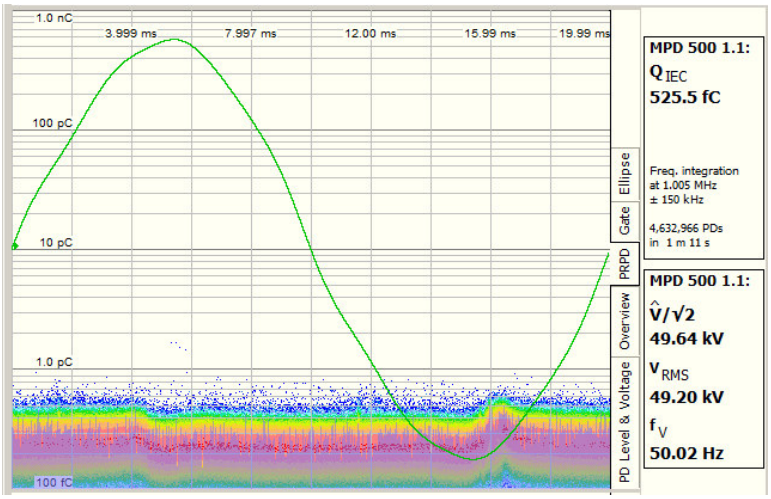

Figure 4 Measurement result withouth partial discharge

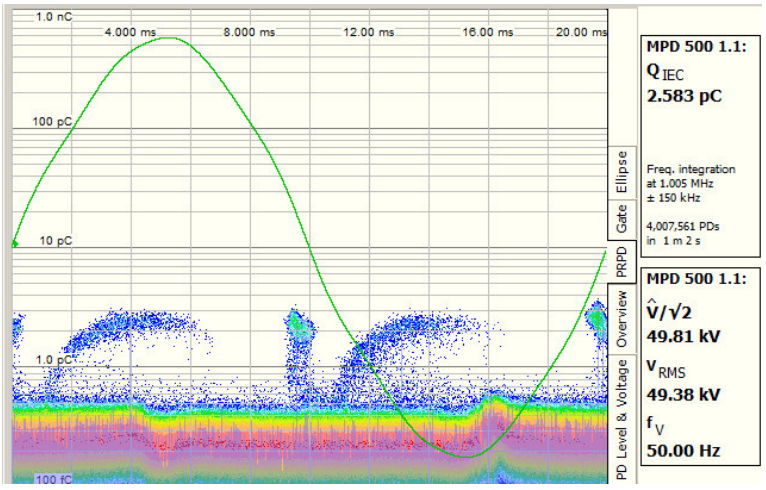

Figure 5 Measurement result with partial discharge

2.2 Measurements of Capacitance and Dissipation Factor

The measurement of capacitance and dissipation factor should be done in conformity with 60034-27-3 [4]. In case of an ideal capacitor, there is not any kind of losses. The current vector is faster with 90°compare to voltage vector, but in reality there are some losses determinated by: conduction, surface currents or dielectric losses due to polarization. In this case the angle between current and voltage is lower than 90°. The most simple representation of a real capacitor is a capacitor in paralel with a resistance. The resistance represent the losses.If the current throught the resistor is higher then the losses are bigger. In figure 6 is presented a high voltage Schering Bridge measurement system which is used for measurement of dielectric looses and capacitances of capacitors. The difference between normal and high voltage measurement systems is that for high voltage bridge the B point is grounded. This grounding is necessary for operator safety point of view. The measurement system contains the next:

- voltage regulator from 0V to 400V
- step up tranfomator up to 200kV
- $C1$- The unknown capacitor

- $R1$ - A series resistance representing dielectric loss in the capacitor $C1$
- $R3$- a non inductive resistor
- $R4$ - a variable non-inductive resistor
- $C2$- a standard capacitor, which is loss free. It is filled with SF6 gas
- $C4$- variable capacitor paralell with R4

The C1 and C2 capacitors are high voltage capacitors and have high impedances. The impedances of R3 and C4-R4 components are lower compare to first two.

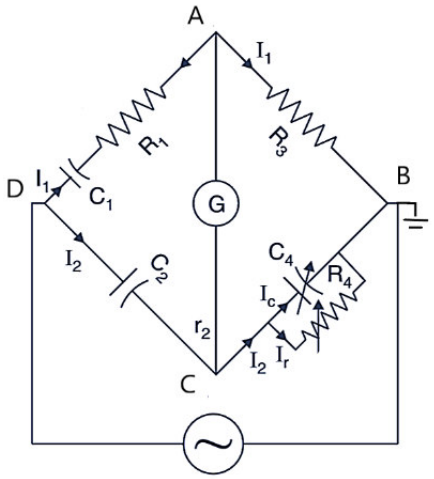

Figure 6 Schering bridge measurement system

The measurement method is next: With help of variable capacitor and resistor C4-R4 the the ballanced condition is reached and the capacitance and the dissipation factor is reading. Tipically for the same capacitor the measurement is done for five different voltages. In table 1 is presented a measurement results for a 1 nF 50kV capacitor. In case of capacitor filled with SF6 gas the dielectric loss is zero.

Table 1

Contains the result of comparing in pairs with the final result

U(kV)	C(pF)	tgδ(10^{-4})
9,860	993,718	9,18
20,32	993,512	7,7
30,42	993,557	7,62
39,67	993,713	7,73
50,37	993,987	8,42

Conclusions

Tipically the high voltage capacitor are used in hard accessible places where their changes are not so simple. This is the reason why it is a good method if every capacitor is tested by the manufacturer. This kind of test have to be done in high voltage laboratories.

References

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[3] Matthew Sze, Mathieu Lachance: A Guide for Partial Discharge Measurements on medium voltage (MV) and high voltage (HV) apparatus, Omicron Technical paper , october 2020

[4] IEC 60034-27-3:2015 Rotating electrical machines - Part 27-3: Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines