MODELING AND SIMULATION OF PARTIAL DISCHARGE PULSE GENERATOR

AJITESH NAYAK (111EE0221)

PRIYADARSINI BHUTIA (111EE0200)

Department of Electrical Engineering

National Institute of Technology Rourkela

Modeling And Simulation of Partial Discharge Pulse Generator

A thesis submitted in partial fulfillment of

the requirements for the award of the degree of

Bachelor of Technology **in "Electrical Engineering"**

By

PRIYADARSINI BHUTIA

(Roll No: 111EE0200)

&

AJITESH NAYAK

(Roll No: 111EE0221)

Under guidance of

Prof. SUBRATA KARMAKAR

May-2015

Department of Electrical Engineering

National Institute of Technology, Rourkela

Rourkela-769008, India

http//:www.nitrkl.ac.in

DEPARTMENT OF ELECTRICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
ODISHA, INDIA-769008

CERTIFICATE

This is to certify that the thesis entitled "**Modeling and Simulation of Partial Discharge Pulse Generator**", submitted by **Ajitesh Nayak (111EE0221) and Priyadarsini Bhutia (111EE0200)** in partial fulfillment of the requirements for the award of **Bachelor of Technology** in **Electrical Engineering** during session 2014-2015 at National Institute of Technology, Rourkela. A bonafide record of research work carried out by them under my supervision and guidance.

The candidates have fulfilled all the prescribed requirements.

The Thesis which is based on candidates' own work, have not submitted elsewhere for a degree/diploma.

In my opinion, the thesis is of standard required for the award of a bachelor of technology degree in Electrical Engineering.

Place: Rourkela
Dept. of Electrical Engineering — **Prof. Subrata Karmakar**
National institute of Technology — **Assistant Professor**

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Priyadarsini Bhutia

Roll No (111EE0200)

Ajitesh Nayak

Roll No (111EE0221)

ABSTRACT

In HV power system, the insulating tools used, is not immaculate in every aspect and holds impurities. The occurrence of air particles is a major contaminations in insulating equipments and extremely unwanted as it causes a local region inside the insulator which is very weak as compared to its surroundings. The kind of faults created because of insulation breakdown as an outcome of localized electrical strain inside the insulation, whether solid or fluids is broadly pervasive and it is known as partial discharge (PD).The high voltage equipments have to be tested for PD to ensure its present quality. PD technology used for diagnosing the state of such equipment has been of extreme importance. Thus, accurateness should be increased and uncertainty should be decreased in the measurement of PD. The reliability of the measurement results is strongly depends on the calibration of the PD measurement system. Such an arrangement needs a standard PD pulse generator which can trace the uncertainties of its components and estimate the expanded uncertainties.A PD pulse generator is being modeled in SIMULINK to generate PD pulses having identified charge magnitude. The whole simulation has been done with MATLAB platform.

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LIST OF ABBREVIATIONS

IEC standard	International Electro Technical Commission
PD	Partial Discharge
HV	High Voltage
PDG	Partial Discharge Generator

CHAPTER 1

INTRODUCTION

Introduction
Literature review
Motivation and Objective of the Thesis
Organization of the Thesis

1.1. INTRODUCTION

The quick development of electrical vitality utilization, progressively in the developing nations like India, has stimulated the progression of several HV transmission and distribution frameworks and along with the enlarged modernity level. Anyhow, similar to the instance with all the instruments, though idealize their beginning condition is, consistent utilization of the equipment inescapably prompts the disappointment of protection. Vibration, heat and the vicinity of extreme electric stress are real cause in charge of debasement of uprightness of the dielectric framework[1]. Subsequently the significant issue connected with expanding levels of many-sided quality and productivity is dependability and lifetime of equipment .

Thus, as is self-evident, it gets to be much correlated to calculate nature of protection at occasional intermission. PD estimation is a unique routine used for focusing both on lifetime and quality of equipments. PD can be characterized as confined electrical release which just partly connects insulation among electrodes. It can be realized that no kind of protection is totally unadulterated. Certain manifestation of contamination and air pockets is always present throughout the assembling procedure [2]. The vicinity of the pollutants debilitates the protection and in charge of event of PD. Subsequently PD estimation turns into a vital procedure to focus the condition of insulation. PD technology is of extreme important to diagnose the state of HV equipment [3]. Accurateness of the measurement system should be improved so that failure of insulation can be reduced. So, reliability of the measurement system strongly depends upon the calibration of the PD measurement system. So, we need a standard PD pulse generator which can trace the uncertainties of its components and estimate the expanded uncertainties

1.2. LITRETURE REVIEW

Despite the fact that HV advancement for electrical transmission and distribution systems, was displayed amid a century prior, by then PDs had been seen as a ruinous hotspot for maturing of HV protector .As the time passes, various techniques have been produced for acknowledgment, estimation and investigation of PDs behavior in protection. In the year 1777, amid a meeting of Royal Society in Gottingen, Lichtenberg expounded on his novel eventual outcomes of exploratory results. Starting then onwards, various researchers have shown their efforts on the revelation and estimation of PDs, and studied the PDs attributes. It was a century ago, where it was enlightened that Lichtenberg figures produce PD passages on the plane of the dielectrics [4].

After that HV transmission voltage level increased rapidly to meet the requirement. So, a upgrading in quality of protecting materials is essential. So, at the beginning of the last century the first equipment for electrical PD detection were introduced, which helped a lot in enhancement of ideas about PDs. With the enhancement of knowledge about PD detection, PD detectors for industrial application were familiarized in the middle of the preceding era, which essentially helped a lot for additional research in the area of partial discharge.

In the 1970's, the PD measurement in pC scale was insisted because of the launch of contamination in equipments used for power cable protection. So, PDs of a small amount of pc might cause an insulation breakdown. This upgraded the advancement of PD measuring frameworks with better change in quality, which can additionally fit for acknowledgment of PD locales in long separation power transmission lines [5]. Beside all these tests, IEC 60270 standards were applied compulsorily for the quality HV equipments.

Since the 1970s, customary simple equipments have been supplanted by advanced equipments which are more exact and create better results, which had the capacity fulfill the constantly expanding experimental and specialized enthusiasm in the characteristics of PDs. During the initial period, multi-channel analyzers were utilized, that were later replaced by automated PD measuring equipments equipped for preparing, procurement and stage-resolved visualization of exceptionally complex PD information. Presently, the computerized PD estimation method is utilized as a part of regular practices inside the research facilities in the whole planet.

1.2. MOTIVATION AND OBJECTIVE OF THESIS

PDs, which are brought on because of flaws in the protection system which unavoidably prompts disappointment of HV instruments. The protection system of these instruments plays a real part in the existence of HV instruments. Thus, it is essential for the insulation system to be prominent caliber to keep up the effectiveness. Anyhow, it is near difficult to create protecting materials, which are entirely devoid of contaminants, so detection of PD is of fundamental significance. Generally gas, solid or liquid contaminants are present. It is generally noticed that, during assembling methodology of solid insulating materials, air pockets are available which prompts debilitating of the insulating material during the implementation of HV [6].

Since it is fundamentally hard to quantify the PD that gets to be unmistakable in protecting (insulating) materials. Thus, an apparent charge q, an electrical quantity, is utilized to assess the PD impact. The description of apparent charge, q, is that it is the charge that when infused over the DUT for a brief time period in a predefined circuit, makes the same result like the PD pulse make itself [7] .The extent of the information PD add up to the reading of the instrument is called scale factor which is figured by an appropriate calibrator. Along these lines, PD calibrator utilized as a part of electrical system must be exact [8].

The principal objectives of this thesis are:

- To design a MATLAB based SIMULINK model for PD pulse generator.

1.4 ORGANISATION OF THESIS

This thesis is separated into five unique chapters.

- **Chapter 1**: It consists of introduction, objective and motivation of the project work along with the literature review on PD features along with the organization of the thesis.
- **Chapter 2**: It explains fundamental ideas of PD like the need and detection of PD in HV equipments and the function of apparent charge to measure PD.
- **Chapter 3**: This section incorporates the apparent charge idea and the technique to outline PD pulse generator. A MATLAB-SIMULINK model of PD pulse generator is finished for various charge levels.
- **Chapter 4:** Here the simulation results of PD pulse generator having RLC configuration is shown and analysis of result is represented.
- **Chapter 5:** conclusion and future work has been done in this chapter.

CHAPTER 2

FUNDAMENTAL IDEAS OF PARTIAL DISCHARGE (PD)

Partial discharge
Need of Detection of PD
Categorization of PD
Consequences of PD
PD Detection Techniques
Role of Apparent Charge in PD Measurement

2.1 PARTIAL DISCHARGE

As per IEC60270 Standard,” *PD is an electrical discharge that is localized in nature and partially joins the insulation present in between the conductors and that may or may not happen next to a conductor. Thus, PDs are basically an effect of local electrical pressure on the insulation surface. Usually, such type of discharges emerge as pulses of less than 1micro-second duration*” [8]. In general, occurrence of PD is observed in HV equipments like transformers, bushings, and in other electrical equipments.

2.2. NEED OF PARTIAL DISCHARGE DETECTION

PD for the most part happens inside parts, voids, conductor-dielectric interface inside a strong insulating material, likewise in bubbles inside fluid mediums. Because PDs are simply confined to a part of insulation, the partition between terminals is joined by the discharges. PD can moreover happen on the insulating material boundary, also on the exterior of solid equipments if the electric field tangential to the surface, is adequately extreme enough to achieve a breakdown on the boundary of the insulating material [9]. Such type of activity is for the most part demonstrated in transmission line insulating materials, essentially amid the times of high dampness. This is generally called as corona effect.

Presence of air bubbles makes the insulator impure which in turns responsible for weakening of insulator and PDs will appear .Reasons for such type of discharge is the less dielectric stress of void in comparison to its surrounding .So, PDs ultimately leads to failure of HV equipments. Thus, PD location and estimation is of most extreme significance.

2.3. CATEGORIZATION OF PD

PD is categorized into two different types

- **External Partial Discharge**: PD which happens in surrounding atmosphere, otherwise called corona discharge. This is for the most part reversible. And it is considered as harmless.
- **Internal Partial Discharge**: It happens because of flaws in fluids and solid dielectrics additionally in compressed gases [10].

PD phenomenon consists of four different types of discharges

- ➢ **Corona Discharge:** such type of discharges occurs because of the irregular electric field distribution on the sides of conductor which is subjected to HV. Fluid or solid insulation may be used for such type of discharges [11].This kind of discharges appear for a extended time which results in formation of ozone layer and ultimately causes the degradation of insulator.
- ➢ **Surface Discharge:** It happens on interfaces of gas/solid dielectric material .This for the most part happens in end of lines, bushings, on the surfaces of insulators, between HV terminal & ground. The presence of such discharge relies upon different components, for example,:
    - ✓ Permittivity(Ɛ) of the materials utilized
    - ✓ Division of voltage across the conductors
    - ✓ Characteristics of the dielectrics
- **Treeing Channel:** High intensity fields are produced at the sharp edge of insulator, ensuing in degradation of the insulating material which results in an uninterrupted discharge called Treeing Channel.
- **Cavity Discharge:** It usually occurs in solid/liquid insulators. At the point when the fluid filled void gets to be exceptionally strained, partial discharge happens which is called cavity discharge.

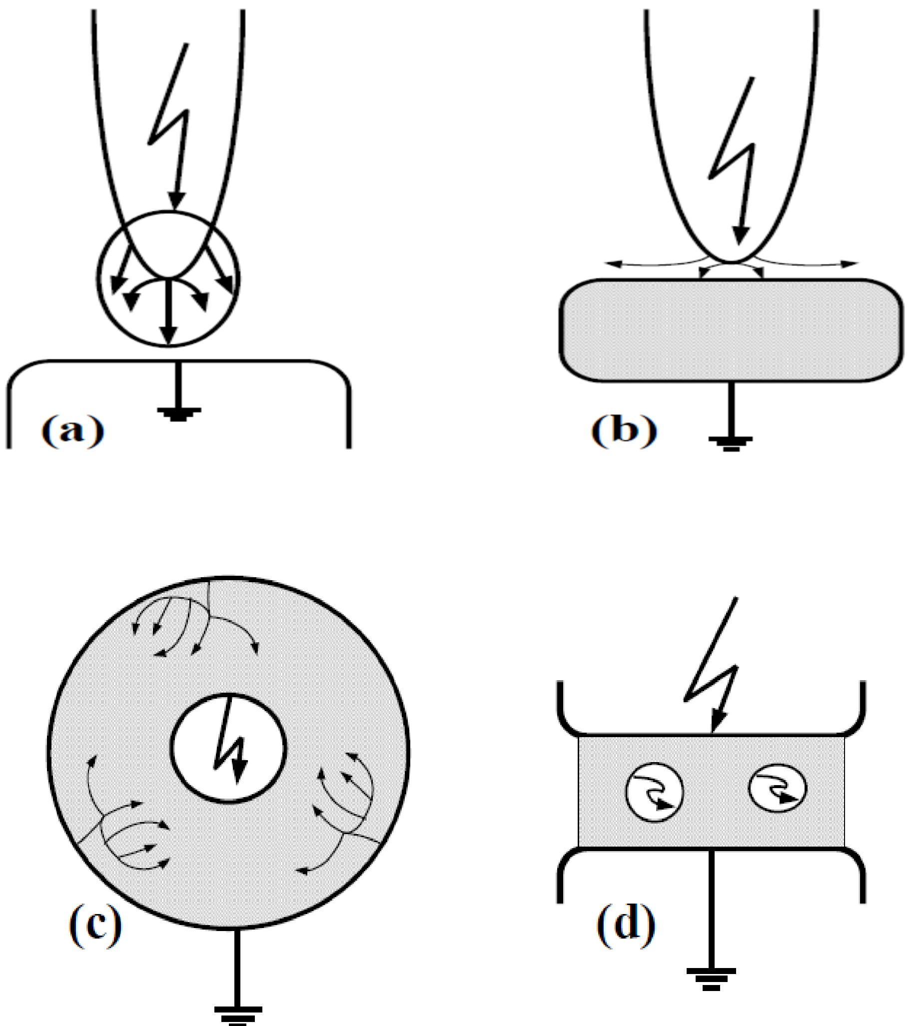


Fig 2.1: Different types of PD a) corona discharge b)surface discharge c)treeing channel d)cavity discharge

2.4. CONSEQUENCES OF PD

PD makes dynamic decay of the protecting material if once began which causes breakdown of the electrical network. The impacts of PD inside HV materials can be intense. The aggregate impact of PDs inside solid dielectrics prompts treeing effect which causes the arrangement of various somewhat directing release channels. Monotonous releases cause irreversible chemical and mechanical weakening of the protecting material. Each discharge occasion produces a decay of materials by the energy effect of electrons moving with high speed or quickened particles, bringing about substance changes of numerous sorts. The substance change of the dielectric is additionally in charge of increment in the insulating material's conductivity encompassing the cavities that prompt increment in the electric stretch in the unaltered crevice locale, quickening the collapse procedure of the insulating equipment. The quantity of discharge occasions amid a fixed time is firmly reliant on the sort of voltage connected and is greatest for ac voltages. It is likewise evident that the genuine declination is dependent upon the material utilized.

PD disseminates vitality, by and large as warmth, however some of the time as stable and light also, for instance the murmuring and faint gleaming around the overhead line protectors. Heat vitality scattering may bring about warm debasement of the protection, in spite of the fact that to a little degree. For HV hardware, the dependability of the protecting material could be affirmed by observing the PD exercises. PD in HV equipments ought to be observed nearly to guarantee source dependability and long haul operational supportability, alongside right on time cautioning signs for examination and upkeep.

2.5. PD DETECTION METHODS

The measurement and detection of partial discharges are based on the energy exchange occurring. The exchanges are categorized as: (i) sound (noise)
(ii) Losses in dielectrics (iii) Electromagnetic radiation (light) (iv) electrical pulse currents
(v) Chemical reactions (vi) Increase in pressure of gas.

Some techniques for PD measurement are,

(a)Chemical detection technique
(b) Electrical detection technique
(c)Optical detection technique
(d) Acoustic detection technique

2.5.1: Chemical detection technique

In this system, PDs can be recognized by watching the concoction changes in the insulating material. Here, high performance liquid chromatography (HPLC) system and the dissolve gas analysis (DGA) and utilized for PD investigation.

2.5.2: Electrical detection technique

Electrical detection technique is a standout method amongst the most mainstream strategies in HV power hardware for PD estimation. Here, procedure for electrical detection is used in the model transformer to reenact the estimation of PDs. The arrival of the pulses of voltage and current made by the present streamer in the cavities and contaminations is focused here [10]. Pulses are generally below one second and difference in frequency parts in scope of kilohertz. Pulse shape and event of phase position inside alternating cycle provides data on the sort of PD and data about the failure in insulation. A time space recording gadget is utilized for perception of PD pulses in this technique. This technique is likewise material for online electrical PD recognition.

2.5.3: Optical detection technique

In this technique light is dispersed as ionization, excitation methodology amid the presence of PD. The outflow of light radiance is reliant on the dielectric utilized and different quantities like weight, temperature. This technique is appropriate for transparent kind of materials. Thus, some trouble emerges if there should arise an occurrence of usage in high voltage transformers because of hazy character of mineral oil.

2.5.4: Acoustic detection technique

The most established and easiest strategy is the 'hissing test'. The frequently low sensitivity and challenges emerging in recognizing releases and superfluous commotion sources, especially during the time when tests are done on industrial facility sites. Acoustic systems have numerous focal points over different routines. Electromagnetic interference (EMI), that lessens the difference of the systems, doesn't affect the acoustic system.

2.6 ROLE OF APPARANT CHARGE IN PD MEASUREMENT

Difficult issues are prompted in HV equipments because of PD. The estimation of charge put away in the cavities can't be specifically determined as the sources of PD are not open. Hence, PD can't be measured by direct systems. To get over this issue, a clear charge strategy is utilized for the estimation of the PD action in an insulation model. The definition of apparent charge is that it is the measure of charge which when infused over the terminals of the Device Under Test (DUT) in a predefined circuit delivers the same effect on the instrument as does the PD pulse itself. The charge is more often than not in Pico-coulombs. What's more, so as to gauge the apparent charge, the measuring instrument is required to be balanced as the PD is very needy on the geometrical shape of the void area.

2.7 RELEVANT DEFINITIONS

2.7.1: PD pulse

Voltage or current pulse which occurs from a PD occurring inside the test object. Appropriate detector circuits are used to measure the pulse, by introducing them in the circuit.

2.7.2: Apparent charge

Apparent charge of a PD pulse is that charge which, if injected for a very brief time between the terminals of the test object in a particular test circuit, would give the same reading on the measuring instrument as the PD current pulse itself. It is usually expressed in Pico coulombs (pC).

2.7.3: pulse repetition rate (n)

It is the ratio between the numbers of PD pulses recorded in a particular time interval to the duration of this time interval.

2.7.4: pulse repetition frequency (N)

Total amount of PD pulses per second, considering equidistant pulses.

2.7.5: average discharge current (I)

It is a resulting quantity and is defined as the summation of the values of individual apparent charge magnitudes q_i during a chosen reference time interval T_{ref} divided by this time interval:

$$I = \frac{1}{Tref}(|q_1|+|q_2|+|q_3|+\ldots\ldots+|q_n|) \qquad (1)$$

2.7.6: radio disturbance voltage (URDV)

It is also a derived quantity which is the reading of a radio disturbance meter when used for indicating the apparent charge *q* of PDs. URDV is generally expressed in pV.

2.7.7: Partial discharge inception voltage (Ui)

The inception voltage Ui is the lowest voltage applied at which the magnitude of a PD pulse becomes equal to or exceeds a value specified at a low level.

2.7.8: partial discharge extinction voltage (Ue)

The voltage at which repetitive partial discharges cease to occur in the test object.

CHAPTER 3

Analysis and simulation of Partial Discharge Pulse Generator

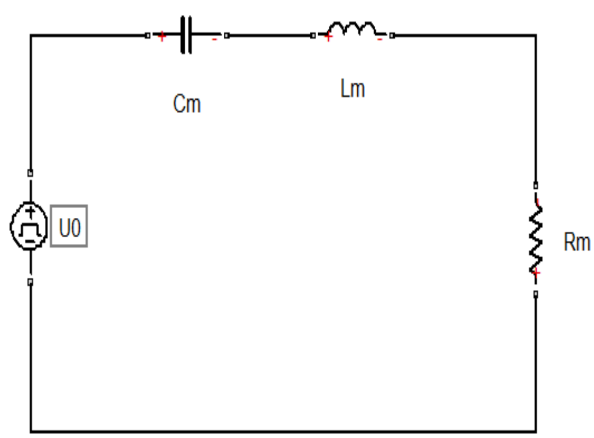
Electrical Circuit Modeling of PDG

Parameters Involved in Pulse Shape

3.1 ELECTRICAL CIRCUIT MODELLING OF PDG

PD, which appears across the insulation, cannot be measured directly. So, the apparent charge Q_a, another electrical quantity is utilized to measure the PD. The 'apparent charge' can be described as the charge which when inserted for a very brief period of time across the DUT in a particular circuit that give the same outcome in the instrument as the PD pulse. The tests can be done by directing a high voltage through the DUT and by measuring the consequent to the PD event. The scale factor can be measured by the proportion of the input quantity to the instrumental reading, which can be performed by using an appropriate calibrator in the circuit, as the circuit configuration directly influences the parameters. The calibration procedure involves the injection of a current pulse of known charge magnitude across the DUT which is generated by a PD pulse generator when high voltage supply is not present .So, the generator mainly consists of a series capacitor, inductor and a step input voltage.

Fig 3.1: schematic diagram of PD pulse generator



Where,

U_0 = Step input voltage

C_m = Calibrating capacitance

U_m = Voltage across Rm

The magnitude of calibrating charge is given by,

$$Q_0 = \int i_m(t)\, dt \qquad (2)$$

$$Q_0 = (1/R_m) \int i_m(t)\, dt \qquad (3)$$

3.2 PARAMETERS INVOLVED IN PULSE SHAPE

Generally transfer of charge from PD site to terminals of object under test is completed in a very few ns(nanoseconds). So, step pulse generator must have a comparable rise time, as transmit of charge by capacitor is directed by rise time. The effect of step pulse shape on the undefined of calibrating charge may be omitted by the conditions given below [12]:

Table 3.1:IEC60270 standard for pulse shape parameters

Sl. no.	**Parameters**	**Conditions**
I.	Rise time	Tr<60 ns
II.	steady state time	Ts<500 ns
III.	Duration of steady state	Td>5µs
IV.	percentage overshoot	Ud<0.1U0
V.	Percentage undershoot	Ut<0.1U0

The various parameters used in pulse generating circuit are as follows:

Table3.2: Capacitors Used in Simulation of PD Pulse Generator

Sl. No.	**Parameters**	**Value**	**Unit**
i.	C1	0.86	pF
ii.	C2	7.02	pF
iii.	C3	12.56	pF
iv.	C4	61.11	pF
v.	C5	121.95	pF
vi.	R	1000	kΩ

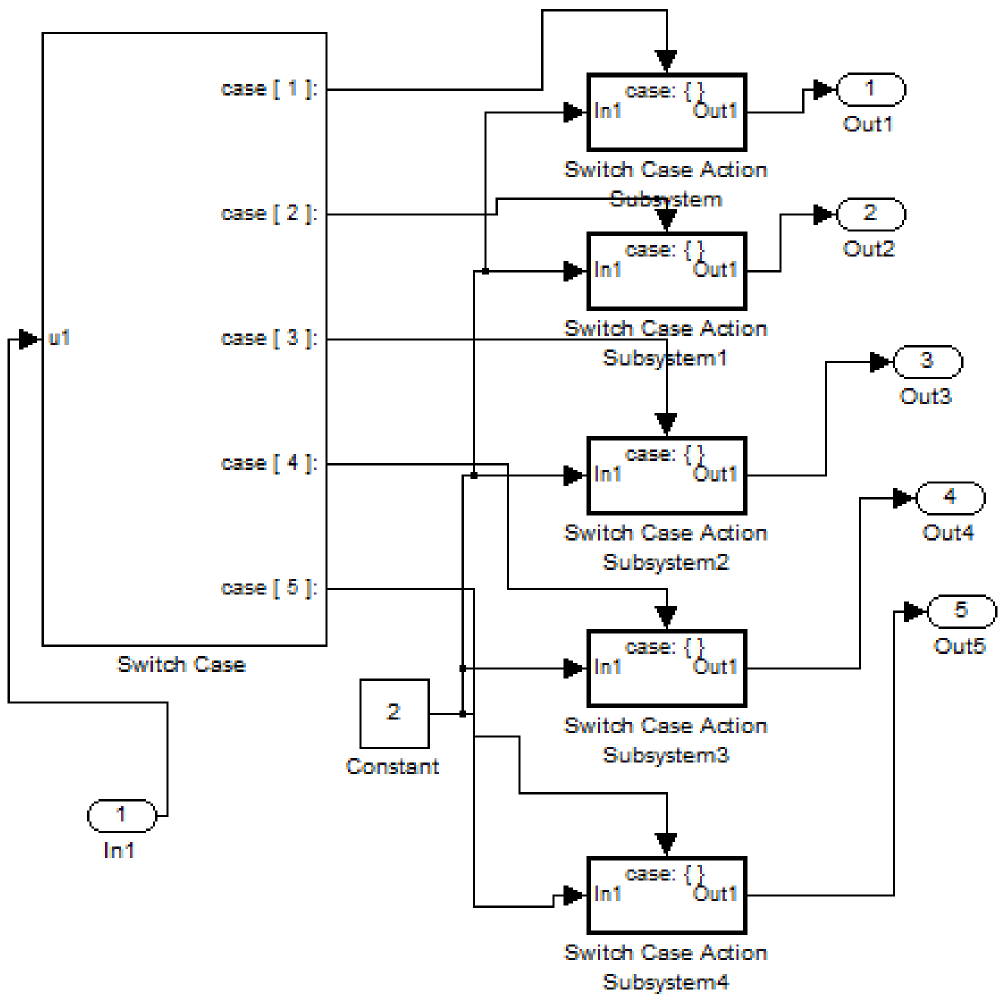


Fig 3.2: Simulink model of controller subsystem

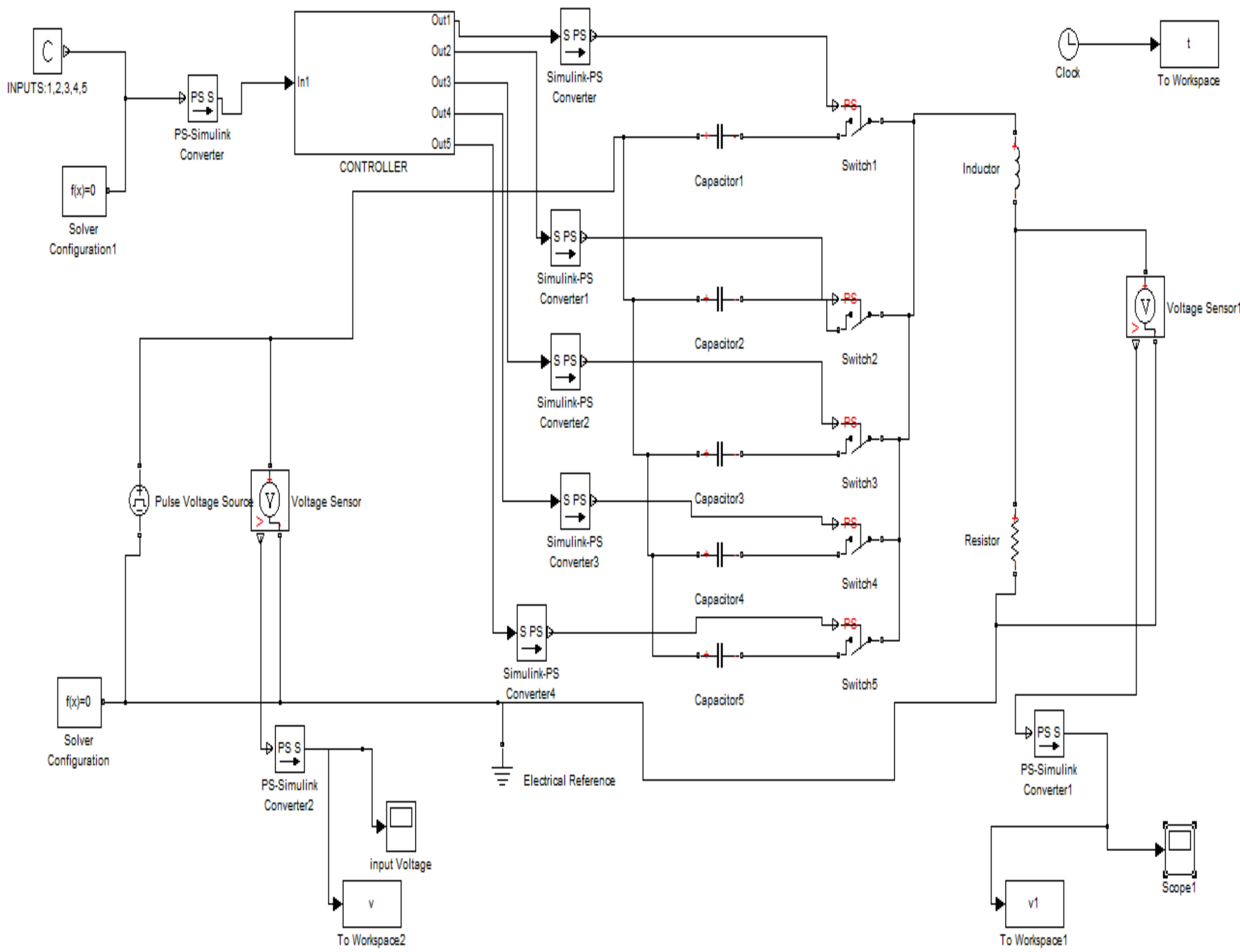


Fig 3.3: Simulink model of PD generator with R, L and C

CHAPTER 4

SIMULATION RESULT AND DISCUSSION

SIMULATION RESULTS AND DISCUSSION

To generate partial discharge pulse, an electrical circuit was modeled using a capacitor, inductor, resistor. A pulse voltage source is used to provide pulse to the circuit and the PD pulse characteristic is measured across resistor. The value of the capacitance is modified to attain the desired charge level of known magnitude.

The series RLC circuit was fed by the output of pulse voltage source.

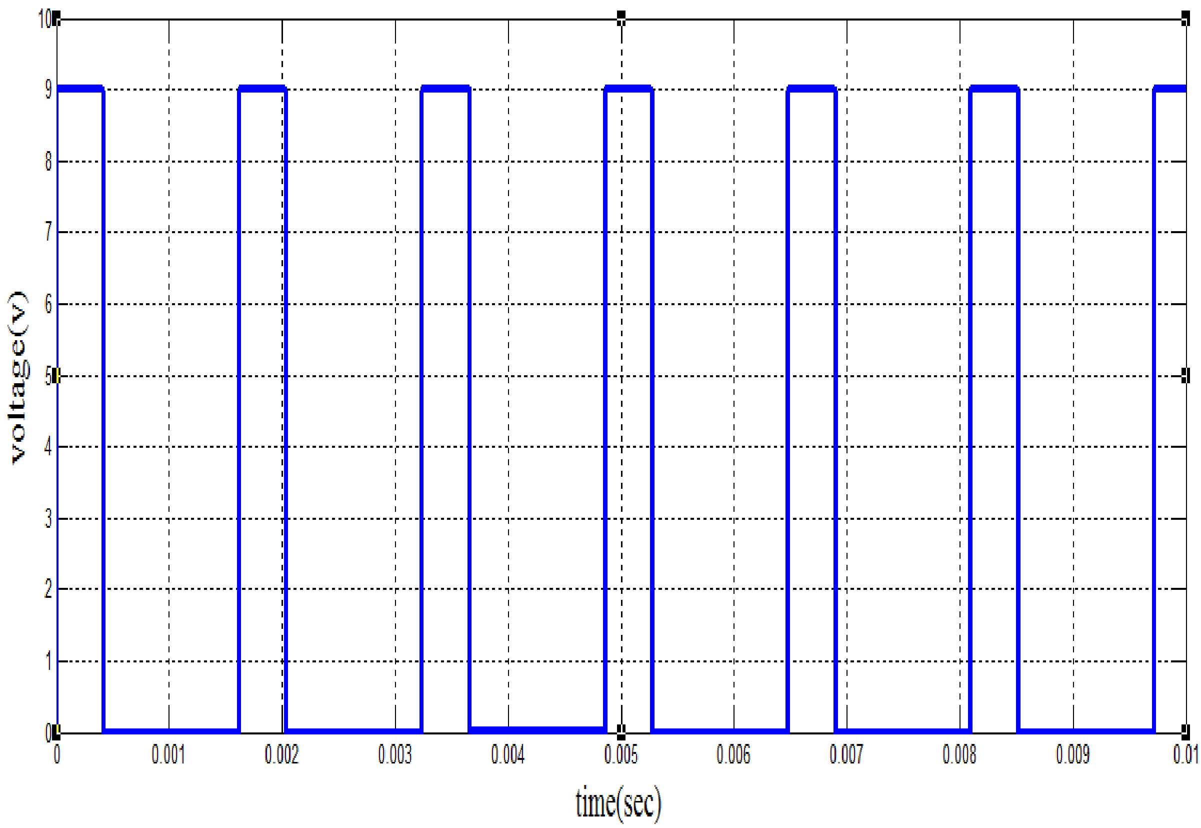


Fig 4.1: Input from Pulse voltage source

The output of PD generator was taken by measuring the voltage across resistor R in the series RLC circuit.

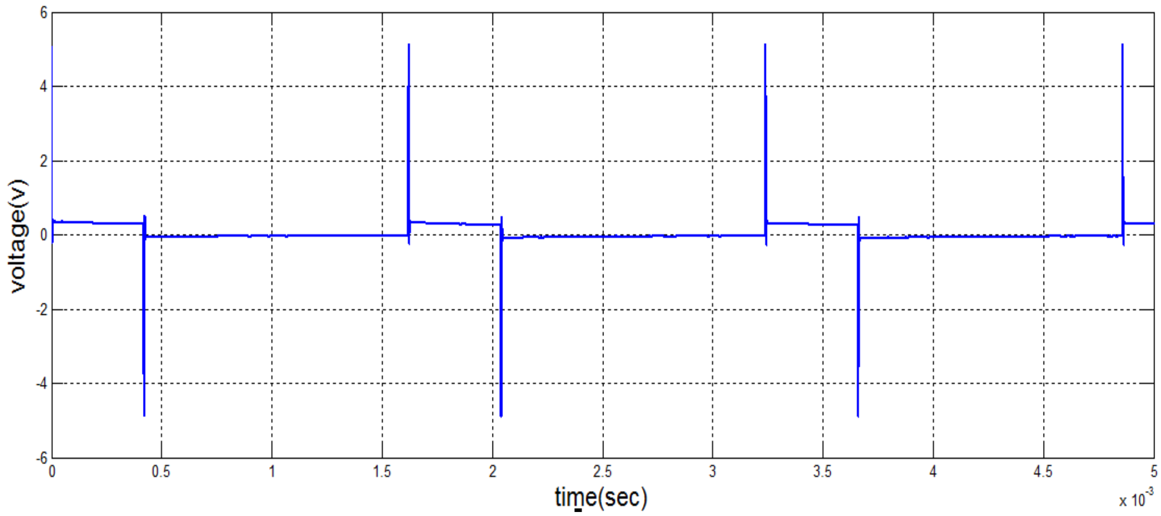


Fig 4.2: PD pulse of charge magnitude 5pC

Fig 4.2 shows a peak output voltage of 5.81V was calculated from the output waveform, when 0.86pF Capacitor was connected, and the charge associated is: C1× V = 0.86×5.81=5pC.

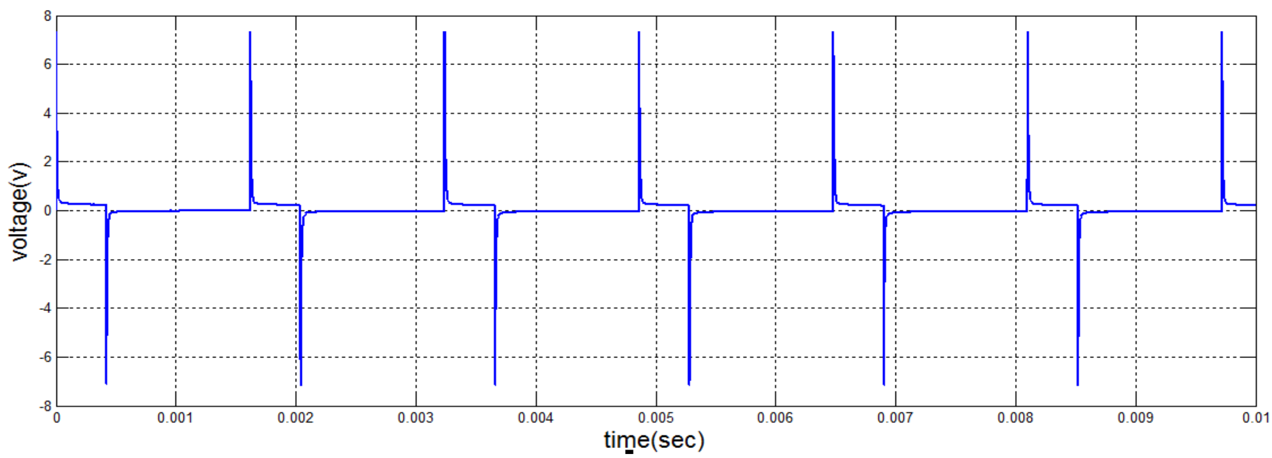


Fig 4.3: PD pulse of charge magnitude 50pC

Fig 4.3 shows When 7.02pF capacitor was connected, a peak output voltage of 7.12V was calculated from the output waveform, and the charge associated is: C2× V = 7.02×7.12=50p

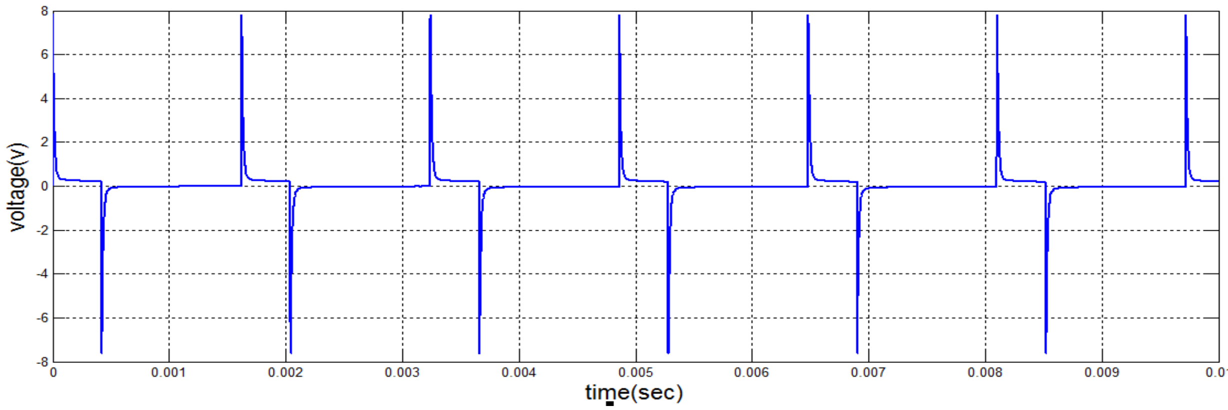


Fig 4.4: PD pulse of charge magnitude 100pC

Fig 4.4 shows that by connecting 12.56pF capacitor, a peak output voltage of 7.96V was Calculated from the output waveform, and the charge associated is: C3× V = 12.56×7.96=100pC

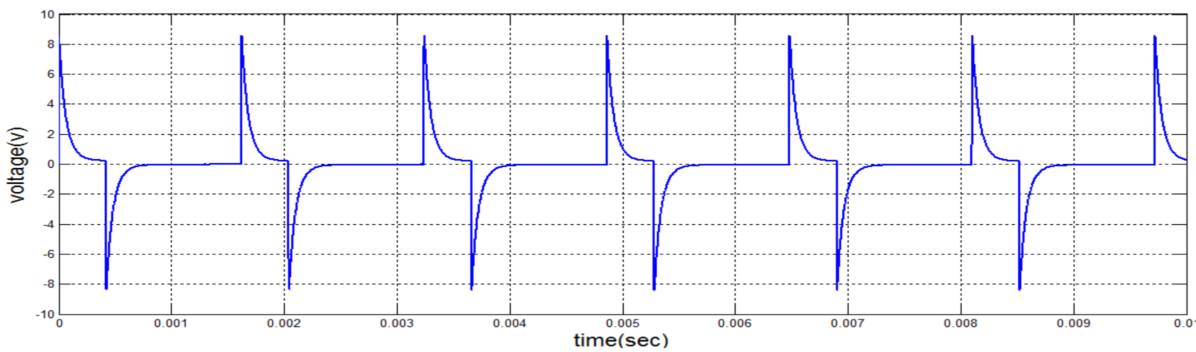


Fig 4.5: PD pulse of charge magnitude 500pC

Fig 4.5 shows a peak output voltage of 8.18V was calculated from the output waveform, when 61.11pF capacitor was connected, and the charge associated is: C4× V = 61.11×8.18=500pC

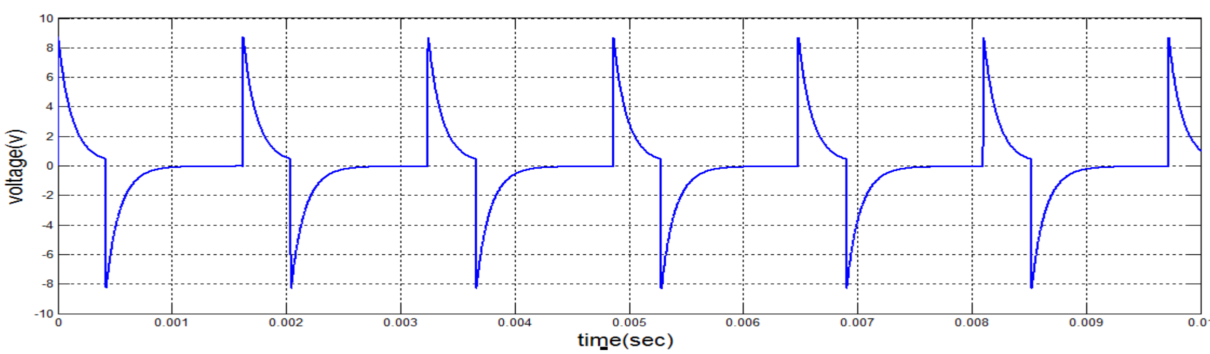


Fig4.6: PD pulse of charge magnitude 1000pC

Fig 4.6 shows the connection of 121.95pF capacitor produces a peak output voltage of 8.2 V was calculated from the output waveform, and the charge associated is:

C1× V = 121.95×8.2=1000pC

Table 4.1: Peak Voltage level Vs. Required Charge Magnitude of PD pulse

Figure Number	Peak Voltage Level of Pd Pulse(V)	Required Charge Magnitude Of Pd Pulse(pC)
4.2	5.81	5
4.3	7.12	50
4.4	7.96	100
4.5	8.18	500
4.6	8.20	1000

.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

A PD pulse generator has been modeled in SIMULINK for generating PD pulses having charge of identified magnitude namely 5 pC , 50 pC , 100 pC , 500 pC , 1000 pC. The high voltage equipments have to be tested for PD to ensure its present quality. PD technology used for diagnosing the state of such equipment has been of extreme importance. Thus, accurateness should be increased and uncertainty should be decreased in the measurement of PD. The reliability of the measurement results is strongly depends on the calibration of the PD measurement system. Such an arrangement needs a standard PD pulse generator which can trace the uncertainties of its components and estimate the expanded uncertainties.

5.2 FUTURE WORK

The PD pulse generator can be used to produce higher pc (Pico-coulomb) level. The simulated circuit can be physically implemented. This model can be applied across a test object and the output can be measured from the measuring circuit. The simulated output can be compared with the actual output obtained from an existing PD pulse generator to improve the accurateness of the PD pulse generator.

REFERENCES

REFERENCES

[1] M. S. Naidu and V. Kamaraju, High Voltage Engineering. New Delhi: Tata McGraw-Hill, pp. 69-85, 2004.

[2] International Electrotechnical Commission, “Partial Discharge Measurement”, IEC 60270, Third edition, Dec., 2000.

[3] DAKIN, T. w., WORKS, c. N., and MILLER, R. L. : 'Utilisation of peak reading voltmeters and recorders for corona measurement', IEEE Paper 31 PP 66-341, 1966.

[4] P. Degn, "Partial Discharges in Solid Dielectrics", PhD Thesis, Technical University of Denmark, Lyngby, 1971.

[5] International Electrotechnical Commission, “Partial Discharge Measurement”, IEC 60270,First edition, 1968.

[6] S.A. Boggs, G.C. Stone, "Fundamental Limitations in the Measurement of Corona and Partial Discharge," IEEE Trans EI, April 1982, p 143.

[7] K. Schon et al., “Intercomparison of PD calibrators and PD instruments,” Proc. 11th ISH, London, pp 1.5.S1 – 1.8.S1, 1999.

[8] J. Fuhr et al, "PD-Fingerprints of Some High Voltage Apparatus", Proc. IEEE International Symposium on Electrical Insulation", June 1990, p129.

[9] Kreuger, F.H , Partial Discharge Detection In High Voltage Equipment, Butterworth and Co. Ltd, London, 1989

[10] Wagner. K.W.: The Physical Nature of Electrical Breakdown in Solid Dielectrics. Journal of American Institution of Electrical Engineering 61 (1922) pp.1034

[11] Loeb, L.B. Basic Processes of Gaseous Electronics. Wiley, London(1939).

[12] Walter S. Zaengel and Kurt Lehmann, “A Critique ofPresent Calibration Procedure for Partial Discharge Measurement”, , IEEE Trans. on Electrical InsulationVol. 28 No. 6, December 1993, pp. 1043-1049.