SUBSTATION TRANSFORMERS MONITORING FOR ANALYSIS AND CLASSIFICATION OF PARTIAL DISCHARGES

Nikolina Petkova

Department of Theoretical Electrical Engineering, Technical University of Sofia,
8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, phone:, +3599652498,
e-mail: npetkova@tu-sofia.bg

Abstract: *In this paper the instructions for preparing a partial discharge signal analysis are given. The algorithm is applied to discover the correct position of partial discharge in power transformer. The program solution and all modules in MS Visual Studio are implemented.*

Key words: *partial discharge, measuring system, power transformer.*

1. INTRODUCTION

The electrical partial discharge measurement is the most suitable method for assessing the condition of insulation systems in high voltage equipment. Conventional partial discharge measurement systems have proven to have some difficulties in the measurements, particularly in online conditions and noisy environments.

2. MODULE SYSTEM CONFIGURATION

The measurement of the partial discharge begins with the sensors placement around the transformer, where their outputs are linked to the software monitoring system – Transformer Diagnostic Expert System. During the process of sensors positioning, the power transformer should be switch off from the electricity network. When the measurement system is connected, the signals from partial discharges (PD) are registered and transferred to the Comparison Module. There are obtained the time delay between registered PDs from each measuring channel as well as the time of their occurrence. This information is then transferred into the Calculation Module, where the approximate position of PD is established. This position of the PD is visualized through the Visualization Module and an expert determines the part of the transformer that the partial discharge occurs, based on the technical design of the transformer. Using the partial discharge signal structure, the Module of Classification determines the type of the partial discharge.

Together with the chemical condition of the oil in the power transformer, the final decision is taken in the Module of Decision.

Software of Transformer Diagnostic Expert System starts with a window which is shown in Fig. 1.

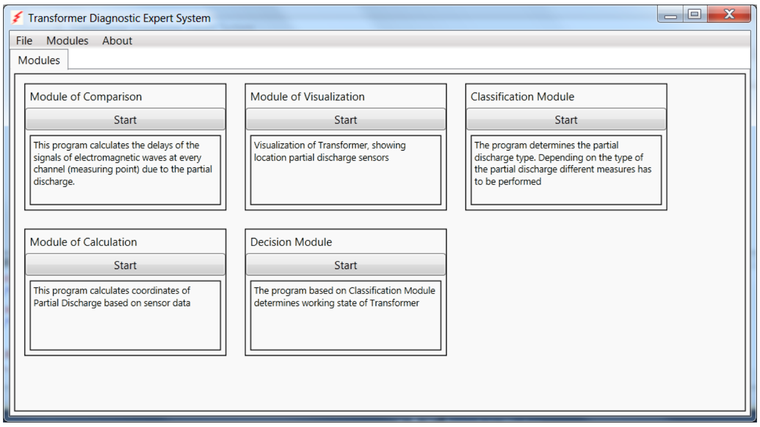

Fig. 1. Transformer Diagnostic Expert System

2.1. Module of Comparison

When the button “Start” of Module of Comparison is pushed, first window from Module of Comparison is appeared and it has to choose folder with data (measured signals), for example folder with name “TEST1”. Then OK should be pushed [1].

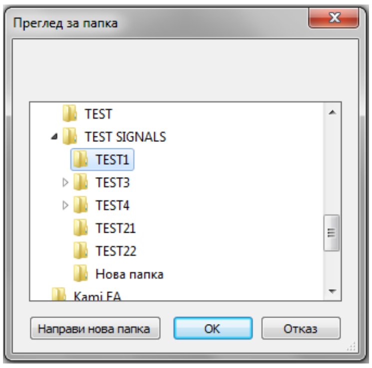

Fig. 2. Module of Comparison – first window

The input data are load from the computer folder “TEST1” and press “CALCULATE RESULT”. The software will generate the results and time delays between signals (Delta T) are calculated, which is shown in Fig. 3:

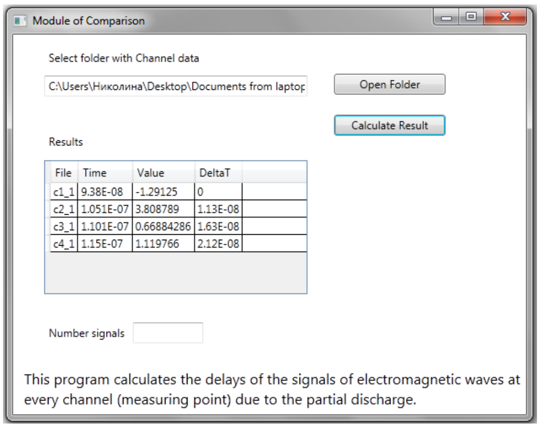

Fig. 3. Module of Comparison – screenshot with data

Results explanation/description:

c1_1 ÷ c4_1 –name of measurement channels, which are four for TEST1

Time – time delay for each channel;

Value – the voltage value of the measurement signal for this point, which describes time delay;

Delta T – time delay between signals

2.2. Module of Calculation

When the button “Start” of Module of Calculation is pushed, first window from Module of Calculation is appeared.

Then the data should be entered, required by the software:

- n – number of measurement sensors (in this example the sensors are four);
- V– speed of the electromagnetic wave (in this example V is the average speed of passing through each one of the materials that the power transformer is made of – copper, steal, oil, barrier oil, paper and others);
- Xi, Yi, Zi – coordinates of the sensors;
- Delta Ti – time delay for each sensor.

In the Calculation Module all parameters have to be given in International System (SI). The results are the coordinates of partial discharges in the power transformer volume, i.e., there is information for the estimated position of the fault with the exact coordinates x, y and z.

After all the sensors coordinates are provided, the “CALCULATE” button is selected and then the program calculates the coordinates of the partial discharge in the transformer volume, which are shown in down left corner in Fig. 4:

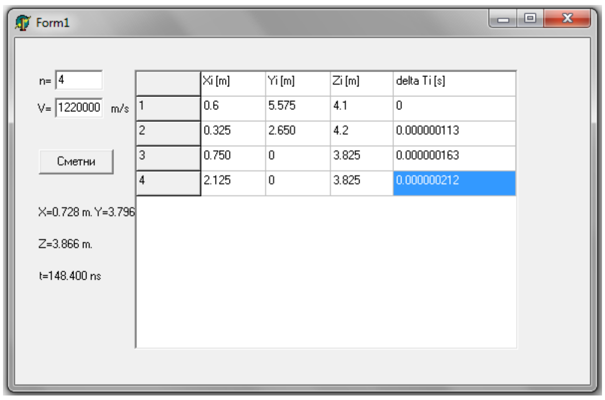

Fig. 4. Calculation Module – screenshot with data

2.3. Module of Visualization

When the icon with button “Start” of Module of Visualization is chosen, the basic window from Module of Visualization is appeared. If the button “File” is pressed than three functions are appear – “Open model”, “Save model” and “Save model as”.

These functions allowed opening a model of transformer, which is done. It is possible to save changes or make new different models. If it is chosen “File”, “Open model”, “Transformer model” and push button “Open”, then the model from Module of Visualization are appear [1].

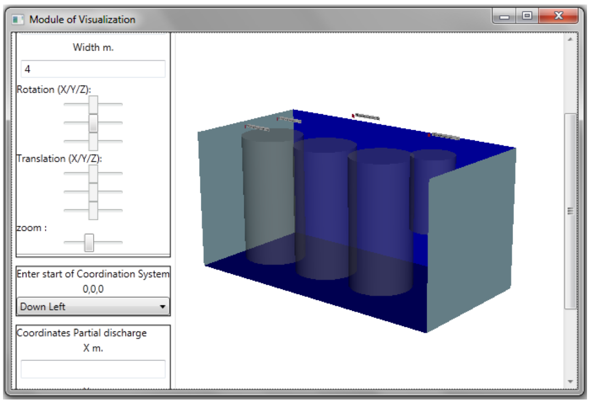

Fig. 5. Module of Visualization with Transformer model

When “Model parameters” is chosen, then two functions are allowed - “Coils” and “Sensors”. The geometric parameters of coils and sensors could be entered. The data is shown at Fig. 6 and Fig. 7.

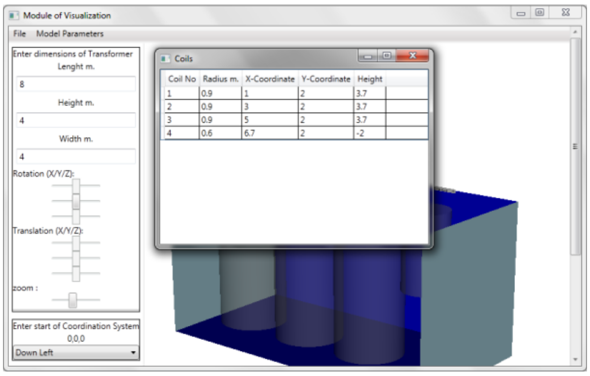

Fig. 6. Module of Visualization with Coils data

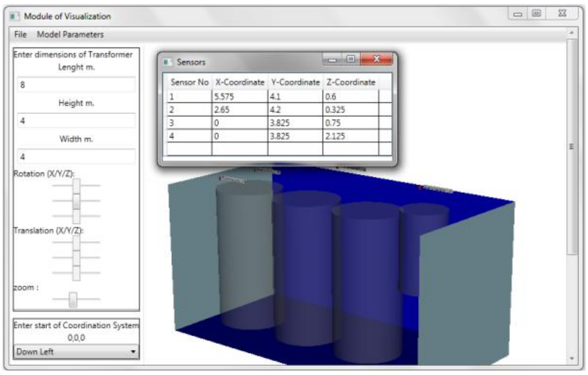

Fig. 7. Module of Visualization with Sensors data

After all data has been entered, the button “Visualize” should be pressed. The software generates the graphical representation of the partial discharge (red point), as in Fig. 8.

At the end of this module the operator decides where the partial discharge occurs, e.g. tap changer, tank, leads, winds or other.

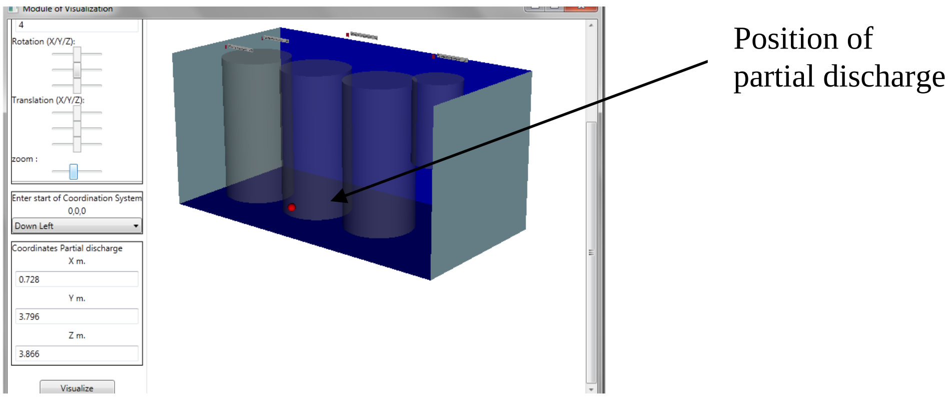

Fig. 8. Module of Visualization –position of PD

2.4. Module of Classification

When the button “Start” of Module of Classification is chosen, the general window from Module of Classification is appeared.

The user has to choose the following parameters: location of discharge on test waveform, variability of response, relative magnitude of discharges, test voltage and time of application. After that the button “Calculate” have to be pressed. Then like output data, this module generates result – one of the most popular cases of PD appears - from A to N which is given in [2].

In the specific case, for example “Transformer model”, the input data is:

- Location of discharge: most pulses in advance of the voltage peaks.
- Variability of Response: random movement.
- Relative Magnitude of discharge: different magnitude on two half cycles.
- Test voltage: rises with test voltage.
- Time of application: constant with time.

The output data is the result case “H”**:**

In case “H”, discharges that occur in advance of the test voltage peaks are described and these discharges on one half cycle of the test waveform are greater in number and smaller in magnitude than on the other half cycle. The amplitude difference on the two half cycles may be as low as 3:1, however a difference of 10:1 is possible if the applied voltage is raised. There is a degree of random variation in both amplitude and location [2].

Indication: Internal discharges between metal or carbon and dielectric in a number of cavities of various sizes are possible. It is often difficult to ensure that a response of this type indicates cavities between metal or carbon and dielectric, as cavities within the dielectric may have metallic or carbonaceous inclusions or non-uniform surface conductivity [2].

There are surface discharges taking place between external metal or carbon and dielectric surfaces and internal discharges in a dielectric-bounded cavity.

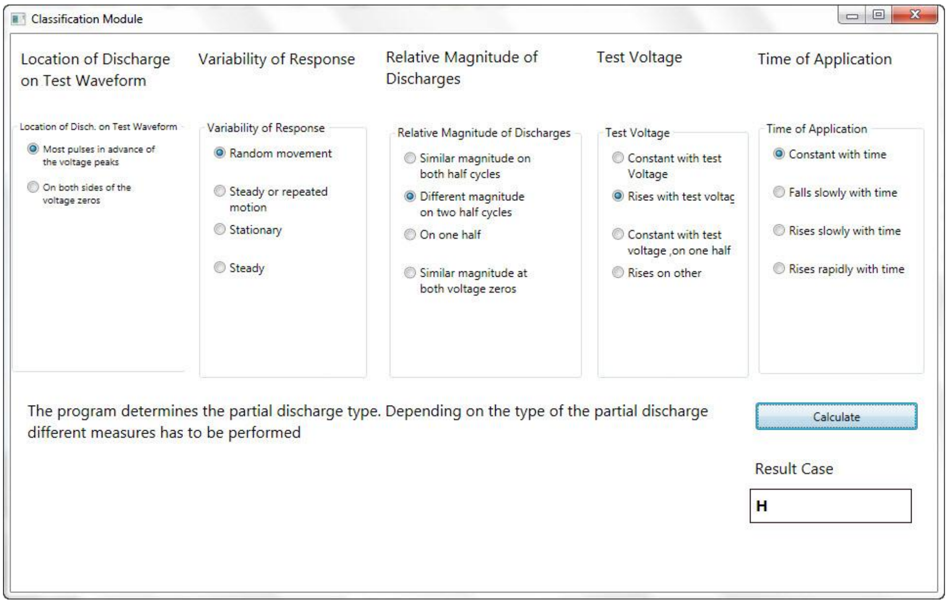

Fig. 9. Classification Module with data

2.5. Decision Module

If the expert chose “Start” of Decision Module Start, the first window from Module of Decision is appeared. Then the correct data for the next parameters: case of PD occurrence, partial discharge location and oil condition have to be selected. It depends on the output data from previous modules. After that the button “Calculate” have to be pressed and the software determines the level of criticality of the power transformer state.

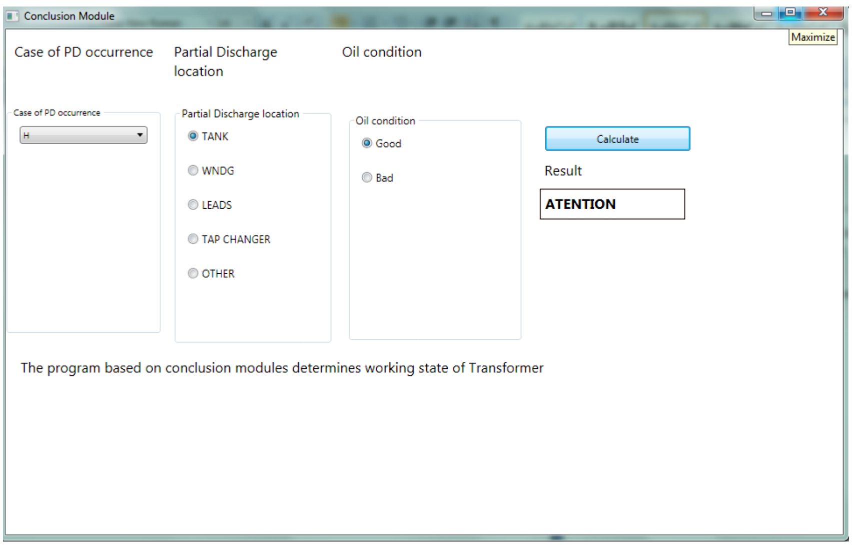

Fig. 10. Conclusion Module– screenshot

The output data is related to the state of the transformer. It can be: Work, Attention or Danger.

For our example “Transformer model”, the software result was: ATTENTION.

It means attention should be paid till the transformer should be open for maintenance checking.

3. CONCLUSION

The system for uninterrupted monitoring provides an early warning for any impending damages, which assures a long enough period of time for bringing out of operation, and do maintenance or repair, which guarantees that little problems will not be turned into bigger ones.

4. ACKNOWLEDGEMENT

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References

[1] SEETSOC, Deliverable D5.4.2, “Substation system implementation”, 2011

[2] IEC 60270:2000, “High-voltage test techniques - Partial discharge measurements”

Reviewer: Assoc. Prof. PhD Sn. Terzieva