IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 9, September 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

9940 572 462 | 6381 907 438 | ijareeie@gmail.com | www.ijareeie.com

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 9, September 2021 ||

DOI:10.15662/IJAREEIE.2021.1009010 |

Partial Discharge Simulation using Three-Capacitor model in Multisim

Lekshmi Kaimal[1], Ramesh Kulkarni[2]

Ph.D. Scholar, VES Institute of Technology, (Affiliated to University of Mumbai), India[1]

Dept. of Electronics and Telecommunications, VES Institute of Technology,

(Affiliated to University of Mumbai), India[2]

ABSTRACT:The insulation material undergoes various stresses during its operation which causes deterioration in the insulation material. Partial Dischargecan be used asa major indicator of this deterioration. It is essential to understand the complicated PD physics. This paper presents the simulation of thethree-capacitance model using National Instruments Multisim and LabVIEW. The model implemented here allows simulation of the random nature of the PD pulses. The randomness of the PD pulses is implemented using Poisson distributed pulses. The PD occurrence is simulated using the closingof the switch connected parallel to the void capacitance. These pulses are used to drive the switch operation which simulates the PD occurrence. GUI and formulation engine is implemented using LabVIEW. The user input isfurther processed using LabVIEW. The void-dielectric model is implemented in Multisim and it uses the processed values from LabVIEW as input. The PD pulse details generated by the circuit implementation are then transferred to LabVIEW for further processing and display. The PD pulses generated using this model, though not as accurate as the other models, are in the same range as the experimental results. This model aids in understanding the characteristicsof PD phenomenon. It can be useful in teaching environmentas a laboratory teaching aid and also in PD measurement for diagnosis of PD.

KEYWORDS: Partial Discharge, electrical insulation,three-capacitor model, Multisim

I.INTRODUCTION

Insulation degradation is one of the major reasons for the failures in electrical equipment. Partial Discharge (PD) is one of the indicators of the health of the insulator [1]. It will also give information regarding the continuing degradation of insulation. Therefore, the measurement of PD is a vital parameter to identify the health of the insulation and eventually the electrical equipment [2]. Different types of PDs are seen in electrical equipment. Discharges that come from or due to gas-filled cavities in solid dielectrics is regarded as the most damaging, as they cause irreversible damage to the insulator [3]. It is, thus, essential to effectively analyse the PD signals received from the field [1]. An electrical model of the void, having the ability to represent the physical phenomenon related to PD as accurately as possible, will be helpful [2]. Modelling of the discharge process gives a better understanding of the phenomenon. It is necessary to find out the charge that is transferred from the cavity in the solid insulation to the electrodes, i.e., the charge as measured from the outer terminals. In addition, PD simulation can also be used along with the measurement systems to improve diagnosis [4].

Research has been carried out widely in this important field [5-24]. The process from the PD inception to breakdown can be analysed using modelling and simulation of the PD process [5]. The dielectric ageing process taking place inside the insulator can also be investigated. Its dependence on the various parameters like temperature, applied voltage and frequency can also be examined. Various research is done on the modelling and simulation of the PD process. The different models used for representing the cavity inside solid insulation, are the Three-capacitance or "abc" model [6-10], Analytical model [11-18], Finite-Element-Algorithms (FEA) model [19-24]. The Three-capacitance model represents PD as an impulse change in the capacitance of the specimen [6-10]. The circuit is simple and deterministic. [2] An analytical based PD model uses the induced charge concept to simulate the discharges [11-16,25]. The scheme estimates the primary supply of free electrons to assess the PD occurrence [18]. The surface-emission and volume ionization phenomena are considered. The values of real and apparent charge produced due to PD are calculated [2]. Several researchers have implemented this model various software simulation tools, one such being [26]. The uniqueness of this simulator is that complete and detailed PD can be done, and it does not require the use of a high voltage (HV) setup. The simulator generates PD pulses as seen in real situations using National Instruments LabVIEW software as a base platform. When using FEA for modelling the discharge in a void-dielectric, the electric field

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 9, September 2021 ||

DOI:10.15662/IJAREEIE.2021.1009010 |

throughout the dielectric is mathematically calculated [2]. Better insight into the field distribution is obtained when modelling the PD process using the FEA method, which eventually gives an insight into the pre-discharge event.

The objective of this paper is to model the PD discharge process to give a better understanding of the complicated PD phenomenon. It can be seen that the three-capacitance model of PD depicts the PD characteristics - qualitatively and quantitatively. For the benefit of the researchers intending to work in this field aid to understand the phenomenon is needed. Therefore, in this paper, an attempt has been made to simulate the PD process using the deterministic three-capacitor model using National Instruments Multisim and LabVIEW. PDs are random in nature. PD is said to occur when the field inside the void is more than a particular threshold known as the PD inception field and the first electron is present to start the ionization. The input details like the applied input voltage are provided by the user and the inception voltage is computed using LabVIEW. These details are then passed to the circuit implementation in Multisim. A Poisson distributed pulse generator is developed and used for implementing the randomness in the PD occurrence. The PD pulse details generated from Multisim are then given back to LabVIEW for further processing and display.

The organization of this paper is as follows. A brief introduction to PD is included in Section 2, followed by a detailed explanation of the three-capacitor method to model the PD inside a gas-filled void in a solid dielectric in Section 3. For brevity, the basic concept of capacitance has also been detailed in Section 3. The design and implementation of the PD model in LabVIEW and Multisim are detailed in Section 4. The results obtained are examined in Section 5 and subsequently concluded in Section 6.

II.INTRODUCTION TO PARTIAL DISCHARGE

Partial Discharge (PD), according to IEC standard 60270 [27] is defined as a localized electrical discharge that only partially bridges the insulation between conductors. In insulation system with localized imperfections, electrical discharge or spark is seen only in that small portion of the insulation, not the entire bulk of the dielectric [28]. Such discharges are called Partial Discharges. The main causes of PD are various stresses on the insulator over the period, especially dielectric damage from electric stresses, overheating involving insulated conductor and mechanical deformation. Some materials like non-organic dielectrics are less susceptible to partial discharge. As compared with organic and polymer dielectrics, relatively less PDs are seen in non-organic dielectrics such as glass, mica and porcelain.

A single low energy discharge may not cause damage to the insulation [29]. However, over a period of time the energy is built-up in a localised area of the insulation. This build-up causes deterioration of the insulation, which further leads to occurrence of more PDs. This further causes ageing and continuing damage to the insulator. Hence PD detection can be considered as an early warning sign of the impending deteriorating health of the high voltage devices. If ignored, these discharges will occur frequently leading to a complete breakdown of the equipment.

The necessary and sufficient criteria for the occurrence of a PD are [11-18]:
1. local field enhancement in the void must be higher than the threshold, which indicates the capability of the electric field to cause ionization to enhance the release of electrons than its absorption or trapping into atom
2. presence of a free electron in the defect such that the ionization is initiated.
The PD phenomenon thus is time unpredictable.

III.ELECTRICAL MODEL OF VOID

The three-capacitance deterministic model has been shown to characterise the PD accurately. However, a hybrid model which add probabilistic view point and result in a better model [30]. It uses a time varying conductance for combining the Whitehead model and the classic Pederson`s theory. The simplicity and the deterministic nature of the method makes it apt to be used as an aid forteaching purposes [2].
The magnitude of the apparent charge and current of the PD is shown to be represented accurately by this simple model especially when void sizes are small. In this case, simulation time required is very small and the distribution of charge along the surface can be neglected [3,17].

IIIA.A PARALLEL PLATE CAPACITOR WITH TWO DIELECTRICS

The concept of capacitance is revisited here for the completion sake. Figure 1 shows two charged conductors L_1 and L_2enclosed by air. Conductor L_1 carries a charge of '+Q' and L_2carries '-Q' charge. The total charge in thissetup is zero, since there are no other charges present[1].

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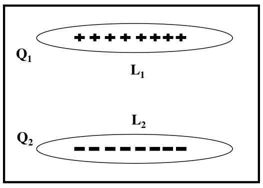

Figure 1. Conductors with opposite charges

Figure 2a shows a parallel plate capacitor made up of two different dielectric materials withpermittivityε_1 and ε_2 respectively. The two dielectrics have thickness d_1 and d_2 respectively with a plate area of A.This configuration is equivalent of two capacitors in series as shown in Figure 2b. The resultant capacitance is given by [31],

$$C_t = \frac{1}{\frac{1}{C_1}+\frac{1}{C_2}} \quad (1)$$

Here, the capacitances of the two dielectric materials used areC_1 and C_2 respectively.

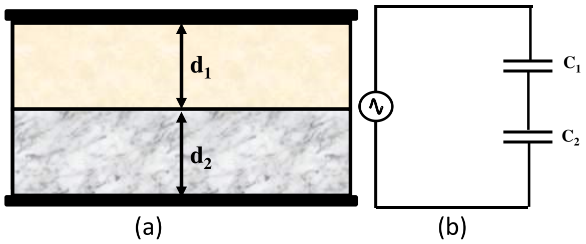

Figure 2. (a) A parallel plate capacitor containing two dielectrics (b) its electrical equivalent circuit [1].

IIIB. THREE-CAPACITANCE MODEL

The three-capacitance model also knownabc-model is based on the capacitance in series fundamentals as described in previous section.Astandard three-capacitance configuration which can depict the cavity in a dielectric materialis shown in Figure 3a **[2]**. Here, V is the applied voltage andC_c characterizes the void capacitance.The capacitance of the void-free material surrounding the void is represented by $C_{a1}$and C_{a2} while $C_{b1}$and C_{b2}model the area of the insulation on either side of the void as series capacitancesto C_c. Figure 3b shows a simplified equivalent circuit of the void-insulation scheme. $C_a$and$C_b$represents theresultant capacitances of $C_{a1}$and $C_{a2}$and$C_{b1}$and C_{b2} respectively. Thevoltage obtained across the voidis given by V_c. Figure 3c gives the equivalent circuitusing a spark-gap F, to illustrate the PD event.

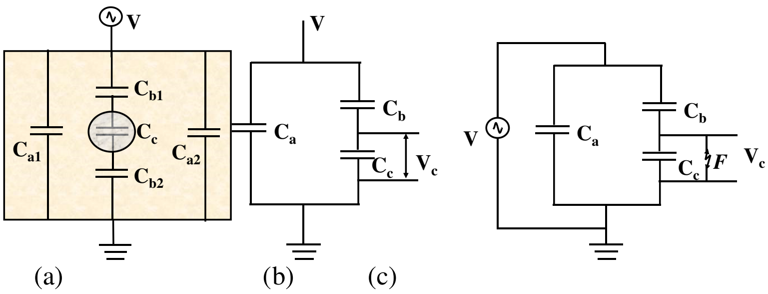

Figure 3. (a) The three-capacitancevoid-dielectric resultant circuit and (b) its electrical equivalentc) Model with spark-gap F

The simulation of PD is initiated when the spark gap F placed across the void capacitance C_c is closed [3]. This will occur when the voltage across the void capacitance, $V_c \geq V_{inc}$, where V_{inc} is the PD inception voltage, until$V_c \leq V_{ext}$where $V_{ext}$is the extinction voltage [6-10]. Here, it is seen that the spark gap F is controlled by the voltage which is a function of the geometry of the void and the inception field and residual field.
Now, the voltage across the void,V_c, before a PD occurs equals to

$$V_c = \frac{C_b}{C_b + C_c} V \quad (2)$$

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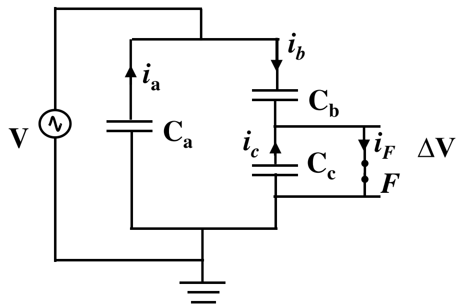

Figure 4. The representation of the currents during a discharge event.

Duringa discharge event, a short circuit is created through the spark gap$F$causing a sudden voltage reduction, ΔVas shown in Figure 4. This causes a transient current to flowthrough C_b and $C_a$given by$i_F = i_c + i_b$.

The real PD charge, q_{real}, in the void then becomes,

$$q_{real} = (C_c + \frac{C_a C_b}{C_a + C_b})\Delta V \quad (3)$$

The electrode charge undergoes a change as known as, the induced chargeor apparent q_{app}can be calculated using

$$q_{app} = C_b \Delta V (4)$$

WhenC_c<<C_b, the detectable charge at the electrodes of the specimenis much lower than the internal charge[4]. Therefore, apparent charge has been named so. As per IEC 60270 [27], the apparent charge $q_{app}$is not equal to the actual charge at the location of the dischargeq_{real}, which is difficult to be measured.[4].

The electrical model of the void-dielectriccan be simulated with a switch parallelto Cc instead of spark gap *F*, as shown in Figure 5 [3].

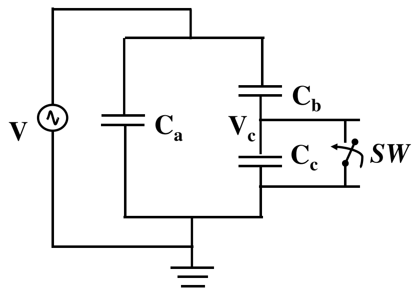

Figure 5. PD three capacitance circuit with switch operation.

IV. DESIGN AND IMPLEMENTATION OF MODEL USING LABVIEW AND MULTISIM

Figure 6 shows the block diagram of the three-capacitance model implemented in this work using this model using National Instruments Multisim and LabVIEW. A Graphical User Interface (GUI) and physics formulation engine is implemented using LabVIEW. The void-dielectric model and the associated circuitry to implement PD occurrence is executed in Multisim. The processed data from LabVIEWacts as an input to the Multisim circuit.

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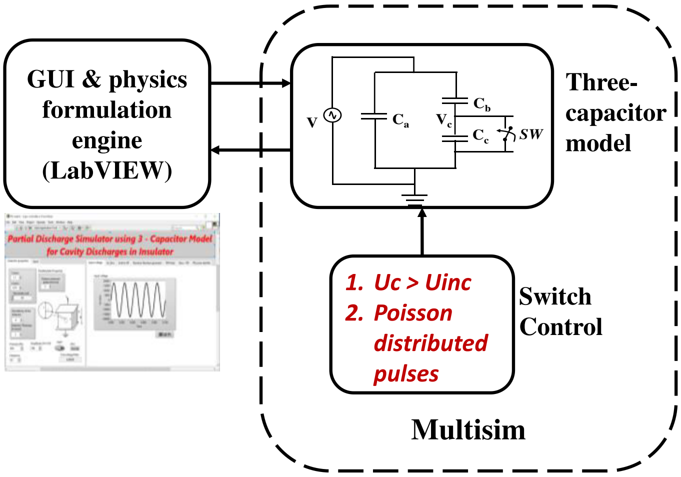

Figure 6. Block Diagram of the three-capacitance model implementation using National Instruments Multisim and LabVIEW

The necessary condition for the occurrence of a PD i.e., local field enhancement in the voidV_c must be higher than the threshold,V_{inc}, is checked first. Then sufficient criteria, i.e.,the presence of a free electron to initiate the ionization in the cavity, is implemented based on the statistics involved in PD occurrence.The time between consecutive pulses is said to follow an exponential pattern. Hence the randomness of PD is realized using a Poisson distributed pulse generator. The PD pulses generated by the Multisim model is then sent back to LabVIEW for display and further processing.

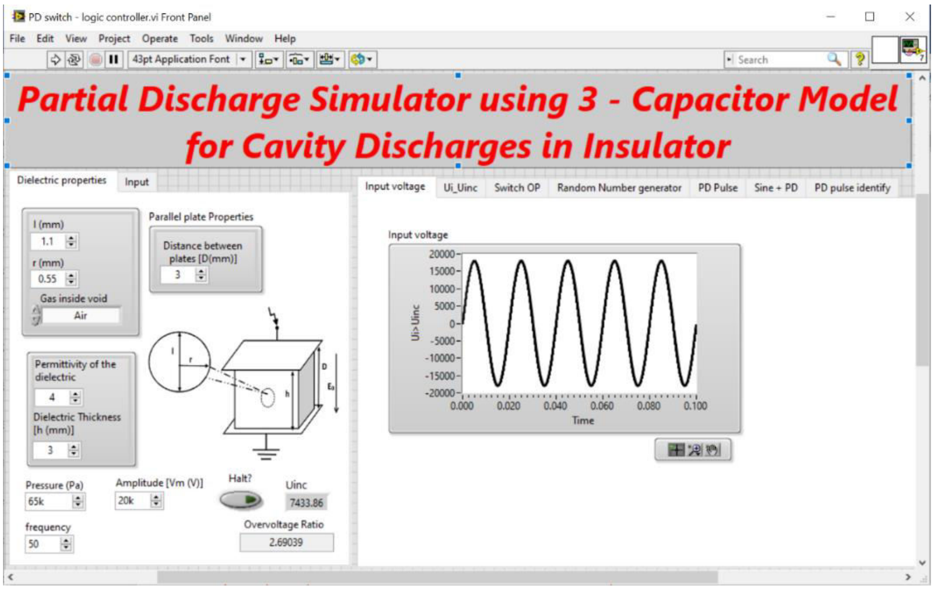

Figure 7. LabVIEW GUI and physics engine.

Figure 7 shows the LabVIEW based GUI and engine. The void-dielectric model circuit is implemented in Multisim. The input details like the applied input voltage are obtained from the user and the inception voltage is computed using LabVIEW. These details are then passed to the circuit implementation in Multisim.

Figure 8 shows the void-dielectric model as implemented in Multisim. Fast switching analog switch ADGHS201 is used for simulating the PD.

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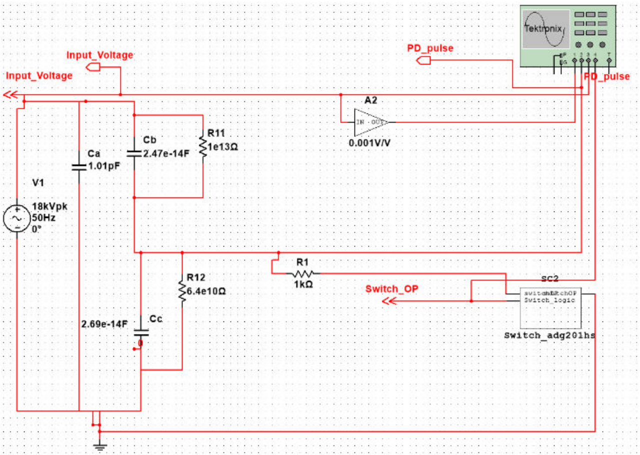

Figure 8. Void-dielectric model implemented in Multisim

Figure 9a shows the implementation of the switch operation design in Multisim. When the $V_c \geq V_{inc}$, then the logic operations can be used to control the switch. The presence of the first electron to start the ionizationis necessary condition for PD to occur. The random nature ofPD depends on this first electron appearance. Therandom behaviour of the switch should be considered while controlling the closure of the switch.The time between pulses is said to follow Poissondistribution [32].Hence, aPoisson distributed pulse generator is developed in LabVIEW and used as a LabVIEW instrument (XLV2 as shown in Figure 9a) in Multisim, for implementing the randomness in the PD occurrence. The comparator LM311 is used for V_c and V_{inc} comparison.

Figure 9b shows the associated circuitry of the switch operation designed in Multisim. The high input voltage in the range of 'kV' is applied to the capacitor model. However, the components used for the switch operation works on low voltages in the range of '5-10 V'. Hence an associated circuitry is used for rectification and attenuation of the high voltage signals.

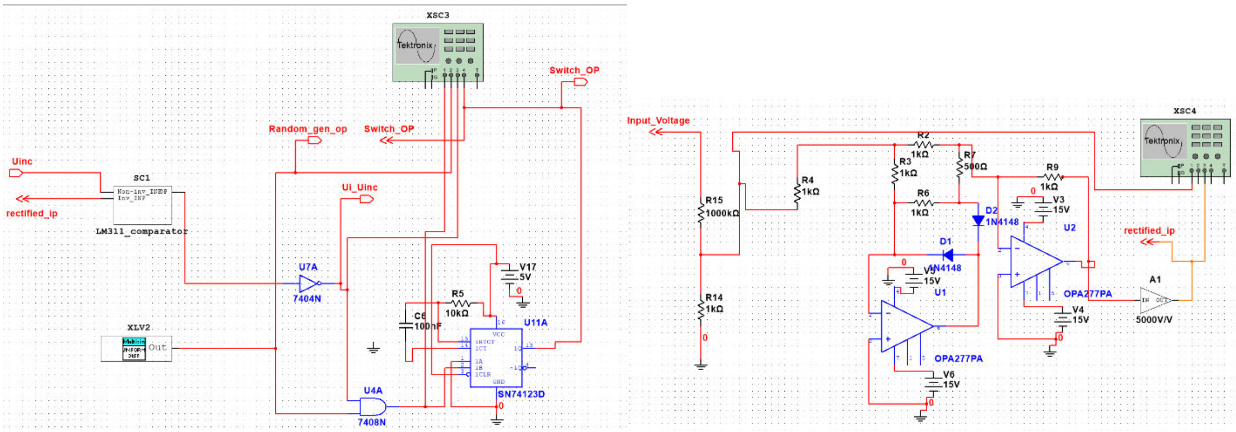

Figure 9. Switch operation circuit and associated circuitry; a) Poisson distributed pulse generator used for switch operation. b) Associated circuitry for switch operation

The PD pulse details generated from Multisim are then given back to LabVIEW for further processing and display. Figure 10 shows the LabVIEW GUI displaying the PD pulses. The number of positive and negative pulses are computed as well as the pulse charge details.

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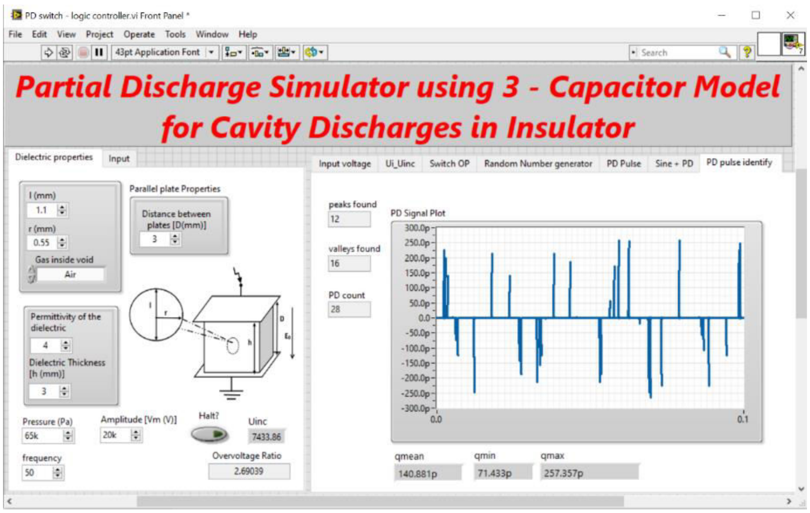

Figure 10. LabVIEW GUI with PD pulse display

V. RESULT AND DISCUSSION

The model developed is applied to the experimental work reported in [33].In [33] and [5], the PD was simulated using the different models and the results were compared to the experimental studies carried out in [33]. The sample used for the experimental study involved an epoxy resin dielectric of 3mm thickness with an air-filled spherical void of diameter 1.1mm.The cylindrical electrodes with 10mm diameter were used. An AC voltage of 18 kV, 50Hz was used to energize the setup.

The three-capacitance model scheme designed in this work as seen in the previous section was used for simulation.Table 1 summarizes the simulation results with respect to the experimentalvalues stated in [33] as well as the simulation results obtained in [5].

Table 1. Results summary.

Method/Variable	Measured*	Three-Capacitance model in Ref [5]		Three-Capacitance model using Multisim in the present work	
		Magnitude	Error (%)	Magnitude	Error (%)
PD per cycle	6.5	6.134	5.631	6.6	1.55
Minimum PD magnitude, q_{min} (pC)	80	81.31	1.648	78	2.56
Maximum PD magnitude, q_{max} (pC)	373	296.98	20.381	302	23.5

*Experimental values specified in [33].

Table 1 shows that a higher error rate is seen in reproducing the maximum PD magnitude. This is seen in the results given in [5] as well. The simulation values obtained in this work have values close to the simulation results in [5]. This shows that Multisim can be used as a tool to simulate PD. It is seen that the error rates can be reduced by optimising the parameters of the Poisson pulse generator. The future scope of this work is optimization of the Poisson parameters.

Even though the error rates seen are high, the values obtained using the three-capacitor model are of a similar range as the experimental values. In this model, the potential on the cavity surface is assumed to be equal throughout the area of the void and the accumulation of the surface charge at the boundary of the cavity is not considered, However, this assumption may not always be true [2].

VI.CONCLUSION

The theoretical concepts behind the capacitance model of PD have been covered in this paper. The model simulated the experimental data given in the literature using National Instruments Multisim and LabVIEW. The results obtained with the model have the same order as the experimental values.

Themodel implemented here allows simulation of the random nature of the PD pulses. Poisson distributed pulses are used to implement this stochastic nature. These pulses are used to drive the switch operation which simulates the PD occurrence. LabVIEW based GUI and formulation engine is implemented. The input details are obtained from the user and processed using LabVIEW. These processed values act as aninputto the circuit implementation in Multisim. The PD pulse details generated from Multisim are then given back to LabVIEW for further processing and display.

This model allows an estimated,quantifiableand characteristicnature of thePD phenomenon. The three-capacitance model is based on several assumptionsand may not give as accurate results as the other models. However,in teaching environments, it can be usedas a tool to learn the basic characteristics of the PD process. It could also complement the condition monitoring tools,for example, in locating PD in power transformers using electrical measurements.

ACKNOWLEDGMENT

The authors would like to thank Dr. P. P Vaidya, HOD, R&D and Departmentof Instrumentation, VES Institute of Technology, Mumbai, India and Prof. Himanshu Bahirat and Prof. S. V. Kulkarni, Department of Electrical Engg., IIT Bombay, India for the valuable insights and technical help extended during thestudy related to this paper. The authors would also like to thank the editorsand anonymous reviewers for providing insightful suggestions and comments to improve the quality of research paper.

REFERENCES

[1] Zenon Achillides, George E. Georghiou and Elias Kyriakides, “Partial Discharges and Associated Transients: The Induced Charge Concept versus Capacitive Modeling”, IEEE Transactions on Dielectrics and Electrical Insulation Vol. 15, No. 6; December 2008, pp. 1507-1516

[2] H.A. Illias, G. Chen and Paul L. Lewin, Comparison between Three-Capacitance, Analytical-based and Finite Element Analysis Partial Discharge Models in Condition Monitoring, IEEE Transactions on Dielectrics and Electrical Insulation Vol. 24, No. 1; February 2017 pp. 99-109 Q. Wang, H. Zheng, “Route and spectrum selection in dynamic spectrum networks,” in Proc. IEEE CCNC 2006, pp. 625-629, Feb. 2006.

[3] E. Lemke, "A critical review of partial-discharge models," in IEEE Electrical Insulation Magazine, vol. 28, no. 6, pp. 11-16, Nov.-Dec. 2012, doi: 10.1109/MEI.2012.6340519.

[4] Albarracin, R.; Robles, G.; Ardila-Rey, J.A.; Cavallini, A.; Passaglia, R. Partial discharges: Keys for condition monitoring and diagnosis of power transformers. Power Transform. Cond. Monit. Diagn. 2018, 104, 39–85.

[5] Rodríguez-Serna, J.M.; Albarracín-Sánchez, R.; Dong, M.; Ren, M. Computer Simulation of Partial Discharges in Voids inside Epoxy Resins Using Three-Capacitance and Analytical Models. Polymers 2020, 12, 77.

[6] T. Okamoto, T. Kato, Y. Yokomizu, Y. Suzuoki, and T. Tanaka, "PD characteristics as a stochastic process and its integral equation under sinusoidal voltage," IEEE Trans. Dielectr. Electr. Insul., Vol. 8, pp. 82- 90, 2001.

[7] N. Hozumi, H. Nagae, Y. Muramoto, M. Nagao, and X. HengKyun, "Time-lag measurement of void discharges and numerical simulation for clarification of the factor for partial discharge pattern," Int'l. Sympos.Electr. Insulating Materials, pp. 29-32, 2001.

[8] M. Hikita, K. Yamada, A. Nakamura, T. Mizutani, A. Oohasi, and M. Ieda, "Measurements of partial discharges by computer and analysis of partial discharge distribution by the Monte Carlo method," IEEE Trans. Electr. Insul., Vol. 25, pp. 453-468, 1990.

[9] H. Suzuki, K. Aihara, and T. Okamoto, "Complex behaviour of a simple partial-discharge model," EPL (Europhysics Letters), Vol. 66, p. 28, 2004.

[10] Z. Achillides, G. Georghiou, and E. Kyriakides, "Partial discharges and associated transients: the induced charge concept versus capacitive modeling," IEEE Trans. Dielectr. Electr. Insul., Vol. 15, pp. 1507-1516,2008.

[11] A. Pedersen, G. C. Crichton, and I. W. McAllister, "The functional relation between partial discharges and induced charge," IEEE Trans. Dielectr. Electr. Insul., Vol. 2, pp. 535-543, 1995.

[12] M. G. Danikas, I. W. McAllister, G. C. Crichton, and A. Pedersen, "Discussion: partial discharges in ellipsoidal and spheroidal voids," IEEE Trans. Electr. Insul., Vol. 26, pp. 537-539, 1991.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

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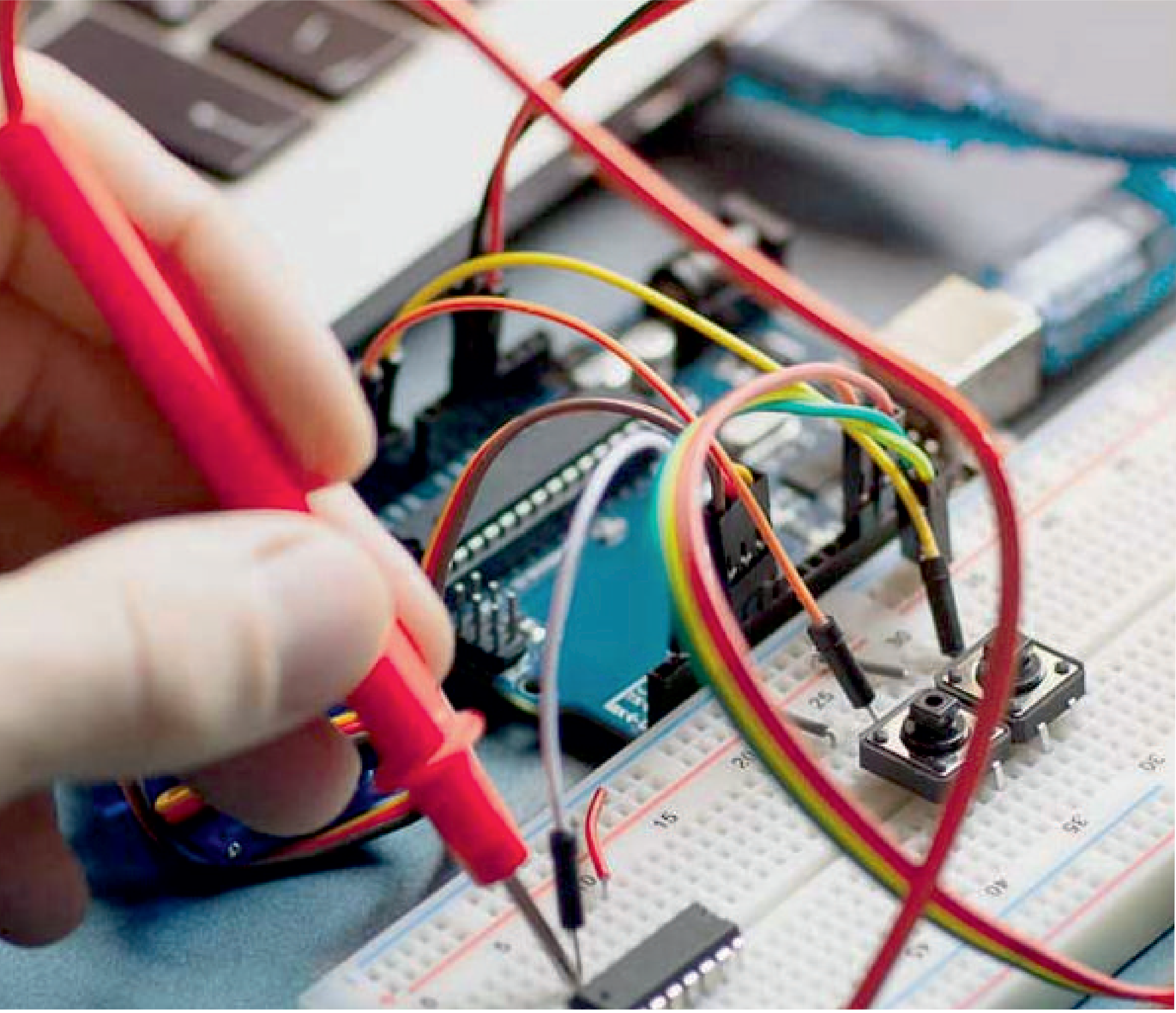
[13] G. C. Crichton, P. W. Karlsson, and A. Pedersen, "Partial discharges in ellipsoidal and spheroidal voids," IEEE Trans. Electr. Insul., Vol. 24, pp. 335-342, 1989.
[14] A. Pedersen, G. C. Crichton, and I. W. McAllister, "The theory and measurement of partial discharge transients," IEEE Trans. Electr. Insul., Vol. 26, pp. 487-497, 1991.
[15] A. Pedersen, "On the electrodynamics of partial discharges in voids in solid dielectrics," 3rd Int'l. Conf. Conduction and Breakdown in Solid Dielectr., pp. 107-116, 1989.
[16] A. Pedersen, G. C. Crichton, and I. W. McAllister, "PD-related stresses in the bulk dielectric for ellipsoidal voids," IEEE Conf. Electr. Insul. Dielectr. Phenomena, 1994, pp. 79-84.
[17] F. Gutfleisch and L. Niemeyer, "Measurement and simulation of PD in epoxy voids," IEEE Trans. Dielectr. Electr. Insul., Vol. 2, pp. 729-743, 1995.
[18] L. Niemeyer, "A generalized approach to partial discharge modeling," IEEE Trans. Dielectr. Electr. Insul., Vol. 2, pp. 510-528, 1995.
[19] C. Forssen and H. Edin, "Field model of partial discharges at variable frequency of the applied voltage," Nordic Insulation Sympos. - Nord-IS05, pp. 121-124, 2005.
[20] C. Forssen, Modelling of Cavity Partial Discharges at Variable Applied Frequency," Ph.D. Thesis, KTH Royal Institute of Technology, Sweden, 2008.
[21] C. Forssen and H. Edin, "Partial discharges in a cavity at variable applied frequency part 2: Measurements and modeling," IEEE Trans. Dielectr. Electr. Insul., Vol. 15, pp. 1610-1616, 2008.
[22] C. Forssen and H. Edin, "Modeling of a discharging cavity in a dielectric material exposed to high electric fields," FEMLAB Conf., 2005.
[23] C. Forssen and H. Edin, "Modeling partial discharges in a cavity at different applied frequencies," IEEE Conf. Electr. Insul. Dielectr. Phenomena, pp. 132-135, 2007.
[24] H. Illias, G. Chen, and P. L. Lewin, "Partial Discharge Behavior within a Spherical Cavity in a Solid Dielectric Material as a Function of Frequency and Amplitude of the Applied Voltage," IEEE Trans. Dielectr.Electr. Insul., Vol. 18, pp. 432-443, 2011.
[25] I. W. McAllister, "Partial discharges in spheroidal voids. Void orientation," IEEE Trans. Dielectr. Electr. Insul., Vol. 4, pp. 456-461, 1997.
[26] L. A. Kaimal, H. J. Bahirat, P. P. Vaidya and S. V. Kulkarni, "Design of a Universal Partial Discharge Simulator," 2019 IEEE 4th International Conference on Condition Assessment Techniques in Electrical Systems (CATCON), Chennai, India, 2019, pp. 1-6
[27] IEC60270: High-voltage test techniques - Partial Discharge measurements
[28] http://www.partial-discharge-academy.com/what-is-partial-discharge
[29] http://en.wikipedia.org/wiki/Partial_discharge
[30] G. Ala, R. Candela, P. Romano, and F. Viola, "Simplified Hybrid PD Model in Voids," in IEEE International Symposium on Diagnostics for Electric Machines, Power Electronics and Drives, Bologna, Italy, September 5-8, 2011, pp. 451-455.
[31] W. H. Hayt and J. A. Buck, Engineering Electromagnetics, 7th ed.McGraw-Hill, 2005.
[32] T. Ficker, J. Macur, L. Pazdera, M. Kliment and S. Filip, "Simplified digital acquisition of microdischarge pulses," in IEEE Transactions on Dielectrics and Electrical Insulation, vol. 8, no. 2, pp. 220-227, April 2001
[33] Illias, H.A.; Chen, G.; Lewin, P.L. Comparison between three-capacitance, analytical-based and finite element analysis partial discharge models in condition monitoring. IEEE Trans. Dielectr. Electr. Insul. 2017, 24, 99–109.



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