VOL. 11, NO. 10, MAY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

IN HOUSE CALIBRATION OF PD DETECTOR SYSTEM FOR FIELD TEST RESULT RELIABILITY

Avinash Raj[1], Chandan Kumar Chakrabarty[1], Rafidah Ismail[1] and Basri Abdul Ghani[2]
[1]College of Engineering, University Tenaga Nasional, Kajang, Selangor, Malaysia
[2]TNB Research Sdn. Bhd, Kajang, Selangor, Malaysia

ABSTRACT

Partial Discharge is a phenomenon that indicates cables or joints deterioration in an electrical transmission or distribution system. Mechanical damages, voids or contamination in the insulation of cables or joints may contribute to the degradation thus emission of PD is present. The electromagnetic pulses emitted may represent the condition of the insulation. Current PD detector designed using Patch Antenna with combination of FPGA and ADC is capable to pinpoint the PD source however to ensure the reproducibility between PD detectors, a calibration method has to be established.

Keywords: partial discharge, cable insulation, XLPE.

INTRODUCTION

Partial Discharge measurement is very vital and has been established for more than half decade [1, 2]. Partial discharge measurement is associated to high voltage electrical insulation's quality. Partial discharge (PD) can occur in any high voltage assets. Mechanical damages, voids or contamination present in the insulation system directly contributes to the emission of PD [3]. The voltage at which PD is detected is known as inception voltage. Stress in weak spots of the insulation contributed by voids causes it to breakdown faster than voltages that contribute to operating stresses on cables/joints due to breakdown strength is much lower for gas [5].

Electromagnetic sensing is dominant in PD detection methods as PD is associated with the emission of electromagnetic pulses. PD pulses have pulse width of several nanoseconds [4]. These pulses propagate Omni-directionally from the PD source [6, 7]. The higher the frequency, the more quickly the attenuation that takes place along the cables. The electromagnetic (EM) wave emitted from PD includes a broadband signal of VHF/UHF (Very High Frequency: 30MHz to 300MHz/ Ultra High frequency: 300MHz to 3000MHz) [8]. A reliable Partial Discharge system is needed to monitor most types of HV equipments or cables [9].The PD detectors objectives is to locate a defect and allowing the replacement of the cable or defective joints to be performed. The PD detectors accuracy and consistency to locate PD pulses is vital to detect underground defects in the cable or joints [10].

The PD Detector System displayed in Figure-1 is developed to be applicable in various situations. It is a user-friendly, light-weight portable device which is capable of detecting PD activities inside medium and high voltage cables. This device is targeted to indicate localized PD signals inside joints, terminations as well as signals along the cable. The General usage is when the PD Detector System can be used to detect any PD activity inside medium and high voltage XLPE cable joints and terminations. It can also be used as a pre-indicator whereby the PD Detector System can be used as a first indicator of new occurred PD activities inside joints and terminations before using other more methods to diagnose the power cables such as Oscillating Wave Test System (OWTS). The PD detector can also be used as a verification tool whereby it can be used to verify the results of other PD tests and pin point along the cable where PDs originate. For example, in the case of replacing underground joints and cables, the PD Detector System can be used after excavating the area to verify the source of PDs and determine which segment needs to be replaced.

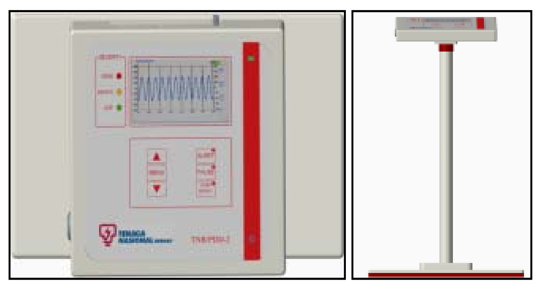

Figure-1. Partial discharge detector prototype.

Figure-2. Evolution of partial discharge detector (Uniten).

One obstacle is that the assembled units have to be calibrated and tested before given to power utility group for their diagnosis. This is to ensure the units delivered provide consistent and accurate measurement results in the field when measuring underground cables or joints. Bringing the PD detector to the site is redundant and there are very limited known locations to be used for calibration. This is the limitation to perform on site calibration. Therefore a calibration method has to be established utilizing simulated pulses which represent the

VOL. 11, NO. 10, MAY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

PD signal in the field. This calibration method will be conducted in the lab environment.

PD MEASUREMENT SYSTEM

Since PD occurs in VHF/UHF, The E-shaped patch antenna designed with partial ground plane with operating range of 236 MHz to 370 MHz is selected [11].

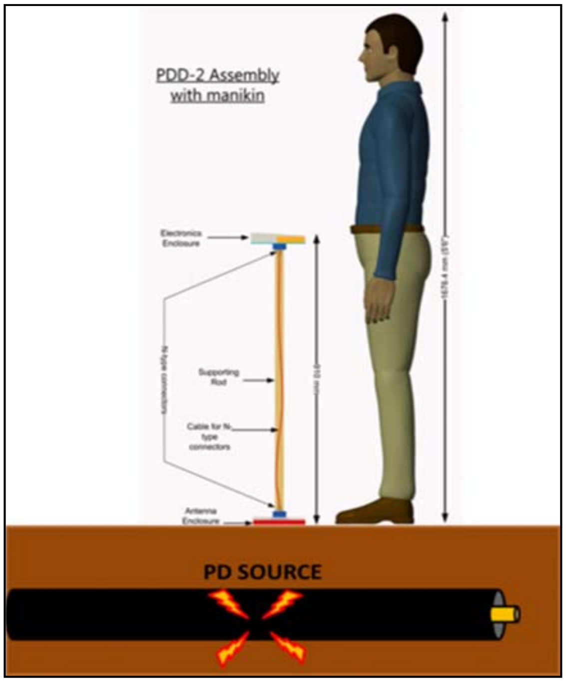

Figure-3. Utilization of PD detector prototype to detect PD.

The PD detector's ADC only acquires data for 10ms and remains dormant for 990 ms. During this time the ARM processor will be performing the computation (number of counts and severity calculations) and plotting OR Displaying the bar graph OR real time energy plot.

$$T = \frac{1}{50Hz} = 20ms \text{ (periodic time of AC power signal)}$$

τ = Selected acquisition time of ADC in PDD1 and PDD2 = 10ms (window)*

*10ms is chosen to ensure the detectability of the PD signals

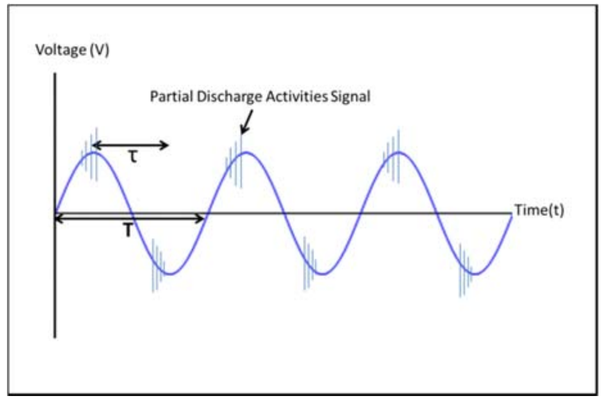

Figure-4. Typical PD pulses seen on synchronize AC (50 Hz) power signal.

The ADC has 3 Giga sample/sec acquisition rate. In the 10 ms, the ADC acquires $3x10^9$ samples/sec x 0.01sec = $3x10^7$samples. And this number of samples is shown in the real time energy vs. time (screening mode). The energy is selected instead of the Voltage as it has higher sensitivity as E α $(Voltage)^2$

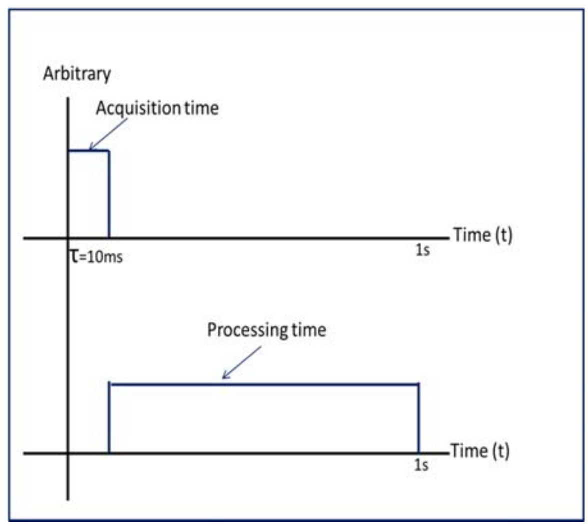

Figure-5. ADC data acquisition on gate pulse.

METHODOLOGY

The calibration methodology flow chart is displayed in Figure-6. The calibration method is simplified in the flowchart for future calibration. The reason for using selected parameters for simulation test will be explained in result/discussion section.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

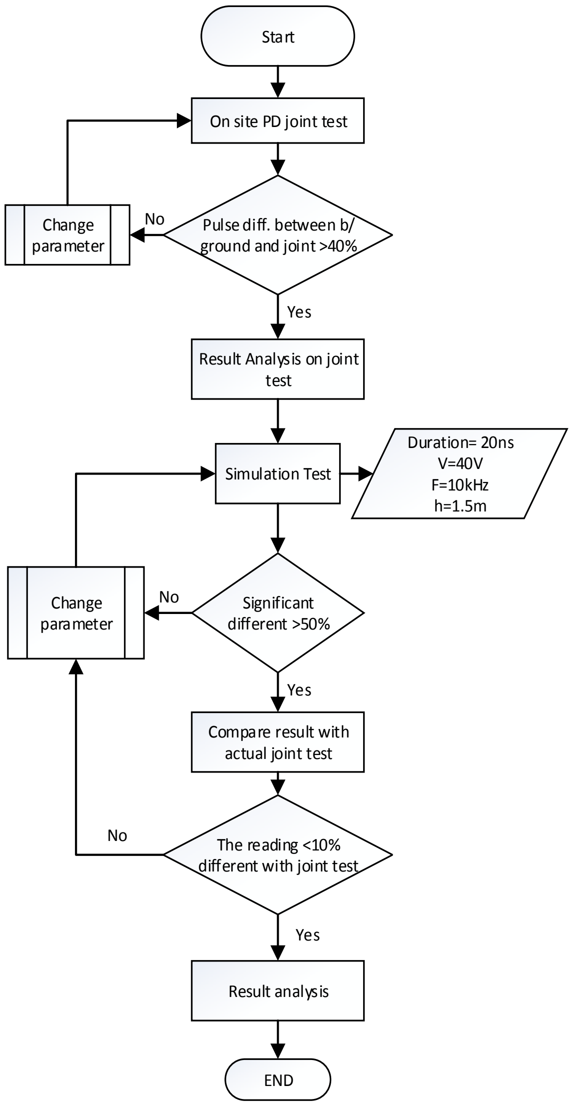

Figure-6. Methodology flow chart.

RESULTS AND DISCUSSIONS

The Bar chart represents the pulse density in a minute using the Monitoring mode. Bar chart is plotted based on the average of pulse densities per minute. Also Pulse Density Maximum value, Minimum value and Average value can be observed per minute. This cycle continues for a period of 10 minutes, once completed, maximum average value for Pulse discharge is displayed for a period of 10 minutes. The results performed at a high PD joint which was measured using OWTS at 6.35kV showed 4000pC which signifies a bad or degraded joint.

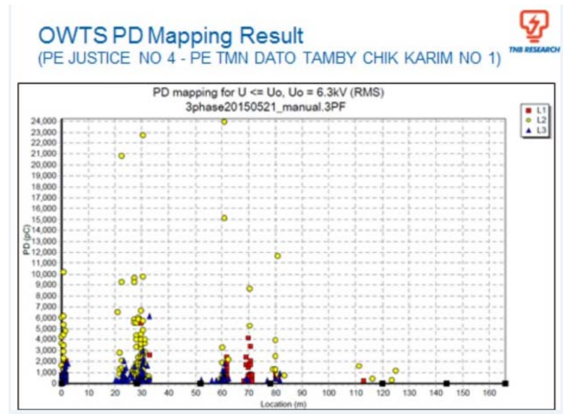

Figure-7. Results performed at a high PD joint which was measured at 6.35kV using OWTS.

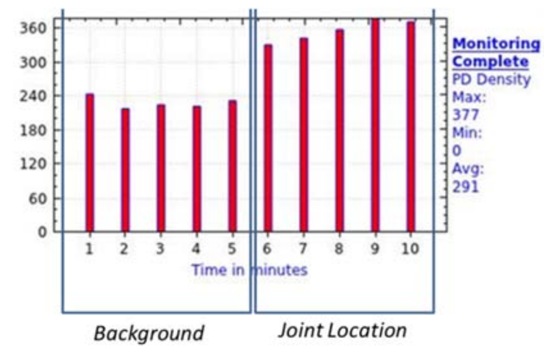

Figure-8. PDD monitoring mode (comparison between background and joint location).

- Background measured range: 220-240
- Joint Location measured range: 340-360

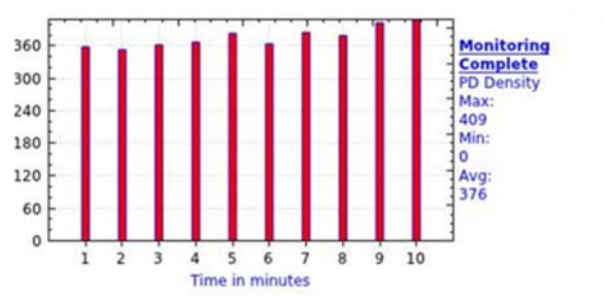

Figure-9. Average results is 376 at joint location.

VOL. 11, NO. 10, MAY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

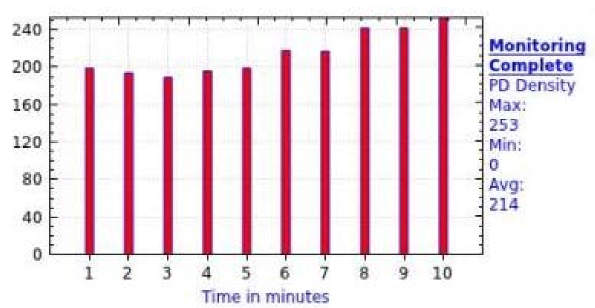

Figure-10. Average results of background signal.

The average 10 minutes reading as in Figure-9 and Figure-10 represents the Background and Joint Location Pulse reading. The average Pd density at joint location recorded 376 meanwhile the background 214. The difference of 75.7% from the background was recorded.

To simulate the PD in the lab a pulse generator is required to create an artificial pulse. Figure-7 displays the pulse generators used which have Maximum repetition rate of 100 kHz and duration of 1 to 100ns. The amplitude can range from 2.8mV to 40V.

Figure-11. Pulse generator- picosecond.

Simulated pulse parameters are 20 ns duration and amplitude 40V. Frequency used was 10 kHz. Height between transmitter and antenna is 1.5 m. The average 10 minutes reading as in Figure-9 and Figure-10 represents the Background and Joint Location Pulse reading. The difference of 83% from the background was recorded. But if the 5 minutes reading is used as in Figure-11, with average joint pulse density of 585 and background pulse density of 330 measured, this will give a difference of 77.3%. The 5th minute has to be neglected due to delay to configure Pulse generator resulting in pulse not being captured. If the ceiling of background signal which is the maximum 330 is compared with the floor of Joint location signal of 584 this will give a difference of 76.9%. This differs from the measured PD at site which difference is 75.7%. Using this setting the PD prototype is able to detect simulated PD with a range of 76.9-83% incremental from background. This experimental setup may be used to calibrate other PD sets to give a consistent result in the field in the future.

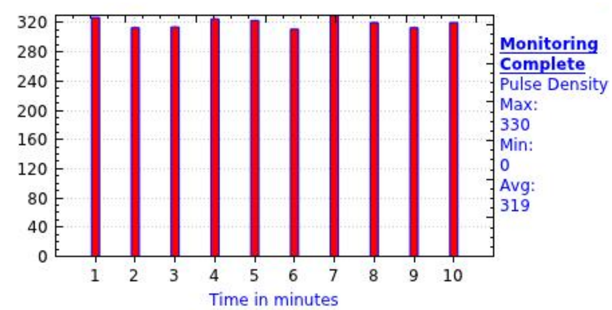

Figure-12. Average results is 319 when pulse generator is switched off.

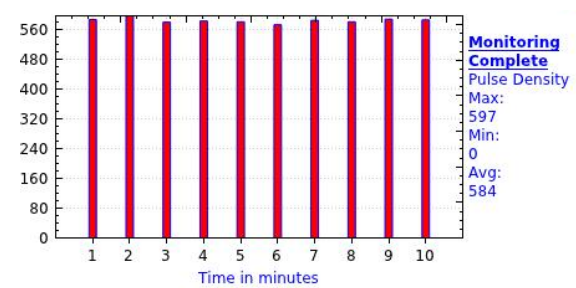

Figure-13. Average results is 584 when pulse generator is switched on.

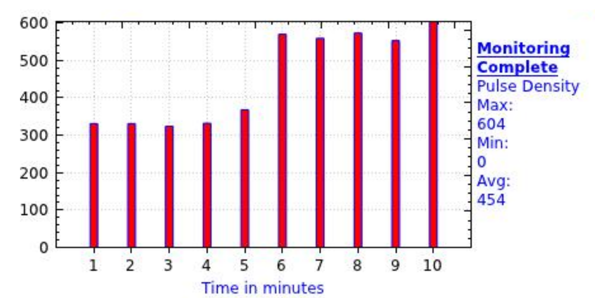

Figure-14. Pulse generator is switched off for 5 minutes and turned on for next 5 minutes.

ARPN Journal of Engineering and Applied Sciences

Figure-15. In house experimental setup.

CONCLUSIONS

The calibration in house technique has been succesfully created to simulate artificial PD's to represent cable joints that are degraded or aged cables. In future more calibraton to discriminate minor/major/good joints will be performed to fine tune the in house calibration.

ACKNOWLEDGEMENTS

This research work is sponsored by TNB Distribution and TNBR.

REFERENCES

[1] T. Brincourt and V. Regaudie. Evaluation of different diagnostic methods for the French underground MV network. JICABLE 99, Versailles. France. Paper no. B5, 2, pp. 451-456.

[2] Frank Petzold. 2005. Experiences of PD Diagnosis on MV Cables using Oscillating Voltages (OWTS). Transmission and Distribution Conference and Exhibition. pp. 1-7.

[3] Renforth, L, Mackinlay, R, Seltzer-Grant, M, Clark, D and Shuttleworth, R. 2011. Experiences from over 15 years of On-line Partial Discharge Testing of In-service MV and HV Cables, Switchgear, Transformers and Rotating Machines. in IEEE IX Latin American Conference on Automatic Control and Industry Applications (LARC).

[4] Consideration of Ageing Factors in Extruded Insulation Cables and Accessories. 1990." Report prepared by CIGRE WG 21-09 and published in Electra, No. 140, pp. 57-75.

[5] Electric Cables Handbook Publisher. 1997. Wiley-Blackwell; 3 edition.

[6] N. H. Ahmed and N. N Srinivas, "Online partial discharge detection in cables," IEEE trans. Diel. Elect. Insul. vol. 5, no. 2, pp. 181-188, 1998.

[7] N. de Kock, B Coric, and R. Pietsch. 1996. UHF PD detection in GIS- suitability and sensitivity of the UHF method in comparison with the IEC 270 method. IEEE Elect. Insul. Magazine, vol. 12, no. 6, pp. 20-26.

[8] M. Kawada. 2002. Ultra wide-band UHF/VHF ratio interfereometer system for detecting partial discharge source," IEEE Trans.

[9] Suhaimi, A.; Halim, H.S.A.; Marie, T. 2013. Assessment of on-line diagnostic using partial discharge mapping systems in MVUG cable. Electricity Distribution (CIRED2013), 22nd International Conference and Exhibition on, vol., no., pp. 1-4.