

# Artificial Neural Network Based Load Forecasting and Economic Dispatch with Particle Swarm Optimization.

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**ABSTRACT**-This project is done to forecast the load and Economic Load Dispatch(ELD) by applying ANN for the optimal power system operation with the help heuristic particle swarm optimization . The sizes of the electric power systems are increasing rapidly to meet the energy requirements. A number of power plants are connected in parallel to supply the system load by interconnection of power station. With the development of integrated power system, it becomes necessary to operate the plant units economically. Thus evolves Economic Load Dispatch (ELD) problem. Load forecasting is an important component for power system energy management system. Precise load forecasting helps the electric utility to make unit commitment decisions, reduce spinning reserve capacity and schedule device maintenance plan properly. Besides playing a key role in reducing the generation cost, it is also essential to the reliability of power systems. The system operators use the load forecasting result as a basis of off-line network analysis to determine if the system might be vulnerable. If so, corrective actions should be prepared, such as load shedding, power purchases and bringing peaking units on line. Since in power systems the next days' power generation must be scheduled every day, day ahead short-term load forecasting (STLF) is a necessary daily task for power dispatch. Its accuracy affects the economic operation and reliability of the system greatly. This paper presents a ANN based method to forecast tomorrow's load and also economic scheduling for that particular load. The patterns are generated using PSO. Numerical testing shows that this method provides accurate predictions and seems to be fast enough.

**Keywords:** Artificial neural network-Economic dispatch- neural network -short term load forecasting -similar day selection

## I.INTRODUCTION

The efficient and optimum economic operation of electric power systems has always occupied an important position in electric power industry. In recent decades, it is becoming very important for utilities to run their power systems with minimum cost while satisfying their customer demand all the time and trying to make profit. With limited availability of generating units and the large increase in power demand, fuel cost and supply limitation, the committed units should serve the expected load demand with the changes in fuel cost and the uncertainties in the load demand forecast in all the different time intervals in an optimal manner.

The basic objective of ELD of electric power generation is to schedule the committed generating unit outputs, so as to meet the load demand at minimum operating cost while satisfying

all unit and system equality and inequality constraints. The ELD problem has been tackled by many researchers in the past. ELD problem involves different problems. The first is Unit Commitment or pre-dispatch problem where in it is required to select optimally out of the available generating sources to operate to meet the expected load and provide a specified margin of operating reserve over a specified period of time. Hence it is important to forecast the future load for ELD.

The Economic Dispatch can be defined as the process of allocating generation levels to the generating units, so that the system load is supplied entirely and most economically. The objective of ELD is to minimize the overall cost of generation. The system load is the sum of all the consumers' load at the same time. The objective of system STLF is to forecast the future system load. A good

understanding of the system characteristics helps to design reasonable forecasting models and select appropriate models operating in different situations. The use of artificial neural networks (ANN or simply NN) has been a widely studied load forecasting technique since 1990. Neural networks are essentially non-linear circuits that have the demonstrated capability to do non-linear curve fitting. The outputs of an artificial neural network are some linear or non-linear mathematical function of its inputs. Particle swarm optimization is a population based stochastic optimization technique inspired by social behavior of bird flocking or fish schooling.

## II. PROBLEM STATEMENT

The ELD problem is defined as to minimize the total operating cost of a power system while meeting the total load plus transmission losses within generator limits. Mathematically the problem is defined as (including losses)

$$\text{Minimize } F(P_j) = \sum_{i=1}^{NG} (a_i P_i^2 + b_i P_i + c_i) \dots \dots (1)$$

Subject to (1) the energy balance equation

$$\sum_{i=1}^{NG} P_i = P_D + P_L \dots \dots \dots (2)$$

(2) The inequality constraints

$$P_1(\text{min}) \leq P_1 \leq P_1(\text{min}) \dots \dots \dots (3)$$

Where,

$a_i, b_i, c_i$  : cost coefficients

$P_D$  : load demand

$P_i$  : real power generation

$P_L$  : power transmission loss

$NG$  : number of generation busses

One of the most important, simple but approximate method of expressing transmission loss as function of generator powers is through B-coefficients. This method uses the fact that under normal operating condition, the transmission loss is

quadratic in the injected bus real power. The general form of the loss formula using B-coefficient is

$$P_L = \sum_{k=0}^n \binom{n}{k} x^k a^{n-k}$$

$$P_L = \sum_{i=1}^{NG} \sum_{j=1}^{NG} P_i B_{ij} P_j \dots \dots \dots (4)$$

where,

$P_i, P_j$  : real power injection at the  $i$ th,  $j$ th buses

$B_{ij}$  : loss coefficients which are constant under certain assumed conditions.

The above loss formula is known as the George's formula.

The above constrained optimization problem is converted into an unconstrained optimization problem. Lagrange multiplier method is used in which a function minimized (or maximized) is subjected to side conditions in the form of equality constraints. Using Lagrange multipliers, an augmented function is defined as

$$L(P_i, \lambda) = F(P_i) + \lambda (P_D - P_L - \sum_{i=1}^{NG} P_i) \dots \dots \dots (5)$$

Where,  $\lambda$  is the Lagrangian multiplier.

Necessary conditions for the optimization problem are

$$\frac{\partial L(P_i, \lambda)}{\partial P_i} = \frac{\partial F(P_i)}{\partial P_i} + \lambda \left( \frac{\partial P_L}{\partial P_i} - 1 \right) = 0 \dots \dots \dots (6)$$

Rearranging the above equation

$$\frac{\partial F(P_i)}{\partial P_i} = \lambda_i \left( 1 - \frac{\partial P_L}{\partial P_i} \right) \dots \dots \dots (7)$$

Where,

$$P_L = B_{00} + \sum_{i=1}^{NG} B_{i0} P_i + \sum_{i=1}^{NG} \sum_{j=1}^{NG} P_i B_{ij} P_j \text{ MW} \dots \dots \dots (8)$$

$$\frac{\partial F(P_i)}{\partial P_i} = \text{Incremental cost of the } i^{\text{th}} \text{ generator (Rs/MW h)}$$

$\frac{\partial P_L}{\partial P_i}$  : incremental transmission losses.

Equation 8 is known as the exact coordination equation and

$$\frac{\partial L(P_i, \lambda)}{\partial \lambda} = P_D + P_L - \sum_{i=1}^{NG} P_i = 0 \quad \dots\dots\dots(9)$$

By differentiating the transmission loss Eq. 9 with respect to  $P_i$ , the incremental transmission loss can be obtained as

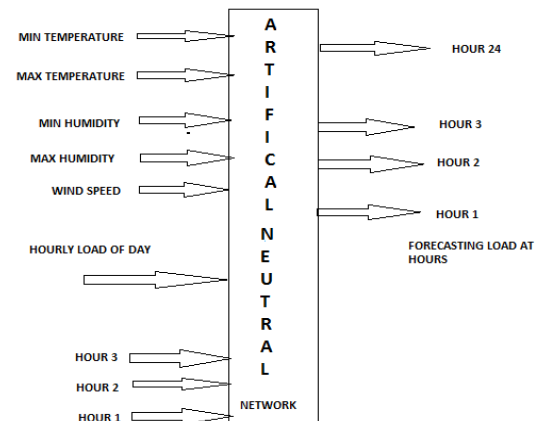
$$2(a_i + \lambda B_{ij})P_i + 2 \sum_{j=2}^{NG} B_{ij}P_j = (\lambda - b_i) \quad \dots\dots\dots(10)$$

The above linear equation 10 can be solved to obtain the value of  $P_i$  if  $\lambda$  is known.

### III LOAD FORECASTING USING ANN

This approach is based on searching historical data for days within one, two or three years with similar characteristics to the forecast day. Similar characteristics include weather, day of the week and the date.

The load of a similar day is considered as a forecast. Instead of a single similar day load, the forecast can be a linear combination or regression procedure that can include several similar days. The trend coefficients can be used for similar days in the previous years. The neural network model for this approach is shown in Fig 3.1



**Fig 3.1 Neural Network Model for the approach**

Two three-layer perceptron networks are separately used for the low frequency component and the high frequency component. For the low frequency network, inputs are selected based on our testing experience, and include weekday index, wind-chill temperature, humidex, wind speed, cloud cover, and low frequency components of the input load (the similar day's load and today's predicted load at hour 24). To improve network performance while providing the capabilities to forecast beyond (or below) the historical maximum (or minimum) load level, the input weather and load are normalized to values in (0.05, 0.95) by using the corresponding historical maximal (or minimal) values.

For the high frequency network, the inputs are also selected based on testing experience, and include weekday index, wind chill temperature, humidex, wind speed, cloud cover, high frequency components of the input load, and precipitation. The high frequency component of the similar day's load is a major input in view of its good correlation with tomorrow's high frequency load. Precipitation is another important input for this network since testing results show that prediction errors are large for rainy days if it is not used. The two networks are first trained by using historical actual data, with the similar day-based selection criteria presented in Section II applied to each day in the training period. For each network, the training process terminates when the training error is less than or equal to a specified threshold. To avoid over-fitting, for each network, its number of hidden neurons, input

selection, and threshold value for terminating training are determined based on extensive testing. Furthermore, the two networks are trained with several years' historical data. In the prediction phase, the two predictions generated by the two networks are added up to be tomorrow's forecasted load

#### IV. PATTERN GENERATION USING PSO FOR ECONOMIC DISPATCH

The sequential steps of the proposed PSO methods are given below

- The individual of the population are randomly initialized according to the limit of each unit including individual dimensions
- Each set of solution in the space should satisfy the equality constraints. So equality constraints are checked
- The evaluation function of each individual  $P_{gi}$  is calculated in the population using the evaluation function  $F$ .
- Each pbest values are compared with the other pbest values in the population . The best evaluation value among the p-bests is denoted as gbest.
- The member velocity of each individual  $P_g$  is modified according to the velocity of update equation
- The velocity components constraint occurring in the limits from the following conditions are checked.
- The position of each individual  $P_g$  is modified according to position update equation
- If the evaluation value of each individual is better than previous pbest , the current value is set to be pbest is better gbest , the values is set to be gbest.
- If the number of iterations reaches the maximum , then go to step 10. Otherwise , go to step 2.
- The individual that generates the latest gbest is the optimal generation power of each unit with the minimum total generation cost.

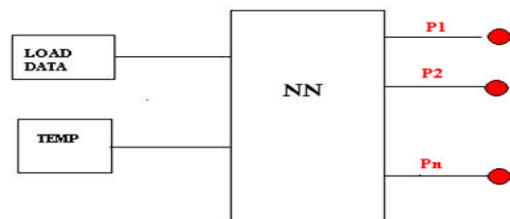
TABLE 1. PATTERN GENERATION USING PSO

POWER DEMAND (MW)	P <sub>1</sub> MW	P <sub>2</sub> MW	P <sub>3</sub> MW	P <sub>4</sub> MW	P <sub>5</sub> MW	P <sub>6</sub> MW	LOSS MW	F <sub>r</sub> Rs	TIME IN SEC
600	23.8	10	95.7	100	202.6	181.2	14.24	32091.68	7.3
700	28.2	10	118.53	118.53	230.2	214.16	19.4	36912.2	8.7
800	31.95	10.8	153.2	151.8	247.3	229.69	24.95	41896.2	8.09
950	39.05	24.4	191.8	172.56	294.5	262.4	34.90	49681.38	9.4

#### V. ED USING ANN

In this project the ED problem has been solved by using ANN based on the forecasted load. The forecasted load is given as the input to ANN. The ANN is trained by the set of patterns generated by

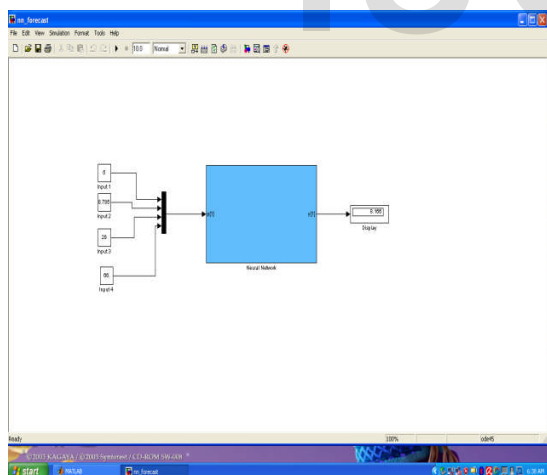
using PSO. The ANN model for the ED is given in the fig.



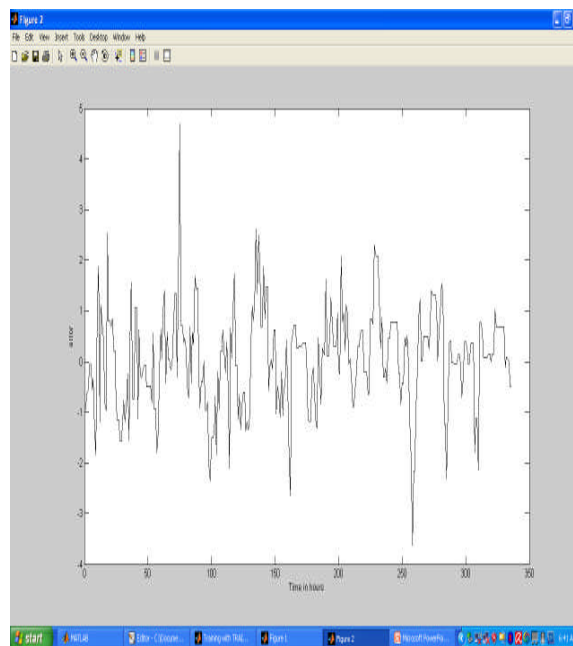
**Fig 5.1 Neural Network model for Economic Dispatch**

In this model the forecasted load and the corresponding temperature is given as the input to the ANN. The results obtained from this model is compared with the conventional Lamda-iteration method.

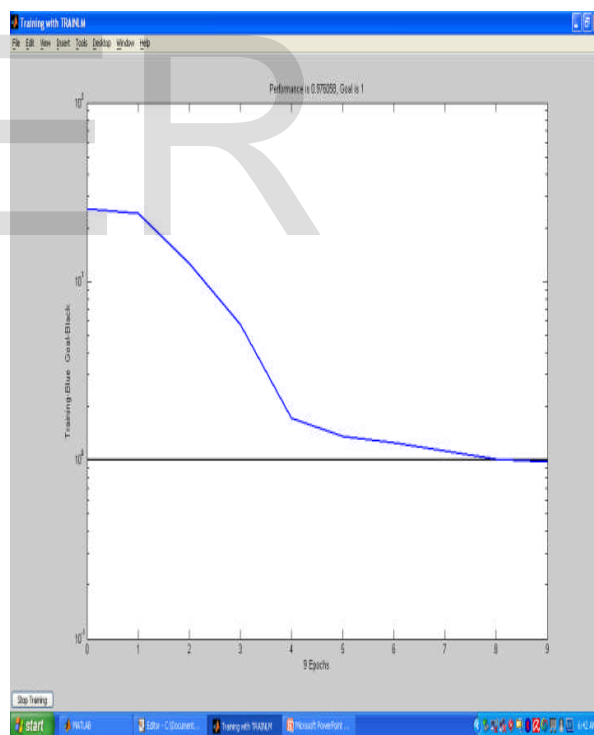
## VI.RESULTS



**Fig 6.1 Neural Network Model**



**Fig 6.2 Mean Square Error**



**Fig6.3 Training of ANN**

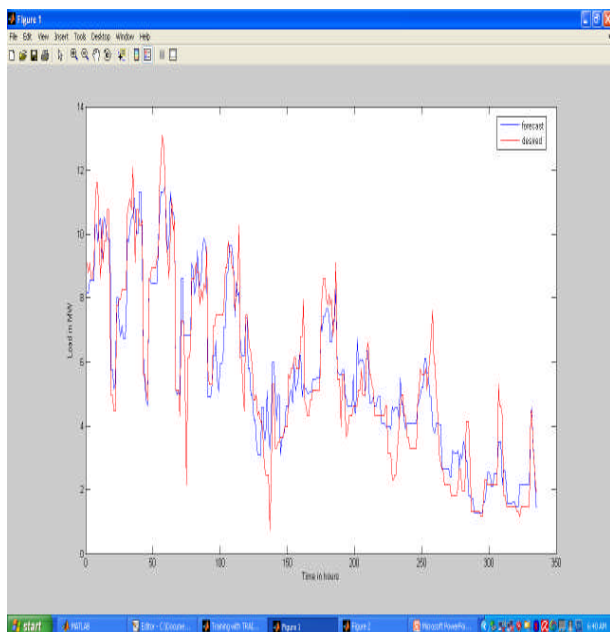


Fig6.4 comparison of load curves



Fig 6.5 Pattern Generation using PSO

## VI CONCLUSION

In this paper, a ANN based method is proposed for short-term load forecasting and its application in ED problem. A multilayer feed forward structure and it has been trained to give as output to predefined set of inputs. To this purpose PSO technique has been proposed to train the ANN. The test results proved the ability of the designed ANN in performing short-term load forecasting as well as economic dispatch problem. The future work of this paper involves LF and ED with different neural network structures.

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