International Journal of Engineering Research and Reviews ISSN 2348-697X (Online)
Vol. 3, Issue 1, pp: (121-127), Month: January - March 2015, Available at: www.researchpublish.com

A Review on Partial Discharge Behavior in Insulators

Pragati Sharma[1], Arti Bhanddakkar[2]

[1] Research Scholar, Shri Ram Institute of Technology, Jabalpur, India
[2] H.O.D. of Electrical Engineering Department, Shri Ram Institute of Technology, Jabalpur, India

Abstract: **The insulation quality plays a vital role in high voltage power system equipment. It has been seen by power engineers that one of the major problems in high voltage (HV) power system is breakdown of insulators or degradation of insulators. Modeling of the partial discharge (PD) process allows a better understanding of the phenomena. Partial discharge inception, propagation and breakdown (BD) characteristics under ac voltage application were obtained and discussed at atmospheric and pressurized conditions. Therefore it is necessary to monitor the condition of the insulation property .Modeling of the partial discharge process allows a better understanding of the phenomena. Partial discharge (PD) inception, propagation and breakdown characteristics under ac voltage application were obtained and discussed at atmospheric and pressurized conditions. A comprehensive survey of PD has been presented in this paper. The survey shows that, much of the work has been carried out on model voids. Research has to be extended to obtain a figure of merit for PD of single and multiple discharges and for complex PD patterns observed in practical insulation systems.**

Keywords: **Partial discharge, Dielectric Material, insulation, Modeling and Simulation.**

1. INTRODUCTION

Partial discharge (PD) occurs as a result of defects in the insulation system. There are two types of breakdown in insulations stressed by high voltage applications. In complete breakdown insulation is completely bridged between the electrodes by low ohmic resistance. During incomplete breakdown only a small portion of insulation is collapsed because of high local electric field stress and healthy portion is still withstanding high voltage stress. It is also termed as a partial discharge. When the electric field in the defect exceeds the threshold field it results in partial discharge there are different types of partial discharge, e.g. surface discharge, gliding discharge, internal discharge and corona discharge. Partial discharge can take place in all medium of insulations. It can take place in mixed insulations also. The main sources of partial discharges are voids, cavities, gas bubbles in liquid insulation or solid liquid insulation and sharp particles or edges in insulation. When partial discharge take place in liquid impregnated papers it can also generate gas bubbles that further produce partial discharge. Corona is different from other types as it is visible and creates hissing sounds. Discharges occurs in gas filled voids and gas bubbles because the gas has lower dielectric constant than the material surrounding the voids if the electric field is high enough to ionize the gas it results in electric breakdown of gas. Surface discharges occur when tangential electric field is high enough to cause electric breakdown on surface.

2. PD BEHAVIOR IN SOLID INSULATOR MATARIALS

H. Illias et. al.(2011) had studied on partial discharge behavior within a spherical cavity in a solid dielectric material as a function of frequency. Modeling of the partial discharge (PD) process allows a better understanding of the phenomena. The simulation model for spherical cavities within a homogeneous dielectric material has been developed. The model was implemented using finite element analysis (FEA) software in parallel with a mathematical package. This method provides many advantages over previous pd models because discharge events could be simulated dynamically and the electric field in the cavity could be calculated numerically. The model has been used to study the effect of different amplitudes and frequencies of the applied voltage and simulation results have been compared with experimental measurement results. He was found that certain model parameters were dependent on the applied stress and parameters that clearly affect PD activity could be readily identified, these parameters include; the electron detrapping time constant, the cavity surface conductivity, the initial electron generation rate and the extinction voltage. The influence of surface charge decay through conduction along the cavity wall on PD activity has also been studied. However their study is first limited to spherical cavities within a homogeneous dielectric material. Cavities in dielectric material not is only spherical other types also possible. Second they use only finite element analysis not compare with other available analysis method [1].

L. Seenivasagam et.al. (2013) have been discussed partial discharge behavior in a cavity within the solid dielectrics use the different analysis system other then finite element analysis (FEA) for partial the identification and performance assessment of an insulation system within high voltage equipment is very significant. The central phenomenon to be subjected in insulation diagnostics and performance assessment is partial discharge (PD) measurement. Insulation degradation due to various physical factors such as voids, cracks, ageing and premature failure present within it is always linked to PD occurrence. Even though PD does not root immediate insulation failure and result in breakdown, it indicates the presence of an imperfection within the insulation which can affect its long term performance. The intention of this effort is to design and simulate the pd activity inside the cavity of various solid dielectric materials namely, polycarbonate, silicone rubber and silicon carbide insulation exposed to high electric fields in various shapes of cavities (cylindrical, spherical and unsymmetrical) using a industrial simulation tool named COMSOL (Communication Solution) Multiphysics , and interface it with MATLAB. The simulations of PD activity within cavities in the insulation have been performed for different shapes and position of voids present in various insulating materials. They cover maximum possibility in this study but still need to apply all these technique in liquid dielectric [2].

Fasil V.K and S. Karmakar et. al.(2012) Have been proposed modeling and simulation based study for on-line detection of partial discharge of solid dielectric. Nowadays electric utilities are facing major problems due to the ageing and deterioration of high voltage (RV) power equipments in their operating service period. There are several solid materials are used in high voltage power system equipments for insulation purpose. The insulators used in RV power equipment always have a small amount of impurity inside it. The impurity is mainly in the form of solid, gas or liquid. In most cases the impurities in the form of air bubbles (void) which creates a weak zone inside the insulator. Therefore, this void is the reason for the occurrence of partial discharge in high voltage power equipments while sustaining the high voltage. Ageing and deterioration is mainly occurs due to the presence of partial discharge in such insulator used in the high voltage power equipments. The presence of partial discharge for a long period of time is also causes the insulation failure of high voltage equipments used in power system. Therefore, the partial discharge detection and measurement is necessary for prediction and reliable operation of insulation in high voltage power equipments. Their study is on-line detection of partial discharge an epoxy resin is taken as a solid dielectric for simulating and modeling purpose. This epoxy resin with small impurity (air bubble) under high voltage stress creates a source of partial discharge inside the dielectric. The generated partial discharge is continuously detected and monitored by using Lab VIEW software. Simulation of real time detection, de-noising and different analytic techniques of partial discharge signal by using Lab VIEW software is proposed which gives the real time visualization of partial discharge signal produced inside the high voltage power equipment [5].

Y. Z. Arief et. al. (2012) have proposed modeling of partial discharge mechanisms in solid dielectric material. Partial discharge represents a physical phenomenon, in which discharges are involved in electrically weak regions of solid insulation materials (mostly within gaseous or liquid inclusions). They cause damage to the insulation and often start from the enclosed voids and/or at interface defects. The period in which the insulation is still in good operating condition is of great practical interest. The effect of PD also results in failure of the dielectric much before the expected life-time. This project was conducted by simulations based on an extended pd equivalent circuit in order to understand the characteristics of pd in solid dielectric materials. In this project, PD mechanism in solid dielectric material was modeled using SIMULINK in MATLAB. Their project focused on the results of the partial discharges in solid dielectric with a single cavity as defect. AC source with 50Hz frequency voltage was applied. It is observed that the discharge current is proportional with the input voltage. The discharge current amplitude for input 10 kV is half the input of 20 kV and a third of 30 kV input. All discharge currents and discharge voltages occur in nano-seconds [15].

3. PD BEHAVIOR IN LIQUID INSULATOR MATARIALS

Qing Xie (2013) et al had studied location of partial discharge in transformer oil using circular array of ultrasonic sensors. Partial discharge in transformer oil is one of the major causes of electrical insulation failures in oil transformers. An accurate location of PD provides important information required for detection and elimination of insulation defects. To improve accuracy of PD location, he had proposed a new location method which is based on circular array of ultrasonic sensors (CAUS) and implemented as follows. First, the fast independent component analysis (FastICA) algorithm is used to de-noise PD signal obtained by CAUS. Second, the total least square (TLS) algorithm is used to transform the wide-band signal obtained by CAUS to the narrowband one. Third, the mode excitation algorithm and the fast direction of arrival (FastDOA) algorithm are combined together to find three different directions of arrival (DOA) of the signal from PD to CAUS. Next, using the azimuth and pitch angles of these three DOAs, the PD location is determined in the center of a sphere whose surface tangents to these three DOAs in three different planes. Finally, the improved genetic algorithm is used to obtain accurate coordinates of the PD source. An experimental system of PD-location has been developed, which consists of (i) CAUS made of 8 sensors evenly placed along a circle, and a single sensor placed in the center of the circle, (ii) classic three-capacitance PD model, (iii) 16-channel synchronous data collector, (iv) oil tank, and (v) computer. The preliminary experimental results show that the accuracy of PD location after denoising is better than that before de-noising [3].

Shigemitsu Okabe et. al.(2012) developed the partial discharge criterion in ac test of oil-immersed transformer and gas-filled transformer in terms of harmful partial discharge level and signal rate .the soundness of a power transformer under an operating voltage is evaluated in partial discharge test of long-duration induced ac voltage test. The acceptance criterion for this PD test is 500 pC according to IEC standard; however, few basic data backing this criterion are available. To establish a clear criterion for this PD test, the authors initially conducted a study on the harmful PD level of materials themselves constituting the insulation of an oil-immersed transformer and a gas-filled transformer. This PD level was evaluated based on the rate of decline in the lightning impulse breakdown voltage using the insulating materials themselves and the element models simulating the insulating structure which had been exposed to a PD. Consequently, it emerged that insulations of both types of transformers were degraded if exposed to a PD of 7,000 pC to 10,000 pC. With the safety factor for this PD value taken into account considering the long-term operation and the structural difference of an actual transformer, 5,000 pC was deemed as the harmful PD level at the PD occurrence position. Subsequently, using a winding model of a transformer ,PD signal propagation characteristics inside the winding were investigated through actual measurement and analysis. As a result, it was found that the PD having occurred inside the winding is measured as the signal significantly damped depending on the position of occurrence. The transmission rate was 2.2% for an oil-immersed transformer and Transmission 2.8% for a gas-filled transformer in the respective lowest cases. What should be controlled in the PD test of an actual transformer is the value of the harmful PD level at the PD occurrence position multiplied by the transmission rate at the PD detection position. Therefore, the conclusion was reached that the acceptance criterion in the test should be set to 5,000 pC .2.2% = 110 pC or less for an oil-immersed transformer and 5,000 pC .2.8% = 140 pC or less for a gas-filled transformer, respectively [4].

Supawat Naprasert et. al. (2006) discussed the effect of humidity on partial discharge measurement .the study of the effect of humidity on partial discharge measurement in rotating machine. As we know, partial discharge measurement is effected by several factors and the humidity is one of the most important factors. To study the effect of humidity on partial discharge test, slot defect stator bar models were manufactured for data acquisition at 40°0, 60% and 70°0 relative humidity respectively. Statistical values were also calculated in order to compare the trend of those parameters at each level of relative humidity. The test result shows that visual inspection in the same stator bar model at each level of relative humidity had different patterns. In addition, the statistical parameters change upon the variation of relative humidity. Therefore, partial discharge measurement without consideration on humidity could lead to misinterpretation [6].

M. Muhr ,et al (2007) have been studied on ,Partial discharge measurement as a diagnostic tool for HV-Equipments. Insulation monitoring and diagnostic is the base of condition maintenance and essential for an economic usage of high voltage equipment. Electrical breakdowns in a small region of the insulating system are called partial discharge. The appearance and the intensity of these partial discharges are a quality criterion for an electrical equipment rating and therefore an estimation of the condition of the insulation system can be done. So the partial discharge measurement has become a fix part in industrial applications as a non destructive high voltage test. It uses the different physical effects in different insulating systems to detect significant parameters to give directly or indirectly information about the equipment condition. Not only high frequency electrical transient phenomena and especially currents are caused by partial discharges also optical, acoustical and chemical reactions and effects occur. Different techniques are in use to observe relevant parameters and are supposed to provide an early warning. In the full paper an overview of partial discharge measurement techniques, particularly in the area of non conventional measurements, for diagnostics is given [7].

Umar Khayam et al (2006) have studied on partial discharge measurement on three phase construction They used partial discharge measurement on three phase construction. It was shown that the measurement must be conducted on all phases simultaneously to obtain measurement result of partial discharge occurring in whole region of three phase construction with high sensitivity and to obtain information of the partial discharge location. Partial discharge from artificial defect was measured. Experimental results showed some special characteristics of partial discharge in three phase construction. These results were discussed with considering electric field characteristic in three phase construction and coupling capacitance between three phase conductors and between the conductors and the tank [8].

S. Karmakar et. al. (2009) proposed partial discharge measurement of transformer with ICT Facilities Recent development in Information and Communication Technology (ICT) has drawn attention of scientists and engineers to develop ICT enabled laboratories. The context development of an ICT enabled high voltage laboratory with facilities of remote operation is required because of its demand in the Engineering education as well as the assessment of insulation for continuous monitoring of the health of power equipment. The insulation of the power equipment is degraded due to the cumulative effect of the electrical, thermal, chemical and mechanical stress caused by the partial discharges (PD). Partial discharge detection and measurement constitute an important tool for quality assessment of insulation systems in high voltage (HV) power equipment. This paper reports on the development of ICT enabled remotely operated high voltage laboratory (ICTRHVL) for on-line measurement of partial discharges (PDs) of a model transformer. The remotely operated high voltage laboratory includes the partial discharge assessment facilities with ICT enabled technology will help the users to perform partial discharge tests and assessment on-line, in real time on real equipments, by sitting at their own place by local area network (LAN) as well as through the internet [9].

Rencheng Zhang et al (2011) have discussed the arithmetic and experiment research on ultrasonic detection of partial discharge for switchboard partial discharge detection for switchboard was effective method in insulation fault diagnosing. The different kinds of typical partial discharge for switchboard based on ultrasonic method are studied. Partial discharge detection system simulation model is established, including partial discharge model, measuring system for ultrasonic signals. Numerous figures of domain and frequency about ultrasonic signals were obtained and analyzed. Two ultrasonic bands of 20k~40kHz and 80k~140 kHz for the partial discharge detection are chosen as characteristic parameters and input of support vector machine (SVM). SVM is used to recognize the discharge models and the recognition rate can reach up to 100%. The results proved that this method can recognize partial discharge effectively, which provides a new arithmetic for detecting ultrasonic signals [10].

R. Ambikairajah et. al. (2011) Detected partial discharge signals in high voltage XLPE cables using time domain features. Almost all cases of insulation degradation in high voltage cables are due to PD activity. To date, wavelet based analysis has been widely used to extract PD pulses from noisy environments. The use of time domain features, namely short-time energy and short-time zero crossing counts, to detect the presence of partial discharge signals prior to de-noising the signal for further investigation. In order to demonstrate the effectiveness of short-time energy and zero crossing counts to identify PD signals embedded in noise, these features are tested with laboratory data. To further verify these results, real data was collected from a substation and the overall results demonstrate that these two time domain features are very effective in identifying PD pulses and are computationally efficient such that they can be considered for use in online PD monitoring [11].

I. Candel et al (2012) have studied the partial discharge detection in high voltage cables using polyspectra and recurrence plot analysis. They approach the challenges of partial discharges (PD) detection in high voltage cables using signal processing techniques based on time frequency methods combined with Recurrence Plot Analysis (RPA) and high order spectrum analysis (HOSA). Detection of PD poses many problems in terms of speed of calculation and selection criteria, due to the nature of PD spectrum (frequency varying from a few hundreds of kilohertz up to hundreds of megahertz) and multitude of causes which lead to the occurrence of PD. These challenges take a great toll on the computing capability of today's PD detection systems. In order to overcome these drawbacks, we have developed an algorithm which uses the spectrogram to perform a fast detection of parts from the signal which are susceptible of partial discharge (PD) activity. The second stage calculates for each zone a detection curve using the HOS concept of bispectrum and RPA. The latter has been applied in many non-linear systems in order to characterize the process on the basis of the recurrence matrix obtained from a time series given by the system [l2].

Primas Emeraldi et al (2013) studied design of matching impedance for ultra wide band partial discharge .partial discharge detection in the ultra wide band (UWB) at frequency from 100 khz up to and above 1 ghz give some benefits especially for nature observation of PD pulse shape and frequency spectrum. One of the methods to measure the UWB PD signal is a method of impedance matched. Impedance of 50 ohm corresponding to the characteristic impedance of the coaxial cable and the internal impedance of oscilloscope is used as a coupling device to maximize the power transfer of

PD current so that it can obtain real PD signals. This paper designs matching impedance which composed from attenuator as detecting impedance and UWB amplifier as signal amplifier and evaluates the performance using S-parameter value. The matching impedance has good reflection loss below -1O dB over low frequencies up to 3 GHz frequency bandwidth, with a minimum value of S I I is -28.8 dB at a frequency of 322 MHz and -18.3 dB at 3 GHz. The input impedance and output impedance values are close to 50 ohm over the frequency bandwidth. The gain (S2 1) of the impedance matching circuit is 14 dB at a frequency close to DC and down to a 6 dB at a frequency of 100 MHz and have flat value of 6 dB up to 3 GHz frequency. From the simulation results, the designed matching impedance has frequency bandwidth from DC up to 3 GHz that can be implemented as a coupling device for UWB PD detection [13].

David Clark et al (2013) have studied partial discharge pulse propagation, localisation and measurements in medium voltage power cables this paper considers the measurement and propagation of partial discharge pulses on distribution class power cable circuits, with the idea of attempting to determine discharge location sites on cables based on the parameters of individual pulses. Single-ended discharge location techniques based on partial discharge pulse parameters and shape will not be as accurate as time-domain reflectometry methods but can be done on-line without the need for double-ended techniques. Power cables used for the transmission of 50/60 Hertz electrical power, are by design not intended to carry transients or partial discharge pulses. The geometry and construction of such power cables present a transmission line that can heavily attenuate and distort the partial discharge pulses, making their detection and discrimination all the more difficult. Experimental and field work has been carried out to develop basic knowledge rules to describe how the time-domain parameters of individual pulses alter as a function of the distance propagated from the discharge sites for medium voltage power cables [14].

Kannan M, et al (2013) has given the partial discharge detection in solid dielectrics. Partial discharge (pd) measurement and characterization provide vital information on insulation condition, different aspects of insulation ageing useful for equipment integrity verification and diagnosis. The work demonstrates standard test methods which employs capture of PD parameters with the aid of discharge detector. In investigates on the voltage amplitude at which PD of a specified magnitude commence and determines the apparent charge, discharge energy and power dissipation for discharge quantity at a specified voltage. PD detection and measurement procedures suitable for use on Current Transformers, Insulators and Air Break (AB) switches are examined [16].

Amita Jain et al (2013) have studied on improvement electrical insulation for partial discharge : using large capacitors technique system partial discharge developments of dielectric materials and their applications, including improvement of insulating oils, development of new insulating oils, and introduction of polypropylene films. The power capacitor advancement and a technical overview of capacitors used this simulation model MATLAB based digital analysis of partial discharges (pds) in power apparatus is addressed. This work serves as a basis for future investigations, to provide a guide for those attempting to set acceptances levels to parameters of PD measured using digital techniques, and to present methods for the graphical representation of these parameters commercially available PD detectors are described, along with their important characteristics. The primary characteristics that detectors have in common and that are used as a basis for classification are the number of inputs used, the bandwidth of the detector, and the method of display processing. Ancillary test components, which complete an integrated test system, are discussed. PD measurements for quality assurance require not only a detector, but an entire system coordinated to maximize the measurement sensitivity for the specific type of apparatus under test. To illustrate how a coordinated system is applied, examples of some systems in commercial use are discharge measurements on capacitor units are reported. For large capacitance objects the inception and extinction levels are very clear and distinct in the HFCT technique. The technique can be extended to the in-site diagnostic testing of power capacitors [17].

Sedat Adili1 et al (2013) studied investigating the inception mechanism of pulsed x-ray triggered partial discharges by time resolved measurements. The effect of ultra-short (50ns) x-ray pulses on the triggering and the discharge mechanism of partial discharges in voids of solid insulation is investigated by time-resolved pd current measurements with an ultra-wideband detection circuit and a photomultiplier tube. PD current pulses from naturally incepted and X-ray incepted voids at different doses and different field strengths are compared. The PD pulse shapes of each inception are compared for rise-time, pulse-width and peak current amplitude. In addition, the potential effects of X-rays on the solid insulation material itself are discussed. It is shown that no negative effect of the X-ray pulse on the solid insulation is expected and that no significant differences are found between X-ray and naturally incepted PD. However, the first pulse of each PD inception is distinctly different compared to all subsequent pulses, especially with varying applied field strengths at the instant of inception. It is concluded that the method of using ultrashort X-ray pulses to trigger PD is generally applicable and only those voids are triggered that would have incepted naturally with longer waiting times. No particular overvoltage stress is needed to test the insulation system [18].

Sedat Adili et al (2011) have been work on theory and application of pulsed x-ray induced partial discharge measurements for HV-equipment ,the statistical time lag of partial discharge inception was eliminated by using short x-ray pulses (duration 50 ns) for triggering. It was shown that the x-ray pulses provide the necessary start electrons to start an avalanche by gas ionisation. Phase resolved PD (PRPD) measurements were performed at low electric field levels with self-produced spherical voids in epoxy samples. Even very small voids were detected without statistical time lag and no significant difference between the PRPD patterns after X-ray pulse triggering and naturally incepted PDs was observed. A minimum X-ray dose which is needed to provide at least one start electron in the void for successful PD inception was experimentally determined. Further, in order to study the effect of the X-ray pulse on the triggering and on the discharge mechanism, time-resolved PD measurements with an ultra-wideband detection circuit was made. Particular emphasis was placed on the effect of the X-ray dose on the PD mechanism and its differences to a naturally incepted PD without X-ray application [19].

4. DISCUSSION

A comprehensive survey of PD has been presented in this paper. It has been seen by power engineers that one of the major problems in high voltage (HV) power system is breakdown of insulators or degradation of insulators. Modeling of the partial discharge (PD) process allows a better understanding of the phenomena. Partial discharge (PD) inception,propagation and breakdown (BD) characteristics under ac voltage application were obtained and discussed at atmospheric and pressurized conditions.

The survey shows that, most of the work on PD has been carried out with consideration of voids. Research has to be extended to obtain a figure of merit for PD of single and multiple discharges and for complex PD patterns observed in practical insulation systems.

5. CONCLUSION

In order to obtain fine PD location accuracy, quite a lot of problems need to be solved:

(1) The types of actual PDs are numerous (point discharge, bubble discharge, suspended discharge, etc.). This is difficult to simulate different discharge signals by means of a single discharge model in the lab, so the special 3-capacitive model is used. Location of various types of PDs is the key object for the future study.

(2) The method proposed in different papers is used to locate a single PD, while there may be multiple PDs in the actual. The method allowing locating multiple PDs is also an area for the future research work.

REFERENCES

[1] Illias, H.Chen,G. and Lewin,P.L. (2011).Partial discharge behavior within a spherical cavity in a solid dielectric material as a function of frequency:IEEE Transactions on Dielectrics and Electrical Insulation Vol. 18, No. 2; April 2011.

[2] L. Seenivasagam R.V.Maheswari Dr.P.Subburaj,(2013).Partial discharge behaviour in a cavity within the solid dielectrics:2013 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2013]

[3] Qing Xie, Shuyi Cheng, Fangcheng Lü and Yanqing Li(2013).Location of partial discharge in transformer oil using circular array of ultrasonic sensors:IEEE Transactions on Dielectrics and Electrical Insulation Vol. 20, No. 5; October 2013, IEEE Transactions on Dielectrics and Electrical Insulation Vol. 20, No. 5; October 2013

[4] Shigemitsu Okabe and Genyo Ueta,(2012).Partial discharge criterion in ac test of oil-immersed transformer and gas-filled transformer in terms of harmful partial discharge level and signal rate:IEEE Transactions on Dielectrics and Electrical Insulation Vol. 19, No. 4; August 2012

[5] Fasil V.K and S. Karmakar (2012).Modeling and simulation based study for on-line detection of partial discharge of solid dielectric:2012 IEEE 10th International Conference on the Properties and Applications of Dielectric Materials July 24-28,2012, Bangalore, India.

[6] Supawat Naprasert, Somboon Chongchaikit, Surapol Puthwattana(2006).The effect of humidity on partial discharge measurement:1-4244-0189-5/06/$20.00 ©2006 IEEE.

[7] M. Muhr, R. Schwarz(2006).Partial discharge measurement as a diagnostic tool for hv-equipments:1-4244-0189-5/06/$20.00 ©2006 IEEE.

[8] Umar Khayam,Shinya Ohtsuka,Satoshi Matsumoto,and Masayuki Hikita (2006).Partial discharge measurement on three phase construction:1-4244-0189-5/06/$20.00 ©2006 IEEE.

[9] S. Karmakar, N. K. Roy ,P. Kumbhakar (2009).Partial discharge measurement of transformer with ict facilities:2009 Third International Conference on Power Systems, Kharagpur, INDIA December 27 29 Paper No.: 327

[10] Rencheng Zhang ,Li Xie ,Erli Liu,Jianhong Yang(2011).Arithmetic and experiment research on ultrasonic detection of partial discharge for switchboard:978-1-4244-8728-8/11/$26.00 ©2011 IEEE

[11] R. Ambikairajah, B. T. Phung, J. Ravishankar, T. R. Blackburn and Z. Liu(2011).Detection of partial discharge signals in high voltage xlpe cables using time domain features:2011 Electrical Insulation Conference, Annapolis, Maryland, 5 to 8 June 2011

[12] I. Candel1,A. Digulescu,A. ¸Serb˘anescu,E. Sofron(2012).Partial discharge detection in high voltage cables using polyspectra and recurrence plot analysis:978-1-4577-0058-3/12/$26.00 ©2012 ieee

[13] Primas Emeraldi, Umar Khayam(2013).Design of matching impedance for ultra wide band partial discharge:978-1-4799-0425-9/13/$31.00 ©2013 IEEE Detection ,

[14] David Clark, Ross Mackinlay, Riccardo Giussani, Lee Renforth, Roger Shuttleworth, "Partial discharge pulse propagation, localisation and measurements in medium voltage power cables:978-1-4799-3254-2/13/$31.00 ©IEEE

[15] Y. Z. Arief, W. A. Izzati, Z. Adzis(2012).Modeling of partial discharge mechanisms in solid dielectric material:(2012),International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 4, April 2012

[16] Kannan M, Prof. P. Sreejaya,(2013).partial discharge detection in solid dielectrics:International journal of scientific & engineering research, volume 4, issue 8, august 2013 issn 2229-5518 IJSER

[17] Amita Jain,Prof. Arun Pachori(2013).Improvement electrical insulation for partial discharge using large capacitors technique:System Volume 1, Issue 2, July 2013 ISSN: 2320-9984 (Online) International Journal of Modern Engineering & Management Research

[18] Sedat Adili, Lorenz G. Herrmann and Christian M. Franck ,(2013).Investigating the inception mechanism of pulsed x-ray triggered partial discharges by time resolved measurements 1k:5405 Baden-Dättwil, Switzerland© 2013 IEEE http: // dx. doi .org/10.1109/TDEI.2013.6633709

[19] Sedat Adili.Theory and application of pulsed x-ray induced partial discharge measurements for hv-equipment power systems and high voltage laboratories:ETH Zurich Physikstrasse 3, 8092 Zurich, Switzerland