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AUTOMATIC THRESHOLD OF STANDARD DEVIATION TO REJECT NOISE IN RAW DATA OF PARTIAL DISCHARGES

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ABSTRACT

The raw data PD measurement results by using a computer usually contain noise that can lead to miss interpretation. So as to obtain an accurate diagnosis, then this noise must be separated from the raw data. In this study, the electrodes used were needle-plane electrode and the samples tested are polymer films placed on the electrode plane and the air gap is located between the needle and polymer films. There are two types of arrangement of the electrodes, the first electrode needle wrapped with the film and the second polymer are not wrapped with polymer films. To separate the data PD of raw-data is necessary algorithms that can automatically select the threshold value of the standard deviation value. To obtain the optimum value, the threshold value selected based on the standard deviation of each value segment. The results show that this method has been used to distinguish between the electrode pattern PD wrapped or not wrapped polymer.

Keywords: ceramic insulator, leakage current, partial discharge, infrared images, pollution.

1. INTRODUCTION

Reliability and quality of electrical power transmission are determined by the quality of electrical insulation. Disturbances and faults often occur even though the insulators are not in ageing condition. The most common initial cause of failure of the insulators that has been found in the field is partial discharge. Partial discharge (PD) will decrease the insulation strength of the insulator. If this degradation occurs continuously then the insulation may experience a breakdown condition. PD can be caused by material defect such as void, bump and impurities.

The 90% peak value PD max of digital measurement has been analysed using sampling rate (SR) frequency setting[1]. A higher SR provides a more accurate measurement of the peak value which in turn also provides a more accurate measure of the peak and phase of PD in one cycle of a voltage wave. Peak measurement of PD is determined by threshold value of the measurement. If the threshold is low the noise will be accumulated in the PD measurement. In contrary, a high threshold value will cause some of PD data cannot be measured. Therefore, an optimum threshold is needed. There are some methods to find an optimum threshold such as fuzzy logic, standard deviation threshold using statistical method[2]. PD wave forms are divided into 3600 parts. Usually at the beginning and the end of the waveform, the chance of occurrence of a PD is very small; therefore these sections are used as a comparison of standard deviation. This standard deviation is then compared with the 3600 parts. If a measurement is higher than the comparison of standard deviation then the particular section is analysed as PD data and the rest as noise.

When a PD occurs which is followed by the gathering of the same electrical charge at the surface of the insulator, the electrical charge will reduce the potential of air gap hence the discharge will stop instantly. A PD will takes place if the potential differences between the two sections is the same or higher than the dielectric strength of air. This condition can be achieved using either of two ways i.e. by increasing the source voltage or by reversing the polarity of the source voltage. Reversing the polarity of the source voltage of AC system means when the voltage is back to zero, the PD will occur when the voltage is going toward zero. This is called back discharge[3]–[7]. Therefore, application of standard deviation as a comparison for calculation at the beginning and the end of the wave form is not correct for this case. Therefore, additional logics or new possible logics are needed in order to have the correct value.

2. MATERIALS AND METHODS

a) Measurement technique

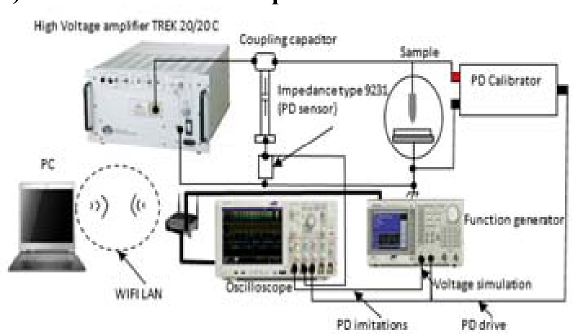


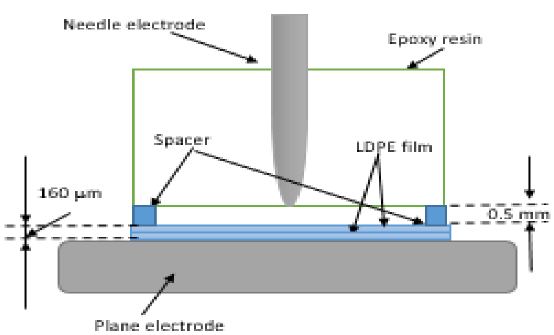
Figure-1. Experimental set up.

Figure-1 show a measurement which is controlled by computer with Labview software. All the devices are connected to Local Network Area (LAN) through cables hence the devices can be read or controlled from PC using IP address that have been provided automatically or can be set manually. The PC is as a control device or data receiver which is sent from wireless LAN connected oscilloscope.

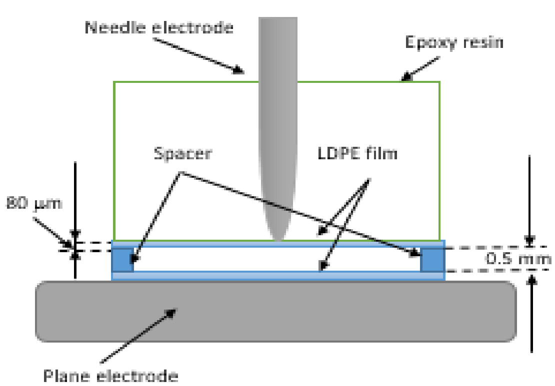
The voltage source which is generated by a high voltage amplifier device (Model C 20/20 Trek Inst) with 2000 amplifier ratio and the maximum input 10 Volt peak for 20KV peak output. This research uses 3 KV peak output amplifier and 50 Hz frequency. The input amplifier is connected to the function generator AFG 3000 series, where this device is controlled by Labview software in a PC through LAN network.

The source of high voltage which is utilised as a PD phase resolved reference is provided at a voltage monitor of high voltage amplifier devices. This signal is read by oscilloscope on channel 1 (CH1). Moreover, PD detector Haefly Type 9231 is utilised for PD detection on the samples. This signal is read by an oscilloscope on channel 2 (CH2). The oscilloscope is a digital oscilloscope type DPO 5000, 1GHz, 10GS/s which can be controlled or read through LAN. The communication of reading and controlling of this devise is carried out by PC using LabVIEW. The PC connection is provided by a WIFI LAN.

Figure-2 show two type of conductors are used i.e. the first electrode needle are not wrapped with the film (NWF), see in Figure-2a and the second polymer are wrapped with polymer films (WF) see in Figure-2b. The air gap at both conductors are 0.5 mm. In the air gap the PD could be happened. The material of the polymer is LDPE film with 80 mm thickness. Moreover, scanning electron microscopy (SEM, Hitachi S-3400N Japan) was used to investigate the surface change due to PD.



(a)Without wrapped



(b)wrapped

Figure-2. Type of conductors.

b) Data processing

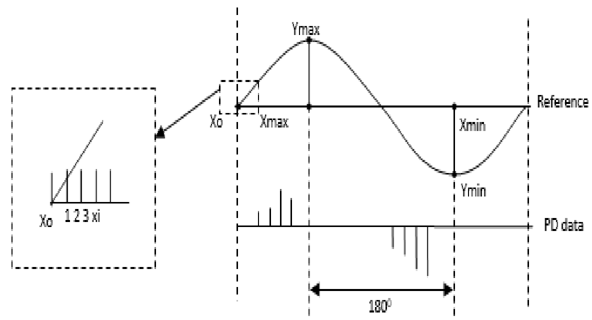


Figure-3. Synchronisation voltage and PD data.

$$step = \frac{|X_{min} - X_{max}|}{180} \quad (1)$$

$$X_0 = 90-(step\times X_{max}) \quad (2)$$

$$X_i = X_0 + (step \times x_i) \quad (3)$$

Where, x_i is the number of sampling; $step$ is the change position on phase; X_0 is the starting position; X_{max} is the position of the maximum magnitude and X_{min} is the position of the minimum magnitude.

Figure-3 is a source voltage in form of sine wave which is a function of sampling number. The sine wave is used as a phase value in PD occurrence. Phase angle between Ymax and Ymin has a phase value of 1800, a value of step per phase is derived from equation 1. Ymax of the sine wave is equal to phase degree of 900. By using this mathematical assumption, a value of the initial degree of the wave can be calculated by equation 2. Then the sampling value lies within the sine wave can be converted in form of phase as in equation 3. A phase of PD occurrence can be positioned on a phase degree as in equation 3.

Figure-4 is a flowchart of Peak Measurement of PD using standard deviation. Figure-4.a is the old method. If one period of voltage wave divided by 3600, then it results of 0.1 phase degree. There are around 110 SD samplings (SDs). To determine whether a segment has peak value PD, a SD threshold (SDo) is used where its value taken from occurrence probabilities of PD in range of 0-0.50 and 359.5-3600[2]. As it has been mentioned in the introduction, PD occurs on cross section. The SDo raises and produces bigger SDo, as consequences the low magnitudes PD read as noises. Therefore it needs a new algorithm to define a SDo to avoid the problem as shown on Figure-4b. On Figure-3b, after getting SDs for every segment, they are tabulated to gain the frequency of a SD and added by a logic that PD is not going to be occurred greater than 100 in a period. It is also to eliminate the

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problem constraint of the low probability of PD. This SDo called SDo dynamic (SDDo) as described as in Figure-4b.

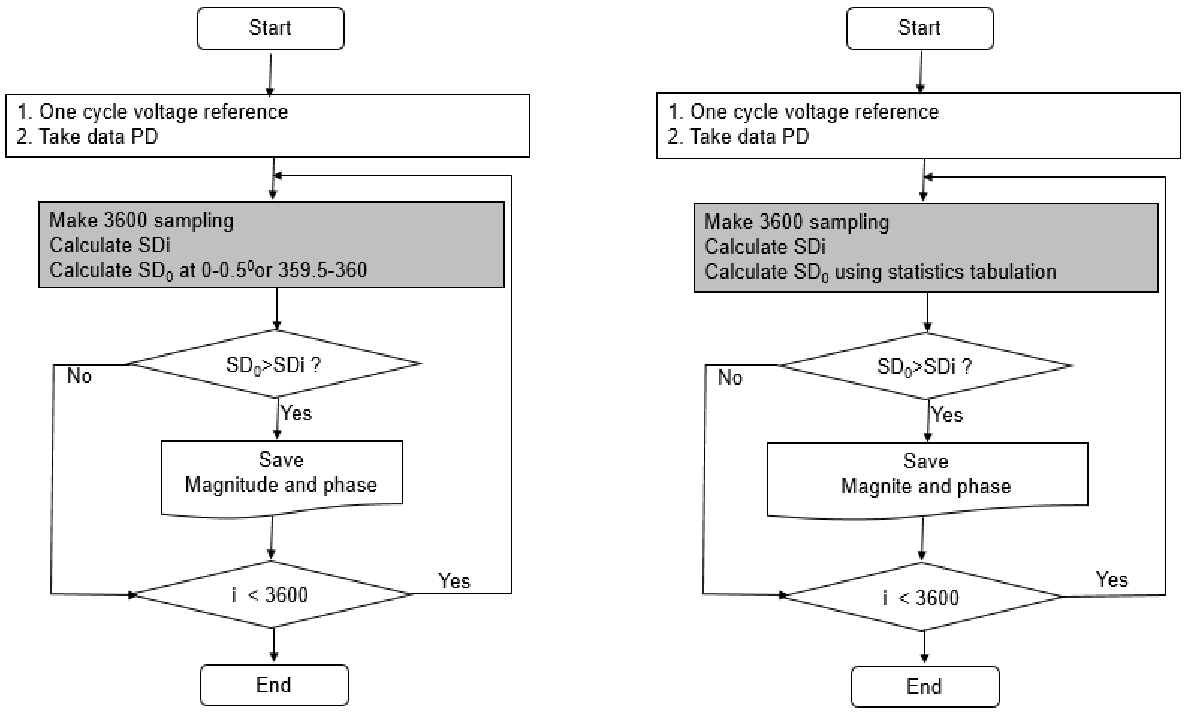
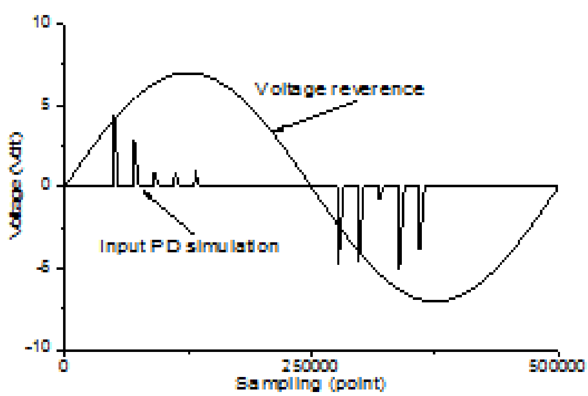
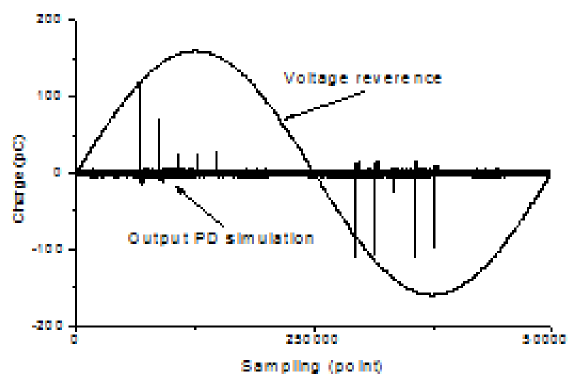


Figure-4. Flowchart for SD threshold, a) from the past logic[2] b) New logic.

3. RESULTS AND DISCUSSIONS



(a)



(b)

Figure-5. Flowchart for SD threshold, a) from the past logic b) New logic.

Figure-5b is the results of the simulated PD data using LabVIEW refer to the 50 Hz reference voltage. These results of the simulated PD data than become the input for PD Function generator to enable the simulated can be read by an oscilloscope as shown in Figure5b. The sampling rate was 25 MS/s, and the points gained was $5x10^5$. Even though the large data can read by oscilloscope but only 10 peaks and 10 position is qualified to be analysed.

In general, there are two steps that must be performed to determine 10 of the peak value and its

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position. The first is separating the PD signals the raw data, and the second is to determine the maximum and minimum values that represent the positive and negative PD. The statistical measures of PD separates from the raw data is as follows; First of all raw data is divided as many as 3600 segments, each segment of its standard deviation is calculated as shown in Figure-6, at the same time also made calculations maximum or minimum value included phase angle. Positive PD are in phase -30 up to 130 degrees, PD value while the rest is negative. Not all segments of the value of the wave reflects PD, for that use SD threshold [2] where the threshold value contained in the phase0-0.5 degrees or 359.5 to 360 degrees. If the value is greater than SD threshold it will be stored as the peak value PD. The results of the calculations in the plot in a graph as shown in Figure-6.

In this research primary election threshold is only at its initial position to avoid reading of error. As an illustration, if the initial PD located at 0-0.5 degrees, then the SD threshold value on the Figure-6 is as much as 15 with 3 PD value positive, the other data is not data PD. For that we need the addition of the algorithm so that the selection of SD threshold value more accurately. First, tabulate the value of existing SD and SD happens only one time occurrence. But in some regions, which is worth one SD, SD eliminates sought value at which the number of SD is more than one, then the SD threshold value can be determined by the value of which amounted to a minimum SD and SD greater than the amount greater than one shown in Figure-7. For example In Figure-8 there are 5 positive and 5 PD negative, as well as on the results of measurements that have been using the SD threshold.

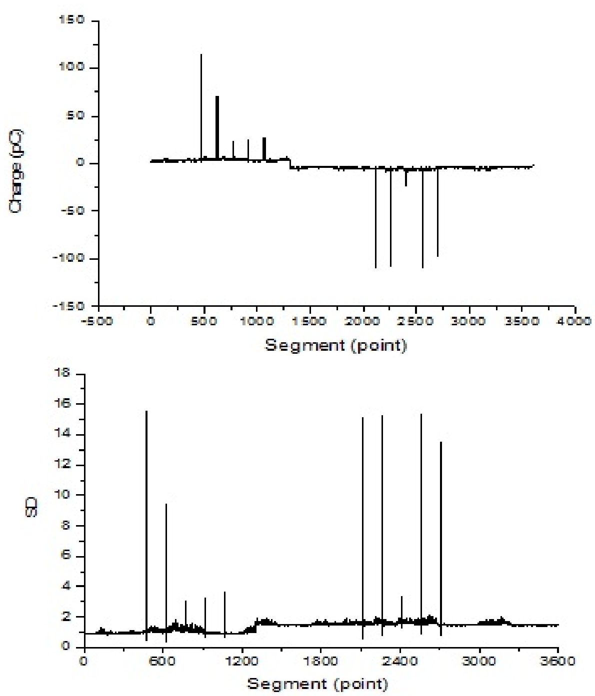


Figure-6. PD and SD in the segment.

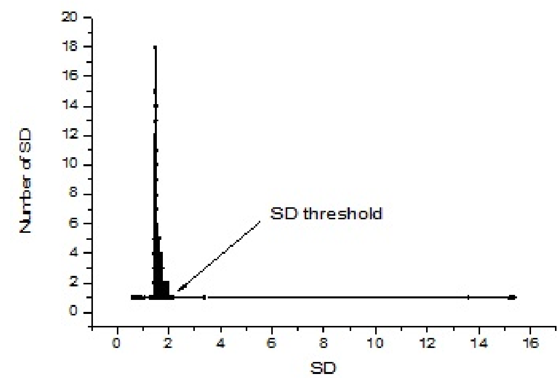


Figure-7. SD tabulation.

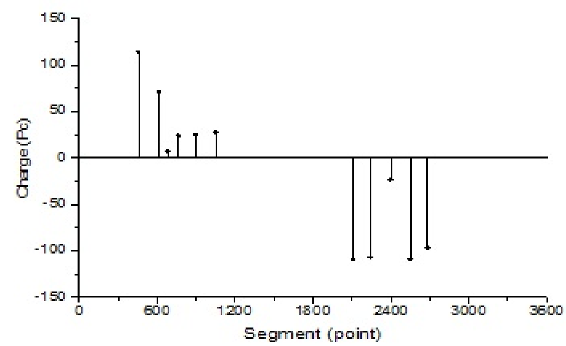
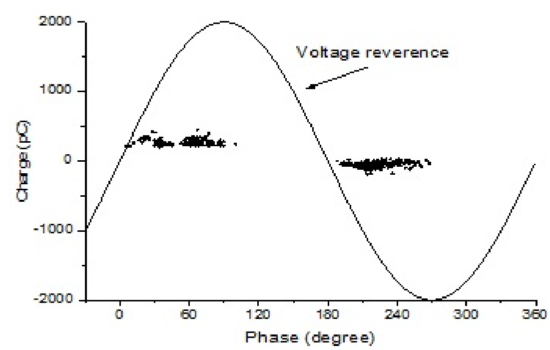
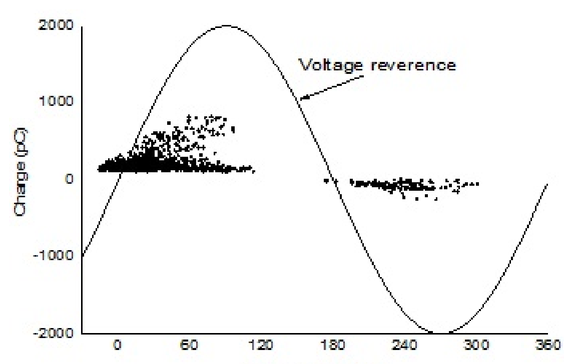


Figure-8. SD tabulation.



(a) WF



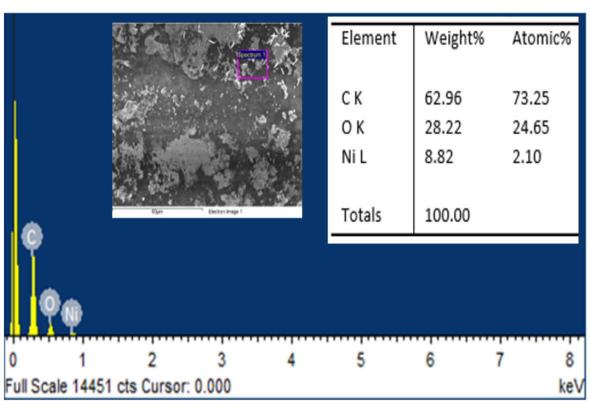
(b) WWF

Figure-9. PD patter WF and WWF.

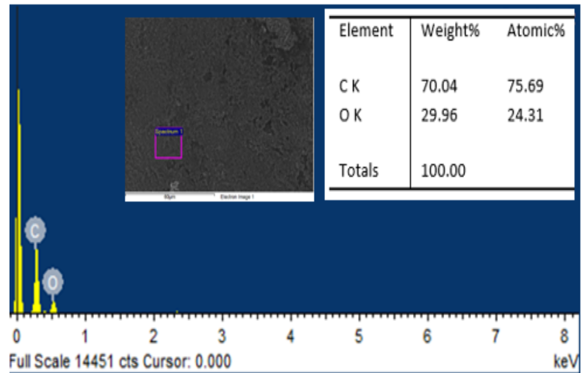
PD activity corresponding to each a wave source voltage for a long time is random, either magnitude or position. PD activities usually are collected in accordance with the phase to form a specific pattern [3][7][8]. Some of the factors that influence the pattern of PD is the condition of the gas, charge-free as the initiation of PD and of surface degradation by PD activity. PD activity in a closed void decline against a function of time, and a change in gas pressure caused by combustion and other gases can form [7], in addition to the electrode configuration also affects the magnitude of PD.

The magnitude of the PD at a certain time would be significantly reduced [4], but the PD pattern always has a specific form. In examining the WWF and WF (see Figure-9), PDmax WWF is greater than WF. WWF ionization probability is greater than the WF for electron inization directly from the needle, while WF hindered by polymer and electron initiation of the rest of the PD before.

Figure-10 show the pictures of the surface of the insulation that was taken using the electron microscope (SEM). Observations on the WWF shows that there are metal elements on the surface of the insulation. It is also shown that PD height of magnitude is also influenced by the initials condition of free charge. In the discharge portion where the needle was not wrapped, there is the possibility of archive material from the needle on the surface of the polymer when the incident PD. This is indicated by the damage to the tip of the needle [5] and the visible presence of metal elements on the surface of the insulation WWF. While on the WF surface, there are none metallic element was shown.



(a) WWF



(b) WF

Figure-10. Image and data content on the surface due to PD with WWF and WF.

4. CONCLUSIONS

- Using automatic threshold make the readings more precision PD peak value.
- The program is able to distinguish the sample configuration by displaying PD pattern.

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