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# POSITIONING OF ANTENNA TO LOCATE PD IN POWER TRANSFORMER

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**ABSTRACT**

Partial discharge (PD) online monitoring is an effective tool of examining the conditions of insulation and detecting faults in power transformers. From literature it is acknowledged that, the PD detection is not adequate to take a decision about intervening, so the location of fault is necessary to evaluate the hazard to corrective actions. The aim of this experiment is to determine the location of antenna to obtain the strong PD signal. The method used is an experimental work in the laboratory. A sample of two antenna model is made, one antenna is considered as a PD source (transmitting antenna) and other is used as a receiver. The height of transmitting antenna is kept at 25cm. Measurements have been taken by changing the distance between antennas from 15cm and 30cm and also varying height of receiving antenna from 3cm to 45cm. After analyzing the results, it is found that the strong signal has been received when receiving antenna's height is same as transmitting antenna. Otherwise receiving antenna catches weak signal if the height of receiving antenna is lower or higher than 25cm. It means that the receiving antenna only received strong signal when both antennas are face to face with each other. It is concluded that many antennas must be used for locating the PD source. So that PD location can easily be found and can perform necessary actions on it.

**Keywords:** horn antenna, location, PD, power transformer, signal.

## 1. INTRODUCTION

Power transformer plays an important role of transmitting power to the consumer. Meanwhile, as time goes on more and more power transformers are in speed up aging process. Any fault with power transformer may lead to great loss to our economics and society. Among all the faults, insulation problem, which always begins with partial discharge (PD), accounts for a significant portion. Therefore it is important to monitor partial discharge in power transformer (Chaojie, Z., *et al*., 2012).

Electromagnetism is a branch of Physics in which the electromagnetic phenomena are studied. It contains the study of physical bases and of the propagation of electromagnetic field. This work refers to physical bases only (Nicolaide, A., 2012). So, by measuring partial discharge and analyzing its data it is possible to locate defects inside transformer. Up to now a variety of techniques such as electrical winding modeling and acoustic detection are implemented to detect PD. Without any doubt these techniques have many advantages, but these methods are going through some disadvantages that did not allow the accurate localization for all cases of imperfections in different parts of transformers. For example, the electrical winding modeling is unable to locate PD source. Using this method, it is only possible to predict the turn in which PD occurs (one dimensional localization). Using acoustic method a 3D PD localization is accessible, but because of the high damping of acoustic waves propagating through windings, this method is not very sensitive to PDs occurring inside them. Recently Ultra High Frequency (UHF) PD detection has been implemented in power transformers for PD detection which is able to perform accurate 3D defect localization.

Special UHF sensors for partial discharge detection typically work in the frequency range between 100 MHz and 2 GHz. This frequency range has the advantage that a suppression of external noise can be easily achieved (Gautschi, D, *et al*., 2012) One of the advantages of UHF method is its ability in accurate PD detection and localization for defects in inner parts of the windings which are hardly detectable by acoustic method and high signal-noise ratio (SNR), no electrical connection between PD source and UHF antenna and so on (Mirzaei, H.R, *et al*., 2012). The monopole antenna has simple structure and good radiation characteristic, which makes it suitable for installation in release valve of transformer. The method of matching network and load can improve the low bandwidth of monopole antenna, but these methods will decrease the antenna's gain, especially in the low side of frequency gain. The input impedance of the monopole antenna can be changed by optimization design of the antenna's parameter, which makes the antenna has good standing-wave characteristic in frequency range and higher gain (Zheng, X., *et al*., 2010).

## 2. REVIEW OF LITERATURE

Antennas are basic components of any electric system and are connecting links between the transmitter and free space or free space and the receiver. Thus antennas play very important role in finding the characteristics of the system in which antennas are employed. Antennas are employed in different systems in different forms. "An antenna is any device that converts electronic signals to electromagnetic waves (and vice versa)" effectively with minimum loss of signals as shown in Figure-1 (Dhande, P., 2000).

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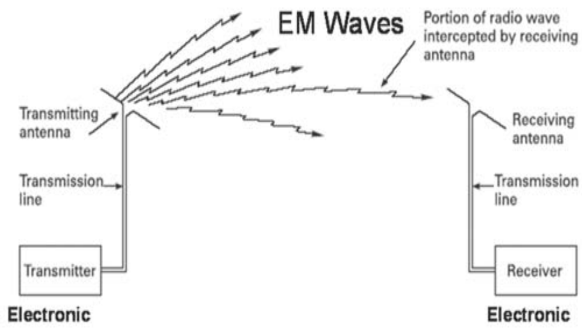


**Figure-1.** Wireless communication system (Dhande, P., 2000).

Monopole antenna PD sensors were designed to pick up the Electromagnetic waves, electromagnetic field generated by the PD traveling in the surrounding media and sensitive to the PD source position, can improve significantly the effectiveness and the field of applicability of the method. The field of antenna sensors is very large and rich of solutions for different applications. In the case of on-line partial discharge measurements, small overall dimensions are important requisites, moreover, a sensor with directional sensitivity can make easier to locate PD source. The frequency response of the sensor must be chosen with maximizing the sensor sensitivity for PD pulses, and optimizing the output signal according to the PD detector bandwidth. The PD Check allows noise rejection and separation of different PD phenomena on the basis of two characteristic parameters of the pulse waveforms, which are the equivalent time-length and bandwidth (Cavallinil, A., *et al*., 2008)

A large portion of power transformers breakdowns are caused by faults of oil-paper insulation, which frequently starts with partial discharges (PDs). PDs generate electromagnetic emissions which can be detected by ultra-high-frequency (UHF) antennas in the frequency band greater than 300 MHz. The performance of UHF antenna determines the ability of PD online detection systems of high voltage equipment. Currently, various UHF antennas have been used for PD detection (Li, J., *et al*., 2012). Ultra high frequency (UHF) detection has increasingly been paid attention in the field with encouraging results. This mainly because the advantages of UHF technique (Ye, J, 2011).

(i) Relatively high frequency band (0.3 - 3 GHz) immune against external disturbing signals on-site
(ii) No electrical connection between the sensors to the high voltage equipment
(iii) The potential of determining the failure location by using arrival times of signals received

## 3. RESEARCH METHOD

The experiment was performed in applied electromagnetic laboratory of Universiti Tun Hussein Onn Malaysia (UTHM). Two monopole antennas were used for transmitting and receiving the electromagnetic signal. One of antenna is considered as a PD source (transmitting antenna) and other is used as a receiver. The height of transmitting antenna is kept at 25cm. Measurements have been taken by changing the distance between antennas from 15cm and 30cm and also varying height of receiving antenna from 3cm to 45cm as shown in the Figure-2.

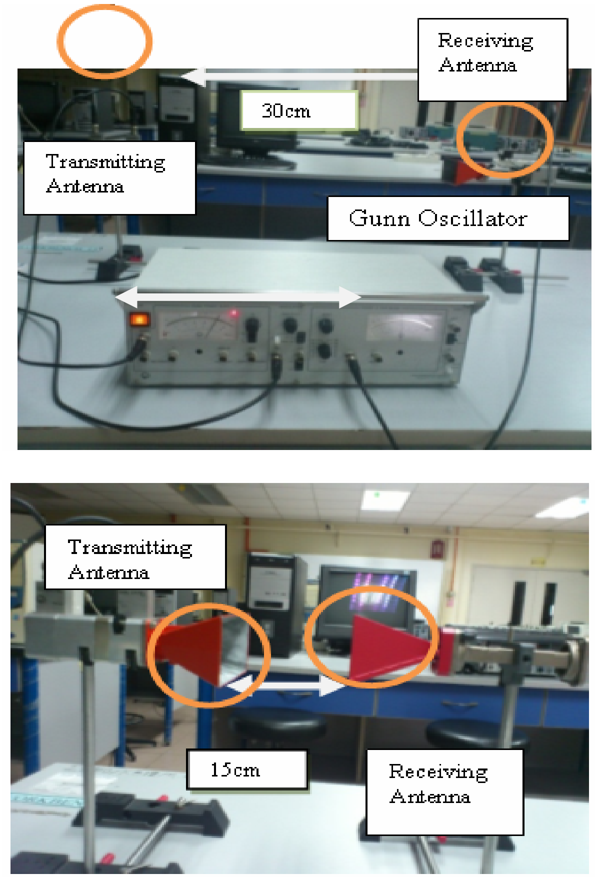


**Figure-2.** Experimental set up of Monopole antennas at 30 cm and 15cm.

There are two monopole antennas as shown in Figure-2. One of the monopole antennas was used as a transmitting antenna and other was used as a receiving antenna and one Gunn Oscillator. It can also measure the received power in dB. The transmitting monopole antenna was connected with Gunn Oscillator which supplies 8V to the transmitting antenna.

## 4. RESULTS

Figure-3 and Figure-4 show the signal patterns of single pair antennas at 15cm. In Figure-3, height of antenna is taken along x-axis, while amplitude of received signal is taken along y-axis whereby in Figure-4 the height of antenna is taken along x-axis while the received power is taken along y-axis. From Figure-3, it is found that if the height of receiving antenna is above or below than height of transmitting antenna, the amplitude of received signal will be reduced. Due to this, receiving antenna receives a weak signal. A strong signal will be received when both of the antennas have an equal height. Based on Table-1, maximum received power at 25cm is 680mV when both antennas have an equal height. Lowest power is obtained when the antenna is placed at a height of 3 cm by 4.70mV and when the antenna is placed at a height of 45cm by 3.900mV.

**Table-1.** Single pair of antennas at 15cm apart.

| Height of receiving antenna (cm) | Amplitude (mV) | Received Power (dB) | Receiving Frequency (Hz) | Time Period (ms) |
|---|---|---|---|---|
| 3 | 4.70 | -27.30 | 976.6 | 1.024 |
| 5 | 7.10 | -25 | 976.5 | 1.024 |
| 6 | 13.20 | -23 | 976.6 | 1.024 |
| 7 | 15 | -21.50 | 976.6 | 1.024 |
| 8 | 15.20 | -21 | 976.6 | 1.024 |
| 9 | 16.50 | -20.80 | 976.5 | 1.024 |
| 10 | 18.10 | -20 | 976.6 | 1.024 |
| 11 | 18.40 | -19 | 976.6 | 1.024 |
| 12 | 19.60 | -18.50 | 976.6 | 1.024 |
| 13 | 22.80 | -18 | 976.6 | 1.024 |
| 14 | 30.00 | -17 | 976.5 | 1.024 |
| 15 | 47.00 | -15 | 976.6 | 1.024 |
| 16 | 65.00 | -13 | 976.6 | 1.024 |
| 17 | 96.00 | -11.3 | 976.6 | 1.024 |
| 18 | 182.0 | -9 | 976.6 | 1.024 |
| 19 | 264.0 | -7 | 976.6 | 1.024 |
| 20 | 326.0 | -6 | 976.6 | 1.024 |
| 21 | 410.0 | -5 | 976.5 | 1.024 |
| 22 | 436.0 | -4 | 976.6 | 1.024 |
| 23 | 590.0 | -3.8 | 976.6 | 1.024 |
| 24 | 660.0 | -3.6 | 976.5 | 1.024 |
| 25 | 680.0 | -3.3 | 976.5 | 1.024 |
| 26 | 464.0 | -4.5 | 976.5 | 1.024 |
| 27 | 416.0 | -5.5 | 976.6 | 1.024 |
| 28 | 302.0 | -6 | 976.6 | 1.024 |
| 29 | 235.0 | -7 | 976.5 | 1.024 |
| 30 | 172.0 | -8.5 | 976.6 | 1.024 |
| 31 | 122.8 | -11 | 976.6 | 1.024 |
| 32 | 80.40 | -13.5 | 976.5 | 1.024 |
| 33 | 38.80 | -15.5 | 976.6 | 1.024 |
| 34 | 34.80 | -16 | 976.5 | 1.024 |
| 35 | 31.60 | -16.5 | 976.5 | 1.024 |
| 36 | 18.60 | -19 | 976.6 | 1.024 |
| 37 | 15.90 | -19.5 | 976.6 | 1.024 |
| 38 | 11.70 | -20 | 976.6 | 1.024 |
| 39 | 10.88 | -21 | 976.6 | 1.024 |
| 40 | 10.20 | -21.5 | 976.5 | 1.024 |
| 41 | 8.640 | -22 | 976.5 | 1.024 |
| 42 | 7.240 | -23 | 976.5 | 1.024 |
| 43 | 6.80 | -24 | 976.6 | 1.024 |
| 42 | 7.240 | -23 | 976.5 | 1.024 |
| 43 | 6.80 | -24 | 976.6 | 1.024 |

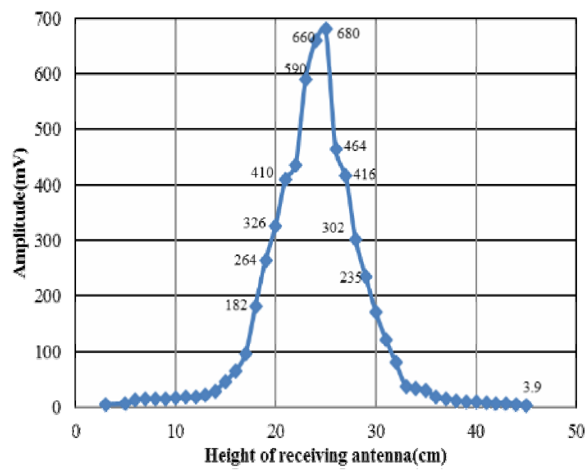


**Figure-3.** Signal pattern of single pair antenna at 15cm.

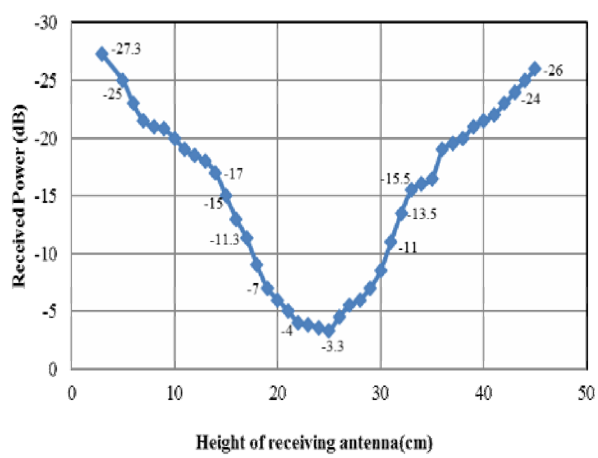


**Figure-4.** Signal pattern of single pair antenna at 15cm.

Based on Figure-4, it is found that received power in dB will be reduced when the height of receiving antenna is above or below the height of transmitting antenna. A minimum power received at height of 25cm, which is equal with the height of transmitting antenna.

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**Table-2.** Single pair of antennas at 30cm.

| **Height of receiving antenna** (cm) | **Amplitude** (mV) | **Received power** (dB) | **Receiving frequency** (Hz) | **Time period** (ms) |
|---|---|---|---|---|
| 3 | 3.700 | -25 | 976.6 | 1.024 |
| 5 | 8.00 | -21 | 976.6 | 1.024 |
| 6 | 10.40 | -20 | 976.6 | 1.024 |
| 7 | 13.00 | -19.2 | 976.5 | 1.024 |
| 8 | 20.00 | -17.5 | 976.3 | 1.024 |
| 9 | 25.70 | -16.5 | 977.6 | 1.024 |
| 10 | 34.00 | -15.5 | 976.3 | 1.024 |
| 11 | 54.00 | -13.5 | 976.5 | 1.024 |
| 12 | 64.00 | -12.5 | 976.8 | 1.024 |
| 13 | 82.00 | -11.4 | 976.6 | 1.024 |
| 14 | 108.0 | -10 | 976.8 | 1.024 |
| 15 | 126.0 | -9.5 | 976.5 | 1.024 |
| 16 | 158.0 | -8.5 | 976.4 | 1.024 |
| 17 | 196.0 | -7.5 | 976.7 | 1.024 |
| 18 | 224.0 | -6.9 | 976.7 | 1.024 |
| 19 | 252.0 | -6.5 | 976.6 | 1.024 |
| 20 | 280.0 | -6 | 976.6 | 1.024 |
| 21 | 310.0 | -5.6 | 976.6 | 1.024 |
| 22 | 312.0 | -5.5 | 976.6 | 1.024 |
| 23 | 316.8 | -5.4 | 976.6 | 1.024 |
| 24 | 322.0 | -5.1 | 976.6 | 1.024 |
| 25 | 328.0 | -4.5 | 976.7 | 1.024 |
| 26 | 248.0 | -7 | 976.6 | 1.024 |
| 27 | 236.0 | -7.5 | 976.6 | 1.024 |
| 28 | 224.0 | -8 | 976.5 | 1.024 |
| 29 | 200.0 | -9 | 976.5 | 1.024 |
| 30 | 164.0 | -10 | 976.6 | 1.024 |
| 31 | 146.0 | -10.5 | 976.6 | 1.024 |
| 32 | 132.0 | -11 | 976.6 | 1.024 |
| 33 | 112.0 | -11.5 | 976.6 | 1.024 |
| 34 | 82.0 | -12 | 976.6 | 1.024 |
| 35 | 60.0 | -13.5 | 976.5 | 1.024 |
| 36 | 46.80 | -14.5 | 976.6 | 1.024 |
| 37 | 33.20 | -16 | 976.5 | 1.024 |
| 38 | 24.0 | -17 | 976.5 | 1.024 |
| 39 | 14.60 | -19.5 | 976.6 | 1.024 |
| 40 | 8.400 | -22.5 | 976.6 | 1.024 |
| 41 | 6.500 | -23.5 | 976.5 | 1.024 |
| 42 | 4.900 | -25 | 976.7 | 1.024 |
| 43 | 3.460 | -26 | 976.5 | 1.024 |
| 44 | 3.400 | -27 | 976.6 | 1.024 |
| 45 | 2.940 | -28 | 976.6 | 1.024 |

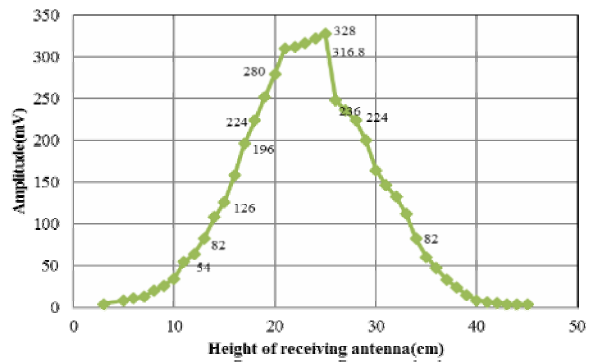


**Figure-5.** Signal pattern of single pair antenna at 30cm.

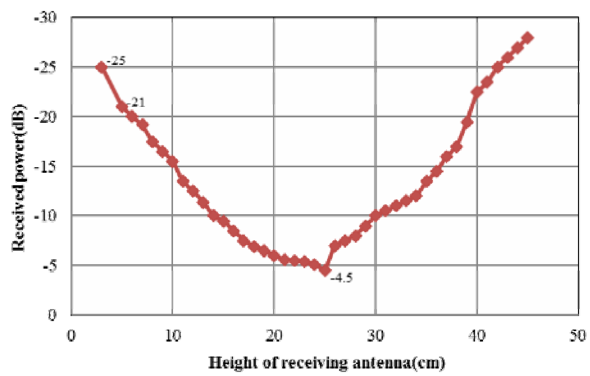


**Figure-6.** Signal pattern of single pair antenna at 30cm.

Figure-5 and Figure-6 show the signal patterns of single pair antennas at 30cm. In Figure-5, height of antenna is taken along x-axis, while amplitude of receiving signal is taken along y-axis whereby in Figure-6 height of antenna is taken along x-axis while received power is taken along y-axis. From Figure-5, it is found that if the height of receiving antenna is above or below the height of transmitting antenna, the amplitude of received signal will be reduced. Due to this, receiving antenna receives a weak signal. Receiving antenna will receive strong signal when both antennas have an equal height. From Table-2, maximum received power at 25cm is 328.0 mV when both antennas have an equal height. Lowest power is obtained when the antenna is placed at a height of 3.7 cm by 4.70mV and when the antenna is placed at a height of 45cm by 2.94 mV.

Based on Figure-6, it is found that received power in dB will be reduced when the height of receiving antenna is above or below the height of transmitting antenna. A minimum power received at height of 25cm which is equal with the height of transmitting antenna.

## DISCUSSION AND CONCLUSIONS

After analyzing the results, it is found that, if the height of receiving antenna is above or below the height of transmitting antenna than less amplitude signal will be received because of losses and the medium (such as air). On other hand, the amplitude of received signal will be reduced when the receiving antenna is placed away from the transmitting antenna. Therefore it is concluded that height of antenna and distance between antenna influence the amplitude of received signal. In other word, if the distance is more between antennas than very weak signal will be received and if height is unequal with the height of transmitting antenna, weak signal will be received. Due to this, multiple UHF sensors will be used to locate the PD source in transformers. To be concluded, this simple experiment was performed to locate the position of maximum received PD signal in transformer by varying the distance and height between the antennas. Early stage of locating PD position will be able to reduce the breakdown of transformer. Ultra high frequency sensors have less noise immunity than the acoustic and electrical sensors.

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