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SHORT TERM LOAD FORECASTING OF 66KV SUBSTATION USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT: *Load forecasting is necessary to know electric power demand ahead of time. Load forecasting is done on basis of planning horizons like hourly, daily, weekly, monthly and yearly. Short term load forecasting is done to predict future load from one hour to one week. While preparing load forecasting model seasonal factor, time factor and category of consumers must be taken into consideration. Load forecasting models are different for different utility as the factors affecting load forecasting are vary from utility to utility. Accurate load forecasting on utility side reduces per unit generation cost, reduces load shedding, power crises in peak hour, reduces tariff etc. Load forecasting on consumer side reduces the per unit energy charges. Reduction in forecasting error has great saving potential these saving are realized when load forecasting is used for control operation, decisions such as dispatch & unit commitment, fuel allocation, network security analysis and off-line network analysis.*

For prediction of load on 66KV Vartej substation, Bhavnagar, short term load forecasting models are proposed for 11KV industrial feeders, 11KV commercial feeders and 11KV Urban (mix-load) feeders of that substation. As load on agriculture feeders remain constant throughout the season medium term load forecasting models are proposed for 11KV agriculture feeders

This paper presents models for short-term load forecasting using Artificial Neural Networks (ANNs), for industrial feeder 11KV vartej GIDC-II. Hourly Pole data report is obtained for duration December 2017 to January 2018 and December 2016 to January 2017 from 220kv Vartej substation GETCO Bhavnagar. This data are taken for network training, testing, and validation and Second week data of January 2018 are used for load forecasting.

Result obtained from Artificial Neural Network model that is forecasted load is compared with actual load. The proposed models are capable of forecasting hourly loads for an entire week. Matlab is used for preparation of Artificial Neural Network models for short term load forecasting. By making use of two mathematical models proposed herewith and from load pattern, load forecasting models are prepared for urban feeders, industrial feeders, and commercial feeders. These mathematical models are also used for medium term load forecasting of agriculture feeders.

(***Keywords-*** *Short-term load forecasting, Medium term load forecasting, Artificial Neural Network, Hidden Layer Neurons, Normalization).*

INTRODUCTION:

Load forecasting is concern with the prediction of hourly, daily, weekly, monthly and yearly load. According to time horizon load forecasting is divided into three categories like Long term, Medium term and Short term. Short term load forecasting is carried out for prediction of load from one day to one week, Medium term load forecasting is carried out for prediction of load from one week to one month and long term load forecasting is carried out for prediction of load from several months to several years. Medium term and long term load forecasting are generally used for long term maintenance and infrastructure development planning. Short term load forecasting is necessary for making important decision in day by day activities of load management unit. It plays a key role in helping load management unit to make important decision on generation scheduling, unit commitment, hydrothermal co-ordination, load frequency balancing, fuel allocation, security function etc. Short term load forecasting which forms the focus of this paper gives a forecast of electric load one hour ahead of time for entire week.

DATA FORMULATION:

Load can be represented mathematically as a function of different factors such as time, season, day of the week, customer class etc. Weekly Load duration curve of 11KV Vartej GIDC-II for the month of December 2017 and January 2018 is as shown in figure.

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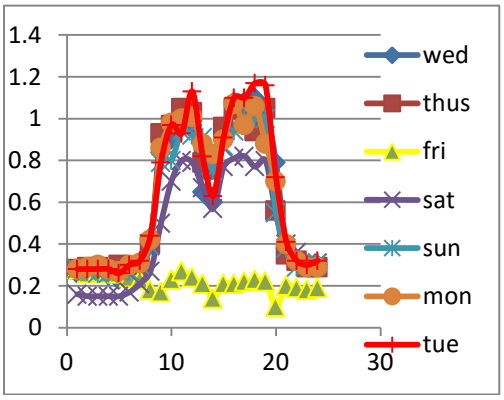

Fig.1. Load duration curve 1/12/2017 to 7/12/2017

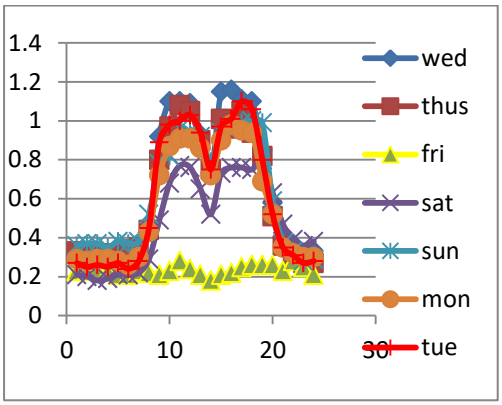

Fig. 2. Load duration curve 8/12/2017 to 14/12/2017

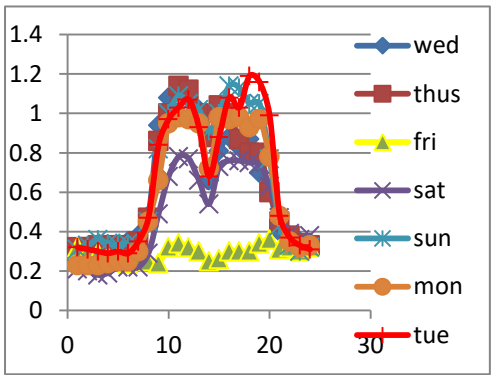

Fig. 3. Load duration curve 15/12/2017 to 21/12/2017

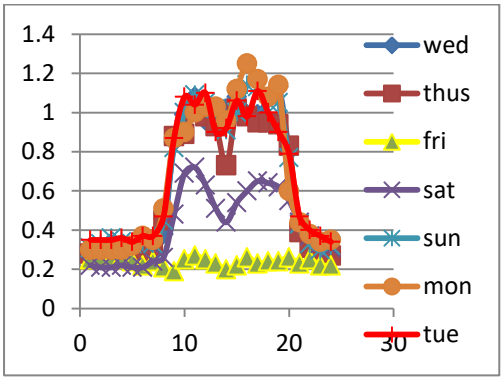

Fig. 4. Load duration curve 22/12/2017 to 28/12/2017

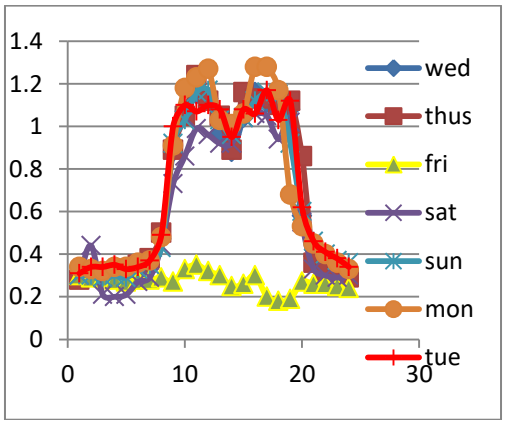

Fig. 5. Load duration curve 29/12/2017 to 4/1/2017

It is observed from the load duration curve that the load profile of particular day depends mainly on the same days in the previous week and same days in the two and three week back and assume that days one year back. It is observed that Friday have dissimilar load behavior because of staggering holiday. And weekdays from Saturday to Thursday have almost same load profile. Hence two short term load forecasting models are suggested. First one is for forecasting load of Friday. Second one is for forecasting load of Saturday to Thursday.

MATHEMATICAL REPRESENTATION:

Model-1

For First model similar day approach is proposed to predict the load.

$x_{t+1} = f(x_1, x_2, x_3, x_4, x_5, x_6)$

Where,

$x_1 = x(t)$
$x_2 = x(t - (7 * 24))$
$x_3 = x(t - (14 * 24))$
$x_4 = x(t - (21 * 24))$
$x_5 = x(t - (28 * 24))$
$x_6 = x(t - (365 * 24))$

Model-2

$x_{t+1} = f(x_{(t-24)}, T, D, S)$
T=Hour of the day=0,1,2…….23
D=Day of the week{ sun=0,mon=1,tue=2,wed=3,thus=4,fri=5,sat=6,sun=7}
S=Season {winter=0, summer=1, monsoon=2}

Data Scaling Methods:

Before presenting data to the neural network it is necessary to normalize the data within closed unit interval [0, 1] or [-1, 1]. [2]
Input data can be normalized and output result can be renormalized using following equations.

$$\textit{Normalized value} = \frac{\text{Actual value - Minimum value}}{\text{Maximum value-Minimum value}}$$

Denormalized value = Output result (Maximum value-Minimum value) + Minimum value

ARTIFICIAL NEURAL NETWORK MODEL

Artificial Neural Network Model is desigend for short term load forecasting.
Selection of the Artificial Neural Network model architecture depends on the problem to be solved. The architecture includes number of layers, number of neurons within each layer, number of input variables, number of output variables and transfer function for hidden layer neuron and output layer neuron. Transfer function in the Artificial Neural Network maps the input variables to output variables. Transfer function is the key element to invoke the nonlinear relation between input variables and output variables. The architecture for feed forward neural network is as shown in fig.6.

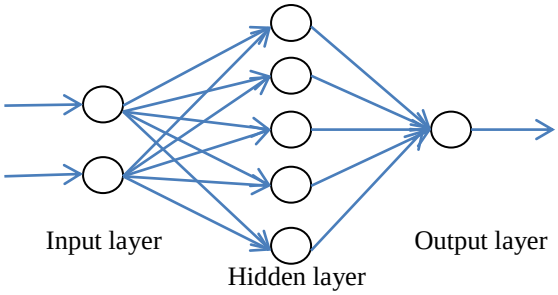

Fig. 6. Feed Forward Neural Network Architecture (2:5:1)

Number of neurons within each layer depends upon the efficiency of the learning rule. In learning operation output is compared with target value and deviation is fed back to modify the weight .Process of weight adjustment is carried out until the error between actual and desired output is reduced to acceptable level.
The Feed Forward Neural Networks is used for short term load forecasting modeling because it is fault tolerant and come up with solutions for ill-defined irregularities, through the use of hidden layers. Back-propagation learning algorithm is used for weight adjustment to reduce the forecasting error to minimum. Number of hidden layer chosen is one. More number of hidden layers required if problem is complex. Transfer function used for the hidden layer neurons is tan sigmoid and for output layer is purelin as shown in figure 7.

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RESULT:

1] Model-1 have similar day approach

Neural Network model for Short Term Load forecasting for Friday.

Neural Network : Feed forward type
Training/Learning Algorithm : Back propagation
Neural Network connection : 6:7:1
Transfer function for hidden layer : TANSIG
Transfer function for output layer : PURELIN
Performance function : MSE

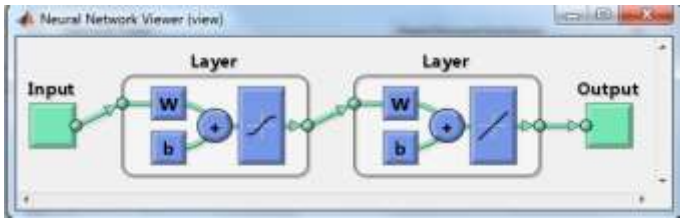

Fig.7.Neural network viewer

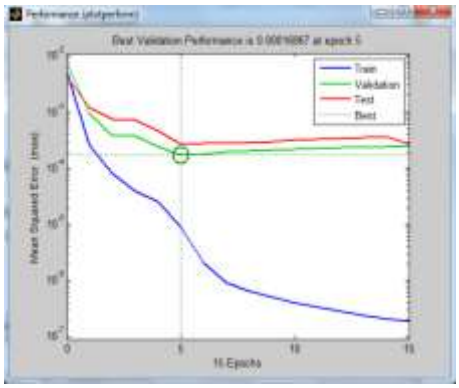

Fig. 8. Best validation performance at epoch 5

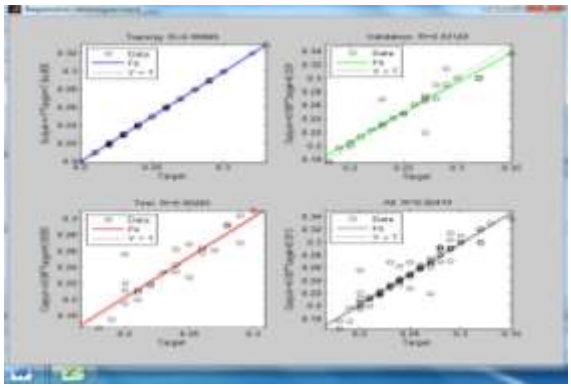

Fig.9. Regression plot

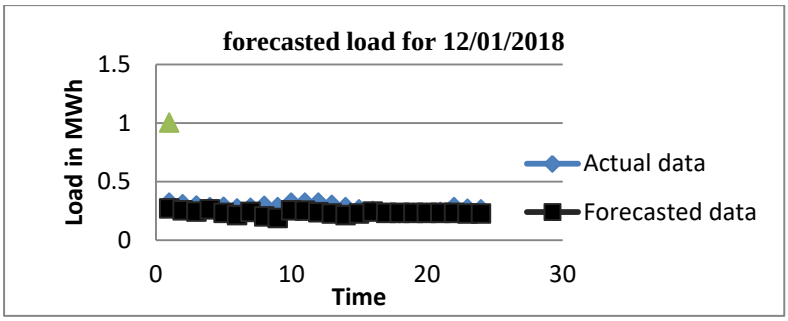

Fig.10. Actual load and forecasted load for 12/1/2018

2] Model-2

Neural Network model for Short Term Load forecasting for other days.

Neural Network : Feed forward type
Training/Learning Algorithm : Back propagation
Neural Network connection : 4:9:1
Transfer function for hidden layer : TANSIG
Transfer function for output layer : PURELIN
Performance function : MSE

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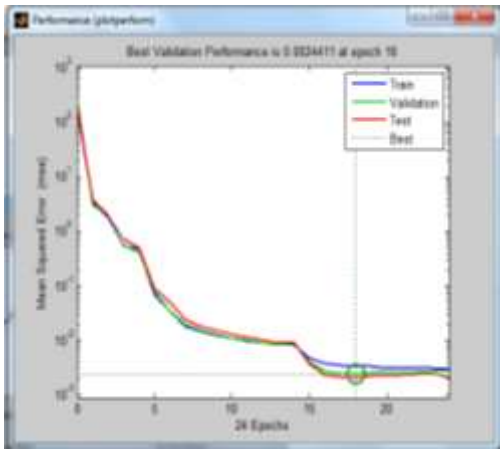

Fig. 11. Best validation performance at epoch 18

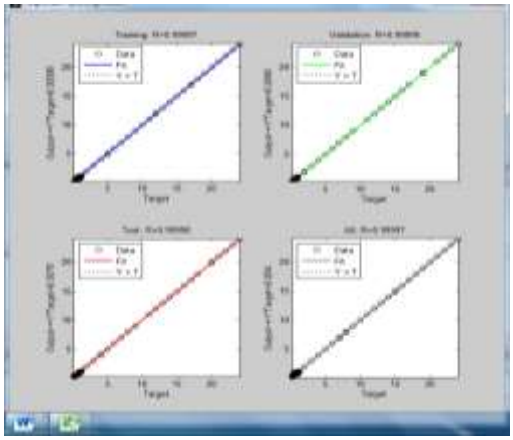

Fig.12. Regression plot

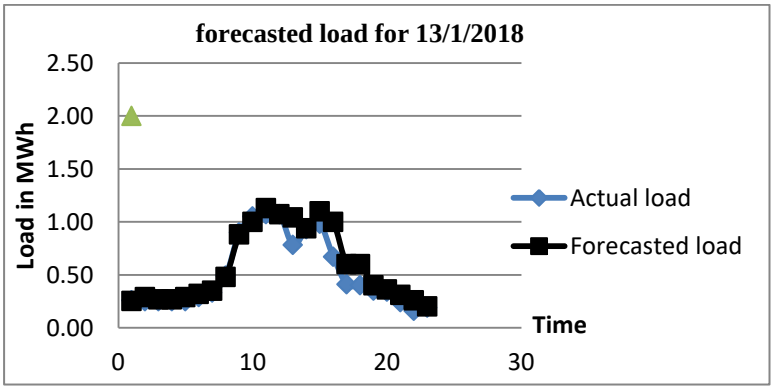

Fig.13. Actual load and forecasted load for 13/1/2018

DISCUSSION:

Since the yesterday's load does not have a good enough correlation with tomorrow's load, the input load used in these methods has restricted prediction power, resulting in limited prediction accuracy.[3] Artificial neural networks are employed for nonlinear short term load forecasting due to their powerful nonlinear mapping capabilities.[4].

In this paper key idea is to select the similar day's load from historical data as the input and target data, Model-1 is proposed for load forecasting of Friday.

For other days load pattern is very much similar, Model-2 is proposed for other days.

Similar way load forecasting models are prepared for all types of 11KV feeders using above two mathematical models for 66KV substation. Reduction in forecasting error has great saving potential; both models proposed here have high accuracy.

CONCLUSION:

Load modeling in power distribution system is complex problem to solve because of sometime bad data measurement and deficiency in classification of consumers. Knowledge of load profile helps to understand the power consumption pattern and hence to propose load forecasting models. In this paper Industrial load feeder is selected for load forecasting. Short term load forecasting models are prepared for 11kv Vartej GIDC-II feeder. Prepared models are capable of forecasting hourly load for entire week with acceptable accuracy limit.

Here attempt is made to classify the total load of substation into three categories; Industrial feeders load, commercial feeders load, Agricultural feeders load and urban (mix load) feeders load. By making use of above two mathematical models, separate models are prepared for each category of feeders. Total forecasted load is total aggregate load of all feeders and that can consider as total forecasted load on 66KV substation.

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Best features of Artificial Neural Networks over conventional network are self-adjustment of their weight to minimize the mean square error; constitute distributed-associative memory and hence fault tolerant; learn by example.

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