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Simulation of Solar PV and Wind System Using Voltage Droop Control

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Abstract – In this paper modelling, simulation of MPPT boost converter are described for PV module. MPPT control is implemented using perturb and observe P& O method is employed to control boost converter. The power drawn through the PV array is then connected to the DC-DC converter which boosts the voltage by changing the duty cycle. This duty cycle are fed to MOSFET which switches to extract maximum power from the PV system under different operating conditions. The effectiveness of proposed system is shown using MATLAB simulation results. The Matlab simulation of solar PV and Wind with Voltage droop control is successfully done in this paper.

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INTRODUCTION

Due to increasing power demand many new alternatives of power generation are used effectively. Out of all these photovoltaic generation is effective and can easily be implemented. The power from the PV system have different outputs depending on the condition of temperature and irradiance. To extract maximum power from PV array different MPPT algorithms are available such as, perturb and observe (P&O), incremental conductance (INC) and many more. Out of all these perturb and observe (P&O)have some advantages and commonly implemented in many PV applications. This mppt controller is used to extract maximum power under all the irradiance conditions using boost converter.

SOLAR PHOTOVOLTAIC ARRAY

The Solar Photovoltaic Array is formed by connecting several solar panels in series and parallel combination to generate the required power. The smallest component of the solar photovoltaic array is called photovoltaic(PV) cell. The ideal solar photovoltaic cell is represented by the equivalent circuit shown in Fig 1. These cells are connected in series of 36 or 72 cells to form one module. Similarly, several modules are assembled into a single structure to form array. Finally, assembly of these photovoltaic arrays are connected in parallel to obtain the required power. In PV module, series resistance (R_s) is comparatively more predominant and R_{sh} is considered equal to infinity ideally. The open circuit voltage (V_{oc}) of the PV cell is directly proportional to solar irradiation and V_{oc} is inversely proportional to the temperature. The PV Array is characterised based on the I-V and P-V characteristic. As we can see from Fig.2 and Fig. 3, the variation in irradiation result variation in the current and the curves of I-V characteristic vary largely for different level of irradiation. The irradiation directly affects the PV Array current while the change of temperature directly affects the voltage generated by the PV Array as shown in Fig. 4 and Fig. 5. So same observation we can made from the below graphs of I-V and P-V characteristics at different irradiation and temperature level.

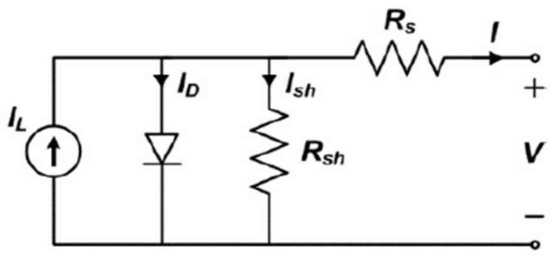

Figure 1: Equivalent circuit of PV cell

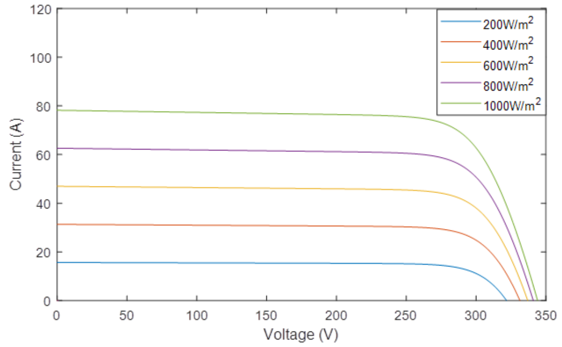

Figure 2: I-V characteristics of 20kW PV Array at different irradiation levels

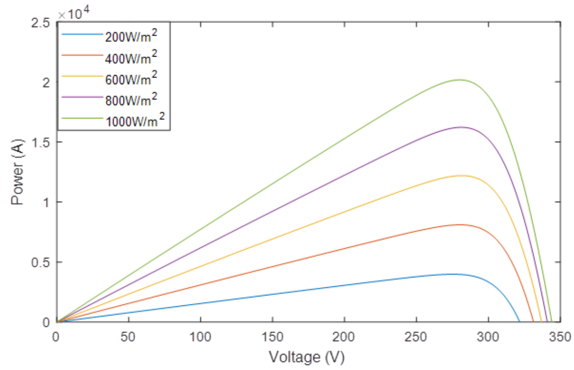

Figure 3: P-V characteristics of 20kW PV Array at different irradiation levels

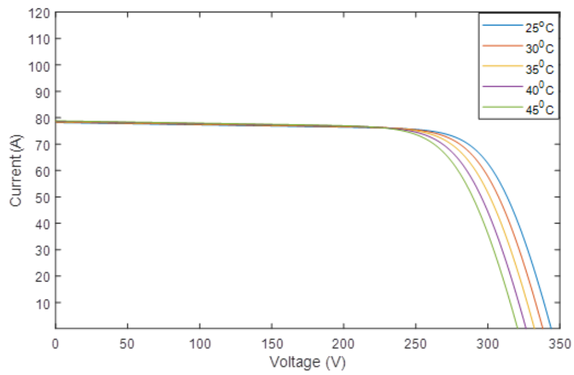

Figure 4: I-V characteristics of 20kW PV Array at different temperature levels

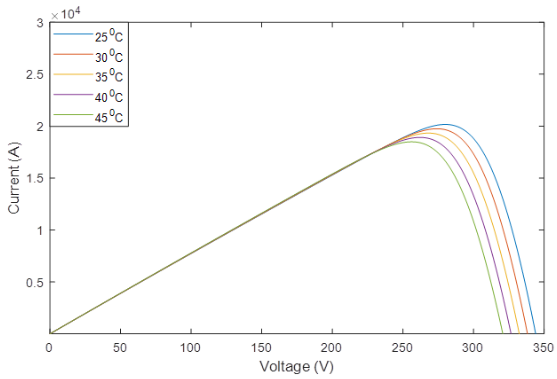

Figure 5: P-V characteristics of 20kW PV Array at different temperature levels

MAXIMUM POWER POINT TRACKING AND BOOST CONVERTER

Perturb and observe (P&O) MPPT is used along with boost converter to boost dc voltage to the required DC link voltage. An mppt control algorithm for INC is designed in MATLAB embedded function. The control of the switch used in boost converter is provided by the duty cycle generated using algorithm. Switching frequency of PWM generator is 20 kHz. Fig. 7 shows the INC algorithm and Fig. 6 shows the design of boost converter.

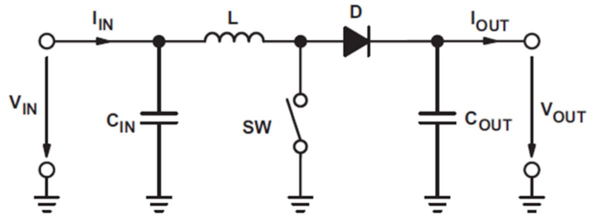

Figure 6: Boost Converter

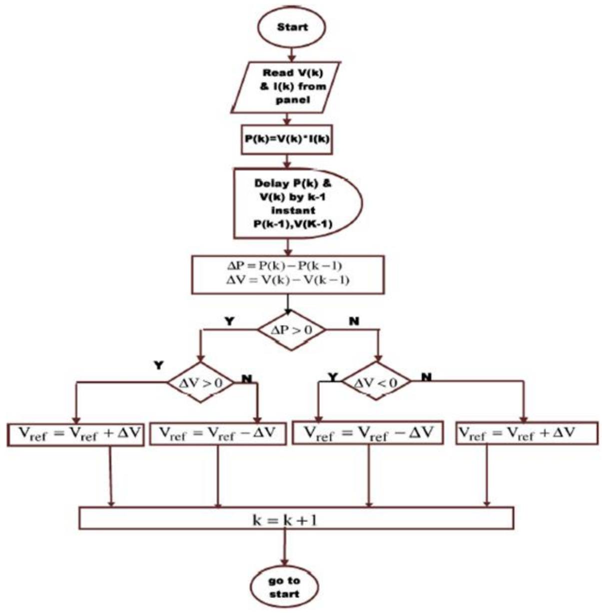

Figure 7: Perturb and Observe Algorithm

The most commonly used MPPT algorithm is P&O method. This algorithm uses simple feedback arrangement and little measured parameters. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle. In this algorithm a slight perturbation is introduce to the system. This perturbation causes the power of the solar module various. If the power increases due to the perturbation then the perturbation is continued in the same direction. When the stable condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the perturbation size is remain very small. The technique is advanced in such a style that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts to transfer the operating point of the module to that particular voltage level. It is observed some power loss due to this perturbation also the fails to track the maximum power under fast changing atmospheric conditions. But remain this technique is very popular and simple. The algorithm can be easily understood by the following flow chart which is shown in figure 7.

Table-1 Parameters of the PV module at 25°C, 1000 W/m²

Imp	2.88 A
Vmp	17 V
Pmp	49 W
Isc	3.11 A
Voc	21.8 V
Rs	0.55 Ω
Kv	-72.5×10^{-3} V/K
Ki	1.3×10^{-3} A/K
Ns	36

DC-DC BOOST CONVERTER

Boost converter steps up the voltage. The PV system have low efficiency and thus to boost its voltage we are using this DC-DC boost converter. Maximum point tracking system it obtains the maximum power then on the boost converter it boost the voltage at higher level.

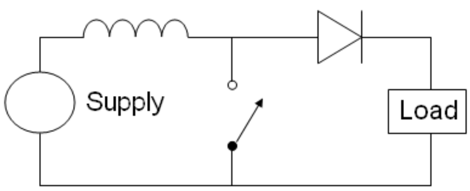

Fig 8 DC-DC Boost Converter

The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. In a boost converter, the output voltage is always higher than the input voltage. A schematic of a boost power stage is shown in Figure 1.

(1) When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. Polarity of the left side of the inductor is positive.

(2) When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current towards the load. Thus the polarity will be reversed. As a result, two sources will be in series causing a higher voltage to charge the capacitor through the diode D.

If the switch is cycled fast enough, the inductor will not discharge fully in between charging stages, and the load will always see a voltage greater than that of the input source alone when the switch is opened. Also while the switch is opened, the capacitor in parallel with the load is charged to this combined voltage. When the switch is then closed and the right hand side is shorted out from the left hand side, the capacitor is therefore able to provide the voltage and energy to the load. During this time, the blocking diode prevents the capacitor from discharging through the switch. The switch must of course be opened again fast enough to prevent the capacitor from discharging too much.

Solar PV Simulation with Voltage Droop Control

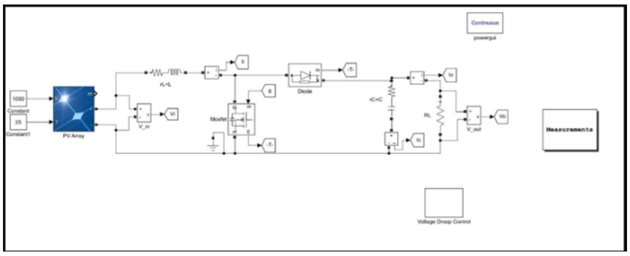

Fig.9- Solar PV system with Droop control

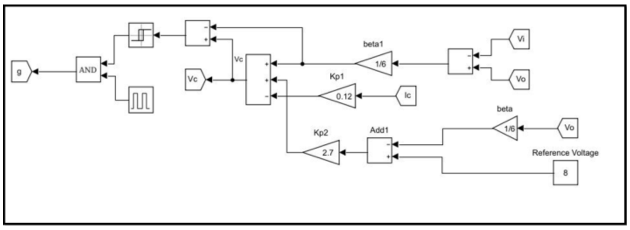

Fig 10- Voltage Droop control subsystem

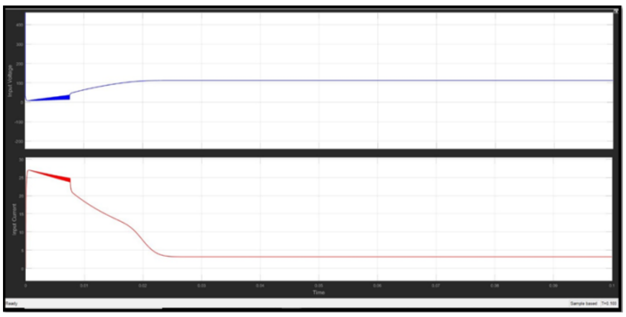

Fig 11- Solar PV input Voltage and Current

Fig 12- Solar PV Output Voltage and Current with droop control

Solar PV-Wind hybrid Simulation with Voltage Droop Control

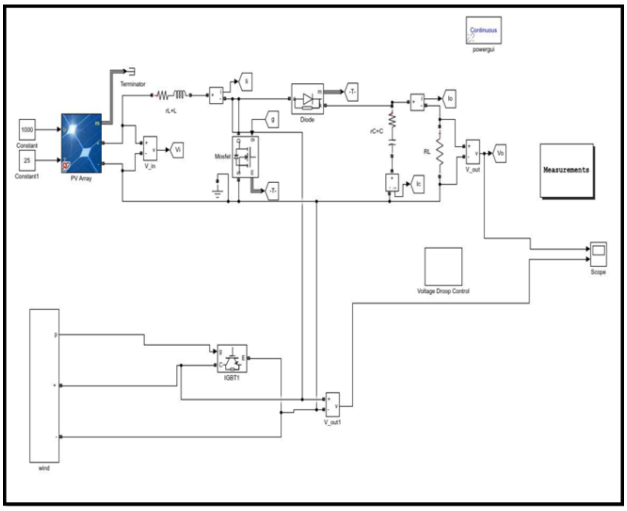

Fig 13- Solar-Wind Hybrid with Voltage Droop control

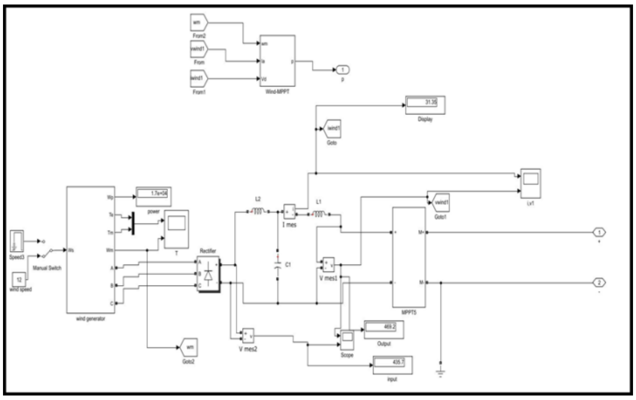

Fig 14- Wind Simulation subsystem

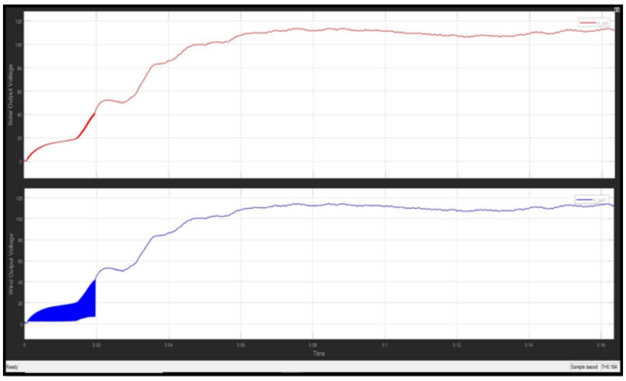

Fig 15- Output for Solar & Wind with voltage droop control

CONCLUSION

This work presents a performance study of a dc micro grid when it is used a voltage droop technique to regulated the grid voltage and to control the load sharing between different sources. A small model of a dc micro grid comprising micro sources and loads was implemented in the Simulink-Matlab environment. Some aspects about centralized (master-slave) and decentralized (voltage droop) control strategies as well as the procedures to design the controllers, with and without droop control, are presented and discussed. Simulation results obtained with the digital model of the dc micro grid with three micro sources will be presented to validate the effectiveness of the voltage droop strategy, applied to proportional and proportional-integral controllers, to regulate the micro grid voltage.

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