

# Simulation of Continuous Mode Hybrid Power Station with Hybrid Controller

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## Abstract

In this paper design of continuous mode Hybrid power station with battery and Diesel generator (DG) is. The controller is designed to maximize the usage of energy sources and reduces the use of diesel generator. The state of battery charging is maintained. This paper firstly focuses on design of hybrid power station is to full fill load demand. Secondly a controller is designed to select the best optimal power output as per availability of sources to minimize the use of DG and Battery operation. A supervisor control modes are further discussed for hybrid controller as per the load demand. The simulation results validated the proposed system.

**Keywords:** DG; Hybrid Controller; Supervisor Controller

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## I. Introduction

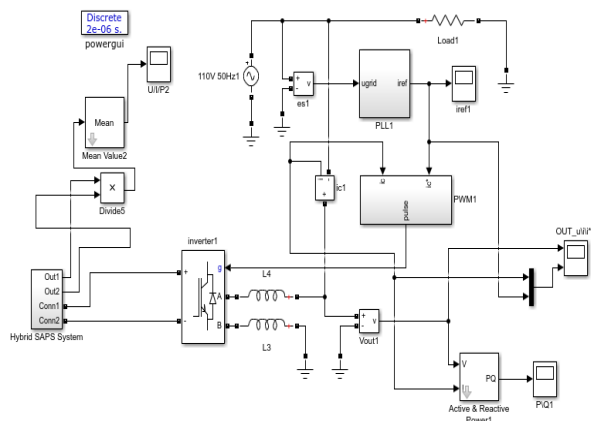
A common application of renewable energies is electricity generation. Renewable energy facilities generally require less maintenance than traditional generators, so has minimal impact on the environment. Among all the renewable energy resources, the solar and wind energies have the greatest potential as a power generating energy source, because of their many advantages like low or zero emission of pollutant gasses, low cost, inexhaustible sources and easy availability of these energy sources. But these systems have some disadvantages also like dependency on weather conditions. The difficulty to generate the quantities of electricity is one of the major disadvantages that are as large as those produced by traditional fossil-fuel generators. So it's necessary to reduce using the amount of energy or simply find an alternate source of energy. Using different power sources is the best solution to balance our energy problems [1]. In this paper, a hybrid power station is proposed, modeled and studied in Matlab/Simulink. Since the controlling of voltage and frequency are one of the most important cases; therefore, control schemes are designed in order to it, within changes of loads and whether [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]. When properly applied, plant-wide instrumentation and control systems can increase plant operating efficiency, operability and maneuverability, robustness and reliability, as well as plant availability, thus contributing to keep down fuel, operation, and maintenance costs, which account for most of the expenses in a power plant [2]. Therefore, there is urgency to develop effective plant-wide automation systems, and consequently the associated overall unit control systems and strategies, to keep them running profitably. Also, it should be noted that the intensive use of computer based instrumentation and control systems, with everyday more reliable and powerful general purpose information processing digital devices, allows 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, great effort and care should be paid in the design and development of general and comprehensive software systems to ease the incorporation of advanced operation (i.e., protection, control, and automation strategies) applications to enhance the performance of the power units [4]. The advantage of hybrid power systems is the combination of the continuously available diesel power and locally available, pollution-free wind energy. With the hybrid power system, annual diesel fuel consumption can be reduced and pollution can be minimized at the same time. [5] [6]. To take full advantage of the 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, measured by the quality of electrical performance, meaning that both the voltage and the frequency must be controlled. Because of this, a simulation study of each new system is needed to confirm that a control strategy results in desired system performance.

The simulation study can 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 hybrid power station consisting of renewable energy sources as a fuel. A diesel generator is also used in the combination to achieve continuous mode power supply in case of failure of renewable energy sources. 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.



**Figure 1- Simulation of Hybrid Power station**

The simulation of hybrid power station consisting of Solar, wind and diesel generator is performed in the MATLAB and Validated through simulation. The output of simulation is matched 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 this model priority is given to wind energy since it can generate power both in day and night. However, solar PV is also considered to operation depending on load demand. Initially diesel engine provides support until the power 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 se closed if total power generation reaches 12.5kW. So, total available load for stand-alone hybrid energy system is 15kW.

Here, PT is total power, PPV, PWT and PDE is 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 load 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 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

## III. 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.

**Mode-1:** In this mode only PV is sufficient to meet the load demand while the other sources are in operative. This mode will operate for  $t=0$  to  $t=5$  sec. The output is found to be constant and through converter fed to the load. 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 in operative. This mode will operate for  $t=6$  to  $t=10$  sec. The output is found to be 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 will operated for  $t=11$  to  $t=15$  sec.

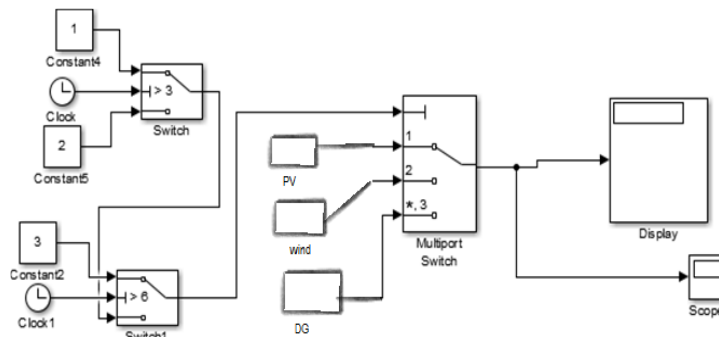


Figure -2 Operation of Controller

Table-1 Selection Modes of Controller

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

#### IV. Results and Discussion

Figure 3 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 10kW 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. 7. The breaker for first additional load bank is closed when both solar PV and wind energy conversion system is in operation and empowering 10kW 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 being added along with additional loads between 0.8s to 1.5s shown in figure 4. The frequency regulator turns them off gradually when the frequency is stable at 60Hz after 1.5s. Figure 5 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.

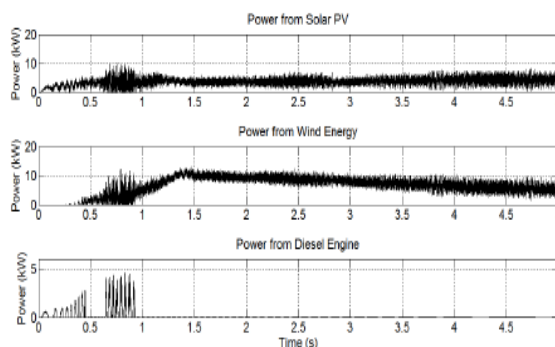
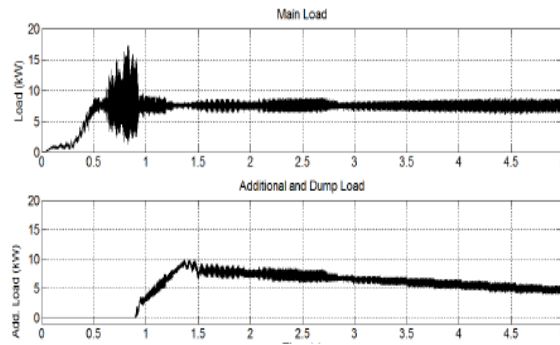
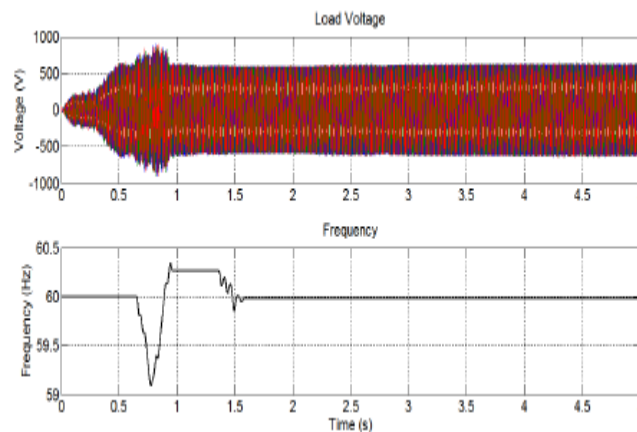


Figure 3- Output Power from Hybrid Stations



**Figure 4- Main and Dump Load Profiles**



**Figure 5- Load Voltage and Frequency Synchronization**

## V. Conclusion

This study presents an elaborative model of a hybrid energy system (HES). The simulation model is developed to study the behavior of stand-alone solar-wind-diesel HES. In this paper the mathematical model of solar and wind energy conversion system is described. Both solar and wind energy conversion system consists maximum power point tracking and voltage regulation technique. A simple power management strategy is developed to analyze the reliability of hybrid energy system. A set of resistive dump load 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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