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Modeling and Simulation of Grid Connected PV/WT Energy System Using Super-Capacitor

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Abstract-*The development of solar photovoltaic and wind energy system for producing electricity is most needed facility for the human being. Basically this system has to integrate the two energy systems that will give every time continuous power.This model consists for annexations of induction generator, controller, converters. The efficiency of electricity output is improves the reliability and integration of renewable power into the grid. The model is implemented using Matlab Simulink software package.This paper deals with grid connected energy system have using of super-capacitor and the Dcsupplycan be stored in the dc battery as well as the Ac source is connected to the grid. The MPPT and hysteresiscontrollers get the controlled supply.*

Keywords: Dc to Dc power conversion, Hybrid power systems, Modeling, Photovoltaic systems, Super capacitor, Grid, Wind power generation.

I. Introduction

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their

Conventional counterparts. Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water and various forms of biomass. This energy cannot be exhausted and is constantly renewed.

Wind and solar energy are reliable sources of electricity that can diversify our nation's energy portfolio. It's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. Wind turbines don't produce atmospheric emissions that cause acid rain or greenhouse gasses.

Wind is a form of solar energy. Due to the uneven heating of the atmosphere by the sun wind flow. Due to the earth terrains, bodies of water and vegetation the wind flow patterns are modified. Wind turbine converts the kinetic energy in the wind in to mechanical then to electrical by rotating the generator which is connected internally. Due to this concept of wind energy it is an unreliable one and less used.

So it is better to use hybrid generation system which is better than individual wind or individual PV generation system. So it is overcome the demerits of individual system. Grid interface of hybrid generation system improves the system reliability.

The major advantage of solar / wind hybrid system is that when solar and wind power productions are used together, the reliability of the system is enhancedThe major advantage of solar / wind hybrid system is that when solar and wind power productions are used together, the reliability of the system is enhanced.

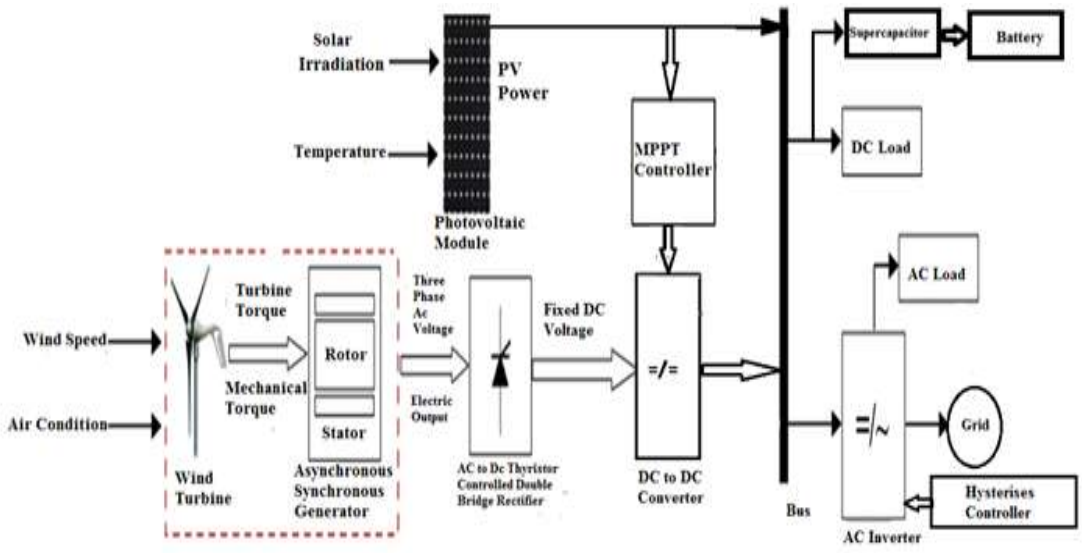

Fig. 1Grid Connected PV/WT Energy System Using Super-capacito

A. Super Capacitor

Super capacitors also known as Electric double-layer capacitors, or electrochemical double layer capacitors (EDLCs), or ultra-capacitors, are electrochemical capacitors that have an unusually high energy density when compared to common capacitors, typically on the order of thousands of times greater than a high capacity electrolytic capacitor. For instance, a typical electrolytic capacitor will have a capacitance in the range of tens of mill farads.

We focus then our study of the reduction in battery stresses by the use of SCs. We aim at investigating the optimal SCs/battery combination with respect to the cost price of super capacitors. This investigation is

threefold; first, super capacitors and battery models are developed then validated using MATLAB/Simulink software. In a second stage, the architecture and the simulation of the designed system combining the two types of storage devices are shown. The study emphasizes on UPS autonomous running for grid faults lasting few minutes, the super capacitors supply the transient demand of power and the battery is responsible for the smoothness requirement for energy. By allowing the battery to charge up the super capacitors pack at a suitable rate, the energy stored in the SCs would be available to satisfy the maximum of the pulsating load power demands.

The same size super capacitor would have a capacitance of several farads, an improvement of about two or three orders of magnitude in capacitance but usually at a lower working voltage. Larger, commercial electric double layer capacitors have capacities as high. The same size super capacitor would have a capacitance of several farads, an improvement of about two or three orders of magnitude in capacitance but usually at a lower working voltage.This charge separation creates a potential between the two plates, which can be harnessed in an external circuit. The total energy stored in this fashion increases with both the amount of charge stored and the Potential between the plates.

The control system presented in this section is designed to benefit the fast charge and discharge capability of the super capacitors in order to reduce the battery stresses due to instantaneous power demands. The purpose of the combination between SCs and the battery is to make the SCs supply the power transients and to smooth the high-power demands applied to the battery during autonomous operationEDLCs [1]. Do not have a conventional dielectric. Rather than two separate plates separated by an intervening substance, these capacitors use "plates" that are in fact two layers of the same substrate, and their electrical properties, the so-called "electrical double layer", result in the effective separation of charge despite the vanishingly thin (on the order of nanometers) physical separation of the layers.

II. Implementation of the Controllers

Controller is the heart of the system, a device which forces the controlled variable of the plant or process to behave in a desired manner. There are two types of controllers used in order to make the hybrid system to work in an efficient manner namely,

- MPPT controller

A.Maximum Power Point Tracking

The efficiency of a Solar PV module is measured to be not more than 30%. As seen from the Power Vs Voltage curve the module has to operate at a specific range of voltage values in order to extract maximum power thus improving the efficiency. The Maximum power transfer theory says that maximum power can be extracted from a source when the load impedance matches the source impedance (Thevenin equivalent impedance). Hence our problem of tracking the maximum power point reduces to an impedance matching problem.

B. Flow chart of perturb & observe technique

The P&O method is claimed to have slow dynamic response and high steady state error. In fact, the dynamic response is low when a small increment value and a low sampling rate are employed.

To decrease the steady state error low increments are essential because the P&O always makes the operating point oscillate near the MPP, but never at the MPP exactly. When the increment is lower, the system will be closer to the array MPP. In case of greater increment, the algorithm will work faster, but the steady state error will be increased.

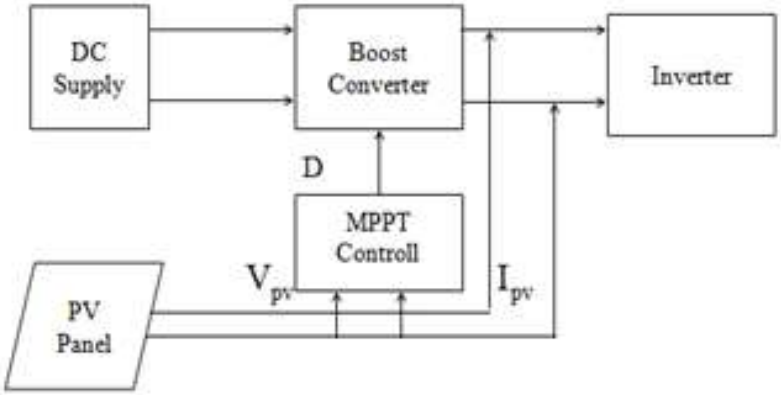

Fig. 2 Block diagram of solar array with MPPT controller

Where,

D = Duty cycle

Vpv = PV voltage

Ipv = PV current

III. Photovoltaic System

A. ***Photovoltaic System***

The photoelectric effect was first noted by French physicist Edmund Becquerel in 1839. He proposed that certain materials have property of producing small amounts of electric current when exposed to sunlight

A photovoltaic system makes use of one or more solar panel electricity. It consists of various components which include the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output.

B. ***Modeling Of A Solar Cell***

PV array are formed by combine no of solar cell in series and in parallel. A simple solar cell equivalent circuit model is shown in figure. To enhance the performance or rating no of cell are combine. Solar cell are connected in series to provide greater output voltage and combined in parallel to increase the current. Hence a particular PV array is the combination of several PV module connected in series and parallel. A module is the combination of no of solar cells connected in series andparallel.

The governing equation for this equivalent circuit is formulated using Kirchhoff's current law for current I:

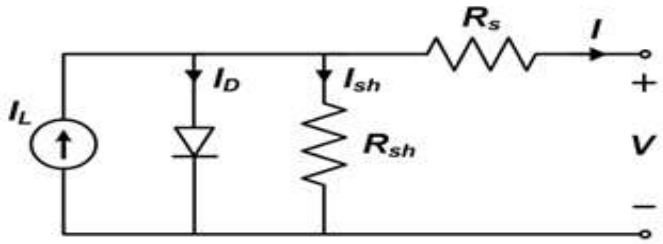

Fig.3 Circuit diagram of a single PV cell

$$I = I_L - I_D - I_{sh} \quad \text{..... (4.1)}$$

Here, I_L represents the light-generated current in the cell, I_D represents the voltage-dependent current lost to recombination, and Ish represents the current lost due to shunt resistances. In this single diode model, I_D is modeled using the Shockley equation for an ideal diode

$$I_D = I_0 \left[\exp\left(\frac{V + IR_s}{nV_T} \right) - 1 \right] \quad \text{.... (4.2)}$$

Where n the diode ideality is factor (unit less, usually between 1 and 2 for a single junction cell), Io is the saturation current, and V_T is the thermal voltage given by:

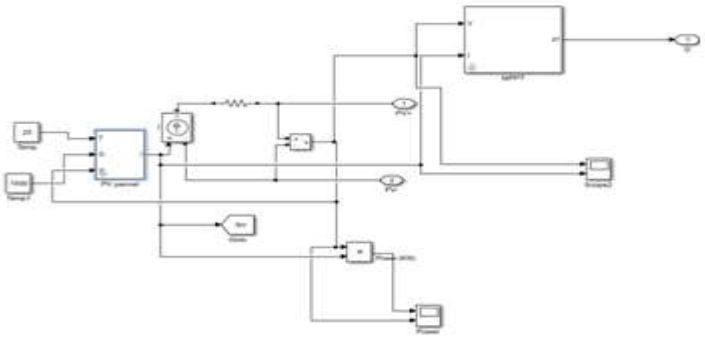

Fig. 4 Simulation for solar model

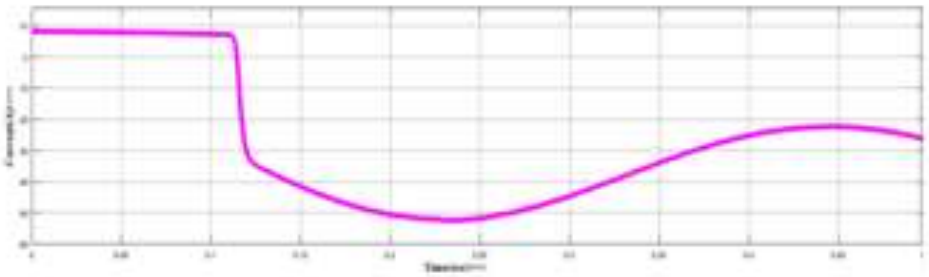

Fig. 5 Output current of solar model

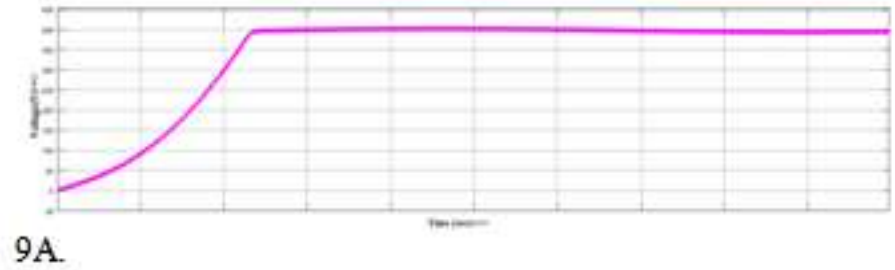

Fig. 6 Output voltage of solar model

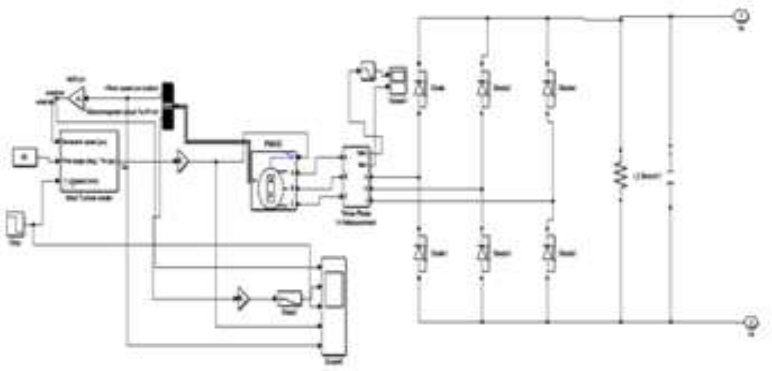

Fig. 7 Simulation for wind model

$$V_T = \frac{kT_C}{q} \quad \ldots(4.3)$$

Boltzmann's constant $(1.381 \times 10^{-23}\ J/K)$ and q is the elementary charge $(1.602 \times 10^{-19}\ C)$.

Writing the shunt current as $I_{sh} = (V + IR_s)/R_{sh}$ and combining this and the above equations results in the complete governing equation for the single diode model,

$$I = I_L - I_0 \left[\exp\left(\frac{V + IR_s}{nV_T} \right) - 1 \right] - \frac{V + IR_s}{R_{sh}} \quad \ldots\ldots$$

(4.4)The five parameters in this equation are primary to all single diode equivalent circuit models:

I_L : light current (A)

I_o : diode reverse saturation current (A)

Rs : series resistance (Ohm)

R_{sh}: shunt resistance (Ohm)

n : diode ideality factor (unit less)

For a photovoltaic module or array comprising N_s cells in series, and assuming all cells are identical and under uniform and equal irradiance and temperature (i.e., generate equal current and voltage), $I_{module} = I_{cell}$ and $I_{module} = N_S \times V_{cell}$

Fig.1.5Simulation diagram MPPT (P&O Technique)

The single diode equation for a module or array become

$$I_M = I_L - I_0 \left[\exp\left(\frac{V_M + I_M N_S R_S}{nN_S V_T} \right) - 1 \right] - \frac{V_M + I_M N_S R_S}{N_S R_{sh}}$$

$$a = \frac{N_S nkT_C}{q} \quad \ldots (4.5)$$

IV. Simulation

The simulation of following solar and wind model will be consist of following blocks,

- PV panel
- MPPT controller
- DC-DC converter
- Wind turbine

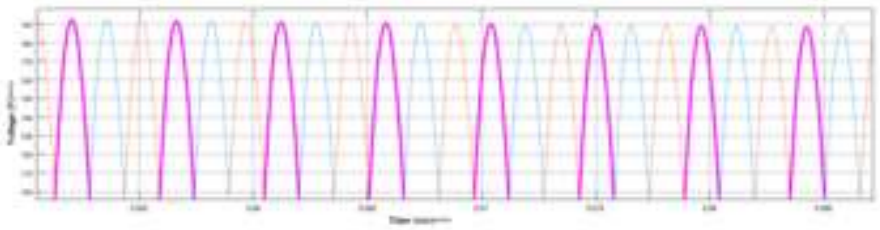

Fig. 8 Output voltage of wind model

The above Fig. 5 shows the output current waveform. In this waveform the maximum current attains 9A.

Fig. 9 Output current of wind model

The above Fig. 9 shows the output current waveform. In this waveform the maximum voltage attains 30A**.**

V. Grid Connected Hybrid System

The simulation results for different types of load is discussed,

- Grid connected hybrid PV and Wind
- Stand-alone wind
- Stand-alone solar

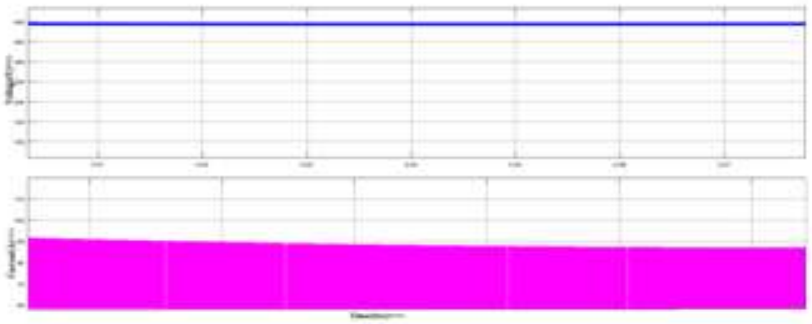

Fig. 10 Output for Hybrid system of solar and wind

The above Fig.10 shows the output voltage of hybrid system waveform. In this waveform the maximum voltage and current is attains 400V and 92A.

VI. Conclusion

The controller current harmonics are minimized and it is almost sinusoidal irrespective of the load current will be controlled, it has been established through simulation that the two controllers are MPPT controller and hysteresis-current-controller which are designed specifically for the proposed system have exactly tracked the maximum powers from both the sources.And finally supercacitor energy will goes to battery and the store power given to the appliances. The various waveform of this system were obtained by using the software Matlab/Simulink. The simulation result showed excellent performance from the Wind –PV hybrid system.

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