SMC BASED GRID INTEGRATED SOLAR PV SYSTEM USING SUPERLIFT BOOST CONVERTER

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Abstract—**Due to the insufficient non-renewable resources, industrial growth and technological development in India, there is an energy scarcity in now a days. So it is necessary to overcome and to produce power from the renewable energy resources. The solar power production technique plays a vital role in the modern world. This paper presents a conversion of renewable energy source into electrical power and integrated with an existing grid, which is having same voltage and frequency. The major concentrations in this work is to focus the Super Lift Boost Converter (SLBC),which is used to step up the voltage and current into higher level and a grid tracking inverter which is used to track the grid voltage. The incremental conductance method is used to extract the maximum power from the PV Cells to achieve maximum efficiency. This work is aimed to assess an incremental conductance method to extract the maximum power from solar cells and integrated with live grid with low cost and high reliability.**

Keyword-Super lift boost converter, MPPT, PV Cell,Incremental conductance,Grid Integration,SMC

I. INTRODUCTION

The main objective of this work is to feed the generated power from the solar panels to the grid by using the grid tracking inverter. Most of the power generation is carried out by non-renewable resources such as coal and fossil fuel based power plant which contribute heavily to greenhouse gas emission and highly pollute the environment. But in case of solar power plant which is the renewable resources, and does not produce any environmental effects and it is zero or low carbon electric power generation. The solar power production is most widely used renewable power system. The electricity generated by a grid connected PV system will reduce the power bill and we can supply the surplus amount of electricity to the local electricity supplier. This work uses the MPPT technique which is used to extract the maximum power from the PV panels. The MPPT is the process of finding the maximum power point and keeping the load characteristics there. This paper uses the Super lift Boost converter which is used to boost the input voltage to the higher level at different stages without any parasitic effect. It also increases the efficiency and reliability. The super lift boost converter is implemented by using the diodes and capacitors at each stage. Then the power is stored in the battery bank and then it is supplied to the grid tracking inverter from this inverter, the power is given to the load and the remaining power is fed to the grid based on the synchronization. It is mostly used because they maintenance free and also pollution free.

The power produced from the solar panels will be low voltage, direct current (DC) and cannot be applied to AC machines. The objectives of this proposal are to develop a system that converts the power from the solar panel to the supply having the same voltage, same frequency with respect to the traditional power plant.

Despite all the advantages presented by the generation of energy through the use of PV cells, but the efficiency of the energy conversion is currently low and the initial cost implementation is still high, so it is necessary to extract the maximum power from the panel to achieve the maximum efficiency in the operation. To extract the maximum power the MPPT technique is used. This paper also aims to asses an improved incremental conduction method to extract the maximum power.

1.1.Block diagram:

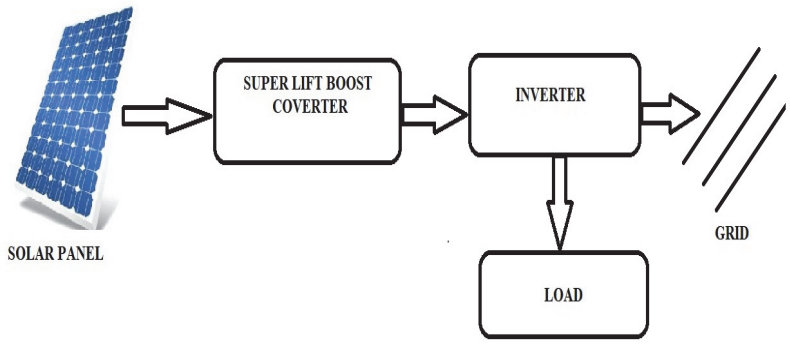


Fig. 1.Block diagram

The solar panel produces DC voltage when the sunlight falls on it.The Converter will make the produced by the solar panel to constant DC current by super lift boost converter. Produced power is converted to 230v/50Hz and synchronized with the grid's supply with the help of grid tracking inverters.

The organisation of this paper is as follows. The block diagram of the entire grid integrated system with its components is explained in section1.The PV cells and MPPT technique is described in section2. The super lift boost converter for grid integration is focused in section3.In section 4; the controller(sliding mode) are explained. The results and discussion of this work arepresented in section5.The conclusion of this work is described in section6.

II. SOLAR CELL AND MPPT

The photovoltaic cell or photoelectric cell is a semiconducting converter, which converts the light energy into electrical energy based on the irradiance fall on the PV panel throughout the day. If the sun rays fall on the panel is higher, it results the more current. The current flow in the

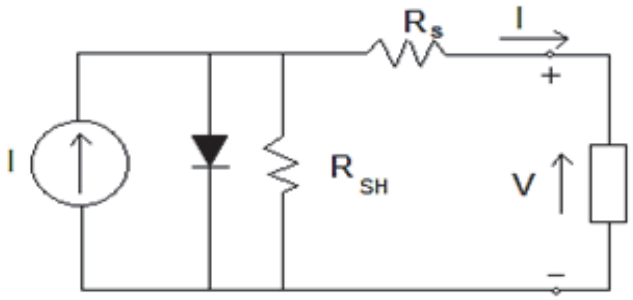


Fig. 2.Equivalent circuit for solar cell

Panel with diode is I, R_s is the series resistance and R_{sh} is the shunt resistance. The solar

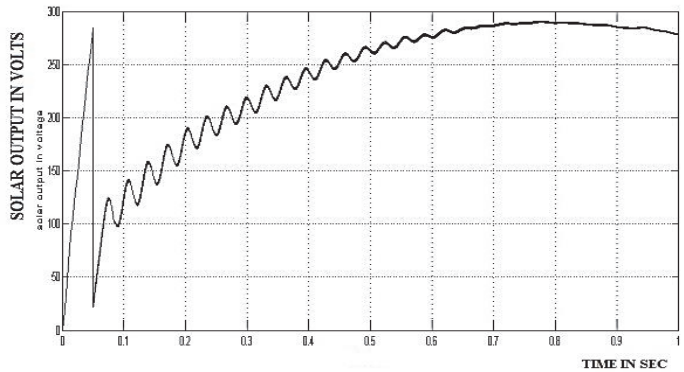


Fig.3.Solar panel output voltage

panel produces 300v and it is shown in fig 3. The output equation of solar panel is

$$I = I_{SC} - I_d \quad (1)$$

$$I_d = I_0(e^{qVd/kt} - 1) \quad (2)$$

Where I_0 is the reverse saturation current of diode, q is the electron charge, V_d is the voltage across the diode is the Boltzmann constant ($1.38*10^{-19}$ J/K), T is the temperature in kelvin(K)

$$I = I_{sc} - I_0(e^{q(\frac{v+IRs}{nkt})}) \quad (3)$$

$$I = I_{sc} - I_0\,(e^{qVd/kt} - 1) \quad (4)$$

Where ,I is the photovoltaic current, V is the voltage and T is the temperature .The Solar panel output voltage – current characteristics is shown in fig 4.

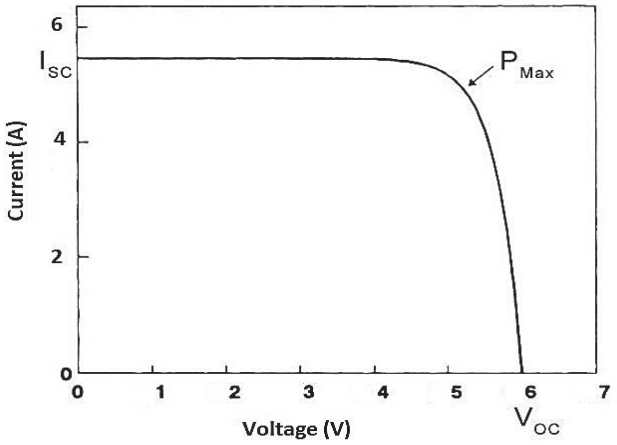


Fig.4. VI Characteristics of solar panel

2.1 MPPT Technique

The Maximum Power Point Tracking (MPPT) technique is used to obtain maximum power from the solar and also to attain maximum efficiency. In this, paper the Incremental Conductance method is used because it overcomes the disadvantages of perturbs and observes (P&O) method. TheIncremental conductance method determines that MPPT has reached a maximum power point and stop the perturb. This algorithm has advantages over P&O and the maximum power point is easily determined than P&O. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P& O. In this method the peak power of the module lies at above 98% of its incremental conductance.

$$(dp/dv)_{MPP} = d(VI)/\mathrm{dv} \quad (5)$$

$$0 = I + Vdi/dv_{MPP} \quad (6)$$

$$\frac{dI}{dv_{MPP}} = -\frac{I}{V} \quad (7)$$

The above equations are the equations incremental conductance

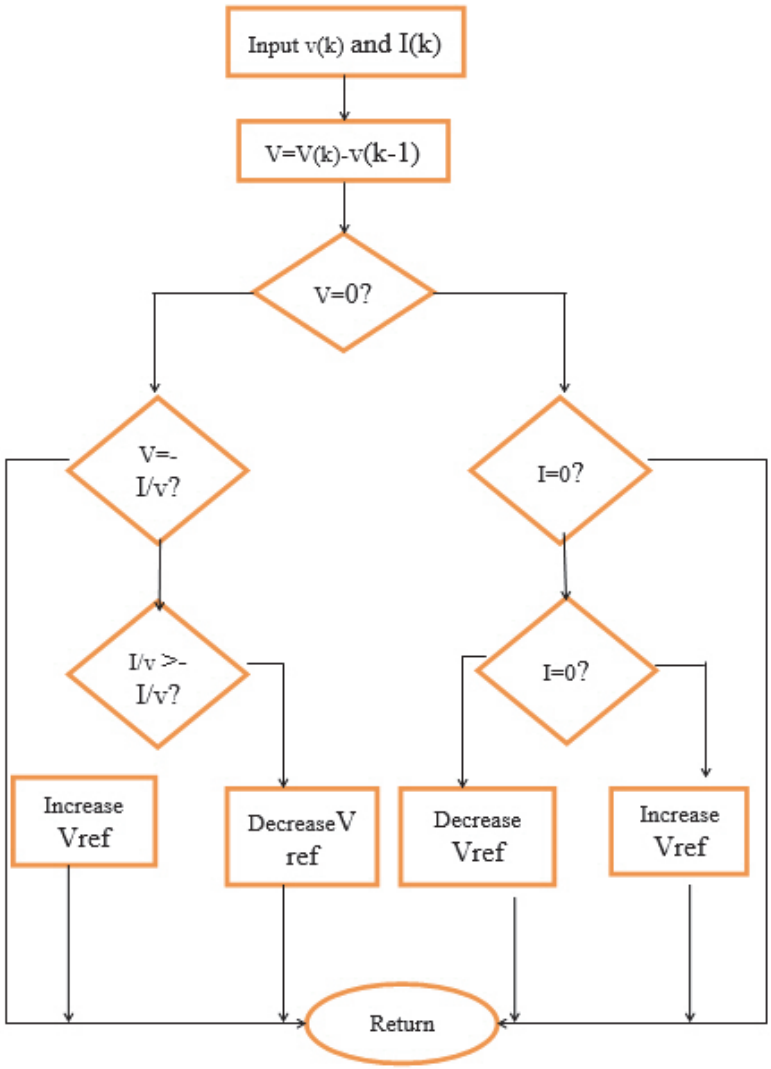


Fig 5. Flow chart of incremental conductance MPPT

The Fig.5is the Flowchart of incremental conductance MPPT.The fig.6 shows the simulation of the incremental conductance method. The output from the MPPT controller is given as the gate pulse to the MOSFET in the converter circuit. The incremental conductance method has more efficient than the other MPPT controllers. It tracks the maximum amount of output from the solar panel.

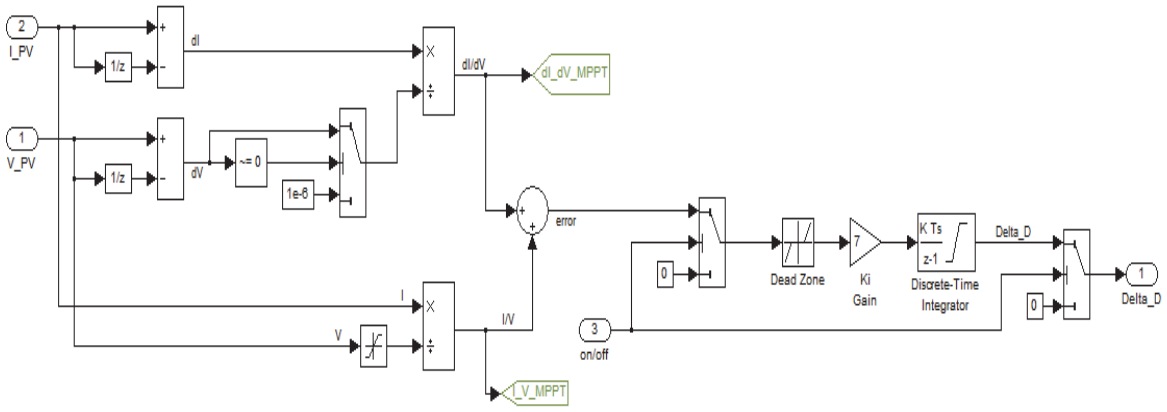


Fig.6.Simulation for incremental conductance

III. SUPER LIFT BOOST CONVERTER

The super lift boost converter is used to regulate the produced DC powerfrom the PV panel and boost the produced power up to 4 times without parasitic effect, thereby increasing efficiency and reliability. The Super-lift converter works in current fed full bridge transformer topology to increase the voltage transfer gain. It effectively enhances the voltage transfer gain in power series. Super lift boost converter lifts the voltage stage by stage in geometric progession.

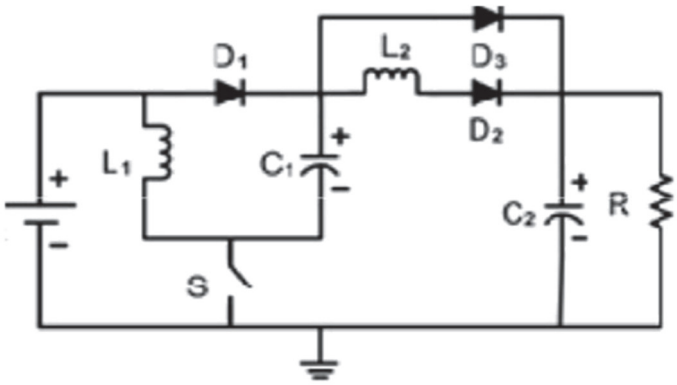


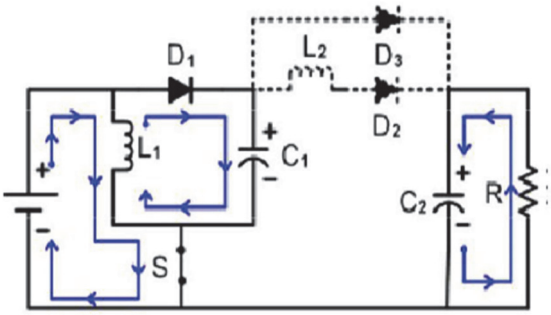
Fig.7.Super liftBoost Converter

From the above Fig.7, $$V_0 = [\frac{2-k}{1-k}] \quad (8)$$

Where k is the duty cycle

The output equation is given by $$V_0 = [\frac{2-k}{1-k}]^2 \quad (9)$$

It works in two modes .In Mode 1 Switch is in ON position and under Mode 2 Operation switch is in OFF position.The detailed operation with direction of current flow is shown in fig.8 and Fig.9.
MODE 1:



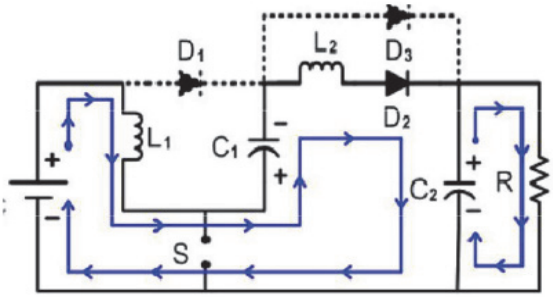
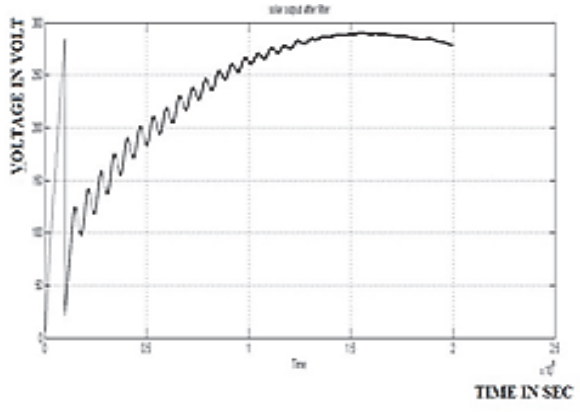


Fig.8 Mode1 operation of SLBCFig.9 Mode2 operation of the SLBC

The fig.8 shows the operation of mode I, here the switch is under ON condition. The current flows through the inductor L_1 and capacitor C_1 and energy is stored in capacitor C_2.The fig.9 shows the operation of mode 2. Here the switch is under the OFF condition. The stored energy in inductor L_1 and capacitor C_1 gets discharged across L_2 and C_2,which boost the output voltage.The super lift boost converter is used because there is no parasitic effect.The fig 10 and Fig 11 are the input and output voltage waveforms of SLBC.



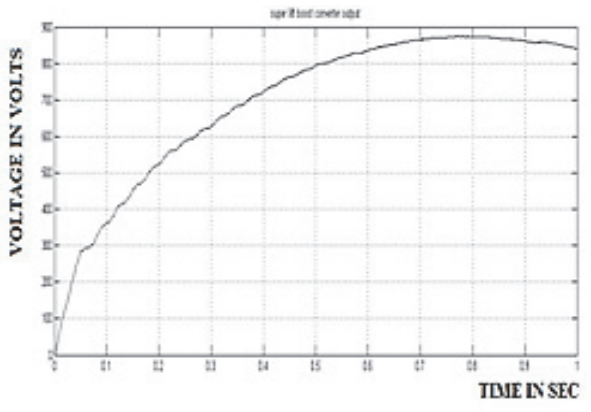


Fig. 10 input waveform of SLBCFig. 11 output waveform of SLBC

IV. CONTROLLER

The controller adopted in this work is sliding mode controller, which controls the circuit by constant frequency. The steady state error elimination is necessary because it uses constant frequency operation.Sliding-mode control of variable structure systems, such as power converters, is particular interesting because of the inherent robustness, capability of system order reduction, and appropriateness to the on–off switching of power semiconductors.All the designed controllers for power converters are in fact variable structure controllers, in the sense that the control action changes rapidly from one to another of, usually, two possible d values, cyclically changing the converter topology. The Fig.12 is the Simulink model of the Sliding Mode controller (SMC)

The steady state error elimination is necessary because it uses constant frequency operation.Bythe Control law theSlidingSurface is,

$$dx_j/dt = \sum_{i=h}^{j-1} (ki/kh) \tag{10}$$

$$dx_j/dt = \sum_{i=g}^{j-1} dx_i/k_j \, dt \tag{11}$$

Where k,j are independent variable of the system and x is the system

By Switching Law

$$u_h(t) = \left\{ \begin{matrix} U/b_e(e), s(e_{xi},t) > +э \\ -U/b_e(e), s(e_{xi},t) < -э \end{matrix} \right\} \tag{12}$$

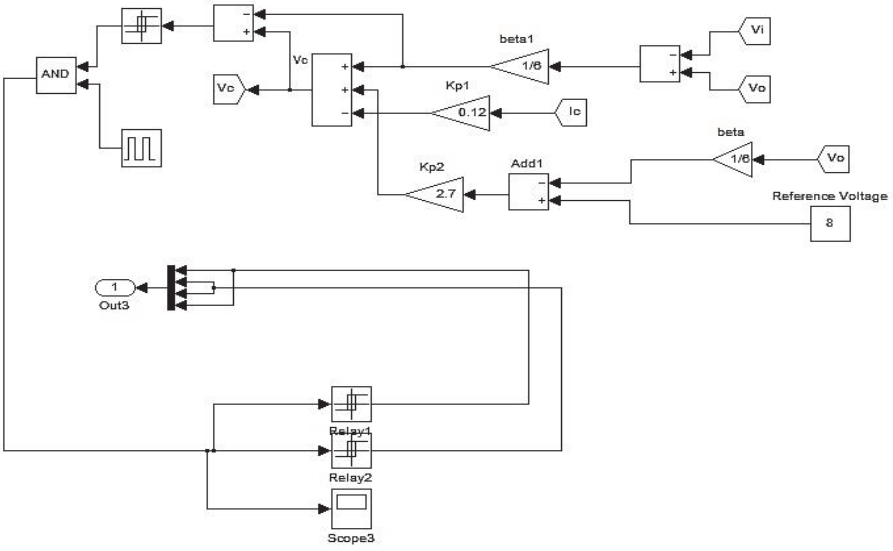


Fig.12. Simulation circuit for Sliding Mode Controller

V. RESULTS AND DISCUSSION

The MATLAB software is used to simulate the proposed system to get results rapidly to the expectations and requirements. With fast simulation and easy user interface, MATLAB provides a powerful simulation .The detailed simulation diagram for the Sliding Mode Controller (SMC) with the super lift boost converter is shown in fig.13 and its output current waveform is shown in fig.14.

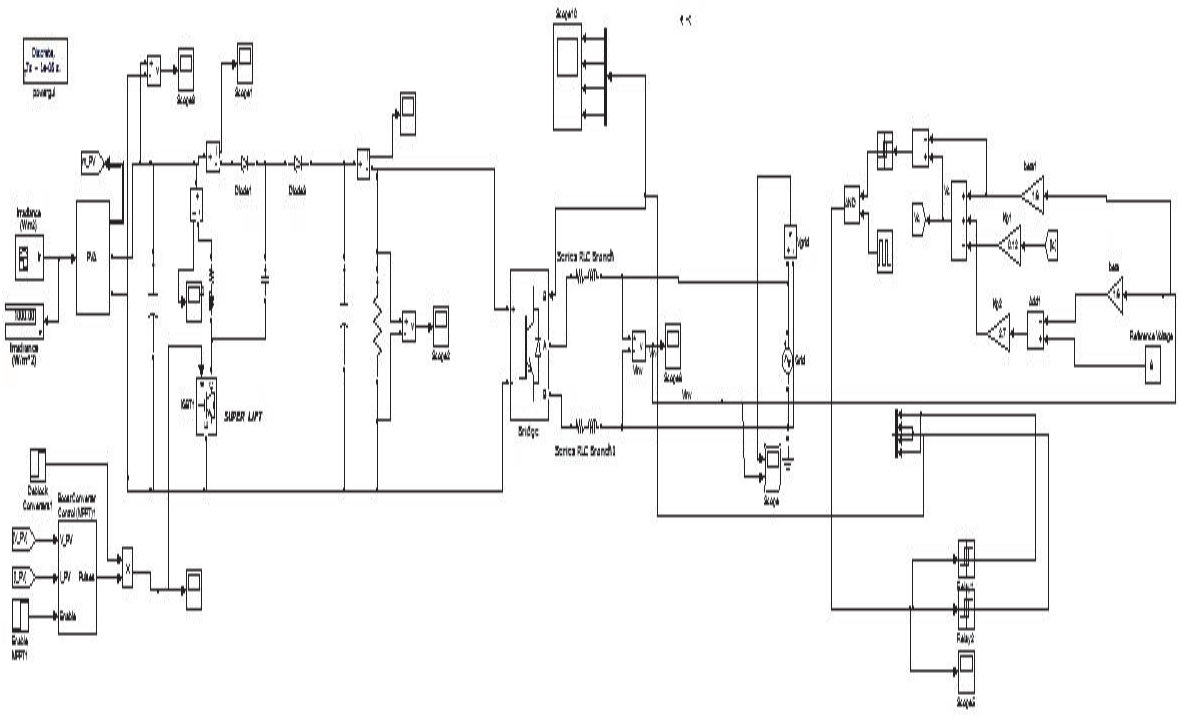


Fig.13. Simulation circuit for SMC based PVgrid integration

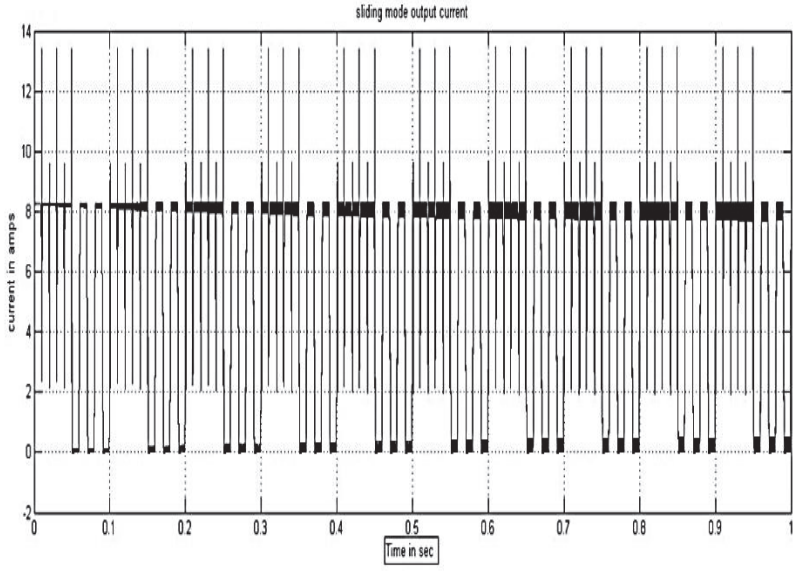


Fig.14. Output current by sliding mode

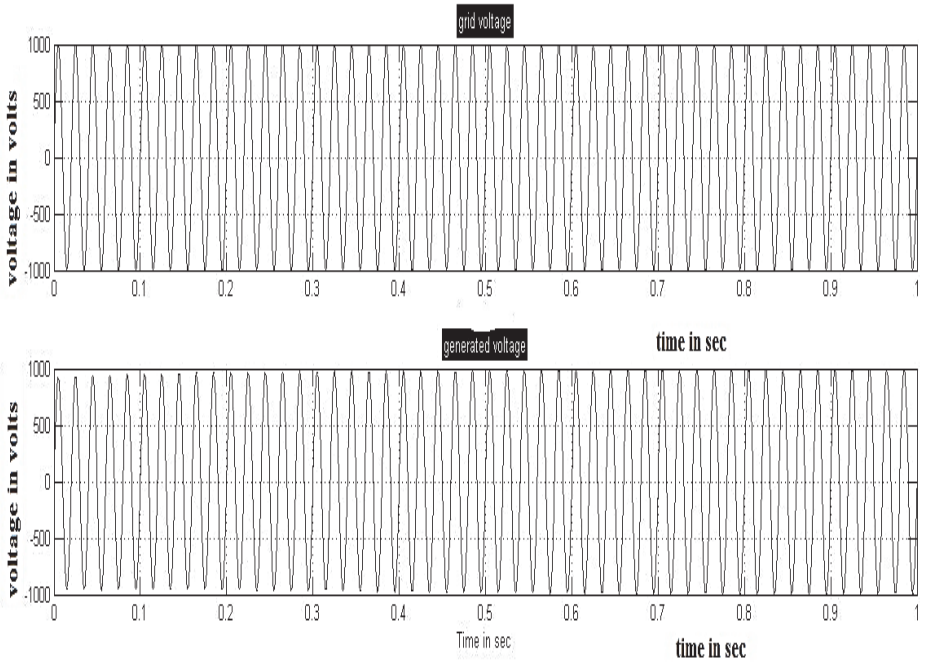


Fig.15.Synchronization waveform between grid and generated voltage

The generated voltage in SLBC with sliding mode controller (SMC) is synchronized with the supply voltage and it is shown in fig 15. It is easy to understand that the produced voltage is synchronized with the grid voltage and it is tested with hardware implementation as a prototype and it is shown in fig16 and fig.17.

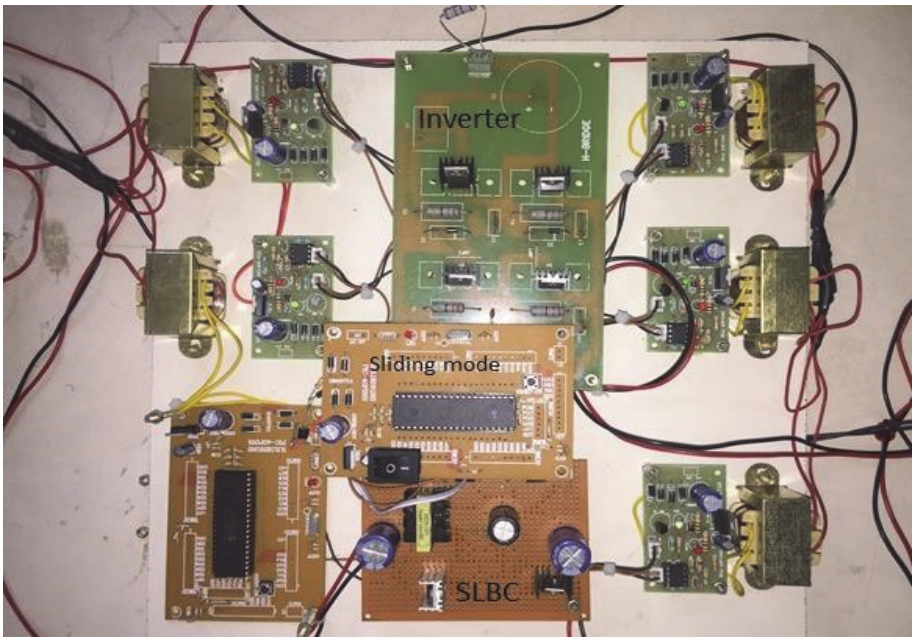


Fig. 16.Grid interconnected solar PV system usingSliding Mode Controller

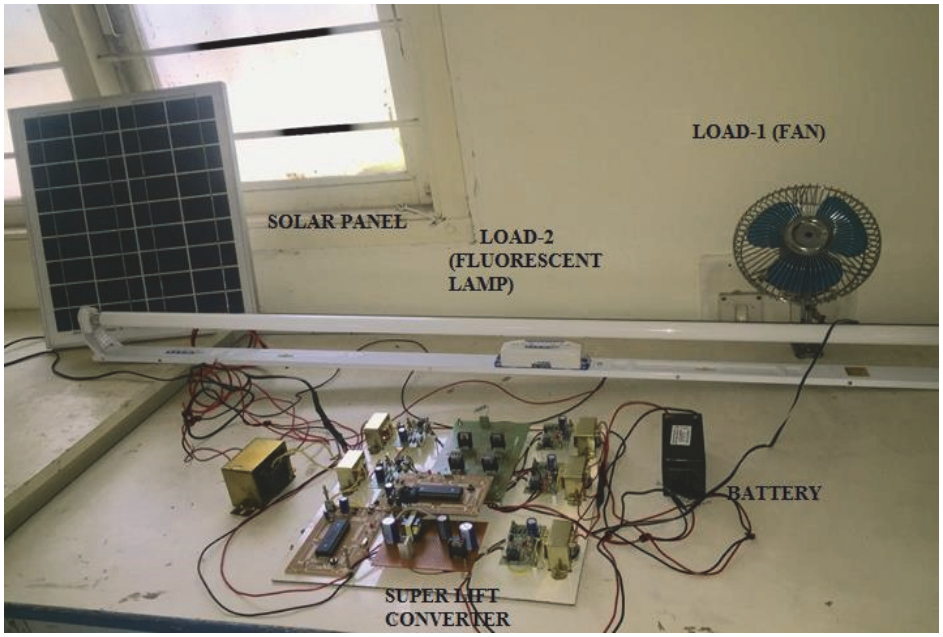


Fig. 17.Grid interconnected solar PV system with Load (Fluorescent lamp & DC fan)

The output voltage obtained from the SLBC hardware is shown in fig.18.It is clear that, the obtained voltage from the Simulink model PV based SLBC is matched with the implemented prototype output.

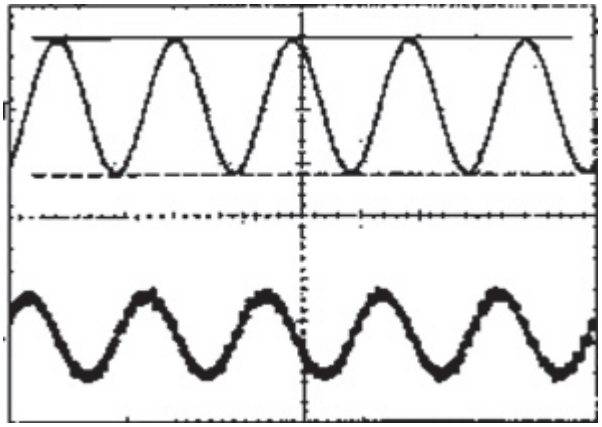


Fig. 18.Synchronization waveform in CRO display

CONCLUSION

The Sliding mode controller based Super lift boost Converter been proposed and modeledusingMatlab-Simulink for the Fluorescent lamp & DC fan.The results obtained has been verified with the implemented hardware using PIC Microcontroller.The proposed Incremental Conductance method in SLBC produces the sufficient grid voltage and it is integrated with the supply voltage fruitfully.

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