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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

EFFICIENT MONITORING AND CONTROL SYSTEM FOR HYBRID SMART GRIDS USING FUZZY LOGIC AND IOT

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Abstract

Smart grids are electric grids that are composed of multiple power sources and devices connected to each other to provide better reliability in power generation and power management, modern developments of the smart grid aim at either improving the control of power sources and loads connected to the smart grid by developing a specialized software/hardware, or by improving the communication between the components of the smart grid and the central control. In this paper we aim at improving both sides of the smart grid system (communication and control), we propose a fuzzy logic based controller for renewable energy and fossil fuel sources in a smart grid and an internet of things based monitoring system which oversees the state of the smart grid, faults that occur in the smart grid , and how the fuzzy controller overcomes those faults, all in which provide an extra layer of support to the smart grid.

Keywords: PV. Solar energy. Fuzzy logic. Smart grid.

BULANIK MANTIK VE IOT KULLANARAK HİBRİT AKILLI ŞEBEKELER İÇİN VERİMLİ İZLEME VE KONTROL SİSTEMİ

Özet

Akıllı şebekeler, güç üretimi ve güç yönetiminde daha iyi güvenilirlik sağlamak için birbirine bağlı birden fazla güç kaynağı ve cihazdan oluşan elektrik şebekeleridir; akıllı şebekenin modern gelişmeleri, güç kaynaklarının kontrolünü ve akıllıya bağlı yükleri kontrol etmeyi amaçlamaktadır. özel bir yazılım / donanım geliştirerek veya akıllı şebekenin bileşenleri ile merkezi kontrol arasındaki iletişimi geliştirerek. Bu makalede akıllı şebeke sisteminin (iletişim ve kontrol) her iki tarafını da geliştirmeyi hedefliyoruz, akıllı bir şebekede yenilenebilir enerji ve fosil yakıt kaynakları ve devleti denetleyen şeylere dayalı bir izleme sistemi için bulanık mantık tabanlı bir kontrolör öneriyoruz akıllı şebekeye, akıllı şebekede meydana gelen arızalara ve bulanık denetleyicinin bu hataların üstesinden nasıl geldiği, bunların hepsi de akıllı şebekeye ekstra destek katmanı sağlar.

Anahtar Kelimeler: PV. Güneş enerjisi. Bulanık mantık. Akıllı ızgara.

1. INTRODUCTION

Improving the grid based electrical infrastructure occur on multiple levels of improvement and upgrade, in some cases the focus was on improving the level of assets and renewing the devices connected to the smart grid that are considered the back bone of the grid based system, in other cases the focus was on improving the level of communication between the connected asses of the smart grid and among the grid sectors. Aqeel et al. implemented a hierarchy-based system of fuzzy logic control to prioritize the different assets in the smart grid by coping a decision analyses scheme in the Saudi electric infrastructure. Simoes et.al. proposed a frequency support system for a wind turbine farm connected to the smart grid and control that frequency using fuzzy-based controller in order to provide better stability in power generation for the load as shown in the figure below:

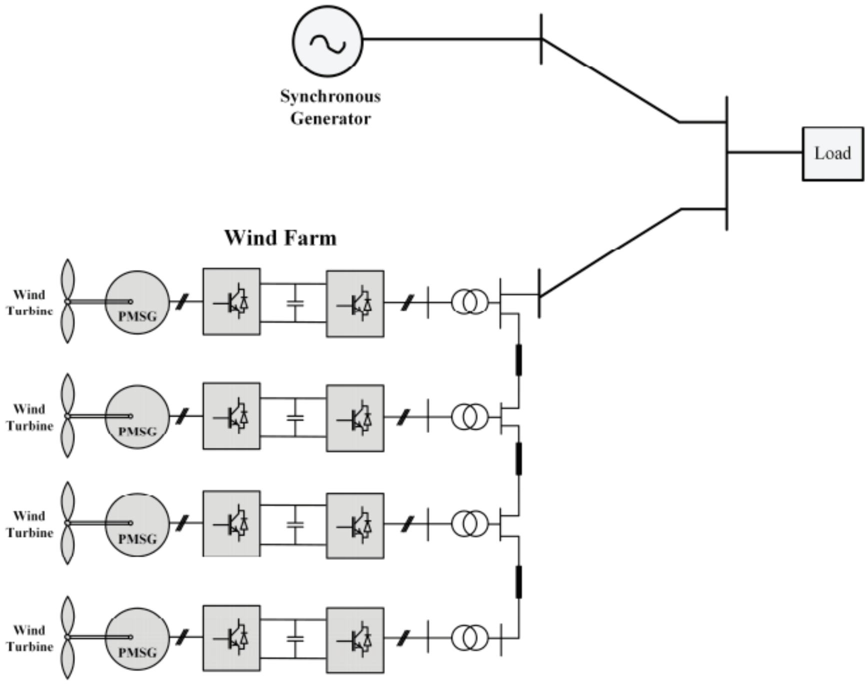

Fig. 1 Wind farm smart grid system structure consisted of 4 wind turbines, a load, and a fuzzy logic controller.

Alnasser et al. aimed at improving the communication between smart grid sectors by implementing a secure routing scheme based on fuzzy logic trust model. Kaile et.al implemented a smart metering system in smart grid-based electricity consumption for the average consumption patterns in Chinese residential neighborhoods. Zhao et.al reviewed the stability in multiple smart grid-based systems that use the ANFIS fuzzy logic-based control, Zeng et.al review the smart grid-based system response to the peak load demand in distributed systems using fuzzy logic data mining techniques. Wu et.al reviewed the security measures taken by smart grid connections in order to prove the stability of the fuzzy based control of the smart grid. Tiar et.al implemented a fault tolerant control system based on the neuro fuzzy logic control ANFIS and achieved voltage stability in the smart grid while Soetedjo et.al implemented a wireless control of the smart grid based on the neuro fuzzy logic in order to control the voltage stability in the grid. In this work we implement an IOT based monitoring system and fuzzy logic based control system to monitor and control the loads and sources in the hybrid smart grid using the MATLAB simulation toolkit SIMULINK and the TCP/IP/UDP modules to send and receive commands from one MATLAB proxy to another. The rest of the paper is organized as follows: Section 2 is where we explain our model and implementation of that model, Section 3 is where we simulate our model and record the results obtained. Section 4 is where we conclude our work and put a future scope into perspective.

2. PROPOSED METHOD

We implement our scheme by modelling a simulation of a smart grid inside MATLAB using the various tools available in the MATLAB SIMULINK modules, then we create a visualization of every status of every component in that grid to send and receive from one MATLAB to another using the UDP module as shown in the figure below:

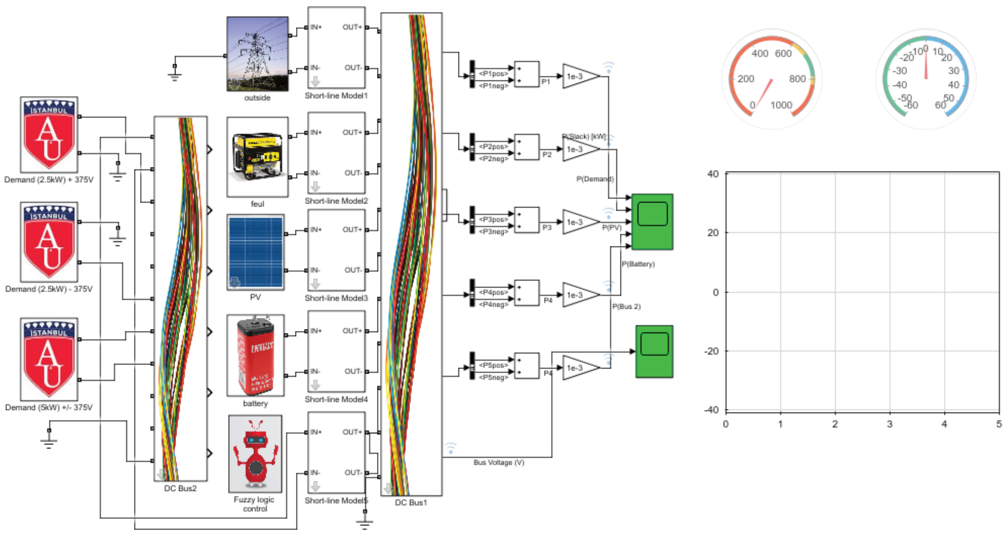

Fig. 2 Proposed smart grid and component status visualization.

2.1 Smart grid control using fuzzy logic

Fuzzy logic is a mathematical approach to computing the level of truthiness in a Boolean value rather than using the conventional TRUE/FALSE approach, in this model we propose a fuzzy based control system to control the load demand and source generation in our smart grid in order to achieve voltage stability, the figure below figure 3 shows the general approach to the defuzzification method in a fuzzy logic controller:

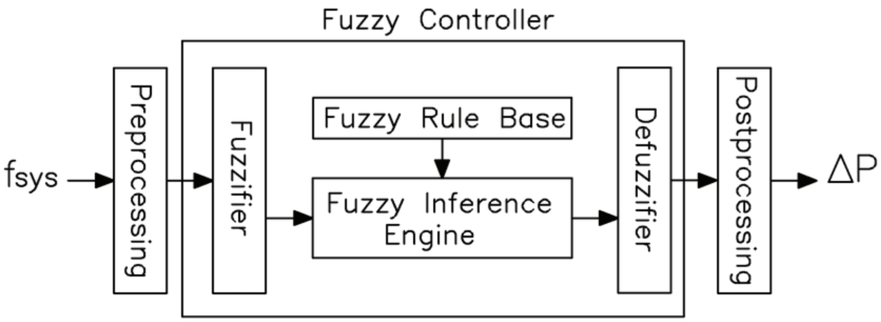

Fig. 3 General implementation of fuzzy logic.

The fuzzy logic control system controls the power sources generation and the switching between these sources, if one source fails to provide power, the fuzzy controller switch to the power source with the same power generation in order to achieve stability, the fuzzy controller controls the overall switching (on/off) in a power source thus controlling every aspect of the power generation, the hybrid smart grid system include sources of conventional energy sources and some renewable energy sources such as battery and solar PV array, the figures below figure 4 shows the PV array simulation in MATLAB and figure 5 shows the space vector pulse with modulation voltage control of the PV array power generation.

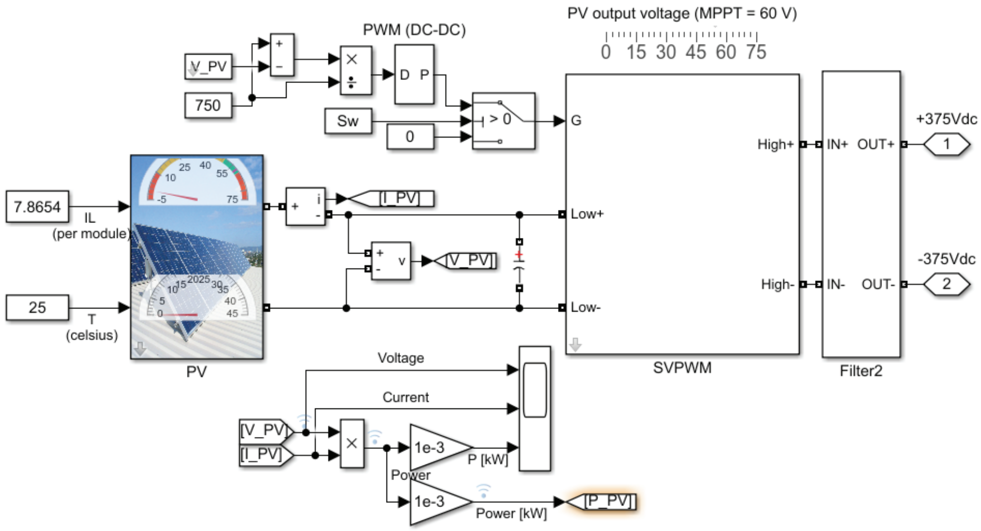

Fig. 4 Matlab implementation of the PV array.

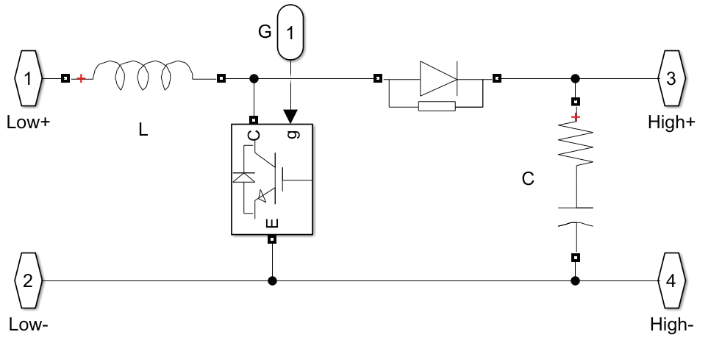

Fig. 5 SVPWM voltage control of the PV array.

While the figure below figure 6 shows the battery power source implementation in MATLAB and the monitoring scopes of the battery status:

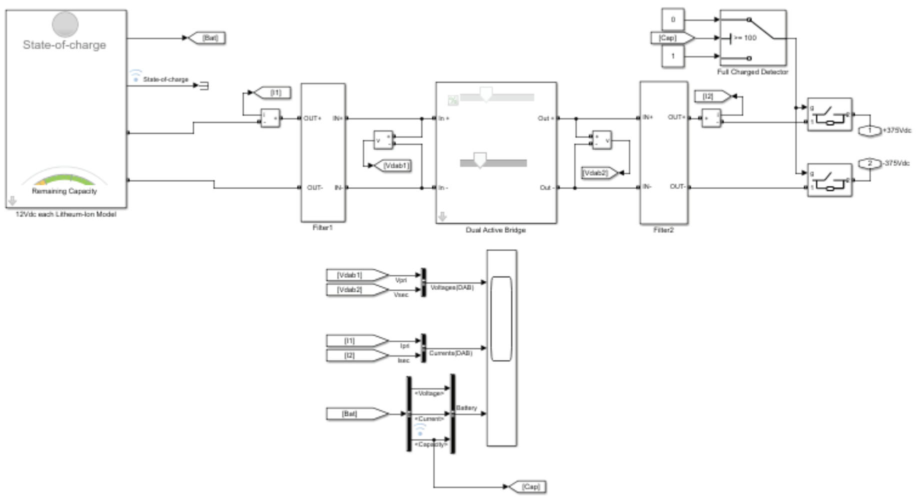

Fig. 6 MATLAB implementation of the Battery power source.

2.2 IOT based monitoring system

In order to achieve better control over the smart grid we must have a dynamic view and monitoring of the overall status of every aspect of the smart grid, this can be achieved through the power of IOT systems, we implement our IOT system by sending the visualization of the smart grid status to a receiver device that acts as a monitor for the system, we achieve that by using the UDP/IP modules inside MATLAB, where we set an IP for the communication between devices, and send data from one MATLAB to another, the other device receives the data and present it in a scope, the figure below figure 7 shows the UDP module inside MATLAB while figure 8 shows a practical implementation of that module:

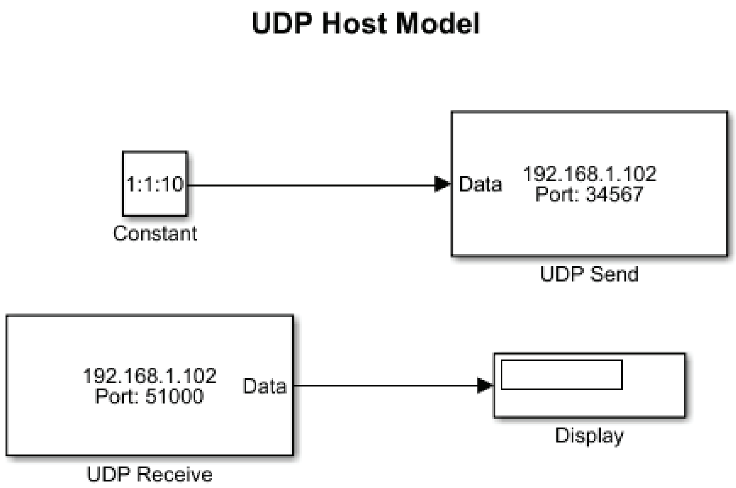

Fig. 7 Matlab UDP send and receive module.

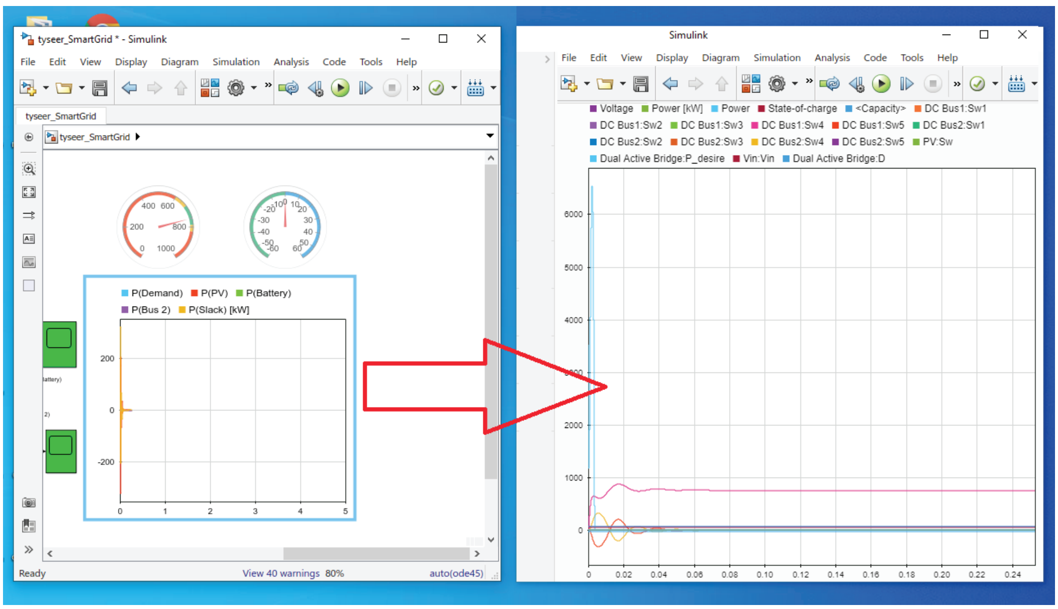

Fig. 8 communication between windows where one acts as a sender (control) and the other acts as a receiver (monitor).

3. SIMULATION AND RESULTS

In order to evaluate the efficiency of our model we must monitor the performance of the grid in multiple cases, one case being the performance in normal conditions where all the loads receive power and all the source work normally, and another case where there are faults and errors in a source or a load demand or both, the figure below figure 9 shows the stability of the voltage flow in the busses.

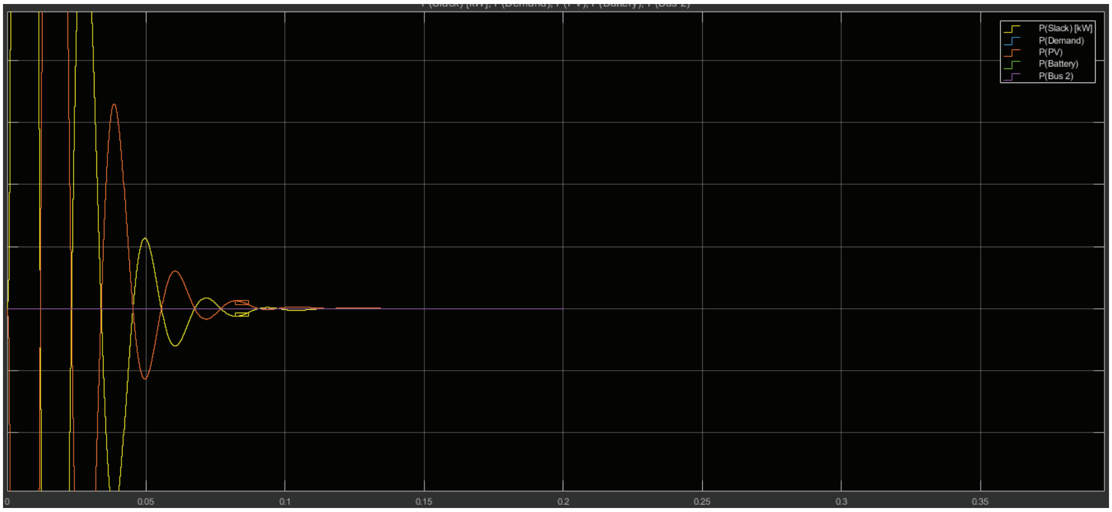

Fig. 9 Smart grid performance under normal conditions.

As seen in the figure 9 above, the stability is volatile in the first stage of the power generation, because all the sources generate power at once and all the loads demand power, but when the fuzzy logic respond to that generation/demand, the controller achieved voltage stability, the figure 10 below further shows the stability of the voltage in a bus:

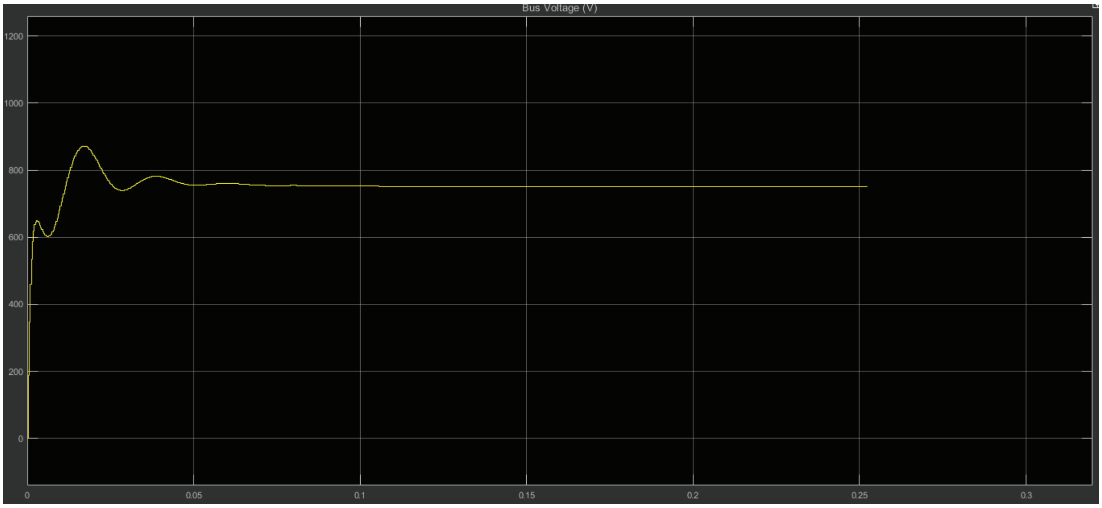

Fig. 10 Voltage stability in the bus before and after the fuzzy logic control.

Lets take the other case where one power source fails to generate power yielding a gap in the power generation and the voltage stability, lets take for example a fail in the fuel generator, the fuzzy logic control acts fast and increase the power acquired from the solar PV array battery to compensate for the gap, the figure below figure 11 shows the voltage flow as it drops in the fossil fuel generator bus in the first yellow line , and increase in the battery bus in the middle yellow line, while the last yellow line shows the stability in the load demand bus, we can see that it was not effected by power fluctuation thus proving the effectiveness of our model.

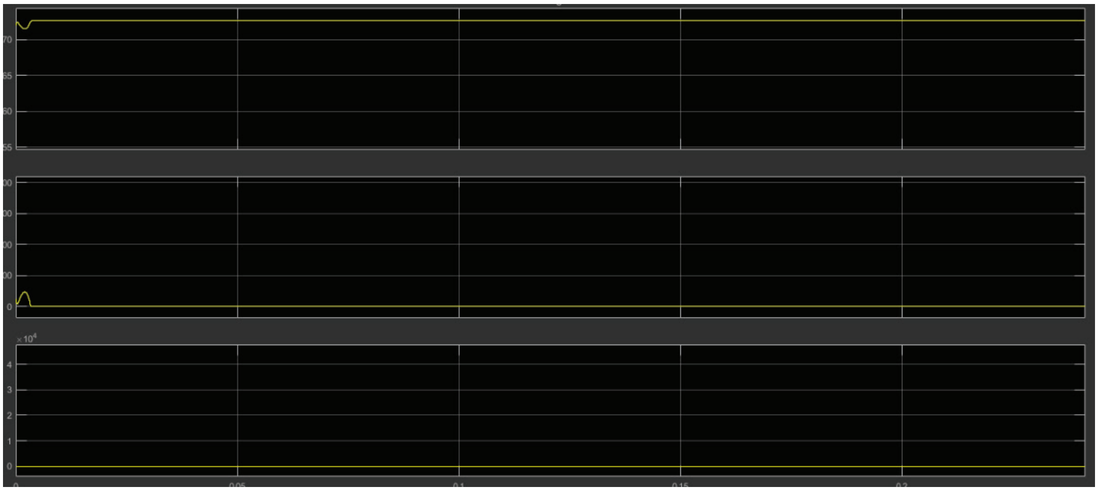

Fig. 11 Voltage stability and fluctuation in the fossil fuel, battery and load demand busses.

4. CONCLUSION

Smart grid improvements occur on two aspects: improvements on the assets connected to the smart grid, and improvements on the communication method used in the smart grid. In this paper we improved the two aspects of the smart grid by implementing a control and monitoring system for the hybrid smart grid using fuzzy logic and IOT, we simulated a smart grid inside MATLAB and performed a fuzzy based control operation on the smart grid considering multiple cases of normal and abnormal conditions, then we monitored the performance of the fuzzy control using the UDP module to send and receive the visualizing the grid status. In the future we suggest using a clustering algorithm to segment the grid and classify the appropriate load demand and the power flow in the grid.

CONFLICT OF INTERESTS/ÇIKAR ÇATIŞMASI

Authors declare no conflict of interests/Yazarlar çıkar çatışması olmadığını belirtmişlerdir

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