Design And Implementation Of PV Power Conversion By Using Modular Multilevel Converter

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Abstract : In this paper, A high efficiency modular multilevel converter (MMC) is used in the utility grid for photovoltaic conversion. In photovoltaic conversion system, PV cell is the basic structural unit of the PV module. PV cell generates very small power. Each solar or Pv cell generate 5V. When large set of PV cell connected in series or parallel to form PV module and several module are connected to form solar array. The modeling of solar power conversion using modular multilevel converter (MMC) as interface unit into the grid system. In this paper hill climbing method of maximum power point algorithm is used to regulate the Dc voltage of the modular multi-level converter and synchronize the utility grid with current for attaining near the unit power operation due to increase in the environmental pollution, prices of fossil fuel etc. The result presented in this paper verify the proposed MMC topology such that AC output free from the high order harmonics and grid current and voltage are in phase. The aim of this paper is to convert the photovoltaic power into usable ac power for grid connectivity by using modular multilevel converter and the experimental result are shown in Matlab/Simulink software.

***IndexTerms* - Voltage Source Inverter(VSI), Current Source Inverter(VSI), Photovoltaic Module(PVM), Controller Voltage Source.**

I. INTRODUCTION

As per the Law of Energy conservation," *Energy can neither be created nor it can be destroyed, it can just be transformed from one form to another form of energy"*. We require energy for all our day to day activities that gives us comfort and also liberty to increase our productivity in order to achieve our goals in life. We have various forms of energy like gravitational, chemical, nuclear, motion, thermal energy that could be exploited to meet our energy demands. As contradiction to the available sources of energy we use only electrical energy to meet our energy demands. As per the law stated above energy transformation from one form to the other is achievable and we use exactly the same concept of energy transformation. As we know that electrical energy cannot be stored and it is the most convenient form of energy to use with ease, we have devised a way to convert it to different form of energy and use it according to our energy requirements.

Photovoltaic power system is one of the important power systems for saving energy due to increase in the prices of fossil fuel, pollution co2 in the environment. Renewable energy power supplied in the grid due to increase in the demand of the fossil fuel and emission of co2 in the environment. There are various renewable energy resources which are used for utility grid such as wind, biomass, and solar energy. The solar energy system is more attractive than other renewable resources. The light energy is directly converted by solar voltaic system into the electrical energy. The energy obtained from the photovoltaic module is very low and act as low voltage dc source and it has low conversion efficiency. To improve the conversion efficiency and convert the output of PV or Solar module into usable ac source. The power electronics converters are used to convert the output DC into usable AC. The single stage power conversion satisfy all the objectives of control such as MPPT, lower harmonic content in the output current This project present the design of the photovoltaic power conversion by using MMC. Modular multilevel converter having many advantages over conventional multilevel inverter. The few significance of the modular multilevel converter are:- it allow to extending the no. of level , it eliminate the requirement of filtering when it generate low harmonic output voltage. In medium voltage application, modular multilevel converter having strong potential to replace with cascaded multilevel converter. This paper shows the effective implementation of the photovoltaic power conversion support with MMC (modular multilevel converter) for grid interfacing which satisfy all the objective of the control.

In this paper, we have discussed in section II the complete design and implementation of photovoltaic or solar power conversion using MMC- Modular multilevel converter. We have also have discussed observation and analysis. The next section, that is section III the results achieved from experimentation whereas section IV describes the conclusion for the project.

II.DESIGN AND IMPEMENTATION

2.1 PHOTOVOLTAIC MODULE (PV MODULE) OVERVIEW

A photovoltaic cell is a basic structure unit of the photovoltaic module. It is a semiconductor diode which converts the visible sun light into direct current. It can also convert the infrared radiation and ultraviolet radiation into dc electricity. PV cel*l generate* 5v. PV cell made up of silicon material combined or doped with other element which affects the *behaviour* of electron or holes. There are two basic types of semiconductor material are used to form PV cell. The two basic elements are P- type and *N* - type and these material are combined together to form a boundary between them is *called P*-N junction. When such radiation falls or strike on the PN junction, a voltage difference is produced between P- type and N-type material. Some electrodes are connected with semiconductor layer that allow current to be drawn from the device. When large set of PV cell can be connected in series or parallel to form PV *module, array*, panels. The use of PV cell and batteries for generation of usable electrical energy is known as photovoltaic. Each PV cell generates very small power when sunlight falls on it. The output of PV cell can be increased by connecting no. of PV cell in series or parallel to form PV module. The below Figure-1. Show the equivalent circuit of PV cell.

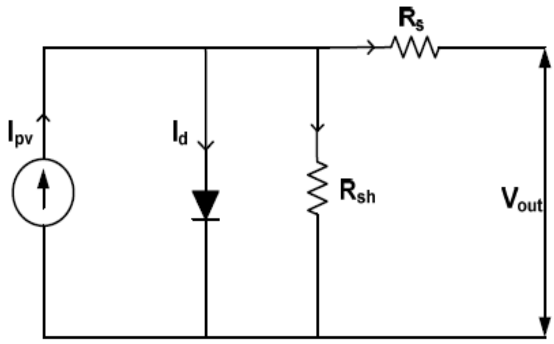

Figure 1. Equivalent circuit of PV cell.

The characteristics of photovoltaic module is highly non linear. These characteristics changes according to change in the radiation of the sun light and temperature of the cell. When radiation of solar affects the output current and temperature of cell affects the terminal voltage. The I-V characteristics of PV module under varying solar radiation.

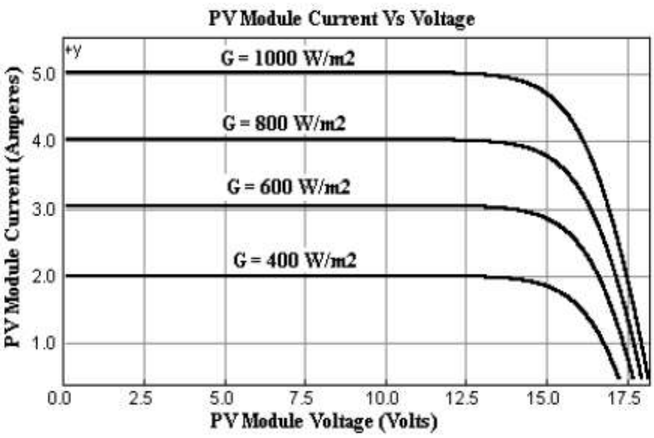

Figure 2 . current versus voltage at constant temp.

Below fig. shows the IV characteristics of the photovoltaic module under varying temperature of cell at contant solar radiation(1000W/m2)

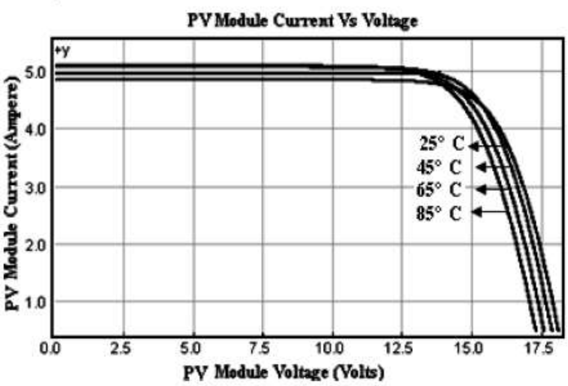

Figure 3 I(current) Vs V(voltage) at constant solar radiation.

2.2 MODULAR MULTILEVEL CONVERTER (MMC)

The modular multilevel converter is the latest technology which is suitable for the application of medium voltage. The modular multilevel was designed by lesnicar and marquardt in 2002. The Sub-module is the basic component of the modular multilevel converter(MMC). As shown in the figure it is basically a half bridge with capacitor Figure basic structure of sub-module. Each sub-module having two insulated gate bipolar transistor (IGBT) and two diode switches. Whereas two insulated gate bipolar transistor namely as S1 and S2 and two diode switches namely as D1 and D2. All the switches in the sub-module are in complimentary fashion. Each sub module consist of two switches , S1 is the main switch and S2 is the auxiliary switch. When the main switch S1 is ON and other auxiliary switch S2 is OFF, then the output voltage of sub module is equal to1/2Vdc and at that time no charging take place at the capacitor. When the main switch S1 is OFF and other auxilliary switch S2 is ON, then the output voltage of submodule is equal to 0 and at that time capacitor is charging.

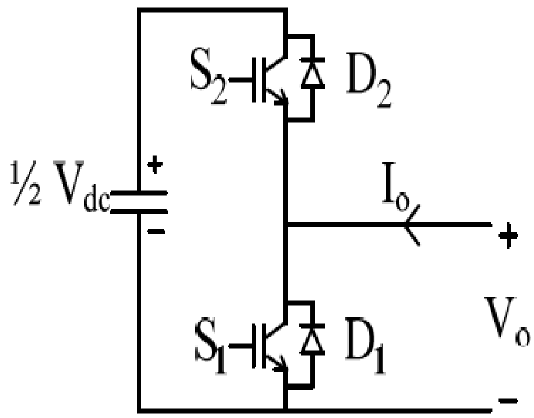

Figure 4. Basic structure of one sub-module.

The total number of voltage level in modular multilevel converter (MMC) can be calculated by using this formula:

$$N_v = n/2 + 1$$

Where n - total no. of sub-module
N_v - No. of voltage level

Table 1.SUBMODULE SWITCHING STATE

Main switch (S1)	Auxilliary switch (S2)	Output voltage (V0)	Capacitor state
ON	OFF	1/2V_{dc}	Not Charging
OFF	ON	0	Charging

The above table shows the switching state of sub-module of modular multilevel converter. Figure 5 shows the basic structure of single phase of multi-level level modular multilevel converters. Where on the upper arm of the single modular multilevel converter two sub module are connected in series fashion and on the lower arm another two sun module are connected in same fashion. Both the inductance UIa and LIa are suitable to take the difference between both the upper arm and lower arm. Both load resistance RL and load inductance as shown in the below figure of modular multilevel converter. The sub-module are inserted upon the upper arm and lower arm by depending on the requirement of voltage.

This paper shows the effective implementation of the photovoltaic power conversion support with MMC (modular multilevel converter) for grid interfacing which satisfy all the objective of the control like maximum power transfer under the varying condition of environment. Below figure 6. Shows photovoltaic array supports the eight- levels MMC in photovoltaic power conversion.

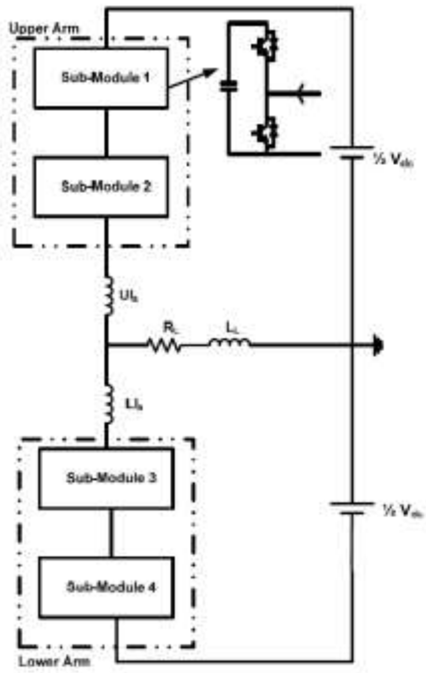

Figure 5 shows the basic structure of single phase of three level modular multilevel converter

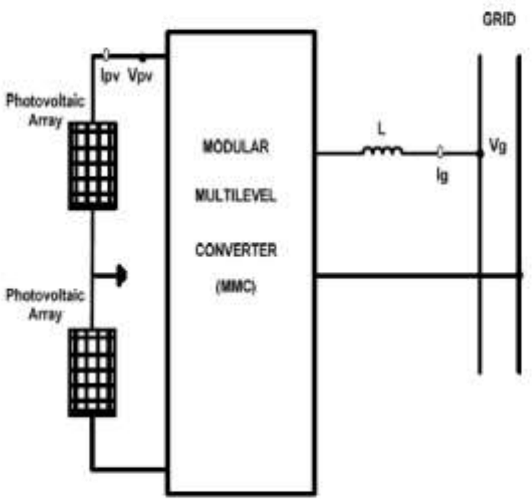

Figure 6. Photovoltaic supports eight level MMC

The most important algorithm is the perturb & observe which is also called hill climbing algorithm. The modular multilevel converter controlled by two control loops. One is inner control loop and other is outer control loop. In the inner control loop, it is used to control the grid current to be sinusoidal and it synchronized with grid voltage. The outer control loop is used to generate the reference DC link which is generated by MPPT algorithm; it sensed Ipv and Vpv and then it generate Vmax. The DC link voltage Vmax required to regulate across modular multilevel converter. The error generated by DC voltage control loop is passed through the PI controller. A sin signal are in phase with grid is multiplied by the current reference to make a input reference current for inner control loop. Below figure shows the block diagram of the outer and inner control loop.

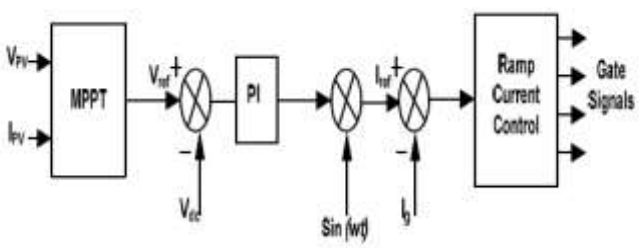

Figure 7. Block diagram control loops (outer and inner)

2.3 SIMULATION SETUP & RESULTS

In section II, we have studied design and working of the ball mill machine. In this section, we will study the experimental procedure followed to carry out the experimentation. The proposed setup of modular multilevel converter is used to convert the photovoltaic power conversion is simulated with MATLAB/SIMULINK software. In experimental setup of photovoltaic array is composed of number of cells connected in series or parallel to form a module. Number of module are connected in series to generate voltage of 1200V. The capacitor voltage across the lower arm and upper arm of modular multilevel converter; observe that converter voltages (V) through the capacitor are balanced and it maintain less voltage ripple. This increased the life time of photovoltaic. The modular multilevel converter is connected with PV system for grid connection. The modular multilevel converter controlled by two control loops. One is inner control loop and other is outer control loop. In the inner control loop, it is used to control the grid current to be sinusoidal and it synchronized with grid voltage. The outer control loop is used to generate the reference DC link which is generated by MPPT algorithm; it sensed Ipv and Vpv and then it generate Vmax. The DC link voltage Vmax required to regulate across modular multilevel converter. The error generated by DC voltage control loop is passed through the PI controller. A sin signal are in phase with grid is multiplied by the current reference to make a input reference current for inner control loop. Figure simulation model of modular multilevel converter used by photovoltaic power conversion. In this setup, modular multilevel converter taking power from sub system as shown in figure all the submodule of MMC are connected in series with each other. The simulation setup of photovoltaic power conversion used MMC. Figure shows the circuit of submodule of MMC in which two mosfet, two diode and one capacitor is used. Mosfet is connected with diode in parallel. Figure shows the simulation result of subsystem output which is used for giving input to the MMC. The result of simulation of this system adapt the PV power conversion using Modular multi-level Converter for taking a fast response and good transient response, and result of this system shows the increased efficiency by reducing the switch losses in the system

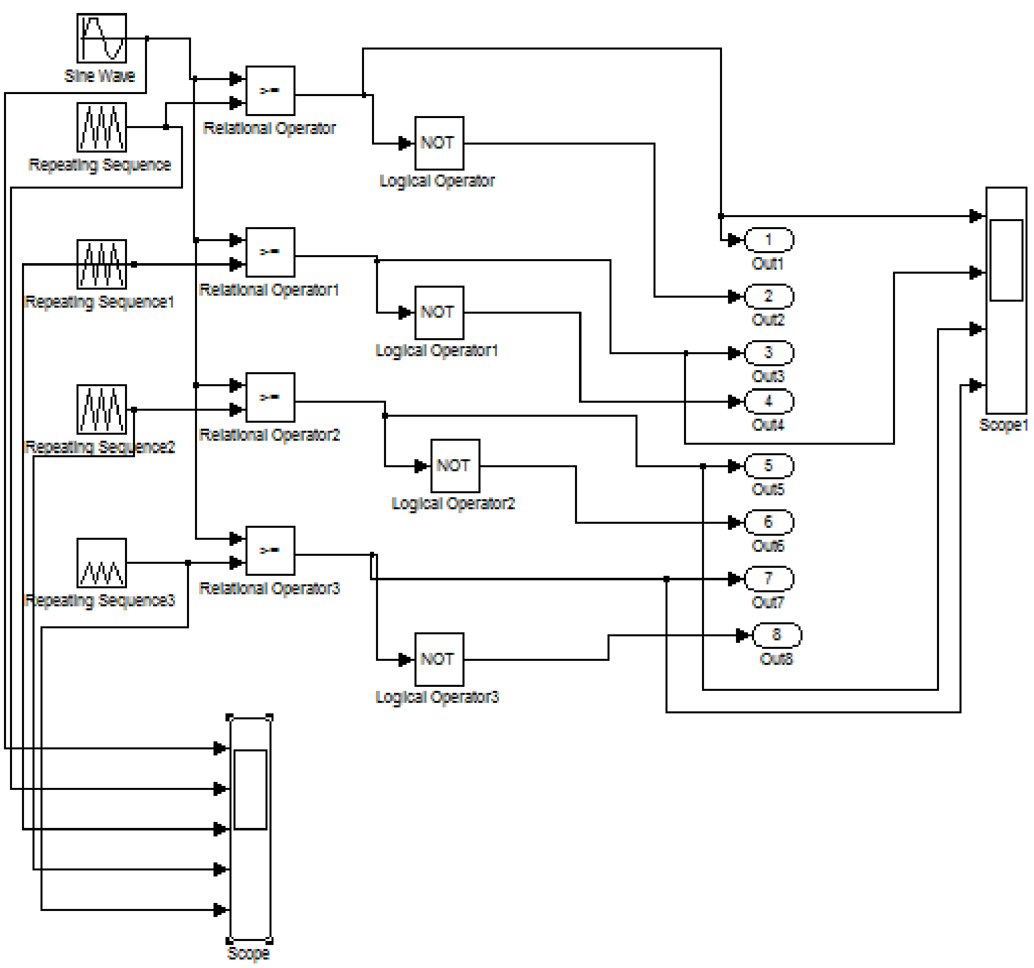

Figure 8 Simulation of initial setup of input power for MMC

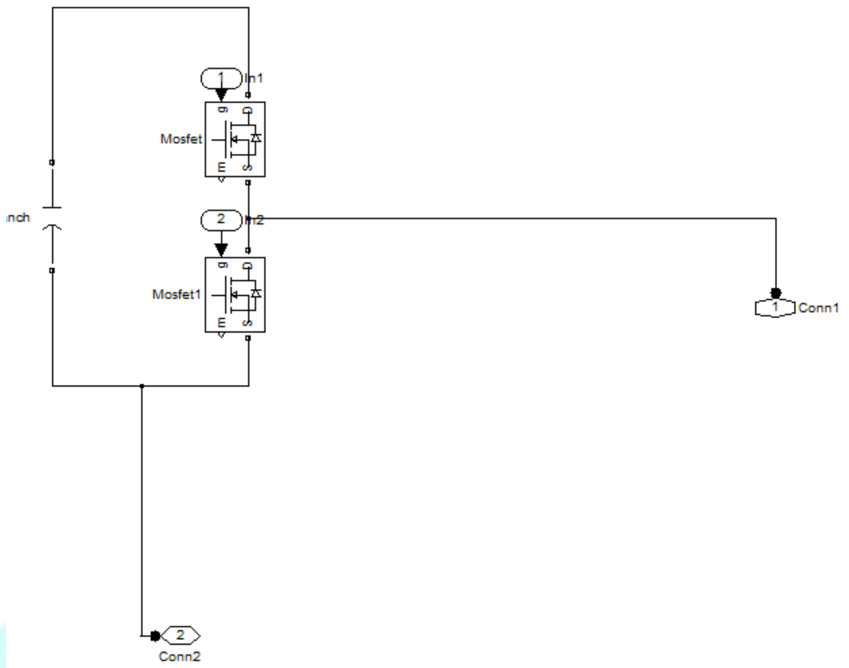

Figure 9 Simulation model of sub module of MMC

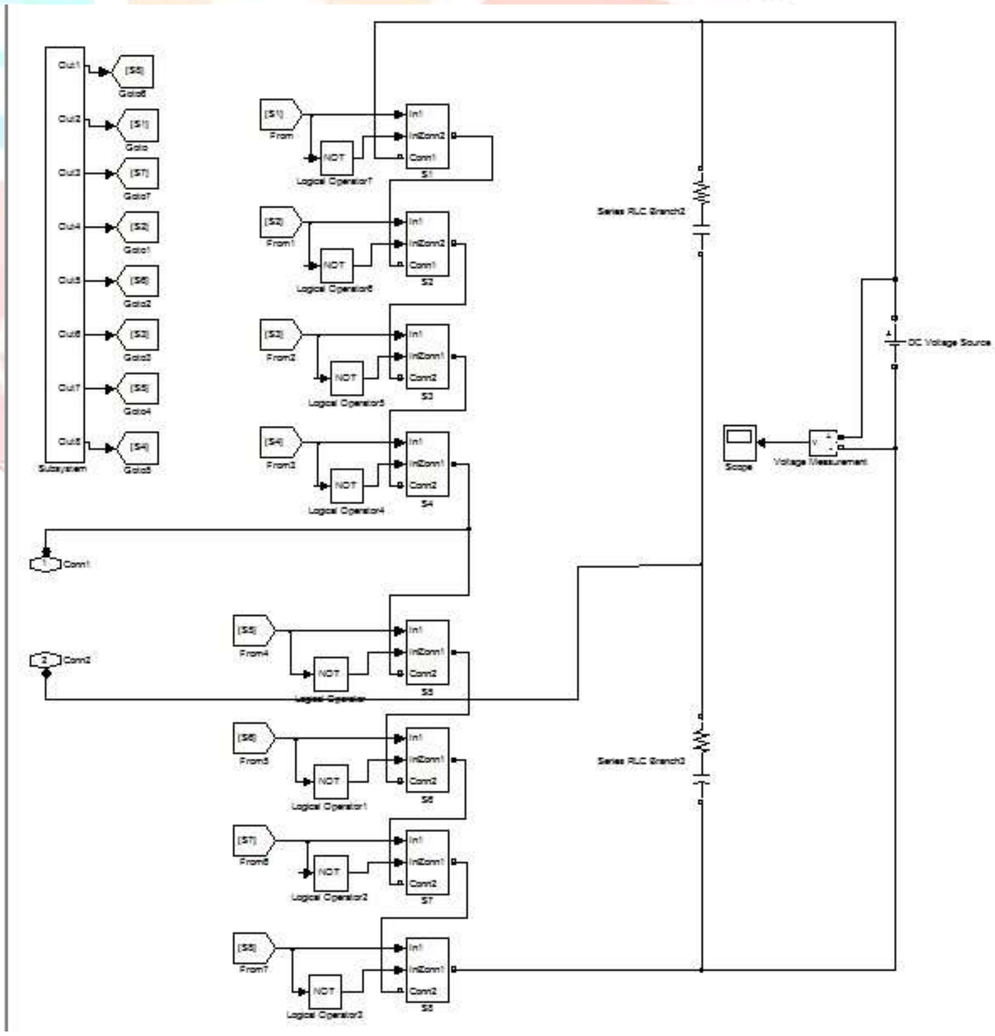

Figure 9 Simulation model of MMC

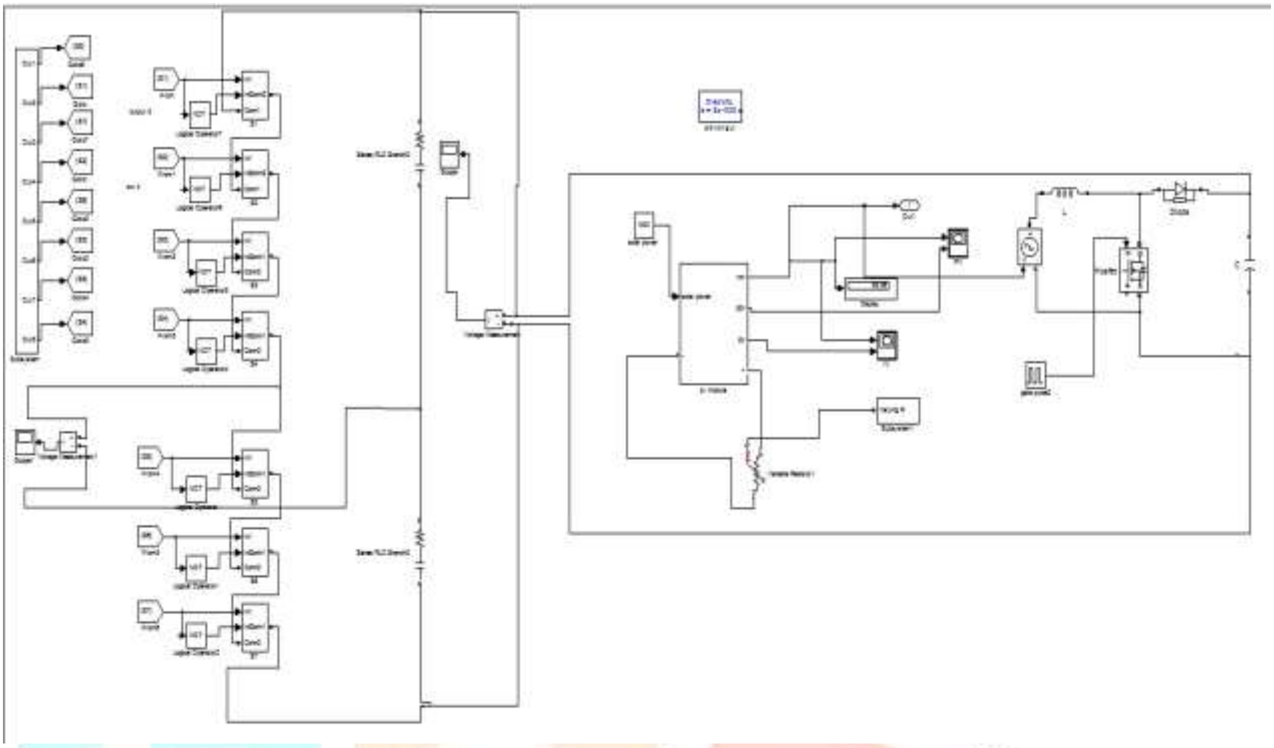

Figure 10. Final simulation model of PV Power conversion by using MMC

III. RESULTS

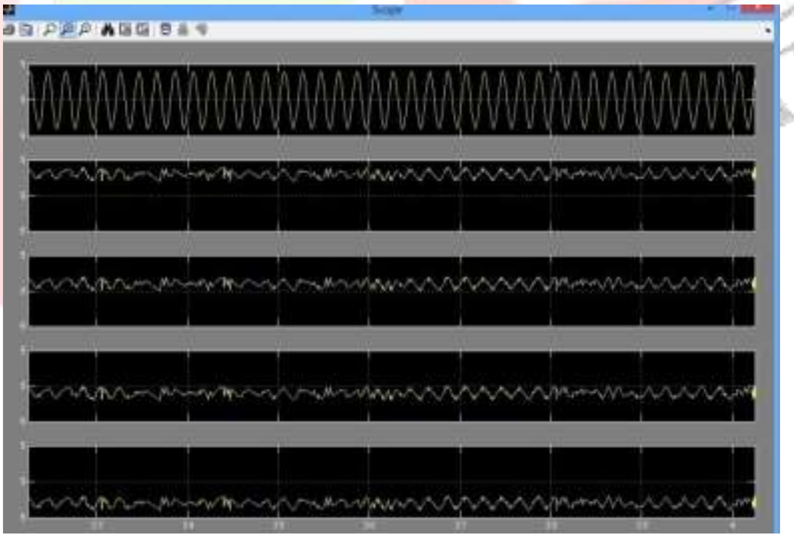

Figure 11 Input voltages to MMC sub-module.

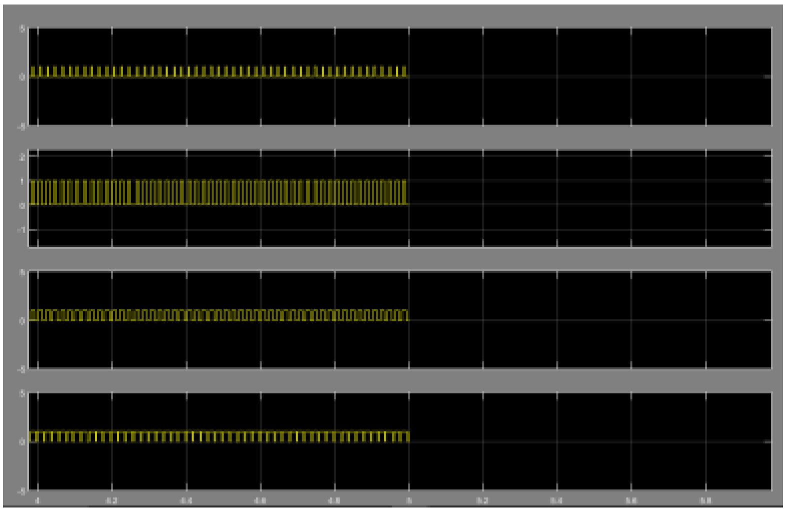

Figure 12 output voltage given to MMC sub-module.

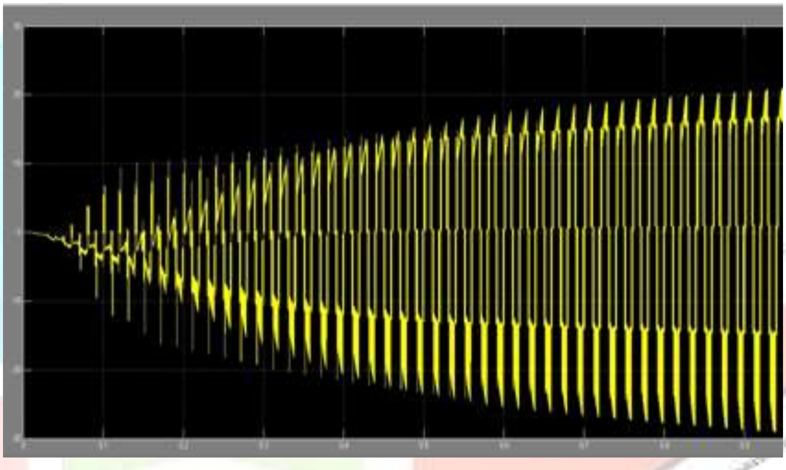

Figure 13 final output from the Modular Multilevel converter

IV. CONCLUSION

In this paper, Multi-level Converter based grid connected photovoltaic system is proposed. The modular concept allows the application to be extended for wide power range. This study makes an attempt and verifies that the MMC system is capable of injecting power into the grid with low total harmonic distortion, unity power factor and high efficiency. Conventional multilevel converter requires interfacing transformer for grid connected system applications, whereas MMC topology requires filter to connect inverter into the grid. Low switching frequency of the switches in the Modular multilevel converter leads to low power loss. The effectiveness of the proposed grid connected with modular multilevel converter power converter is demonstrated through simulation studies.

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