

Design of Intelligent Insulation Degradation Sensor

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Abstract

Insulation aging diagnosis system provides early warning in regard to electrical equipment defects. Early warning is very important in that it can avoid great losses resulting from unexpected shutdown of the production line. For solving this problem, many researchers proposed a method that diagnose power plant by using partial discharge. In this paper, we design the intelligent sensor to diagnose insulation degradation state that uses a Microprocessor and AI. Proposed sensor has MCU that is used to diagnose insulation degradation and communicate with main IDD system. And we use a fuzzy model to diagnose insulation degradation.

Key Words : Fuzzy Model, MCU, IIDS(Intelligent Insulation Degradation Sensor),IDDS(Insulation degradation diagnosis System), IDD(Insulation Degradation Diagnosis)

1. Introduction

Power plant became a high capacity and quality system in natural process, because industrial plant became large and accuracy system. And securing a reliability in power plant is very important in industry safety and improvement of productivity. It is well known that partial discharge is closely related to insulation degradation that is the main cause of failure in high-voltage electrical equipment. Insulation aging diagnosis system provides early warning in regard to electrical equipment defects. Early warning is very important in that it can avoid great losses resulting from unexpected shutdown of the production line. Many researchers report that the persistent observation of partial discharge is effective in insulation degradation diagnosis because it doesn't give a stress to system[1-3]. The study of diagnostics for insulation degradation has concentrated on the investigation of new analysis method in PD(Partial Discharge) and its application to the development of practical diagnosis. In 1992, M. Kosaki suggested a new parametric method and in 1993, G. Zingales proposed the standardization of 3D pattern of PD[6-7]. The literature tried artificial intelligence in the study of PD evaluation, many researchers applied back-propagation learning algorithms in artificial neural networks to get optimal inference instead of using complex mathematical equations. Recent literature studied diagnosis that analyzes acoustic waves and electromagnetic waves generated by PD correlated data to known insulation degradation[3,4]. Previous methods had difficulties in field testing since dynamic characteristics of insulation degradation are nonlinear and can't be easily

modeled. Further more, they need more complex, precise hardware[5]. And reported IDDM(Insulation Degradation Diagnosis Method) is very complex and those evaluation method can't be generalized because many factors are related to IDD. To remedy this problem, this paper suggests a fuzzy diagnostic model for insulation degradation using 3D trend data pattern of acoustic signal and expert's experiment. And so we design an intelligent sensor for IDD system that define abnormal status of objective power plant on site.

2. Design of IIDS

IIDS with a built-in MCU for getting an intelligence is composed of hardware modules and softwares those are soft-filtering algorithm for robustness to disturbance and IDD algorithm for defining state of insulation degradation by using fuzzy logic, IDDS's hardwares.

(1) Design of Hardware

Acoustic sensor is used to measure an ultrasonic signal generated from partial discharge in transformer for forecasting the insulation degradation. IIDS is constructed in measurement part for measuring the signals and filtering part for rejecting the noise signals, signal arithmetic part for signal processing, control part and communication part. Hardware structure is shown in Fig 2-1.

This work was supported by the RRC program of MOST and KOSEF through the Research and Development Center for Facility Automation and Information Systems (FAIS) at Yosu National University

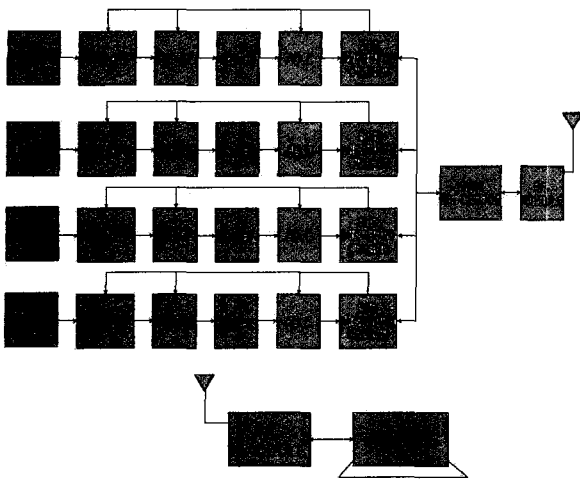


Fig. 2-1 Hardware structure of IIDS

when a partial discharge occur in an electrical plant, acoustic signal is generated from partial discharge. In Fig. 2-1, acoustic sensor sense this signal from external wall of object plant. and then Pre-Amp amplifies the output signal of acoustic sensor by 10, 100, 1000 times. Amplified signal is amplified again by programable amplifier, then this signal pass the band pass filter for rejecting a noise signal. In comparator, passed signal is compared with threshold value, then and passed signal when this is higher then threshold value. Impulses in passed signal is counted by high speed counter that is one of 3D. At a time passed signal is applied to A/D converter through buffer and is converted digital signals. Counter's value and Digital signal value is stored in RAM of Sub-microprocessor. In Sub-microprocessor, 3D data(Count Value, Magnitude, Phase) is acquired by signal processing, and this data history is managed. Sub-microprocessor controls amplifier, filter and threshold value in sensor module, and transmit low-level(source) data to Main-microprocessor, receive the control signal from Main-microprocessor. Main-microprocessor in Sensor system can control at a time four intelligent sensor modules. LCD of proposed IIDS is monitor that displays the processing state of all of intelligent sensor modules. Communication module is designed to communicate with main monitoring system on RF, or RS232C, LAN. Fig.3-1 is an outward shape of developed system.

(2) Soft-filtering algorithm and IDD model

It is not reliable because other sources to generating the ultrasonic signals are there in the circumstance of electrical plant in operating. and so it is necessary to reject an unreliable data.

In experience, an abrupt change in data is unreliable because the phenomenon of partial discharge is very slow. And then it is necessary for evaluation this data to reject from trend data.

In this paper, we use the fuzzy model that is modeled by experience to select an unreliable data from a data group.

Fuzzy rule used is singleton. Input variables are three those are PV(present value), ΔMav (variance of moving average), ΔPV . In this paper, we say "Soft-filtering algorithm" as this

selecting method.

IDD model with input variables are variances of phase, magnitude, counts of each sensor module is used to diagnose electrical plant. Fig.2-2 is process of fuzzy modeling algorithm. This experience is shown in paper[8]. If you want to review this experience, see the reference paper please.

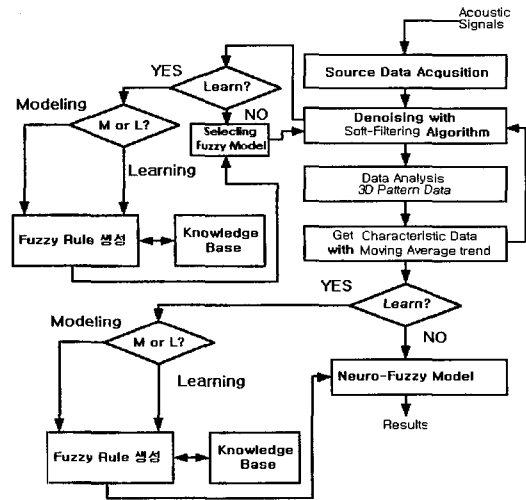


Fig. 2-2 Algorithm of Fuzzy modeling

3. Experience and Consideration

In this paper, IDS is composed of sensor signal processor to analyse acoustic signals and main processor to communicate and control with other systems. Main control computer controls the other sensor system.

It is difficult to diagnose with usual method the state of insulation degradation because process of insulation degradation is complex and nonlinear with various environments. Since each of electrical plants has its independent characteristics, it is necessary to manage each sensor's history for monitoring the insulation degradation of electrical plant. Therefore proposed IIDS is designed to manage the trend history of object plant's acoustic signal and decide the insulation degradation state of object plant.



Fig.3-1 Outward shape of IIDS

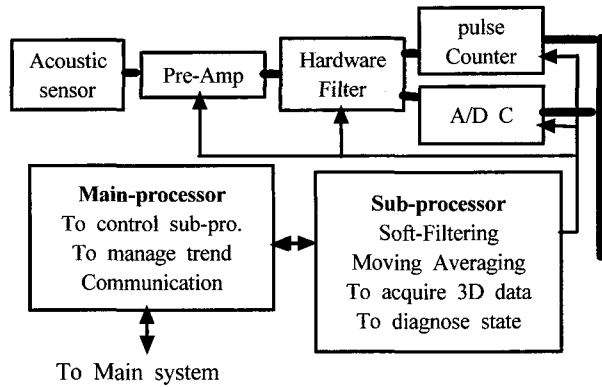


Fig. 3-2 Operating process of IDDS

Acoustic signal's frequency is high because partial discharge signal is an impulse trains, and consequently data acquisition time and cost of IDDS must be high. For that reason, each IIDS has a Sub-microprocessor(PIC16C74) that is low-cost but high speedy.

The operating process of IDDS system using IIDS is following as Fig. 3-2.

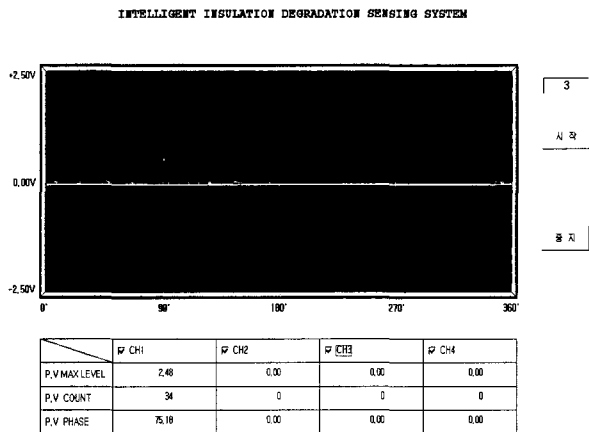


Fig. 3-3 Screen of IDDS Main system

4. Conclusion

In general high-voltage electricity handling, it is difficult to reliably manage the status of insulation degradation. There are many problems applying conventional methods since they are offline methods that shut down power, stop production lines and still need positioning measuring devices properly. Many researchers suggest solution to these problems and come up with almost practical systems using PD measuring methods. These methods still have problems because PD is discontinuous and Characteristics of object electrical plant is very various. To solve these problems, this research suggests the possibility of diagnosis system based on proposed IIDS, with experiment results verifying usefulness.

Proposed IDS is an intelligent sensor based on diagnosis algorithm of ID using 3D data trend generated from object

electrical plant. IDDS using IIDS overcomes the discontinuity of PD signal and produce general reference patterns for various electrical power systems and can be used to diagnose on-site the power plant in live.

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