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PARTIAL DISCHARGE DIAGNOSIS ON LIVE EHV POWER CABLE USING PLANAR UWB ANTENNA

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ABSTRACT

In this paper, PD diagnosis technique is presented with a planar type of ultra-wideband antenna as a detecting sensor. A new type of microstrip UWB antenna was designed by finite integration method and fabricated on planar flexible dielectric substrate. We obtained proper PD signals from proposed antenna reducing various electromagnetic noises where ground plane of antenna operated as a shield restricting EM noises effectively. Also, conventional detectors are compared with proposed UWB antenna employing near field EM pulse detection where we analyzed detection signals on both time and frequency domain under live EHV power cable environments. In this study, we design new kind of patch antenna and make many experiments compare with the existing HFCT sensor on MV XLPE cable in the laboratory. As a result, we developed planar UWB antenna for PD diagnosis on live EHV power cable with higher levels of PD signals. According to our experimental results our new sensor can detect pure PD and wider bandwidth 20MHz to 70MHz than HFCT and can easily localized manually on the cable.

KEYWORDS

PD, XLPE, patch sensor, UWB sensor, HFCT sensor, electromagnetic sensing, wideband measurement

INTRODUCTION

Partial discharges are localized electrical discharges that only partially bridge the insulation between the conductors. Partial discharge is important reason to cause insulation deterioration. From the middle of 20^{th} century, people start making research on partial discharge [1, 2].

During the partial discharge process, there are many forms of exchanges of energy such as electrical pulse current, dielectric loss, electromagnetic radiation, sound, ultrasonic, acoustics emission, increased gas pressured, and chemical reactions [3].

In detection partial discharge, depending on the sensing on the kinds of energy exchange different detecting methods were approached in last few decades [4]. In these methods, electromagnetic sensing is one of the best kind of partial discharge detection and localization of PD source [5].

The main advantages of this method can reduce electrical noise. In this paper, we will show some experimental results over HFCT (High Frequency Current Transformer) sensor and our patch antenna sensor in detection partial discharge in MV XLPE cable of 22.9kV.

EXPERIMENTAL SYSTEM

Design and Implementation

Geometry of the double-sided parallel strip antenna sensor is shown in Fig 1. The coaxial fed point is connected to the center of the patch by using 50Ω SMA connector. We used polyethylene (dielectric constant =2.25) film sandwiched between 20 [cm] x 0.5 [cm] copper foil. This antenna sensor can operates at the frequencies range of 5MHz and 70MHz.

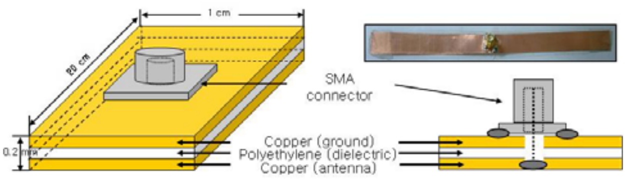

Figure 1: Structure of Prototype Patch Antenna

Measurement Methodology

The measurement system is as shown in Fig 2. We used 20dB amplifier which operates at the frequency range of 1 to 400MHz to amplifier. First, we measured the calibration signal of 10pC, 20pC, 50pC, and 100pC increasing step by step compare between the existing HFCT sensors and capacitive patch sensor. Secondly, we measured the PD signal by injection high voltage of 19kV.

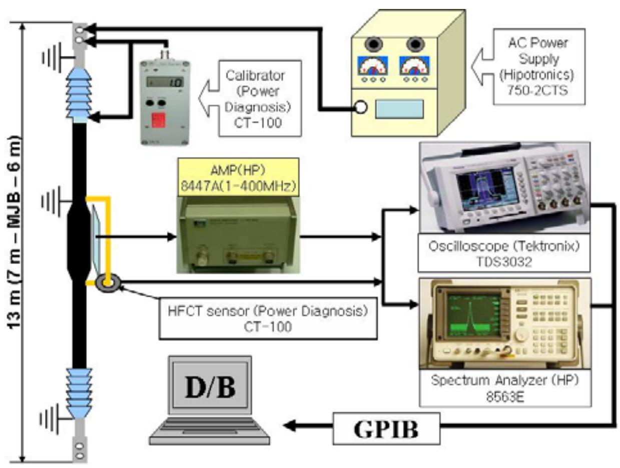

Figure 2: Test Map for Partial Discharge Detection

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RESULTS AND DISCUSSION

Our experiment includes two kinds: calibration signal injection and high voltage of 22kV injection to the cable. We used measuring instruments of oscilloscope for time domain analysis and spectrum analyzer to check frequency domain using with GPIB interface to Computer. In calibration testing, 20pC, 50pC and 100pC calibration signals are injected and detect by both patch antenna and commercial HFCT sensor. The detecting results for calibration signals are shown in Fig 3 and Fig. 4 in comparison of HFCT and patch antenna sensor in time domain.

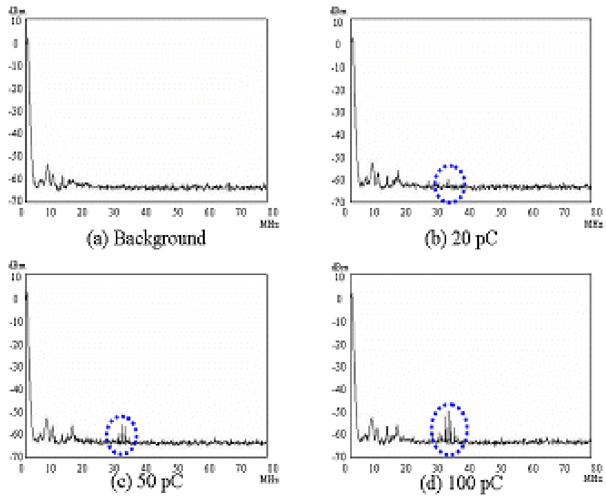


Figure 3: Each calibration signals using by UWB Sensor

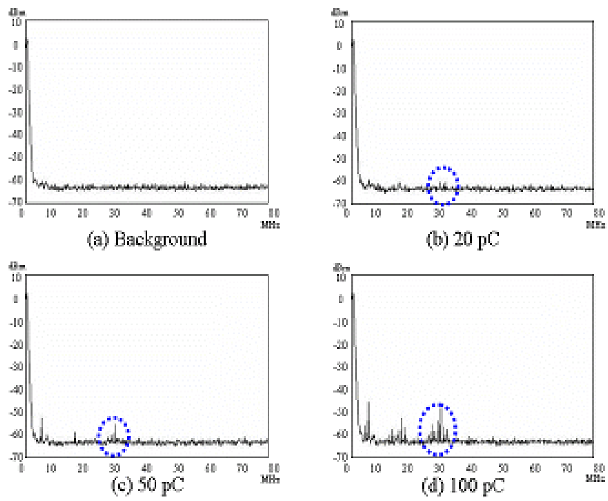


Figure 4: Each calibration signals using by HFCT Sensor

For phase resolve partial discharge analysis, we use oscilloscope to see in time domain. Sometime noise surges are occurred from the HFCT output but we found that capacitive patch antenna sensor gives only pure calibration signal. The calibrations signal results measuring in oscilloscope is shown in Fig 5.

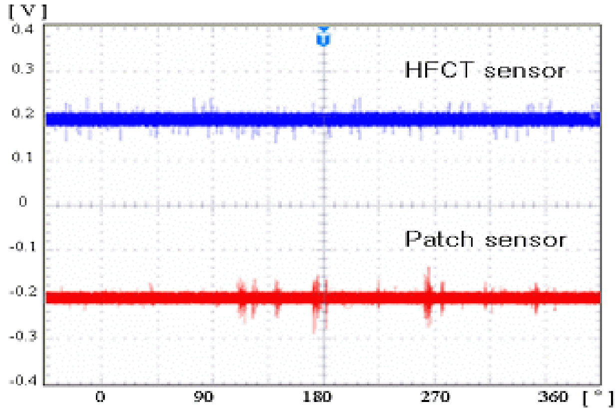


Figure 5: Comparison calibration signals of HFCT and Antenna

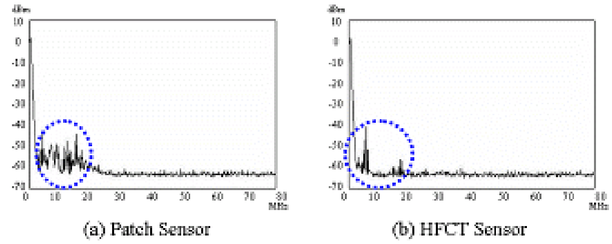
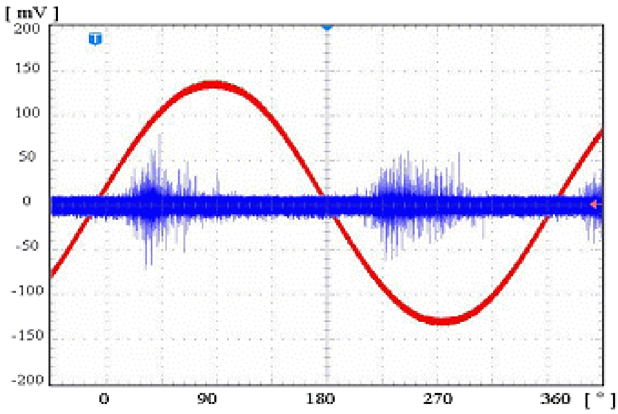
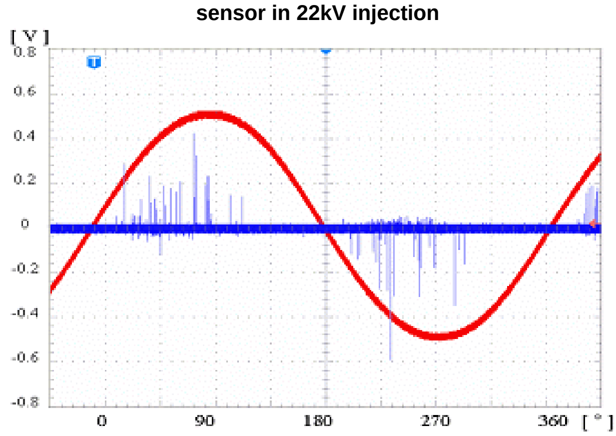


Figure 6: PD signals of 22kV inject time



(a) Oscilloscope results of PD signals detecting by HFCT sensor in 22kV injection



(b) Oscilloscope results of PD signal detecting by patch antenna in 22kV injection

Figure 7: Time domain measurement in 22kV

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In offline real power injection experiment, MV cable was supplied step by step raising voltage by the external HV source in the laboratory. We found PDIV (Partial Discharge Inspection Voltage) at 19kV. And detect by both sensor. Fig 6 shows the wideband confirmation of capacitive antenna sensor compare to the HFCT sensor from the Spectrum analyzer output. This result was obtained by injecting High Voltage of 19kV to the cable. Capacitive antenna sensor can operates the frequency range of 5MHz to 70MHz. Fig 7 shows the Oscilloscope results of PD when 22kV is applied to the cable. This results show our antenna sensor can separate positive PDIV and negative PDIV by giving different polarities out put in 1st quadrant of positive rise time and 3rd Quadrant of negative rise time.

CONCLUSION

In contrast, the detection PD by patch antenna sensor can reduce the electrical disturbances or interferences and PD signal can be separately seen in positive and negative cycle. Moreover, patch antenna is easy to fabricate and cost effective compare with the other types of PD sensors.

Acknowledgments

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