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On Recent Advances in Electrical Engineering

Polarization Current Measurement of Power Transformer- a Simulation Study

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***ABSTRACT* :**The Polarization and Depolarization Current (PDC) analysis is a non-destructive dielectric testing method for determining the conductivity and moisture content of insulation materials in a transformer. The predominant influence of oil conductivity on the initial amplitudes of polarization / depolarization currents can be used to estimate the oil conductivity of a transformer even without performing direct conductivity measurements on its oil sample. In the same way, an estimation of the conductivity of the pressboard can be obtained from the long term values of the polarization and depolarization currents. Moisture and ageing strongly influence the dielectric properties of oil-pressboard insulation system of power transformer.
***Key words*—Power transformer, polarization current. Simulink**

I. INTRODUCTION

The Demand for reliable electricity supply has significantlyincreased during the last few decades. Therefore fault freeoperation of power system has become very important.However due to high cost of power system components,especially transformers, it is not economical to replace themin order to increase reliability, by considering their age.Moisture increases the risk of dielectric failures and has adouble function: it accelerates ageing and also ageinggenerates it. Additional moisture can penetrate from theatmosphere into the tank. Independent of its origin moistureis absorbed into the oil-pressboard insulation system. Hence,measurement of moisture in different stages of transformerslife becomes a challenge for transformers experts. Arelatively large number of power transformers that are stillworking in fairly good condition although they have beenused longer than their designed life .Therefore correctcondition assessment of power transformer is needed beforemaking any conclusion about replacement andrefurbishment. Failures of power transformer mainly occurdue to degradation of power transformer insulation, whichmainly consist of oil and pressboard. Chemical andelectrical measurements are used to monitor the condition ofpower transformer insulation. Among these, chemicalanalysis provide direct information on parameters, such aswater content, degree of polymerization of paper ,sludgecontent in oil and quantity of different gasses dissolved inoil. However most chemical analysis must be performedunder laboratory conditions. On the other hand, electricalmeasurements are simpler and it is possible to perform themon site. Due to this simplicity, Electrical tests, such asInsulation resistance (IR), Polarization index and loss factor(tan δ) provide very little information about the transformerinsulation since they are limited to a single valuemeasurement. To overcome this disadvantage, dielectricresponse measurements, namely return voltagemeasurements (RVM), polarisation and depolarisationcurrent measurements (PDC) and frequency domainspectroscopy measurements (FDS), have been introducedfor condition monitoring of transformer insulation,especially for the evaluation of water content in transformerpressboard. In the early stages, RVM was introducedbecause voltage measurements were simpler thanmeasurements of low currents. The other two methods,requiring current measurements, were introduced recentlydue to improvements provided by the use of sophisticatedelectronic devices.

The focus of this paper is kept on PDC technique whichis a non destructive testing method for determining theconductivity and moisture content in the insulation materialslike oil and pressboard separately. This paper describes theeffect of moisture on a prototype model which is similar tothat of power transformer insulation.

II. PDC MEASUREMENT

The principle of measurement of polarization anddepolarization current is based on application of a dcvoltage across a test object for a long time (e.g., 5000sec.).During this time, the current, arising from the activation ofthe polarization process with different time constantscorresponding to different insulation materials and due tothe conductivity of the object is measured. Then the voltageis removed and the object is short-circuited. The previouslyactivated polarization process now gives rise to thedischarging current in the opposite direction, where nocontribution of the conductivity is present. The schematicdiagram of the PDC measuring set-up is shown in Figure 4.Figure 5 shows the typical nature of these currents due to astep charging

voltage$U0$.Charging and discharging currents(i.e. polarization and depolarization currents) are influencedby the properties of the insulating materials as well as by thegeometric structure of the insulating system .

III. Simulink Model

Theoverall geometric capacitance of the system was 1.00 pFand the applied voltage was 500 V DC. The polarization anddepolarization currents were measured for 5000 sec.

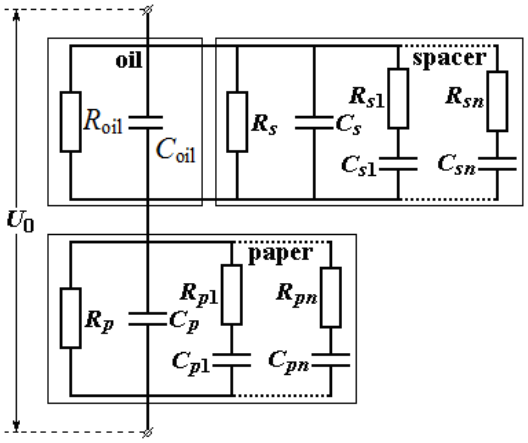


Fig.1 Equivalent scheme for the paper-oil insulation (according to [2])

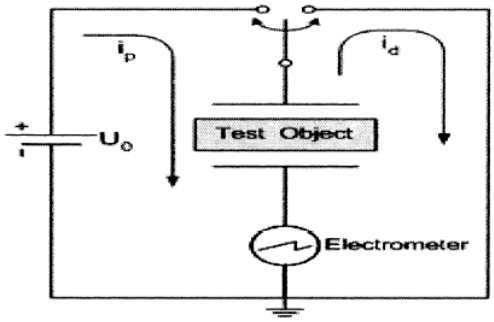


Fig. 2 Basic PDC Measuring Circuit

In this paper, the Insulation model using Simulink is proposed to study for the practical transformer insulation system. The specifications taken for the study are:

1) For Transformer oil :
   Resistance Ro= 1 GΩ, and Capacitance Co= 1 pF
2) For Transformer Spacers:
   Resistances Rs= 1 GΩ, and Capacitances Cs= 1 nF
3) For Transformer Paper:
   Resistances Rs= 1 TΩ, and Capacitance Cs= 1 pF
4) For Transformer Press Boards:
   Resistance Rs= 1 GΩ, and Capacitance Cs= 1 nF

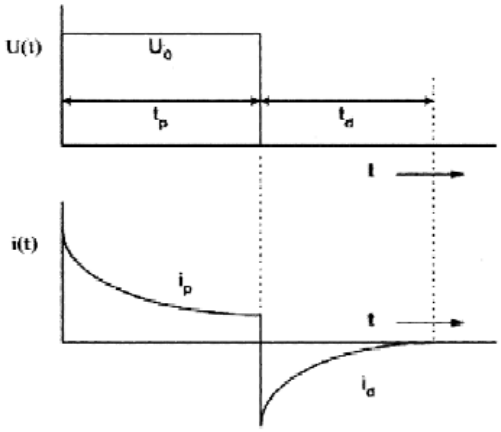


Fig. 3 Polarization and Depolarization Current Waveforms

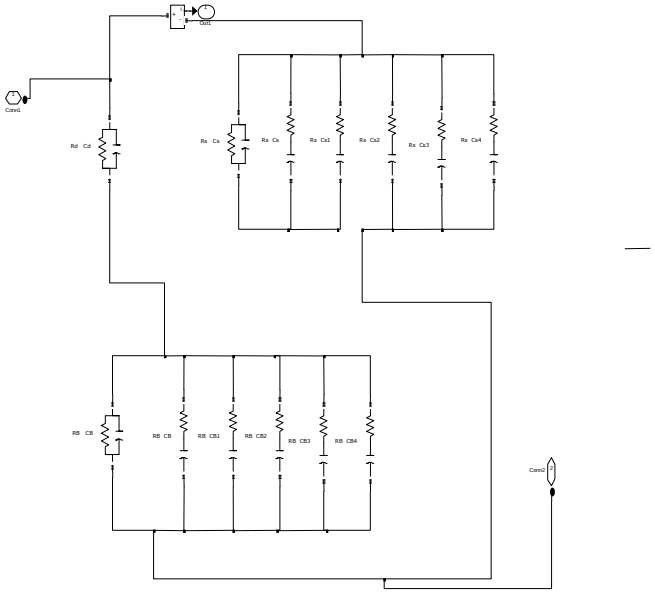


Fig. 4 Insulation Model using Simulink

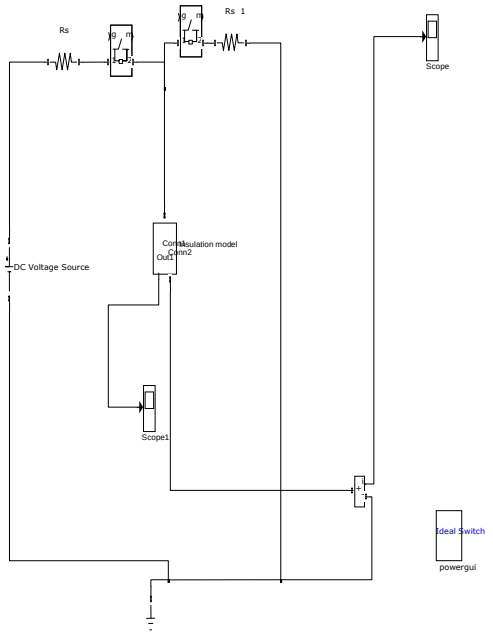
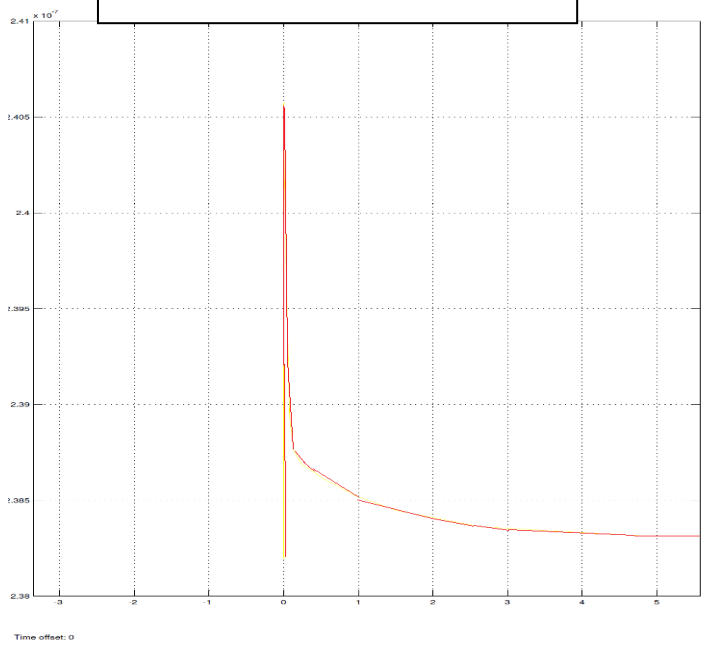


Fig.5 Simulink Model of PDC Measuring Circuit

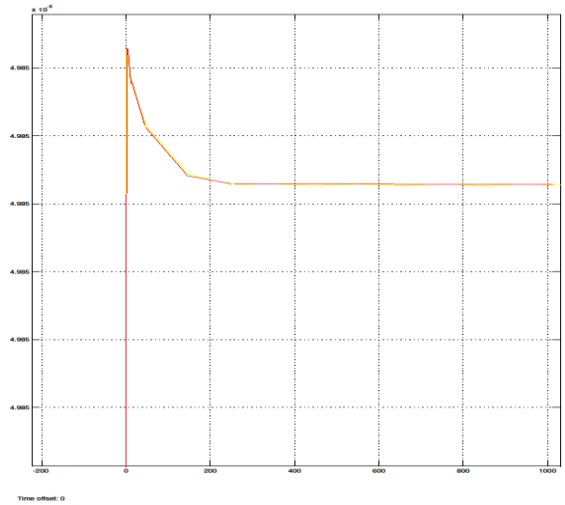
IV. SIMULATION RESULTS

1) The simulation results of polarization current obtained using Simulink Software is as follows in fig. 6(a),(b),(c)and (d).

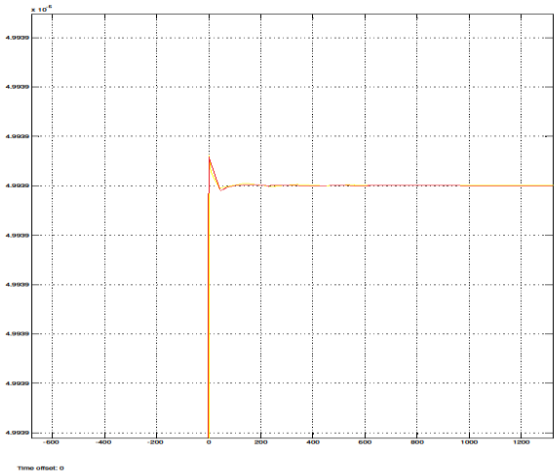
Case1: Simulated Polarization Current Output when oil contains small amount moisture.



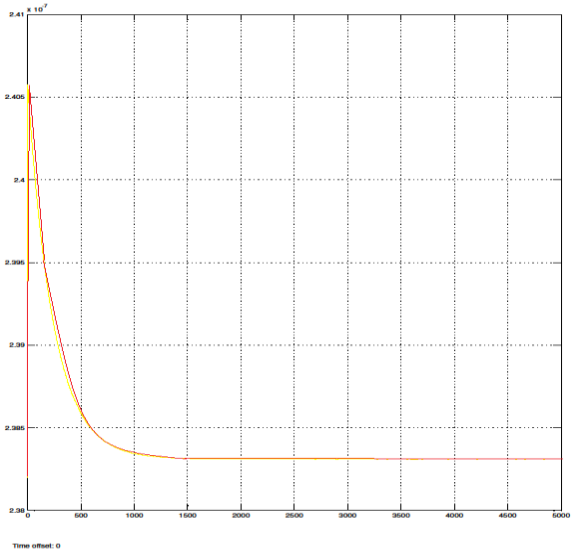
Case2: Simulated Polarization Current Output when oil contains large moisture.



Case3: Simulated Polarization Current Output when Press board contains large moisture.



Case4: Simulated Polarization Current Output when paper insulation contains large moisture.



V. CONCLUSION

From the simulation results it is observed that the polarization current and depolarization method can be used to find the moisture content of insulation system of a power transformer. And from the above simulated results, it can be concluded that, is the transformer insulation is new then, the moisture content of the composite insulation system i.e., oil-paper (cellulose) is less. If the insulation is aged then, the moisture content is more and accordingly the conductivity of the oil is more and more polarization current value is obtained. Similarly, if the paper is aged, its moisture content is more and its, conductivity is more and therefore the polarization current and depolarization current values will be increasing.

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BIOGRAPHIES

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