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Simulation and Analysis for Water Pumping System using Solar Energy

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Abstract: This paper presents a scheme and simulation of DC-DC converter for water pumping system using solar energy. Now-a-days solar power is more popular for water pumping system. In this paper, the DC – DC boost converter is designed to step up the voltage produced by the PV array to drive a single phase AC induction motor. The inverter converts DC to AC which is controlled using the sinusoidal pulse width modulation (SPWM) technique. The simulation analysis gives direct to the AC utility the design of a directly coupled solar water pumping system powered by photovoltaic panels, DC to DC boost converter, full-bridge sinusoidal pulse width modulation (SPWM) inverter. The model was implemented using PSIM with SPWM controlled inverter model.
Keywords: SPWM, PV arras, Boost convertor, Induction Motor.

I. INTRODUCTION

Solar-based waters know more popular days because grids are less popular and unreliable. Due to the huge increase in global energy demand and rapid consumption of traditional fossil fuel resources. The main advantage of this system is pollution free and low running and maintenance costs. In this system, the DC voltage is taken from the solar panel and is then used in a DC motor or induction motor pump set. DC motor pump sets are used to reduce initial cost, inverters are also not required but maintenance costs are high due to problems in the commutator and brush. The initial cost using an AC motor is high but V / F control can be obtained using an energy-efficient solution. In the proposed system the output voltage from the solar panel is increased by the DC / DC booster converter and the output of the booster converter as input is increased. DC link voltage of inverter. This system mostly applies to areas where the grid is not readily available. MPPT algorithm is used to get maximum power from solar panel. There are various methods to track maximum power. Depending on the efficiency and reliability, the incremental conduction method is used to track the maximum power from the solar panel. The key features of solar cells play an important role in designing solar powered equipment. The two major parameters of solar cells are Voe (open circuit voltage) and Ise (short circuit current). The current from the solar cell is calculated by the characteristic equation of the solar cell which includes Ise, Voe, Ru (series resistance) and temperature. [11]

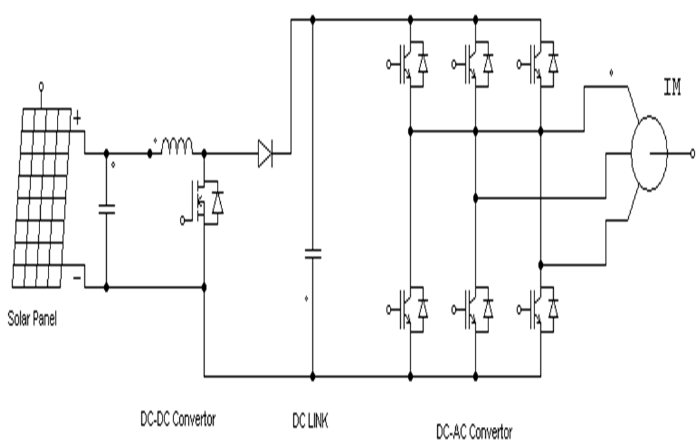

Fig-1 Basic Block Diagram of Solar water Pumping System

Fig. 1 shows a basic block diagram of the solar water pumping system. The output voltage from the solar module is in the form of dc. With the effect of changes in temperature and solar radiation. The output voltage available from the solar module is 180–210 V. The voltage is increased as the dc-link voltage for the 600 V dc function. Here, for variable speed operation of induction motor, V / F control technique is applied.

II. BOOST-CONVERTOR

In this topology, 1.2 kW electric motor-pump sets are used. As a result, the solar panel rating has been taken 1.25 to 1.25 times i.e. 1.5 kW. A solar panel has a rating of 210 W, so by adding 9 panels in series, a desired output of 1.5 kW is obtained. Considering solar radiation and temperature, the output voltage available from the solar array is in the range of 180 V to 270 V. Required to drive a 600 V three-phase motor-pump DC-link. The converter is used to boost this voltage[11].

A. Design of Inductor

The steps for inductor design are as shown below.

$$Vout = \frac{1}{1-D} * Vin \tag{1}$$

Where,
V_{out} = Output voltage of the boost-converter
V_{in} = Input voltage of the boost-converter
D = Duty cycle of the boost-converter

$$600 = \frac{1}{1-Dmax} * 180 \tag{2}$$

Where D_{max} = Maximum duty cycle

$$D_{max} = 0.6 \tag{3}$$

$$600 = \frac{1}{1-Dmin} * 270 \tag{4}$$

Where D_{min} = Minimum duty cycle

$$D_{min} = 0.48 \tag{5}$$

$$L = \frac{Vi\,min * Dmin}{\Delta i * fs} \tag{6}$$

Where,
Vi_{max} = Maximum input voltage
Δi = Ripple in inductor current
f_s = Switching frequency

$$L = 3.8mH \tag{7}$$

Hence, from above calculation the value of inductor obtained is of 3.8 mH.

III. MPPT ALGORITHM

There are basically two problems in solar panel production: -

1) The production of solar panels is very low, as the efficiency of solar panels is 10% to 15%.
2) The output of the solar panel changes with the change in weather conditions i.e. the output is low during cloudy conditions and the output varies throughout the day. Morning And in the evening, it is less than in the afternoon when the maximum output from the panel is available. It is also seen that the I-V and P-V characteristics of solar cells are not linear. Therefore, there is a point on the graph where the maximum power can be tracked from the solar panel. The incremental conduction method is used to achieve this maximum power point [1].

Fig. 2 shows the closed-loop control of the boost converter. Close-loop control of the boost-converter is achieved with the MPPT algorithm. Here the voltage and current from the solar panel are sensed and given to the MPPT algorithm. The reference voltage (Vref) arises from the algorithm, which is compared to a triangular waveform of 16 kHz frequency that controls the duty cycle of the switch. As a result, the DC-link voltage remains constant[2].

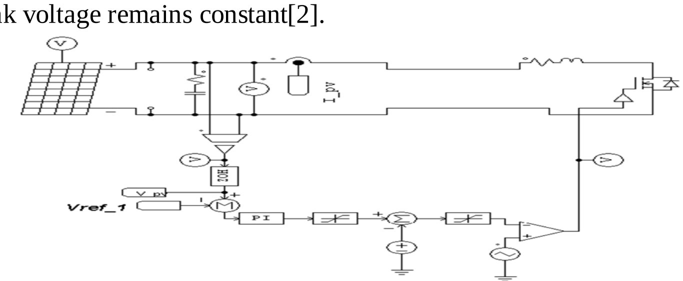

Fig. 2 Closed-loop control of boost-converter

IV. INVERTER

The inverter is used to convert DC voltage to AC voltage. Acts as a DC-link voltage for a 600 V DC inverter obtained from a booster converter. This dc is converted to ac. An inverter, the sine-triangle pulse width modulation (SPWM) technique, is used to pulverize the IGBTs of the inverter[7]. PWM pulses are generated with the help of sine-triangle comparisons. Here, the triangle will be a carrier signal, and the sign will be a reference signal. The output of the inverter changes or is controlled by changing the modulation index[11].

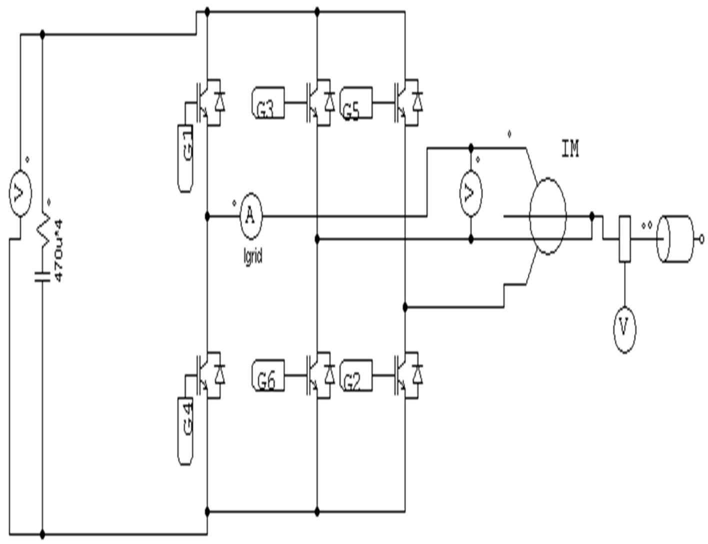

Fig- 3 Three-Phase Inverter

V. SIMULATION RESULT

Fig. 4 to 6 show the simulation results of the topology as shown in fig. 4. Simulation results in fig. 4 shows DC link voltage. Fig. 5 shows the pulses obtained by comparing the reference voltage generated by the MPPT algorithm with a triangular wave. In relation to pulses too, the charge and discharge of the inductor are shown[11]. During ON-time, the inductor current reaches its maximum value, and during OFF-time, the inductor current reaches its minimum value.

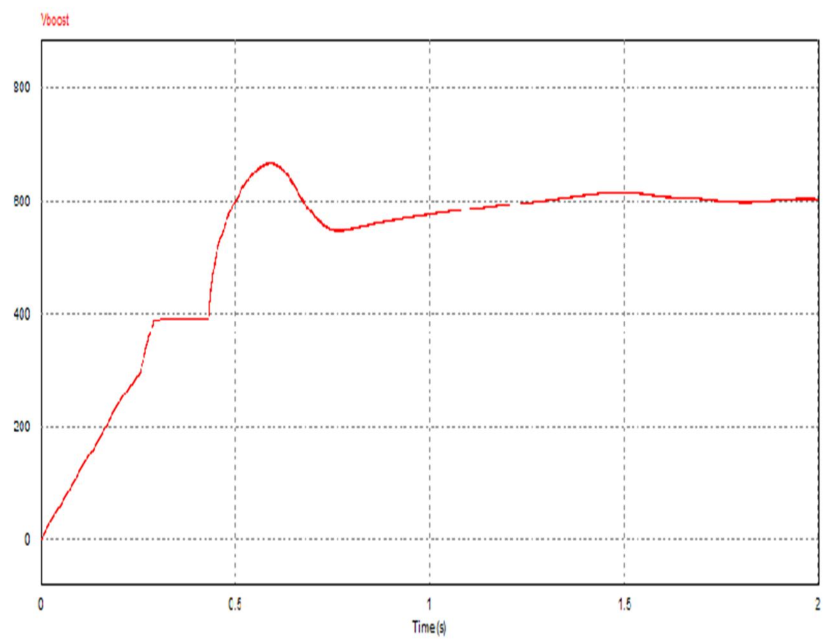

Fig- 4 DC Link Voltage

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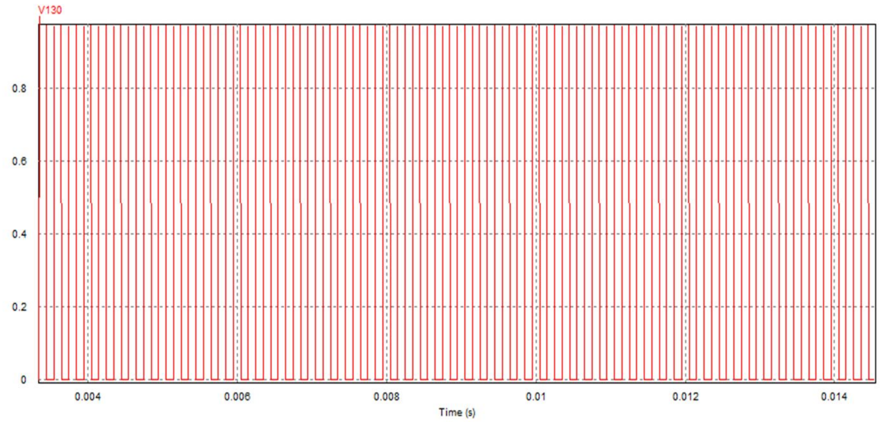

Fig.-5 Gate pulses of IGBT

Fig. 6 shows the output voltage of the inverter. The rms values of the voltage and the current, respectively are 415 V

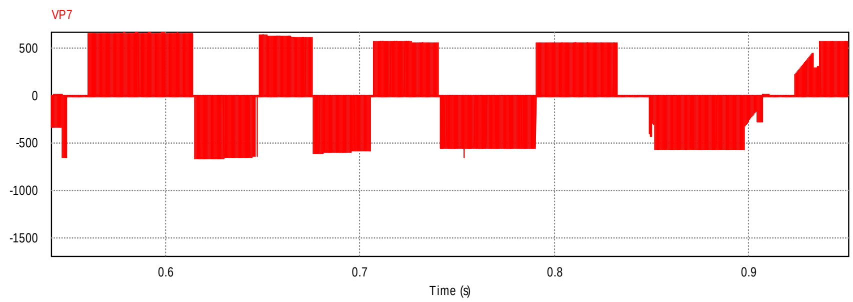

Fig-6 Output voltage of Inverter

VI. CONCLUSION

In this paper, solar pumping system at resistive load is demonstrated. First the boost-converter is designed, then the inverter is designed. After the specifications and ratings of each component are obtained, a simulation is performed. Once the desired results are obtained in the simulation, the system is therefore running successfully at resistive loads. This can be further tested at the motor pump and synchronized with the AC drive to run the motor-pump when solar power is not available.

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