

Multilevel Inverter for photovoltaic system

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Abstract— Multilevel inverters are mostly used for high power applications. The photovoltaic (PV) power generation has low efficiency due to the various factors. This paper gives a new method to enhance the performance of the PV system. Solar panel is directly connected to the multilevel inverter (MLI) so as to improve the efficiency. MLI is used in high power medium voltage converter to reduce the harmonic component which is present in the output due to the filter. In the proposed MLI there are 3-H bridge inverters to achieve 7-level output voltage. The inverter produces seven level output voltage: +3V, +2V, +V, 0, -V, -2V and -3V. Microcontroller unit (MCU) is used to produce control signals for the gate of MOSFET of MLI.

Keywords— PV cell, Cascaded H-bridge multilevel inverter, Microcontroller unit.

I. INTRODUCTION

The increase in demand of clean energy can be fulfilling by wind, solar, hydro, and other renewable energy sources. Clean and non polluting energy is a renewable energy. [1]. The demand for renewable energy has increased rapidly because of shortage of fossil fuel solar power is clean and green source of electricity that is obtained from sunlight or with the help of heat from the sun. In the process of producing electricity solar energy does not emit any greenhouses gases or toxic waste. It is convenient energy source which can be used for long term. Due to the decreasing cost of solar panel use and demand of solar panel is also increases gradually. [2]

Electrical energy which is generated from solar energy, by using PV sources has many application fields. We cannot extract the power from renewable energy sources easily it has many limitations. We have to enhance the power extracting method in order to minimize the power demand. To extract power from solar cell multilevel inverter can be used It gives the desire ac output waveform from several dc sources. [4]

II. PROPOSED SYSTEM

A. Photovoltaic system

To converts solar energy into electrical energy a photovoltaic (PV) system or solar PV power system used.

The PV system is the basic device of a PV system. All cells are grouped together they form arrays. Light falling on the cell is directly proportional to the output of the given power source.

B. Multilevel inverter

Inverter is an electronic device which converts DC power to AC power at required output voltage and frequency level. The output of PV array is in dc form. For local use purpose it needs to convert in to AC form, because most of the loads are AC loads and power utilization is mostly in ac form so multilevel inverter is used to convert this Dc power to Ac power. There are two part in which inverters can be broadly classified are 1. Two level inverters 2.Multilevel inverter. The two-level inverter can only create two different output voltages levels 0 or $\pm V_{DC}$. These two level inverters have some limitations in operating at high frequency in high-power and high voltage applications, mainly due to switching losses and constraints of device ratings. These limitations can be overcome using multilevel inverters. [3] There are 3 types of multilevel inverters (MLI) named as diode clamped multilevel inverter, flying capacitor multilevel inverter and cascaded H-bridge multilevel inverter. Multilevel inverter use power conversion method in which the output voltage is obtained in the form of steps so that output voltage closer or to a sine wave and reduces the harmonic distortion. [8]

C. Cascaded H-Bridge Multilevel inverter

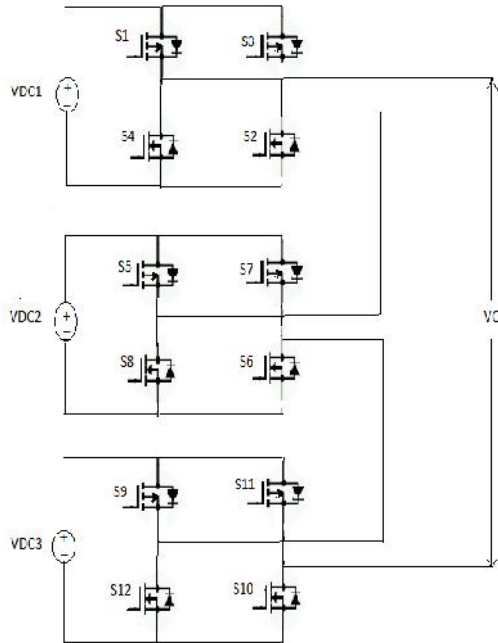


Fig. 1 Seven-level Cascaded Multilevel Inverter

The cascaded seven-level multilevel inverter is produce output voltage in the form of stepped. The steps to synthesize the seven- level voltages are as follows:

Table I Switching Table for seven-level Inverter

V_o	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
+V	1	1	0	0	0	1	0	1	0	1	0	1
+2V	1	1	0	0	1	1	0	0	0	1	0	1
+3V	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	0	1	0	1	0	1	0	1	0	1
-V	0	0	1	1	0	1	0	1	0	1	0	1
-2V	0	0	1	1	0	0	1	1	0	1	0	0
-3V	0	0	1	1	0	0	1	1	0	0	1	1

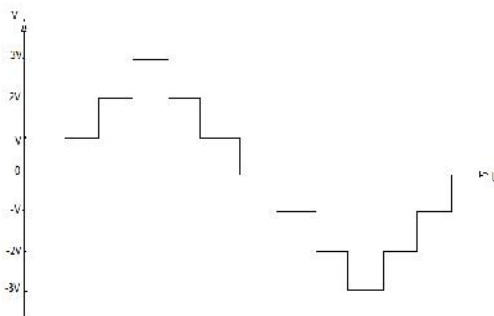


Fig. 2 Output Voltage Waveform of 7-Level Inverter

D. Multilevel inverter for PV application

As shown in Fig.3 all solar panel are connected in parallel to the H-bridge inverter .K is the number of H-bridges and value of k is depends upon the number of levels. As the number of levels increases output waveform contains better sinusoidal waveform and the current waveforms. Complexity and the cost of the system increases when the number of levels increases and switching frequency also reduces as compared to two-level converters.

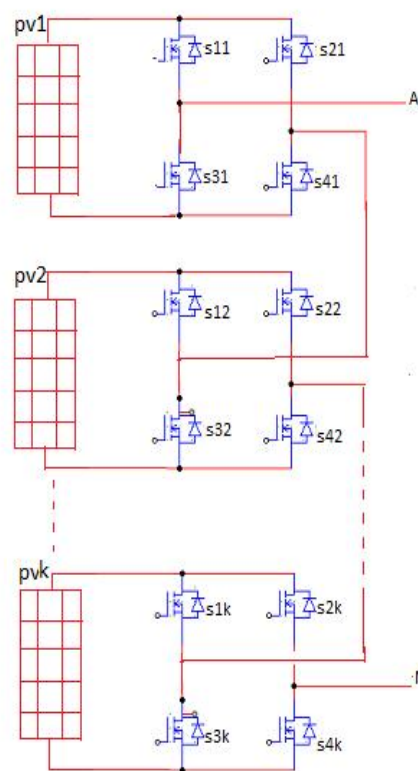


Fig.3 Cascaded n-levels H-bridge inverter

III. OVERVIEW

A. Discription

PIC18F452 this microcontroller unit is the brain of whole system. For design of 7 level multilevel inverter 3 PV panel & 3 H-bridges are required. The microcontroller unit will continuously switch the MOSFET using PWM technique to achieve voltage changes. The output of both the H-bridges will be added together to provide AC output voltage. The microcontroller unit generates PWM signals from 6 channels and sends it to Optocoupler unit with definite timing to generate a sine wave. Optocouplers prevent the high voltage from affecting the system receiving the signal. Optocoupler unit is used for providing voltage isolation between two circuits. The generated

signal is ~ 50 Hz as our total cycle is 20.4 ms ideally it should be $20\text{ ms} = 50\text{ Hz}$. H-bridge can generate both positive as well as negative signals by just changing the combinations of switches. So by utilizing this feature a Cascaded H-bridge Inverter can be developed. Inverter is nothing but conversion of DC energy to AC. We are concerned with AC sine wave energy. And a Sine wave has two parts Positive Half cycle and Negative half cycle. So we can use H-bridge to generate both voltages Positive and negative to generate respective cycles. So to change the combination of switches rapidly we have used microcontroller unit. This generates PWM signals along with changing combinations of switches. And H-bridge is constructed using MOSFETs to rapidly switch signal. Output from the H-bridge is nothing but AC output voltage.

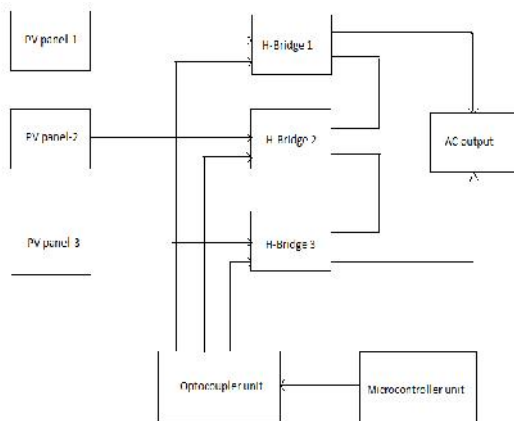


Fig. 4 Block diagram of proposed system

B. Waveform

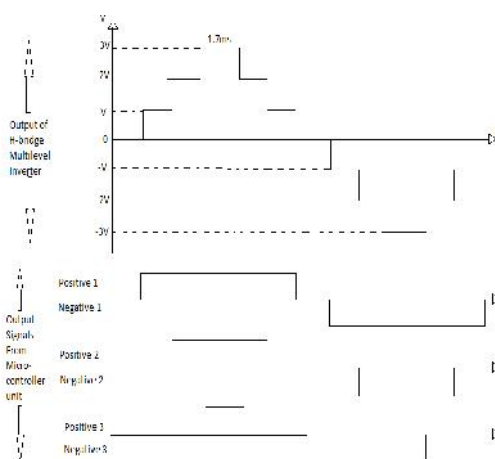


Fig. 5 Waveform of proposed system

C. working

PIC18F452 is used as main MCU which handles all timing and switching of MOSFETs.

PIC has internal timers which can work as timer or counter. So to get a time base for switching of MOSFETs Timer0 is used to generate overflow interrupt on every 0.064ms. A 50 Hz sine wave has a period of 20ms. In which the positive and negative half cycle has 10 ms of time. So MCU by generating timer interrupts switches MOSFETs such that the half cycles be of 10ms each. As this is a 7 level inverter, there will be 3 steps of positive half cycle and 3 steps of negative half cycle and zero level being a level. For it PIC's RD0, RC5, RD3 are used for positive half cycle steps. And RD1, RC4, RD2 are used for negative half cycle steps.

D. Steps involved in switching

Positive Half Cycle:

Firstly all pins are at Logic zero state hence all MOSFETs will be OFF and hence output will be zero. Then only low level positive half cycle is set to start positive half cycle. This will generate output from lowest level H-bridge. And after all initializations first Timer 0 interrupt takes place and fills the counter. It means 1.7 ms has elapsed and it's time to start high level Positive half cycle so second level Positive signal is set by setting appropriate Output pin of MCU. This adds one more step to low level step of positive half cycle. Now Positive half cycle has 2 steps. Again after 3.4 ms the highest level positive step is set and added in Positive half cycle. Now Positive half cycle has 3 steps. Now it's time to decrease levels to complete positive half cycle. So after 6.8 ms the Top most positive step is removed by resetting the appropriate MCU output pin. Now the Positive half cycle has only 2 levels. Again after 8.5 ms the second positive step is removed by resetting appropriate MCU output pin. Now Positive half cycle has only one level which is lowest level. Again after 10.2 ms the lowest positive level is removed by resetting appropriate MCU output pin. Now positive half cycle is completed.

Negative Half cycle:

Now negative half cycle will be started so lowest level negative step will be started. Now again for every Timer 0 interrupt and counter is filled. After 1.7 ms has elapsed and it's time to start high level negative half cycle So second level negative signal is set by setting appropriate Output pin of MCU. This adds one more step to low level step of negative half cycle. Now negative half cycle has 2 steps. Again after 3.4 ms the highest level negative step is set and added in negative half cycle. Now negative half cycle has 3 steps. Now it's time to decrease levels to complete negative half cycle. So after 6.8 ms the Top most negative step is removed by resetting the appropriate MCU output pin. Now the negative half cycle has only 2 levels. Again after 8.5 ms the second negative step is removed by resetting appropriate MCU output pin. Now negative half cycle has only one level which is lowest level. Again after 10.2 ms the lowest negative level is removed by resetting

appropriate MCU output pin. Now negative half cycle is completed. And again Positive half cycle will be started by same steps as mentioned above. This process repeats itself continuously to generate sine wave of 7 Levels: +3V, +2V, +V, 0, -V, -2V and -3V. Maximum Output Voltage when intensity of the light is high will be 55Vac.

E. MPPT

A MPPT means maximum power point tracker is an electronic device which is dc to dc converter they convert a higher dc voltage output from solar panel down to lower voltage needed to charge batteries. Maximum power point tracking is a digital electronic tracking. The charge controller find the output of the panels, and compares to the battery voltage. It then observes the best power that the panel can put out to charge the battery. It takes this and converts it to the best voltage to get maximum Amps in to the battery. Modern MPPT's are around 93-97% efficient in conversion.

IV. EXPERIMENT AND RESULT

A. Hardware Discription

Cascaded Multilevel inverter consists of three H-Bridges. Each H-bridge consists of four MOSFET and each H-bridge is made up with 2 P-channel MOSFET 2 N-channel MOSFET Therefore total 12 MOSFET (6-IRF9520 & 6-IRF540) are used. Here IRF9520 is the P-channel MOSFET & IRF540 is the N-channel MOSFET. In order to generate 7-level voltage waveform 3 PV panel (output 20V, 10W) are required. The pulses are generated by Microcontroller unit i.e. PIC18F452 and given to the inverter switches. 6 Optocoupler 4N25M unit is used for providing voltage isolation between microcontroller unit and inverter unit.

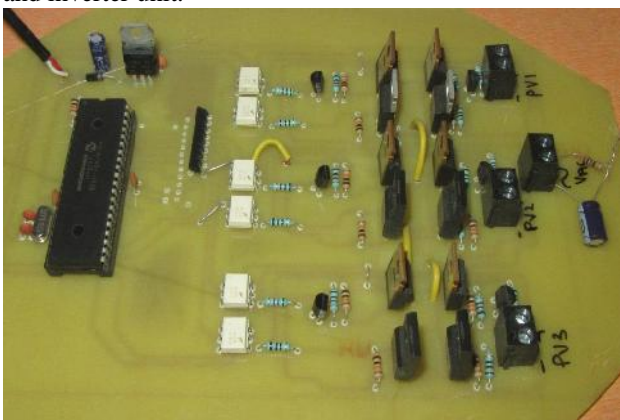


Fig. 6 Hardware setup



Fig. 7 Experimental set up of proposed system

B. Result



Fig. 8 Result of proposed system

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V. CONCLUSION

This paper gives clear idea about the 7-level cascaded multilevel inverter topology for PV cell. The circuit topology and operational principle of the proposed

inverter is analyzed in detail. As the level increases harmonic distortion decreases but complexity and cost of the system increases. Thus hardware is implemented with seven levels. The output voltage waveform of the multilevel inverter is a stepped wave with seven levels +3V, +2V, +V, 0, -V, -2V and -3V. In the proposed MLI there are three H-bridge inverter to achieve the seven level output voltage. Maximum Output Voltage when intensity of the light is high will be 55Vac.

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