

## Using an Intelligent Technique

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### Abstract

The paper discusses a method to get the hourly load data from the peak daily load (i.e. to store one value and get 24 values). The method uses one of the intelligent techniques (Artificial Neural Network ANN).

The annual load duration (ALDC) is used in different studies, such as power system planning, reliability study . . . etc. In this work the ALDC is used as an example for the application of the proposed method. When the hourly load data for a year are available, it is easy to find the ALDC. In the studies where the ALDC is needed, the load is usually forecasted (future load) where the hourly data are not available.

A proposed ANN is explained to overcome this difficulty. The method develops the daily load (24 hours) from the peak load. The required days are encountered, which means that the ALDC is obtained for the required days. Also if there is a missing period, the proposed method can develop that missing period in the data.

The data of the Iraqi North Region National Grid (INRNG) for the year 2001 is used to verify the validity of the proposed method. The results of a conventional method are also given.

Key words: ALDC, Daily load, Hourly load, ANN.

### استحصال منحني فترة الحمل السنوي باستخدام الطرق الذكية

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### الخلاصة

يناقش هذا البحث طريقة جديدة للحصول على قيم الحمل لساعات اليوم من ذروة الحمل اليومي، أي أنه يخزن قيمة واحدة يتم الحصول على 24 قيمة. تستخدم الطريقة المقترحة احدى التقنيات الذكية وهي الشبكات العصبية الاصطناعية.

يستخدم منحني فترة الحمل السنوي في دراسات مختلفة مثل تخطيط المنظومة الكهربائية، دراسات الموثوقية، وحسابات كلفة الطاقة . . . الخ. عند توفر قيم احمال ساعات السنة يكون من السهل الحصول على منحني فترة الحمل السنوي ، ولكن تقتضي الحاجة في مثل هذه التطبيقات الى تخمين قيم الاحمال لفترات مستقبلية حيث لا تتوفر فيها احمال

الساعات. تتغلب الطريقة المقترحة على هذه المشكلة وذلك بالحصول على قيم أحمال ساعات اليوم من قيم ذروة الحمل لذلك اليوم. من الممكن اختيار الايام المطلوبة واستخراج فترة الحمل لها.

تم استخدام بيانات الحمل للشبكة الكهربائية الوطنية الشمالية للسنة ٢٠٠١ وذلك لتحقيق نتائج الطريقة المقترحة. وقد اعطيت النتائج المستحصلة بالطريقة التقليدية والطريقة المقترحة.

## 1- Introduction

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Power system planning, operation and maintenance need to deal with load data. Load data can be recorded in different ways. One of these methods is to record the daily peak load. Another way is to record the hourly load data in which the total data for a year is 8760[1, 2, 3]. The load of an electrical system during a given period can be represented in a plot which gives system power loads (hourly data) as a function of time. Chronological load data can be converted into a load duration curve (LDC). A LDC is a reordering of the chronological load data into a commutative form, in which the x-axis shows how many hours the load was equal or greater than the load level shown in the y-axis (as will be shown in article 2) [1].

LDC is used in different studies, such as power system planning, reliability study, energy pricing . . . etc [4-7]. In such studies it is assumed that the shape of the LDC will not change over the forecast period and only the area under the curve will increase [8, 9].

Developing LDC needs the hourly load data. It is obvious that the data of several years will be too much. This needs more processing time and higher memory capacity. Besides, the assumption that the shape of LDC is not changed will give rise to greater error in results.

This paper suggests a method using ANN intelligent technique to store the peak daily load data from which the hourly load data are obtained.

The data of the INRNG for the year 2001 is used to verify the validity of the proposed method. The results of a conventional method are also given.

## 2- Developing ALDC Using Conventional Method

ALDC may be derived without difficulty providing that load data determined at regular intervals (hourly data) are available. A typical daily load curve for the season's winter, summer and spring are shown in Fig 1. Also a typical daily load curve of four days (Saturday, Monday, Thursday and Friday) are given in Fig 2. The two figures show that the shape of the daily load curves for different seasons and days are similar in shape but differ in value.

The ALDC may be developed using the hourly data available. These data are sorted in a spreadsheet in the Excel program. The descending order of load is plotted against cumulative hours. Fig 3 shows the ALDC of INRNG for the year 2001.

## 3-Developing ALDC Using Intelligent Technique

### 3.1- Basic Theory

Intelligent system is that which its performance improves by experience, i.e., the system that learns by training. ANN is one example for the intelligent techniques. Neural Networks are composed of simple elements (neurons) operating in parallel. These elements are inspired by biological nerves systems. As in nature, the network function is determined largely by the connections between elements. A Neural Networks can be trained to perform a particular function by adjusting the values of the connections (weights) between elements.

Commonly Neural Networks are adjusted or trained, so that a particular input leads to a specific target output. There, the network is adjusted, based on a comparison of the output and the targets until the network output matches the target. Typically many such input/output pairs are used, in this supervised learning, to train a network. A two-layer

network having  $R^1$  inputs,  $S^1$  neurons in the first layer, and  $S^2$  neurons in the second layer is shown in Fig 4.

The choice of the type of network and its type of implementation is based on the nature of the application, the nature of the data and performance consideration [10, 11]. The Neural Network implementation is achieved through three stages:-

- 1- Initialization (creating) of Neural Network.
- 2- Training of the initialized network.
- 3- Simulating (testing) of the trained network.

Once the network weights and biases have been initialized, the network is ready for training. The training process requires a set of examples of proper network behavior, network input  $p$  and target outputs  $t$ . During training the weights and biases of the network are iteratively adjusted to minimize the network performance function. The default performance function for feed forward networks is mean square error, i.e. the average squared error between the networks outputs  $a$  and the target  $t$ .

There are several different training algorithms for feed forward networks. All of these algorithms use the gradient of the performance function to determine how to adjust the weights to minimize performance. The gradient is determined using a technique called back propagation, which involves performing computations back wards through the network. The flow chart of the program used is shown in Fig. 5.

Since the early to mid 1980s the effort in power systems analysis has turned away from the methodology of formal mathematical modeling which came from the fields of operation research, control theory and numerical analysis to the less rigorous techniques of artificial intelligence (AI). Today the main AI technique, found in power systems applications are those utilizing the logic and knowledge representations of expert systems , fuzzy systems , ANN and more recently, evolutionary computing [12].

### 3.2- ALDC Development

A two-layer back propagation Neural Network was used. The hidden layer has 25 neurons and the output layer has 24 neurons corresponding to the 24 hours of the day. The ANN is used in this work for obtaining the daily load by giving the peak value only for that day. The LDC can be developed using the daily load values obtained. The input to the ANN is one, which represents the peak load of that day. The outputs are 24 values, which represent the hourly load of that day. The network is trained on available data of daily loads with the corresponding peak values. The ANN is tested by giving the peak(s) for the day(s) for which the load(s) is (are) required.

The available data was divided into two sets: The training data set and the test data set. Different division ratios for the data were investigated for the best or optimum performance. In our case, the training data is 50 % of the available data. The Matlab software version 6.5 (release 13, June 2002) is used in data management and implementing the ANN.

### 3.3- Results and Discussion

The data of INRNG for the year 2001 are used. The data are divided into two sets, training and test. The two portions of the data are equal, i.e. each portion is 50 %.

Neural network training can be made more efficient if certain preprocessing steps are performed on the network inputs and targets. Several preprocessing routines can be used . Postprocessing routines are used to get the original data. The input patterns are preprocessed to get the normalized data. Different train functions are examined and best results are obtained using the Matlab train function (trainlm) [13]. The (trainlm) algorithm was designed to approach second order training speed without having to compute the Hessian matrix. This algorithm appears to be the faster method for training moderate size feed forward neural networks up to several hundred weights.

A period of seven days is considered to show the results of proposed method. Fig 6 shows two curves for the original and obtained values of the test data. The accuracy of the results is checked using an error formula. The error is the sum of absolute difference between the original and obtained values divided by the sum of the

original values. This error ranges from 0.5- 3.5 % for the trained data. While it is 2.5- 6.5 % for the test data.

$$\text{error \%} = \frac{\sum |\text{original values} - \text{obtained values}|}{\sum \text{original values}} \times 100 \%$$

#### 4- Conclusions

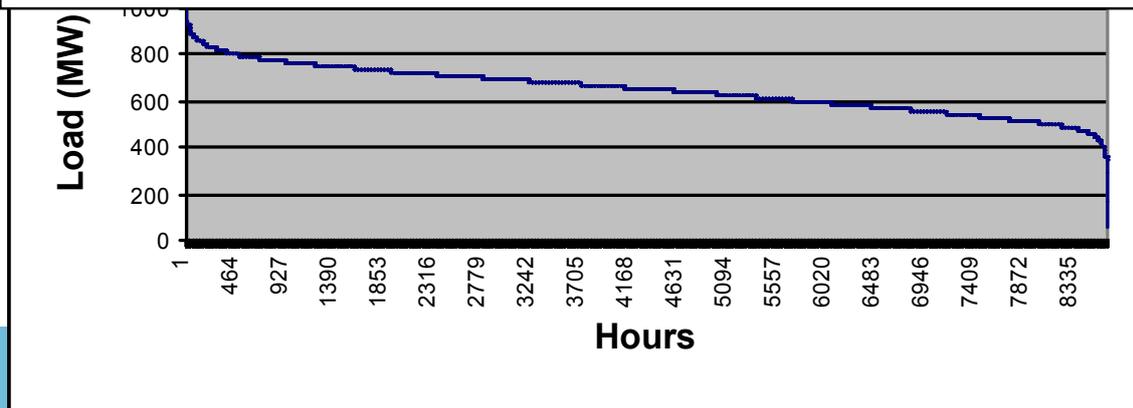
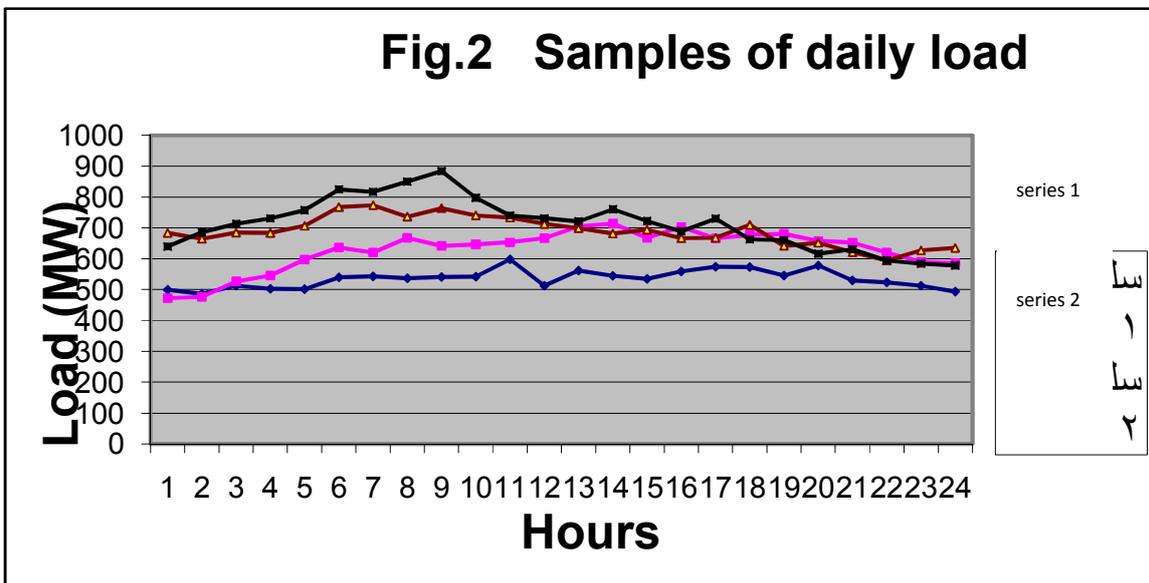
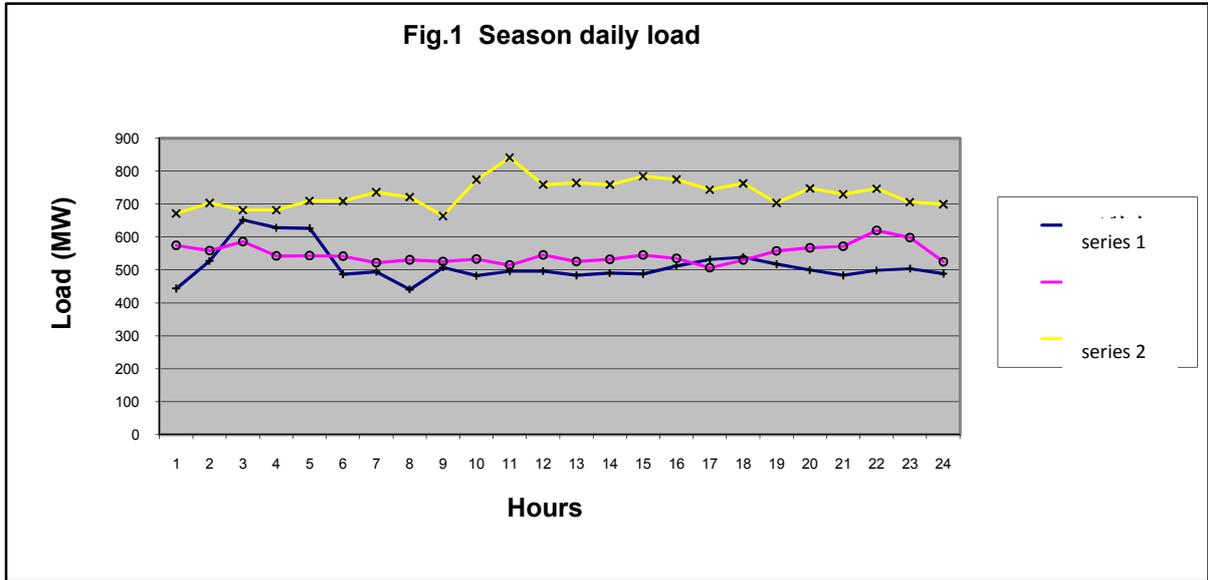
The effort in power system analysis has turned toward the techniques of AI. The use of ANN in load data analysis is a promising solution for many problems in this field. An intelligent technique, the ANN is implemented to obtain the daily load data from the peak load. A general software package is developed by which any recorded load data can be processed and the corresponding duration curve is obtained. The accuracy of the results obtained is measured using an error formula and its value is well accepted according to the result obtained (error range is 2.5-6.5%).

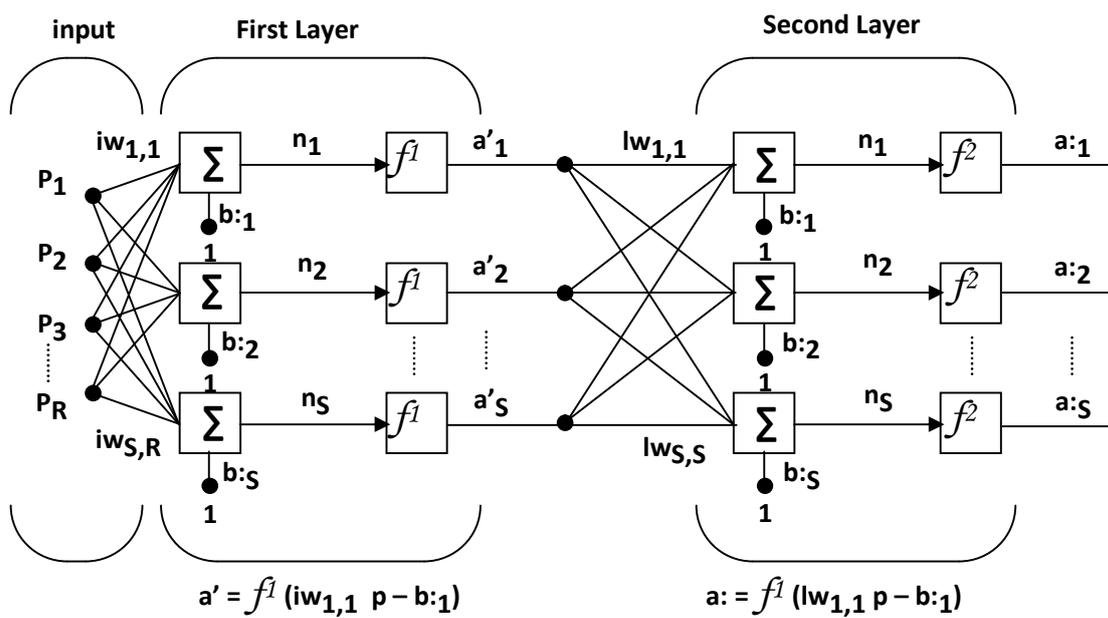
The annual load duration curve (ALDC) is used as an example of the application of the proposed method. A practical example is analyzed using a conventional method and the proposed method. The results are given.

#### 5-References

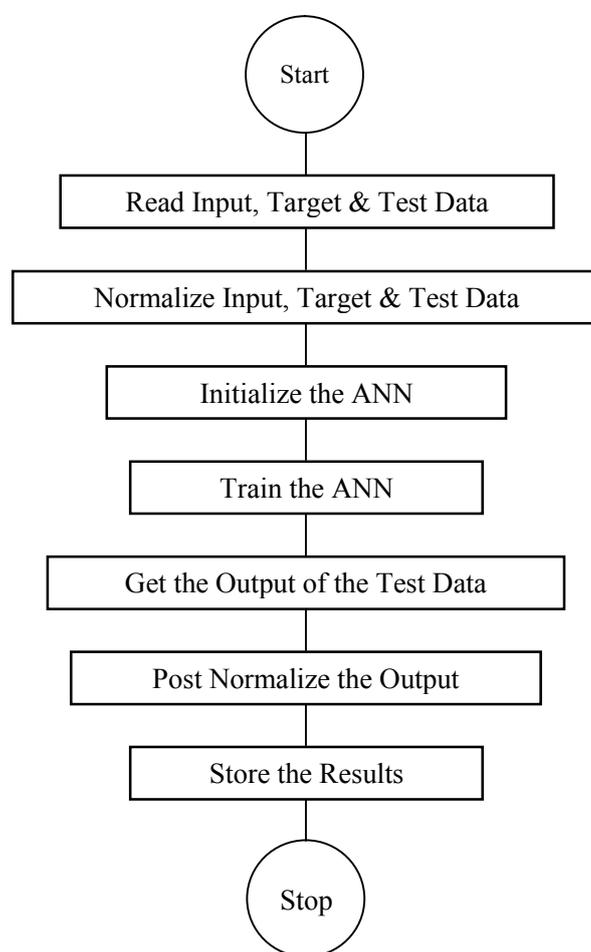
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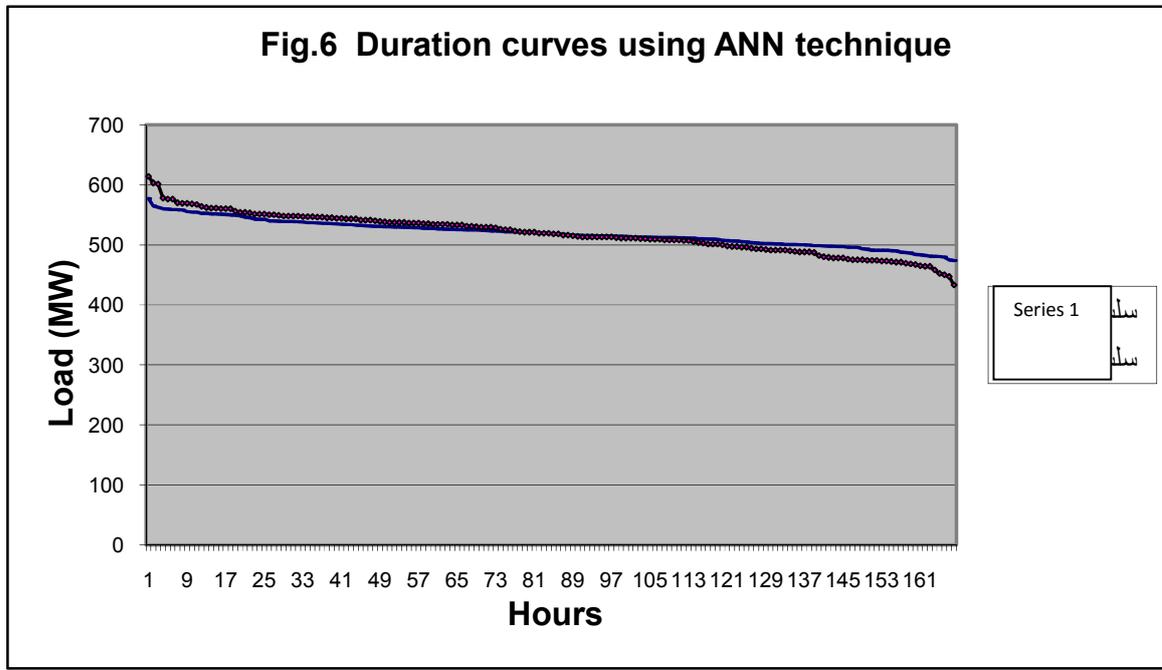




**Fig. 4 A two layer Neural Network**



**Fig. 5 The general ANN flow chart**



# Water Resources

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