

An improvised modelling of hybrid power system in MATLAB using solar power and fuel cell with the Internet of Things implementation.

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Abstract - The fundamental necessity of every human is the electrical energy. Electrical energy is used extensively from its invention for various purposes. Previously, the power plant that generates electrical energy was based on fossil fuel or hydro power. Nuclear power plant has also seen a tremendous growth in the recent decade. As the population of the world is increasing day by day, consumption of fossil fuels is also increasing proportionally. There is a need of alternative source of energy that should not only available in abundance but should also be easy to harness. Solar power, wind power, fuel cell, biomass energy, etc., are some of the examples of alternative source of energy. Combination of two or more source of energy is called hybrid power source. The power plant that depends on hybrid power source is called hybrid power plant.

in this paper, A modelling of hybrid power plant made up of solar power and fuel cell is done in MATLAB Simulink. the model has been improvised by adding auto-switching, noise filtration mechanism, single phase inversion mechanism, and also with the internet of things implementation. the result obtained from their simulation is found to be satisfactory. In the future scope, similar improvised modelling can be done for different hybrid power sources.

Key Words: hybrid power system, simulations, solar, fuel cell

1. INTRODUCTION

With the fossil fuel crisis, danger of dependence on oil pushed the research and the development of the alternative energy sources. Current trend in electricity generation is to utilize the renewable energy resources such as solar, wind, biomass, micro-hydro systems. With the expectation of promoting electricity generation based on non-conventional renewable energy, the government of country is always providing various schemes. The dependency on fossil fuels are to be minimized

as much as possible. Based on the above discussion, switching on the renewable energy resource is very much essential.

Power from the alternative source of energy will be the backbone of the power supply to various system because of the limited fuel resources and the effect of that on the environment [1]- [2]. The main advantage of the alternative source of energy is that they are pollution free, easily available and present in a very large amount with zero slope of consumption. An alternative source is a source that does not depend on the fossil fuel [3][4] or the nuclear actions [5].

Solar system depends on the sun rays to generate electricity. Solar power generation has seen a great improvement in the recent years. Three types of solar panel are used currently, mono-crystalline, poly-crystalline and amorphous thin film. The efficiency of Mono-crystalline solar panel is the highest [6]. It has been observed that the cost per watt peak of mono-crystalline is high as compared to amorphous and polycrystalline panels [6]. As the temperature increases above 450 the efficiency of all the three types of panel becomes almost equal. In the region of higher temperature, amorphous solar panel is the best choice as it gives the same power with less cost per watt peak [6].

It has been estimated that by the year 2050, solar will provide the 45% of the total power requirement [7]. A fuel cell is a cell that converts a chemical energy to the electrical energy [8]. With the rapid advancement of the fuel cell, hydrogen based energy production is becoming more practical [9]. The combination of these two power sources provides a sustainable power generation.

Hybrid power system is the best option to cater the global energy demand [10]. In the Hybrid power system, the power is taken from two or more than two different types of energy sources. Solar and Fuel cell together is a good option to form a hybrid power system. Different Mathematical models of hybrid power system have been developed using MATLAB. Solar panel is used to be a main source of energy in such hybrid power system while the fuel cell is used as a secondary source of power. When the climatic condition changes, solar panel may not provide the sufficient power to the load, under such condition, the power is taken from the backup source, which is a fuel cell [11]

The main objective of the paper is to design and assess the performance of the Solar-Fuel cell hybrid power system for the electricity generation.

Specific objectives are discussed below

1. Discuss on the energy crisis from the conventional sources of energy
2. Development of Simulink model for the hybrid power system based on the solar cell as well as the fuel cell
3. Development of the controller to switch between the sources based on the environmental condition
4. Implementation of filtering action and the inverter model to the hybrid power system
5. Implementation of Internet of Thing technology to the model to enhance its capability to visualize the data over the internet on mobile/PC.

2. System Design

The hybrid power system model has been made in the MATLAB Simulink. Simulink is a tool in the MATLAB that has a large number of libraries in it. Each library has a function block that can be connected together to form an overall system [12].

The block diagram of the complete model is shown below

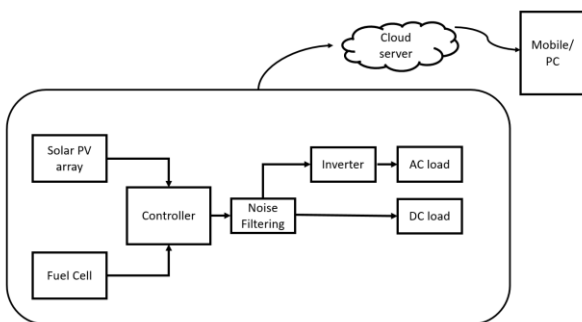


Figure 1 Block diagram of overall system

As shown in the above block diagram, the hybrid power system is comprising of solar cell and the fuel cell. The solar cell and fuel cell are connected to the controller. The controller controls the power flow from the source to the load. To run the AC loads, single phase inverter model has been Implemented. Noise filtering has been done to remove the noise from the signal. Finally, the data from the model is sent over the mobile/PC via internet of Things.

3. Modelling of Hybrid power system

The hybrid power system model has been made in the MATLAB Simulink. Simulink is a tool in the MATLAB that has a large number of libraries in it. Each library has a function block that can be connected together to form an overall system [12].

The parts of complete Simulink model of the developed hybrid system are shown below

Simulink model of hybrid power system

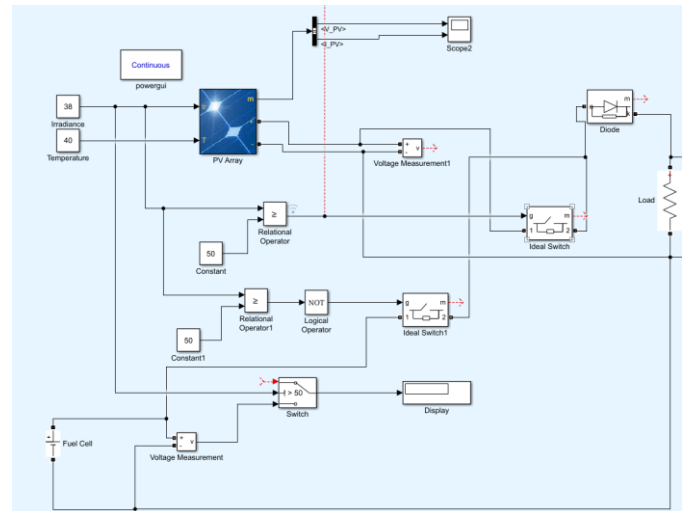


Figure 2 Simulink model of hybrid power system

Description: In the above Simulink model, the irradiance of the PV array is mapped to a knob. By rotating the knob in the clockwise direction, the irradiance value increases and vice versa: The mapped knob is shown below

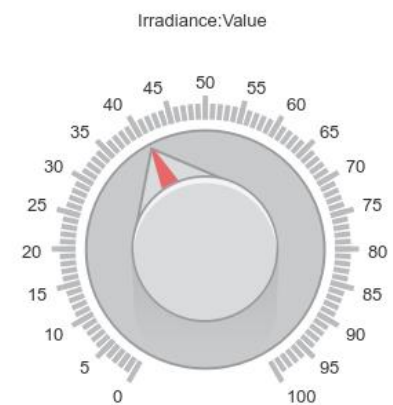


Figure 3 Knob for controlling the radiation intensity

Along with the knob two lamps are used in the model to show the status of the power source which is delivering the power to the load. As shown in the figure below the power is taken from the fuel cell. Here the blue colour is assigned to the fuel cell.

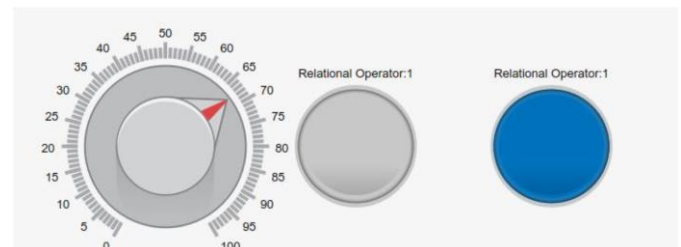


Figure 4 Indicators showing power is taken from Fuel Cell

As shown in the figure below, the power is taken from the PV array. The green colour is assigned to the solar power.



Figure 5 Indicator showing power is taken from Solar cell

Simulink model to provide filtering action:

A signal may get contaminated with the external noise. These external noise may decrease the life time of the load. There was a need of adding filtering action to the hybrid power system. The model of filtering action is shown below

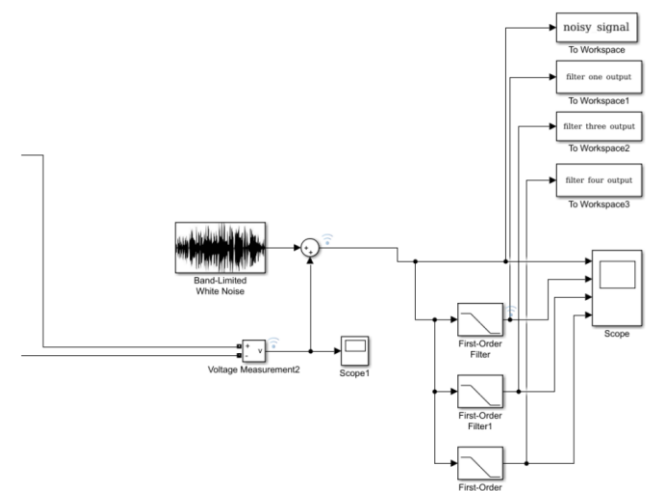


Figure 6 Simulink model to provide filtering action

Simulink model of Inverter:

The power from the power system may be used to power a DC load or an AC load. Our model produces a DC voltage. To run the AC loads from our model, there was a need of incorporating an inverted in the hybrid power system. The model of inverter is shown below

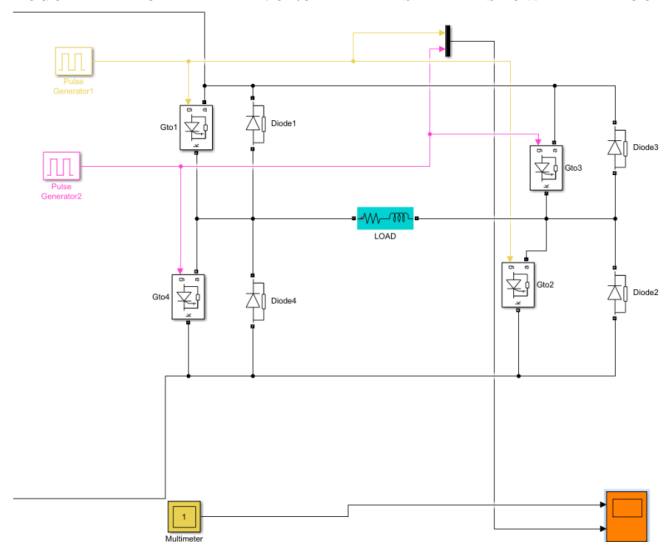


Figure 7 Simulink model of Inverter

Complete Simulink model of Hybrid power system

Each of the subparts have been discussed. The Simulink model of complete hybrid power system is shown below

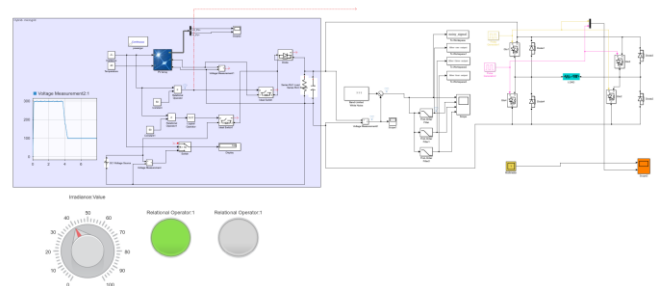


Figure 8 Complete Simulink model of Hybrid power system

IOT Implementation with the model

The IoT implementation in the model has been done using ThingSpeak platform. ThingSpeak is an IoT platform used to visualize and analyse the real time data from the model or the sensor or any IoT enabled device.

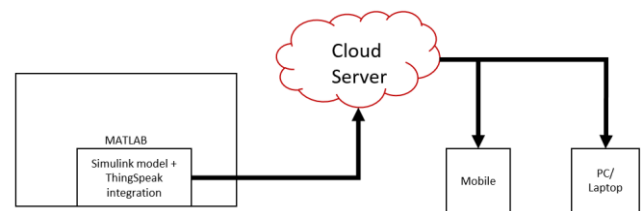


Figure 9 Block diagram showing IOT implementation with model

4. Simulation Results

1. Simulation result of controller

The complete model works in this way, whenever the irradiance value is greater than the reference irradiance value, the top ideal switch gets activated and makes a connection between load and PV array. Whenever the irradiance value is lesser than the reference irradiance value, the bottom ideal switch gets activated and makes a connection between load and Fuel cell (DC Voltage source).

The voltage across the load resistor is given to the oscilloscope and the obtained waveform is shown below



Figure 10 The voltage across the load resistor

2. Simulation result of noise filtering model

The actual noisy signal and the output from these three filters are given to the scope. The waveforms from the oscilloscope is shown below

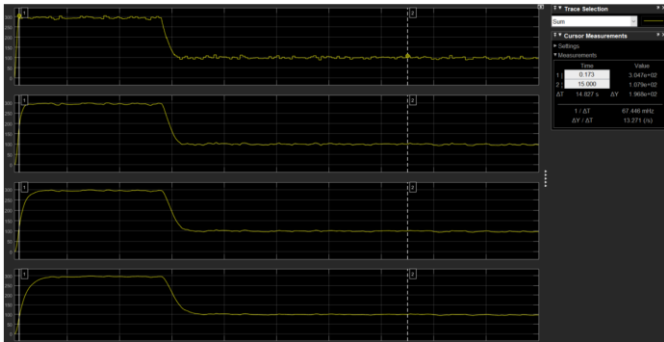


Figure 11 Simulation result of noise filtering model

Following are the observation done from this simulation

1. As the time constant increases, there is a significant reduction in the noise.
2. As the time constant increases, the rise time of the system is increasing. The system is becoming sluggish.
3. As the time constant increase, the switching time also increases.

3. Simulation result of the single phase inverter model

The current through the RL load and the pulse are given to the oscilloscope in the Simulink model. The waveform obtained is shown below

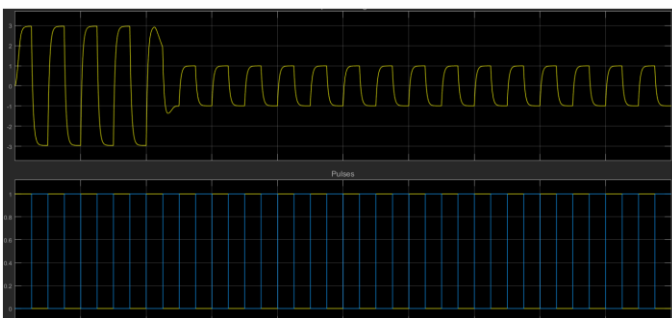


Figure 12 Simulation result of the single phase inverter model

In the above diagram, following points were noted

1. When the solar power was activated the current through the load was 3A
2. When the solar power gets deactivated and the power was taken from Fuel cell, the current through the RL load is 1A

4.Result of the IoT Implementation

Given below is the data visualization done in the mobile



Figure 13 IOT implementation of the model

5. Conclusion

the present model shown good simulation results with the iot implementation. In the future, studies can be carried out for testing the combination of different type of Fuel cell with the solar power. In the future model, ageing effect should be taken in account to estimate the life time of the overall hybrid system. Reliability analysis should be done in the future to compare the reliability of different type of systems.

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