論文
6-2-7

XLPE/EPR 계면의 부분방전 패턴 분석을 위한 신경망 모형 (Neural Network Model for Partial Discharge Pattern Analysis of XLPE/EPR Interface)

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요 약

최근 들어 우리나라에서는 설치의 간편성과 높은 신뢰도를 가진 전력케이블의 사용이 증가하고 있다. 전력케이블은 출고 전에 IEEE std. 404-1993 시험을 거쳐 안정성을 확인하고 있지만 포설시 발생하는 접속부 내부의 결함으로 인하여 많은 문제가 발생하고 있다. 특히 불순물 혼입 또는 공극 발생시 고장율은 증가하게 된다. 부분방전 검출은 포설 후 전력케이블의 상태를 관측할 수 있는 유용한 방법이다. 본 연구에서는 부분방전 특성을 평가하고자 케이블 접속재인 EPR과 케이블 절연체인 XPLE 사이에 인공 결함을 발생시킨 후 데이터 취득 시스템을 이용하여 Φ-q-n 특성을 검출하였으며, 부분방전의 정량적 해석을 위해 필요한 통계량을 계산하였으며, 신경망 모델을 적용하여 패턴 분석을 수행하여 88~96%의 구별이 가능하였다.

Abstract

The prefabricated type used generally in Korea to join cable runs on new installations or to repair broken Cable runs on existing installations, because installation is very simple and save time. This type is a permanent, shielded and submersible cable joint for direct burial or vault application. It confirms to the requirements of IEEE std. 404-1993 by factory testing, but many problems of insulated cable systems are caused by internal defects of the joint part which have to be mounted onsite. Faults arise from impurities or voids. A suitable solution for a monitoring of cable joints during the after-laying test and service is partial discharge detection. <중략> Φ-q-n properties were measured using detection impedance, high pass filter and computerized data acquisition system. Statistic Value like maximum charge, repetition rate, average charge, etc. are calculated. It is possible to quantitative analysis of Φ-q-n properties from this statistic value and pattern analysis.

Keywords: partial discharge, lifetime diagnostics, power cable, XLPE/EPR

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1. INTRODUCTION

When the defect exists on the insulator inside, the partial discharge occurs and the efficiency of localized degradation of insulator. It makes lifetime decreasingdue to discharge pulse. If an accident occurred, time hangs on the breakdown section detection and a rehabilitation cable. But, a case is in an accident of cable by not only a defect to occur during manufacturing but also installation and an operation by a defect to occur to produce. Withstand voltage and the discharge test are verified to manufacturer, but administration method about defect that occur in addition among installation and operation was not standards. Defect that occurs from joint part is a metal, semiconductor, defect, and pollination while manufacturing the cable and operating the difference gadfly of construction of interface pressure decrease and the oil of the rubber parts and connection region variation and thermal expansion coefficient the defect due to occurs.

The technique that detects the occurrence of partial discharge from insulation diagnosis of the cable and, deterioration it is important in pattern of the partial discharge that is detected to decide. When deciding deterioration, to previously depend in the statistics quantity that the maximum discharge, electric charge quantity and the discharge occurrence frequency are simple. But the partial discharge is very short interval to occur at thelarge quantity that statistical nature interprets to respect and is enormous data in necessity. Uses the data control technique which uses the computer in partial discharge measurement and the control which partial discharge signal is quick is possible. That result it will be able to calculate the statistics quantity against the whole pulse that occurs. And the occurrence of the partial discharge which is accurate and decision of deterioration were possible and. The application is few from domestic. When connecting the cable, it will be able to occur in the defect it will be able to occur and operation early stage defect from the research which it sees modeling.

2. POWER CABLE JOINT

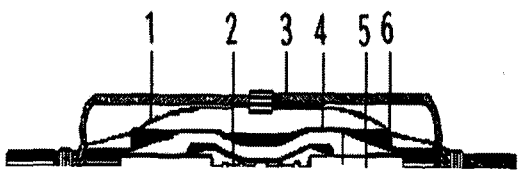


Fig 1 Premolded Type Power Cable Joint

1	Wire	Cu
2	Connector	Cu(+Tin Plate)
3	Metallic Screen	Cu
4	Insulation	EPR
5	Insulation	XLPE
6	Molded Shield	EPR

Table 1 Description

Power cable connection bringing up for discussions cable joint part(EPR) and insulating material of cable(XLPE) interface defect modeling it did the partial discharge that occurs. In order to raise the reliability of result, 1mm thickness with the insulation layer of the power cable is used. The EPR with 1mm thickness used the fact that it

presses at production line. In order to confirm the partial discharge quality due to a defect it made an artificial defect which is void, bits of copper and semiconductor impurities in the center of EPR/XLPE interface

3. EXPERIMENTAL

The defects which exist generally on the cable inside experimented. They are very small but size a defect in the objective, which will analyze the tendency where the defect gives an effect to electric quality a lot. The electrode piles up the EPR and the XLPE seat and the structure, which gives a schedule one pressure with the spring it is becoming. The mechanical pressure between EPR/XLPE interface was maintained at 2kg/cm2. It followed in use and the pressure diminishes the fact that it considered.

possibility where the model electrode the discharge will occur from different partial model electrode whole, the silicone oil which viscosity is 100 Cst put in inside and tested. The partial discharges are measured to determine their time dependence for 60 minutes. The test when the partial discharge starts until, after raising a voltage, measured the discharge pulse of 600 cycles. The applied voltage was 10 to 30 kV. Partial discharge signals could be discriminated with a sensitivity of 1 to 10 pC.

4. DATA ACQUISITION

The artificial defects it occurred a defect and after authorizing a high voltage, for a partial discharge detection it embodies and the data acquisition system which a power cable partial discharge and a statistics quantity it used it measured it calculated.

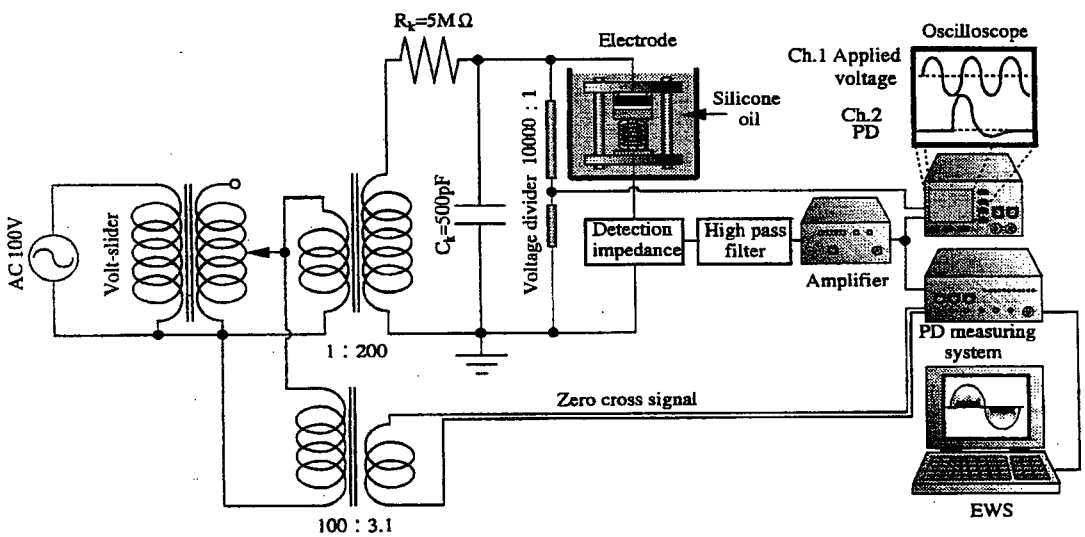


Fig 2 Experimental Diagram

When it authorizes a high voltage, there is a

It evaluated the partial discharge quality that it follows in type of defect. Applied voltage that controlled by variable AC autotransformer is input of the transformer. Output voltage passed condenser and electrode, and occurs a partial discharge. The partial discharge leads and detection circuit, the highpass filter and the amplifier it is input in data acquisition system. In order to get phase information of partial discharge variable AC autotransformer input a zero cross signal in data acquisition system. When two signals are input in the computer, there is a possibility of getting the statistics quantity of phase, electric charge quantity and occurrence frequency. The partial discharge signal pulse used the amplifier because the size is small quite and it amplified. The signal by the converter changes with 12 bit digital signal.

From the zero cross signal that is output occurs the square type green onion pulse from zero cross detection circuit. It inputs this pulse in counter circuit and it calculates total cycle. This as zero cross count(ZCC) signal. Also by a divide circuit divides 4096 bits 1 cycle and the partial discharge pulse occurs the phase data signal where it occurs. When it inputs a partial discharge signal and a measurement control zero cross signal in data acquisition system, the ZCC which is three digital signals, it is converted with the amplitude of partial discharge pulse(AMP) and phase of partial discharge pulse(PHA) signal. When the operation order comes from the computer, after sending the data, which is stored inside the buffer to an order broad way memory, it is stored in the hard disk. Phase information and partial discharge electric

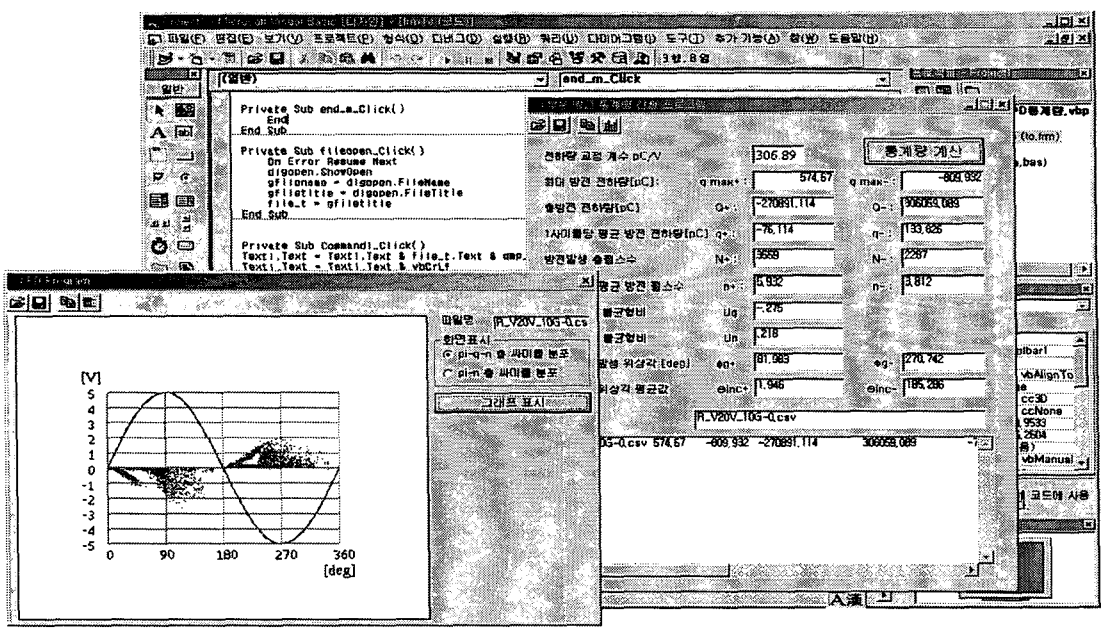


Fig 3 Data Acquisition

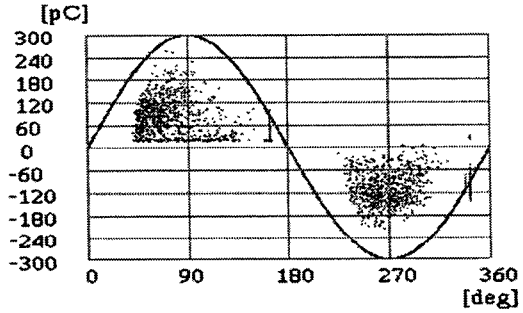
charge quantity data output a quality and a various statistics value from the graphic user interface(GUI) environment, which it embodies with Visual Basic.

Φ-q-n CHARACTERISTICS

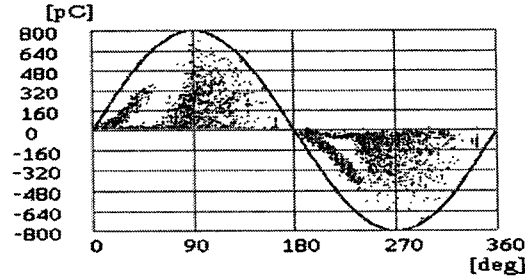
The Φ-q-n characteristic has been reported to change with the progress of the deterioration of insulation. Fig 4, 5 and 6 show the relation between phase, partial discharge amount and number of discharge (Φ-q-n characteristics) The assembly of cable joint is a critical step in ensuring the reliability of a cable system. The material interfaceare a very sensitive part of the cable joint from an electric stress point of view. Contaminants or defects at EPTR/XLPE interface can lead to treeing and ultimately premature breakdown of cable joint. Partial discharge measurement is effective methods by insulation diagnosis through defect detection and reliability estimation by method of insulation performance verification after connection work end. Test completion for high voltage system, is verifying new defect factor that can happen by driving primitive thermally behavior that is right on interface to partial discharge examination.

Different type of defects may occur in cable joint, especially a premolded joint. Depending on the type of defects, partial discharge may occurat different voltages and their presence can initiate a premature failure of cable joint. These phenomenon means that insulation diagnosis of joint can be achieved by observing partial discharge characteristics.

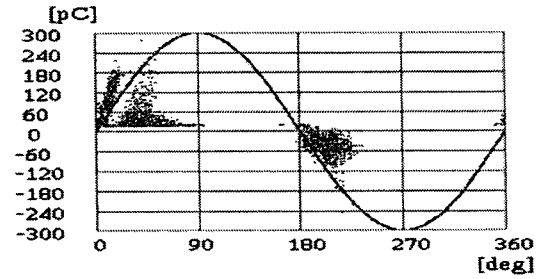
After establishing against the interface which it connects specially, the long and short term operation whistle it confronted to the occurrence of defect element at the joint part, the research is advanced from CIGRE Joint Task Force 15/21 intensively and it distinguishes while the internal organs operating the defect factor it will be able to occur additionally it classifies the type of defect.



(a) 10kVrms

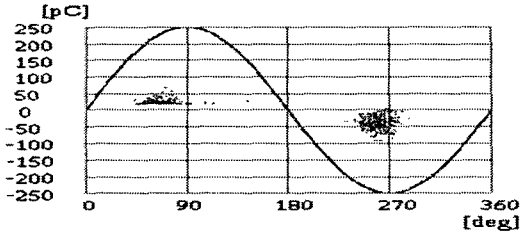


(b) 20kVrms

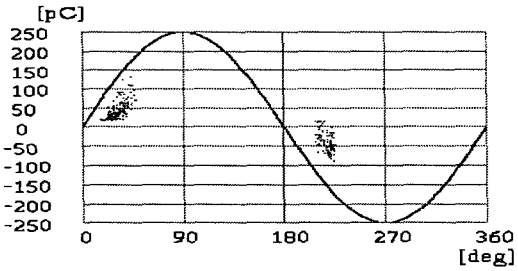


(c) 30kVrms

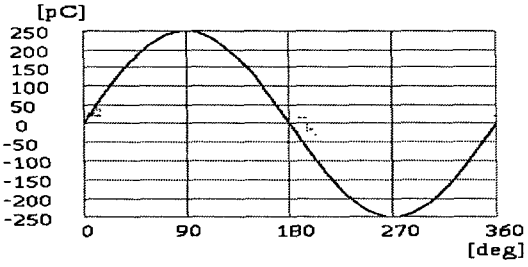
Fig 4. Φ-q-n Characteristics with Void



(a) 10kVrms

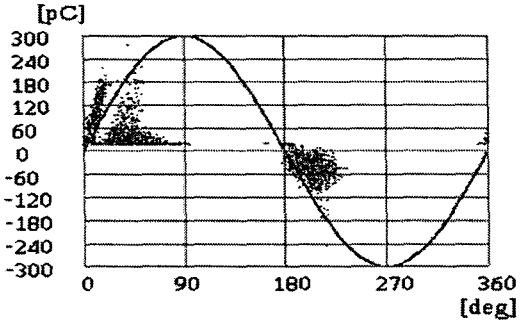


(b) 20kVrms

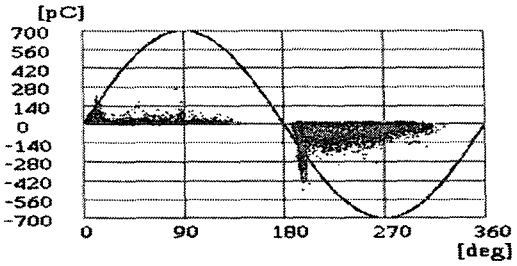


(c) 30kVrms

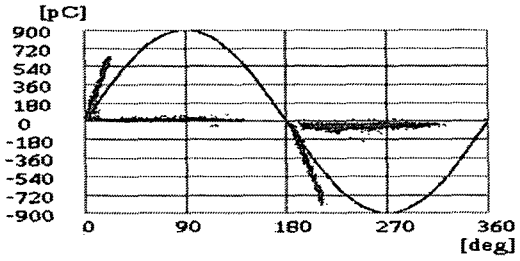
Fig 5 ϕ-q-n Characteristics with Copper



(a) 10kVrms



(b) 20kVrms



(c) 30kVrms

Fig 6 ϕ-q-n Characteristics with Semiconductor

5. STATISTIC VALUE CALCULATION

Maximum charge(Q Max)
Maximum value of discharge that appear during 1 cycle.
Total charge(Q)
Total value of discharge that appear during 600 cycles
Average charge(q)
Q divides whole discharge quantity of partial discharge
Number of discharge(N)
Total number of discharge that appear during 600 cycles
Repetition rate(n)
N divides 600 cycles
Initial phase degree(Inc)
Degree that occurs the first discharge

These statistic values are used for a data of pattern analysis by neural network. Neural network have promising capabilities as automatic discriminators and intelligent alarm processors. They have the ability to learn from examples without the intensive effort required for defining explicit rules learned patterns, to adopt to differing pieces of equipment and with only minimal customization necessary. Neural network systems have been studied recently and applied to the discrimination of partial discharge, classification of partial discharge patterns, alarm processors, and lifetime diagnosis systems.

Table 3 Pattern Recognition using Neural Network

	Learning Acquisition Counts	Number of Test Data Set	Discriminati on
Void - Copper	67 : 88	29	89.65%
Copper - Semiconductor	88 : 73	35	88.57%
Semiconductor - Void	73 : 67	33	96.96%

6. CONCULATION

There are large differences in the partial discharge pulse characteristics of joint

Table 2 Statistic Value Calculation

	Void		Copper		Semiconductor	
	Positive	Negative	Positive	Negative	Positive	Negative
Q Max[pC	224.473	-205.143	188.7662	-187.991	862.87199	-680.923
Q[pC]	40409.38	-39787.1	39462.86	-36472.9	230942.746	-287483.074
q[pC]	107.5978	-82.5748	66.59637	-68.7979	45.0573	-121.654
N	292.4	398.4	602.4253	494.3448	4688.9	2264.6
n	0.4874	0.6638	1.004471	0.824241	7.81551	3.774957
Inc[deg]	7.5184	185.743	9.482264	192.5957	17.63349	199.6937

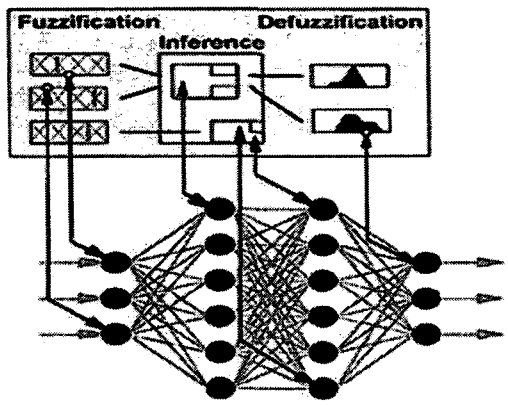


Fig 7 Neuro Fuzzy Module

interface with defect. All defects have a large influence on partial discharge pulse characteristics, resulting from an increase in the electric field along EPR/XLPE interfaces. Defect such as semiconductor has a significant influence on statistic value. It is possible to quantitative analysis of Φ -q-n properties from this statistic value. We think that this research is useful for the study of pattern analysis and lifetime prediction of insulation degradation at power cable joint part.

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