SIMULATION AND DESIGN OF BOOST CONVERTER FOR SOLAR PHOTOVOLTAIC SYSTEM

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Abstract: Variable speed drives for PV-fed water pumping system (WPS) in rural areas prove highly promising for economic and social growth. Being more economical without winding and permanent magnets on rotor,is emerging as an attractive option in variable speed drives. Such a system demands for a suitable controller with simple and reduced components. This paper presents the essence of PWM technique over single pulse mode (SPM) in PV-fed WPS. Performance characteristics such as: torque ripple, phase peak current and DC-link current of the PWM technique tested at various insolation levels are presented in this study. This simulation can be useful in specifyingthe appropriateness of the MPPT algorithms for the different PV system applications. For this study, SPVhas been used to build a look-up table based simulation model for SPV in Matlab/Simulink. The system is then implemented using high parallel computing system.

Keywords: Water Pumping system, PWM, Solar photovolatic, Variable speed drives.

I.INTRODUCTION

One definition of a solar panel is an electrical or thermal energy collector that uses the sun's rays as an input. A photovoltaic (PV) module consists of a connected assembly of solar cells, usually 6x10. The photovoltaic array of a business or domestic photovoltaic system is made up of photovoltaic modules. This system uses solar energy to produce and distribute electricity. Typically, modules are rated from 100 to 365 W, which is the DC output power under standard test conditions (STC). Given the same rated output, the size of a module is proportional to its efficiency; for example, a 230 W module with an efficiency of 8% would have double the area of a 230 W module with an efficiency of 16%. Some solar modules on the market are able to achieve efficiencies of 22% or even 24%, according to some reports. Most solar power setups use many modules since a single module has a limited power output. A solar tracking mechanism is an optional addition to a photovoltaic system that normally consists of an array of photovoltaic modules, an inverter, a battery pack for storage, and connector cable. Solar water heating systems are the most prevalent use of solar panels. Solar power is now more affordable than grid-connected energy generated by conventional fossil fuels in many nations due to its steadily declining price.

Using the photovoltaic effect, photovoltaic modules convert the energy of the sun's rays into usable power. Crystalline silicon cells based on wafers or thin-film cells are used by most modules. Either the top or bottom layer of a module might serve as its structural (load-bearing) part. Additionally, it is crucial to shield cells from mechanical stress and humidity. Although most modules are inflexible, thin-film cell-based semi-flexible options are also available. The electrical connections between the cells should be in series. Most solar panels' exteriors have MC4 connectors, which allow for simple, weatherproof connections to other components of the system. To get the voltage or current you want out of a module, you link its electrical components in series or parallel. Silver, copper, or other non-magnetic transition metals may be used in the conducting wires that remove electricity from the modules. To make the most of the light reaching the parts of the module that are still exposed, bypass diodes may be built in or utilized externally in situations when there is partial shadowing.

Concentrators are a kind of solar PV module that uses lenses or mirrors to concentrate light onto smaller cells. This allows for the cost-effective use of gallium arsenide cells, which have a high cost per unit area.

In terms of efficiency, which is defined as the ratio of wattage production to panel size, monocrystalline silicon solar PV is often the gold standard. This efficiency, however, is not without its price. Solar photovoltaic (PV) technology that offers the greatest value is polycrystalline silicon, which may provide efficiency levels comparable to monocrystalline panels at half the price. The process of generating only one crystal results in monocrystalline solar panels. The characteristic patterns that give monocrystalline panels their unmistakable look are carved into the silicon cells, exposing the missing corners in the grid-like structure. This is done since these crystals often have an oval form. Monocrystalline materials are the most pure and efficient because their crystal structures are perfectly flat, resulting in a uniform blue hue with no visible grain boundaries.

II. LITERATURE SURVEY

[1]. Paper Name: Global status of renewable energy and market

Author Name : Singh D, Sharma N.K,Sood Y.R and Jarial R.K Year ; 2011

Just a quick rundown: A solar photovoltaic (PV) power system's output power-voltage (P-V) curve shows a single peak when there is uniform light, but it often shows highly nonlinear multi-peak behavior when there is partial shadow. However, finding the MPP may be a challenge for traditional maximum power point tracking (MPPT) control techniques. There are a number of MPPT control methods that may be used to modify the PV system's generating efficiency and peak power output. The most common maximum power point tracking (MPPT) algorithms for photovoltaic (PV) systems are summarized in this paper, which sorts them into three groups according to the control theory and optimization they use. Our main objective is to examine and contrast the benefits and drawbacks of MPPT methods for PV systems that function under PSCs. Our discussion concludes with a few suggestions for further research into MPPT.

[2]. Paper Name :IEEE Power and energy magazine.

Author Name : Arjun p, Gupta and Jayant S Year :2009

The central emphasis of this work is a photovoltaic cell model developed in Matlab/SIMULINK. An analogous circuit with a photocurrent source, a diode, a series resistor, and a shunt resistor describes this model, which is based on mathematical calculations. With the help of the created model, one may anticipate how PV cells will react to various environmental and physical conditions. Another use of the concept is extraction.

[3]. Paper Name : Challenges to dissfusion of small wind turbines in india .
Author Name :Anindita Roy, A.Rathod and G.N Kulkarni Year :2013
The primary goal of this study is to identify, beyond what is often stated in product specifications, a subset of the performance metrics that define the operation of a certain kind of photovoltaic (PV) panel. Based on this, a basic model of the PV panel's electrical behavior may be developed.

III. PROPOSED SYSTEM

A) DESIGNING OF PV MODULE

Equivalent Circuit

Figure 1 represents a single diode model which is widely used as compared to other PV module design. In this circuit, Rsh is shunt resistance, I is open circuit currentof a solar cell, Io is diode saturation current, Iph is the light-generated current which depends upon solar radiation and cell temperature, Ish is shunt resistance current which flows through Rsh and flows between the n and p layers, Rse is series resistance which represents the losses due to flowing current across highly resistive emitter and contacts, Voc is terminal voltage of a solar cell, respectively.

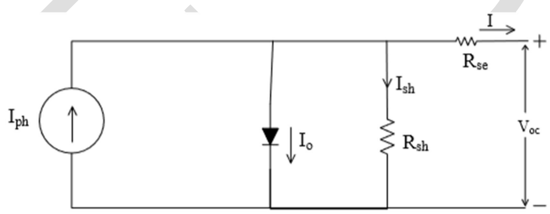

Fig. 1 Solar cell equivalent circuit

In this circuit the mathematical expression for cell current in single diode model is obtained by applying KCL,

I= Iph-Io-Ish(1) 1

Where, Iph= [Isc+Ki (Tk-T)] *G/1000 2

Iph is photocurrent under standard test conditions (STC), with reference solar radiation of 1000 W / m2 at solar spectrum of 1.5A and reference temperature of solar cell Tk of 25°C. T is instantaneous solar cell temperature, Ki is current temperature coefficient and G is an instantaneous solar radiation.

Module Reverse Saturation Current (I_{rs})

Module reverse saturation current, I_{rs}, is expressed as,

$I_{rs}= I_{sc}/ [\exp (q*V_{oc}/Ns*k*A*T)-1]$ 3

Where q is the electron charge (1.6 × 10í19 C), V_{oc} is Solar module open-circuit voltage (21.24V), Ns is the number of cells connected in series (36), A is the ideality factor (A=1.6). and k is the Boltzmann constant (k= 1.3805 × 10í23 J/K).

Module Saturation Current (I_0)

Variation of module saturation current I0takes place with respect to cell temperature. It is expressed as,

I_0=Irs [T/Tr] 3*exp [q*E_{g0}/Ak*{(1/T_r)-(1/T)}] 4

Where E_{g0} is the band gap energy of semiconductor (For polycrystalline Si at 25ħC, Eg0=1.1 eV). Simulation of equation (4) has been done and represented in Figure 1. Here, the inputs are module reverse saturation current, module operating temperature and reference temperature.

Module Output Current (IPV)

The PV module output current of single diode model isI_{PV} represented in Figure 1 is described by a basic equation and is expressed as,

I_{pv}=N_p*I_{ph}-N_p*I_0 [exp {q*(V_{pv}+I_{pv}*R_{se})*Ns*A*k*T1]

5

B) PV MAXIMUM POWER EXTRACTION SYSTEM DESIGN

The PV module output power changes significantly as there is variation in irradiation and temperature. To extract the maximum power of from solar photovoltaic module and transfer this power to the load, the maximum power point (MPPT) algorithm is used [15]. To transfer the maximum power of the PV module to the load, a DC-DC converter is used as shown in Figure, which acts as an interface between the load and the module. Here, step up type DC-DC Converter is used.

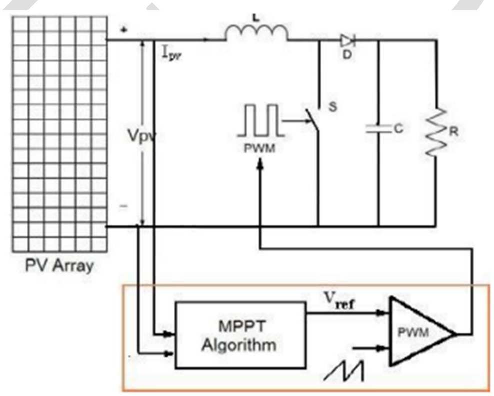

Fig.2 Block diagram of the DC-DC converter for MPP operation

Boost converter

To obtain the maximum performance of the maximum power point, PV modules are always used with DC-to-DC converters. Buck, boost, and buck-boost are types of converters used for this purpose. For grid-connected applications boost converter is used where as buck-boost configuration is used for battery charging applications.

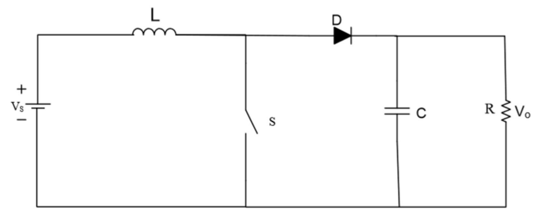

Figure 3: DC to DC boost converter configuration

Figure. represents the configuration of boost converter and it is composed of load resistance R, filter capacitor C, diode D, control switch S, boost inductor L, and DC input voltage source Vs. The voltage gain of boost converter when switch operated with a duty ratio D is expressed as,

$M_v = V_o/V_s = 1/1 – D$ 6

Where Vo is output voltage, Vs is input voltage, and D is duty cycle of PWM (pulse width modulation) signal and used to control ON and OFF states of MOSFET.

For value of inductance L >Lb, the operation of boost converter is in continuous conduction mode where,

Lb= (1 í D2) DR/ 2 f 7

Where Lb is smallest inductance value required for continuous conduction. As current supplied to output RC circuit is discontinuous.

Therefore, to limit the output ripple voltage a large filter capacitor is required. Cmin is minimum value of filter capacitor. It supplies output DC current to the load when diode D is off. The smallest value of filter capacitance results in ripple voltage Vc and it is expressed as, $C_{min} = DV_o/ V_rRF$ 8

Table 1 gives the DC-DC boost converter design component values which are used for simulation.

MPPT Methods For maximum power point tracking many methods are used. Some of the methods are:

- Constant Current method
- Constant Voltage method
- Parasitic Capacitance method
- Incremental Conductance method
- Perturb and Observe method
- Particle swarm optimization
- Cuckoo Search Algorithm

Perturb and Observe method

It is widely used method. Minimum sensors are used in this method. In this method, sampling of operating voltage is done and operating voltage is changed in a specific direction by using algorithm and therefore it samples dp / dv. The algorithm increases the voltage value towards MPP until dp / dv is negative if dp / dv is positive. This iteration continues until the algorithm arrives at MPP. When there is a large variation in solar irradiation then this algorithm is not suitable. The voltage perturbs around the maximum power point (MPP) and never actually reaches an exact value.

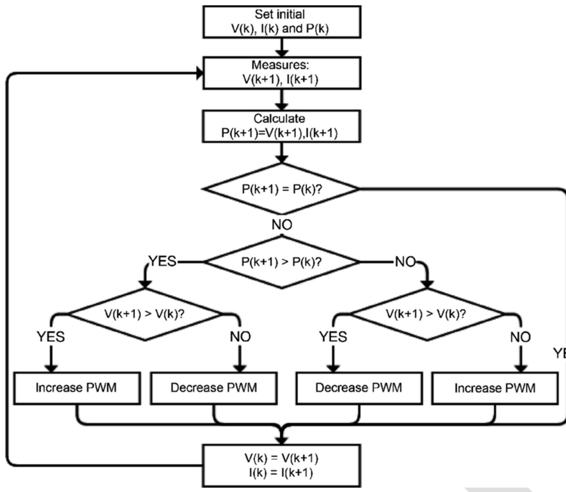

Fig.4 MPPT flowchart P&O algorithm

V. RESULTS

We run the simulations in Matlab and show you the results. Booster for open-loop solar power conversion systems.

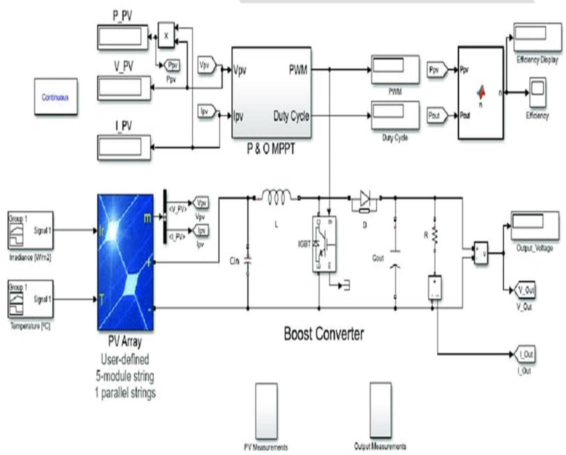

Fig.5 Simulink model of PV panel with single-chopper boost converter

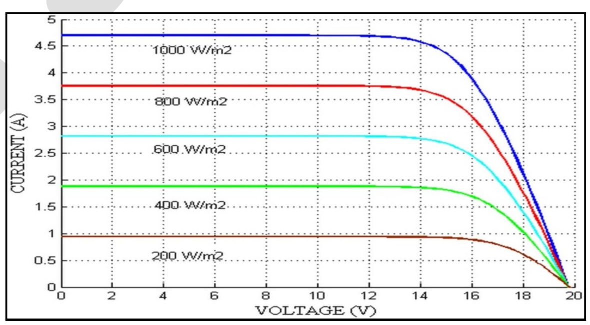

Fig.6 Performance of pv model

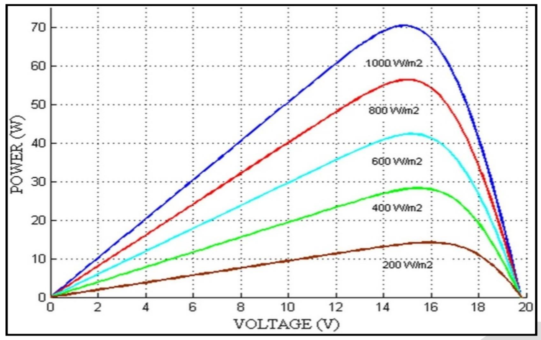

Fig.7 Power performance of proposed model

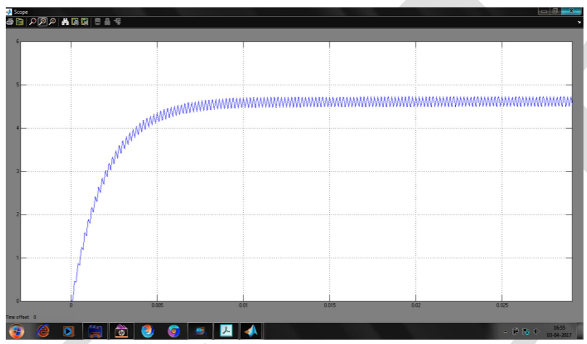
Fig.8 Output Voltage

CONCLUSION

The purpose of this study is to provide a blueprint for a boost dc-dc converter that can be used to control the voltage of a solar PV system. With a high power boost dc-dc converter and the P & O MPPT algorithm, tracking power loss may be significantly reduced. Results from a MATLAB/SIMULINK simulation of a boost DC/DC converter with an MPPT controller are shown, along with P-V and I-V curves acquired for a range of operating circumstances. The paper details the SRM PWM control technique for PV-fed WPSs, including its purpose, modeling, simulation, implementation using FPGAs, and performance assessment. The PV-fed SRM WPS may be made more cost-effective and space-efficient using this technique instead of hysteresis control, which requires current sensors, frequency limiters, and current limiters. Even if SPM control offers comparable benefits, a PWM control technique might lead to zero or full voltage during commutation, reducing the current gradient and noise even more. Considering these benefits, researchers have examined the PWM strategy's impact on performance metrics including torque ripple and peak current over a range of insolation levels in PV-fed WPS systems. By comparing PWM with SPM for different amounts of solar radiation, we find that the former method minimizes torque ripple, which in turn lowers system noise. This study shows the development of a PWM approach for PV-fed WPS utilizing a Spartan 3AN FPGA on an 8/6 2.2kW SRM, taking advantage of the arrival of FPGAs with increased parallel processing capacity. The simulated and experimental findings are consistent with one another. Future research should expand to examine the performance characteristics of SRM control in PV-fed WPS with real PV and pump employing PWM control, since current work primarily focuses on SRM control in this context.

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