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뉴우럴 네트워크에 의한 부분방전 패턴 인식

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Partial Discharge Pattern Recognition using Neural Network

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ABSTRACT

In this study, a neural network algorithm through a data standardization method was developed to discriminate the phase-shifted partial discharge(PD) patterns such as a ϕ-q-n pattern. Considering the PD measurement in the field, it is not so easy to acquire absolute phase angles of PD pulses. As a consequence, one of the significant problems to be solved in applying the neural network algorithm to practical systems is to develop a method that can discriminate phase-shifted ϕ-q-n patterns. Therefore, authors established a new method which could convert phase-shifted ϕ-q-n patterns to a standardized ϕ-q-n pattern which was not influenced by phase shifting. This new standardization method improved the recognition performance of a neural network for the phase-shifted ϕ-q-n patterns considerably.

1. INTRODUCTION

The precise measurement and proper analysis of the PD signals from the electrical equipment such as cables, transformers, GISs are essential in developing reliable diagnosis methods and putting them to a practical use.

Basic parameters of the PD signals can be classified into three quantities: phase angle(ϕ), repetition rate(n) and discharge magnitude(q) of a PD pulse. Recently, a lot of research with regard to analyzing the PD signals have been conducted using the ϕ-q-n pattern [1,2], which can represent all of the three quantities at once.

As a means of analyzing ϕ-q-n patterns, the pattern recognition techniques using the neural network algorithm have been introduced and have shown remarkable performances in recognizing the ϕ-q-n patterns.

In many cases of PD measurement in the field, it is not so easy to acquire the absolute phase angles ϕ of the PD pulses while the frequency of an applied voltage is known. For an example, the underground cable joints are a few hundred or kilometers distant from the cable terminals, from which the absolute phase angles of PD pulses can be measured by voltage divider. Therefore, the produced ϕ-q-n patterns from the PD signals without absolute phase angles might be phase-shifted patterns along ϕ axis. As a consequence, one of the significant problems in applying the PD pattern recognition using a neural network to practical systems is to develop a method that can recognize the kinds of defects through the phase-shifted ϕ-q-n patterns.

This paper describes the PD pattern recognition by the neural network using a new data standardization method which can discriminate the phase-shifted ϕ-q-n patterns.

2. EXPERIMENT AND ϕ-q-n PATTERN

2-1. Electrode Systems and Experiment

To obtain test patterns of the ϕ-q-n distribution for the experiment, PD pulses were measured from the three kinds of electrode systems: IEC(b), needle to plane and CIGRE method I electrode which simulate the surface, corona and void discharge, respectively. Figure 1 shows a schematic diagram of the PD measurement system used in this research [3].

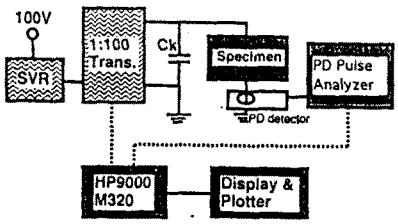


Fig. 1 Schematic diagram of pd pulse measurement system

2-2. The ϕ-q-n pattern

The ϕ-q-n patterns were used for pattern recognition. Figure 2 (a) , (b), (c) are the examples of a 3 dimensional ϕ-q-n pattern that were accomplished by the experimental PD data from the IEC(b) electrode, needle to plane electrode and CIGRE method I electrode, respectively.

3. STANDARDIZATION OF ϕ- q-n PATTERN

To extract phase-shift independent characteristics from the ϕ-q-n pattern, one of the properties of the Fourier transformation expressed in eq.(1) was used.

$$F\{x(t-t_0)\} = e^{-j\omega t_0} X(\omega) \qquad \text{----} \qquad (1)$$

where $X(\omega)$ is the Fourier transform of $x(t)$.

On the basis of this property, the standardization of the ϕ-q-n pattern was performed using the procedure described in Table 1.

Table 1 Algorithm for standardization of ϕ-q-n pattern

Primary ϕ-q-n pattern
↓
Projected curve on to ϕ-n plane
↓
Fourier transformation
↓
Calculation of angle between reference phasor and positive real axis on complex space
↓
Shifting primary ϕ-q-n pattern along ϕ-axis according to calculated angle
↓
Standardized ϕ-q-n pattern

4. NEURAL NETWORK

A three-layer perceptron was adopted as a neural network in this research. The number of units of the input, hidden and output layer were 320, 24 and 3, respectively. Each of the input units was corresponded to each cell of the ϕ-q-n pattern and the repetition rates(n) were given as the input values of the neural network. This network was trained by the back-propagation algorithm. We gave three kinds of teacher signal groups, (1,0,0), (0,1,0), and (0,0,1) corresponding to IEC(b), needle to plane and CIGRE method I electrode, respectively.

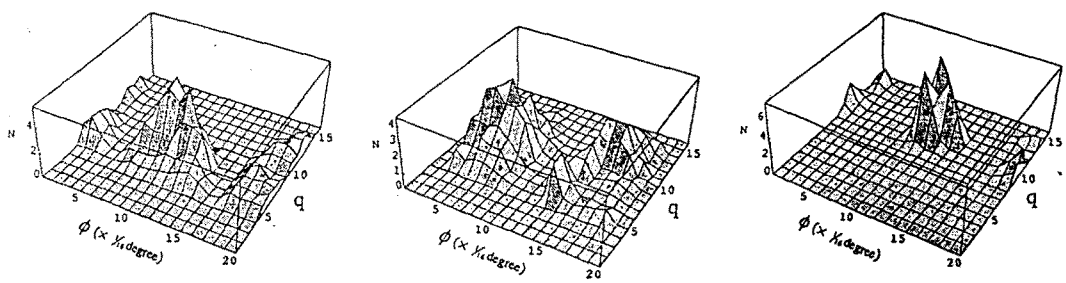
5. DISCRIMINATION OF PHASE-SHIFTED ϕ-q-n PATTERN

5-1. Pattern Recognition without Standardization

Figure 3 shows the result of recognition of a conventional network for the virgin patterns and its 3-D expression. As shown in the figure, the correct answer ratio is 100% and this indicates that a well-trained neural network can successfully discriminate the virgin patterns which are not phase-shifted. The phase-shifted patterns were tested with the same network and its discrimination results are shown in Fig.4. In the case of phase-shifted patterns, the outputs are extremely scattered and the correct answer ratio is only 42.9%.

5-2. Pattern Recognition after Data Standardization

Figures 5 and 6 show the results of recognition of the modified network for the virgin patterns and the phase-shifted patterns, respectively. As shown in these figures, the modified network successfully discriminated the phase-shifted patterns as well as the virgin patterns, and the correct answer ratio was 100% in all cases.



(a) IEC(b) (b) needle-plane (c) CIGRE method I

Fig. 2 Examples of ϕ-q-n pattern

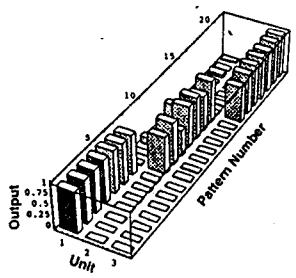


Fig. 3 Output characteristics of converntional network on virgin patterns

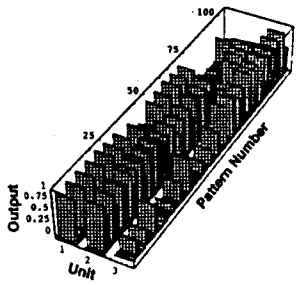


Fig. 4 Output characteristics of conventional network on phase-shifted patterns

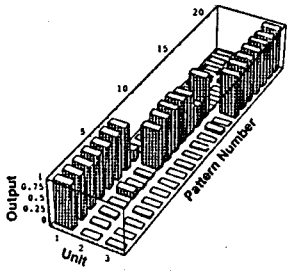


Fig. 5 Output characteristics of standardization adopted network on virgin patterns

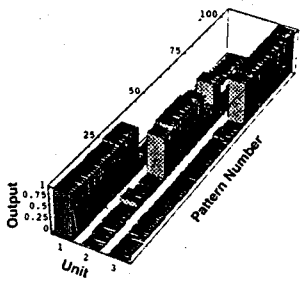


Fig. 6 Output characteristics of standardization adopted network on phase-shifted patterns

6. CONCLUSIONS

For the purpose of recognizing the phase-shifted ϕ-q-n patterns, a new standardization method of the PD ϕ-q-n pattern was proposed. The neural network using this new method was tested to find out whether it could discriminate the virgin and the artificially phase-shifted PD patterns acquired from the three kinds of electrodes. The results can be summarized as follows:

(1) The conventional neural network trained by the back-propagation algorithm discriminated the virgin ϕ-q-n patterns similar to the trained ones well, but could hardly discriminate the phase-shifted ϕ-q-n patterns.

(2) The standardization method of the ϕ-q-n pattern was established using a property of Fourier transformation, by which the phase-shift independent characteristics could be extracted from primary patterns.

(3) It was found that the neural network using the standardization method showed a reliable performence in discriminating phase-shifted ϕ-q-n patterns as well as virgin patterns.

REFERENCES

[1] N. Hozumi, T. Okamoto and T. Imajo, "Discrimination of Partial Discharge Patterns using a Neural Network", IEEE Trans. on Elect. Insul., Vol. 27, pp. 550-556, 1992.

[2] B. Fruth and L. Niemeyer, "The Importance of Statistical Characteristics of Partial Discharge Data", IEEE Trans. on Elect. Insul., Vol. 27, pp. 60-69, 1992.

[3] June-Ho Lee, Naohiro Hozumi and Tatsuki Okamoto, "A New Standardization Method for PD Pattern Recognition using Neural Network", Jour. of KIEE., Vol. 8, No. 1, pp. 34-41, 1995.