**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 59-65

# Partial Discharge Testing of Transmission Line Insulator

Pallavi Mankar, Dr. Aparna Telang
*Electrical Engineering Department P.R.Pote (Patil) Educational & Welfare Trust's College of Engineering & Management Amravati, Maharashtra, India*
*Electrical Engineering Department P.R.Pote (Patil) Educational & Welfare Trust's College of Engineering & Management Amravati, Maharashtra, India*

***Abstract:*** *The insulation quality plays a major role in high voltage grid instrumentality. It's been seen by power engineers that one in each of the foremost problems in high voltage (HV) grid is breakdown of insulators or degradation of insulators. Modeling of the partial discharge (PD) methodology permits a stronger understanding of the phenomena. Partial discharge breakdown (BD) characteristics beneath ac voltage application were obtained and mentioned at section and pressurized conditions. Thus it is necessary to look at the condition of the insulation property. Modeling of the partial discharge methodology permits a stronger understanding of the phenomena. During this paper the various ways for stuff testing introduced and comparative analysis for each methodology given here. This paper will be very much useful for students those want to do study in the field of partial discharge analysis of transmission line insulator.*
***Keywords:*** *Partial Discharge, Insulator, Underground cables*

## I. Introduction

Centralized power generation systems are facing the twin constraints of shortage of fossil fuel and need to reduce the emissions. Long distance transmission lines are one of the main causes for electrical power losses. So, emphasis has increased on distributed generation (DG) networks with integration of renewable energy systems into the national grid, which lead to efficiency and reduction in emissions. With the rise of the renewable energy penetration into the grid, power quality of low voltage power transmission system is becoming a major area of interest. Most of available integration of renewable energy systems to the grid takes place with the aid of power electronics converters. The primary use of the power electronic converters is to integrate the DG to the grid in compliance with power quality standards. But, high frequency switching of inverters can inject more harmonics to the systems, creating major PQ problems if it is not implemented properly.

Filtering methods like Hybrid Filtering (Combination of series passive and shunt Active Power Filter) & Inductively Active Filtering are the latest development of interfacing devices between distribution supply (grid) and consumer appliances to overcome voltage/current disturbances and improve the power quality by compensating the reactive and harmonic power generated or absorbed by the load.

Solar is the one of most promising DG sources and their penetration level to the grid is on the rise. Although the advantage of Distributed generation includes voltage support, decrease in transmission & distribution losses and improved reliability. PQ problems are also of growing concern. This paper deals with a research and development of PQ problems related to solar integrated to the grid and the impact of poor power quality. The connection topologies of filtering into the system to overcome the PQ problems are also discussed.

## II. Partial Discharge Analysis Techniques

Transients related to partial discharges in voids are often represented in terms of the fees evoked on the terminal electrodes of the system. The connection between the evoked charge and also the properties that area unit typically measured is mentioned. The technique [1] is illustrated by applying it to a non-circular void settled in an exceedingly straightforward disk-type GIS spacer. The right rationalization of partial-discharge transients are often earned solely through the conception of evoked charge. The appliance of this idea has enabled a partial-discharge theory to be developed through that the influence of all relevant void parameters are often properly assessed.

The development of ICT enabled remotely operated high voltage laboratory (ICTRHVL) was bestowed [2] for on-line activity of partial discharges (PDs) of a model electrical device. The remotely operated high voltage laboratory includes the partial discharge assessment facilities with ICT enabled technology can facilitate the users to perform partial discharge tests and assessment on-line, in real time on real instrumentality, by sitting at their own place by Local area network (LAN) in addition as through the net.

**Fig.1**. A photograph of the schematic experimental setup of partial discharge measurement

The most of the PDs occurred within the 1st (0-90°) and third (180°-270°) quadrant of positive and negative half cycle of the applied voltage, severally, that indicates that the PDs gift within the model transformer is 'floating partial discharge type'.

In some technique [3], a simulation model for spherical cavities inside a homogenized insulator material has been developed. The model is enforced mistreatment Finite element Analysis (FEA) code in parallel with a mathematical package. This technique provides several blessings over previous metal models as a result of discharge events may be simulated dynamically and also the field within the cavity may be calculated numerically.

It is found that bound model parameters area unit smitten by the applied stress and parameters that clearly have an effect on palladium activity is promptly known, these parameters include; the lepton de-trapping time constant, the cavity surface physical phenomenon, the initial lepton generation rate and therefore the extinction voltage. The influence of surface charge decay through conductivity on the wall on palladium activity has conjointly been studied.

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The established model [4] of the electric discharge of associate degree dielectric, whose surface is roofed with a damp, conducting layer of pollution, envisages that it develops from the formation and bridging of a dry band by a partial-arc pre-discharge. This pre-discharge is assumed to possess arc characteristics, so the electrical field across the dry band can fall because the partial arc current will increase. Observations of insulators that are solely gently contaminated, however, show that pre-discharges are of low physical property and made in ultraviolet, and tally the spark leader beginning and extension sequence in air gaps. This as a result of this limitation by low values of surface-layer conductance can inhibit the transition to associate degree arc at the pre-discharge stage. An alternate model victimization simplified voltage-current equations is developed to represent these spark properties instead of associate degree arc characteristic. The predictions of the partial-arc model and this new approach are each tested here; victimization revealed experimental information from light-pollution fog tests within the authors' laboratory. For this purpose, the partial-arc theory is additional developed so as to reveal its tacit prediction for the rise of pre-discharge length with applied voltage before electric discharge. A corresponding relationship is obtained for the rise of spark leader length victimization the new model. It's found that for light-weight pollution, the dry-band spark model higher represents the check information than the partial-arc model. Furthermore predictions are created for the variation of electric discharge voltage with pollution severity during this regime, which can account for abnormal insulation failures.

Partial discharge detection system simulation model was established [5], together with partial discharge model, measuring instrument for supersonic signals. Varied figures of domain and frequency regarding supersonic signals square measure obtained and analyzed. Two supersonic bands of 20k~40kHz and 80k~140kHz for the partial discharge detection square measure chosen as characteristic parameters and input of support vector machine (SVM). SVM is employed to acknowledge the discharge models and also the recognition rate will reach up to 100%. The results prove that this methodology will acknowledge partial discharge effectively, that provides replacement arithmetic for police work supersonic signals.

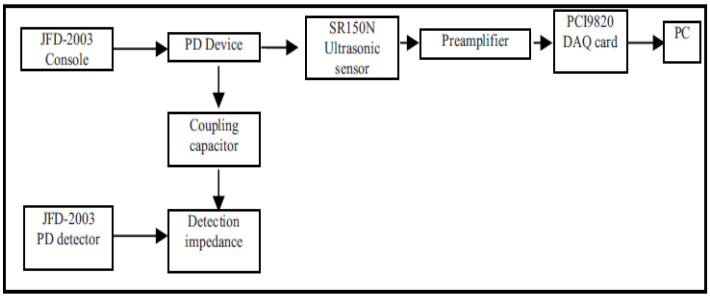


**Fig.2.** the principle diagram of PD experimental device [5]

The challenges of partial discharges (PD) detection in high voltage cables mistreatment signal process techniques supported time frequency ways combined with return Plot Analysis (RPA) and high order spectrum analysis (HOSA) was bestowed [6]. Detection of PD poses several issues in terms of speed of calculation and choice criteria, because of the character of PD poses spectrum (frequency varied from a couple of many kHz up to many megahertz) and multitude of causes that result in the prevalence of PD. These challenges take a good toll on the computing capability of today's PD detection systems. So as to beat these drawbacks, author developed AN algorithmic rule that uses the exposure to perform a quick detection of elements from the signal that are prone of partial discharge (PD) activity. The second stage calculates for every zone a detection curve mistreatment the HOS conception of bi-spectrum and RPA. The latter has been applied in several non-linear systems so as to characterize the method on the idea of the return matrix obtained from a statistic given by the system.

Design and simulate the PD activity within the cavity of assorted solid dielectric materials particularly, Polycarbonate, synthetic rubber and carbide insulation exposed to high electrical fields in varied shapes of cavities (cylindrical, spherical and unsymmetrical) employing a industrial simulation tool named COMSOL (Communication Solution) Multi-physics, and interface it with MATLAB was given [8]. During this work, the simulations of PD activity at intervals cavities within the insulation are performed for different shapes and position of voids gift in various insulating materials.

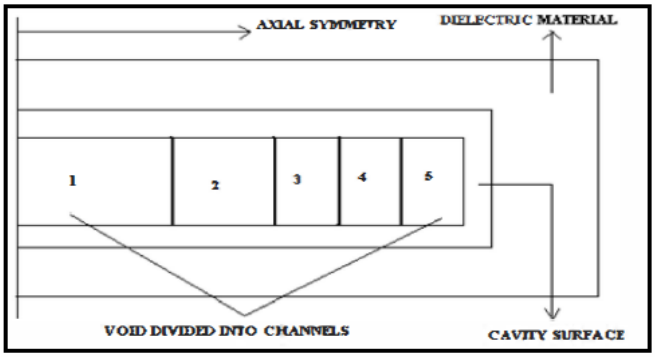


**Fig.3.** Partial discharge model in COMSOL software

Insulation of the electrical power system instrumentation step by step degrades within the dielectric thanks to collective impact of electrical, chemical and thermal stress. Thanks to the high voltage stress the weak zone within the dielectric causes the partial discharge (PD) that is thought as local electrical breakdown. As a result the insulation properties of such materials square measure hugely degrades its quality due to PD. The simulation of partial discharge activity thanks to presence of a little cylindrical and cube-shaped void within the solid insulation material of high voltage power instrumentation is studied with the MATLAB Simulink platform was bestowed [9].

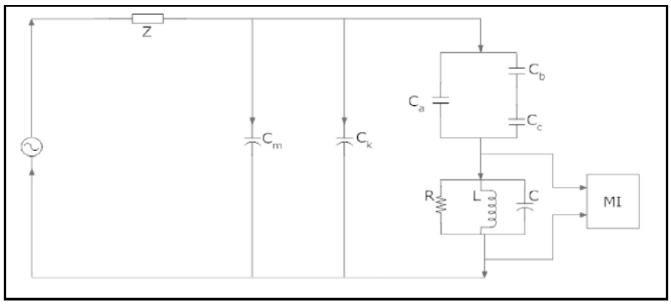


**Fig.4**. Electrical equivalent circuit model of void (test object) in solid insulation

Silicone gels square measure wide wont to encapsulate power electronics modules. The target of this technique [10] is to review the partial discharge (PD) mechanism in a very silicone polymer gel, victimization electrical measurements and quick visuvalization. Experiments square measure disbursed in a very purpose geometry, victimization either impulse voltage or ac. underneath impulse voltage, the image shows that the primary discharges recorded in a very new sample square measure because of the initiation and propagation of "streamers", with options near to those antecedently rumored in viscous liquids. Under ac, a stable PD regime quickly establishes: a streamer creates a cavity with an extended period, and PDs occur during this cavity throughout the next ac waves. Since slow streamers develop throughout long times (some ms), classical PD measurements don't offer associate degree adequate analysis of the particular discharge magnitude: terribly little PDs (1 pC) square measure recorded, whereas massive cavities with a complete charge in way 10PCs are literally present in the gel. Once PDs square measure recurrent permanent degradations of the gel quickly occur, showing the restricted self-healing capabilities of silicone gels.

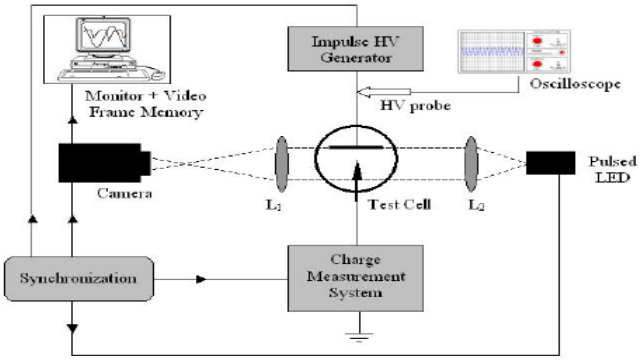


**Fig.5.** Experimental set-up for measurements under impulse voltage

In one among the tactic [11], a digital dc Pd pulse detection system with bandwidth measure of 10KHz-40MHz is introduced, that was developed mistreatment some AI methodologies. Focus is created on digital detection, grouping and classification of random pulse signals generated by Pd phenomena at dc voltage. Digital detection is developed solely resorting to a band-pass filter, a high-speed analog-to-digital converter (100 MS/s) and a laptop with processing software package. Grouping is realized with feature extraction of pulse wave shapes mistreatment equivalent time-frequency methodology (ETFM), creating the 2nd parameters plane or 3D parameters house, then mistreatment the unsupervised clump Fuzzy C-Means (FCM) methodology to attain quick separation for pulse sequence. And classification resorts to least sq. support vector machine (LS-SVM) supported a fingerprint, that is derivate type 2nd histograms of basic parameters, the discharge magnitude letter of the alphabet and therefore the time between discharges Δt of every sub-group. Field application is created for typical defects of oil-paper insulation underneath dc voltage. At last, many ways to enhance disjuncture of the grouping technique also are given for a few special cases, as well as threshold worth grouping, marginal coordinates grouping supported 2nd parameters plane and grouping mistreatment ETFM preprocessed by wave denosing.

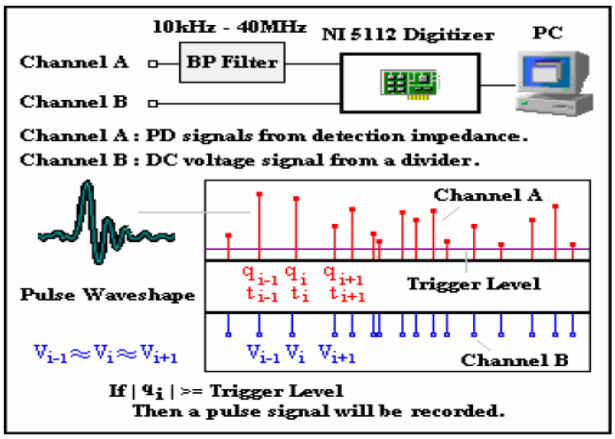


**Fig.6.** DC PD measuring system description [11]

The measurement of partial discharges (PD) could be a non-destructive and sensitive diagnostic tool for the condition assessment of insulating systems [12]. Two major tasks of PD measurements could also be distinguished, (i) PD detection, thence providing proof and also the sort of the PD and (ii) the placement of the PD. The question "Where is that PD source?" is amongst others staggeringly necessary for planning and beginning maintenance/repair actions price and time expeditiously or to perform a risk analysis. Here the likelihood to geometrically localize the flaw, by means that of arrival times of acoustic PD signals, gets a very attention-grabbing choice. Precise acoustic arrival times are consequently essential to accurately find PD in an exceedingly power electrical device. The averaging of acoustic PD signals helps to boost the acoustic sensitivity. The acoustic detection limit is down considerably and also the determination of the arrival times is created attainable for weaker PD. Supplementary steps, like automatic objective time of arrival determination or extra wavelet-based de-noising any improves the general location accuracy. A replacement location approach works with pseudo-times and permits for the employment of strong direct solvers rather than the antecedently used repetitious algorithms.

This methodology [13] provides basically a outline of PD measurements applying the UHF limit in order to extend the detection threshold, to enhance the localization accuracy and to perform on-line measurements of Partial Discharge (PD) in vociferous environments [13]. The magnetic force UHF technique offers smart signal to noise ratios, as a result of external metallic element signals and disturbances will be protected effectively. a replacement developed methodology permits the localization of metallic element in gas-insulated substations (GIS) by frequency domain measurements. The fundamental plan is that the displacement law of Fourier transformation. The interference phenomena of superposed signals from two devices provide info regarding the time delay of the sensor signals. On-site metallic element measurements square measure created at cable connectors by suggests that of monopole antennas housed in a very barrel sleave, whereas the cable is in commission. So a sensitive metallic element measurement even in vociferous surroundings is feasible. Metallic element measurements on many seventy two potential unit cable connectors were performed in associate degree unprotected laboratory. on-site measurements throughout operation showed the good potential for condition assessment. For decoupling sensitive UHF metallic element signals from the inner of an influence electrical device tank UHF sensors applied through drain/oil valves square measure used. Experimental studies indicate that each one relevant forms of metallic element presumably occurring inside a electrical device emit high frequency spectra to be detected with UHF sensors. Moreover in laboratory experiments and on-site measurements terribly moderate UHF signal attenuations are discovered.

Partial discharges (PDs) generate band radio-frequency interference which might be used for noninvasive watching of discharges. This technique presents a unique technique supported this principle for PD watching of substations [14]. The many advantage of this technique lies within the ability to observe PD sources in energized instrumentation anyplace at intervals a station compound throughout traditional operative conditions. The results obtained from the prototypes put in within the U.K. and U.S. substations are according. Results embody correlation with apparent charge and daily recordings obtained before, during, and once the failure of a 132-kV current electrical device and 69-kV voltage electrical device.

The genesis of the analysis work bestowed during this methodology constitutes [15] the difficulty of the effective and economical recognition of single-source one-time partial discharge forms which will occur in insulation systems of power transformers. The strategy presents analysis results concerning the employment of single-direction artificial neural networks for recognizing basic partial discharge forms which will occur in paper-oil insulation impaired by aging processes. The analysis work results bestowed show the popularity

effectiveness of basic partial discharge forms counting on the descriptor of the analysis of the acoustic emission signal analysis. The elaborated psychological feature aim was choice of input parameters and a man-made neural network which might be the most effective, considering recognition effectiveness and time interval that may well be used as a classifier in a professional diagnostic system creating identification of partial discharges measured by victimization the acoustic methodology potential.

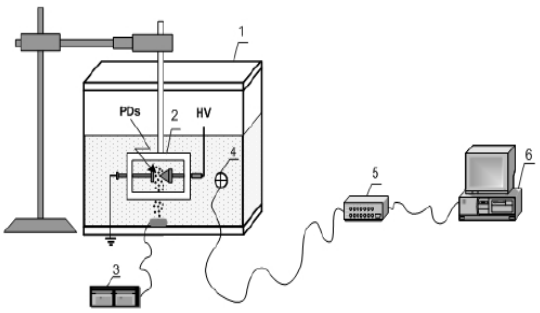


**Fig.7.** Diagram of the measuring set-up for insulation

Partial discharge (PD) measurements square measure a very important tool for assessing the health of power equipment of power system. Totally various sources of PD have different effects on the insulation performance of power equipment. Therefore, discrimination between PD sources is of nice interest to each system utilities and instrumentality makers. One of the technique investigates the utilization of a large information measure metallic element on-line measure system consisting of a frequency current electrical device (RFCT) sensing element [16], a digital storage cathode-ray oscilloscope and a high performance notebook computer to facilitate automatic metallic element supply identification. Three artificial PD models were wont to simulate typical metallic element sources which can exist among installation equipment. Rippling analysis was applied to pre-process measure knowledge obtained from the wide information measure metallic element sensing element. This knowledge was then processed exploitation correlation analysis to cluster the discharges into completely different teams. A machine learning technique, particularly the support vector machine (SVM) was then wont to establish between the various metallic element sources. The SVM is trained to differentiate between the inherent options of every discharge supply signal. Laboratory experiments wherever the trained SVM was tested exploitation measure knowledge from the RFCT as critical standard measure knowledge indicate that this approach contains a sturdy performance and has nice potential to be used with field measure knowledge.

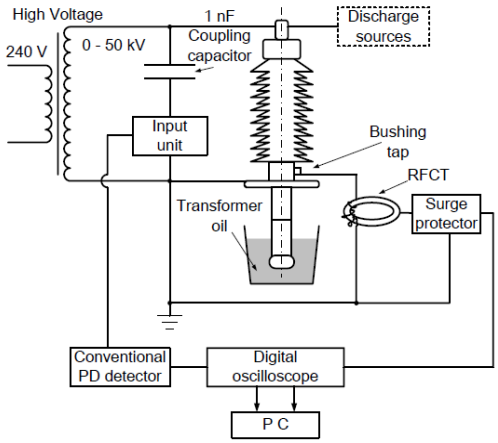


**Fig.8.** Schematic diagram of the PD measurement circuit [16]

## III. Conclusion

Partial discharge is the main problem in high voltage power equipment system. Therefore, finding and measurement of partial discharge is necessary to maintain the power equipment's in healthy condition during their operation. This paper review different methods for partial discharge methods. This paper useful for researcher and student those interested or doing research and study in insulator design, protection system design and magnetic tool deign in electrical engineering.

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