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Modelling and Simulation of Grid Connected Photovoltaic System Using MATLAB/Simulink

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ABSTRACT: In the world, energy sources like the fossil fuels and nuclear fission are widely used for electric power generation. But burning fossil fuels like oil, coal and natural gas emits nitrogen oxide, sulphur dioxide, and mercury and other toxic metals into our atmosphere, directly causing increasing incidents of lung disease, polluting soils and waters, damaging crops. Nuclear fission produces radioactive waste, material that will remain deadly for thousands of years. So we need alternative source like renewable energy sources for electric power generation. Energy from the sun is one of the promising options option for electricity generation as it is available everywhere. In this thesis Paper, the performance of a single phase Grid connected system is studied. The system includes a PV module (1kw), a DC/DC converter and a DC/AC inverter. There are two control mechanism in the designed PV system where the first one is for maximum power point tracking of the PV module and another one is for injecting the desired amount of active and reactive power to the grid. The whole system is designed and simulated by MATLAB (Simulink).

1. INTRODUCTION

PV systems are the most direct way to convert solar radiation into electricity and are based on the PV effect, which was first observed by Henri Becquerel in 1839.It is quite generally defined as the emergence of an electric voltage between two electrodes attached to a solid or liquid system upon shining light onto this system. Practically, all PV devices incorporate a PN junction in a semiconductor across which the photo voltage is developed. These devices are also known as solar cells. Light absorption occurs in a semiconductor material. The semiconductor material has to be able to absorb a large part of the solar spectrum [1]. The PV generation is gaining increased importance as a renewable source. It is used today in many applications e.g. battery charging; water pumping, home power supply, swimming-pool heating systems, satellite power systems…. The PV systems have the advantage of being maintenance and pollution-free but their installation cost is high and, in most applications; they require a power conditioner (DC/DC or DC/AC converter) for load interface. Since PV modules still have relatively low conversion efficiency. The overall system cost can be reduced using high efficiency power conditioners which, in addition, are designed to extract the maximum possible power from the PV module.

A Grid Connect solar PV system is a type of electrical inverter that convert direct current electricity from PV module into alternating current (AC). When the PV system is connected to the grid, it can transfer the extra energy to the grid after fulfilling the local demand. But when the system generates less than what is required to support the local demand, than extra energy is extracted from the grid. Thus PV solar energy acts as an alternative resource of electricity. The PV system, designed in this work, aims to transfer electrical power from PV panels to the grid. First, a dc-dc Converter is used to boost up PV voltage to a level higher than the peak of grid voltage. The converter also tracks the maximum power point of PV module. There are many algorithm for tracking maximum power point. The PV generators exhibit non-linear I-V characteristics. On the other hand, the optimum operating point changes with the solar irradiation, and cell temperature [2].Therefore, online tracking of the maximum power point of a PV array is an essential part of any successful PV system. A variety of maximum power point tracking (MPPT) methods is developed in literature.

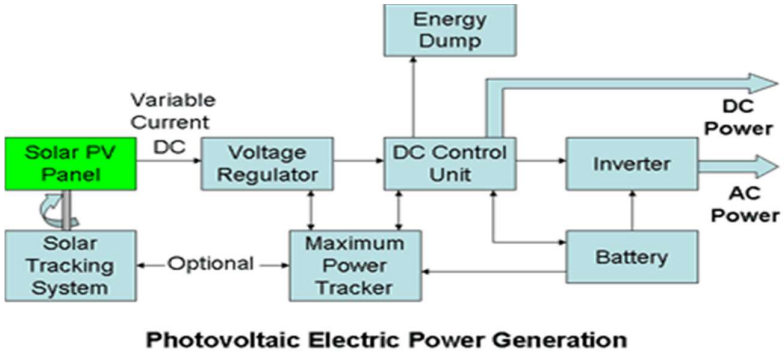

Figure1: Photovoltaic Electric Power Generation

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2. PV MODULE

In order to study the photovoltaic system in distributed generation network, a modelling and circuit model of the PV array is necessary. A photovoltaic device is a nonlinear device and the parameters depend essentially on sunlight and temperature. The photovoltaic cell converts the sunlight into electricity. The photovoltaic array consists of parallel and series of photovoltaic modules. The cell is grouped together to form the panels or modules. The voltage and current produced at the terminals of a PV can feed A DC load or connect to an inverter to produce AC current. The model of photovoltaic array is obtained from the photovoltaic cells and depends on how the cells are connected. The basic equation from the theory of semiconductor to describe mathematically the I-V characteristic of the ideal photovoltaic cell. It is a semiconductors diode with p-n junction. The material used is mono-crystalline and polycrystalline silicon cells.

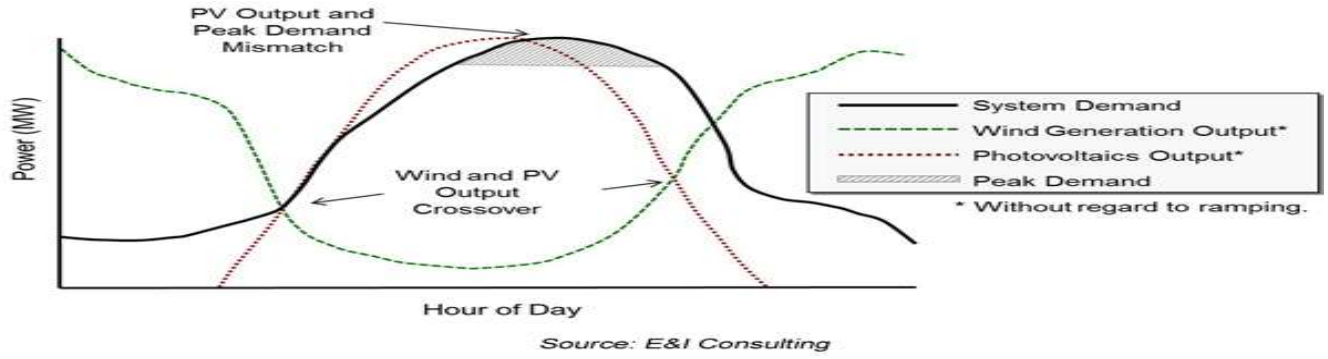

Figure2: I-V characteristic curve of the ideal photovoltaic cell

3. DC –DC CONVERSION SYSTEM

PV array with boost DC-DC inverter are connected to the ac grid via a DC/AC inverter. The inverter is employed to step down and to modulate the output voltage according to the grid voltage. Finally, the filter is designed to reduce high-order harmonics introduced by the PWM modulation of the DC/AC converter.

DC-DC converter is widely used in dc power supplies and dc motor drive for purpose of converting unregulated DC input into regulated DC output at desired voltage level. There are no of different topologies for DC-DC converters. They are categorized into isolated or non-isolated topologies. The isolated topologies use a small sized high frequency electrical isolation transformer which provides the benefits of dc isolation between input and output and step up or step down of output voltage by changing the transformer turns ratio. They are very often used in switch mode DC power supplies; In PV application, the grid connected system use these type of converter is use to step up the DC output When boost converter is in PV applications, the input voltage coming from PV panel is changed with atmospheric conditions. Therefore if the duty cycle varies than we get maximum power point of PV module. The design law of Boost converter is given below:

Inductor, L ≥ Vom ∗Dm ∗(1−Dm) | Δi |∗Fsw input capacitor, Cin ≥ Im∗Dm 2 0.02∗ 1−Dm ∗Vinm ∗Fsw output capacitor, Cout ≥ Im∗Dm ΔV∗Fsw here, Fsw = switching frequency, ΔV = ripple voltage for capacitor, Im = output current at maximum output power, Dm = duty cycle at maximum input power, Δi = ripple current for inductor, Vinm = input voltage at maximum power point, Vom= maximum of output voltage.

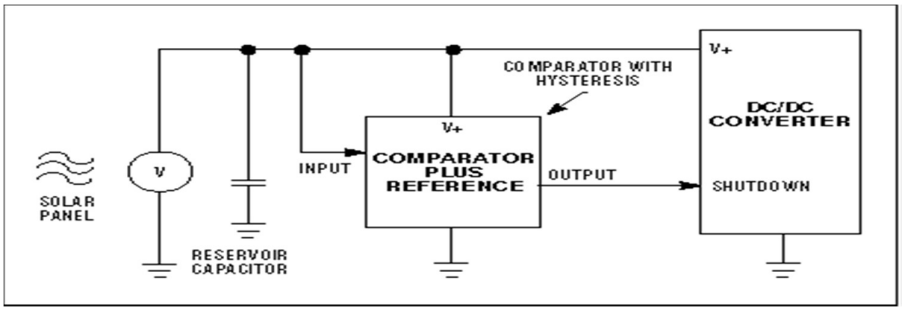

Figure3: DC-DC Conversion System

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When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores the energy. Polarity of the left side of the inductor is positive. When the switch is opened, current will be reduced as the impedance is higher. Therefore, change or reduction in current will be opposed by the inductor. Thus the polarity will be reversed (means left side of inductor will be negative now). As a result two sources will be in series causing a higher voltage to charge the capacitor through the diode D. Incremental conductance MPPT Algorithm [12] there are a large numbers of algorithms that are able to track MPPs. Some are simple, such as those based on voltage and current feedback, and some are complicated, such as perturbation and observation (P&O) or the incremental conductance method. They also varying complexity, sensor requirement, speed of convergence, cost, range of operation, popularity, ability to detect multiple local maxima, and their applications. Having a curious look at the recommended methods, hill climbing and P&O are the algorithms that were in the centre of consideration because of their simplicity and ease of implementation. Hill climbing is perturbation in the duty ratio of the power converter, and the P&O method is perturbation in the operating voltage of the PV array.

4. MODELING USING MATLAB / SIMULINK

The MATLAB/SIMULINK software used for the modelling and simulation purposes. This software prepares all the electrical and mathematical blocks that needed in the project under Power System Block set, Signal Routing and Math Operations (Simulink).This software is easy to use on graphical user interface pertaining to building or modelling any circuits or mathematical equations. The method of modelling of the PV array is shown clearly. First the modelling of the mathematical equation for the diode current and the light generated photovoltaic current for the array model. Next will be modelling for the DC-DC boost converter and connection of PV array with dc-dc boost converter and grid. The Building of the Mathematical Modelling and Circuit To model diode current(Id), the light generated photovoltaic current, solar irradiation block, the components that being use are the voltage measurement block, current measurement block, go to block, from block and control current source block. The circuitry part, DC-DC boost converter, inverter, load, PWM generator, isolation transformer, diode and resistor needed and grid block to fulfil the model.

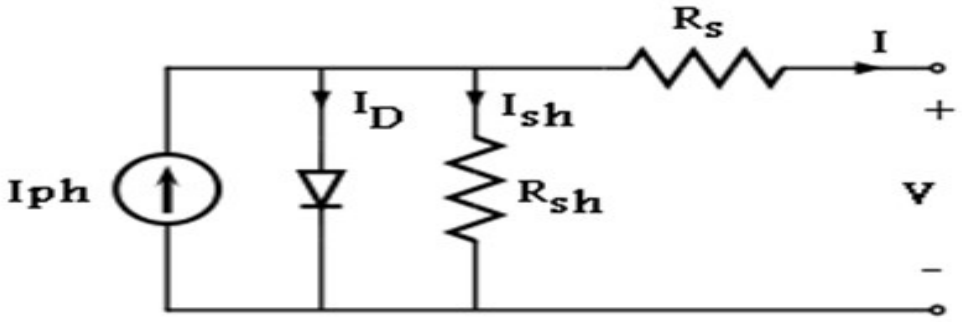

Figure4: Matlab/Simulink simulation of the grid connected PV System with the MPPT algorithm.

All PV array datasheets bring basically the nominal open-circuit voltage (Voc,n), the nominal short-circuit current (Isc,n), the voltage at the MPP (Vmp), the current at the MPP (Imp), the open-circuit voltage/temperature coefficient (KV), the short circuit current/temperature coefficient (KI), and the maximum experimental peak output power (Pmax,e). This information is always provided with reference to the nominal condition or standard test conditions (STC's) of temperature and solar irradiation. The practical PV device has a series resistance Rs whose influence is stronger when the device operates in the voltage source region and a parallel resistance Rp with stronger influence in the current source region of operation. The saturation current I0 is strongly dependent on the temperature so that the net effect of the temperature is the linear variation of the open-circuit voltage according to the practical voltage/temperature coefficient. This equation simplifies the model and cancels the model error at the vicinities of the open-circuit voltages, and consequently, at other regions of the I–V curve.A complete Matlab/Simulink simulation of the grid connected PV System with the MPPT algorithm and power active and reactive control of the grid-side inverter has been carried out with the following parameters:

♣ The PV Generator is composed of 15 series and 2 parallel KC200GT modules. ♣ Each module is composed of 54 series cell, presents the following characteristics: o Nominal peak power: 200 W, o Nominal voltage: 26.3 V, o Nominal current: 8.21 A, o Open-circuit voltage: 32.9 V, o Short-circuit current: 7.61 A. ♣ the DC-bus capacitance: C 200 10 F –3 = × ♣ the grid filter: R = 5Ω , L = 0.02H ♣ The grid voltage: 400/50 Hz.

5. CONCLUSION AND FUTURE SCOPE CONCLUSION:

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- From the theory of the photovoltaic, a model of the PV array has been presented.
- Then, the photovoltaic system with DC-DC boost converter and Grid has been designed.
- Finally, the system has been simulated with Simulink MATLAB.
- Solar cells are connected in series to increase its open circuit voltage.
- The PV modules are connected in series to increase its open circuit voltage and this type of series strings is connected in parallel to increase the short circuit current.
- When PV array connecting to dc-dc converter and grid the out-put current, voltage and power is increases when irradiation is increase. Finally the grid connected PV model can be used for energy output estimation and it's a user friendly system. FUTURE SCOPE In the modelling part, instead of just modelling one parameter which is solar radiation the cell temperature can be use with solar radiation for accuracy simulation result which is help for estimating energy output while designing the PV system. Another one is in MPPT part different MPPT methods can use with using artificial intelligence to get better power output. As grid connected system in power electronics part the different DCDC converter and inverters can also studied too to achieving a better quality energy output.

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