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Measurement and analysis of partial discharge for medium voltage underground power cable

A.Z. Abdullah[1,2,*], M. Isa[1,2], M.N.K.H. Rohani[1,2], M. Othman[2,3], H.A. Hamid[1,2]

[1)] School of Electrical Engineering, Universiti Malaysia Perlis,
02600 Arau, Perlis,Malaysia
[2)] Centre of Excellent for Renewable Energy, Universiti Malaysia Perlis,
02600 Arau, Perlis,Malaysia
[3)] Faculty of Engineering Technology, Universiti Malaysia Perlis,
02100 Padang Besar, Perlis, Malaysia

[*]Corresponding e-mail: zaidiabdullah@unimap.edu.my

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ABSTRACT – The continues and high-quality supply electrical energy is a heard of modern economic. Every time researchers work hard to find a way to provide reliable and safe power supply. Partial discharge (PD) is the most causes of the breakdown due to the degradation of the insulation. This paper considers the measurement and analysis of PD on XLPE cable to determine the ability and advantages of Rogowski Coil (RC) as a sensor. Off-line measurement setup on XLPE cable has been carried out to prove the ability of PD measurement. The characteristic of PD signal also been analyzed to identify and characterize a real signal detected. Results show the ability of RC used as a sensor and some advantages of the application been discussed.

1. INTRODUCTION

In high voltage, electrical insulation is one of the most important parts to be maintain against electrical, mechanical and thermal stress during their operation. The insulation breakdown may occur when there is repetition of PD activity at the defect site. This will cause the defect to grows until the electrodes between the insulation bridges [1]. At present there were reports that high insulation breakdown in high voltage distribution system was originated from cable and jointing [2]. Currently Transient Earth Voltage (TEV) or PD mapping were used to detect PD activity in cable at utility site. For TEV, users need to invest a lot of cost, while for PD mapping the system need to shut down for measurement. Currently in [3,4] the modified RC as PD sensor has been developed and present. This paper continuous work to proof the ability of RC in real PD measurement. The characteristic of PD signal presented in [5] is referred during analysed of the result including of its range of time, frequency and shape. Table 1 shows the comparison of the indicated RC with TEV.

Table 1 Comparison PD Sensor [6,4]

Sensor	Rogowski Coil	TEV
Bandwidth	0.5 MHz – 1GHz	3 – 70 MHz
Cost	Low cost	High Cost
Installation	Flexible	Guided

2. METHODOLOGY

PD measurement technique conducted is followed the IEC60270 standard and using RC as a detection sensor. To study the ability to detect PD signal, experimental measurement was carried out using RC, Lecroy Wave Runner high frequency oscilloscope, function generator and 500-meter 3 core 180 mm XLPE cable as shown in Figure 1 and Figure 2. The PD pulse was injected into only one core of cable by the continues pulse created from function generator. The RC is clamped at each of single core and all core cable. The oscilloscope is connected to the RC thru coaxial cable and all measurement are recorded. Then data analyse is done in MATLAB environment. The concept of pulse reflection from end to end of cable was used during analysis based on Equation (1) for particularly long cable position of PD [7] .

$$PD\% = (1 - \frac{\Delta t}{l}) \quad (1)$$

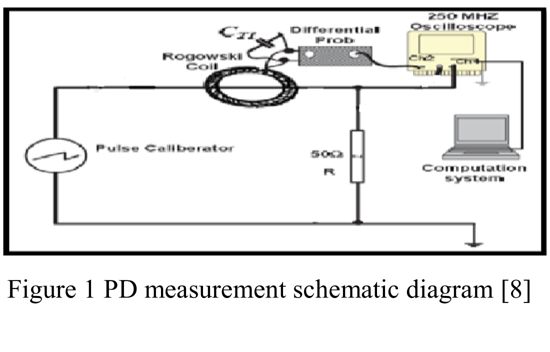

Figure 1 PD measurement schematic diagram [8]

Measurement of rise time and width of the pulse were also carried out and plotted against time as shown in Figure 3 and Figure 4. Then, the analysis is continuing by using Fast Fourier Transform (FFT) technique to determine the overall frequency response of the PD signal.

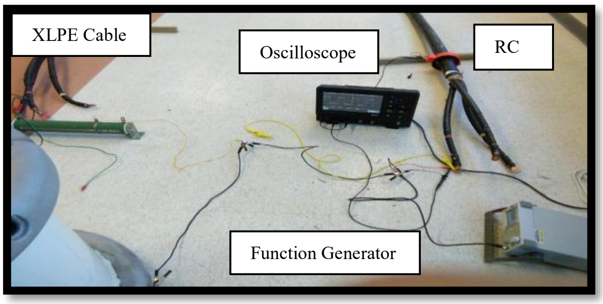

Figure 2 Off line PD measurement setup on power cable

3. RESULT AND DISCUSSION

Measurement is performed by injected 4 MHz PD pulse generated by function generator to the red core of 500-meter XLPE cable. Figure 3 shows the PD signal that injected into cable. Figure 4 presents the result obtain from measurement using RC and clearly shows the PD signal pattern. The characteristic of PD signal is compare with standard [5,9] and shows it's fulfil most of the basic PD criteria. PD pulse which is propagated along the cable is distorted and repeat at several time until it reaches to the end of cable. The result obtain from the time domain is analyse using FFT are presented in Figure 5. Also, it indicates the PD signal with the high amplitude value and the frequency range within normal PD characteristic. From all results, there was a significant positive of modified RC as a sensor to detected PD in cable.

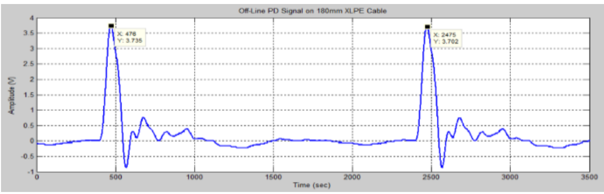

Figure 3 Created and Injected Signal on XLPE Cable

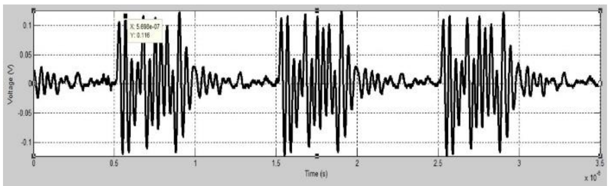

Figure 4 Off-Line PD Signal Detected on XLPE Cable

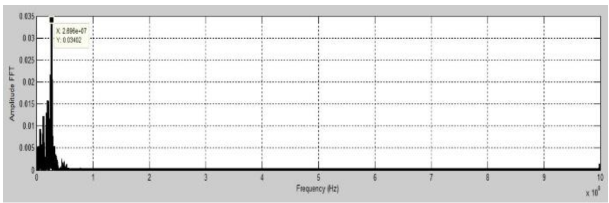

Figure 5 FFT for Off-Line PD Signal

4. CONCLUSION

The new PD measurement technique using Rogowski coil as a sensor was performed. Overall results indicate it most accurately detected the PD pulse in cable. However, the technique to locate of the PD source is still under progress. Work on XLPE cable using Rogowski coil has shown encouraging result, where it easy to measure and with some analysis the location of PD signal can be estimated. Since PD pulse was clear detected using RC, it was possible to use it at real site for PD measurement.

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