Artificial Neural Network Based Transmission Line Loss Evaluation of Power Transmission System

Abstract— The paper presents the application of Artificial Neural Network (ANN) for transmission line loss evaluation of power transmission system. Active and reactive powers of generators and loads, as well as the magnitudes of voltages at voltage – controlled buses and load buses are chosen as inputs to the ANN. System losses are chosen as targets to the ANN. Training data are obtained by Load Flow Studies for different system topologies using Mi-power.

Keywords-Transmission Line losses, Load Flow, Artificial neural Network.

I. INTRODUCTION

Transmission losses are inherent in power system. Utility companies are constantly installing and upgrading their transmission lines, transformers, capacitors etc., in order to reduce the losses. In planning system expansion, for example when there is a need for transmission reinforcement to serve more load demand, costs of different transmission systems designs are often compared with savings from loss reductions. For economic operation of a power system transmission losses are taken into account in scheduling generation. Traditionally, electric utilities have considered system losses in a broad and general manner after is complied by allocating a percentage of total system losses to each of the system components. (example: transmission, step up and step-down transformers, distribution and others) However, utilities are operating in a new environment, which on the one hand complicates the loss calculations and on other hand demands a fair assessment of losses. Indeed, the importance of accurately and rapidly determining transmission system losses has become more recognized and emphasized in the past several years for many reasons, including;

1) There is a continuous need by the electric utilities to improve system operating efficiency.
2) In many instants, electrical losses are the controlling factor while evaluating alternative power system expansion plans.
3) The current impetus in billing and rate design is to consider actual incurred costs.
4) Losses are important considerations in the pricing of all energy transactions among interconnected utilities. Hence, importance of accurate and rapid evaluation of the capacity or demand losses(MW) and energy losses (MWh) in a power system as more recognized now.

A number of approximate methods for estimating transmission system losses have been proposed and used by utilities. However, high accuracy and fast speed are to conflicting requirements in a loss evaluation methodology, as more detailed modelling is necessary for more accurate evaluation. This work presents a new approach with which satisfactory performance in-terms of these two requirements can be achieved. Power system include those at the various levels of transmission systems (i.e., bulk transmission, transmission and sub-transmission) and in the distribution networks. Due to constant variation of operating conditions and the complexity of power system, an accurate and rapid computation of the losses has always a challenge to utility engineers.

II. POWER FLOW MODEL

The power flow problem can be defined as the calculation of the real and reactive powers flowing in each line and the magnitude and phase angle of the voltage at each bus of a given transmission system for specified generation and load conditions. In general, power flow calculations are performed for power system planning and operational connection with system operation and control.

In steady-state operation of power systems generation is equal to load demand. But in practical condition its very difficult to balance load and generation.

The net complex power injected into the ith bus of a power system is

$$S_i = P_i + j\,Q_i = (P_{Gi} - P_{Di}) + j(Q_{Gi} - Q_{Di}) \qquad (1)$$

$$S_{Gi} = P_{Gi} + j\,Q_{Gi}$$

$$S_{Di} = P_{Di} + j\,Q_{Di}$$

Where S_{Gi} and S_{Di} are Complex powers at generation and load sides.

The real and reactive power at ith bus is given as:

$P_i = P_{Gi} - P_{Di}$ and $Q_i = Q_{Gi} - Q_{Di}$ Where i=1,2,…….,n

$$Pi = Vi \sum_{j=1}^{n} Vj\,[Gij\cos(\delta i - \delta j) + Bij\sin(\delta i - \delta j)] \qquad (2)$$

$$Qi = Vi \sum_{j=1}^{n} Vj\,[Gij\sin(\delta i - \delta j) + Bij\cos(\delta i - \delta j)] \qquad (3)$$

The resistance of transmission circuits is significantly less than the reactance so X/R ratio is between 2 to 10 and impedance of the transmission circuit is given by Z=r-jx

$$Y = \frac{1}{z} = \frac{1}{r+jx} = \frac{1}{r+jx} * \frac{r-jx}{r-jx} \qquad (4)$$

After simplifying equation (4) we get values for g+jb

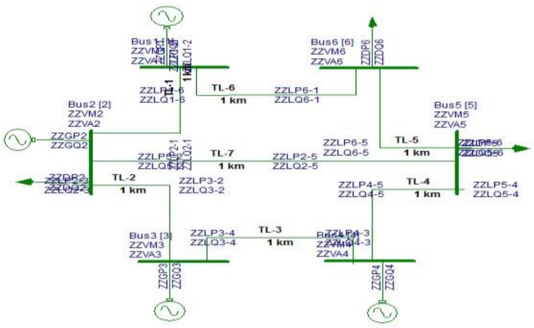
G=r/r^2+x^2 and B= -x/r^2+x^2
if r is small than the x ,then the G will be very small than B so g=0 and b=-1/x
now,the power flow equations can be written as;

$$Pi = \sum_{j=1}^{n} ViVj\,[Bij\sin(\delta i-\delta j)] \qquad (5)$$

$$Qi = \sum_{j=1}^{n} ViVj\,[-Bij\cos(\delta i-\delta j)]$$

III. Case Study

For the Analysis I have taken six-bus system.Bus data,line data, generater and load data are give below. And the system is simulated using MI-Power software.



Fig(1):Six Bus System

Table 1. Load Data

Bus	Real-Power (MW)	Reactive Power(MVAR)
At Bus 2	20	10
At Bus 5	40	15
At Bus 6	30	10

Table 2.Line Data

Line. no.	Bus Code p-q	Positive Sequence Resistance pu	Positive Sequence Reactance pu
1	1-2	0.05	0.20
2	2-3	0.10	0.50
3	3-4	0.20	0.80
4	4-5	0.10	0.30
5	5-6	0.20	0.40
6	6-1	0.10	0.15
7	2-5	0.20	0.50

Table 3. Generator Data

Generator no.	P+jQ	Xd`	V	H	MVA	Bus type
G1	0+j0	0.004	1	8137	100	slack
G2	0.1+j0.05	1.000	1.041	813.6	15	PV
G3	0.30+j0.2	0.500	1.190	610.2	40	PV
G4	0.2+j0.1	0.400	1.071	542.8	30	PV

Table 4. Load level And Loads at each bus

Load level	P_{D2}	Q_{D2}	P_{D5}	Q_{D5}	P_{D6}	Q_{D6}
0.60	12	6	24	9	18	6
0.65	13	6.05	26	9.75	19.75	6.5
0.70	14	7	28	10.5	21	7
0.80	16	8	32	12	24	8
0.85	17	8.5	34	12.75	25.5	8.5
0.90	18	9	36	13.5	27	9
0.95	19	9.5	38	14.25	28.5	9.5
1.00	20	10	40	15	30	10
1.10	22	11	44	16.5	33	11
1.15	23	11.5	46	17.25	34.5	11.5
1.20	24	12	48	18	36	12

IV. Using Artificial Neural Network Analysis

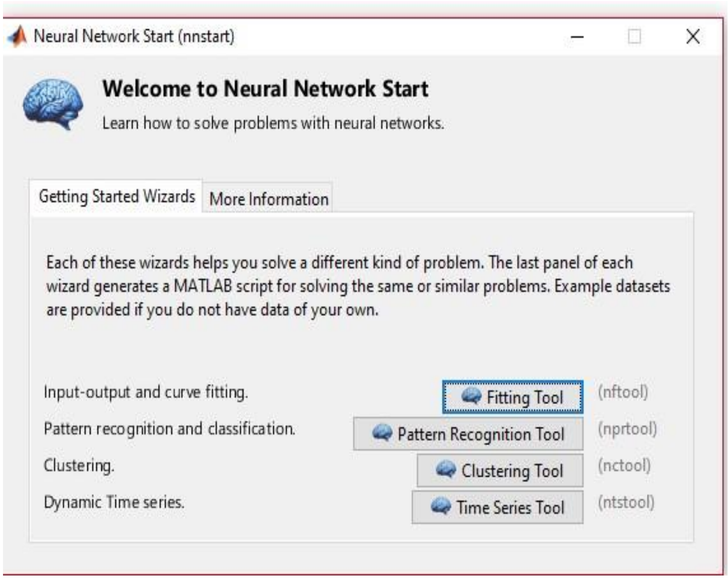
In recent years there has been a confluence of ideas and methodologies from several different disciplinary areas to give rise to an extremely interesting research area called artificial neural net research or connectionist net research. The concept of Artificial Neural Networks (ANN) is one of the greatest developments of this century. These networks resemble the functioning of human brain like intelligent guessing and pattern recognition. ANNs use large number of interconnected, concurrently operating elemental processors to process the information in a collective manner. Neurons are the basic building blocks and the input output relationship solely depends on the interconnection of the nodes and layers. Artificial neural networks are best suitable for nonlinear function approximation, estimation and prediction.

Data set Preparation: As we are using as we are using ANN to evaluate transmission line losses, in this paper 70% to 110% load conditions are considered and for each load condition one normal condition and two topologies are considered (i.e., line 3 and 4 are kept open, line 2 and 5 are kept open). Load flow studies is then carried out. The corresponding real power and reactive power generation and demands, bus voltages at all the buses and total real and reactive power losses of the system were noted down.the matrix (which consists of load condition, PG1, PG2, PG3, PG4, QG1, QG2, QG3, QG4, PD1, PD2, PD3, QD1, QD2, QD3, V1, V2, V3, V4, V5, V6) of the order 30X21 is taken as input to train ANN. And corresponding total real and reactive power losses of the system which is of order 30X2 is considered as target to train ANN.

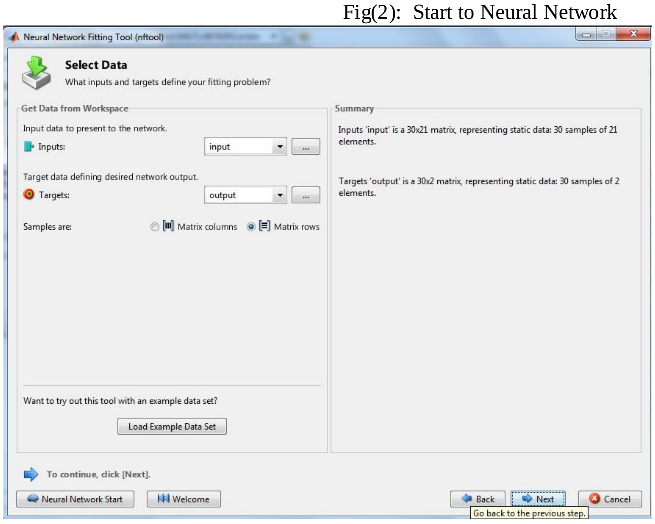
Training of ANN : The ANN is trained using ANN toolbox of MATLAB, the starting window of toolbox is shown in figure 2. The fitting tool app in this window is opened and data prepared in excel sheet is imported for training in window shown in figure 3.

Once the data is imported the number of neurons are fixed and data for validation testing and training are fixed as shown in figure 4. The ANN is then trained using Fig(3) : Importing the INPUT and TARGET variables Lavengerg Marquardit algorithm. The correctness of ANN trained is assured by observing the regression value which should be near one and also MSE should be least. Once the ANN is trained, corresponding Simulink diagram is generated.

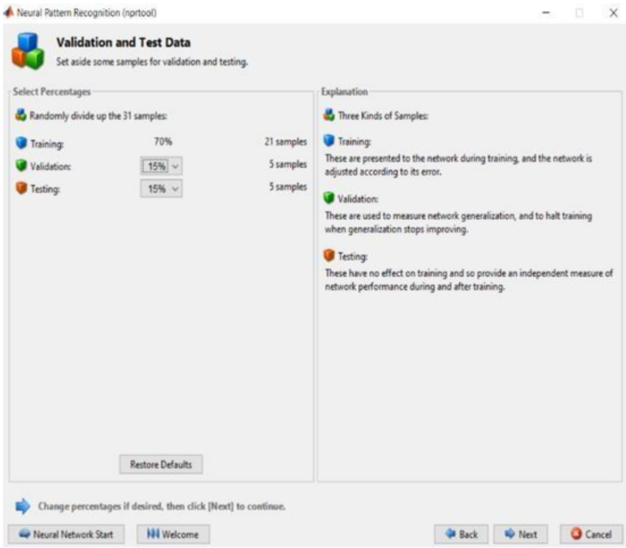
Steps to Perform ANN in MATLAB is shown below.



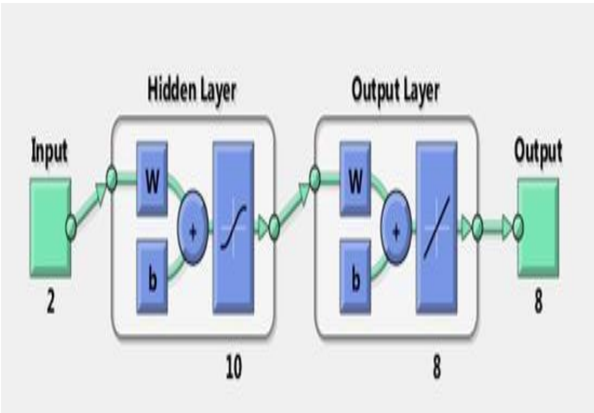
Fig(2): Start to Neural Network



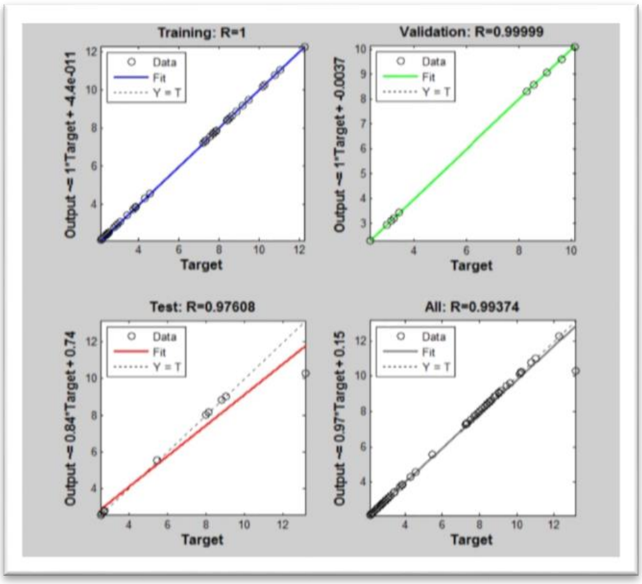
Fig(3):Import Data into ANN



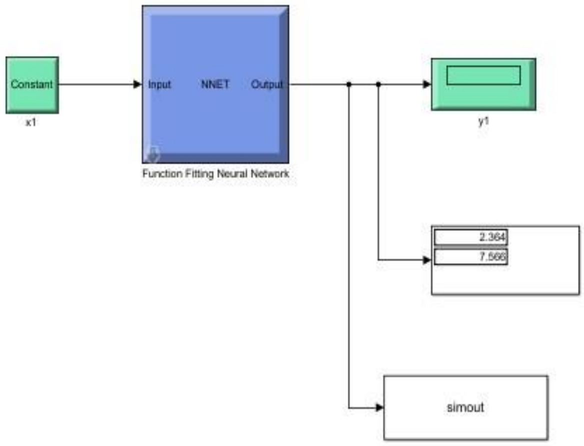
Fig(4):Validation and Test Data



Fig(5): Trained Neural Network



Fig(6). Regression Plot



Fig(7) : Simulink diagram for Neural Netwrork

V.CONCLUSION

An ANN based approach for estimation on demand losses in power transmission system is presented in this work. ANN are used and trained to capture the complex mapping relationships between system losses and system Topologies generation and load patterns as well as controlled bus voltages in a power system. the proposed approach is generalization adoptable capabilities. The computation using the trained ANN is very fast and accurate.

VI. REFERENCES

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