

Examination and Determination of Partial Discharge Type utilizing Statistical Techniques and Back Propagation Method of Artificial Neural Network

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ABSTRACT : Incomplete release (PD) designs are critical instrument for the finding of high voltage (HV) protection frameworks. Human specialists can find conceivable protection absconds in different portrayals of the PD information. One of the most broadly utilized portrayals is stage settled PD (PRPD) designs. So as to guarantee dependable activity of HV hardware, it is vital to relate the noticeable measurable attributes of PDs to the properties of the imperfection and at last to decide the kind of the deformity. In present work, we have obtained and analysed combined use of PRPD patterns (ϕ -q), (ϕ -n) and (n-q) using statistical parameters such as skewness and kurtosis for two patterns viz. (ϕ -q) and (ϕ -n) along with mean, standard deviation, variance, skewness and kurtosis for (n-q) to detect type of PD and we have verified the obtained results by providing obtained statistical parameters as an input for training of artificial neural network (ANN) in MATLAB tools.

KEYWORDS: Partial Discharge, Phase-resolved, Statistical parameters, Artificial Neural Network.

I.INTRODUCTION

PD is a limited electrical release that in part connects the protection among channels and which could conceivably happen nearby a conduit [1]. When all is said in done, PDs are worried about dielectric materials utilized, and somewhat crossing over the terminals between which the voltage is applied. The protection may comprise of strong, fluid, or vaporous materials, or any blend of them. PD is the primary purpose behind the electrical maturing and protection breakdown of high voltage electrical device. Various wellsprings of PD give diverse impact on protection execution. Subsequently, PD arrangement is significant so as to assess the hurtfulness of the release [2].

The ongoing upsurge of research on PD wonders has been driven to a limited extent by improvement of new quick computerized and PC based methods that can procedure and investigate signals got from PD estimations. There is by all accounts a desire that, with adequately refined advanced preparing methods, it should be conceivable not exclusively to increase new knowledge into the physical and substance premise of PD marvels, yet in addition to characterize PD 'designs' that can be utilized for distinguishing the qualities of the protection 'absconds' at which the watched PD happen [3]. One of the undoubted focal points of a PC helped estimating framework is the capacity to process a lot of data and to change this data into a reasonable yield [4]. As each imperfection has its own specific debasement instrument, it is imperative to realize the connection between's release designs and the sort of deformity [4]. Consequently, progress in the acknowledgment of inside release and their relationship with the sort of deformity is getting progressively significant in the quality control in protecting frameworks [5].

Research has been completed in acknowledgment of halfway release sources utilizing factual methods and neural system [6]. We present a strategy for the mechanized acknowledgment of PRPD designs utilizing an ANN for the

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genuine characterization task [12]. In our examination, we have tried different inside and outside releases like void, surface and crown utilizing factual parameters, for example, skewness and kurtosis for $(\phi-q)$ and $(\phi-n)$ and mean, standard deviation, difference, skewness and kurtosis for $(n-q)$ as an underlying advance known as pre-handling and an unfinished copy is made about the aftereffects of PD Type and checked the outcomes by utilizing back engendering strategy for Counterfeit Neural Network in MATLAB programming.

II. STATISTICAL PARAMETERS

The significant parameters to describe PDs are stage edge ϕ , PD charge extent q and PD number of heartbeats n . PD dissemination designs are made out of these three parameters. Measurable parameters are gotten for stage settled examples $(\phi-q)$, $(\phi-n)$ and $(n-q)$.

2.1. Processing of data

The data which extracted from initiator shall involve ϕ , q , n & voltage V . The phase determined trends are get from this analysis.

2.1.1. Investigation of Phase-Resolved $(\phi-q)$ & $(\phi-n)$ utilizing Statistical method:

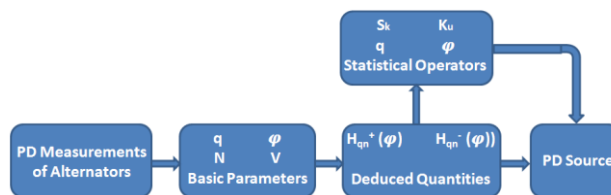


Fig.1(a).Block diagram of discharge analysis for $(\phi-q)$

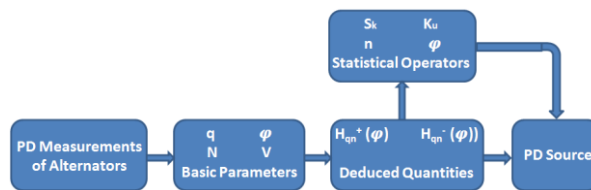


Fig.1(b).Block diagram of discharge analysis for $(\phi-n)$

PD beats are gathered by their stage point concerning $50 (\pm 5)$ Hz sine wave. Subsequently, the voltage cycle is partitioned into stage windows speaking to the stage edge pivot (0 to 360°). The mean estimations of these factual conveyances brings about two dimensional examples of the watched PD designs all through the entire stage point hub [6]. A two-dimensional (2-D) appropriation $\phi-q$ and $\phi-n$ speaks to PD charge size ' q ' and PD number of heartbeats ' n ' as an element of the stage edge ' ϕ ' [3].

2.1.2. Analysis of Phase-Resolved $(q-n)$ using Statistical Techniques

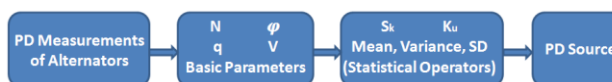


Fig. 2. Block diagram of discharge analysis for $(n-q)$

Where,
S.D = standard deviation

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Sk = skewness

Ku = kurtosis

Statistical analysis is applied for the computation of several statistical operators. The definitions of most of these statistical operators are described below. The profile of all these discrete distribution functions can be put in a general function, i.e., $y_i=f(x_i)$.

III.RESULTS AND DISCUSSION OF STATISTICAL PARAMETERS

Evaluation includes the identification of unknown PD patterns by matching them against known PD patterns including vacuum, surface & corona. The distinction is rendered by analyzing their mathematical metrics [9] [10][11].

3.1. Analysis for (ϕ -q)

Phase-resolved trends are classified into two sorts: (ϕ -q) & (ϕ -n). Phase-resolved patterns (ϕ -q) are reported for 3-known PD patterns: void, surface & corona as mentioned in 3.1.1 & 3.1.2 & 3-unknown PD patterns: data1, data2 & data3 as described below in 3.1.3 & 3.1.4 [9].

3.1.1. 2-D distribution of (ϕ -q) for known PD patterns

Fig.3 (a), Fig.3 (b) and Fig.3 (c) are the stage ϕ versus charge q plot for void, surface and crown releases individually.

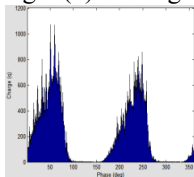


Fig.3(a).Phase plot (ϕ -q) of void discharge

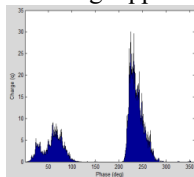


Fig.3(b).Phase plot (ϕ -q) of surface discharge

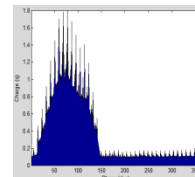


Fig.3(c). Phase plot (ϕ -q) of corona discharge

3.1.2. 2-D distribution of (ϕ -q) for unknown PD patterns

Fig.4 (a), Fig.4 (b) and Fig.4 (c) are the stage ϕ versus charge q plot for data1, data2 and data3 separately.

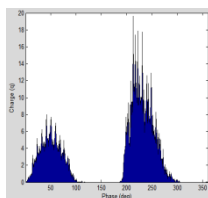


Fig.4(a)Phase plot (ϕ -q) of data1

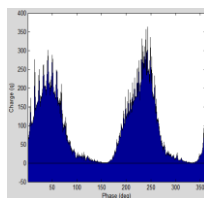


Fig.4(b)Phase plot (ϕ -q) of data2

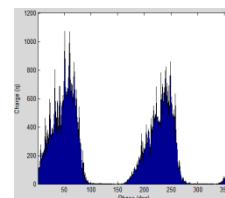


Fig.4(c)Phase plot (ϕ -q) of data3

From Fig.4 (a), it is seen that the accompanying plot is like void and surface release. Fig.4 (b), is likewise like void and surface release and Fig.4(c), is like void release.

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3.2. Analysis for (ϕ -n)

The stage settled (ϕ -n) designs comprise of three realized PD designs: void, surface and crown (as talked about in 3.2.1) and three obscure PD designs: data1, data2 and data3 (as examined in 3.2.3) [9]. The plots are talked about beneath:

3.2.1 Phase resolved plot (ϕ -n) of known PD patterns

Fig.5 (a), Fig.5 (b) and Fig.5 (c) are the stage ϕ versus number of heartbeats n for void, surface and crown releases individually.

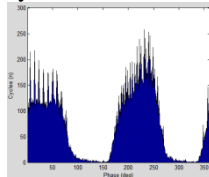


Fig.5(a).Phase plot (ϕ -n) of void discharge

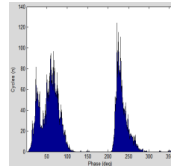


Fig.5(b).Phase plot (ϕ -n) of surface discharge

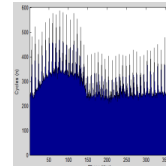


Fig.5(c).Phase plot (ϕ -n) of corona discharge

3.2.2. Phase resolved plot (ϕ -n) of unknown PD patterns

Fig.6 (a), Fig.6 (b) and Fig.6 (c) are the stage ϕ versus number of heartbeats n plot for data1, data2 and data3 individually.

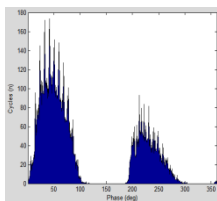


Fig.6(a).Phase plot (ϕ -n) of data1

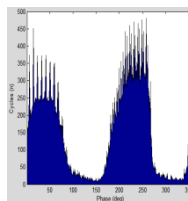


Fig.6(b).Phase plot (ϕ -n) of data2

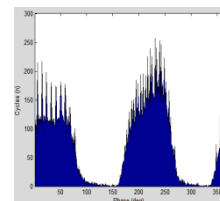


Fig.6(c).Phase plot (ϕ -n) of data3

From Fig.6 (a), it is seen that the accompanying plot is like void and surface release. Fig.6 (b), is like void release and Fig.6 (c), is additionally like void release.

3.3. Analysis for (n-q)

The stage settled examples n-q are gotten for three realized PD designs: void, surface and crown (as talked about in 3.3.1) and three obscure PD designs: data1, data2 and data3 (as examined in 3.3.3) [10].

3.3.1. 2-D distribution of n-q for known PD patterns

Fig. 7(a), Fig. 7(b), Fig. 7(c), Fig. 7(d) and Fig. 7(e) are the n-q plot of mean, standard deviation, fluctuation, skewness and kurtosis for void release individually.

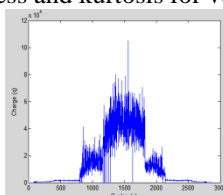


Fig.7(a).Mean plot (n-q) of void discharge

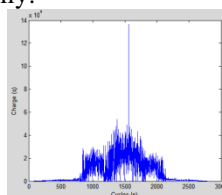


Fig.7(b).Standard deviation plot (n-q) of void discharge

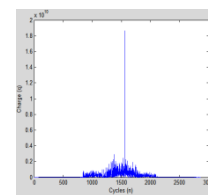


Fig.7(c).Variance plot (n-q) of void discharge

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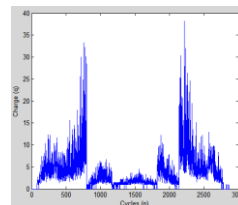
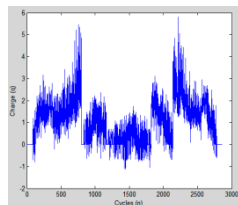


Fig.7(d)Skewness plot (n-q) of void discharge **Fig.7(e)**Kurtosis plot (n-q) of void discharge

Alluding to Fig. 7 (a), Fig. 7 (b) and Fig. 7 (c) of void release, it very well may be seen there is a pinnacle happening some place after 1500 cycle, which is a void release and in Fig. 7 (d) and Fig. 7 (e) of skewness and kurtosis, the worth declines at that cycle where pinnacle happens.

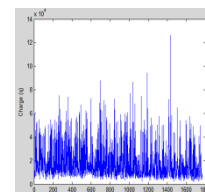
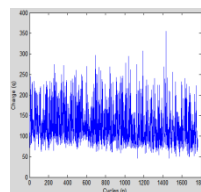
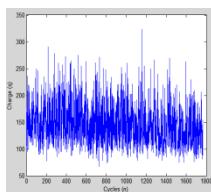


Fig.8(a)Mean plot (n-q) of surface discharge

Fig.8(b)Standard deviation plot (n-q) of surface discharge

Fig.8(c)Variance plot (n-q) of surface discharge

In surface release, charges are dispersed consistently over all cycles for mean, standard deviation, difference, skewness and kurtosis as appeared.

Fig. 9(a), Fig. 9(b), Fig. 9(c), Fig. 9(d) and Fig. 9(e) are the n-q plot of mean, standard deviation, variance, skewness and kurtosis for corona discharge respectively.

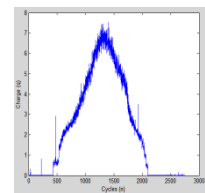
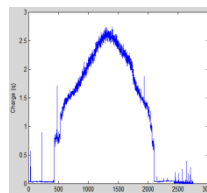
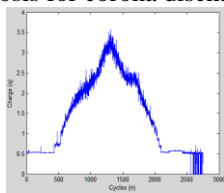


Fig.9(a)Mean plot (n-q) of corona discharge

Fig.9(b)Standard deviation (n-q) of corona discharge

Fig.9(c)Variance plot (n-q) of corona discharge

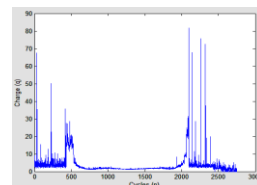
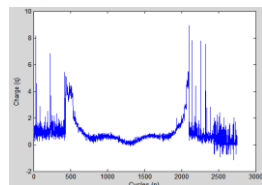


Fig.9(d)Skewness plot (n-q) of corona discharge

Fig.9(e)Kurtosis plot (n-q) of corona discharge

Alluding to Fig. 9(a), Fig. 9(b) and Fig. 9(c) of crown release, it very well may be seen the charges begins happening after 500 cycle expanding some place upto 1200 cycle and afterward diminishing after 2000 cycle, and in Fig. 9(d) and Fig. 9(e) of skewness and kurtosis, the worth declines from 500 cycle till 2000 cycle.

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3.3.2. 2-D distribution of (n-q) for unknown PD patterns

Fig. 10(a), Fig. 10(b), Fig. 10(c) are the n-q plot of mean, standard deviation, fluctuation for data1 separately.

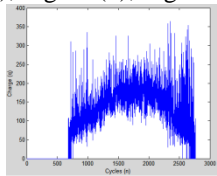


Fig.10(a) Mean plot (n-q) of data1

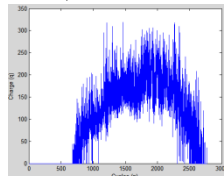


Fig.10(b) Standard deviation plot (n-q) of data1

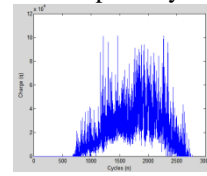


Fig.10(c) Variance plot (n-q) of data1

In Fig. 10(a), Fig. 10(b), Fig. 10(c), the charges are uniformly distributed similar to surface discharge. Hence, it can be concluded that data1 is having surface discharge.

Fig. 11(a), Fig.11(b), Fig. 11(c) are the n-q plot of mean, standard deviation, variance, skewness and kurtosis for data2 respectively.

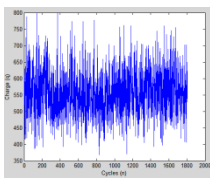


Fig.11(a) Mean plot (n-q) of data2

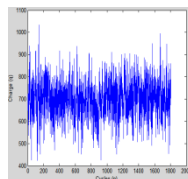


Fig.11(b) Standard deviation plot (n-q) of data2

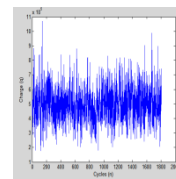


Fig.11(c) Variance plot (n-q) of data2

In Fig. 11(a), Fig. 11(b), Fig. 11(c), the charges are consistently appropriated like surface release. Henceforth, it very well may be reasoned that data2 is having surface release.

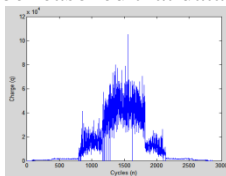


Fig.12(a) Mean plot (n-q) of data3

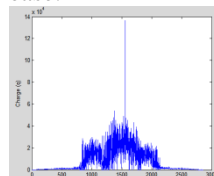


Fig.12(b) Standard deviation plot (n-q) of data3

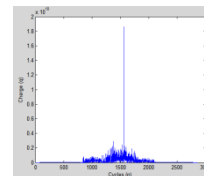


Fig.12(c) Variance plot (n-q) of data3

Fig. 12(a), Fig. 12(b), Fig. 12(c) are the n-q plot of mean, standard deviation, difference, skewness and kurtosis for data3 separately. In Fig. 12(a), Fig. 12(b) and Fig. 12(c), there is an event of top after 1500 cycle and skewness and kurtosis esteem diminishes at that pinnacle which is like void release. Consequently, it tends to be presumed that data3 is void release.

IV. OBSERVATIONS FROM STATISTICAL METHODS

From the above outcomes, following perceptions are made:

Fig. 13(a), Fig. 13(b) and Fig. 13(c) are the qualities of skewness and kurtosis ($H_{qn}+(\varphi)$ and $H_{qn}-(\varphi)$) of information 1, data2 and data3 against void, surface and crown releases individually.

From Fig. 13(a), it is seen that data3 attributes covers void release qualities, it tends to be inferred that data3 is void release. Data2 qualities around fits against void, it very well may be reasoned that data2 is additionally void release.

From Fig. 13(b), it is seen that information 1 attributes is like surface release qualities, it very well may be reasoned that information 1 is surface release.

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From Fig. 13(c), it is seen that none of the information attributes is like crown release qualities, it very well may be presumed that none of the information has crown release.

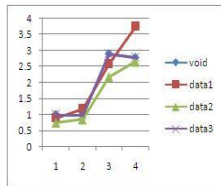


Fig.13(a) Characteristics of skewness and kurtosis($H_{qn}^+(\varphi)$ and $H_{qn}^-(\varphi)$) of data1, data2, and data3 against void

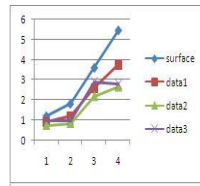


Fig.13(b) Characteristics of skewness and kurtosis($H_{qn}^+(\varphi)$ and $H_{qn}^-(\varphi)$) of data1, data2, and data3 against surface

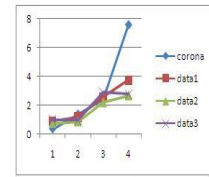


Fig.13(c) Characteristics of skewness and kurtosis($H_{qn}^+(\varphi)$ and $H_{qn}^-(\varphi)$) of data1, data2, and data3 against corona

Fig. 14(a), Fig. 14(b) and Fig. 14(c) are the attributes of skewness and kurtosis ($H_n^+(\varphi)$ and $H_n^-(\varphi)$) of information 1, data2 and data3 against void., surface and crown releases separately.

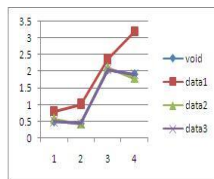


Fig.14(a) Characteristics of skewness and kurtosis($H_n^+(\varphi)$ and $H_n^-(\varphi)$) of data1, data2, and data3 against void

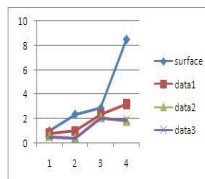


Fig.14(b) Characteristics of skewness and kurtosis($H_n^+(\varphi)$ and $H_n^-(\varphi)$) of data1, data2, and data3 against surface

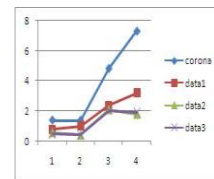


Fig.14(c) Characteristics of skewness and kurtosis($H_n^+(\varphi)$ and $H_n^-(\varphi)$) of data1, data2, and data3 against corona

From Fig. 14(a), it is seen that data3 attributes covers void release qualities, it very well may be reasoned that data3 is void release. Data2 attributes roughly fits against void, it very well may be reasoned that data2 is likewise void release. From Fig. 14(b), it is seen that information 1 attributes is near surface release qualities, it tends to be inferred that information 1 is surface release. From Fig. 14(c), it is seen that none of the information attributes is like crown release qualities, it tends to be inferred that none of the information has crown release.

V. DISCUSSION ON RESULTS OF STATISTICAL PARAMETERS

From all the above perceptions utilizing all the three stage settled examples (φ -q), (φ -n) and (n-q), it tends to be inferred that, data1 is surface release in all the three stage settled examples, data2 is surface release in (n-q) example and void release in (φ -q) and (φ -n), henceforth data2 is both void and surface release and data3 is void release in all the three stage settled examples.

From factual parameters, the PD source can't be finished up precisely so it should be applied to other characterization strategies, for example, neural system, Fuzzy rationale and so forth as a pre-preparing parameters for getting exact PD source.

Anyway it is felt that in data2, the kind of release is marginally unclear and in data1, data3 the sort can be additionally learned by utilizing most recent strategies of Neural Networks. Consequently, technique for BPM of ANN was attempted.

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VI. BACK PROPAGATION METHOD OF ARTIFICIAL NEURAL NETWORK

This Neural Network is named as Back Propagation strategy attributable to its technique for managing the blunder.. It includes an information layer, at any rate one concealed layer and the yield layer. Each layer is totally associated with the succeeding layer.

6.1. Importing Data

Right off the bat, pre-preparing of information is done utilizing Statistical parameters like mean, standard deviation, fluctuation, skewness and kurtosis and an unpleasant outcome is made about PD type. For precise recognition of halfway release type, nntool worked in Matlab is utilized which gives better outcomes in the accompanying GUI (Graphical User Interface) or nntool window.

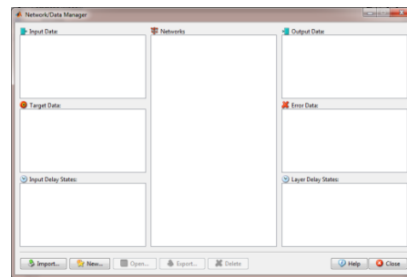


Fig. 15. Network/Data Manager Window

Input data statistical factors are migrated into column INPUT DATA & the targets determined by the customer are import into column TARGET DATA as adopts:

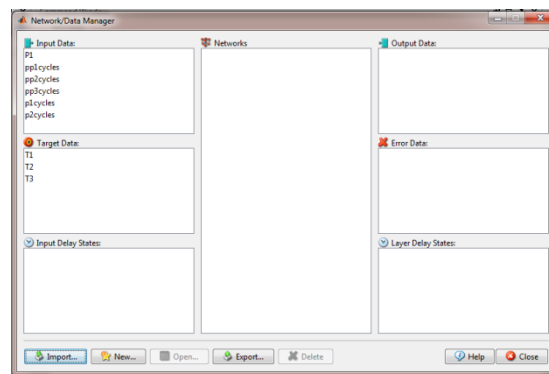


Fig. 16. Network/Data Manager Window

Whereas,

P1 = Known data that are void, surface & corona contain factors like mean, S.D, variance, sk & ku.

pp 1 cycles = Unknown data1 comprise factors including mean, S.D, variance, sk & ku.

pp 2 cycles = Unknown data2 comprise factors like mean, S.D, variance, sk & ku.

pp 3 cycles = Unknown data3 consisting factors including mean, S.D variance, sk & ku.

p1 cycles = Unknown data2007 contain factors like mean, S.D, variance, skewness & kurtosis.

p2 cycles = Unknown data2011 comprise factors like mean, S.D, variance, sk & ku.

T1 = Own targets are decided [50, 60, 70].

T2 = Own targets are decided [60, 70, 50].

T3 = Own targets are decided [70, 50, 60].

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6.2. Creating a New Network

Bigger systems require enormous preparing datasets. Over fitting is almost certain when the model is huge. At that point, a system is made utilizing NEW direction in nntool highlight of Matlab.

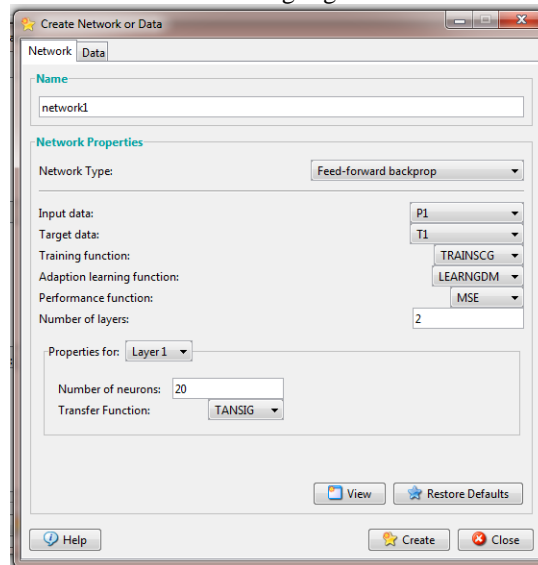


Fig. 17. Network/Data Manager Window

Where,

- Network type: Feed-forward back propagation
- Input data: P1
- Target data: T1
- Training function: TRAINSCG
- Adaption learning function: LEARNGDM
- Performance function: MSE
- Number of layers: 2
- Properties for Layer1 are:
- Number of neurons: 20
- Transfer function: TANSIG

subsequently, utilizing Create, NETWORK 1 is produced.

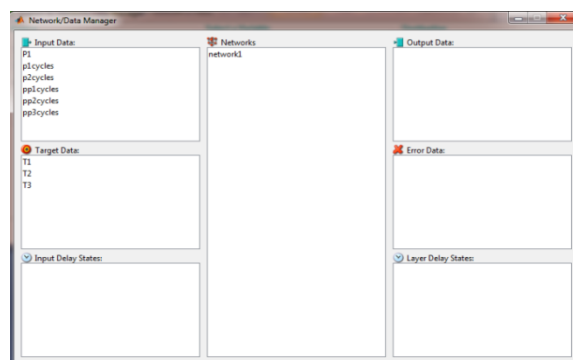


Fig. 18. Network/Data Manager Window

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6.3. Training

Once a network has been structured for a particular application, that network is ready to be trained. To start this process the initial weights are chosen randomly. Then, the training, or learning, begins. There are two approaches to training - supervised and unsupervised.

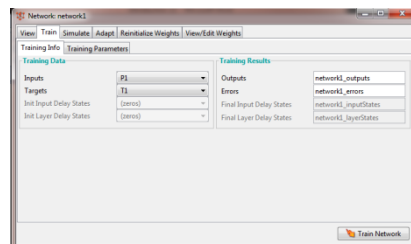


Fig. 19. Training Window

6.4. Simulation

After the neural system classifier has been prepared, the subsequent stage is to decide if the subsequent model of neural system is with the arrangement of best loads and precise enough for putting on the test information? Despite the fact that estimates, for example, entirety of squared deviations or cross-entropy mistake can be utilized, a sensible proportion of precision is essentially the level of right expectations made by the model.

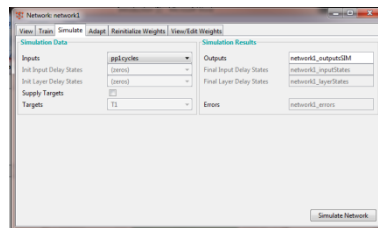


Fig. 20. Simulating Window

6.5. Output

Arrangement of PD utilizing neural systems is a significant, interesting and complex theme. Especially when working with extremely restricted preparing datasets, the variety in results can be enormous. Under such conditions, it is smarter to grow preparing information based on improved ground truth. On the off chance that this is beyond the realm of imagination, age of ideal outcomes can now and again be made through mix of the consequences of various neural system orders.

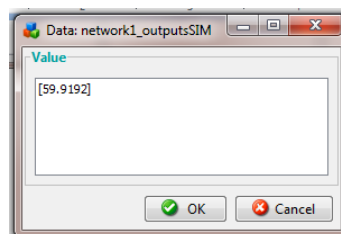


Fig.21. Output Window

The simulation performance obtained 59.9192, and that's relatively similar to the surface discharge target since we reach the target as T1 for training in such a way 50 targets are selected for void, 60 for surface or 70 for corona. When we select T2, instead 60 is for vacuum, 70 is for surface, so 50 is for corona, etc. therefore be inferred which data1 is a surface discharge. Simulation tests are also acquired for certain undisclosed PD details.

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TABLE I: Outputs

Sr. No.	Unknown data	Partial discharge Source
1	Data 1	Surface
2	Data 2	Void/surface
3	Data 3	Void

VII. CONCLUSION

Using the BP algorithm is a superior alternative for ANN training because it implements weight optimization through primary propagate the input signal forward, instead propagate the measured error backwards to change the original weights.

The ANN on performance produces a certain findings as observed in the Statistical Approach for data1 & data3 consequential in the precision of the tests yet over again produces twin findings for data2 suggesting for further input samples in the testing data collection, thus allowing the usage of other specialized Python tools and other techniques of the ANN like the Random Forest Process, the SOM & SVM From either the present study, it can be observed that the PD form may categorized utilizing the phase-resolved template & provided as feedback which probable to distinguish several causes of collapse that occur in isolation and to calculate the precise percentage of this form using the ANN self-organizing map approach in Python program. In future research, we plan to grow a qualified ANN utilizing approaches apart from back propagation.

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