Multiple Input DC DC Converter for Hybrid PV and Wind Power System

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***Abstract* - Tracking solar and wind power effectively and efficiently. The use of single converter structure for interfacing solar photovoltaic(PV) panel and wind turbine coupled synchronous generator is economical. In this paper multiple-input, DC-DC converter steps up the input voltages and tracks maximum power from wind and solar by suitable MPPT switching techniques. The converter circuit utilizes a lesser number of passive components compares to other topologies. Intermittent behavior of the sources will cause unnecessary voltage fluctuations, which can be rectified by a buck circuit. A buck converter with voltage-mode control operation produces varying input to constant output voltage with the help of a PI controller with suitable kp and ki values. The whole system simulated using MATLAB Simulink.**

***Index Terms* - Hybrid system, PV and PMSG wind turbine, MIC.**

I.INTRODUCTION

Renewable energy sources have received wider attention in the past few decades and significant endeavours have been made to develop efficient renewable energy conversion systems. Solar PV and wind energy systems are the most promising renewable energy technologies. Wind power has been considered as an environmentally friendly and economically competitive fashion of electric power generation. The wind energy system produces power in the form of AC power at different frequency levels in case of a variable speed operation [2].

Solar photovoltaic is another type of reliable propitious nonconventional electrical energy source. Solar insolation is abundant in nature. So the solar PV involvement is greater and convenient compared to other renewable sources. The PV cell efficiency maximizes by employing the technique of maximum power point tracking algorithms under different solar irradiance and temperature. Using the data processed by MPPT, the duty ratio of the DC-DC converter is regulated using a PI controller to meet the MPP, which in turn forces the converter to extract the maximum power from the PV cell [5].

This paper is focusing on the single converter technology for multiple inputs as form as a hybrid system. The converter is talk about of a step-up converter with dual inputs and a single output structure. Each source of the converter posses of the respective boosting stage, which is the combination of an inductor and a switch. The output of each boosting stage is controlled by the duty adjusted from the MPP reference. The solar PV and wind turbine operate under different conditions. The scattered behaviour condition leads to voltage fluctuation at the output. This voltage to be maintained for constant DC link by the buck converter with closed-loop control. This system is reliable for a micro grid at remote localities. Section II is discussing the converter topology and their design. Section III is describing the MATLAB simulations and results of the proposed system.

II. PROPOSED SYSTEM

The multiple-input converter(MIC) works in a manner of compliment power extraction, which means that a single source and the energy storage inductor of the second source is delivering power to the output while the other input source stores the energy in the inductor in each half of duty cycle. The maximum power point tracking control technique uses for picking the maximum power from each source. Solar PV and PMSG delivers electrical power from wind and sunlight. The MIC operates with the output buck converter to produce the constant DC voltage and current.

A. Converter Topology

The multiple-input converter has 2 switches and two inductors and a single capacitor. It has two inputs and a single output; it is a voltage-boosting circuit. The inputs of MIC are connected to the output terminals of the solar PV and wind turbine generator. The buck converter is connected to MIC output. The voltage fluctuations at the MIC output are eliminated and maintained at a constant voltage. The MIC is controlled by the method MPPT. The buck converter switching gate pulses are generated by the PI controller with suitable Kp and Ki values

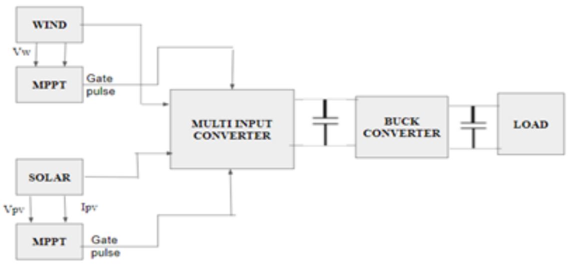

Fig -1: Block diagram of proposed PV-Wind hybrid system

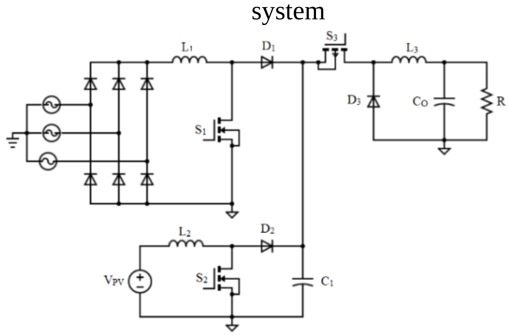

Fig -2: Circuit diagram of MIC

1) Modes operation of MIC: When S_1 is turned ON at the beginning of the period T. Diode D_1 is in reversed biased condition. D_1 blocks the output voltage. The wind generator will then be in parallel with L_1 and L_1 will start charging (inductor current rises). The output capacitor C_1 will start discharging through the load. At the same time, S_2 will be OFF and D_2 will be ON Solar PV and L_2 will be connected in series with the output capacitor, and this will charge the output capacitor causing the output voltage to increase.

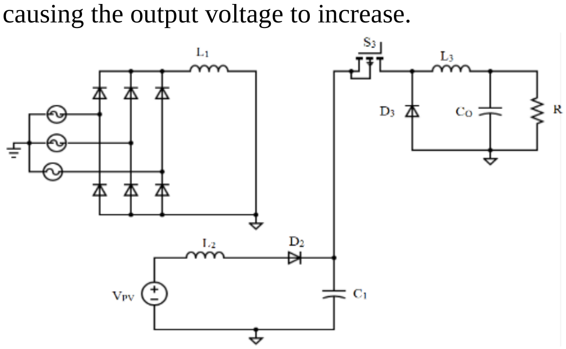

Fig -3: Circuit diagram of S_1 turn on

When S_2 is turned ON PV panel will then be in parallel with L_2, and L_2will start charging. The diode D_1 is forward biased mode. At the same time, S_1 will be OFF and D_1 will be ON PMSG and L_1 will be connected in series with the output capacitor, and this will charge the output capacitor.

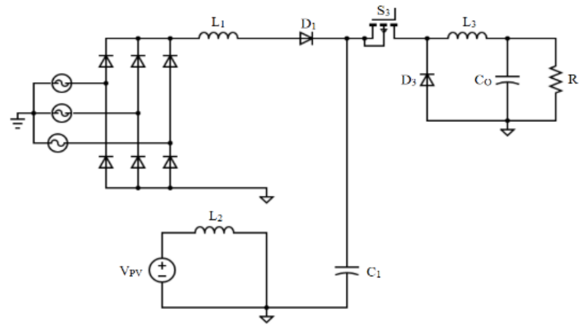

Fig -4: Circuit diagram of S_2 turn on

B. Design of components:

In the continuous conducting mode for a normal boost converter, the output current I can be expressed as follows:

$$I_D = I_L(1-D) \quad (1)$$

$$I_{D1} = I_{L1}(1-D) \quad (2)$$

$$I_{D2} = I_{L2}D \quad (3)$$

$$I_O = I_{L1}(1-D) + I_{L2}D \quad (4)$$

$$L_1 = L_2 = \frac{V_{IN}D}{f_s * \Delta I_{OM}} \quad (5)$$

$$C_1 = \frac{I_O D}{f_s * \Delta V_{OM}} \quad (6)$$

where I_L is the current flowing in the inductance, and I_D is the current flowing through the diode when the transistor connected to that diode is OFF (during the period (1 - D)T). For the proposed converter, I_{D1} and I_{D2} can be represented as: Inductor design is based on the CCM operation of the converter and considering the voltage and current ripples at the desired level for efficient operation. Where D is the duty ratio. V_{IN} is the input voltage converter. f_s is the switching frequency. ΔV_{OM} is the ripple output voltage of MIC.

The voltage ratio of the buck converter is

$$D = \frac{V_O}{V_I} \quad (7)$$

$$L_3 = \frac{(V_{Imax} - V_O)D}{f_s * \Delta I_{L3}} \quad (8)$$

$$C_3 = \frac{\Delta I_{L3}}{8 f_s * \Delta V_O} \quad (9)$$

Where V_I is the input voltage(V_{OM}) and V_O is the output voltage of the buck converter. Switching frequency f_s with a duty ratio of D. L the minimum value of inductors for operates the converter at continuous conduction mode. C values of capacitors for the desired operation. R is the load resistance.

III. SIMULATION AND RESULTS

The input voltage of the MIC is about varied between 160V-210V. The load resistance value is 500Ω. The maximum value of duty is about 0.5. The output ripple voltage and current are 4V and 5A respectively. The buck converter design requirement is 350V DC output voltage. The input to the buck converter is varied because of the intermittent nature of the sources. The input voltage range of 350V to 550V.

Table -1: Components and Specification

Components Parameters	Specification
f_s	20kHz
L_1 ,L_2	540µH
L_3	1mH
C_1	32µF
C_0	500µF

Two MPPT control subsystems are produced suitable switching pulses concerning reference values. The buck converter is connected across the common capacitor and produces the constant dc output voltage (350V). The PV panel is made up of 10 modules connected in series and 7 modules connected in parallel. The parameters of PV module are V_{oc}=23V, V_m=19V, I_{sc}=1.7A, I_{mp}=1.1A.

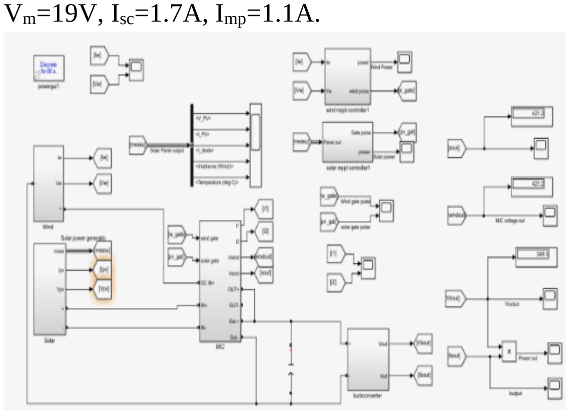

Fig -5: Simulink model of the proposed system

The V_{PV} is around 190V. I_{PV} is 7A The single converter is used for MPPT tracking of two sources is a limitation of duty, varies only between 0-0.5. Hence the low irradiance the MPPT tracking cannot be done effectively. The maximum value of duty is 0.5. The solar output power graphical representation is show in figure7. The PV panel is 1.4kW. The MPP tracked PV output under different irradiation

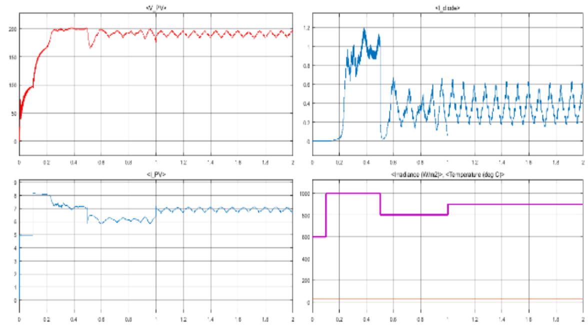

Fig -6: Solar PV panel output waveforms

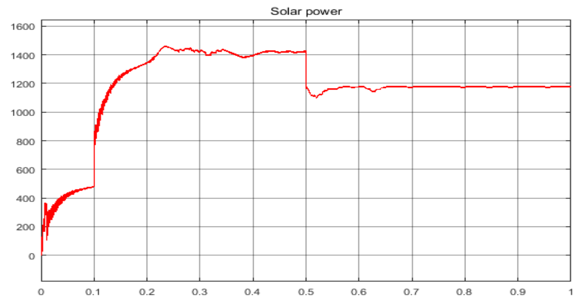

Fig -7: Solar PV panel output power

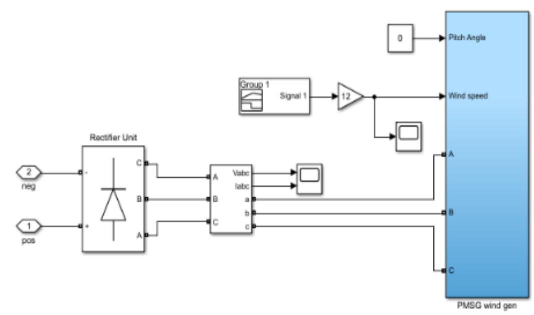

Fig -8: Simulink model of PMSG with rectifier block

The wind speed is created by using a signal builder. The signal builder block gives different wind speeds. Here the system is simulated with wind speed around 12 m/s. The rectifier unit rectifies the AC output of the wind power plant to DC. The wind turbine block input is that the output of signal builder block. The torque output from the turbine block is given to the PMSG block through again element. The prime mover of the PMSM rotates and produces the 3 phase AC voltages.

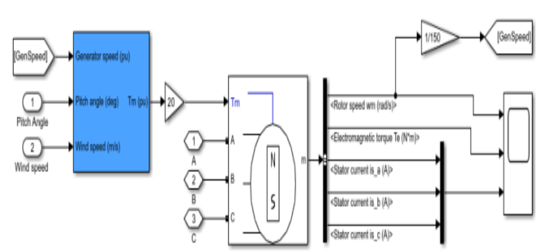

Fig -9: Simulink model of wind turbine with PMSG

The characteristics of the permanent magnet synchronous machine are shown in figure 10. The rotor speed is measured in radian per second and the value is about 250 rad/sec. The electromagnetic torque of the machine was also plotted.

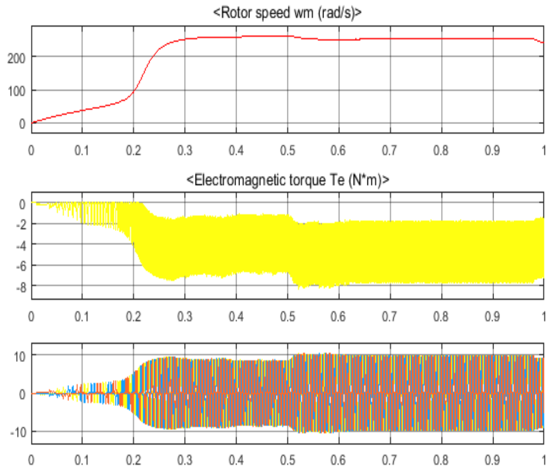

Fig -10: Rotor speed, electromagnetic torque and stator currents of PMSG

The wind turbine coupled with PMSG rating is 1.5kW. The output AC voltage and currents need to be rectified into direct current. The three-phase rectifier block is used to convert the AC parameters into DC parameters. There is some amount of energy is losses during the conversion. This output is given the multiple-input DC-DC converter. The average value of the voltage at a steady state is around 200V under the given inputs to the wind turbine.

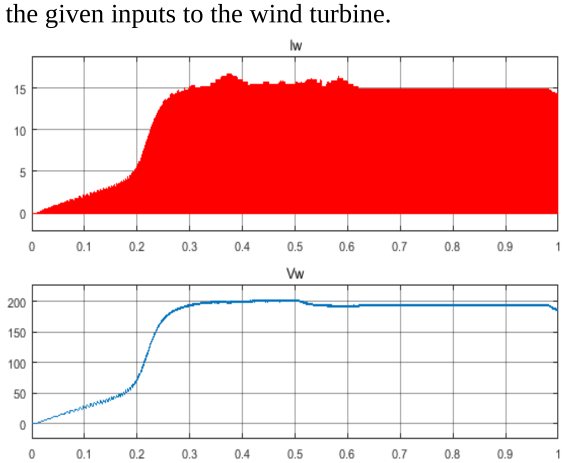

Fig -11:Rectifier output current and voltage

Also, the overall power obtained from the wind system is calculated by using an arithmetic method of multiplying rectified voltage and currents. The power obtained is around 1.5kW.

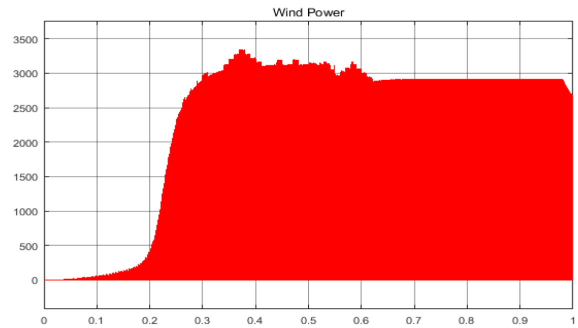

Fig -12:Output power of rectifier

The switching pulses are generated by the MPPT(P&O) controller output with a high-frequency carrier wave. Each converter section is switched in a manner of maximum duty of 0.5. The switching pulses for S1 and S2 are shown in figure 13. The switching frequency of the system is 20kHz.

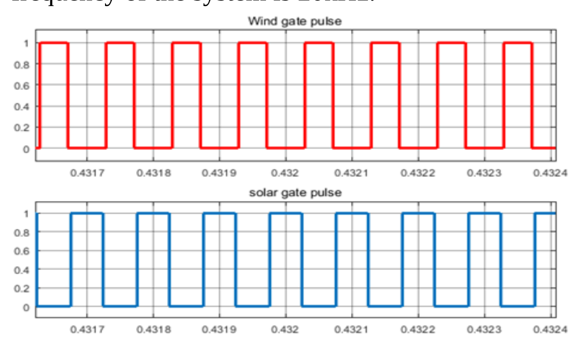

Fig -13:The switching gate pulses of for S_1 &S_2 switches of MIC

The waveform has a rising time of 0.3sec. After the steady converter works based on input conditions. The peak output voltage of MIC is approximately 500V.

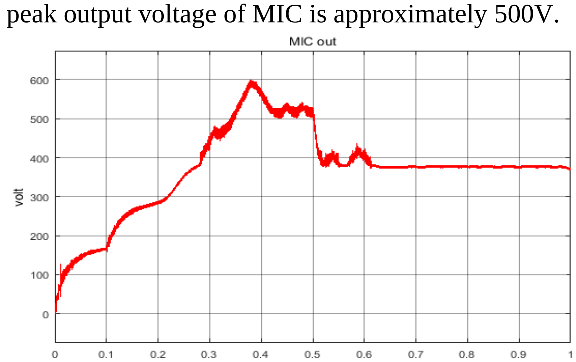

Fig -14: Output voltage of MIC

The output voltage of the buck converter is 350V is shown in figure 15. This constant voltage is obtained from different input conditions of the source. This constant DC link voltage is suitable for producing single-phase 240V RMS AC voltage with the help of an inverter. The dc-link voltage can be used as a DC microgrid line. The output power is obtained arithmetically by the multiplication of output voltage and current.

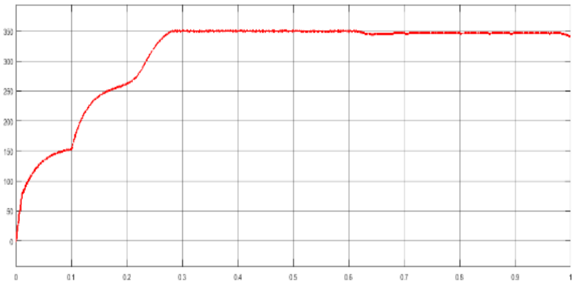

Fig -15: Output voltage of buck converter

IV CONCLUSION

The micro-generation of electricity from the wind turbine and the combination of solar PV is obtained. The electric power from each source was extracted by a single power electronic converter MIC, which reduces the cost and size of components. The solar PV and PMSG outputs are controlled by MPPT techniques for each source. The multiple input no isolated DC-DC converter operates and produces the fluctuating voltage from the intermittent nature of inputs. A buck converter with voltage-mode control operation produces the varying input to the constant output voltage. The PI controller with suitable kp and ki values are identified from the try and error method. The proposed system reliably collected the power by amplifying the output voltage of PMSG and solar PV. Simulations are done in MATLAB Simulink. This operation was conducted without causing loading problems on the input renewable sources

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