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The Clustering Analysis for Evaluating State of the Isulation for Intelligent Electrical Networks

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Abstract

In this work is proposed the method of cluster analysis for evaluating the state of the insulation of electrical devices. With the work of electrical devices on its insulation influence the diverse factors: high or low the rate of temperatures, high voltage, vibration, radiation, chemical materials and yets. The action of all these factors must not to the premature failure of insulation, since this can lead to the emergencies. Thus, reliability of electrical devices work depend on the quality of insulation.

This problem it is especial for the electrical devices, which worked out its period or period of service of which it approaches final.

In the work it is proposed to use a method of continuous control of the state of the insulation of high-voltage devices. The method of the combination acoustic and electromagnetic signals is used. Processing the measurements of signals is performed in the neuron networks. This gives the possibility to self-learning neuron network.

Authors propose to use the algorithm for state insulation analysis in electrical devices obtaining information from acoustic and electromagnetic sensors.

Intelligent agents can separate dangerous situations by critical testimonies of sensors from the regular states of the system, detect and warn about changes in the system and to prevent emergencies, using the intelligent electrical network.
KEY WORDS: *intelligent electrical network, neural networks, clustering, insulation.*

1. Introduction

By the basic reason for aging isolation under the influence of strong electrical pour on they appear the so-called partial discharges. They are local breakdowns it weakened the

Feudatory sections of high voltage isolation. By such it is weakened or defective sections they are gas inclusions. In the process of operation gas inclusions can arise as a result of splitting or stratification of isolation from mechanical loads and vibration or during the decomposition of dielectric to input of gases, for example with the strong heating.

This leads to fact that in the gas inclusions with a certain value voltages go on breakdown. This breakdown is not complete, since the sizes of gas inclusions compose small part of the total thickness of isolation, and the remained isolation serves as the barrier, connected in series with the gas-filled gap. Therefore such breakdowns are called not complete, but partial breakdowns or partial discharges. The rate of destruction depends on that how they are frequently repeated and what energy is scattered in each single partial discharge.

This process leads to worsening in a quality of isolation and to damage its. Therefore it is important to carry out continuous control of state of isolation by electrical devices. The authors in this work propose the method of continuous control of insulation state, using neuron networks.

2. Problem Definition

In this work authors present the method of continuous control of state of isolation by different electrical devices. This method will make possible to detect possible damages for isolation. The system of acoustic and induction sensors is used. Electromagnetic signal enters more rapidly than acoustic and in neuron network input signal about a partial discharge. Neuron network compares the indications of insulation resistance with that minimally permitted and signals, if the value of insulation resistance approaches dangerous. Insulation state is classified with the aid of the cluster analysis.

3. Method of Solution

For solution of diagnostics problem of insulation state authors propose the method of partial discharges. The number of partial discharges is determined per unit time:

$$n_f = 4\, f \left(\frac{U - \eta\, U_{pd}}{U_{cd}\, (1-\eta)} \right), \tag{1}$$

where U – external voltage; U_{pd} – voltage of appearance partial discharges; f – frequency; η – relations coefficient:

$$\eta = \frac{U_B}{U_{pd}}, \tag{2}$$

U_B – partial discharges voltages breakdown.

Measure of intensity of the single partial discharge is:

$$q = \Delta U\, C_x, \tag{3}$$

where C_x – complex capacity of isolation.

The intensity of partial discharges is determined by the average current:

$$I_{pd} = n_f q\,. \tag{4}$$

Intensity of repeated partial discharges

$$I_{pd_i} = \sum_{i=1}^{k} (n_f q)_i\,. \tag{5}$$

With $q=10^{-16}\ldots10^{-14}$ Kl occurs aging isolation, while with $q=10^{-9}\ldots10^{-6}$ Kl isolation is destroyed in very short time. From equation (5) it is possible to determine the maximum permissible quantity of partial discharges:

$$\sum_{i=1}^{k} n_f = \frac{I_{pd}}{q}. \tag{6}$$

For measurement of partial discharges intensity it is possible to use a device, shown in Fig. 1. For the isolation control of electrical devices uses combination of electrical and acoustic sensors. Device contains the subject of studies 1, electromagnetic sensors 2, acoustic sensors 3, recorders 4 and 5. Electromagnetic sensor records current pulse through the partial discharge. Acoustic sensor records the sound of partial discharge. The criterion of detecting the place of partial discharge is a time difference Δt between electromagnetic and acoustic signals from the place it arose of partial discharge to appropriate sensors.

The speed of electromagnetic impulse is more than speed from of sound impulse. Therefore the electromagnetic signal, caused by current pulse, first comes, and then through the time interval Δt comes audio signal. The further source of partial discharge is located, the greater time interval Δt. Consequently, knowing the speed of sound in the known medium and time Δt, it is possible to determine the place of partial discharge.

Uses sensors of signals from the front, on the side and above, is possible to determine all three X, Y, Z coordinates of the place of partial discharge. Output 7 gives signal to the entrance into the neuron network.

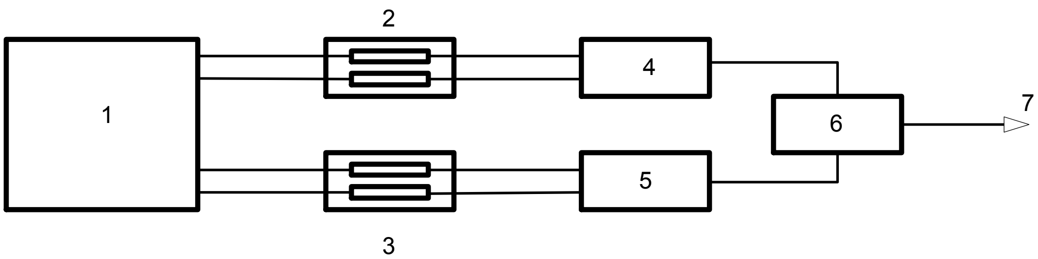
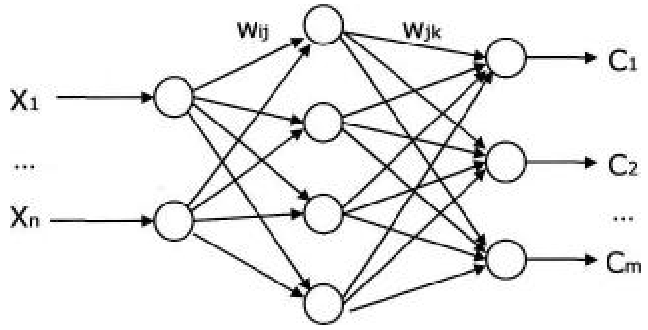


Fig. 1 Installation Diagram: 1 – research of object; 2, 3 – system of sensors; 4, 5 – the register system; 6 – summary system; 7 – output into the neuron network

4. Model of Neural Network for Task Solution

Authors propose to use Artificial Neural Networks to choose electric and electronic devices suitable in insulation control system. Neural Network should be trained to analyze the parameters of electronic device and detect the possibility of its usage in the specific task. Neural network mathematical model is based on perceptron structure, with 3 layers - input, hidden and output. Input will have electric and not electric parameters of electronic devices. Output layer classes are predefined electronic devices types. The class of analysed electronic device will be detected and the possibility to use it for insulation control



Input data set: $X = \{x_1, x_2, \ldots, x_n\}$
Weights: $W = \{w_1, w_2, \ldots, w_n, w_{n+i}\}$
Fitness function: $F = x_1 \cdot w_1 + x_2 \cdot w_2 + x_n \cdot w_n + w_{n+i}$
Result classes: $C = \{c_1, c_2, \ldots, c_m\}$

Fig. 2 Neural Network structure

5. Algorithm of Neural Network Training for Task Solution

Back-propagation is the basis for training a supervised neural network. Static back-propagation is used to produce an instantaneous mapping of a time independent input to a static output. These networks are used to solve classification problems. At the core of all back-propagation methods is an application of the chain rule for ordered partial derivatives to calculate the sensitivity that a cost function has with respect to the internal states and weights of a network. In other words, the term back-propagation is used to imply a backward pass of error to each internal node within the network, which is then used to calculate weight gradients for that node. Learning progresses by alternately propagating forward the activations and propagating backward the instantaneous errors.

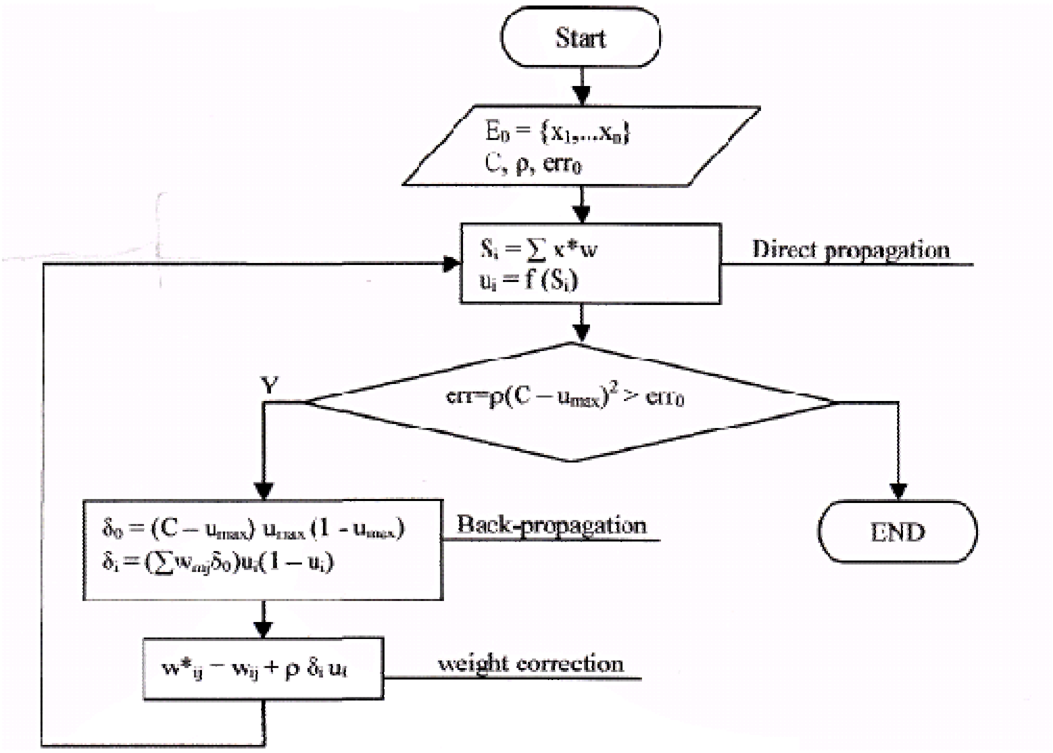


Fig. 3 Back-propagation algorithm for Neural Network training

6. Conclusions

Authors propose the method of cluster analysis and the algorithm for state insulation analysis in electrical devices obtaining information from acoustic and electromagnetic sensors. Neural Network should be trained to analyze the parameters of electronic device and detect the possibility of its usage in the specific task. These networks are used to solve classification problems.

Intelligent agents can separate dangerous situations by critical testimonies of sensors from the regular states of the system, detect and warn about changes in the system and to prevent emergencies, using the intelligent electrical network.

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