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Hybrid Wind-Solar Energy System for Large-Scale Integration in Power Systems

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ABSTRACT: At present, standalone solar photovoltaic, wind systems have been promoted around the globe on comparatively larger scale. These independent systems cannot provide continuous source of energy, as they are seasonal. Hence, energy storage systems will be required for each of these systems in order to satisfy the load demands. Usually storage system is expensive and the size has to be reduced to a minimum possible for the renewable energy system to be cost effective. Hybrid power system can be used to reduce energy storage requirements. A hybrid renewable energy system that combines the generation of power through solar and wind system is installed to meet the load demand of a particular location which has adequate solar insolation and wind velocity. The hybrid wind-solar energy system using MPPT algorithm is simulated using Simulink MATLAB software. A 10-kW Wind-solar hybrid system was considered. The load demand to fulfill is 10 KW throughout the time scale expect at 4 to 5 sec when it increase to 16 KW. The maximum voltage of PV array is observed at around 144 V for 1000 solar irradiation input S (W/m²).

KEYWORDS: Photovoltaic, Wind energy conversion, Wind Turbines

I. INTRODUCTION

Due to technological development in power electronics, a new solution other than traditional and conventional forms of electricity generation for distant sectors is possible. Nowadays, the power generation through solar and wind has received special attention all over the world due to the increased rate of consumption of fuels. Among many renewable energy sources, solar and wind are the fastest growing energy resources because of their no emission of pollutants. Solar and wind energy have unpredictable and random behaviour when they operate individually. Solar energy is available throughout the day with varying intensity (irradiation) level of the sun which is unpredictable. In wind energy, due to atmospheric conditions the direction of flow varies which is also highly unpredictable. Both solar and wind energy are capable of supplying large amount of power but they are not completely reliable. It is more advantageous to use hybrid generation system than individual solar or individual wind generation system. Also, it can overcome the demerits of individual system [1, 2].

The increase in industrialization leads to energy demand. Most of the energy demand is supplied by the fossil fuels. However, increase in air pollution, diminishing fossil fuels and their increasing cost have made it necessary to gaze towards renewable energy sources as a future energy solution. Among these Renewable Energy Sources (RES), solar power systems and wind power systems are the affable solution for electrification.

As the solar energy is available in nature and due to its inexhaustible availability, they become most promising renewable energy sources. Hence, Photo Voltaic (PV) system has been increasingly used in medium sized grid and the wind mill is widely used all around the world. The penetration of power electronic converters used for integration of RES at distribution level may create a hazard to network in terms of power quality problems such as harmonics. This harmonics may lead to malfunctioning of protective relays and other control unit. Hence the harmonics has to be reduced. The implementation of active filter results in an additional hardware cost. In order to overcome these problems, solutions are proposed in this research work [3, 4].

The most effective solution for harmonic compensation is the active filter. This chapter discusses about the background of the solar energy, wind energy and power quality improvement in grid connected Renewable Energy Sources.

II. HBBRID ENERGY SYSTEM

Hybrid energy system is the combination of two energy sources for giving power to the load. In other word it can characterized as "Energy framework which is manufactured or intended to separate power by utilizing two energy sources is called as the mixture energy framework." Hybrid energy framework has great unwavering quality, effectiveness, less discharge, and lower cost. In this proposed framework sunlight based and wind control is utilized for producing power. Sun powered and wind has great focal points than other than some other non-ordinary energy sources. Both the energy sources have more prominent accessibility in all territories. It needs bring down cost. There is no compelling reason to discover unique area to introduce this framework [5].

A. Solar Energy

Solar energy is that energy which is gets by the radiation of the sun. Sun oriented energy is available on the earth ceaselessly and in plenteous way. Sun oriented energy is uninhibitedly accessible. It doesn't deliver any gases that mean it is without contamination. It is reasonable in taken a toll. It has low upkeep cost. Just issue with nearby planetary group it can't deliver energy in terrible climate condition. Be that as it may, it has more prominent productivity than other energy sources. It just needs beginning speculation. It has long life expectancy and has brought down emanation [6].

B. Wind Energy

Wind energy is the energy which is extracted from wind. For extraction we use wind mill. It is renewable energy sources. The breeze energy needs less cost for age of power. Support cost is likewise less for wind energy framework. Wind energy is available very nearly 24 hours of the day. It has fewer outflows. Beginning expense is likewise less of the framework. Age of power from wind is rely on the speed of wind streaming. The real impediments of utilizing free sustainable power source assets are that inaccessibility of energy forever. For conquering this we utilize sun oriented and wind energy together. With the goal that any one wellspring of energy falls flat other will deal with the age. In this proposed framework we can utilize the two sources join [7]. Another way is that we can utilize any one source and keep another source as a remain by unit. This will prompts congruity of age. This will make framework solid. The primary detriments of this framework are that it needs high introductory cost. But that it is dependable, it has fewer outflows. Kept up cost is less. Life expectancy of this framework is more. Proficiency is more. A principle preferred standpoint of this framework is that it gives constant power supply.

III. DESIGN OF HYBRID ENERGY SYSTEM

For design of the hybrid energy system we need to find the data as follows

A. Data required for Solar System:

1. Annual mean daily duration of Sunshine hours
2. Daily Solar Radiation horizontal (KWH/m²/day)

B. Data required for Wind System:

1. Mean Annual Hourly Wind Speed (m/sec)
2. Wind Power that can be generated from the wind turbine

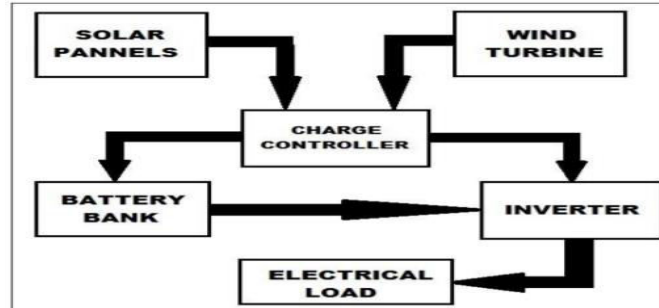


Figure 1: Block graph of Hybrid energy system framework

Above figure demonstrates the square outline of the cross breed control system framework utilizing wind and sunlight based power. This square outline incorporates following pieces.

- Solar panel
- Wind turbine
- Charge controller

i. Solar panel

Solar panel is used to convert solar radiation to electrical energy. The physical of PV cell is very similar to that of the classical diode with a PN junction framed by semiconductor material. At the point when the junction retains light, the energy of consumed photon is exchanged to the electron proton arrangement of the material, making charge bearers that are isolated at the junction [8]. The charge bearers in the junction area make a potential slope, get quickened under the electric field, and circle as present through an outer circuit. Sun powered exhibit or board is a gathering of a few modules electrically associated in arrangement parallel blend to produce the required current and voltage. Sun based boards are the medium to change over sun oriented power into the electrical power.

ii. Wind turbine

Wind turbine is that framework which removes energy from twist by pivot of the sharp edges of the breeze turbine. Fundamentally wind turbine has two composes one is vertical and another is even. As the breeze speed builds control system is additionally increments. The power produced from wind isn't ceaseless its fluctuating. For acquire the non-fluctuating force we need to store in battery and after that give it to the heap.

iii. Charge controller

Charge controller has basic function is that it control the source which is to be active or inactive. It all the while charge battery and furthermore offers energy to the heap. The controller has over-charge security, cut off, post perplexity assurance and programmed dump stack work. It additionally the capacity is that it ought to fluctuate the power according to the heap request. It include the both the power with the goal that the heap request can satisfy. Also, when control isn't producing it should remove control from battery and offer it to the heap.

IV. PROPOSED MODEL

Renewable energy sources use to generate green energy for reduce environment pollution problem. In this work build a hybrid model of PV and Wind by generating of energy from these two sources we give this energy to the grid. For grid connected renewable energy sources required an inverter. Representation of this work using block diagram which is shown in figure 2.

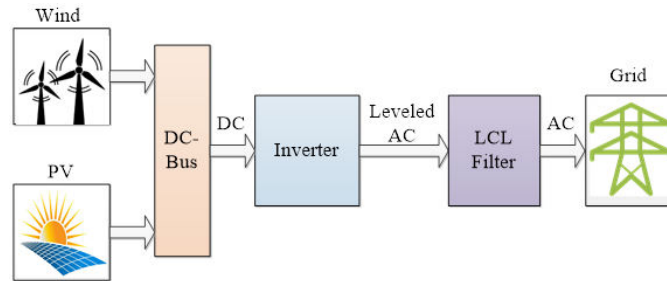


Figure 2: Representation of renewable energy to grid connected system

Designing of Filters

At the inverter's output, a filter is needed. Only the amplitude is high since the inverted signal is the DGM signal again. As a result, there are harmonics at the switching frequency and its multipliers in this signal. The LCL filter is used in the inverter output. The ability to use this filter at low switching frequencies, its advantages in filter dimensions compared to traditional "L" and "LC" filters, and its lower voltage drop and improved damping compared to conventional "L" and "LC" filters are the most significant reasons for choosing it.

Rated current is allowed to fluctuate by 10% for the design parameters, the values in (1) and (2) are obtained.

$$\Delta I_{L_{max}} = \%10 I_{max} \tag{1}$$

$$L1 = \frac{V_{dc}}{6f_{sw} \cdot \Delta I_{L_{max}}} \tag{2}$$

$$Cf = 0.05Cb \tag{3}$$

The value inverter side inductance is L1, Cf is filter capacitance, L2 is grid side inductance, the switching frequency is fsw, and the dc connection voltage is Vdc. The value of the capacitor is limited by the low power factor (less than 5%) in the rated capacity (3) give the capacitance value.

Generate PWM signal

The PWM method should be used to produce necessary switching pulses in order to provide a low and fixed switching frequency suitable for high power and industrial applications. Some switching techniques, such as hysteresis, have a variable switching frequency, which causes irritating audible noises. To modulate the measured reference signal, carriers are transferred vertically. As shown by logic blocks, each carrier is responsible for generating pulses for associated voltage levels and switching states. Furthermore, the corresponding switching pulses for three cycles of the modulated waveform have been shown as fixed switching frequencies in each cycle. In comparison to other topologies, the proposed method ensures low and fixed switching frequency functionality of the h-bridge converter, resulting in low switching losses and high performance.

Simulation Model

The proposed system presents power-power strategies of a grid-connected hybrid generation system with versatile power transfer. This hybrid system allows maximum utilization of freely available renewable energy sources like wind and photovoltaic energies. For this, an adaptive MPPT algorithm along with standard perturb and observes method will be used for the system. Also, this configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind energy and Solar cell operating voltage in the case of output power from solar energy. Permanent Magnet Synchronous Generator is coupled with wind turbine for attaining wind energy conversion system.

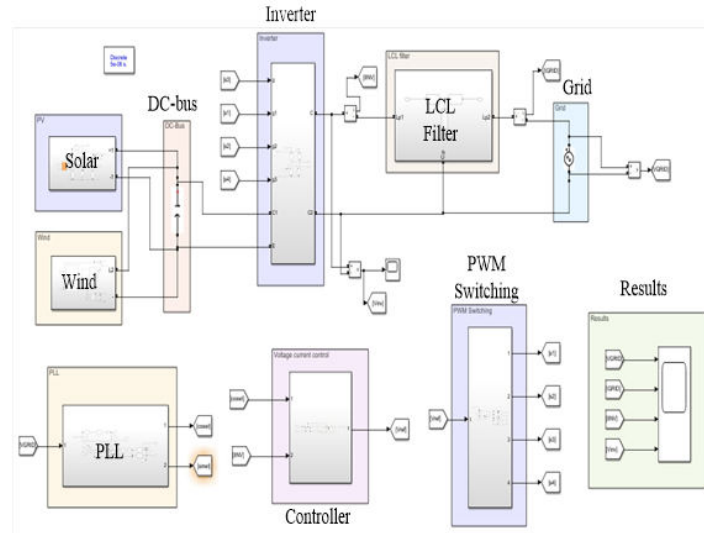


Figure 3: MATLAB Simulink Model of Grid Connected Hybrid Wind-Solar Energy System using MPPT Algorithm

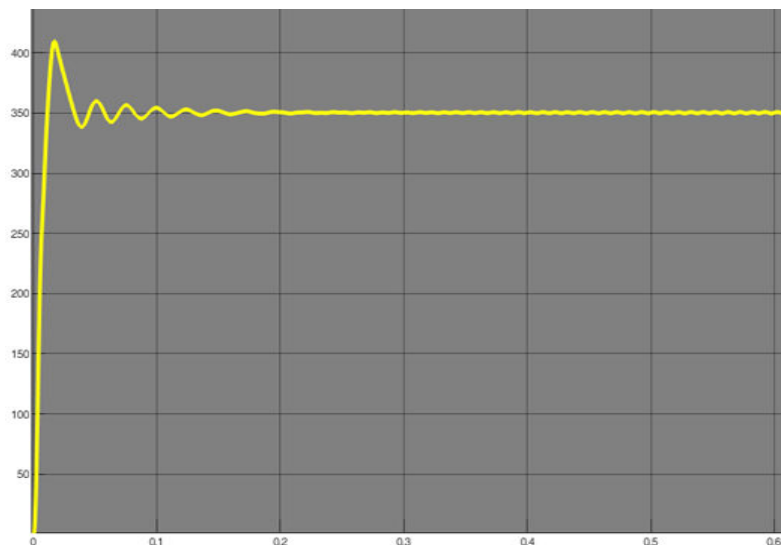


Figure 4: Output Voltage of wind and solar energy hybrid system

The inverter converts the DC output from non-conventional energy into useful AC power for the connected load. This hybrid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy. The simulation results are presented to illustrate the operating principle, feasibility and reliability of this proposed system

It is clearly that the gain is constant according to the gives constant energy of wind and solar energy hybrid system. Energy of wind and solar energy hybrid system is increase than gain is also increase. Figure 5 shows the simulation result for output voltage across DC-bus terminals. From this result we observed that the increase voltage with respect to change in either the wind or solar plants. The output voltage is increase according to the maximum power point tracking system. The maximum output voltage of 350 V in 0.04 load line. Figure 6 shows the mean power of wind and solar energy hybrid system.

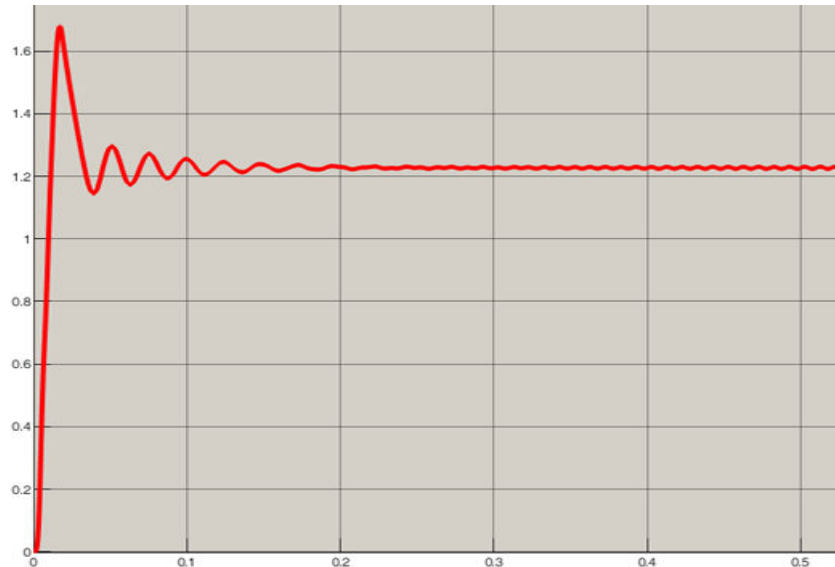


Figure 5: Mean Power of wind and solar energy hybrid system

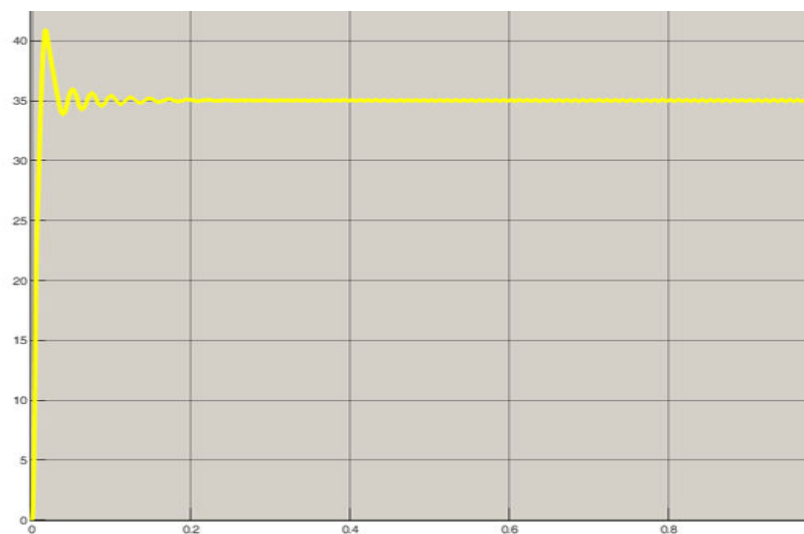


Figure 6: Output Current of wind and solar energy hybrid system

Figure 6 shows the simulation result for Output Current of wind and solar energy hybrid system. If the load is changed or suddenly extra load applied to the system then changes occur in the load current. In this thesis we suddenly applied the load during the time 0 sec to 0.04 sec, then in this period the current rises.

V. CONCLUSION

This topology allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. MPPT control is done for PV and wind energy so that maximum power is tracked and system work more reliably and efficiently. This system has lower operating cost and finds applications in remote area power generation, constant speed and variable speed energy conversion systems and rural electrification. MATLAB/SIMULINK software is used to model the PV panel, wind turbine, DC-DC converters, MPPT controller and proposed hybrid system.

The technological development and the increased power demand have led to harness of energy from solar and wind. PMSG is used as a wind generator due to its self-excitation capabilities and requires less maintenance. A model was developed for an 8kW output power using MATLAB/Simulink. A PV module is modeled and simulated with varying irradiation and temperature. In both solar and wind, a buck-boost converter is designed and simulated. To control the gate pulse of the high frequency switch of the buck-boost converter, MPPT algorithm is used.

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