UWB 센서 설계를 통한 고압회전기의 부분방전 진단 연구

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PD Diagnosis On High Voltage Rotating Machines using UWB Sensor

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Abstract : We studied the partial discharge detecting by sensing electromagnetic pulse emitted from the partial discharge source in the stator winding of HV Rotating Machine with UWB sensor. In this study, we designed new type of compact low frequency UWB sensor based on micro-strip technology and made experiments of offline dismantled testing compare with the traditional HFCT as a reference sensor in the laboratory. We investigated internal discharge, surface discharge, corona discharge and non-defected state normal stator on pre-made stator winding by using UWB patch sensor.

Key Words : PD(Partial Discharge), UWB(Ultra Wide Band) Sensor, Rotating Machine

1. Introduction

Partial discharge testing has been used for decades as a method to evaluate the condition of insulation systems used in medium to high voltage rotating machine. The stator winding insulation of high voltage machines is subjected to several stresses such as electrical stress, thermal stress and mechanical stress during operation [1]. By measuring the PD level, the condition of high voltage insulation can be assessed. Now, partial discharge testing is also rapidly becoming an industry standard as a quality assurance (QA) test for newly installed stator winding insulation system. PD testing can be done either offline (energizing the apparatus with an external transformer) and online (where the apparatus is excited by from the power system) [2]. Three kinds of PD testing; online, offline, and dismantled locating are available in high voltage rotating machine. The electromagnetic (EM) wave emitted from PD includes broadband signal of VHF/UHF (Very High Frequency: 30MHz to 300MHz/ Ultra High frequency: 300MHz to 3000MHz)[3]. We tried to receive UWB signal by using new design compact low frequency UWB antenna sensor.

2. Test

2.1 Sensor design and Fabrication

The basic of this design is a rectangular element improved for wider bandwidth in low frequency and can detect signal from near field. Our UWB sensor design was realized on FR4 substrate (ε_r=4.6,thickness1.6mm) in order to have low cost. Simulation has been carried out with CSTMWS version5.0 ,to determine resonant bandwidth, return loss and input impedance. To increase the antenna bandwidth, two cutting notches are used in the rectangular patch by controlling impedance stability [4]. These notches alter the electromagnetic coupling between the rectangular patch and ground plane [6]. The width of the notches is particularly effective either at low or high frequencies. Matching improvement can be obtained by inserting a slot in the ground plane [5].

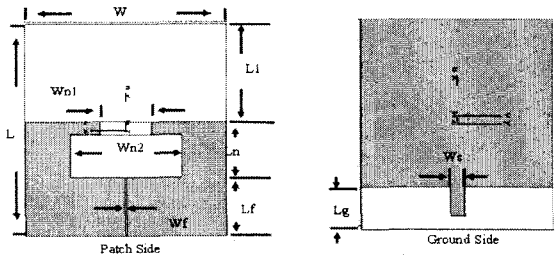
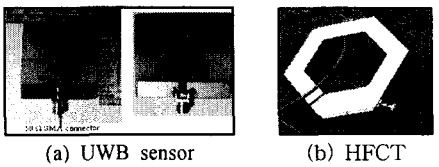


Fig. 1 The structure of UWB sensor

The optimization parameters are W_{n1}, W_{n2}, W_f and W_s while we fixed feed line length L_f(seeFig.1). The overall size of this structure is 40×30mm2. The antenna has the following dimensions: L_g=10mm, W_s=3mm, L_1=23mm, L_n=13mm, L_f=1.4mm, W_{n1}=10mm, W_{n2}=22mm and W_f=2.7mm.



(a) UWB sensor (b) HFCT

Fig.2 Picture of each sensors used in Test

We used 50Ω SMA connector in sensor fabrication and the fabricated picture and HFCT picture used in test are shown in Fig 2 (a) and (b) respectively.

The CST simulation results of this sensor have the -10dB

bandwidth of 734MHz to 3.42GHz and can operate -5.4dB at low frequency which is shown in Fig 3.

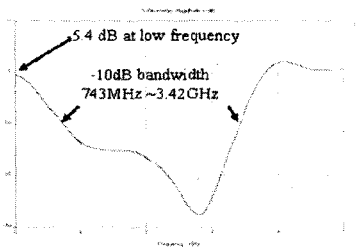


Fig. 3 CST simulation results of operating frequencies and S11 parameter in dB scale

2.2 Experimental Setup

We will investigate dismantled diagnosis on various kinds of discharge in stator winding insulation. In our laboratory testing, pre-made stator coils for corona discharge, surface discharge and internal discharge and the other one is no defected stator winding are injected by external high voltage source. These winding are dismantled from 6.6kV rotating machine. Commercial PD sensor, high frequency current transformer (HFCT) is setup at the ground to compare the results of our UWB sensor. The experimental setup is as shown in Fig 4.

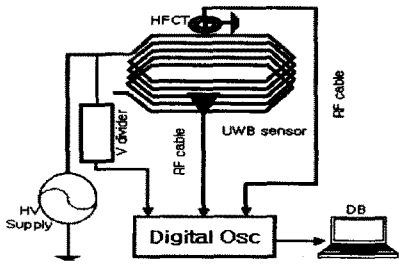
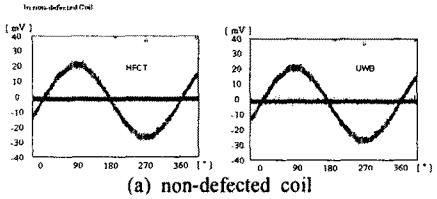


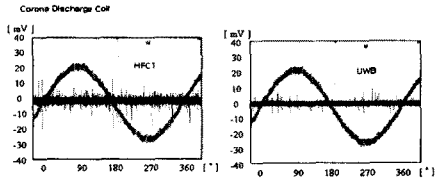
Fig. 4 Experimental setup

3. Test Result and Discussion

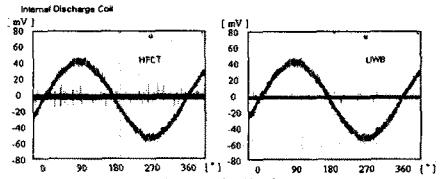
In testing, the injection voltage is raised by the step of 0.5kV on each stator which is being made by particular discharge. Experiment Test results, measured by Tektronix TDS 3032 digital are shown in Fig.5. The detection of discharge activities are 2mV by HFCT and 3mV by UWB, 14 mV by HFCE and 10 mV by UWB sensor in corona discharge coil, 5 mV by HFCT and 4 mV by UWB sensor in surface discharge coil and 8 mV by HFCT and 5 mV by UWB sensor. All coils are injected 4.5kV except internal discharge coil which is injected 5.5 kV.



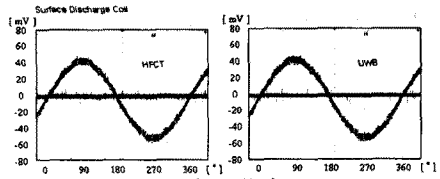
(a) non-defected coil



(b) corona discharge



(c) internal discharge



(d) surface discharge

Fig. 5 Time domain discharge activity oscilloscope results

4. Conclusion

As a conclusion, we verified that our new design of low frequency compact UWB sensor can also detect partial discharge signals compare with the commercial HFCT sensor. Furthermore, we studied discharge activities with different kinds of discharge in the stator winding insulation and found that inception voltage of Corona discharge and surface discharge are 4.5kV and inception voltage of internal discharge can be occurred at 5.5kV in 6.6kV rated rotating machine.

Acknowledgment

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