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DESIGN AND DEVELOPMENT OF NEURAL NETWORK BASED CONTROLLER FOR THE DEMAND RESPONSE MANAGEMENT OF POWER GRID

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ABSTRACT

Energy management refers to the optimization of the energy system, one of the most intricate and significant technological inventions that we are aware of. While optimising has a lot of experience, the demand side is what drives the production and distribution of energy. Research and business are paying more attention to Demand Side Management (DSM) portfolio includes actions to enhance the energy infrastructure next to the consumer. It varies from enhancing energy efficiency by the use of superior materials over clever incentives in energy prices for specific use habits, increasing advanced real-time management of dispersed energy resources. In this paper, Neural Network based contreiler has been designed to perform the load balancing using a load profile of commercial college building dataset. The results obtained shows the regression fir of 99.9% and error of 0.0005%.

Keywords: Demand Response management.

I. INTRODUCTION

It is a reality that the energy distribution networks are undergoing a change right now. New smart distribution networks must be researched and created, as evidenced by the expanding customer base and their needs, as well as the more competitive market in which electricity providers must coexist. Because of the numerous demands and problems brought on by issues with the environment, consumers, markets, and infrastructure, the current network is under a lot of stress. The network has expanded and enhanced its functions to intelligent features with the aid of rapidly developing technologies as a result of these difficulties and needs, which are more vital and urgent than ever.

The term "Smart Network" refers to the change in how transmission networks are developed to make them smarter. These new intelligent energy distribution networks' main objectives include providing for consumers' requirements and the healthy profitability of power firms [1].

Since the end of 2003, people have started using the phrase "Smart Network," however it was first used much earlier. Many definitions of the "Smart Network" place emphasis on either how it functions or its technological components. The application of digital processing and communications to the electrical grid, with data flow and management carried out by a centralized "Smart Grid" system, is the point of convergence for everyone. [2]

An electricity system that can intelligently integrate the actions of all users linked to it, whether they are generators or consumers, in order to ensure an efficient, affordable, and secure electricity supply, is referred to as a "smart grid." A smart network employs cutting-edge goods and services along with deft network status monitoring [3].

By enabling both producers and consumers to determine their operating demands more flexibly and sophisticatedly, the smart network connects supply and demand. Consumption at high prices, for instance, can only occur for very significant reasons, and consumers can shape their consumption based on the knowledge they have of the current consumption price. On the other hand, producers with high levels of flexibility can change their sales prices to maximise their profits while also offering consumers discount periods based on the cost of their power generation, increasing their advertising influence and attracting new customers.

II. DEMAND RESPONSE MANAGEMENT

Electricity distribution networks will need to come up with a new method of meeting these demands due to the increasingly difficult difficulties of the expanding electricity needs, ageing infrastructure, and the integration of renewable green energy supplies. New intelligent power distribution networks, as we've already indicated, deal with these difficulties by controlling the idea of demand response. Demand response management, in its simplest form, refers to the adoption of strategies to reduce consumer energy consumption, increase energy efficiency, and lower the cost of electricity production from electrical providers.

Reducing the discrepancies between energy consumption and average consumption in the network is one of the main goals of demand response management in order to maintain a balance between supply and demand.

To achieve the objectives of the Smart Grid Network, modelling the demand response management challenge is crucial. There are various modelling approaches for this issue, but they all aim to balance consumer demand for electricity and determine the best strategy for electricity supply and pricing from the perspective of businesses, in order to boost and decrease businesses' profit and generation costs, respectively.

III. DESCRIPTION OF THE RESEARCH WORK

In this research work, a three phase power system has been modelled in a MATLAB/ SIMULINK. A neural network controller has been designed to fullfil the demand from the load. Two separate voltage source has been there with two diiferent load condition. Controller is designed in such a way that when the power requirement or the demand increases above 8000W, the controller switches to the another three phase voltage source. Neural network controller has been been trained with the dataset discussed in the next section.

3.1 Data set :

This dataset includes the hourly load profiles for 24 typical facilities from different end-use industries, such as industrial, commercial, and residential users, over the course of a year (8760 hours of data). The dataset contains 18 simulated buildings that were adapted to the climate zone of the state of New Jersey, United States, using our physics-based building simulator, an EnergyPlus-based tool capable of capturing the functionalities of the buildings. Six reference buildings were adopted from EnergyPlus reference buildings, which are publicly available and have been cited here. This dataset can be used to model single-node as well as multi-node energy systems, including nanogrids, microgrids, and other integrated systems in distribution networks where each building is described by its load profile, which reflects its power consumption behaviour. This dataset actually helps researchers and practitioners from all over the world simulate their defined or modified test systems, allowing them to carry out a wide range of studies addressing diverse engineering, economic, and environmental evaluations.

Dataset of commercial college building has been chosen. As shown in the figure below, the load profile for 24 hour of commercial college building is shown below

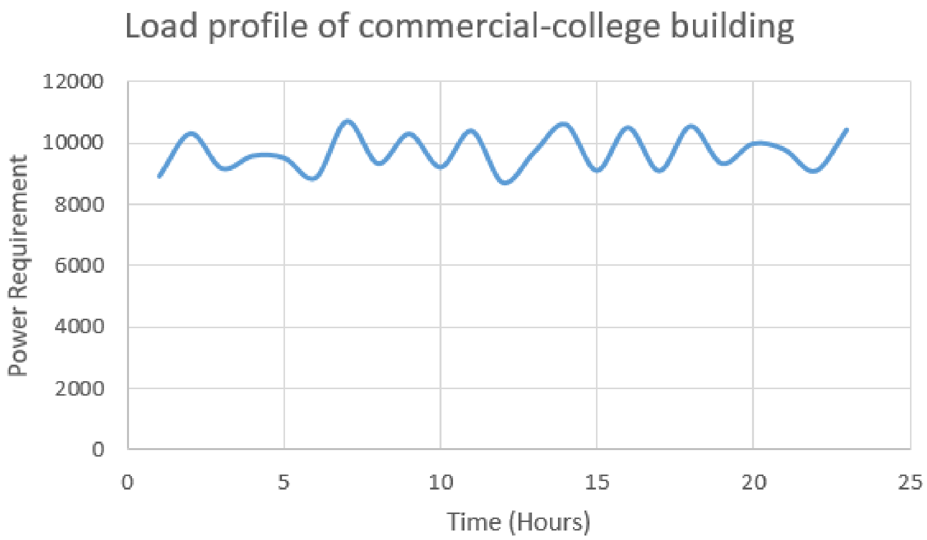

Figure 1: load profile of commercial college building for 24 hour

The distribution of total 8760 hours of data is shown below

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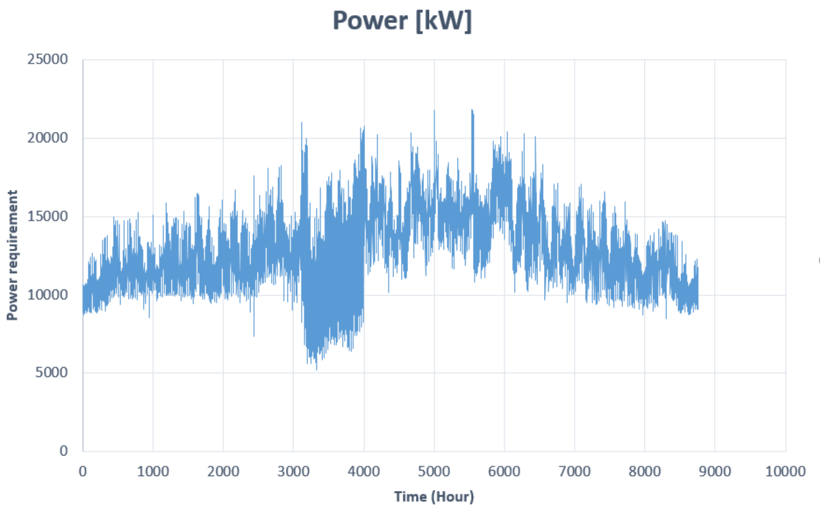

Figure 2: load profile of commercial college building for 1 year

It can be seen the the load requirement during summer is much as compare to the start and end of the year. This dataset has been used to train out neural network.

3.2 Threholding in the dataset

The neural network has been desined as of regression application therefore to fit the dataset, thresholding has been done. A part of the thresholded data set is shown below

8932	0	
10300	1	Switch the source
9182	0	
9586	0	Do not switch the source
9518	0	
8878	0	
10686	1	
9338	0	

Figure 3: Thresholding applied over dataset

It can be seen that when the power requirement was more than the 10000W, a numeric 1 is assigned otherwise numeric 0 is assigned. Here "1" corresponds to the switching of the source and "0" corresponds to the non-switching of the source

IV. SIMULINK MODEL

The complete Simulink model of the three phase transmission line is shown below:

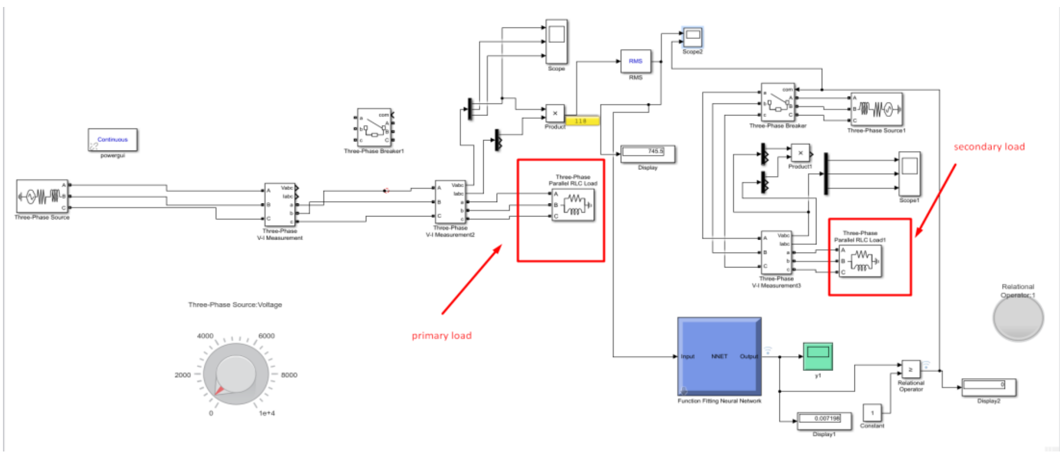

Figure 4: Complete simuling model of microgrid with the developed neural network controller

It can be seen the model that there are two separated three phase AC source has been used to drive two different loads. One of the load here is named as a primary load and second load here is known as a secondary load. A knob has been used in the model that is assigned top the voltage paramenter of the primary circuit. This knob is used to change the power developed during the simulation. As shown in the model, the neural network continuously monitored the power from the primary source. The output of the neural network controller is given to the three phase circuit breaker. The shown neural network has been trained with the thresholded dataset therefore then the power increases above the threshold value, the controller generates a "HIGH" this high signal connect the secondary load to the secondary source. Here two separate load has been used to demonstrate the primary or the secondary load. A dashboard lamp has been used in the model, that work as an indicator of the switching signal.

V. EXPERIMENTAL RESULTS

Simulation has been run for different time interval and the switching action is noted through an oscilloscope.

5.1: Result of the switching

It has been observed the controller is working satisfactorily according to the assigned thresholding. The scope waveform is shown in the figure below

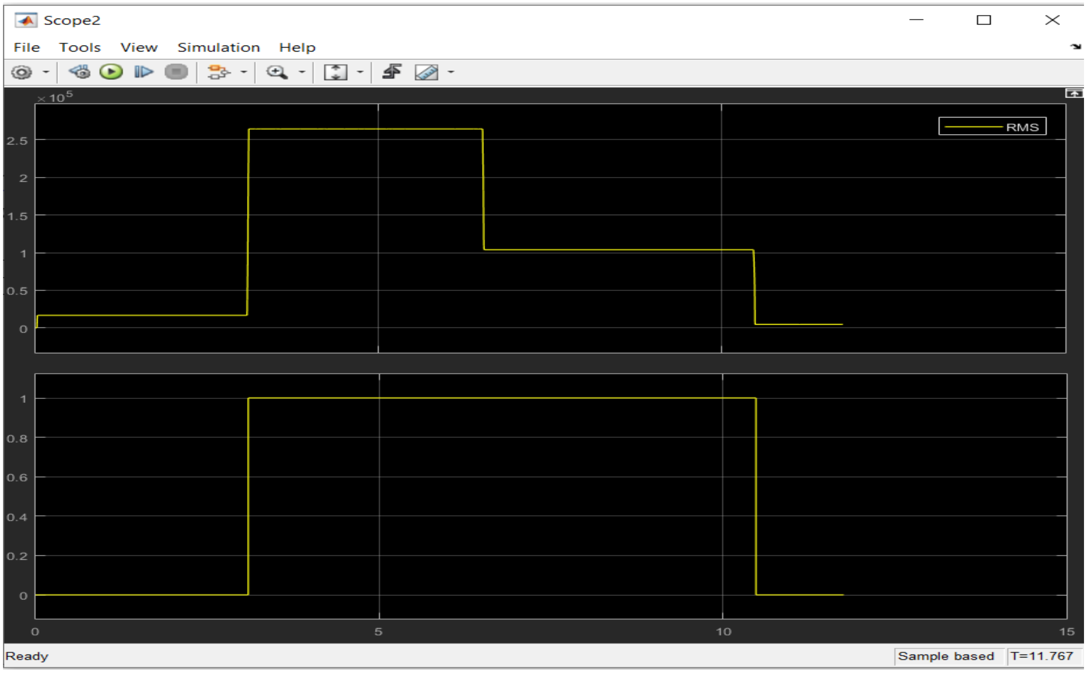

Figure 5: Switching waveforms

The top waveform shows the load change with respect to time and it is done by using the knob settings of the dashboard knob. The bottom signal is a switching signal that can either be 1 or 0 as assigned from the dataset.

5. Performance analysis of the trained network

The error histogram of the trained network is shown below

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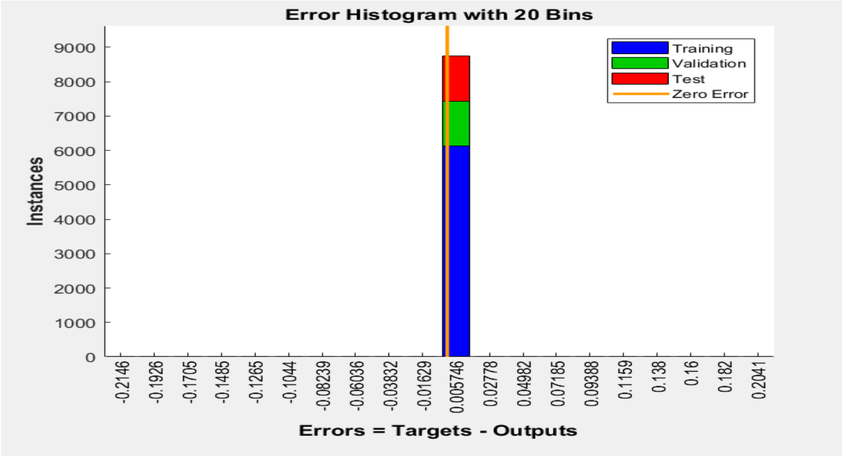

Figure 6: Error histogram

The regression fit of the Neural Network is shown below:

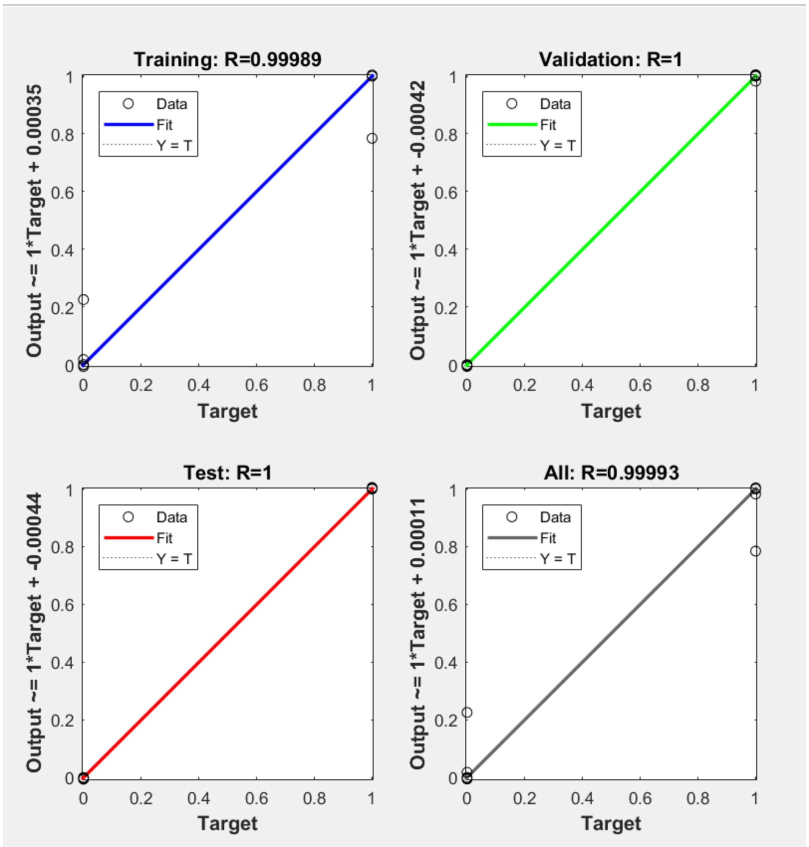

Figure 7: Regression fit

It can be seen that the regression of 99.9% has been obtained overall. The perfomace chart of the trained neural network is shown below.

The validation performance of the Neuralk network is shown below

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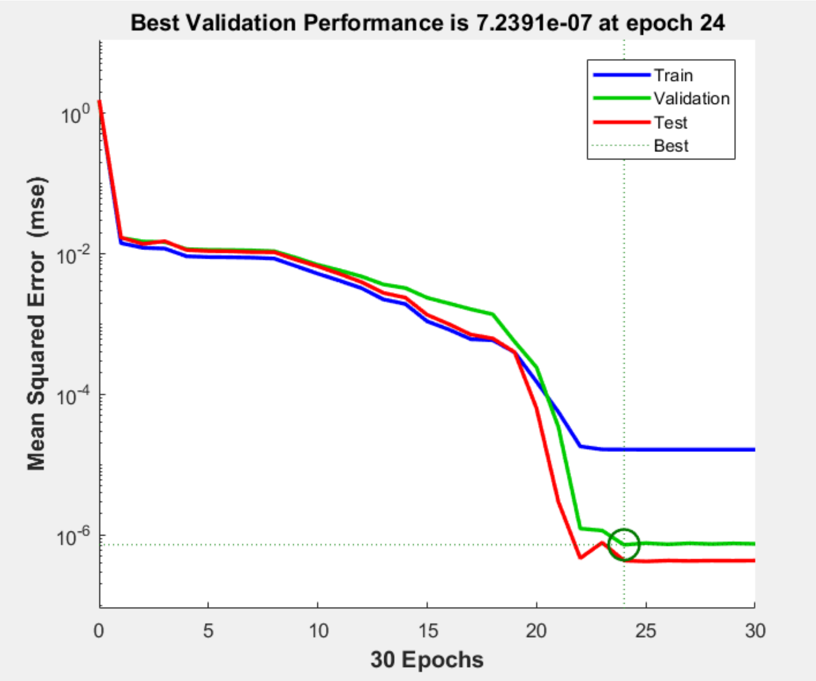

Figure 8: validation performance

VI. CONCLUSION

In this study, we employ the demand response management approach to balance electricity generation and demand. In a demand response management system, customers actively participate in lowering demand during peak hours in exchange for cash rewards. In this research work, a microgrid has been modelled using two separate source and load combination. A neural network has been trained by using the dataset of a commercial college building which consist of 8760 data entries. The neural network was responsible for performing the switching and the result obtained are found to be satisfactory. The maximum error is found out to be 0.0005% and a regression fit of 99.9% has been obtained. In the future, different algorithm may be applied to improve the performance of neural network.

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