DESIGN AND SIMULATION OF WIND AND SOLAR HYBRID SYSTEM UNDER ISOLATED MODE OF OPERATION

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Abstract—The modelling of PV system, wind energy conversion system (WECS) and Boost converter were done with the help of their general equations. Based on them they were accordingly modelled and simulated in Simulink. The output voltage of PV & WECS, output of boost converter & rotor characteristics were observed and matched with the theoretical calculations. An inverter was designed with the help of GTO’s working in 180 degree mode of operation. Triggering sequences were obtained and accordingly pulse generation was done for each GTO. The output produced by the inverter is a square wave which is then fed to a low pass filter to obtain a sinusoidal wave. The output voltage of the filter is fed to a transformer in order to step down the voltage so as to meet the load voltage requirements.

Keywords—Hybrid power system, PV system, Wind Energy system.

I. INTRODUCTION

India is blessed with high solar insolation, already a leader in wind power generation thus hybrid PV/Wind is an ideal combination for power generation in India. According to the 2011 report by GTM Research and Bridge, India is facing a perfect storm of factors that will drive solar photovoltaic (PV) adoption at a “furious pace over the next five years and beyond”. As energy demands around the world is on continuous increase, the need for renewable energy sources that will not harm the environment has been increased. Projections indicate that the global energy demand will almost triple by 2050. The role of new and renewable energy resources in power generation is, as of date, very low, but wind energy contribution is increasing significantly in the recent years due to growing energy demand with minimum environmental effect. Renewable energy sources currently supply between 15% and 20% of total world energy demand. PV and Wind Energy Systems (WES) are the most promising sources for the future energy technology. A 30% contribution to world energy will be supplied by renewable energy sources by 2020, which would reduce the energy related CO2 emission by 25 % [7].

Wind and Solar are complementary, so hybrid Wind/PV power system is an ideal solution for power supply at remote places [9]-[10]. Due to the uncertainty in climatic conditions, isolated PV energy system or wind energy system cannot provide a continuous and reliable power supply. In this perspective, to ensure continuous power, installation of battery bank is necessary. Hybrid Wind/PV system is more consistent and economical when compared to two sources considered separately. This further reduces the overall cost and battery storage requirements. With the development of power electronics there is significant growth in solar-wind application with optimization in the size of the system. Usually sunny days are silent and wind speed is rapid at night and at cloudy days, thus hybrid Wind-solar can eliminate the intermittency of single energy source. Another alternative is to provide battery supply to get constant power with maximum power tracking from both PV and wind energy system.

Different hybrid PV/Wind power system is proposed and discussed in works, these systems use MPPT based DC/DC converters to achieve maximum power from each of the energy sources. A multi input inverter is recommended by, where a buck/buck boost fused multi input DC/DC converter is used and MPPT can be accomplished for both solar and wind energy. A grid connected hybrid wind energy conversion/PV/Fuel cell system is proposed by, this system can maximize the output energy and can reduce the output power fluctuation for stand-alone applications. An alternative multi input rectifier structure is suggested for hybrid wind – solar energy systems by. The structure proposed by is a fusion of the Cuk and SEPIC converter. The inherent nature of these converters eliminates the need of separate input filters.

Fig.1 shows the General block diagram of the proposed system.

Fig.1 General Block diagram

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Recently several research groups have carried out on optimization of hybrid energy systems. Tapas Kumar Saha and Dnaprasad Kastha, has developed an algorithm for optimal sizing of all the components of a standalone hybrid wind-diesel electrical power generation system considering minimum energy cost, but diesel electrical power in present days costs more [7]. A systematic analytical approach for the well-being assessment of small autonomous power systems (SAPSs) with wind and solar energy sources has been presented in literature [8].

Dong Chen, et.al, proposed an improved repetitive control scheme. It adopts a new FIR filter design method, which has adjustable linear-phase low-pass characteristics [1]. The supervisory controller of a standalone hybrid Wind-PV-fuel cell (FC) energy system is proposed in [16]-[25]. Every source is connected to the AC bus bar via an inverter to supply the load. The FC–electrolyser combination is used as a backup and long-term storage system. The battery bank is used in the system in a short-time backup to supply the transient power. At any given time, the supervisory control controls and supplies any excess wind-PV generated power to the electrolyser.

II. OBJECTIVE

This paper focuses on modelling and simulation of Photovoltaic/Wind Hybrid Electric Power System under isolated mode of operation. PV and Wind are used as primary sources and battery acts as back up supply. The computer simulation is finalized in MATLAB/Simulink by applying a realistic model of the circuit. The simulation program shows the waveforms for voltage and power generated by the sources, Photovoltaic array and Wind energy system. We also get to see the output waveforms of both the Boost converters and battery. The output voltage waveforms of inverter and low pass filter are observed to obtain the desired load voltage and power waveforms.

III. THE PROPOSED SYSTEM MODEL

IV. SIMULATION RESULTS AND DISCUSSIONS FOR HYBRID SYSTEM

A. Output Voltage & Power of PV Module

- Output Voltage = 221.6 V getting constant corresponding to 1000 insolation.
- Each PV module produces 15.82 V.

B. P-V & I-V Characteristics for PV Module

- P-V Characteristics – Power on Y-Axis & Voltage on X-axis
- Characteristic is corresponding to 1000 insolation

- I-V Characteristics – Current on Y-axis and Voltage on X-axis
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- Characteristic is corresponding to 1000 insolation

![Fig.6 I-V characteristic curve of PV module](image)

C. Output Voltage from Wind Energy System
- Output voltage of WECS is 269.2V

![Fig.7 Output voltage of WECS](image)

D. Mechanical Input power to PMSG
- It is the mechanical input power from turbine given to PMSG
- It is equal to 3202 W

![Fig.8 Mechanical input power to PMSG](image)

E. Mechanical Input torque to PMSG
- It is the mechanical input torque from turbine given to PMSG
- It is equal to 91.49 N-m
- Power value is divided by 35 rad/sec (rotational speed of turbine)

![Fig.9 Mechanical input torque to PMSG](image)

F. Combined DC link voltage output
- Now the output of both PV and WECS boost is connected in parallel to a common DC link. This DC voltage is then fed to the inverter
- The value is equal to 406 V after transients

![Fig.10 DC link output voltage](image)

G. Battery output

![Fig.11 Voltage output of Battery](image)

![Fig.12 State of charge of Battery](image)

H. Inverter output
- The inverter is working in 180 degree mode of operation
- The 3 phase output produced by the inverter is a square wave
- The maxima of the square wave is the supplied DC voltage which is equal to 406V

![Fig.13 Current output of Battery](image)
I. Output of the low pass filter (3 phases Vab, Vbc, Vca combined)

➢ Since inverter output is a square wave, it has to be converted to sinusoidal wave using 2nd order low pass filter.

J. RMS Voltage output of the inverter

➢ RMS value of line voltage = 331.49 V

K. Load Voltage and current for RL load

➢ Transformers turns are so defined to get the output RMS voltage across load = 400V

➢ Waveform shows instantaneous load voltage with peak voltage = 405 V

L. Active Power drawn by the load

➢ Corresponding to the load voltage and current power is drawn by the load

➢ Rated power of load is 5.2kW

➢ Drawn power is 5.2 kW

Fig.14 Three phase output waveforms of inverter (Vab, Vbc, Vca)

Fig.15 Three phase output waveforms of filter

Fig.16 RMS voltage output of the filter

Fig.17 Load voltage of RL load

Fig.18 Load current of RL load

Fig.19 Active and reactive power drawn by the load

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CONCLUSION AND FUTURE WORK

The modelling of PV module, WECS and Boost converter were done with the help of their general equations. Based on them they were accordingly modelled and simulated in Simulink. The output voltage of PV & WES, output of boost converter & rotor characteristics were observed and matched with the theoretical calculations. A control mechanism is developed that changes the duty cycle of the boost converter so as to obtain the desired or fixed output. A battery is modelled in order to provide the backup supply. An inverter was designed with the help of GTO’s working in 180 degree mode of operation. Triggering sequences were obtained and accordingly pulse generation was done for each GTO. The output produced by the inverter is a square wave which is then fed to a low pass filter to obtain a sinuosoidal wave. The output voltage of the filter is fed to a transformer in order to step down the voltage so as to meet the load voltage requirements.

All the waveforms obtained at each stage were matching with the theoretical calculations. Because of the cut-off frequency and damping factor being used in the derivation of state space model from transfer function model the peak value of inverter and low pass filter is not exactly the same. Compared to any fuel or coal fired plants, the running cost of these systems are very low. Compared to any fuel or coal fired plants, the running cost of these systems are very low. Compared to any fuel or coal fired plants, the running cost of these systems are very low. Since rotating components are few, maintenance cost is less in distribution system. Thus in power generation hybrid power system is a better choice.

REFERENCES


