Fault Diagnosis In Transmission System Using Artificial Neural Network and Fuzzy Logic System

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Abstract: Power system is comprising of generation, transmission and distribution. Short circuit faults can be occured in any side of power system. But majority of faults are occurred in transmission system. Fault diagnosis is very challanging task now a days, as the fault dignosis can be by various techniques but in this paper a method known as ANN and fuzzy based approach is used for diagnosing transmission line short circuit faults. Previous techniques employed for diagnosing fault require the nature and types of fault be classified. The previous classification algorithms are ineffective as they are ineffective in some conditions of the power sytem and may not be able to accurately select the faulted transmission line if the same fault recorder monitors multiterminal and zonal lines. The method described in this paper are ANN and fuzzy logic system has been proven to accurately diagnosis all ten types of faults that may occur in an electric power transmission systm. This technique is also useful where multiterminal transmission system are present. It is able to identify the faulted line even if secondary effects are recorded in the unfaulted lines. A comprehensive evaluation study is implemented to compare proposed fault diagnosis tool with conventional technique.

Keyword—*Three machine nine bus system, NN tools, Matlab, Fault analysis, Fault classification, Fault location.*

I. INTRODUCTION

In last few decades fault location and diagnosis using digital techniques in power system transmission line became a subject of interest. An accurate fault location techniques provide better performance in respect to post fault analysis and hence improving the reliability of the system. By knowing prefault current and hence applying in particular transmission can definitely improve transmission system performance and their operation.[1-10] Different effects are

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applied to detect fault i.e. effect of fault resistance and fault inception angle between fault current and voltage were observed to determine fault location in various positions. Effect of the fault resistance for various ten types of fault like A-G,B-G,C-G,AB, BC,CA,ABG,BCG,CAG,ABC,ABCG. Among these most likely fault i.e. 90-95% is line to groundfault This line to ground fault is proportional to the zero sequence current.[11-17] Fault impedance is ratio of voltage to current. The apparent impedance is given as

$$Z_{app}=\frac{Vr}{Ir}=(R_1+jX_1)D+\frac{RfIo}{Ir} \qquad (1)$$

where Vr is the relay voltage signal, Ir is the relay current signal,Io is thezero sequence current at the relay, D is the distance to the fault, R_1 and X_1 are the line resistance and reactance per mile, R_f is the unknown fault resistance. [28]

$$V_{abc1}= VF_{abc}+DZ_{abc}I_{abc1} \qquad (2)$$

$$V_{abc2}= VF_{abc}+(L-D)Z_{abc}I_{abc2} \qquad (3)$$

From equation 2 and 3

$$V_{abc1}-V_{abc2}+LZ_{abc}I_{abc2}=DZ_{abc}[I_{abc1}+I_{abc2}] \qquad (4)$$

Where Zabc is the three phase series impedance of line per mile, VFabc is voltage vector at the fault.

$$VF_{abc}=V_{abc1}-DZ_{abc}I_{abc1} \qquad (5)$$

$$IF_{abc}=I_{abc1}+I_{abc2} \qquad (6)$$

$$V_{abc1}=V_{Fabc}+DZ_{abc1}I_{abc1} \qquad (7)$$

$$V_{abc2}=VF_{abc}+L_2Z_{abc2}I_{abc2}+(L_1-D)Z_{abc1}(I_{abc2}+I_{abc3}) \qquad (8)$$

$$V_{abc3}=VF_{abc}+L_3Z_{abc3}I_{abc3}+(L_1-D)Z_{abc1}(I_{abc2}+I_{abc3}) \qquad (9)$$

From equation 7 and 8 we get$Vabc_1-V_{abc2}+(L_1Z_{abc1}+L_2Z_{abc2})I_{abc2}+L_1Z_{abc1}I_{abc3}=DZ_{abc1}(I_{abc1}+I_{abc2}+I_{abc3})$ (10)

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Similarly using equation 7 and 9 leads to $V_{abc1}-V_{abc3}+(L_1Z_{abc1}+L_3Z_{abc3})I_{abc3}+L_1Z_{abc1}I_{abc2}=DZ_{abc1}(I_{abc1}+I_{abc2}+I_{abc3})$ (11)

In L-G fault assume prefault current is zero, so $I_b=I_c=0$, $V_{ag}= Z_f\, I_a$

$$V_0+V_1+V_2 = Z_f(I_0+I_1+I_2) \quad (12)$$

$$I_0=I_1=I_2= \frac{Vf}{Z0+Z1+Z2+3Zf} \quad (13)$$

Similarly for others fault i.e. L-L fault $I_b+I_c=0$ and $I_a= 0$, $V_{bg}-V_{cg}= Z_fI_b$

$$I_{f1}=I_{f2}=\frac{V1}{Z1+Z2} \quad (14)$$

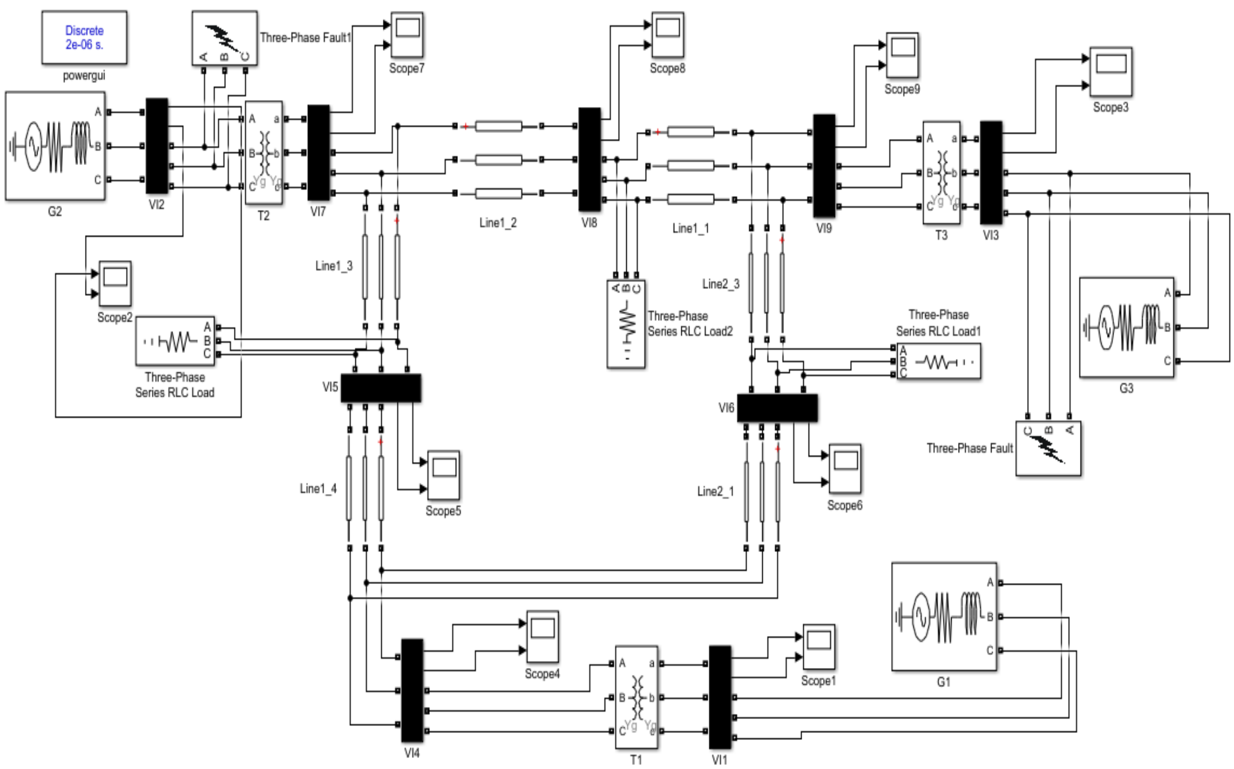

Fig.1. Simulink model of proposed work

Fig.1. is the basic three machine nine bus system simulink model, in which various zones are described, to demostrate the simultanuous effect of fault can be measured. Fault effect in different zones are observed. Transformer and its rating is observed for calculation and analysing purpose. The above mathematical equation is used for validating the results and its behaviour on

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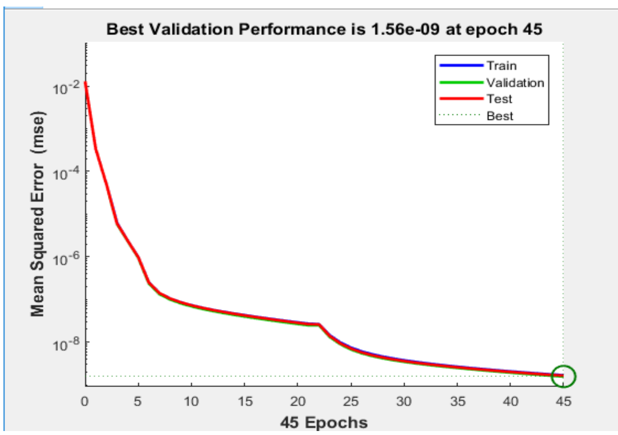
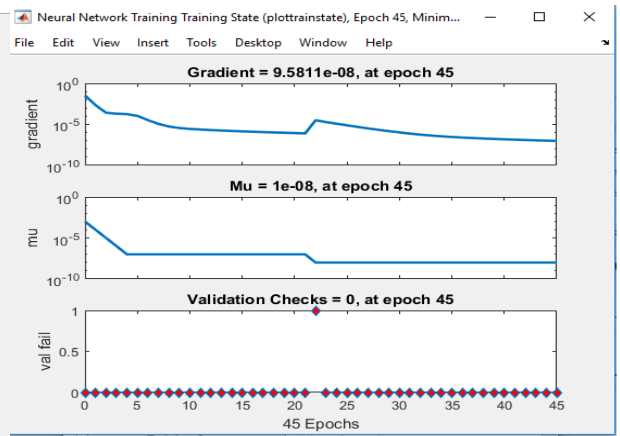
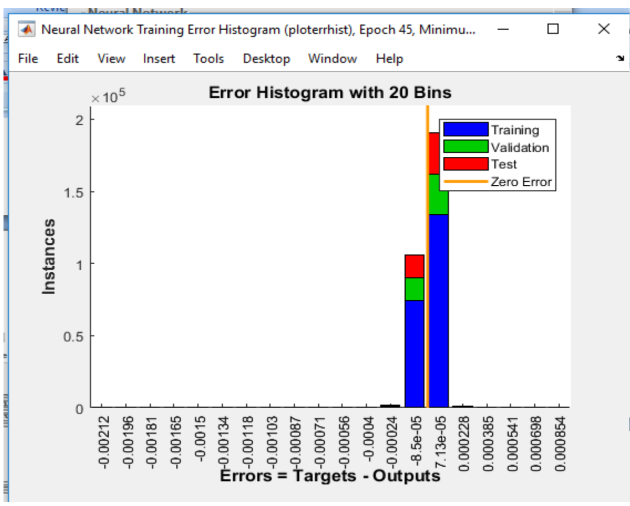
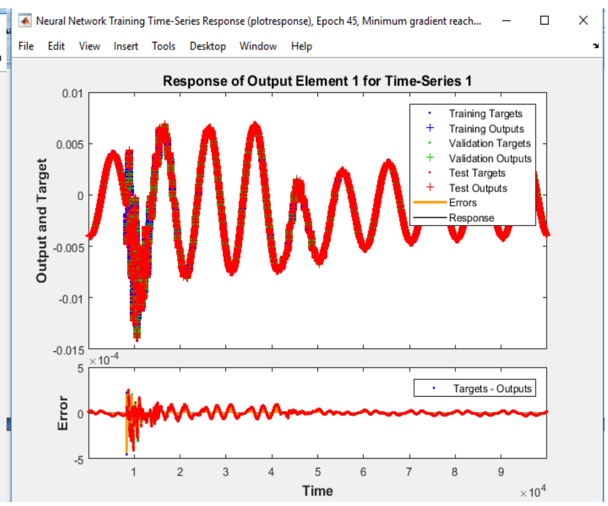
the basis of circuit connection. Both mathematical and simulating based observation are studied for the final validation.





(a) Variation of mean square error v/s epochs (b) Variation of Gradient v/s epochs





(c) Error histogram with output for various instances(d) variation of output v/s time and errorv/s time .

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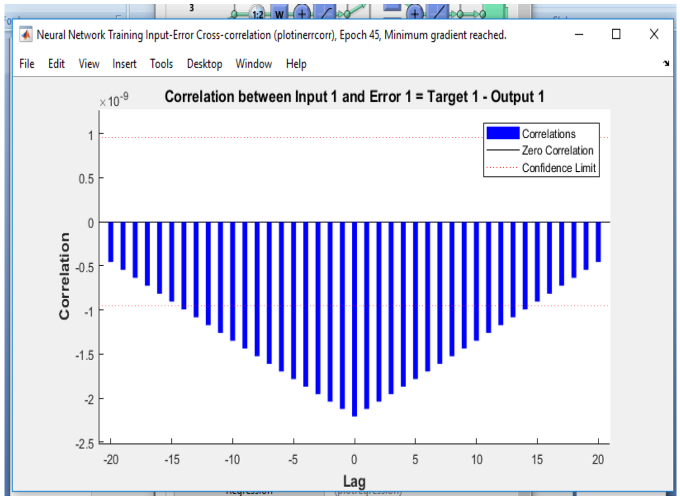
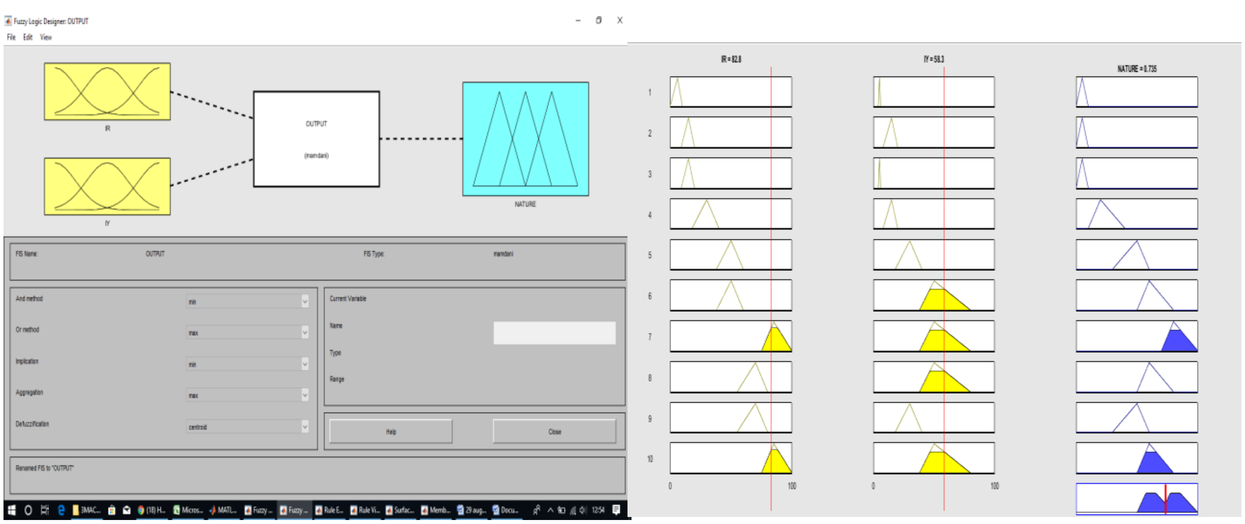


(e) Variation of correlation v/s error

Fig.2. Training and validation graph from NN tools

Fig.2. described the training and testing of various data in neural network tools, in this fig. (a) described the mean square error with various epochs, and described how error is reduced if incease the number of data.



(a)A typical fuzzy logic input and out put model(b)Variation of input phase current and nature output

Similarly fig.(b) described the gradient with variation of epochs, also validate the results, in which increasing large number of data provide best accuracy. Fig.(c) provides error histogram in terms of various instances and also it validates the error targets value for different values/data.

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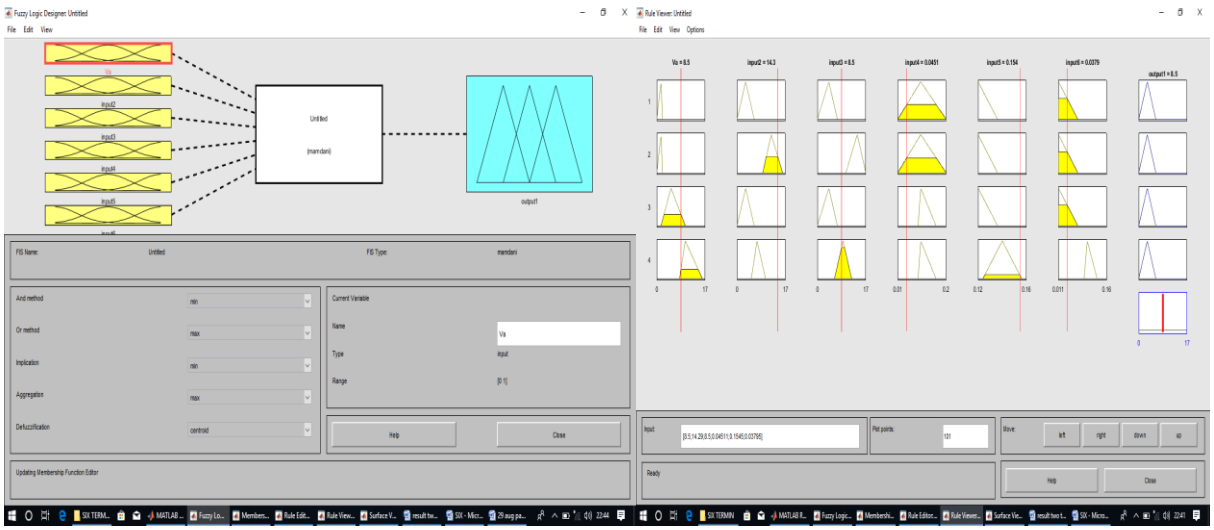
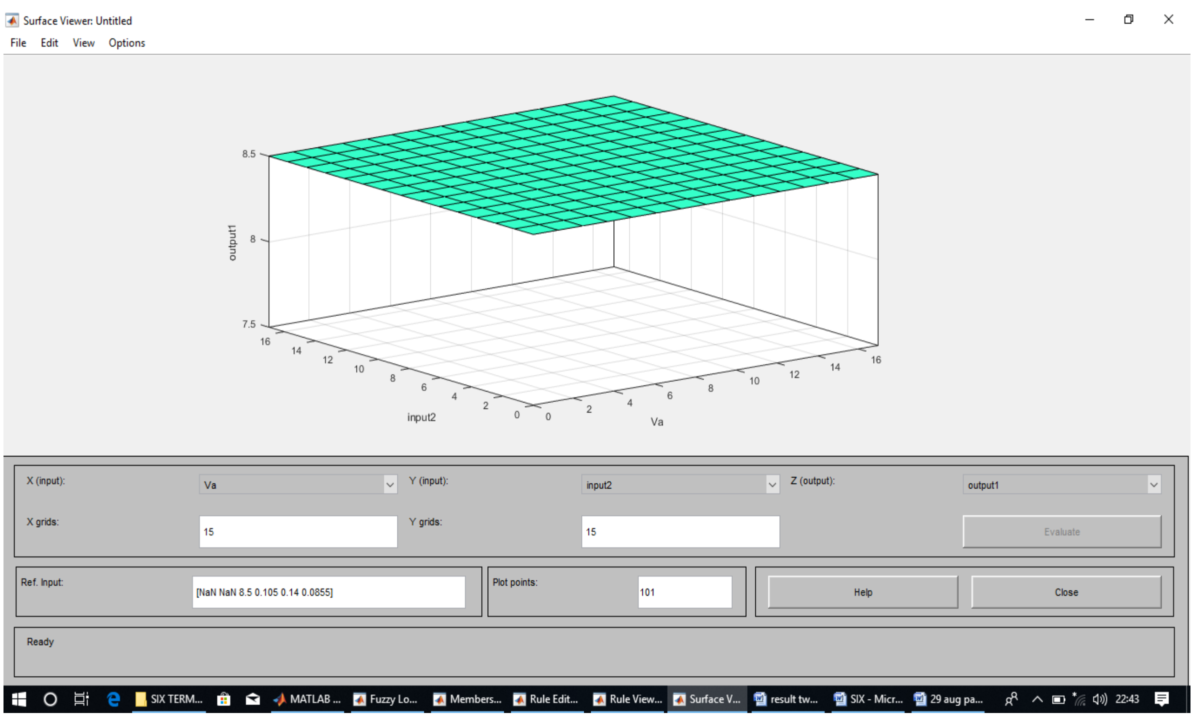
Fig.(d) output and error v/s time in which it validates the results and after 10 sec to 20 sec, it validates the result for others data/values. Fig.(e) described the correlation between input and error and validates the result.



(c) Fuzzy logic membership function model(d)Rule for Variation of input voltage and current with respect to output in Fuzzy logic tools



(e) Three dimensional view of input- output variation
Fig.3. Study the behaviour of nature by Fuzzy Logic tools

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TABLE -1 Per Unit Voltage And Current Training Set

	Input Vector (P.U)						
Case No.	**Va**	**Vb**	**Vc**	**Ia**	**Ib**	**Ic**	**Fault Type**
1	12	12	12	0.001	0.001	0.001	No fault
2	0	16	17	0.16	0.01	0.01	AG
3	17	0	16	0.01	0.16	0.01	BG
4	16	17	0	0.01	0.01	0.16	CG
5	0	0	16	0.3	0.2	0.01	ABG

Fig.3. described the incorporation of fuzzy logic system in the simulink data obtained in MATLAB and forming the various rules in mamdani fuzzy inference system. Fig.(a) is a typical fuzzy logic model based on two input and a output, variation of input current or voltage and diagnosing fault behaviour and validation of fuzzy logic behaviour, fig.(b) described input output plot as it described variation of current and nature of faults. Similar it is described in fig.(c), (d) and (e) described 3-dimensional view. From the above analysis we can conclude that by incorporating fuzzy logic, it gives more accurate result in terms of output and accuracy. By varying input value output changes accordingly as per nonlinear output. If fault occurs in transmission line current becomes maximum and voltage at fault point becomes minimum, as per this output changes and give specific value.

Table –2 Fault variation with several effects

EFFECT	**AG**	**BG**	**CG**
Without fault	VA=12K IA=2.41	VB=12K IB=2.41	VC=12K IC=2.41
WITH FAULT	VA=0 IA=84.51	VB=15K IB=2.74	VC=16K IC=2.85
CAPACITOR	VA=0 IA=252.69	VB=48K IB=918.96	VC=51K IC=963.29
REACTOR	VA=0 IA=168.78	VB=3K IB=136.98	VC=3K IC=137.86
SVC	VA=0 IA=84.51	VB=15K IB=2.74	VC=16K IC=2.85
RESISTOR	VA=0 IA=141.88	VB=10K IB=63.73	VC=15K IC=91.69

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Table- 3 Fault Classification Network Truth Table

Fault Situation	A	B	C	G
A-G	1	0	0	1
B-G	0	1	0	1
C-G	0	0	1	1
ABG	1	1	0	1

Table-1 described the per unit voltage and current with its normalised value and also described the nature of fault and its type. If no fault then normalised value of voltage is maximum and current is minimum, from various faults like a-g, voltage in phase, is minimum while current in that phase is maximum, similarly it can be seen in other types voltage and current variation. Table-2 described the various effects like fault resistance, reactor, svc, fault inception angle in which it described the normalised value of voltage and current, in which it can be seen that effect of capacitor is more dominating as compared to the other effects.Table -3 described fault classification network truth table in which it is described in terms of binary number i.e. either 1 for yes or 0 for no. If fault is occurred in the particular phase then it gives high value in the respective phase and vice-versa.

II. COMPARATIVE STUDY OF VARIOUS EFFECT IN TRANSMISSION SYSTEM

Without fault, voltage in each phase is same and is displaced with certain phase angle. Current is minimum in each phase and are equal as same per the results shown above. With A-G fault voltage in phase ‘A’ is minimum while current in phase ‘A’ is maximum as per result shown above. Other phase voltage is maximum and current is minimum as per results shown. Effect of capacitor as per results increases the current in the faulted branch and increases the voltage in other phase. Effect of reactor in transmission system also reduces voltage in other phase and reduces current in faulted phase, the result justify the physical things. Effect of SVC in power system does not change physical operation of system and results have similar as in case of fault without any effect. Effect of UPFC, SSSC and SVC give same result. The comparative study is shown in Table –I above.

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III. CONCLUSION

Most fault diagnosis techniques that are currently available have been reviewed in the paper. These techniques were basically developed for relaying purposes, and therefore do not operate favourably when used in Neural Networks (NN) that classify various faults in transmission lines. A new conventional technique that overcomes the problems in existing techniques has been also proposed. From above comparative table and training of various data approximate one lakhs give the performance and fault location and diagnosis showed that for farthest from bus give minimum effect while near having more effect of fault current. Hence we can design a protective relay so that we can minimize fault time and overcome fastely and give better performance to the consumer. Relay and circuit breaker both can overcome on the situation when fault occurred at any terminals whether it is away or near the bus or other terminals. From the results obtained in simulink of multi-terminal line, effects of various parameters have analysed and results verified mathematically and almost same results are obtained. The various effects like passive components; compensators etc have been analysed and verified with mathematical equations.

References:

[1] Fault Diagnosis of Electric Transmission Line using Modular Neural Networks Agustin Flores Novelo; Eduardo Quiles Cucarella; Emilio Garcia Moreno; Francisco Morant Anglada IEEE Latin America Transactions Year: 2016, Volume:14, Issue:8 Pages: 3663-3668
[2]Fault diagnosis in distance protection scheme using Rogowski coil and artificial neural networkA. N. Sarwade; P. K. Katti; J. G. Ghodekar2017 7th International Conference on Power Systems (ICPS)Year: 2017 Pages: 451 – 456.
[3]Fault Diagnosis of Electric Power Systems Based on Fuzzy Reasoning Spiking Neural P SystemsTao Wang; Gexiang Zhang; Junbo Zhao; Zhengyou He; Jun Wang; Mario J. Perez-Jimenez IEEE Transaction on Power System Year : 2015, Volume: 30, Issue: 3 Pages: 1182-1194.
[4] A novel nonintrusive fault identification for power transmission networksusing power-spectrum-based hyperbolic S-transform Part I: Fault classificationHsueh-Hsien Chang; Nguyen Viet Linh; Wei-Jen Lee2018 IEEE/IAS 54th Industrial and Commercial Power Systems Technical Conference (I&CPS)Year: 2018 Pages: 1-21.
[5] A novel fault detection and classification technique for double circuit transmission line using Artificial Neural Network Neeraj Kumar Singh; Shilpa S Badge 2017 International Conference on Intelligent Computing, Instrmentation and Control Technologies(ICICICT) Year : 2017 Pages: 1338-1342.
[6]Faults detection and diagnosis of transmission lines using wavelet transformed based techniqueBilal Masood; Umar Saleem; M. Nadeem Anjum; Usman Arshad2017 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT)Year: 2017 Pages: 1 – 6.
[7] Data-Based Line Trip Fault Prediction in Power Systems Using LSTM Networks and SVMSenlin Zhang; Yixing Wang; Meiqin Liu; Zhejing BaoIEEE AccessYear: 2018, Volume: 6 Pages: 7675 – 7686.
[8] Soft fault identification in electrical network using time domaine reflectometry and adaptive neuro-fuzzy inference systemeA. Laib; M. Melit; B. Nekhoul; K. Kerroum; K. Elkhamilichi Drissi2017 5th International

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

Conference on Electrical Engineering -Boumerdes (ICEE-B)Year: 2017 Pages: 1 – 4.
[9] Ultrafast Transmission Line Fault Detection Using a DWT-Based ANNAhmad Abdullah
IEEE Transactions on Industry ApplicationsYear: 2018, Volume: 54, Issue: 2Pages: 1182 – 1193.
[10] Improved ANN-based algorithm for detection and classification of faultson transmission lines Farhana Fayaz; Abubakar Isa; H.K Verma; Soma Deb 2016 1st India International Conference on Information Processing(IICIP) Year : 2016 pages: 1-6.
[11] Neuro wavelet algortihm for detecting high impedance faults in extra high voltage transmission systemsIsa Hafidz; P Elyza Nofi; Dimas Okky Anggriawan; Ardyono Priyadi; Mauridhi Hery Pumomo2017 2nd International Conference Sustainable and Renewable Energy Engineering (ICSREE)Year: 2017 Pages: 97 – 100.
[12] Enhancing the performance of transmission line directional relaying, faultclassification and fault location schemes using fuzzy inference systemAnamika Yadav; Aleena SwetapadmaIET Generation, Transmission & DistributionYear: 2015, Volume: 9, Issue: 6Pages: 580-591.
[13] Intelligent techniques for fault diagnosis in transmission lines-An overview*Sunil Singh; D.N.* Vishwakaram International Conference on Recent Developments in Control, Automation, and Power Engineering (RDCAPE) Year: 2015 Pages: 280 – 285.
[14] Sunil Singh, D.N. Vishwakarma"Impact of Series FACTS Controllers on Distance Protection-A Review." International Conference on Recent Developments in Control, Automation and Power Engineering (RDCAPE) (2015), pp. 129-134.
[15] Sunil Singh, D.N. Vishwakarma"Intelligent Techniques for Fault Diagnosis in Transmission lines –An Overview." International Conference on Recent Developments in Control, Automation and Power Engineering (RDCAPE) (2015), pp. 280-825.
[16] A.A. Mohd Zin, N.A. Omar, A.Mohd Yusof, S.P.Abdul Karim"Effect 0f 132 kV cross-country faults on distance protection system." Aisa International conference on modeling and simulation (2012), pp. 167-172.
[17] Xiangning Lin, Hanli Weng, Bin Wang"Identification of Cross-Country Fault of Power Transformer for Fast Unblocking of Differential Protection." IEEE Transactions on Power delivery, 24 (3) (2009), pp. 1079-1086.
[18] Krzysztof Solak, Waldemar Rebizant"Analysis of differential protection response for cross-country faults in transmission lines." Modern Electric Power Systems (2010), pp.1-4.
[19] Aleena Swetapadma, Anamika Yadav"All shunt fault location including cross-country and evolving faults in transmission lines without fault type classification." Electric Power Systems Research, 123 (2015), pp. 1-12.
[20] P. Jena, A.K. Pradhan"Solution to directional relaying for double circuit line." Int. conference energy, automation and signal (2011), pp. 1-6.
[21] P. Jena, A.K. Pradhan"An integrated approach for directional relaying of the double-circuit line." IEEE Transactions on Power delivery, 26 (3) (2011), pp. 1783-1791.
[22] Tianshu Bi, Wei Li, Zhenyu Xu, Qixun Yang"First-zone distance relaying algorithm of parallel transmission lines for cross-country grounded faults." IEEE Transactions on Power delivery, 27 (4) (2012), pp. 2185-2192.
[23] MohammadAmin Jarrahi, Haidar Samet, Ali Sahebi"An EMD based fault type identification scheme in transmission line." Iranian conference on electrical engineering (2016), pp. 422-427.
[24] Jing Liu, Jiandong Duan, Hialong Lu, Yuanbing Sun"Fault location method based on EEMD and travelling-wave speed characteristics for HVDC transmission lines." Journal of power and Energy Engineering, 3 (2015), pp. 106-113.
[25] LI Bin, SHU Hongchun"Research on fault line detection based on empirical mode decomposition (EMD) in resonant grounded systems." Asia-Pacific power and energy engineering conference (2009), pp. 1-5.
[26] UrmilB. Parikh, B. Das, R.P. Maheshwari"Fault classification technique for series compensated transmission line using support vector machine." Electrical Power and Energy Systems, 32 (2010), pp. 629-636.
[27] Sami Ekici"Support vector machine for classification and locating faults on transmission lines." Applied soft computing, 12 (2012), pp. 1650-1658.