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# PV-Based MPPT for standalone DC Micro Grids using Fuzzy Logic

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## ABSTRACT

***Due to the large variations in production and demand, stand-alone green energy management systems are becoming more important for power sharing and voltage regulation tasks. Traditionally used power management methods use maximum energy factor monitoring (MPPT) algorithms and depend on batteries in the event of a power surge or shortage. However, in order to maintain a constant current-constant voltage (IU) charging regime and extend the life of batteries, energy management methods must be more adaptable with regard to power curtailment. The article offers a technique for battery management of a hybrid solar photovoltaic and wind energy device for stand-alone applications. Due to the non-linear nature of battery charging, which is time-varying with a large time delay, it is challenging to obtain the optimum energy management performance using conventional control methods. The article analyses a fuzzy manipulates method for battery charging and discharging in a renewable energy production system. To extend the battery's life, fuzzy control maintains the appropriate level of charge (SOC). A fuzzy logic-based controller is suggested for use in manipulating the battery state of charge of the intended hybrid system, and its performance is validated in contrast to a conventional PI controller.***

***Keywords:*** *MPPT, PI controller, Renewable Energy Sources, Energy Consumption*

## 1. INTRODUCTION

Any nation's economic, industrial, and social growth need energy. Petroleum derivatives are the major energy sources, which have been over-used, resulting in disastrous consequences such as air pollution and environmental destruction. Consumption of petroleum derivatives releases harmful gases into the atmosphere, which have severe consequences for living areas and also have an impact on human health [1]. They are a non-renewable energy source since they are derived from pre-historic fossils and are no longer available once used. Their supply is limited, and they are depleting at a faster pace. Renewable energy generation is a good way to protect the environment while also providing a solution to the limited availability of non-renewable energy sources.

Increasing energy consumption, high energy prices, as well as worries about environmental effect, health, and environmental change, have enticed many experts and communities to pursue elective energy research. Several studies have been conducted for the use of renewable energy sources (e.g., wind, solar, and biogas) that are self-contained [2], [3]. Wind and solar energy are the two most promising renewable energy production technologies. Normally, load distant regions where mains power supply is unavailable use wind or solar electricity. The use of renewable energy sources is harmed by isolated power systems since their availability is affected by day-to-day and seasonal variations, causing issues with controlling the output power to the load [4]. For example, variable daily wind speeds and reduced solar irradiation throughout the evening and on overcast days causes wind and solar frameworks to provide load throughout the day with poor consistency. Because both solar and wind power are available 24 hours a day, seven days a week, month after month, and year after year, selected breeze or solar power frameworks cannot be used on their own because electrical systems need continuous electricity. The use of hybrid energy frameworks [1] is another viable approach. The control need for optimum productivity is a significant drawback of these hybrid systems [5]. Conventional control methods need a scientific model to ensure that the dynamic framework is controlled. After that, a numerical model is used to build a controller. Generally, it is not feasible to establish a regulated framework with a precise scientific model in a variety of everyday circumstances. Artificial intelligence (AI) control enables the resolution of difficult issues paradigm by enforcing non-formal phonetic control rules derived from master knowledge [6].

Fuzzy logic control frameworks offer the advantage of reproducing every desired aspect of human input while retaining the benefits of automated closed-loop control. The use of fuzzy logic control is one of the main issues because it solves the difficulty of selecting and planning enrollment functions for a particular situation [6]. There is currently no exact method for selecting the kind of enrollment function and the scopes of elements in the discourse universe. For a fuzzy controller to function well, it is critical to tune it through trial and error. However, neural networks are capable of identifying the distinguishing characteristics of a framework that has been extracted from the input-output data. The learning ability of neural networks is coupled with the control capabilities of fuzzy logic frameworks to create a neuro-fuzzy inference framework [6].

Controlling hybrid power frameworks is often a difficult task, since such frameworks cannot be accurately represented due to their complex composition. Various methods for energy management and optimization have been discussed in detail. Current methods have shortcomings in terms of accuracy, adaptability, and efficiency. Thus, there is a need for developing a controller capable of mitigating these disadvantages. The purpose of this study was to examine ways for improving the legal administration and efficiency of energy resources in a hybrid photovoltaic-wind energy system by using artificial intelligence technologies.

This thesis offers a framework for hybrid wind and solar photovoltaic energy storage in stand-alone applications. Because the battery charging process is non-linear, time-varying, and involves a considerable time delay, it is difficult to achieve optimal energy management execution using traditional control methods. The article examines a fuzzy control technique for battery charging and discharging as part of a framework for sustainable energy generation. To prolong the life of the battery, fuzzy control is used to manage the desired state of charge (SOC). The suggested fuzzy logic-based controller is used to manage the battery state of charge of the intended hybrid framework and is compared to an existing PI controller for execution approval. The whole constructed framework is shown and reenacted in MATLAB/Simulink.

The smart load (SG) guarantee is nearing completion. Regardless, society and research cannot wait for the adoption of many load and standard codes, particularly when these energy consumers' freedom is constrained by these provider-imposed codes. In this instance, demand management is accomplished via the use of local energy production and storage structures.

performing microloads or tiny loads in this way. Microloads should be able to address energy problems on a local level, thus increasing flexibility. Power electronics plays a critical role in achieving this ongoing innovation.

The future load is envisioned as a network of linked microloads, with each customer responsible for the production and storage of energy, as well as for transmitting energy to neighbours.

Thus, critical components include microloads for coordinating distributed and renewable energy resources, as well as frameworks for distributed energy storage. This means that in the next decades, new power electronic equipment will exceed the electrical demand. As a result of this new load pattern being significantly more dispersed, the energy production and consumption ranges cannot be envisioned separately. Nowadays, energy and electrical designers must deal with a new scenario in which distributed power is scattered and generators and energy storage devices must be coordinated and integrated into the load. The new electrical load, dubbed SG, would transport power from providers to customers by using digital technologies to regulate apparatuses in customers' houses, thus lowering costs and conserving energy and increasing simplicity and dependability. In this respect, the typical whole energy framework will be very perceptive, dispersed, and intelligent. Without using distributed storage (DS) frameworks to react to energy changes, the use of distributed generating (DG) seems to be inefficient.

## 2. PHOTOVOLTAIC ENERGY CONVERSION

A photovoltaic system converts sunshine into electricity. The solar cell is the critical component of a photovoltaic system [9]. Cells may be grouped together to form panels or modules. Panels may be grouped together to form large solar arrays. The word display is often used to refer to a solar panel (with a few cells connected in series and parallel) or a collection of panels, as shown in Figure 1. Panels connected in parallel increase the current, whereas panels connected in series provide a significant yield voltage [9].

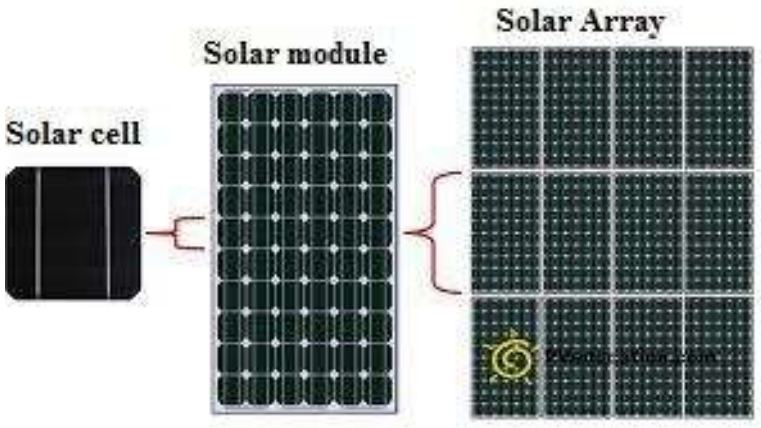

**Figure 1: Photovoltaic cell, module and array**

Photovoltaic cells are created utilising semiconductor materials that are exposed to sunlight in order to generate electrical current. The part of the life a photon delivers to a photovoltaic cell is trapped by the semiconductor material after it hits the cell. When that vigour slams electrons, they are able to stream without obstruction. Electric fields generated between the P-sort and N-sort layers of the cells at that moment govern the free movement of electrons

## 3. MODELING OF PHOTOVOLTAIC MODULE

Reliable information and comprehension of the PV module's performance under a variety of operating situations is critical for making the right item selection and forecasting its vitality performance accurately. The performance of a crystalline silicon photovoltaic module is dependent on the physical properties of the module's material, its temperature, and the sun radiation incident on the module's surface [11].

Numerous studies have examined better simulation models, such as power productivity models [12], that can forecast the time series or average performance of a photovoltaic array under changing climatic circumstances.

Kerr and Cuevas [12] described another technique for determining the mutt rent voltage (IV) properties of photovoltaic modules by concurrently monitoring the open-circuit voltage as an element of a steadily changing light intensity. Additionally, they provided a comprehensive theoretical analysis and interpretation of such quasi-steady-state open circuit voltages (Voc) measurements.

Borowy and Salameh [13] presented a new presentation in which the maximum power output of a photovoltaic module could be estimated provided the solar radiation on the module and the ambient temperature were determined.

Zhou et al. [14] developed a new simulation display for predicting the performance of photovoltaic arrays.

for developing applications that take use of the I-V bends in a photovoltaic module. Five factors are discussed in detail to illustrate the complex relationship between PV module performance and solar radiation power and module temperature. The authors assumed that this simulation display is fundamental and particularly beneficial for architects in calculating the real performance of the photovoltaic modules under operational circumstances using limited data provided by the photovoltaic module manufacturers. Yang et al. [23] developed a model for estimating the maximum power output of photovoltaic modules using the equivalent circuit theory of solar cells. They used eight factors that may be identified from experimental data using the Amoeba Subroutine or Downhill Simplex Method. The accuracy of this model has been verified by experimental data demonstrating a high level of wellbeing.

## 4. RESULTS AND ANALYSIS

**Table 1: Simulation Environment**

| **Wind** | | **Battery** | |
|---|---|---|---|
| Power | 8.5e3 W | Voltage | 300V |
| Speed | 12 m/s | Initial SOC | 60% |
| Maximum Power | 0.8MW | Maximum Capacity | 7KW |
| Rational | 1 P.V | Normal Discharge current | 353.38 |
| | | Resistance | 6.25 Ohm |

| **PV** | | **Simulation** | |
|---|---|---|---|
| Base Power | 100e6 | t | 300-600V |
| P2 Tolerance | 1e-4 | $V_{iv}$ | 26.3V |
| Frequency | 50 Hz | Nominal voltage | 48.0V |

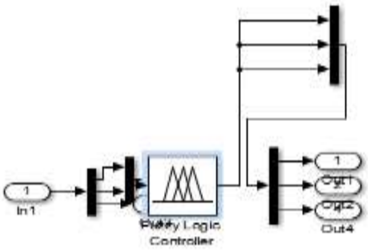

**Figure 2: Fuzzy Interface in Simulink**

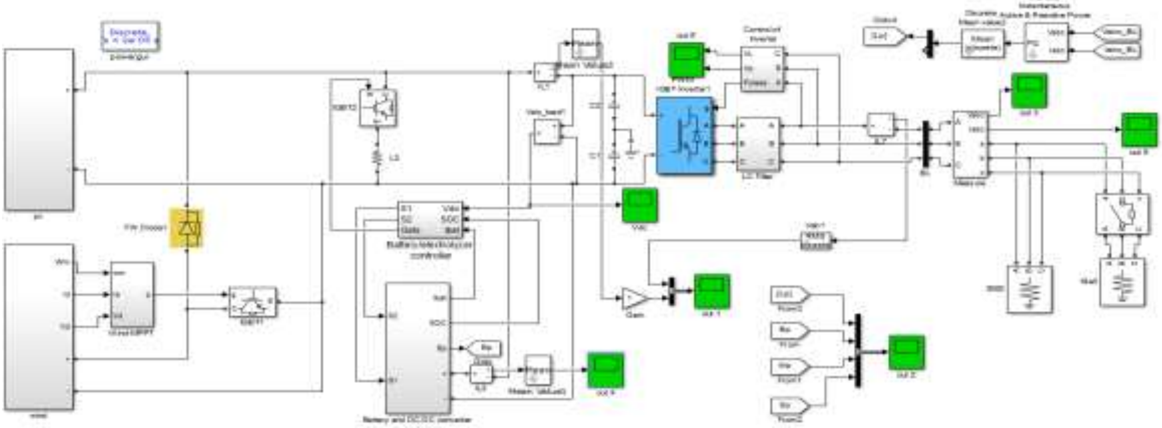

**Figure 3: Simulink Used for Simulation**

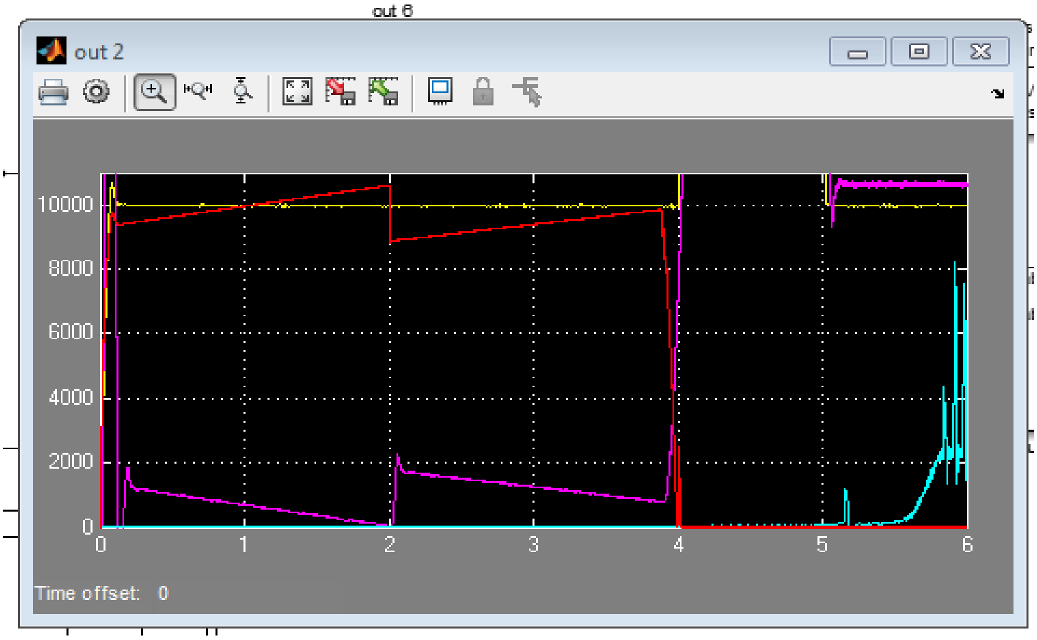

**Figure 4: Voltage angle of PV, Battery and wind during single controller**

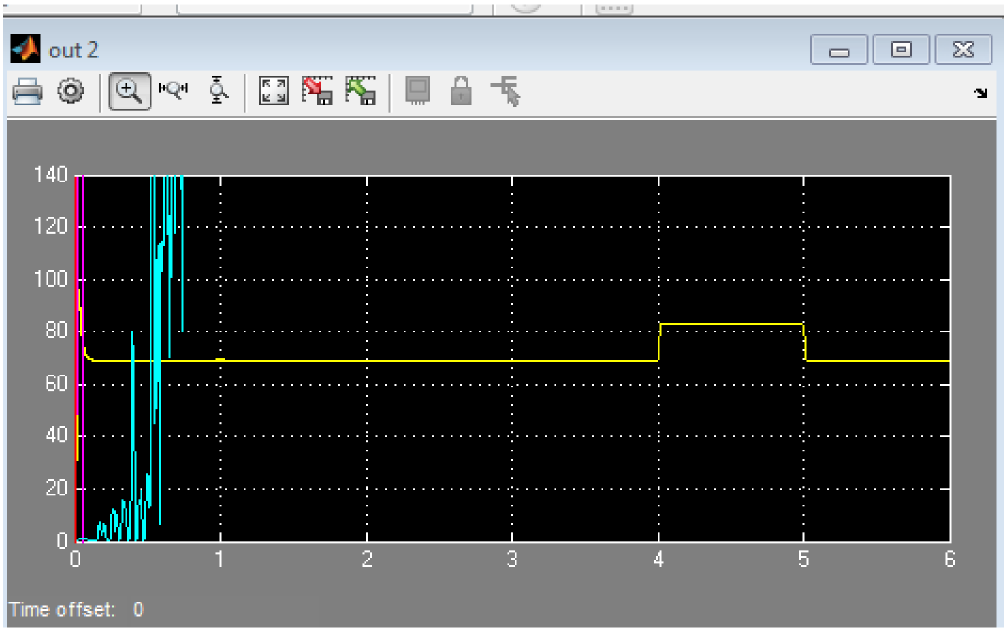

**Figure 5: Voltage angle of PV, Battery and wind during fuzzy controller**

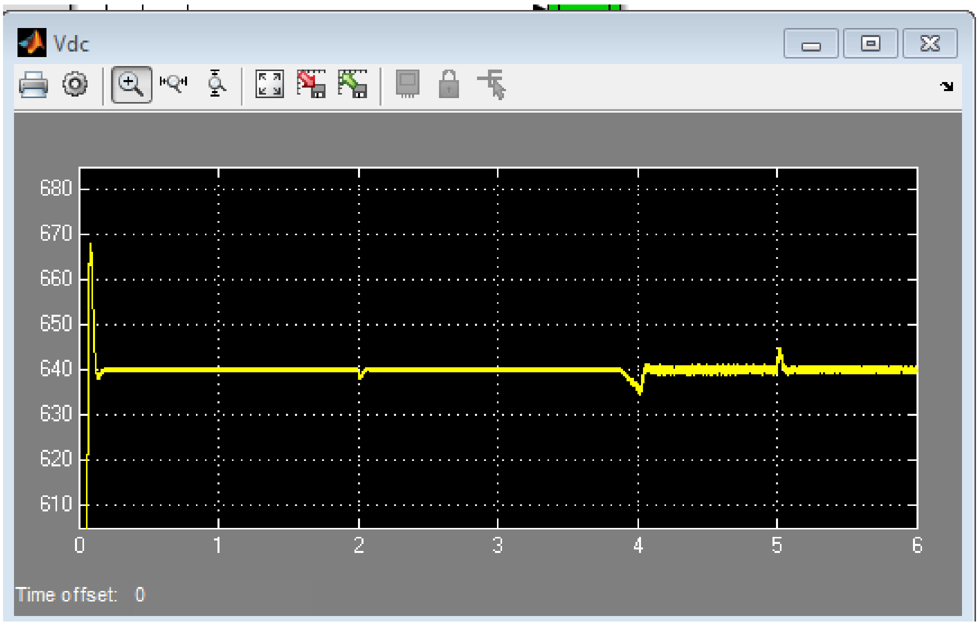

**Figure 6: Battery gain by single controller**

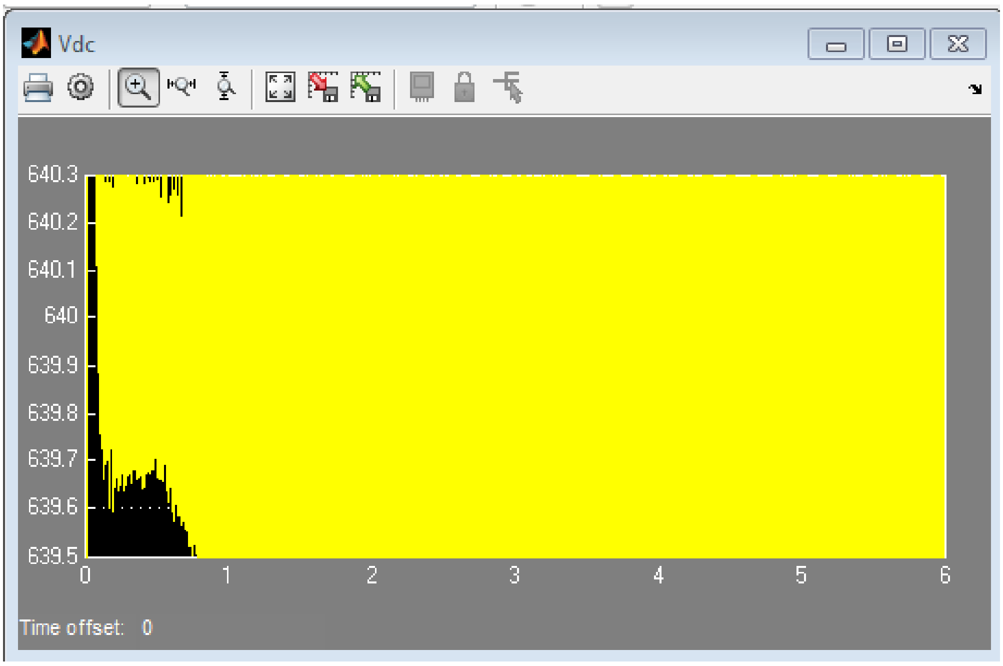

**Figure 7: Battery gain by Fuzzy controller**

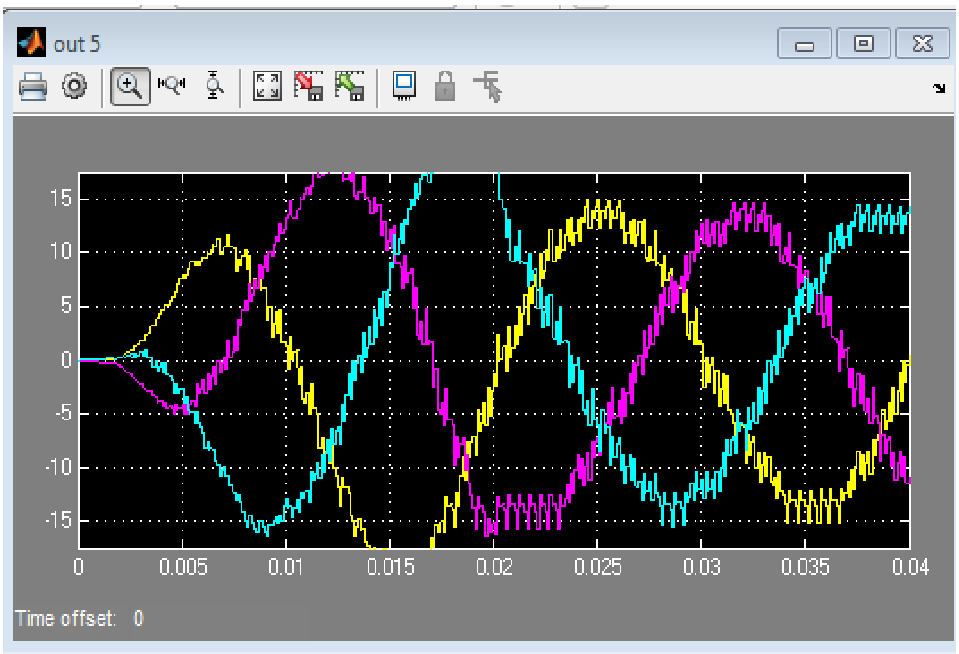

**Figure 8: Load flow by single controller**

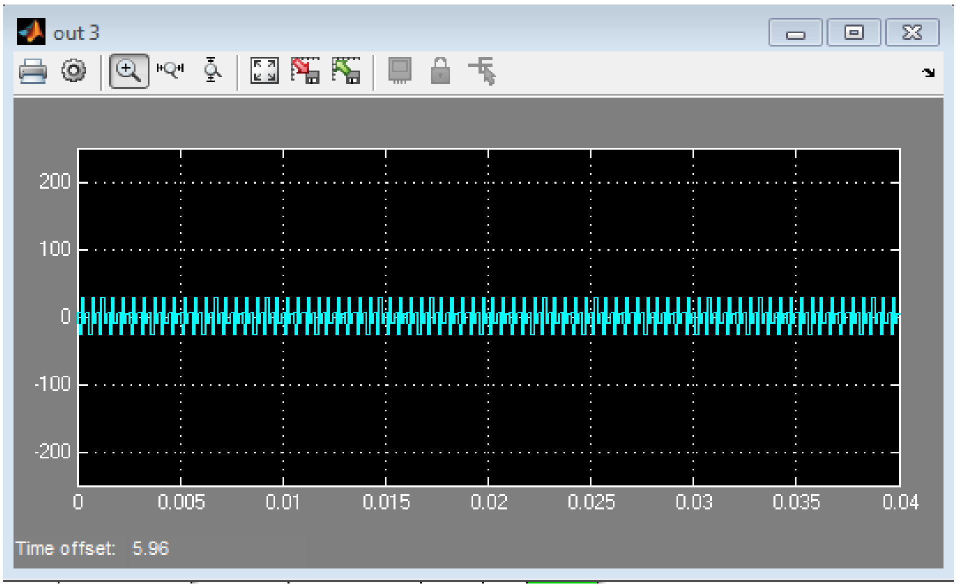

**Figure 9: load low by fuzzy logic**

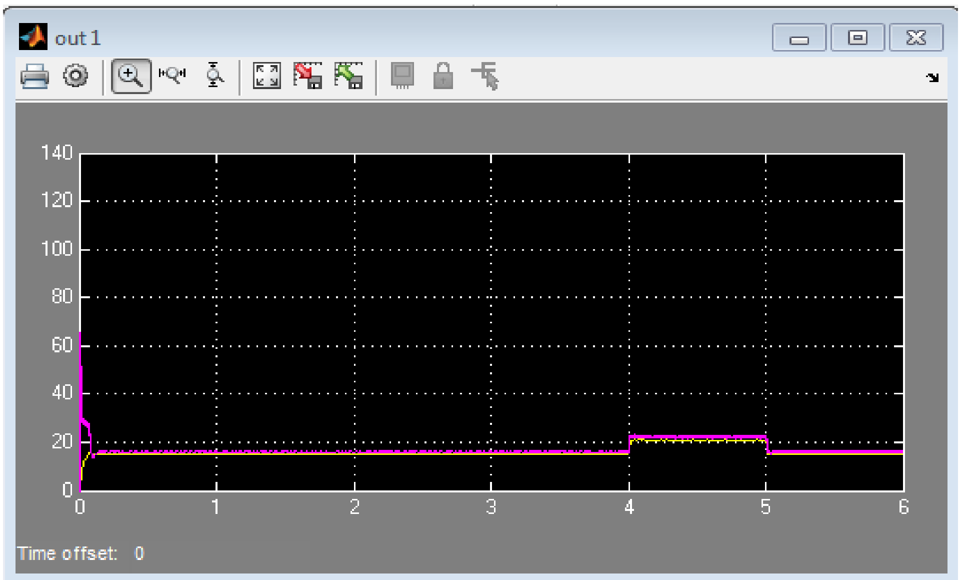

Figure 10: Volume of wind and PV array current by single controller

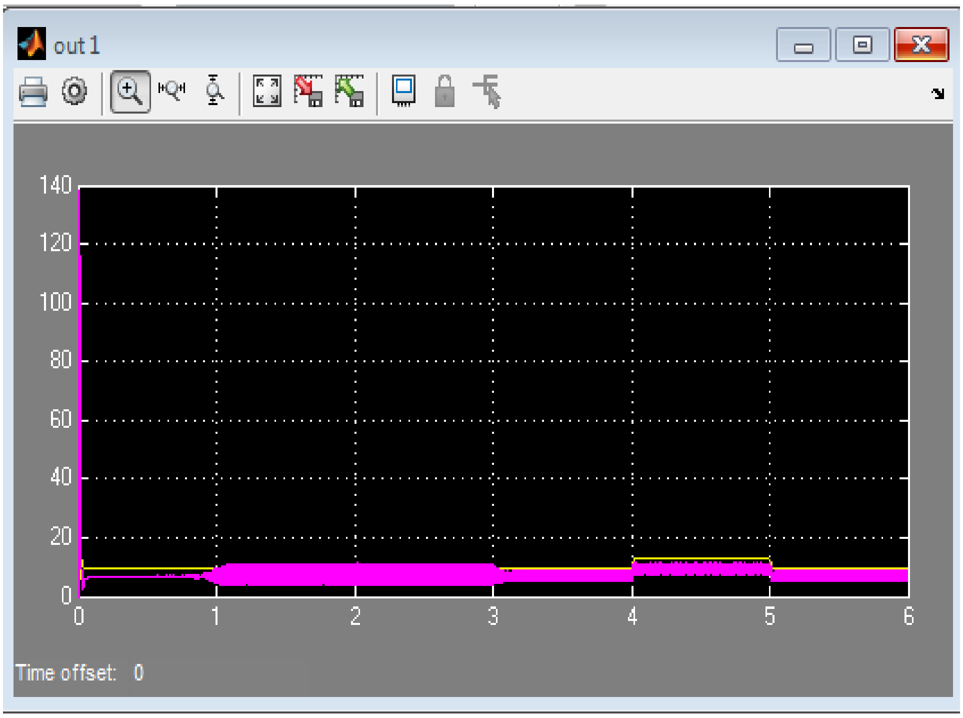

Figure 11: Volume of wind and PV array current by fuzzy controller

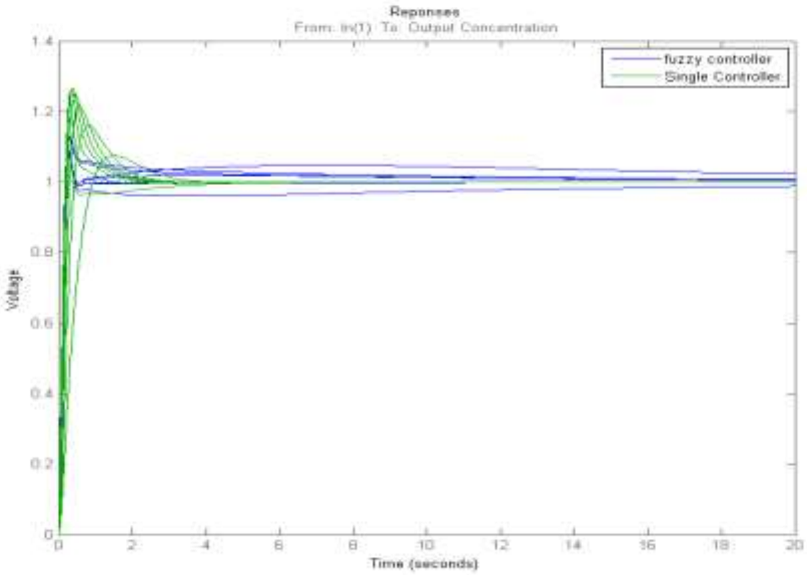

Figure 12: Voltage stability comparison

**Table 2: For case study environment**

| Component | Rating(W) |
|---|---|
| Wind Power | 1500 |
| PV Power | 1500 |
| Battery | 3000 |
| Load | 2000 |

## 5. CONCLUSION

1. The properties of a photovoltaic cell, module, and array are simulated and the impact of external variables on them is investigated.
2. A wind energy system has been investigated and modelled.
3. The FUZZY rules algorithm is used to determine the maximum power point of operation for both systems.

Both systems are interconnected, and the hybrid system is utilised to charge and discharge the batteries.

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