Modeling of solar/wind hybrid energy system using MTALAB simulink

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ABSTRACT

non conventional sources like solar and wind are presented everywhere, cheap or freely available, and they are used to generate power or electricity in remote area also where transmission or grid connection are not possible. In this paper a smart PV/Wind hybrid system developed with any grid connection.A complete hybrid model of wind, solar PV array, with battery system is designed so as to ensure uninterruptible power supply across the load. Due to depletion of fossil fuels, a move towards clean energy has emerged from the last few decades. A basic understanding of different sources and a battery as an emergency can be employed in an isolated area/village where transmission of electricity is quite costly can be overcome using any of these sources. MATLAB simulink software used to design this model. To maximize the power generation Perturb and observe (P&O) algorithm is used maximum power point tracker (MPPT). The dynamic behavior of the proposed model is examined under different operating conditions. The solar PV system is designed to generate approx 45-50kW, the wind system is basically designed for 147kW approx The efficiency of the wind system is maximum 40-45% at the peak wind speed practically so it is considered for higher rating. The model is basically designed in the discrete mode with the sample time 20 µs. To maintain the unidirectional transmission a diode is connected across each source and an ideal switch which maintains the switching of the respective sources.

Keywords: Solar Energy System, Wind Turbine System

INTRODUCTION

Energy is a basic requirement for economic development. Every sector of the national economy like agriculture, industry, transport, commercial and domestic are needs the inputs of energy. The economic development plans implemented since independence have necessarily required increasing amounts of energy. As a result, consumption of energy in all forms has been steadily rising all over the country. Now a days different combinations of renewable sources with battery used for energy generation to uphold the consistency of power. Renewable energy resources are very useful for rural areas where electric grid cannot reach easily. There are some difficulties which can be fulfilled by the renewable energy resources a) It decreases gap between supply & demand, b) Helpful for decrease the environment pollution, c) It gives solution for rural electrification, d) It gives voltage stability at the time of fluctuation. The main drawback to used to renewable sources is that they doesn't generate continues energy to overcome this problem maximum power point tracking is used. Performance in different condition is checked. There are many works upon hybrid energy system modeling and optimization is done previously. In this paper a simple control method tracks the maximum power from the wind/solar energy source to achieve much higher generating capacity factors and simulation results proved the feasibility and reliability of the system

Proposed Hybrid Energy System

configuration structure for hybrid energy system (HES)based solar and wind energy systems shown in figure 1. A complete hybrid model of wind, solar PV array, and battery system is designed so as to ensure uninterruptible power supply across the load. Due to depletion of fossil fuels, a move towards clean energy has emerged from the last few decades. A basic understanding of different sources and a battery as an emergency can be employed in an isolated area/village where transmission of electricity is quite costly can be overcome using any of these sources. From the last few decades scientists are working towards biodiesel which can be made using the vegetable oils is also replacing the present available diesel.

Wind Energy system

Turbine block: A wind energy system is generally employed where the speed of wind is more than 10m/s. Thus to describe the operation of Wind Turbine system, a matlab block of WIND Turbine is used .In the block the general equation of mechanical power(P_{mec}) generated is given as

$$Pmec=\rho AC_p(\lambda,\beta)v^3$$

Where ρ=Air density
A=Area swept by blades
Cp=Coefficient parameters which are constant
λ,β=Tip ratio and pitch angle
Tip Ratio=Velocity of wind striking the tip of blade/Total velocity of the wind

Pitch Angle=The pitch angle is the angle at which the blade surface contacts the wind. It is often variable to ensure optimum operation of the turbine in varying wind conditions.Is used to design the wind turbine block.The block is designed using the basic Simulink blocks.Whem Pmec is divided by ω(angular speed of rotor in rad/sec) we get the required Mechanical torque(T_m).The mechanical torque or load torque is basically used with asynchronous generator so as to bring the rotor into motion. All the quantities in this block are considered in pu.

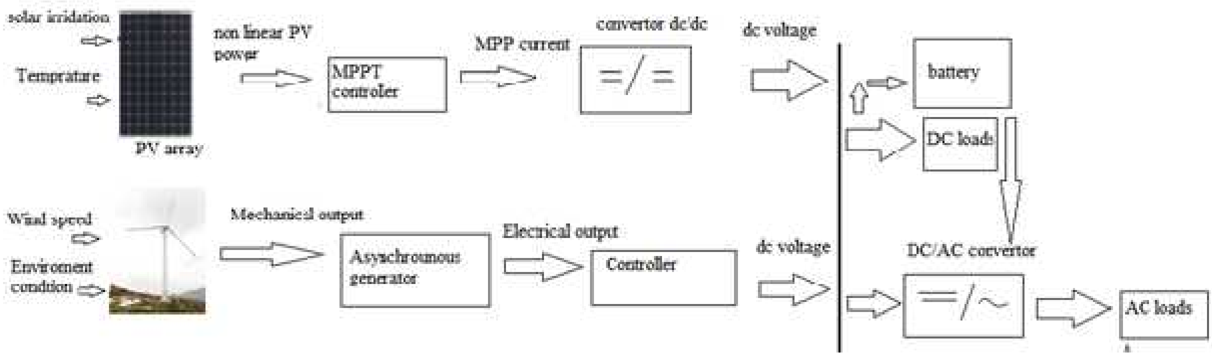

Fig 1: configuration of HRES

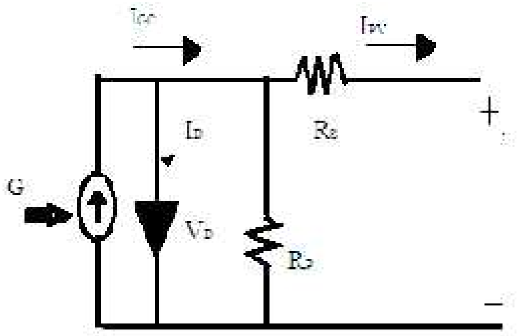

Fig 2: equivalent circuit of PV cell

Asynchronous machine block

The MATLAB has an option of different kinds of machines block which can be used in any of the mode either generating or motoring. In this wind energy system three phase asynchronous machine block(pu) is used .Although the induction generator is used for 149kVA so as to run a 30kW load. The efficiency of wind energy system is not more than 45-50% in real scenario and moreover when imparting an asynchronous machine a separate capacitor banks used to provide the reactive power, which is another drawback of this system.

Transformer

A three phase three winding transformer is used so to convert AC to DC through two different rectifiers. The purpose of using two different rectifier is to get controllable dc output voltage, by tuning the firing angle (α) of the 12-pulse synchronized PWM generator, and the narrowed commutation periods, which causes less harmonic distortioneffects on the source side. In this model a three-phase two winding transformer is used to obtain six input ports with appropriate phase angles for the double-bridge rectifier. The purpose of converting AC/DC is to maintain a common voltage on the DC bus irrespective of the source supplying it. The pulses for synchronised 12 pulse generator and pitch angle is tuned using the PI controller blocks.Also some of the initial parameters which are required in the machine or generator block is calculated using the machine initialization tab in POWERGUI block of simpower systems. Also along with the DC link capacitor in wind system , a small resistor is also connected so to discharge the capacitor. Otherwise the capacitor will hold the voltage while the current will drop down thus causing the problems in the switching.

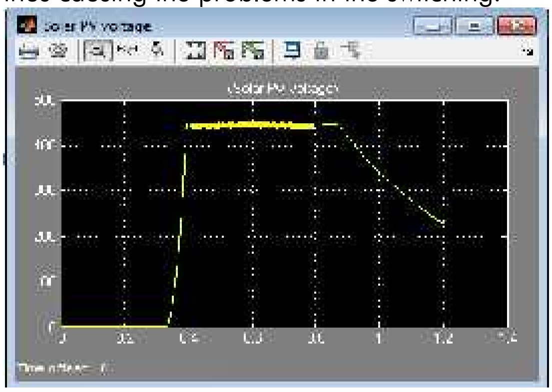

Fig:3 Output voltage of Solar model

Solar PV array: A solar PV array consists of solar modules which are connected in some series or parallel combinations. A module consists of solar cells shown in figure 2. To design a solar module a block modeling of characteristics equation is done using the basic Simulink blocks. For solar PV array one of the important parameters are irradiance and temperature. To calculate the irradiance a data is considered of one of the location through which irradiance is calculated using the parabolic reflector.

The photovoltaic current can be presented as

$$I_{pv} = I_{gc} - I_o\left[\exp^{\left(\frac{ev_d}{KFT_c}\right)} - 1\right] - \frac{v_d}{R_p}$$

Where *Igc* is the light generated current, *Io* is the dark saturation current dependant on the cell temperature, e is the electric charge = 1.6 x 10-19 Coulombs, *K* is Boltzmann's constant = 1.38 x 10-23 J/K, *F* is the cell idealizing factor, *Tc* is the cell's absolute temperature, *vd* is the diode voltage, and *Rp* is the parallel resistance. The photocurrent (*Igc*) mainly depends on the solar irradiation and cell temperature, as

$$I_{gc} = [\mu_{sc}(T_c - T_r) + I_{sc}]G$$

Where *µsc* is the temperature coefficient of the cell's short circuit current, *Tref* is the cell's reference temperature, *Isc* is the cell's short circuit current at a 25oC and 1kW/m2, and *G* is the solar irradiation in kW/m2. Furthermore, the cell's saturation current (*Io*) varies with the cell temperature

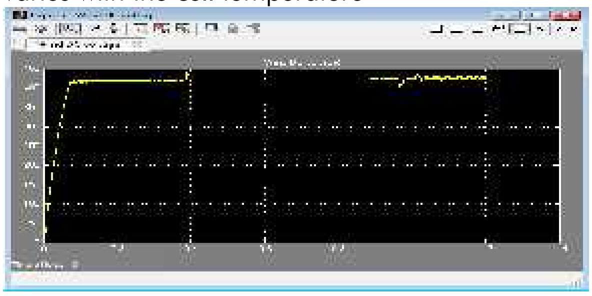

Fig:4 Output form WT model Wind voltage

Boost Convertor

The output voltage generated by the solar PV array is not enough to run a three phase load. As a result before supplying this voltage on the DC Bus, the voltage is boosting up upto 450V so as to maintain 400-415V on DC bus apart from charging a battery. Since a boost convertor involves a switch (say IGBT/GTO), the triggering/pulses of boost converter is provided through MPPT. The MPPT (maximum power point tracking) tracks the direction of sun at which power is maximum, so that maximum output can be extracted from the solar. Once we get the DC, a dc link capacitor is connected so to make the output as uniform with little distortions.

Battery: A battery is connected in parallel with the overall hybrid system so as to provide the emergency backup when none of the system works especially during the night time, Although the standard battery available is generally 12/24V, but to avoid number of batteries in series or parallel, a single battery block available in MATLAB is used. The rating are considered with respect to load. The initial charging state has been considered as 90% which would charge/discharge slowly and can be seen in SOC(State of Charge) graph.The battery can be charged with any of the source and will discharge if the DC bus voltage drops below the certain level. A bidirectional DC-DC converter has been used to charge and discharge the battery as per the required conditions.

Load Side: A three phase 30kW resistive load is considered in the model. Since we are getting the DC voltage, so this DC bus voltage is converted to AC using PWM inverter. The output from the inverter is filtered using the LC filter.The PWM is synchronised with the load voltage so as to maintain the modulation index. All the respective waveforms are shown in different scopes.

Simulation Results

The complete system design i.e hybrid energy system is simulated using SIMULINK. A 30-kW wind/PV/battery. The complete model is made to run in discrete mode so as to have faster simulation. Generally continuous mode is implemented when the models are small. The complete model is run for 1.2 sec which will be scaled to time from 0-24 hours. The ideal switch are implemented so as to switch different sources at different intervals of duration during the day.Output from different section of HRES are shown in figure 3 to figure 5 showing the graphical representation output. The main objective of the work to observe the behavior of the model in different time during night and day time also.

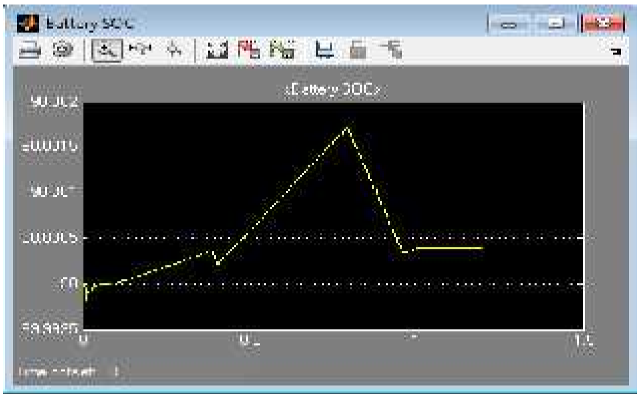

Fig: 5 Battery output

Conclusion

Output from solar and a wind system is converted into AC power output by using inverter. In the given time additional load of 30 KW is connected by using Circuit Breaker. Under all operating conditions to meet the load the hybrid system is controlled to give maximum output power. Battery is supporting to wind or solar system to meet the load and Also, simultaneous operation for the same load, almost uniform voltage, current, irrespective of the source with some spikes but its mainly due to discrete simulation

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