IMPLEMENTATION OF MULTILEVEL INVERTER USING MPPT BASED SLIDING MODE CONTROL FOR PV CELL

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***Abstract*—In this project photovoltaic array is used as source. The photovoltaic energy is used to feed the inverter through the step up converter. The output for solar module is connected to the battery. So the supply is given continuously by the battery to the system. The output of the solar may vary due to the radiation and will affect the battery. So the lifetime of battery is reduced. It is necessary to protect the battery from the non-linear solar energy, charge controller is used. In order to track maximum power, sliding mode controller is used. In the step up converter a new method is used. The new step-up converter consists of coupled inductor and fixed capacitor. The voltage stress of active switch is being reduced by clamp capacitor. The output of the new topology of dc-dc converter is given to hybrid multilevel inverter which consists of reduced number of switches. The overall system is simulated using MATLAB prototype of the proposed system is developed and output is verified with simulation results.**

***Index Terms*—solar module, dc-dc converter, multilevel inverter.**

I. INTRODUCTION.

The green house effects on environment are being caused by intensive utilization of the fossil fuel. In order to protect the our earth from the diminish emission of green house gases, it is necessary to use the pollution free renewable resource. Photovoltaic energy is preferred among all the other renewable resource. Because it does not require more space for installation, it can be installed even on the house roof.

The radiation of the solar energy may vary from time to time so it is essential to track utmost power by the solar module. Sliding mode controller is used for maximum power point tracking. During night hours there will be no solar energy. It leads to discontinuous supply of energy to the system. In order to overcome this problem battery is used. If battery is connected directly to the solar panel it leads to battery failure. So the voltage from the solar panel is need to be regulated. Charge controller regulates the voltage from solar module so that battery can be protected and lifespan of the battery is not reduced. Buck converter is used as charge controller. This buck converter regulate the voltage by stepping down the voltage from the solar panel. So that battery also protected. Because of step down voltage from buck converter lower rating of battery can be preferred.

The output of the battery is connected to step up converter. A new topology of step up converter is used. The purpose of this step up converter is to increment the voltage without sacrifice the effectiveness of circuits. This converter consists of three inductor which are coupled together and fixed capacitor. This clamp capacitor is to diminish the voltage stress on the dynamic toggle. The outflow power of the tied inductor is recycled to output capacitor present at the load terminal. Minimum voltage rating and operating resistance of the dynamic toggle are used. so that conduction loss and switching loss can be reduced. To reduce the harmonics LC filter is used. The output of the step up converter is given to five level inverter.

There are three topologies available in multilevel inverter. They are three (i) Diode Clamped inverter (ii) Flying Capacitor inverter (iii) Cascaded H-bridge. A new topology of multilevel inverter is used. This topology requires minimum count of components present in the conventional topologies.

II. PROPOSED INVERTER

A solar subsystem consists of solar module along with the sliding mode controller. The output of is photovoltaic system is given to the battery. The main function of battery to provide the continuous supply even in the absence of the solar energy. The output of photovoltaic system may vary so it is necessary to protect the battery from damage. By using the sliding mode controller the controlled signal is given as pulse to the semiconductor device so that battery can be protected.[2]

The continuous supply can be obtained from the output of the photovoltaic system which is given to step up converter through the battery. In the boost converter the three inductor which are coupled together and fixed capacitor is used. In order to increase the output voltage, the tied inductor and voltage multiplier are utilized. The clamp capacitor is used clamp and to decrease the voltage stress of dynamic switch.

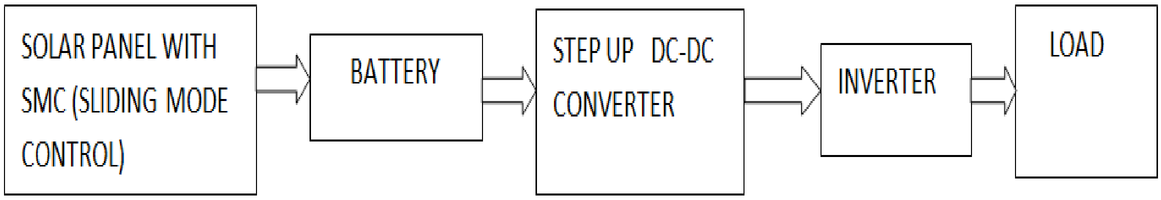

Fig.2.1 Block Diagram of Proposed Inverter

Figure 2.1.The output dc-dc boost converter is given to hybrid five level inverter. This cascaded multilevel inerter converts dc-ac voltage. In the cascaded multilevel inverter number switch used is low. So that loss can be reduced.

III. PHOTOVOLTAIC SYSYTEM

The solar module consists of two types namely current input PV module and voltage input PV module. In current input PV module the current is being measured from the system and it is given as input to PV module. In voltage input PV module the voltage is being measured from the system and it is given as input to the system. The current-input photovoltaic system modules are joined in sequence and distribute the same current. The voltage V_{PV} and power P_{PV} is obtained as output. In the voltage input PV system the modules are connected in parallel share the same voltage. The current I_{PV} and P_{PV} is obtained as output. The output of photovoltaic system vary from time to time so it results in failure for continuous supply to the load. So it is necessary to provide battery for regular supply. At the same time lifetime of battery is also need to be considered by providing constant supply. The constant supply can be provided by using sliding mode controller shown in figure 3.1[1]

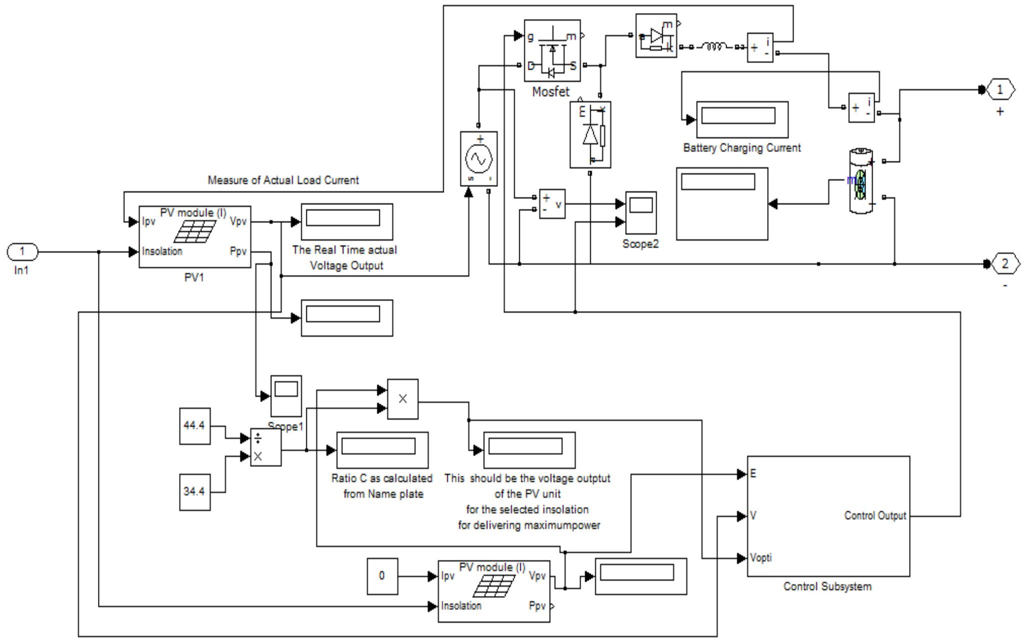

Fig.3.1 Simulation Circuit of Solar Subsystem With SMC

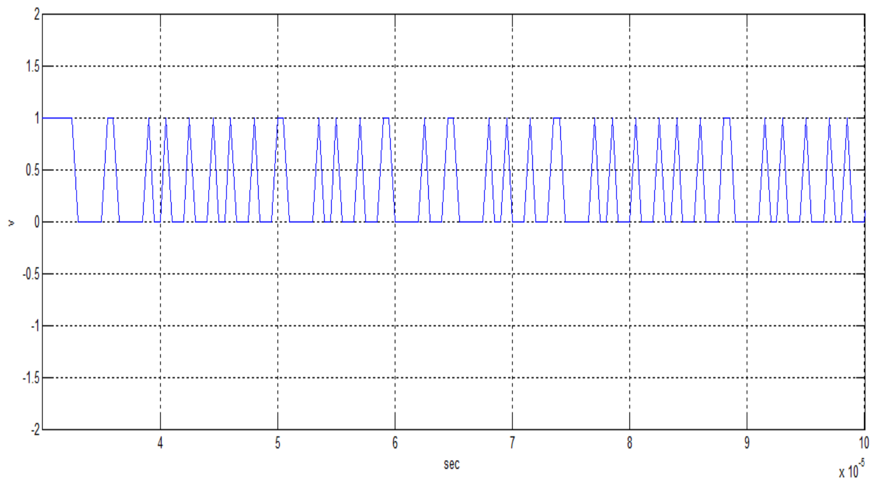

Fig.3.2 Pulse to MOSFET

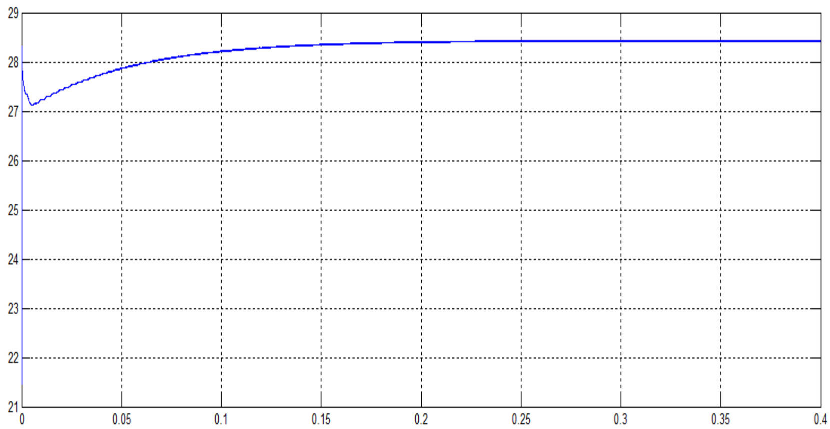

Fig.3.3 Output Voltage of Solar System

The sliding mode control (SMC), changes the dynamics of a nonlinear system by use of a irregular control signal. This signal forces the system to slither along a traverse-sector of the system's typical behavior. It is a nonlinear control method. It can change from a constant structure to another based on the present location.

The SMC provides the discontinuous control signal as controlled pulse to the semiconductor device. By triggering the semiconductor device according to the output of solar module so that the battery can be protected by sliding mode controller. One solar panel is connected to the load and another solar panel is taken as reference which is not connected to the load. The output voltage of the two solar module is connected to SMC. Then the SMC compares the optimum voltage with the voltage obtained from the solar panel connected to the load and gives control signal to the MOSFET switch. By comparing these two signals controlled signal is provided by sliding mode controller to the device. The diodes are used in order to conduct in forward direction. So it helps in opposing the flow of power in another direction. Then supply is given to the battery. It stores the energy. So that it can supply without any termination.

IV. DC-DC BOOST CONVERTER

In this converter three inductor coupled together and a voltage double for voltage transfer proportion lacking severe duty ratio which is required for the converter shown in figure 4.1The voltage strain of the dynamic switch is low because of the fixed capacitor. If the proposed circuit operates in continuous conduction mode then the supply current ripple is decreased. The outflow energy of the tied inductor is given to the capacitor at the load terminal and the efficiency of the circuit also increased when the switch is turned off. The reverse recovery crisis of diode can be overcome by using tied inductor in dc-dc converter. So that efficiency of the converter can be improved.[1]

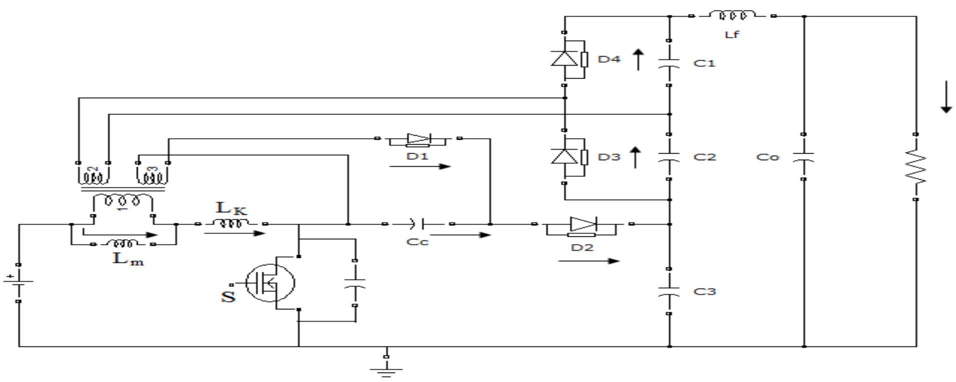

Fig.4.1 Step-Up Converter

The converter consist s of three-zigzag tied inductor, the dynamic switch, fixed capacitor, three supplementary diode, one diode and three capacitor at the output. In step-up converter proportional integral controller is used to give the pulse is given to the active switch. The proportional integral controller compares the output voltage obtained from the converter with reference voltage. By comparing switching frequency and proportional integral output the pulse is given to the active switch of the step-up converter. The following statement are made for step-up converter[3]

1. The converter working in the continuous conduction mode.

2. The coupled inductor is considered as ideal transformer, in equivalent with magnetizing inductance and sequence with leakage inductance.

In the dc-dc converter operates in five modes[4]

4.1 Mode 1[t_0-t_1]

In the mode1 the dynamic switch is turned on, both the magnetizing inductor L_m and outflow inductor are charged by the supply voltage. At the time current linearly with the slope V_{in}/L_m. In mode1 diode D_1, D_2, D_3 are all reverse-biased and only D4 is further biased. Through the output capacitor C_1, C_2, C_3 the load energy is supplied. If the dynamic switch is switched off then the mode1 to a halt shown in figure 4.2

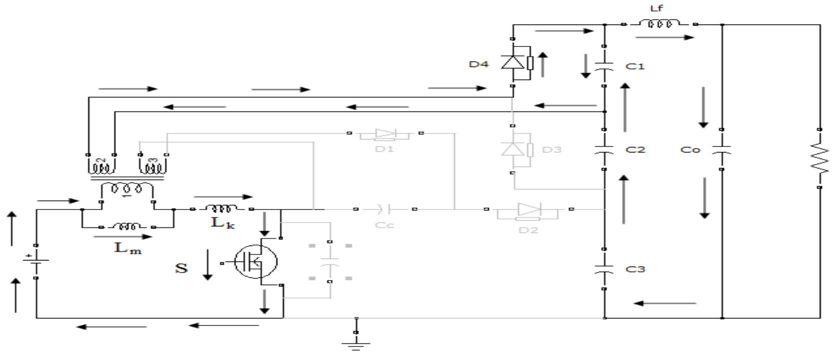

Fig.4.2 Mode1 Operation

4.2 Mode 2[t_1-t_2]

When the dynamic switch is switched off, the capacitor of active switch is stimulated from supply current and partially from magnetizing current I_{lm} and leakage current I_{lk}. The voltage across the dynamic toggle is more. In mode2 D1, D2, D3 are reversed-biased. The output capacitor C1, C2, C3 are used as to deliver the load. If the current across the diode d4 decreases to zero tends to switch over to the next mode shown in figure 4.3

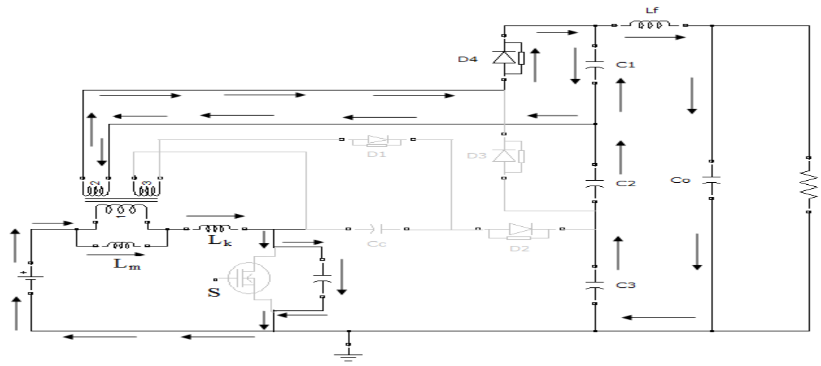

Fig.4.3 Mode2 Operation

4.3 Mode 3[t_2-t_3]

In mode 3, the magnetizing inductor L_m discharges energy to secondary and tertiary winding of the tied inductor. The secondary side of diode d4 is reverse biased and d3 is forward biased and transmits energy to the capacitor c2. The tertiary sides of the diode d1 carry out and a fixed capacitor is charged by outflow inductor. The diode d2 is forward biased by the leakage inductor. If the current through the clamp capacitor is zero means then next mode starts shown in figure 4.4

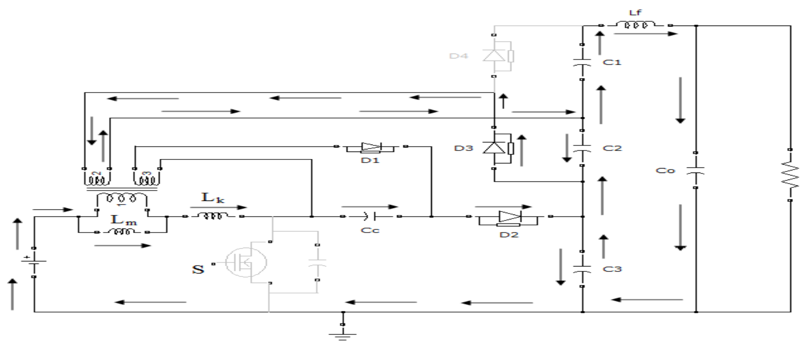

Fig.4.4 Mode3 operation

4.4 Mode 4[t_3-t_4]

In mode4, from the tied inductor the clamp capacitor is charged by the inductance L_m. The outflow inductor discharge energy to the capacitor and the magnetizing inductance discharges the power from tied inductor to secondary and tertiary winding. Here diode D1, D2, D3 are all conducting and diode d4 is reverse biased. The capacitors C1, C2, C3 deliver power to load. When the leakage inductor current and diode D2 current are decreased to zero then this mode stops and go through subsequent mode shown in figure 4.5

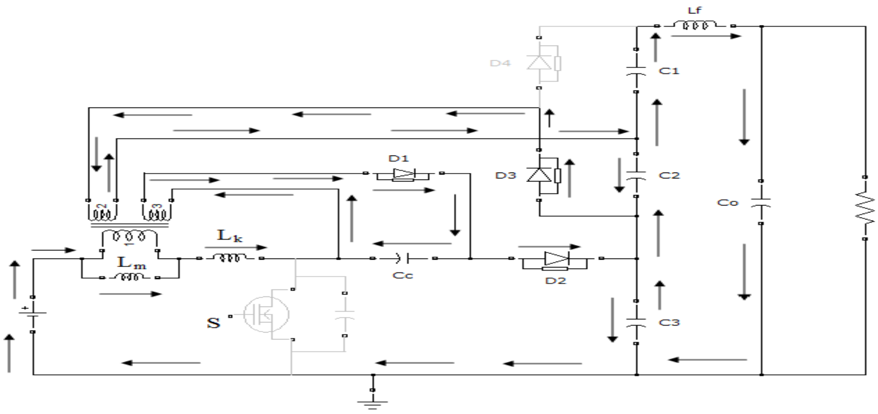

Fig.4.5 Mode4 operation

4.5 Mode 5[t_4-t_5]

In this mode, the energy is released to the secondary and tertiary part of the tied inductor from the magnetizing inductor. Diode D1, D3 still operates with their current reduced throughout this period. Fixed capacitor is stimulated from the L_m by the tied inductor. When toggle is on, the subsequent switching sequence starts shown in figure 4.6

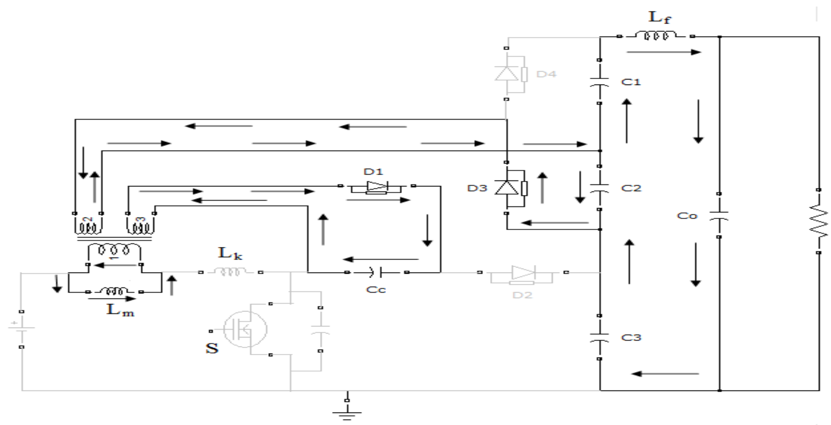

Fig.4.6 Mode5 operation

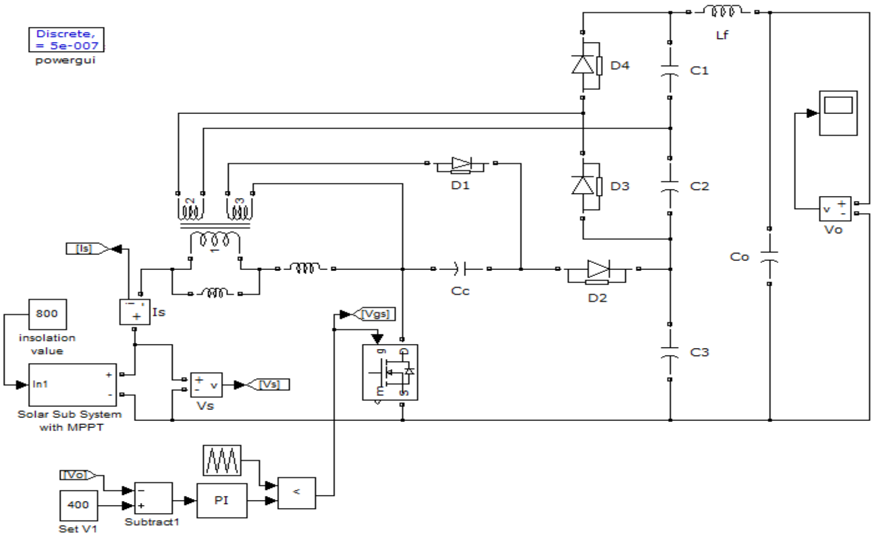

Fig.4.7 Simulation Circuit of Solar Subsystem With DC-DC Converter

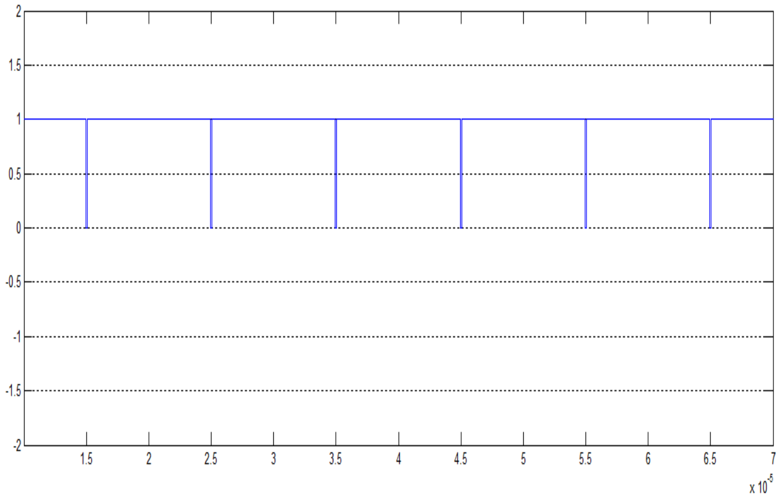

Fig.4.8 Pulse To MOSFET Switch Of dc-dc Converter

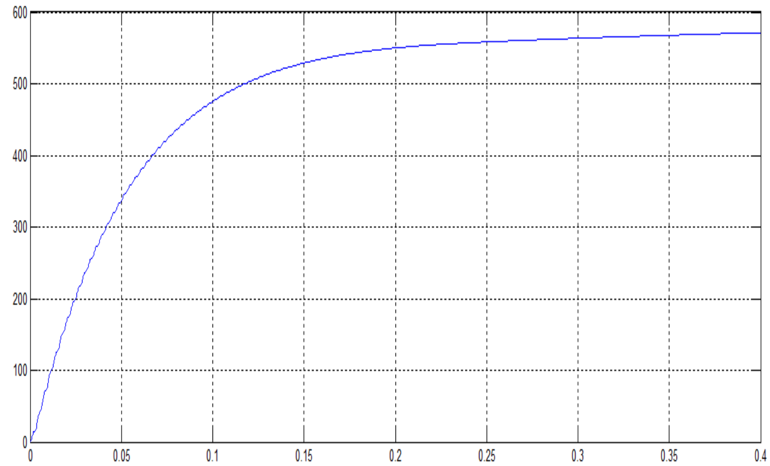

Fig.4.9 Output Of dc-dc converter

V.MULTILEVEL INVERTER

Multilevel inverter provides lower distortions, lower switching losses and also high power capability [6]. It requires more switches, components and control is complex. The proposed topology of 5-level inverter requires 5 controlled switches, 8 diode, 2 capacitors shown in figure 5.1

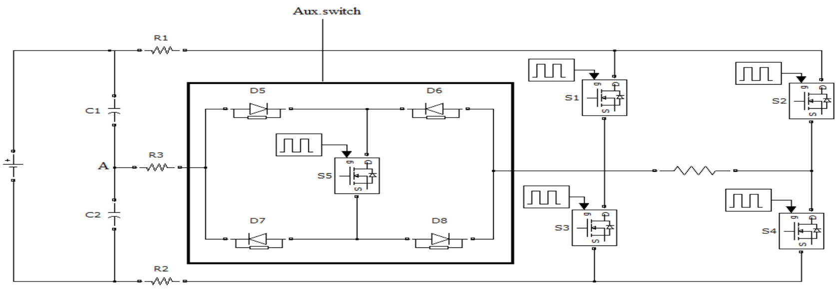

Fig.5.1Five Level H-Bridge Inverter

The five level output voltages are generated as follows:

1. OPTIMUM VOLTAGE V_S

When S_1 and S_4 is switched on the voltage flows through these switches and to the capacitor to attain the output voltage V_s as shown in Fig.5.2

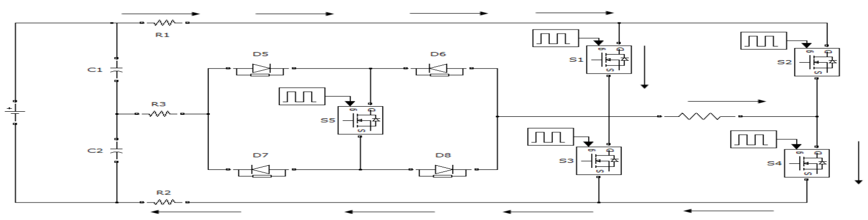

Fig.5.2 Output Voltage Level Of V_s

2. HALF-LEVEL POSITIVE OUTPUT V_S/ 2:

For $V_s/2$ output voltage, supplementary Switch (S_5) is on connecting with diode D_5 and D_8 and along with S_4 will be turned on which is shown in Fig.5.3

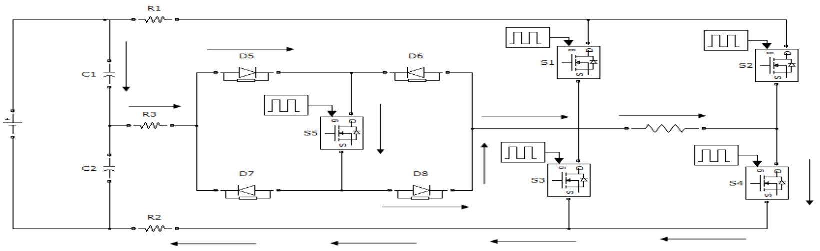

Fig.5.3 Output Voltage Level Of $V_s/2$

3. ZERO OUTPUT:

To attain zero output voltage switches S_3 and S_4 need to be on which is shown in Fig.5.4

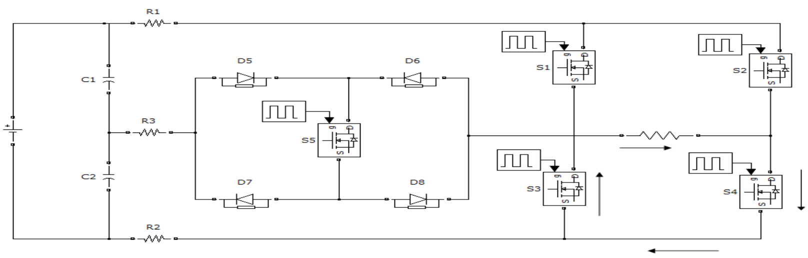

Fig.5.4 Output Voltage Level Of Zero

4. HALF-LEVEL NEGATIVE OUTPUT -V_S/ 2:

For $-V_s/2$ output voltage, supplementary Switch (S_5) is on connecting with diode D_6 and D_7 and along with S_2 will be turned on which is shown in Fig5.5

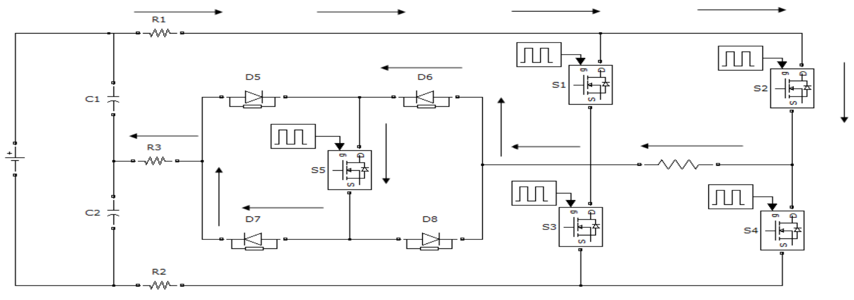

Fig.5.5 Output Voltage Level Of $-V_s/2$

5. MAXIMUM NEGATIVE OUTPUT -V_S:

When S_2 and S_3 is switched on the voltage flows through these switches and to the capacitor to attain the output voltage $-V_s$ as shown in Fig.5.6 [7]

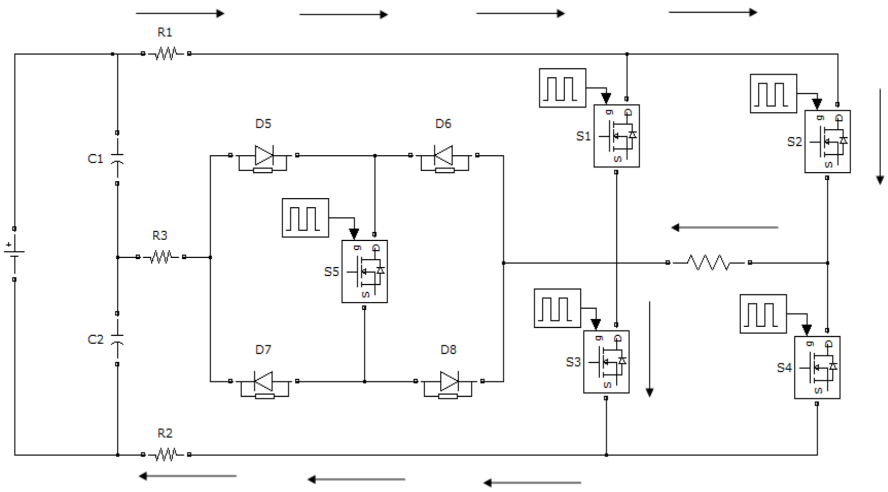

Fig.5.6 Output Voltage Level Of $-V_s$

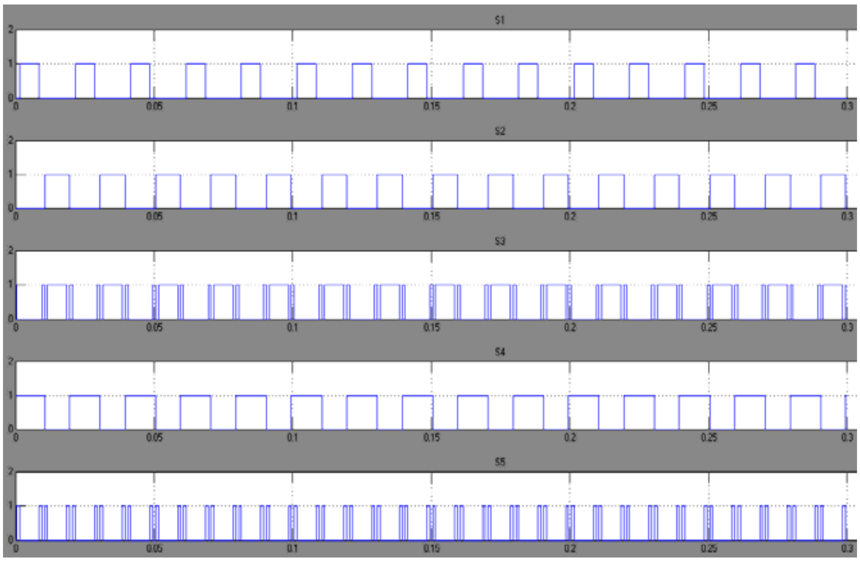

Fig 5.7 Pulse To MOSFET Switches Of Multilevel Inverter

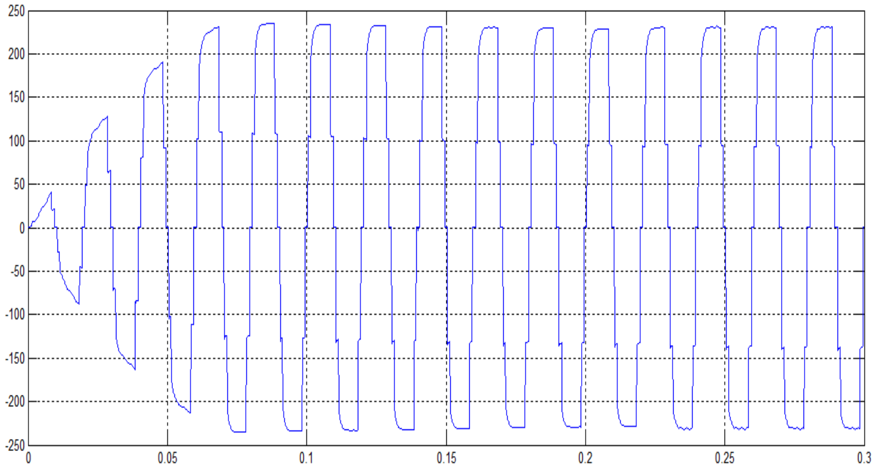

Fig.5.8 Simulated Five-Level Output

VI HARDWARE

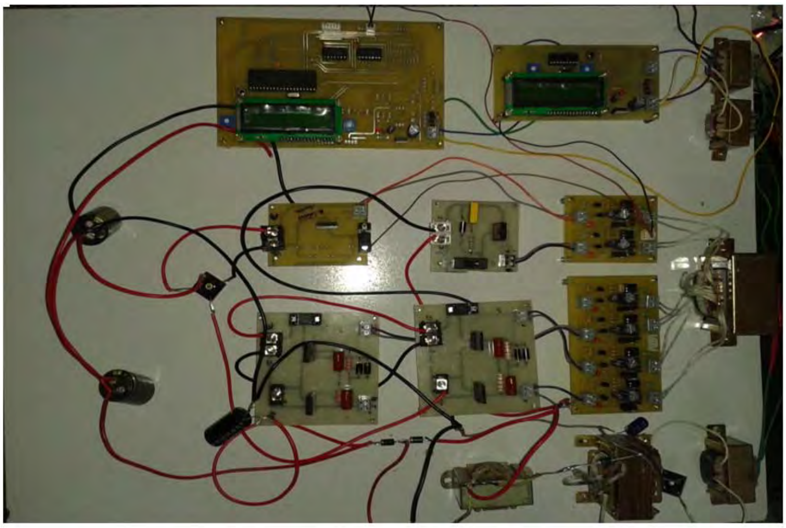

Fig 6.1 Hardware Circuit

FIG6.2 FIVE LEVEL OUTPUT

The hardware is implemented for DC-DC converter ,five level inverter, Seven IRF460 – MOSFET are used in this design which has high voltage and current carrying capability. Gate Driver circuits are used for boosting the pulses which we get from a microcontroller. PIC16F877A is used for generating required pulses.

VII CONCLUSION

A photovoltaic system is used as source and the system is non-linear system. It is necessary to supply the energy continuously so battery is required. The lifetime of the battery is reduced due to the non-linear system. Sliding mode controller is used in the photovoltaic system it provides the discontinuous control signal to the semiconductor device. In order to attain optimum voltage transformation proportion lacking severe duty ratio for the power switch the proposed converter is used. Thus, the voltage ripples of power switch also is clamped effectively. Thus the switching and operating losses are minimized. This multilevel topology with minimized switches, producing the five-level output voltage using only 5 switches, and 2 capacitors are used.

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