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Modeling and Simulation of Grid Connected Solar Wind Hybrid Power System

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Abstract-This paper introduce the hybrid combination of the two resources to get the reliable power supply. These two resources are solar power and wind power. The solar array will extract energy from the solar radiations directly plus wind turbine will extract the energy contain in the air flow. The solar array does not use the heat energy from sun instead it converts photon energy from radiation into the electrical energy. The wind turbine converts energy from the air mass flow into the angular motion of the turbine wheel so that it can be converted into electrical energy by the synchronous generator. Other devices from the matlab simulink have been used to make the model complete as MPPT, dc to dc converter, synchronous generator, voltage source inverter, power transformer and grid model. As there are wide variations in magnitudes of the sun energy as well as wind energy throughout the day, the combination of both the sources will provide a reliable electrical supply to the grid or utility. The results of simulation are introduced at the end of this paper as well.

Index Terms- PV Cell; Hybrid Power System; MATLAB Simulink; Wind Model; MPPT.

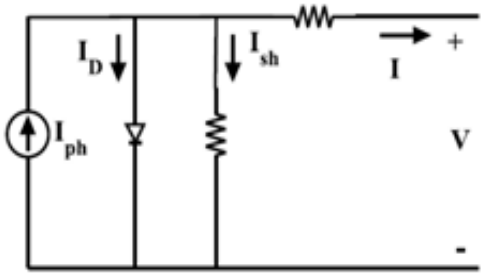
1. INTRODUCTION

With the increasing use of the fossil fuels such as coal, natural has and oil is driving society towards research in the field of renewable energy sources. Now, in todays era, the technologies for the renewable energy conversion have drastically improved in the performance as well as in the reduction in cost. The integration of these renewable energy sources to form a hybrid system with two or more sources will be an excellent option for distributed energy production. The power range of the renewable resources are very small, which can be increased with this type of integration of renewable resources into hybrid system. Solar-wind is such a combination which will provide an excellent reliability and performance of energy conversion and continuity. This hybrid combination have been implemented in matlab simulation environment. The wind turbine converts mechanical energy into the electrical energy and produces ac output voltage. Which is rectified and given to the inverter. Likely, the solar arrays will convert the solar energy into electrical energy which is in dc form. Dc output voltage will have to be kept constant, to regulate this voltage the mppt i.e. maximum power point tracking is used. This voltage from maximum power point tracker is given to the inverter. Inverter converts this dc voltage into AC three phase. This will be fed to the utility grid through a proper step up transformer. If no storage facility is available then this particular option of connecting hybrid system to the grid is the best option at all. This concept is presented in this paper while the simulation has been done in matlab environment. Here only two of the sources i.e. solar and wind are used, but more than two resources can be integrated into hybrid system to increase the reliability further.

2. MODELLING OF SYSTEM COMPONENTS

2.1 *Modeling of Solar System*

The following diagram shows the equivalent circuit of the P-V cell. Which is implemented considering the current generated by the pv cell, the non linear nature of it, the leakage current that flows in the pv cell itself, the internal series resistance of the pv cell. The current source provides the current that is generated in the pv cell by the bombardment of the photon on pn junction, the diode in parallel with current source is to indicate the nonlinear nature of the pv cell, the resistance in parallel with this diode provides the leakage current of the pv cell. The series resistance gives the internal resistance offered by the pv cell causing the voltage drop in it.



$$I=Ipv-I_0[\exp(\frac{V+IRs}{aVr})-1]-(\frac{V+IRs}{Rp}) \quad (1)$$

Where,
IPV–Photocurrent current,
IO–diode's Reverse saturation current,
V–Voltage across the diode,
a– Ideality factor
VT –Thermal voltage
Rs– Series resistance
Rp–Shunt resistance

2.2 Modeling of wind System

There are some assumptions based on which the theoretical modeling has been developed in matlab as follows,

-Friction is less
-stationary wind flow is available
-constant, shear-free wind flow
-rotation-free flow
-incompressible flow
-free wind flow is available around the wind energy converter

There is the total air mass flow on the earth that is due to the temperature and pressure difference. The energy contain in this air mass flow is derived with the help of wind turbine. The wind turbine uses this energy for electrical conversion. Kinetic energy W taken from air mass flow m at speed v1 in front of wind turbine pales and in back side of pales at speed v2 is illustrated by equations:

$$W=\frac{1}{2}m(v_1^2-v_2^2) \quad (2)$$

Theoretical medium power P which can be obtained is determined as ratio of kinetic energy and unit time in which we want to determine this power by the equation:

$$P=\frac{w}{t}=\frac{1}{2}\frac{m}{t}(v_1^2-v_2^2) \quad (3)$$

The rectifiers will convert ac output of the generator into dc output, which is then fed to the inverter.

2.3 Dc to dc convertor

Since solar radiation is variable in an entire day the corresponding solar output and its output voltage is going to vary considerably. If we want to catch up the power even during low irradiance period, we need to boost up the voltage level of the solar array likewise. With doing so, it will be possible to extract the generator maximum power from the solar array. This work of boosting the output voltage of pv array is performed by the so called boost converter, which is fundamentally a step chopper i.e. the dc to dc converter whose voltage level can be varied more than voltage available at its input. We have modeled this dc to dc converter in matlab simulink. The MOSFET have been used as the switch. The control pulses are provided by the MPPT controller called as maximum power point tracker.

2.4 Mppt implementation

Mppt is called as the maximum power point tracking which is the controller used for firing the mosfets in the dc to dc converter. It uses the perturb and observe algorithm (P & O algorithm). The controlling pulses are generated by the pulse width modulation (PWM). It tracks the maximum power point of the solar array so as to extract the maximum power from it.

2.5 Perturb and observe

Each and every MPPT algorithm has its own advantages and disadvantages. Perturb and observe (P&O) method is widely used due its simplicity. In this algorithm we introduce a perturbation in the operating voltage of the panel. Perturbation in voltage can be done by altering the value of duty-cycle of dc-dc converter.

Shortly it's called as the o & p algorithm is an algorithm in which step by step the decision are taken with respect to situations and conditions applied. The p & o algorithm that is used widely due to its simplicity and easiness of implementing and coding. Other algorithms are also present which are also too powerful to track the maximum power point on the P-V curve. In this we preferred to use p & o algorithm.

Many researches are going on this field of maximum power point tracking in order to get control over the wide variation of the photovoltaic array voltage. Also the control system needs to design in such a way to cope up with the problem being arised from the fast response of the control system at the situations when the photovoltaic array voltage variations are too slow. The p & o algorithm has been implemented to control the dc to dc converter. This controls the duty cycles of the dc to dc controller as per requirement of the conditions.

O & p algorithm works on the principle of $\Delta p/\Delta v = 0$ at the point of maximum power on the

maximum P-V curve. Since $\Delta p/\Delta v = 0$ at the maximum power point. At a given point on the P- V curve, if the operating voltage of the P-V array is perturbed in a given direction and $dP > 0$, it is known that the perturbation moved the arrays operating point towards the maximum power point. The O & P algorithm would continue to perturb in that direction. The P - V voltage, is $dp/dv < 0$, that time the change in the operating point will result in the movement of PV array away from the Maximum power point, and the observe and perturb algorithm reverses the direction of its perturbation.

2.6 Voltage source inverter

The three-level VSC regulates DC bus voltage at 500 V and keeps unity power factor. The control system uses two control loops: an external control loop which regulates DC link voltage to +/- 250 V and an internal control loop which regulates Id and Iq grid currents (active and reactive current components). Id current reference is the output of the DC voltage external controller. Iq current reference is set to zero in order to maintain unity power factor. Vd and Vq voltage outputs of the current controller are converted to three modulating signals Vref used by the PWM three-level pulse generator.

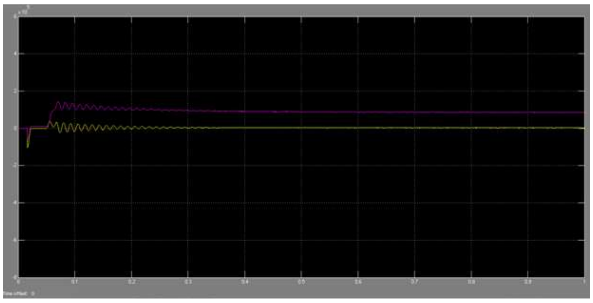
2.7 Utility Grid system

Grid have been implemented with the synchronous generator. Inverter is being fed from the dc voltages coming from the respective sources. Inverter output is supplied to the transformer of the rating 100 kva, 260 v/ 25 kv which is connected to the grid.

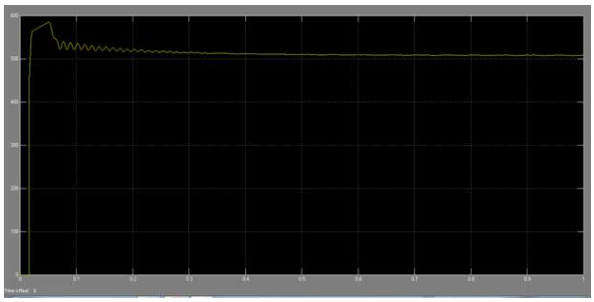
3. CONCLUSION

From this concept of hybridization of the renewable energy sources it has been shown that the reliability of power supply will increase. Also the particular surveyed area can be checked for the generation, whether it will provide loads at that particular area or not and how much installed capacity will be required by the plants in this area to fed electrical loads.

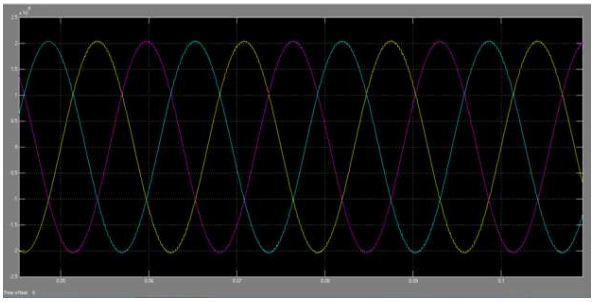
4. RESULTS BY SIMULATION



Simulation waveforms of active and reactive powers at grid



Simulation waveform of dc voltage



Simulation waveform of hybrid power system

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