Research Paper

# IMPLEMENTATION AND ANALYSIS OF CASCADE H-BRIDGE MULTILEVEL INVERTER USING PV SYSTEM WITH MPPT TECHNIQUES

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## ABSTRACT

This paper highlights implementation and analysis of cascade H-bridge multilevel inverter using PV system with MPPT techniques is proposed. The 11-level output voltage is achieved using the cascaded H-bridge multilevel inverter. To maximize the photovoltaic array output power the maximum power point tracking (MPPT) is used in photovoltaic (PV) system. Switching pattern of PWM technique is modified and its Experimental analysis is carried out with the help of MATLAB/SIMULINK. The total harmonic distortion is much less when compare to existing method. The results for different conditions are taken. Finally a prototype is designed and implemented to verify the feasibility and excellent performance.

## INTRODUCTION

The standard of living of any country will be directly associated with per capita energy consumption. Energy crisis is owing to 2 main reasons; initial owes to lack of energy sources and second owes to lack of economical energy conversion techniques. However of late, as a result of a environmental issues the event and demand for renewable energy has increased [1]-[3]. Renewable energy is that the energy from natural resources likes sun, wind, tides, nuclear and water. The renewable energy is called as eco-friendly and it will replace non-renewable energies like oil and coal. Fuels cells, water, wind, and PV energy area unit all renewable energy sources. Electrical phenomenon has no adverse impact caused by wave, earthquake, discharge etc. it's promising clean renewable energy supply. It reduces the exhaust of electrical energy and realizes the spare use of the natural resources.

Power-electronic inverters have become in style for industrial drives applications. IGBT's area unit used as switches within the most of the device circuits thanks to high switch frequency. Harmonic current generated within the nonlinear load is outstanding issue, as additional power equipment has get wide use in industries. So the harmonic current causes degradation of power devices and faults within the installation. This paper work is especially supported victimization alternative energy as supply for structure electrical converter to provide stepped circular function undulation while not losses.

## I. SYSTEM DESCRIPTIONS

### A. *Multilevel Inverter*

The consideration of multilevel converters has been offered due to the fact 1975, the time period multilevel started with the three-level converter. Subsequently, several multilevel converter topologies had been developed. The idea of a multilevel converter is to obtain bigger power in which a series of power semiconductor switches with a few decrease voltage dc sources are arranged to participate in the vigor conversion [4]-[6]. Capacitors, batteries and renewable power sources can be used as the more than one DC voltage sources. A multilevel converter has a few advantages over a traditional two-stage converter that uses excessive switching frequency Pulse Width Modulation (PWM)

The information source PV is utilized to most extreme force point following from the sun panel board giving highest power give the charging battery sustained at course multilevel inverter. The yield voltage waveform of a multilevel inverter comprises of the amount of stages generally speaking purchased from eleven levels. As the quantity of stages achieve endlessness, the yield entire Harmonic Distortion (THD) frameworks zero.

These different multilevel converter structures were connected in mechanical capacities: fell H-spans converter with partitioned dc sources, diode clamped, and parallel capacitors. It will must be celebrated that the time period multilevel converter is used to allude to a force computerized circuit that may work in an inverter or rectifier mode. Multilevel converters now not least complex can produce the yield voltages with low contortion, however also can control the dv/dt stresses; hence Electro Magnetic Compatibility (EMC) issues can be diminished.

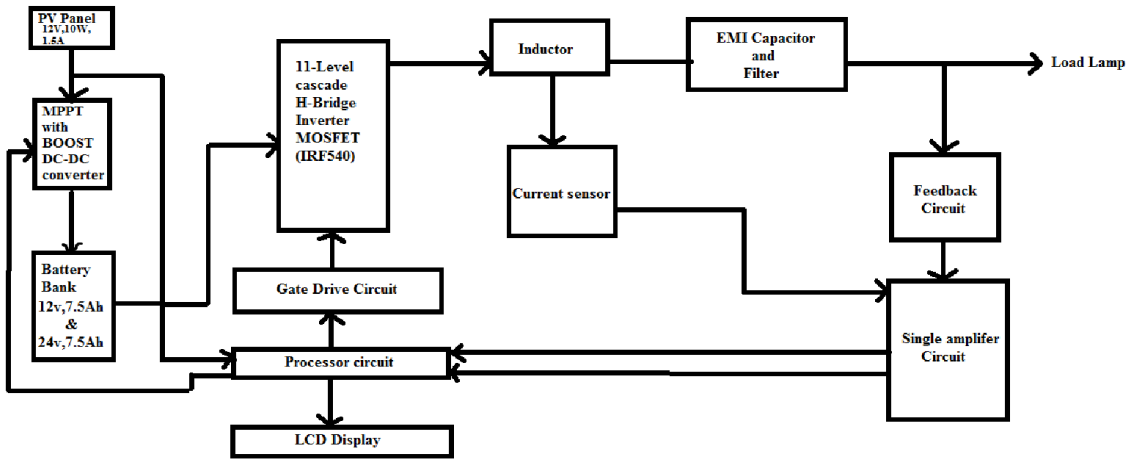


**Fig. 1.Block Diagram**

Multilevel inverters are mixing an extensive number of levels have some portion of advantages, for instance, improved yield waveform, a smaller channel size, lower Electro Magnetic Interference (EMI), and reduced harmonics.[7]-[12] There are various control strategies to decrease sounds in yield voltage waveforms. Ordinarily Pulse Width Modulation (PWM) is by and large used to control yield of static power inverters. The reason behind using PWM is that they give voltage and/or current wave shaping adjusted to the specific needs of the application under thought. In this work, most great essentialness is gotten from the sun based cell which is then given to a multilevel inverter using PWM framework.

*Cascade H-Bridge Multilevel Inverter*

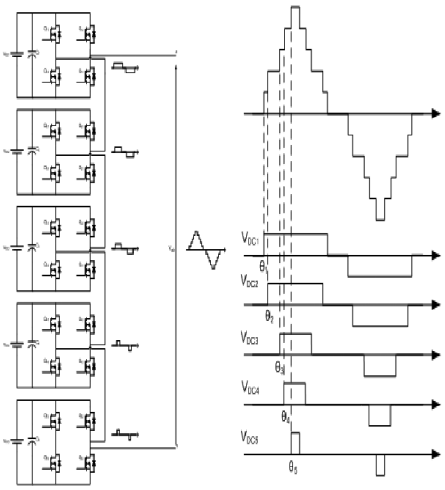

**Fig.2. 11-Level Cascade Multilevel Inverter and Output Voltage Waveform of CML**

A solitary stage structure of a m-level cascade inverter is represented in Fig.2. Every different dc source (SDCS) is associated with a solitary stage full-bridge, or H-span, inverter Each inverter level can produce three distinctive voltage yields, +Vdc , 0, and –Vdc by interfacing the dc source to the AC yield by various blends of the four switches, S1 , S2 , S3 , and S4 .To get +Vdc, switches S1 and S4 are turned on, though –Vdc can be gotten by turning on switches S2 and S3 . By turning on S1 , S2 , S3 , and S4 , the yield voltage is 0. The AC yields of each of the distinctive full-connect inverter levels are associated in arrangement such that the combined voltage waveform is the total of the inverter outputs.[13]-[17] The quantity of yield stage voltage levels m in a course inverter is characterized by m = 2s+1, where s is the quantity of discrete dc sources. In the 11-level cascade multilevel inverter with partitioned DC sources are acquired. The DC sources sustaining the multilevel inverter are thought to be differing in time.

This strategy utilizes hereditary calculations to acquire Switching points disconnected from the net for various DC source values and uses neural systems to decide the exchanging edges that relate to the constant estimations of the DC sources for every stage. The AC output yields the distinctive full-connect inverter levels are associated in arrangement such that the voltage waveform is the whole of the inverter yields [18]-[20] This infers every one of the DC source of this topology can have diverse qualities whenever the yield key voltage will stay steady and the harmonics will in any case meet the details. The exchanging edges are updated at every cycle of the yield central voltage.

The directing points 1.2.3..s can be picked such that the voltage total harmonics distortion is the base. By and large, these edges are picked so that prevalent lower recurrence sounds, fifth, seventh, eleventh, and thirteenth harmonics are disposed of. More detail on harmonics elimination systems will be introduced in the following segment. Three has shown a model multilevel cascade generator associated in parallel with the electrical framework that could supply or draw receptive current from an electrical framework. Cascade inverters are perfect for associating renewable vitality source.

B. *Simulation Model of PV System*

The simplest model of a PV cell is shown in equivalent circuit Fig.3. Below that consists of an ideal current source in parallel with an ideal diode. The current source represents the current generated by photons, and its output is constant under constant temperature and constant incident radiation of light.

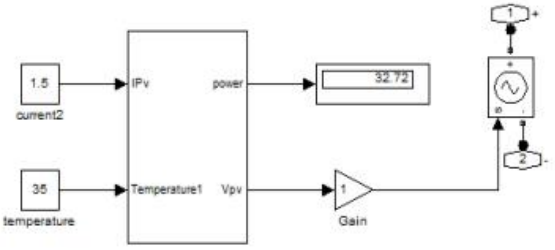


**Fig. 3. Simulation Model Of PV System**

There are two key parameters much of the time used to portray a PV cell shorting together the terminals of the cell, the photon created current will stream out of the cell as a short circuit current(Isc) in this way, Iph=ISC. At the point when there is no association with the PV cell (open circuit) the photon created current is shunted inside by the inherent p-n intersection diode. This gives the open circuit voltage(V) It is seen that the temperature changes influence chiefly the PV yield current.The PV cell yield voltage is a component of the photocurrent that principally controlled by burden current relying upon the solar based light level

**Table.1 Photovoltaic Cell Parameter Values**

| S.No | Type | Control Parameters |
|---|---|---|
| 1 | Constant | Temperature-35°C<br>Current-1.5A |

C. *Output Voltage Waveform of A PV Panel*

The yield of the PV is appeared in Fig.4. The PV yield of 21.8V is obtained by modifying the estimations of temperature. The measure of force delivered by the PV framework relies on upon the measure of PV radiation. The force yield can consequently be enhanced by picking a right framework setup relating to a given burden.

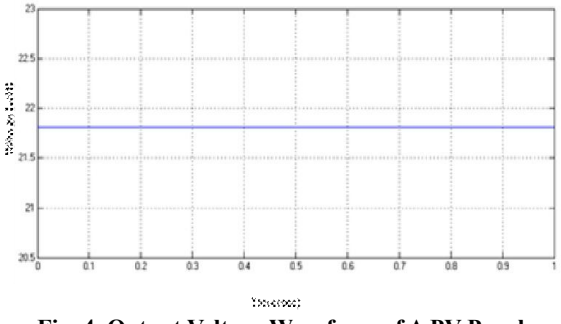

**Fig. 4. Output Voltage Waveform of A PV Panel**

D. *Simulation Model of MPPT DC/DC Converter*

The simulation outline of the MPPT DC/DC

converter is appeared in the Fig.5. If there should arise an occurrence of MPPT calculations are important in PV applications on the grounds that the MPP of a solar based board shifts with the illumination and temperature, so the utilization of MPPT calculation is required keeping in mind the end goal to get the most extreme force from a solar cluster.

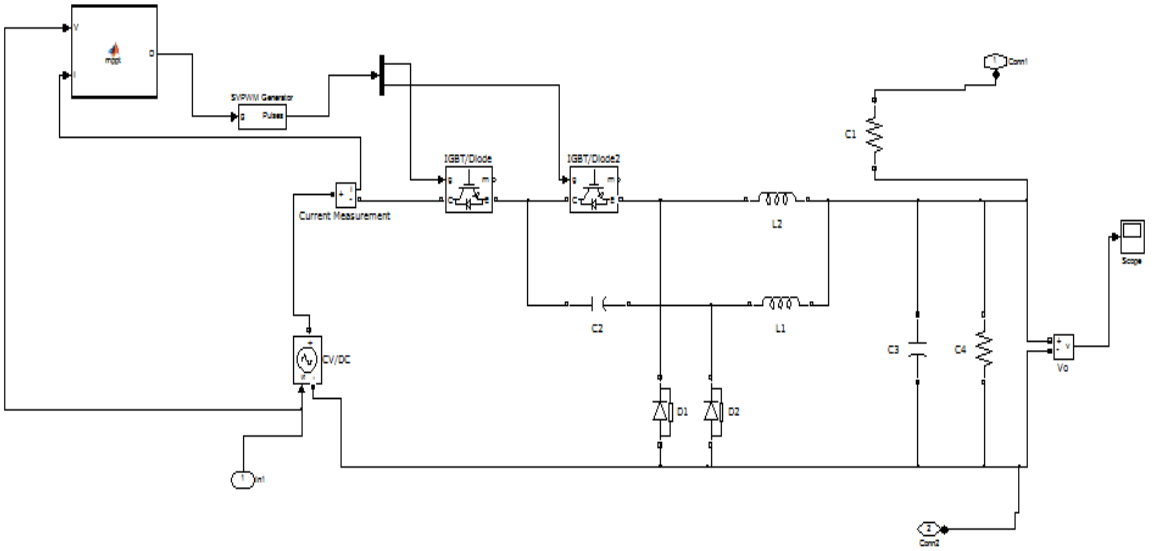


**Fig.5. Simulation Model of MPPT DC/DC Converter**

E. *Output Voltage Waveform of MPPT DC/DC Converter*

The yield of the MPPT DC/DC converter is appeared in Fig.6. MPPT is utilized for solar oriented establishment framework. The yield voltage differs with the info voltage. Furthermore, this MPPT great yield regulation. This MPPT is fit for enhancing the voltage level from 110 V to the required level [9]-[10]

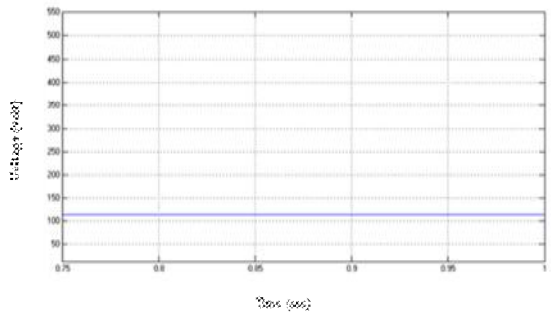

**Fig.6. Output Voltage Waveform of MPPT DC/DC Converter**

F. *Simulation Model of PI Controller with PWM Generator*

The simulation diagram of the PI controller is shown in the Fig.7. The proportional –Integral controller is output signal every sample tim(T), to the control element. PI controller has two tuning parameters to adjust. While this makes them more challenging to tune than a P-only controller they are not as complex as the two parameters PI controller hence is used for pulse width modulation technique.

In control theory, a controller is a device, possibly in the form of a chip, analogue electronics, or computer, which monitors and physically alters the operating conditions of a given dynamical system.

The step response reveals how the controlled variable reacts to a change in the manipulated variable.[8] This is determined by measuring the controlled variable after a step change in the manipulated variable.

$$K_p\Delta + K_1 \int \Delta \, dt$$

where $\Delta$is the error or deviation of actual measured value (***PV***) from the setpoint (***SP***).

$$\Delta = SP - PV$$

A PI controller can be modeled easily in software such as Simulink or Xcos using a "flow

$$C = \frac{G(1+\tau s)}{\tau s}$$

Where ,G = $k_P$ =proportional gain

$\frac{G}{\tau}$ = $k_1$ = integral gain

Setting a value for $G$is often a trade off between decreasing overshoot and increasing settling time. The lack of derivative action may make the system more steady in the steady state in the case of noisy data. This is because derivative action is more sensitive to higher-frequency terms in the inputs.

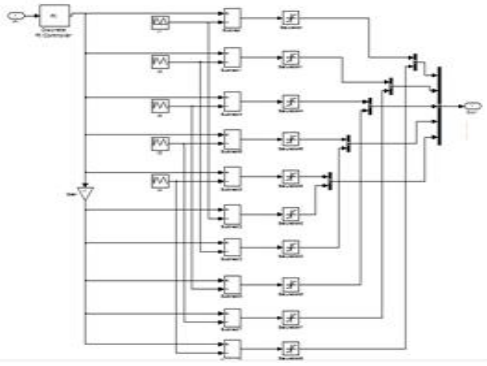

**Fig.7.Simulation Model of PI Controller with PWM Generator**

G. *Simulation Model of 11-Level Cascaded H-Bridge Multilevel Inverter*

The eleven-level inverter has been created by utilizing MATLAB. To work cascade multilevel inverter utilizing a sun powered source. Considering a cascade multilevel inverter with five H-spans and the eleven level ventured yield voltage is acquired.

Reproduction model of eleven level course multilevel inverter adjustment plan are pulse width modulation procedure is obtained. It comprises of PWM generator square has parameters, for example, amplitude, pulse width period and phase delay which are utilized to decide the state of the yield

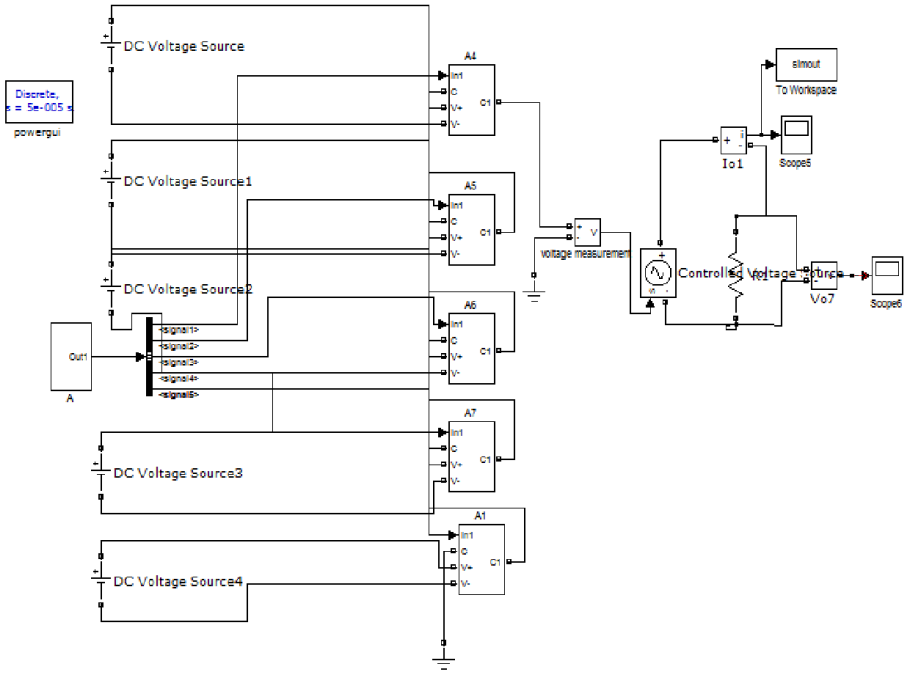


**Fig.8. Simulation Model of 11-Level Cascaded H-Bridge Multilevel Inverter**

H. *Proposed Overall Simulation Diagram*

The proposed model is appeared in Fig.9.The eleven level course H-span multilevel inverter controlled by PV framework has been created by utilizing MATLAB with the utilization of this proposed strategy sinusoidal steeped yield waveform is acquired and the harmonics are decreased. Along these lines the proficiency of the inverter is expanded Fundamental harmonics are additionally essentially diminished. A key segment in this proposed method is the DC to AC eleven level multilevel inverter. The inverter must perform dependably and proficiently to supply an extensive variety of AC loads with the voltage and required power quality essential for solid and effective load and framework execution. The multilevel inverter is intended to permit interconnection MPPT with PV framework.

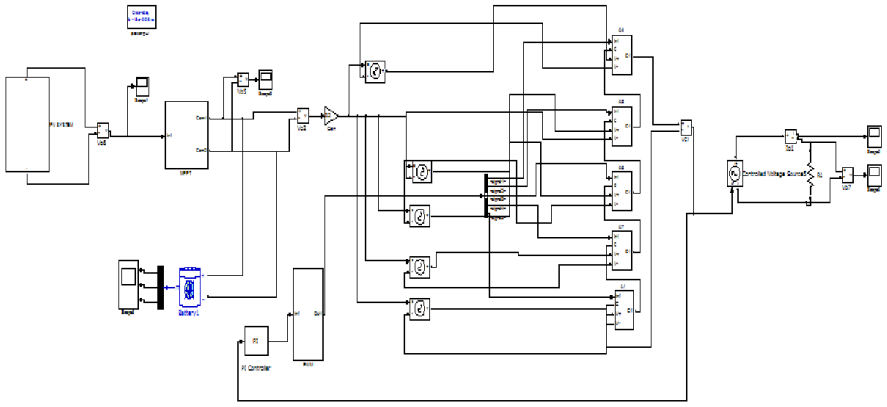

**Fig.9.Overall Simulation Diagram**

**Table 2 Total Parameter Selection**

| Name of the topology | Voltage level on each stage | Number of the output level | Number of switches used |
|---|---|---|---|
| Cascade H-bridge multilevel inverter | S.Vdc | 2S+1=11 | 4S=20 |

I. *Output Waveform of Cascaded H-Bridge Multilevel Inverter*

The yield of course H-span eleven level multilevel inverter is appeared in Fig.10 and 11. The yield voltage and yield current has eleven levels. It can be accomplished by utilizing determination exchanging design strategy. In Figure appeared below waveform is voltage and current Vs time. The yield eleven level multilevel inverter central recurrence is 50 HZ.

The loads associated over the cascade H-span multilevel inverter. Because of the parallel association, voltage stays consistent for all the resistive loads. Be that as it may, current shifts according to the associated load.

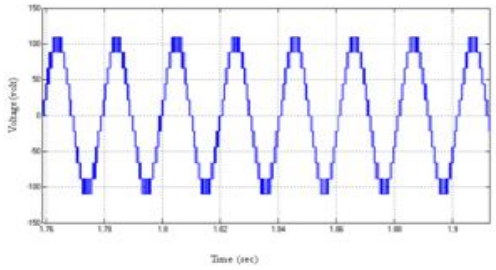

**Fig.10. Output Voltage Waveform of Cascade Multilevel Inverter**

In the Fig.11. The output current of cascaded H-bridge multilevel inverter is (2.3 Amp) for resistive load ($R_{L1}$=10000Ω) at constant 230 voltage.

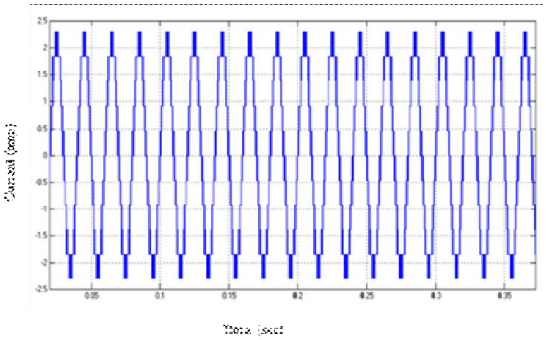

**Fig.11. Output Current Waveform of Cascade Multilevel Inverter for $R_{L1}$ Load**

In the Fig.12. the output current of cascaded H-bridge multilevel inverter is (10.2 Amp) for resistive load ($R_{L2}$=1000Ω) at constant 230 voltage

The detailed function of the various blocks used in the system was understood with this knowledge the same system can be modeled with the help of MATLAB software tool and its respective output waveforms of individual blocks used in the proposed system is discussed in detail. It also includes the THD analysis.

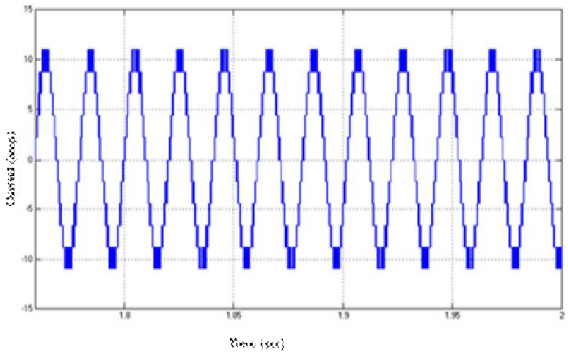

**Fig.12. Output Current Waveform of Cascade Multilevel Inverter for $R_{L2}$ Load**

J. *Result Analysis of simulation circuit*

| SL.NO | OUTPUT PARAMETERS | OUTPUT RANGE |
|---|---|---|
| 1 | Converter O/P Voltage | 110 V |
| 2 | MLI O/P Voltage | 110 V |
| 3 | MLI O/P Current of RL1 (10000Ω) | 2.3 A |
| 4 | MLI O/P Current of RL2 (1000Ω) | 10.2 A |
| 5 | THD of MLI | 17.8% |

K. *Circuit Diagram of Hardware Model*

The circuit diagram of proposed system consists of various circuit units which are mentioned in the block diagram of the system. These circuit units are explained separately in the following sections along with their components specifications.

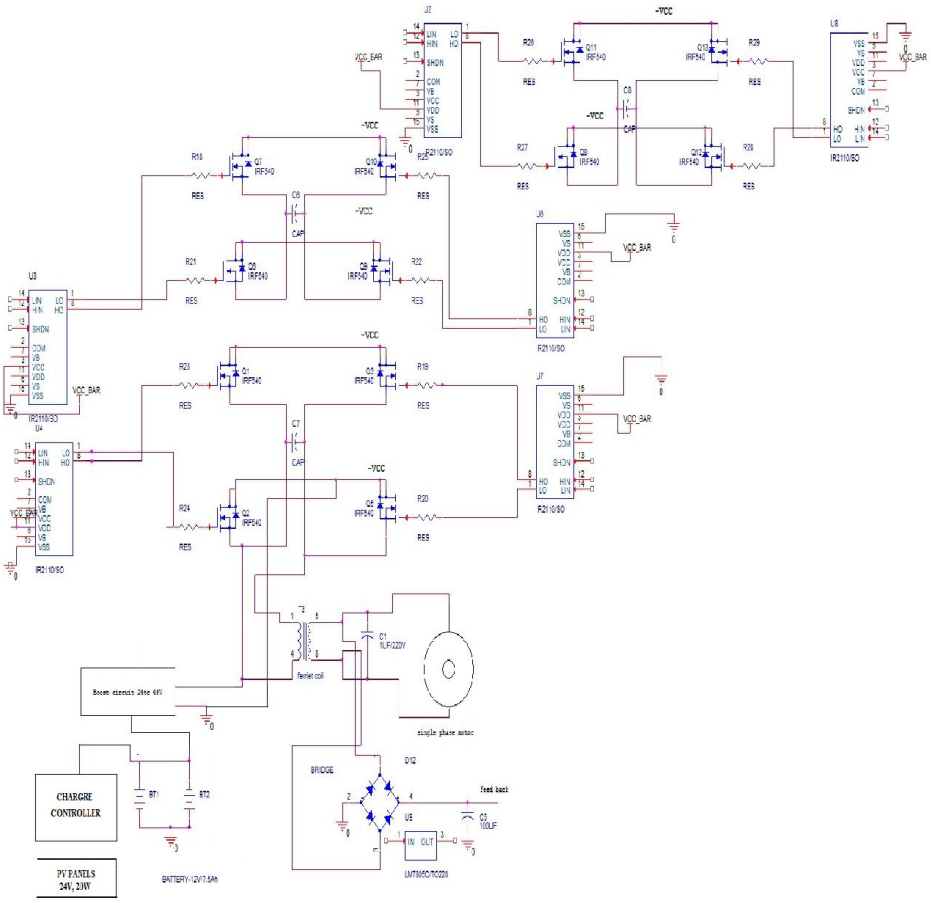


**Fig.13. Overall Circuit Diagram of Hardware Model**

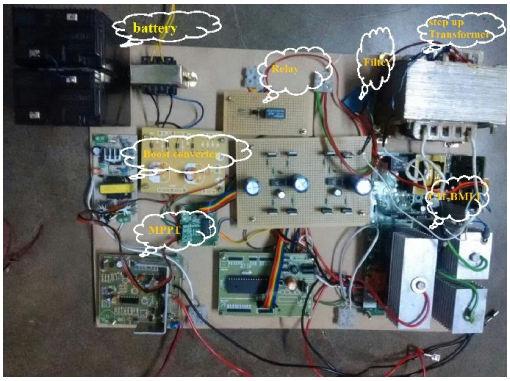


**Fig.13(a) Over View Of Experimental Setup**

L. *AC Stepped Output Voltage Waveform of Proposed Multilevel Inverter*

In CHMLI circuit, when the MOSFET's – IRF640 & IRF3710 are switched at the switching frequency fs of 500Hz with the help of gate driver ISL83202 a stepped output voltage of 48V AC is obtained at the output of FCMLI.

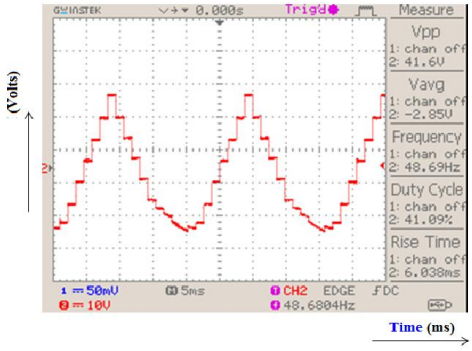


**Fig.14 AC Stepped Output Voltage Waveform of proposed Multilevel Inverter**

The corresponding AC Stepped output voltage waveform of CHMLI is shown in the Figure 14. The AC output voltage waveform of FCMLI is shown by taking X-axis as Time in ms and Y-axis as AC Stepped Output Voltage in Volts. Here the scale taken for X-axis is 1cm = 5ms and the scale taken for the Y-axis is 1cm = 10 Volts.

Since it is a seven level CHMLI, it produces an AC output in stepped manner and number of output levels will be 11. It includes both positive (5 levels), negative (5 levels) and zero (1 level) regions of XY plot.

M. *Load Voltage Waveform of Incandescent Lamp*

Initially for demonstration purpose, a 230V, 60W Incandescent Lamp was connected with the proposed system and the respective load voltage was measured and recorded with the help of DSO. The corresponding load voltage waveform of Incandescent Lamp is shown in the Fig.15.

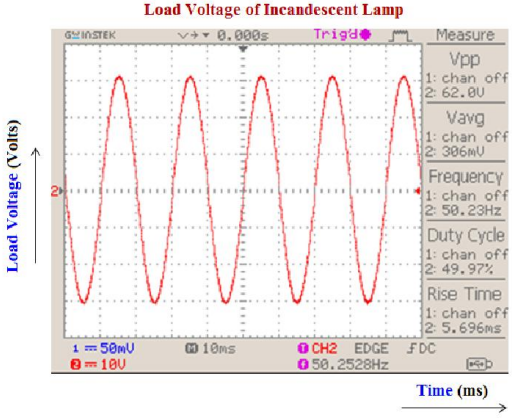


**Fig. 15 Load Voltage Waveform of Incandescent Lamp**

The Load voltage waveform of Incandescent Lamp is shown by taking X-axis as Time in ms and Y-axis as Load Voltage in Volts. Here the scale taken for X-axis is 1cm = 10ms and the scale taken for the Y-axis is 1cm = 10 Volts.

From the waveform, it is clear that the load voltage is sinusoidal in nature with 50Hz as the system frequency. The amplitude of this load voltage depends upon the input of CHMLI and its switching patterns.

N. *Spectrum Analysis of Total Harmonic Distortion*

The Total Harmonic Distortion (THD), of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD is used to characterize the linearity of audio systems and the power quality of electric power systems.

$$\sqrt{\frac{\text{Sum of squares of amplitude of all harmonics}}{\text{Square of amplitude of fundamental}}} \times 100\%$$

THD is the summation of all harmonic components of the voltage or current waveform compared against the fundamental component of the voltage or current wave. The eleven level output voltage 110 V and fundamental frequency is 50 HZ. The Total Harmonics Distortion is much reduced. The cascaded H-bridge multilevel inverter Total Harmonics Distortion is shown in Figure.16. The Total Harmonics Distortion of eleven level multilevel inverter is 17.8%.

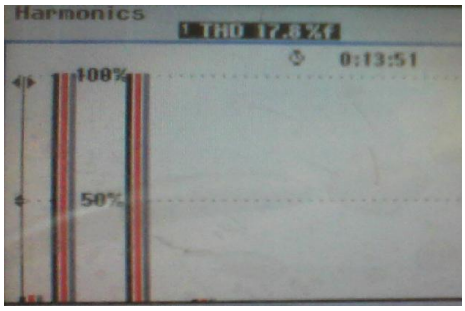


**Fig.16 . Spectrum Analysis of Total Harmonic Distortion**

**Table 3Comparison of Total Harmonic Distortion**

| S.No | Methods | Level of CHMLI | THD% |
|---|---|---|---|
| 1 | Conventional Method | 7-Level CHMLI | 28.37% |
| 2 | Proposed Method | 11-Level CHMLI | 17.8% |

## CONCLUSION

In this paper eleven level cascade multilevel inverter is utilized to get sinusoidal stepped yield waveform furthermore build the effectiveness of the inverter. Multilevel Inverter has favourable circumstances like high power, high voltage limit, low exchanging misfortunes, better effectiveness and low electromagnetic concerns. In the proposed technique low DC voltage is acquired from sun powered board with MPPT and it is put away in a rechargeable battery. Multilevel Inverter has preferences like high power, high voltage limit, low exchanging misfortunes, better proficiency and low electromagnetic concerns. In the proposed strategy low DC voltage is acquired from sunlight based board and it is put away in a rechargeable battery. The put away voltage is given to the multilevel inverter. Since the yield of sun based board is not

generally high it shifts relies on the temperature. To take care of the demand of electrical vitality and to make utilization of renewable vitality, sun based is utilized as a source. The yield is given to the heap. Multilevel inverter is utilized to get ventured waveform furthermore decrease the sounds displayed. Further increment in level will results in decreased harmonics.

Appealing components of the proposed multilevel inverter are compressed as takes after:

- Generation of high quality voltage waves;
- Lower switching activity;
- Low dv/dt stresses forced on switching devices.

The equipment execution of eleven level multilevel inverter with sun oriented source was finished. The estimation of yield voltage, current, recurrence and harmonics are measured utilizing Power Quality Analyzer. The harmonics exhibited in the proposed framework that the yield created won't be simply sinusoidal. This harmonics can be wiped out by expanding the levels of the inverter.

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