

DESIGN AND SIMULATION OF PV FED GRIDCONNECTED SYSTEMWITH ZCD

¹R.Asha, ²N. Saritha and ³V. Jamuna

M.E Power Electronics and Drives, Departmentof Electrical and Electronics Engg, Jerusalem College of Engineering, Chennai-600 100, India

¹asharajian@gmail.com ²saritha.fdma@gmail.com; ³jamuna_22@yahoo.com

ABSTRACT

This project deals with the simulation of PV fed grid connected inverter for single phase grid connected system. This project mainly focuses about the design and simulation of grid connected system and to synchronize the inverter voltage and frequency with the grid voltage and frequency. If the proper synchronizing is not done then power cannot be fed to the grid. The synchronization is done by using Zero crossing detector (ZCD) technique. In order to satisfy the grid interfacing requirements, LCL filters are designed and used.

Keywords— Boost Converter, Grid, Inverter, Solar Photo-voltaic System (PV), zero crossing detector(ZCD)

I. INTRODUCTION

Renewable energy sources such as solar, wind, biomass, has various advantages as it is clean, pollution free. There are several advantages of system grid connected system as it reduces power bill, possible to sell the produced electricity.[1] It is easy to install and no need of battery. Storage losses are eliminated. PV module represents the fundamental power conversion unit of a PV generator system. The output characteristics of a PV module depend on the solar irradiance, the cell temperature and the output voltage of the PV module [2].

The fig 1 shows the block diagram of single phase grid connected system. It consists of PV panel, DC-DC boost converter, Inverter, LCL filter and grid. The output power acquired from the PV panel is fed to DC-DC boost converter. The dc-dc boost converter is used to step up the input voltage .The output of inverter is square wave, in order to obtain pure sinewave from inverter, LCL filters are designed and connected. In this proposed system controller is used to synchronize the grid voltage with the inverter voltage

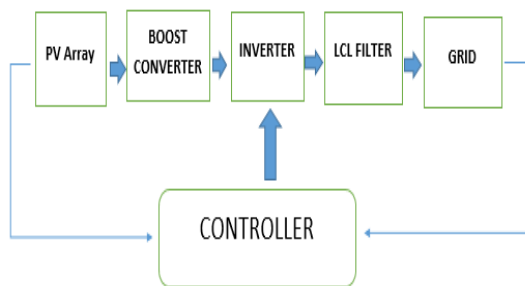


Fig1. Block diagram of PV fed grid connected system

II. P V ARRAY

A photovoltaic system is a system which uses one or more solar panels to convert solar energy into electricity. It consists of multiple components, including the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and modifying the electrical output.

Fig 2 represents the Simulink model of PV system. The value of irradiance determines the total power output of the PV system. The voltage generated by PV cell is very low around 0.5V, several PV cells are

connected in series for high voltage and in parallel for high current to form a PV module for desired output. Separate diodes may be needed to avoid reverse currents, in case of partial or total shading, and at night. The p-n junctions of mono-crystalline silicon cells may have adequate reverse current characteristics and these are not necessary. Reverse currents waste power and can also lead to overheating of shaded cells. Solar cells become less efficient at higher temperatures and installers try to provide good ventilation behind the solar panels. Current changes for different values of irradiance. but voltage is constant. The efficiency of a solar cell is 43.5% for multi-junction concentrator solar cell.

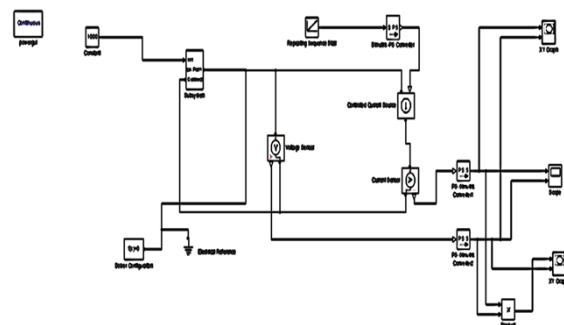


Fig 2.Simulink model of PV system

III. BOOST CONVERTER

In this proposed system two stage conversion technique is used ie the generated power from the PV panel has two convertors before it is fed into the load and grid. Boost converter and the inverter. Inverter plays the major role in the conversion part as it converts the DC power from solar to AC power.The component which is present in between the solar panel and the inverter is the boost converter.Four basic converter topologies exist, they are buck (step-down), boost (step-up),buck boost (step-up or step-down) and cuk converter. In our proposed design boost topology is used because its freewheeling diode can be used for blocking reverse current and it amplify PV panels output voltage into higher level. Fig 3 represents the Simulink model of boost converter. The output voltage from the PV panel is fed into boost converter and it is boosted to the value of 232 V.

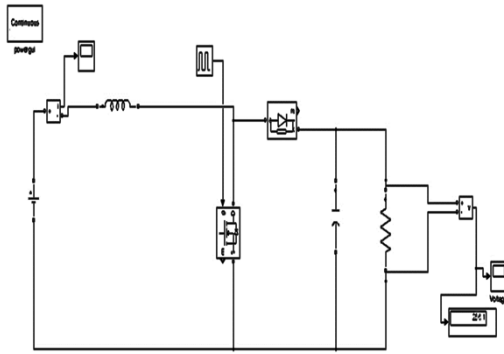


Fig3 Simulink model of boost converter

From the inductor voltage balance equation, we have:-

$$\Rightarrow V_g(DT_s) + (V_s - V_o)(1-D)T_s = 0 \quad (3.1)$$

$$\Rightarrow V_g(DT_s) - V_g(DT_s) - V_gT_s + V_oDT_s - V_oT_s = 0 \quad (3.2)$$

$$\Rightarrow V_o = \frac{V_g}{1-D} \quad (3.3)$$

Conversion ratio,

$$M = \frac{V_o}{V_g} = \frac{1}{1-D} \quad (3.4)$$

From inductor current ripple analysis, change in inductor current,

$$\Delta I_L = (I_{max} - I_{min}) \quad (3.5)$$

$$\Delta I_L = \frac{V_g}{L} \times (DT_s) \quad (3.6)$$

$$\Delta I_L = \frac{(V_g D)}{f_s L} \quad (3.7)$$

$$L = \frac{V_g D}{f_s (\Delta I_L)} \quad (3.8)$$

Where:

D: converter duty cycle

I_L : inductor current

V_o : Output voltage of boost converter

V_s : input voltage of boost converter

Table 3.1 Design of boost converter

| Converter Parameter | Value |
|------------------------------|---------|
| Inductance(L) | 31.52mH |
| Capacitance(C) | 6.3 uF |
| Switching Frequency(f_s) | 25 KHz |
| Gate Voltage(V_G) | 12.75 V |
| Duty Ratio(D) | 0.78 |
| Load Resistance(R) | 100 ohm |
| Output Voltage(V_o) | 232 V |

IV. SINGLE PHASE INVERTER

It consists of four switching devices. The switch used is the IGBT, main advantage of full bridge inverter is it can produce twice output power than the half bridge inverter. The inverter provides power to both load and

grid. After the inverter an LCL harmonic filter is used to reduce the high frequencies in the output inverter voltage. AC output voltage is created by switching the full bridge in an correct sequence .Fig 4 represents the Simulink model of single phase inverter with R-load.

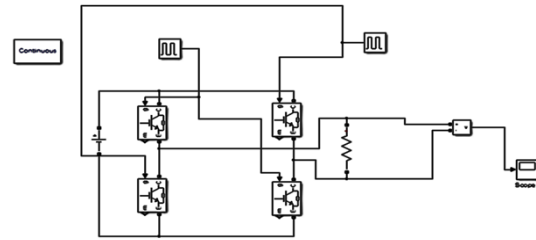


Fig4 Simulink model of single phase inverter

V. DESIGN OF LCL FILTER

The design of the LCL filter should also consider the selection of resonance frequency. The resonance frequency depends upon the circuit elements. So, the resonance frequency range is selected to avoid resonance problems.

Fig 5.1 represents the LCL filter. Filters are used to reduce the harmonics. It provides better decoupling between the filter and the grid impedance. It also has better attenuation ratio with smaller values of L and C. Hence LCL filter is designed for grid connected applications. Resonance is the main problem with LCL filter and it can be damped either by using active damping methods or passive damping methods. But for grid connected applications passive damping method is necessary in case when inverter is switched off and filter is still connected to the grid.

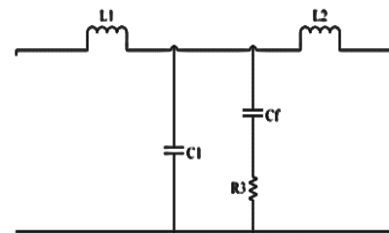


Fig5.1 LCL filter

LCL filters have been used in grid-connected .because they minimize the amount of current distortion injected into the utility grid.

$$L = L1 + L2 \quad (5.1)$$

$$L1 = aLL2 \quad (5.2)$$

$$L_p = \frac{L1 * L2}{L1 + L2} \quad (5.3)$$

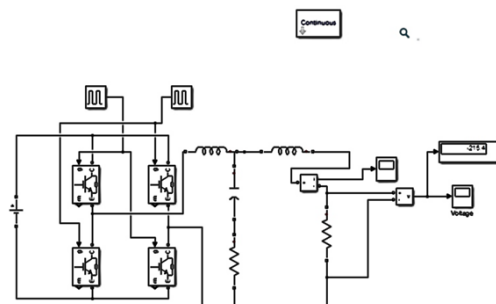


Fig 5.2 Simulink model of Inverter with filter

VI.ZERO CROSSING DETECTOR

It consists of transformer, diode. ZCD is a circuit which detects the transition of AC voltage from one polarity to another. It is used for synchronization of grid voltage with inverter voltage. Fig 6 simulink model of zero crossing detector is represented.

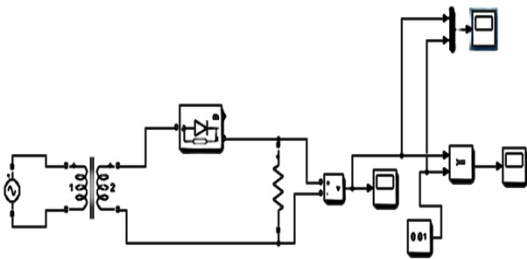


Fig 6 Simulink model of zero crossing detector

VII.SIMULATION RESULTSAND DISCUSSIONS

The proposed system, which consists of a DC-DC boost converter and a DC-AC inverter, A DC-DC boost converter used to step up photovoltaic (PV) output voltage 54V DC into 232V DC .

Fig. 7.1 represents the PV array output current against the output voltage. It is performed using different constant values of solar radiation of 1000 W/m² and 800 W/m².

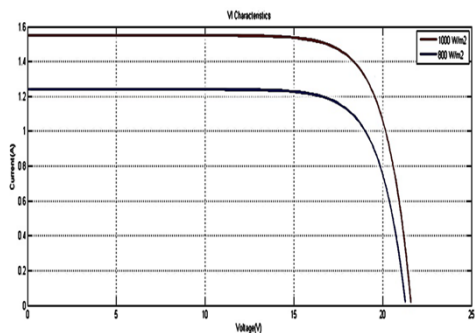


Fig 7.1I-V Characteristics

Fig. 7.2 represents the PV array output power against the output voltage. During sunny day the generated power is more than the cloudy day as the irradiance value is high.

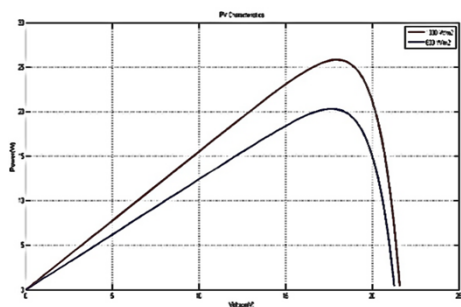


Fig 7.2P-V Characteristics

Fig. 7.3 represents the output voltage waveform of the boost converter. The given voltage from the PV panel is given to the boost converter and it is boosted to the value of 232V.

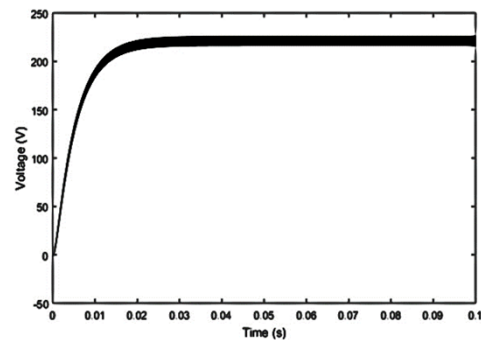


Fig. 7.3 Output voltage waveform of boost converter

Fig 7.4 represents the output voltage waveform of single phase inverter, square wave is obtained from the inverter without the filter, the output voltage obtained from the inverter is 230V.

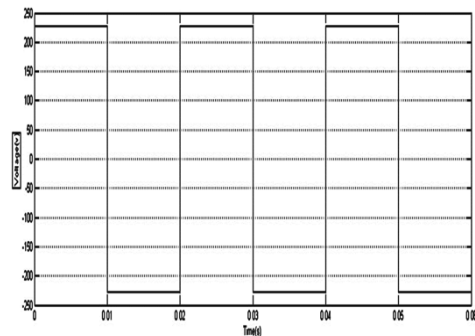


Fig 7.4 Output voltage waveform of single phase inverter

The simulated output voltage waveform of the single phase inverter with LCL filter is shown in fig 7.5. The output of the inverter is sinusoidal waveform with 230V.

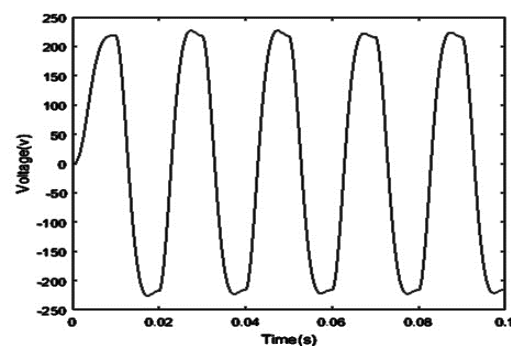


Fig7.5 Output voltage waveform of Inverter with filter

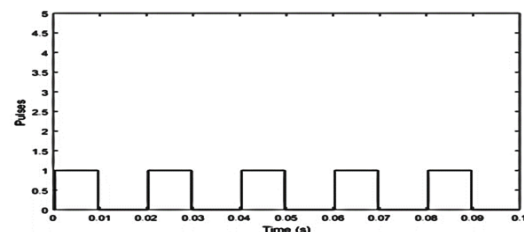


Fig 7.6 Output voltage waveform of zero crossing detector

The simulated output voltage waveform of the PV fed inverter with non-linear load is shown in fig 7.7. Due to the presence of non-linear load output does not attain the steady state. It produces transients from 0 to 0.04sec.

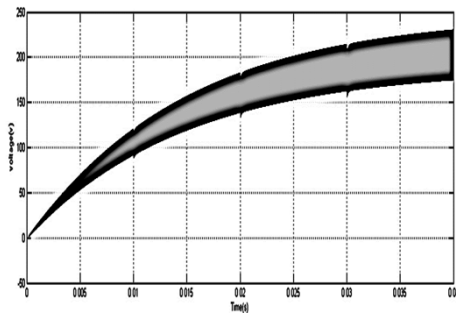


Fig 7.7 Output voltage waveform of PV fed inverter with Non-Linear Load

The simulink model of grid connected system is shown in fig 7.8. when the inverter is connected to the single phase grid, the inverter voltage is transferred to the grid.

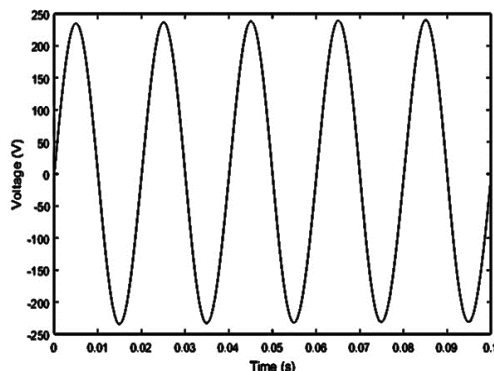


Figure 7.8 Output voltage waveform of grid connected system

VIII. CONCLUSION

In this work the design and simulation of single phase grid connected system is done. To obtain pure sine wave from the inverter, LCL filter has been designed and implemented. In order to feed power to the grid the inverter voltage has to be synchronized. Zero crossing detector is used for synchronization of grid voltage with the inverter voltage.

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