Design Of Continous Mode Hybrid Power Station With Open Loop Hybrid Controller

Arpan Dwivedi*, Anju Sahu***

**Sr. Assistant Professor & Head*
Department of Electrical& Electronics Engineering
SSTC-SSITM, Bhilai, CG (India)
***ME Scholar*
Department of Electrical& Electronics Engineering
SSTC-SSGI, Bhilai, CG (India)

Abstract

The design of a controller for continuous mode Hybrid power station comprising of solar and wind renewable energy sources along with battery and Diesel generator (DG) is presented in this paper. The controller is designed to maximize the usage of energy sources while fulfilling the load demand and select the best optimal power output as per availability of sources to minimize the use of Diesel Generator and Battery operation. The state of battery charging is maintained. The supervisor control modes are discussed for hybrid controller as per the load demand. The simulation results are validated through experimental setup.

Key words

Diesel Generator, Hybrid Controller, Supervisor Controller.WTG, DG

I. Introduction

Renewable energy sources such as solar/wind energy are generally used for electricity generation. These renewable energy resources have greatest potential for power generation due to favorable economics, lower maintenance cost and environment friendliness. Both these sources are inexhaustible and widely available in our country but suffer from the disadvantage of dependency on weather conditions. For dependable power availability, use of a combination of traditional fossil fuel generation with non-conventional renewable sources is essential to meet the large demands of electricity [1].

In this paper, a hybrid power station (comprising of solar and wind renewable energy sources along with battery and Diesel generator (DG)) is proposed, modeled and studied in Matlab/Simulink. For synchronization of different power generation sources, the control of voltage and frequency is extremely important. Hence control schemes have been designed to take care of variation in loads and other factors [2]. Under the current global trend toward market liberalization, an overall approach for operation and control of power units is of paramount importance for the survival of any electric utility [1]. A diligent use of instrumentation and control systems can enhance plant operating efficiency, operability and maneuverability, robustness and reliability as well as plant availability (PLF), thus contributing to keep down fuel, operational, and maintenance costs which account for most of the expenses in a power plant [2]. Therefore, there is an urgent need to develop effective plant-wide automation systems and consequently the associated overall unit control systems and strategies to keep them running profitably. Further, the intensive use of reliable computer based instrumentation and control systems, with dependable and powerful general purpose information processing digital devices allow system designers to focus more on the implementation of software applications to respond to the above mentioned challenges. Since software complexity and the costs of its development and maintenance could easily surpass those of the hardware in which it runs, the design and development of a robust general and comprehensive software systems is essential to ease the incorporation of advanced operation (i.e., protection, control, and automation strategies) applications and thus enhance the performance of power generation units [4]. The advantage of hybrid power systems is in reducing diesel/fuel consumption by utilizing intermittently available renewable energy and minimizing environment pollution [5, 6].

To take full advantage of the solar/wind energy when it is available and to minimize diesel/fuel consumption, a proper control strategy must be developed. The control system is subject to the specific constraints of a particular application [5] [6]. It has to maintain power quality namely, control of both voltage and frequency. Because of this, a simulation study of each new system is needed to confirm that a control strategy results in the desired system performance. The simulation study can also help in the development of control strategies to balance the system power flows under different generation/load conditions. Using the typical modules provided, it is easy to set up a particular system configuration.

II . Proposed System

The proposed system consists of a hybrid power station (comprising of renewable energy sources along with battery and in combination of a diesel generator) to achieve continuous mode of power supply when the renewable energy sources are not available. The supervisory inputs are the measure of current and voltage of the system. The supervisor outputs are the signals to activate or deactivate any renewable energy sources as per the load demand.

I. Simulation of Hybrid Power station

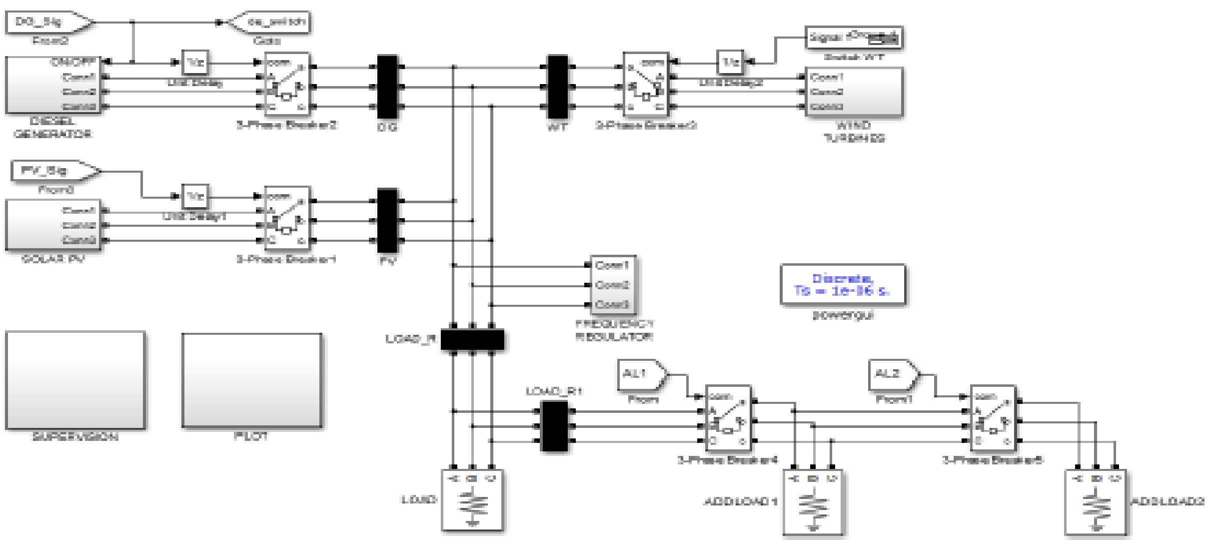

Figure- 1 Simulation of Proposed system

The simulation of hybrid power station consisting of Solar, wind and diesel generator is performed in the MATLAB and the simulation is validated through experimental setup in the laboratory. The output of simulation is compared with the results obtained through experimental setup. The output of hybrid power station is controlled by multiport controller operating at different modes.

Compared to other renewable energy resources the availability of wind energy is very high in certain parts of our country. In this model priority is given to wind energy since it can generate power both in the day time as well as in the night. However, solar PV is also considered as an option, depending on load demand. Initially diesel engine provides support until the power is generated either from solar PV or wind energy or total amount of generated power reaches minimum 5kW. As soon as the total generated power reaches 5kW the supervision system turns off the diesel engine. Two banks of additional resistive load can be added depending on total generated power. If total power generation reaches 10kW the supervision system closes the breaker for first additional load. Breaker for second one is closed if total power generation reaches 12.5 kW. Thus total available load for stand-alone hybrid energy system is 15kW.

The algorithm of supervision for power management can be expressed with following flow chart

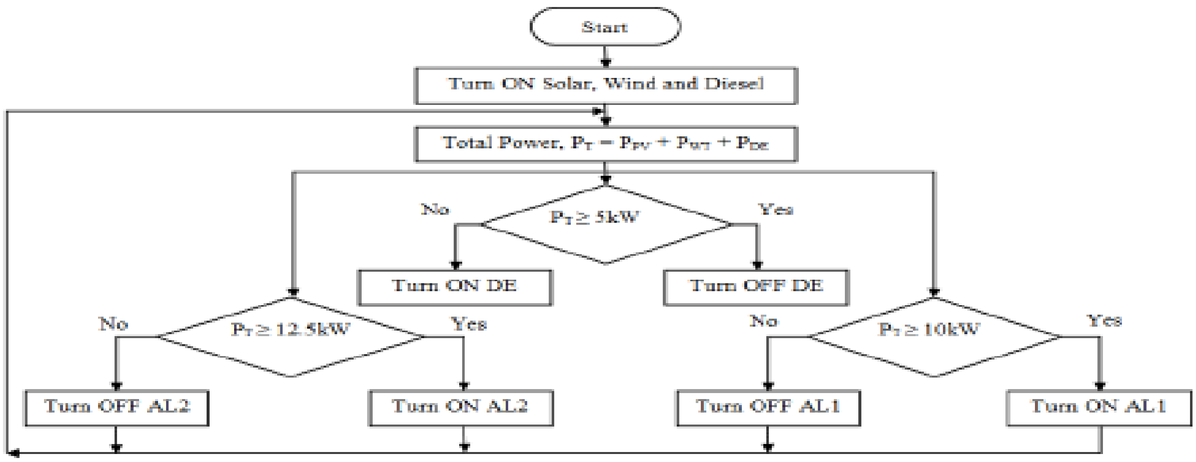

Figure-2 Algorithm for Supervisory Control

Here, PT is total power, PPV, PWT and PDE represent power generated by solar PV, wind turbine (WT) and diesel generator (DG) respectively. AL1 and AL2 are two additional resistive load banks along with the main load.

The frequency regulation of this stand-alone hybrid energy system is developed with a set of resistive dump loads. Total 8 sets of resistive dump loads are used to regulate the frequency in case of over generation of electrical power and each set of dump load consumes 0.5kW power. Maximum power consumed by dump loads in this system is 4kW. First bank of 0.5kW dump load is turned on in case of extra power in the system. If the system requires, rest of the banks are added in operation to regulate the frequency. The controller for frequency regulation is developed with a standard three phase locked loop (PLL) control strategy. It allows the system to operate at a constant frequency and synchronize the operation with multiple sources

II. Operation of controller

The controller will operate as per load demand and availability of energy sources. The operation of the multiport controller is under different modes as described below :

Mode -1: In this mode only PV is sufficient to meet the load demand while the other sources are inoperative. This mode will operate for t = 0 to t = 5 sec. The output is found to be constant and fed to the load through converter. As PV alone is sufficient to meet the demand on load side other sources are deactivated.

Mode -2: In this mode only WTG is sufficient to meet the load demand while the other sources are inoperative. This mode will operate for t = 6 to t = 10 sec. The power output is fed to the load. As wind alone is sufficient to meet the demand on load side, other sources are deactivated.

Mode-3: In this mode both PV and Wind are activated when load demand increases. This mode operated for t = 11 to t =15 sec.

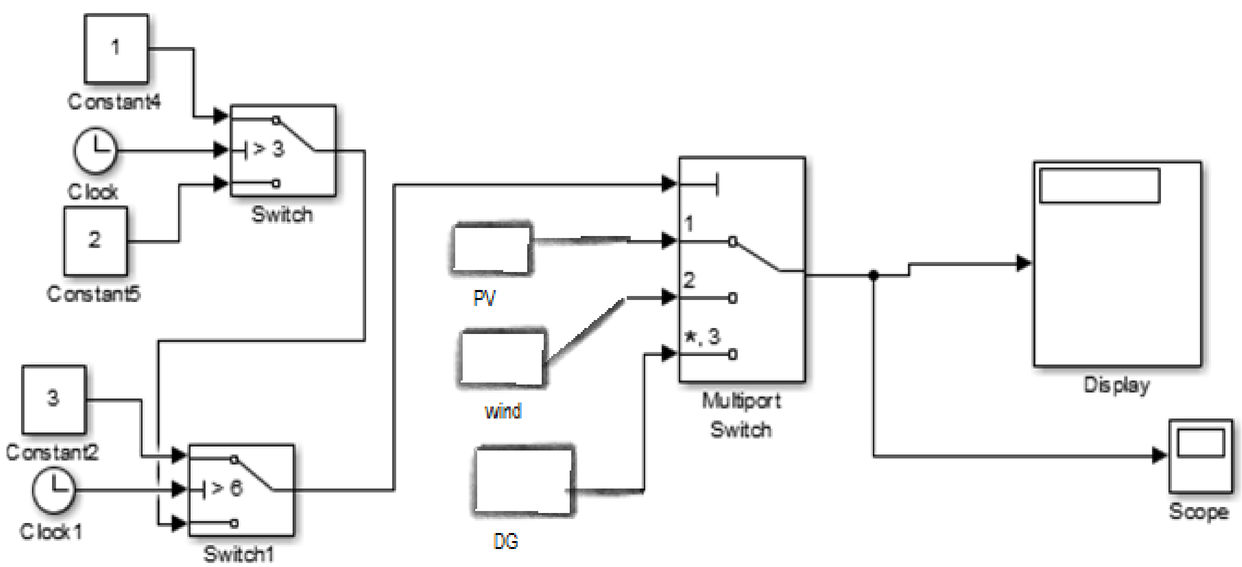

Figure-3 Operation of controller

Table- 1 Operating Modes of Proposed systems

Solar	Wind	Diesel	Sources	Modes	Operating time in sec
ON	OFF	OFF	PV	1	0-5 sec
OFF	ON	OFF	Wind	2	6-10sec
ON	ON	OFF	PV and wind	3	11-15 sec
OFF	OFF	ON	Diesel	4	15-20sec

III. Results and discussion:

Fig 4 shows the power generated by solar, wind and diesel generator. The average power generated by solar PV is approximately 6 kW. Wind energy generates up to 10 kW depending on load demand. Diesel engine is switched off when total generated power reaches 5kW. The load power in kW consumed by resistive main load, additional load and dump load is plotted in Fig. 5. The breaker for first additional load bank is closed when both solar PV and wind energy conversion system are in operation and power is fed to 10 kW main load. Another breaker for second additional load is closed when total power generation reaches 12.5kW.

In order to regulate the frequency, all dump loads are added along with additional loads between 0.8s to 1.5s. The frequency regulator turns them off gradually when the frequency is stable at 60Hz after 1.5s.

Fig. 6 shows the regulation of voltage at load side and the status of system frequency. Some fluctuation in load voltage is noticed between the period of 0.6s to 0.8s when both solar and wind energy are added in operation. The system frequency is being affected during the same period due to same operation.

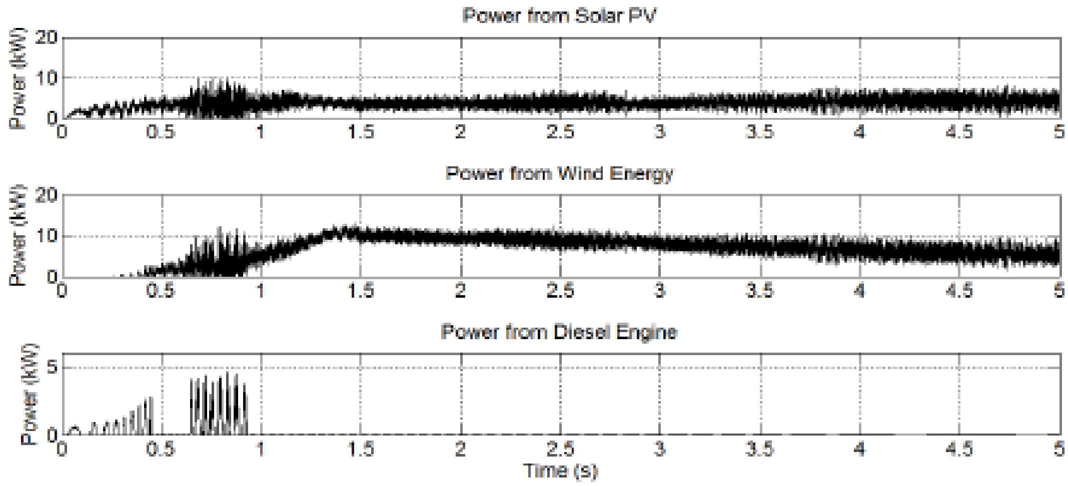

Figure 4 Power Output from generating Units

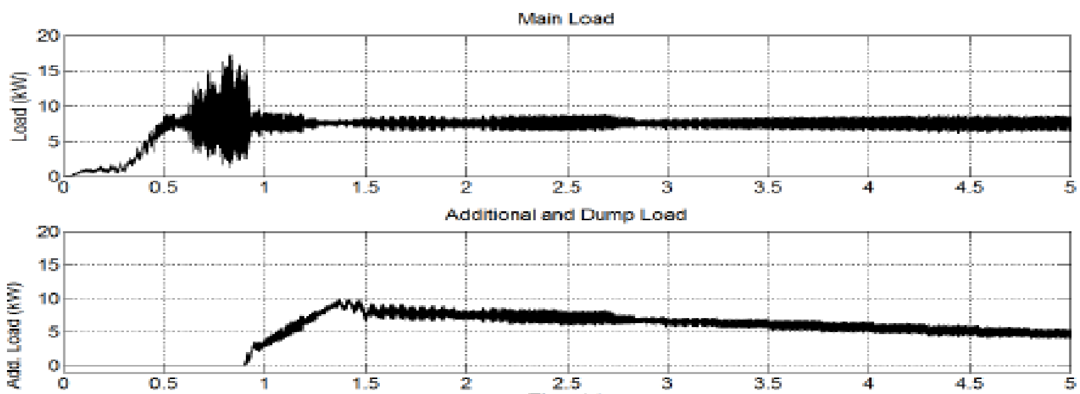

Figure 5 Main Load & Dump Load Profiles

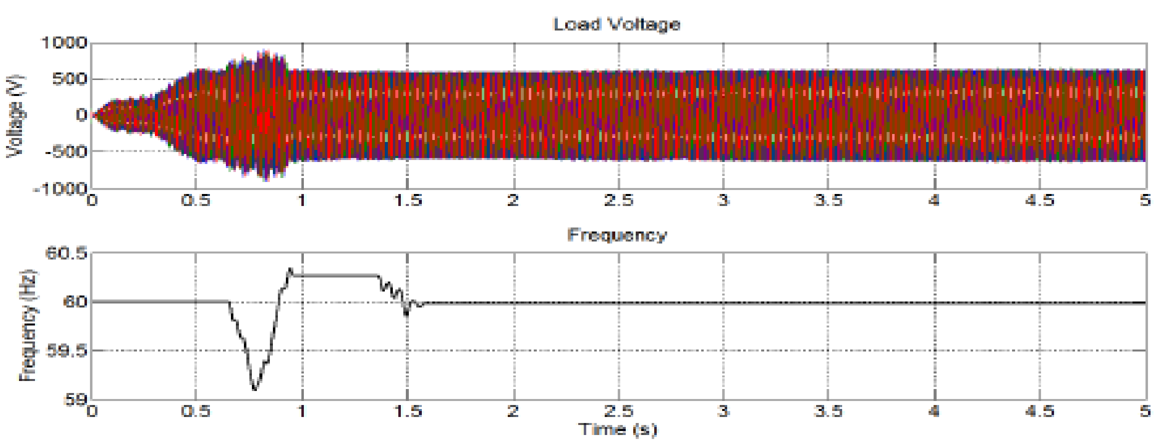

Figure 6 Load Voltage and Variation of Frequency

IV. Conclusion

A simple power management strategy is developed to analyze the reliability of hybrid energy system comprising of solar and wind renewable energy sources along with battery and Diesel generator (DG). A set of resistive dump loads is applied to regulate the system frequency. Continuation of this work will include control systems to minimize the transient effects during different mode of operation and frequency regulation with energy storage

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