

# MODIFIED CASCADED H - BRIDGE MULTILEVEL INVERTER FOR HOUSEHOLD APPLIANCES

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**Abstract** - The inverter is a device which is used for DC to AC conversion. A Multi-Level Inverter (MLI) is one in which a complete cycle of output waveform contains more than three DC levels. Increasing the number of voltage levels in the inverter output can increase the power rating without requiring higher ratings on individual devices. These multilevel inverters require split sources depending on the voltage levels that are meant to be produced. This project is mainly focused on the development of single phase modified cascaded type multilevel inverter for a domestic application using Sinusoidal Pulse Width Modulation (SPWM) technique and elimination of harmonic distortion and its effects.

**Key Words:** Multilevel Inverter (MLI), H Bridge Inverter, Total Harmonics Distortion (THD), Electro Magnetic Interference (EMI) Sinusoidal Pulse Width Modulation (SPWM)

## 1. INTRODUCTION

Electrical power is usually transmitted and used in the form of alternating current. However, some kinds of electrical generation and storage devices produce direct current, examples being PV modules and batteries. An inverter is a power electronic apparatus which converts DC to AC, allowing the DC power from these generators to be used with ordinary AC appliances, and/or mixed with the existing electrical grid. The multilevel inverters have been in the centre of focus of many researchers in recent years. This is partly because of some advantages such as improved output power quality.

The multilevel inverters can generate a near sinusoidal output voltage, the quality of output voltage depends on the number of voltage levels of inverter. The Multilevel inverters are used in flexible power applications because of their high quality output voltage. The basic principle of the multilevel inverters is to divide the operating voltage of the inverter between power electronic switches so that low-voltage switches can be used to process high-voltage outputs. This capability has made the multilevel inverters suitable for high and medium voltage/power applications such as large motor drives, flexible AC transmission systems, VAR compensation and many other applications.

## 1.1 Advantages of Multilevel inverters over two-level inverter

- Devices of lower rating can be used thereby enabling the schemes to be used for high voltage applications.
- Reduced total harmonic distortion (THD).
- Since the  $dv/dt$  is low, the EMI from the system is low.
- Lower switching frequencies can be used and hence reduction in switching losses.
- Input current: The MLI can draw input current with low distortion.
- Switching frequency: MLI can operate at both fundamental switching frequency and high switching frequency PWM.

## 2. CLASSIFICATION OF MLI

### 2.1 Diode Clamped Multilevel Inverter

The main concept of this kind of inverter is to use diodes and it provides the multiple voltage levels through the different phases to the capacitor unit which are connected in series. The diode will transfer the certain amount of voltage alone, thereby reducing the stress on other electrical components. The maximum output voltage is half of the input DC voltage. It's the main drawback of this inverter. This problem can be solved by increasing the switches, diodes and capacitors. The presence of capacitor leads to the voltage balancing problem, because of this reason it's limited up to only three levels. This type of inverters provides the high efficiency because the fundamental frequency used for all the switching devices and it is a simple method of the back to back power transfer systems.

### 2.2 Flying Capacitors Multilevel Inverter

The main element of this inverter uses capacitors. It's having series connection of capacitor clamped switching cells. The capacitors transfer the limited amount of voltage to electrical devices. In this inverter switching states are like in the diode clamped inverter. It doesn't need clamping diodes for this type of MLI. The output is half of the input DC voltage. It is a drawback of the flying capacitors multilevel inverter. It also has the switching redundancy within phase to balance the flying capacitors. It will also control both active and reactive

power flow in the network. But due to the high frequency switching, switching losses will takes place.

### 2.3 Cascaded H-Bridge Multilevel Inverter

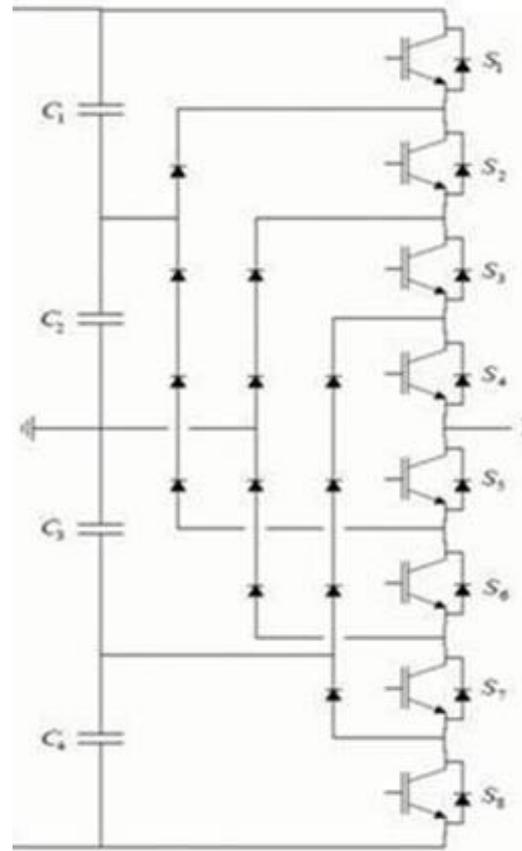
This type of MLI used with capacitors and switches and it requires less number of devices in each level. This topology consists of series of power conversion cells and power can be easily scaled. This arrangement is called H- bridge inverter and gives the separate input DC voltage for each H- bridge. It consists of H-bridge cells and each cell can provide the three different voltages like zero, positive DC and negative DC voltages and it leads to usage of less number of components compared to diode clamped and flying capacitor inverters. It leads to reduce the cost and weight of the inverter are less than those of the two inverters. Soft- switching is possible by the some of the new switching methods.

### 2.4 Modified Cascaded Multilevel inverter

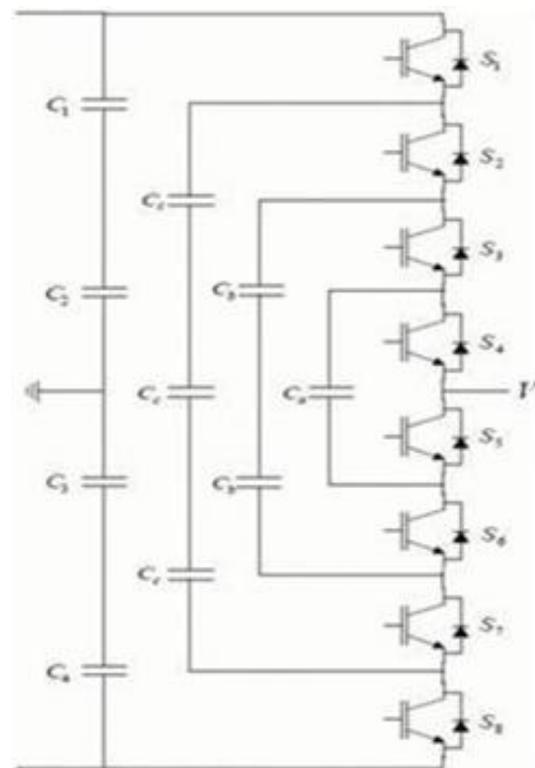
The Modified Cascaded Multilevel inverter consists of 8 Power MOSFET switches and 4 Power Diodes thus by using this inverter the switching losses are reduced because the power semiconductor switches are reduced and the complicity of circuit minimized thus the circuit having 12 power semiconductor switches having more complex network then the modified circuit having only 8 switches. The cost of the inverter is reduced due to switches are reduced and the simulation time reduced due to less number of switches.

**Table -1:** Switching table for modified cascaded multilevel inverter

urations	ON switches	Voltage levels
Positive half cycle	0	0
	S1	+V <sub>dc</sub>
	S1, S2	+2V <sub>dc</sub>
	S1, S2, S3	+3V <sub>dc</sub>
Negative half cycle	0	0
	S1	-V <sub>dc</sub>
	S1, S2	-2V <sub>dc</sub>
	S1, S2, S3	-3V <sub>dc</sub>
	S1, S2, S3, S4	-4V <sub>dc</sub>



**Fig-2:** Diode Clamped Multilevel Inverter (9 level)



**Fig3:** Flying Capacitors Multilevel Inverter (9 Level)

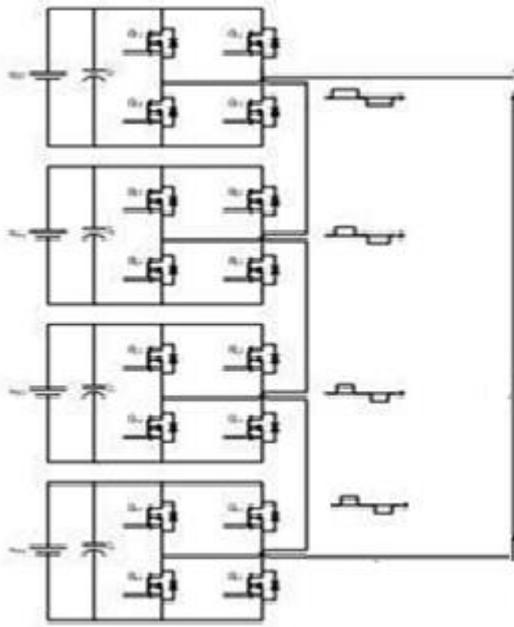


Fig-4: Cascaded H Bridge MLI (9 Level)

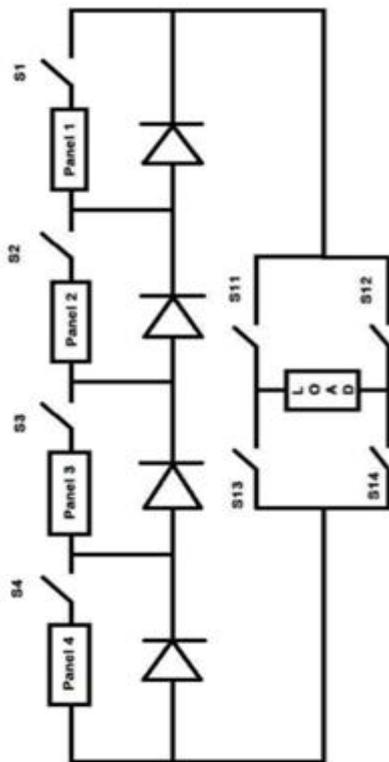


Fig-5: Modified cascaded H – Bridge MLI (9level)

### 3. PULSE WIDTH MODULATION (PWM) TECHNIQUE

The advantage of PWM technique is that power loss in the switching devices is very low. The PWM techniques are used to control output voltage and lower order harmonics are eliminated. The higher order harmonics are easily filtered using LC filters, designing for this filter is very easy and less

cost. The PWM techniques are having three types by using the above techniques we can generate the pulses

1. Single pulse width modulation technique
2. Multiple pulse width modulation technique
3. Sinusoidal pulse width modulation technique

In the above three types of PWM techniques we are going to use sinusoidal PWM technique [3].

#### 3.1 Sinusoidal pulse width modulation

The most advanced PWM technique is Carrier Based PWM (B-PWM) or also called Sinusoidal Pulse Width Modulation (SPWM). This method based on comparison of commanded voltage signal with the High frequency triangular signal as carrier. Result of this operation is rectangular signal. Width of the rectangle is proportional to average value of the commanded signal. Output signal of this operation can be directly delivered to the semiconductor's driver circuit.

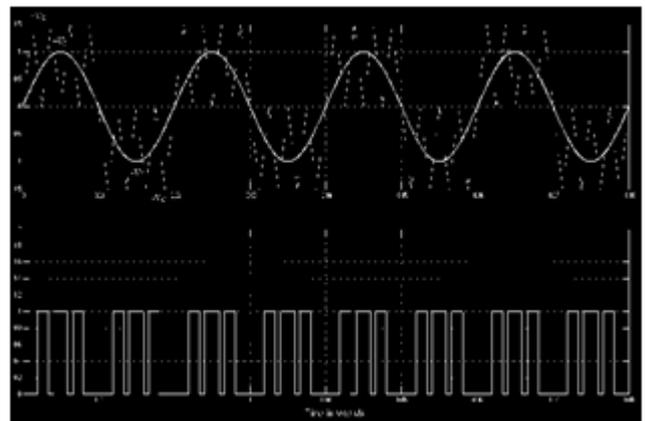


Fig-8: Waveform of SPWM technique

Where,

$V_c$ - is the sum of number of carrier amplitudes.

$V_r$ - is reference signal voltage.

$V_o$ - is output voltage

### 4. SIMULATION AND RESULT

In this paper MATLAB/SIMULINK is used for simulation before hardware implementation. In SIMULINK the nine level inverter circuit is simulated and results of output voltage and THD are shown in figure 9 to 11.

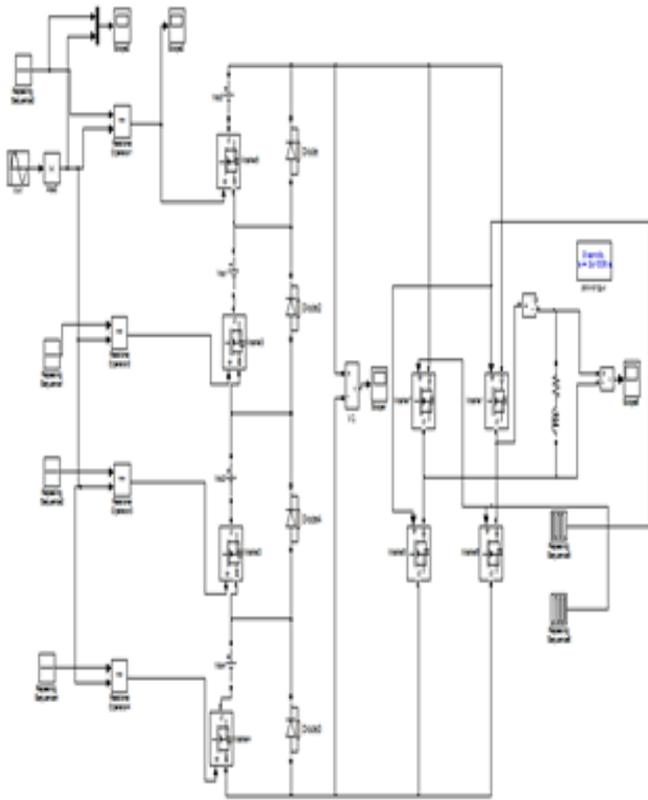


Fig-9: Nine level Inverter Simulink model

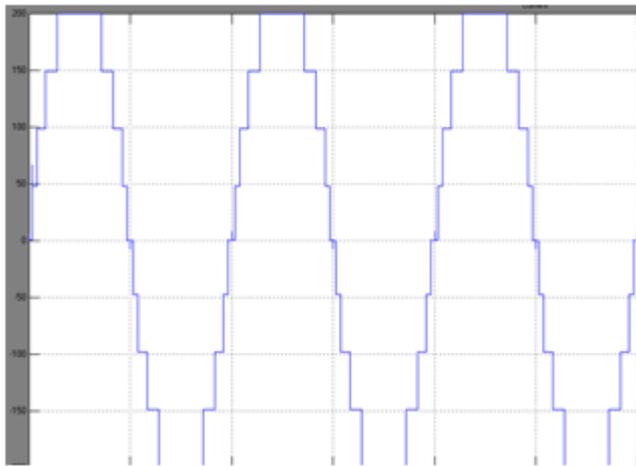


Fig-10: Simulink Output waveform of nine level Inverter

In simulation, the Total harmonic Distortion (THD) is reduced to 9.12 and it is shown by FFT (Fast Fourier Transform) analysis in MATLAB Simulink.

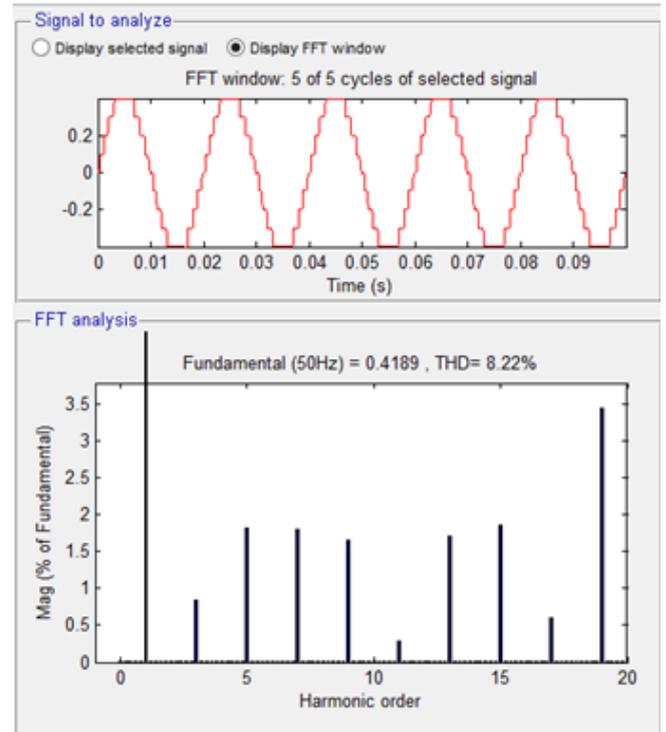


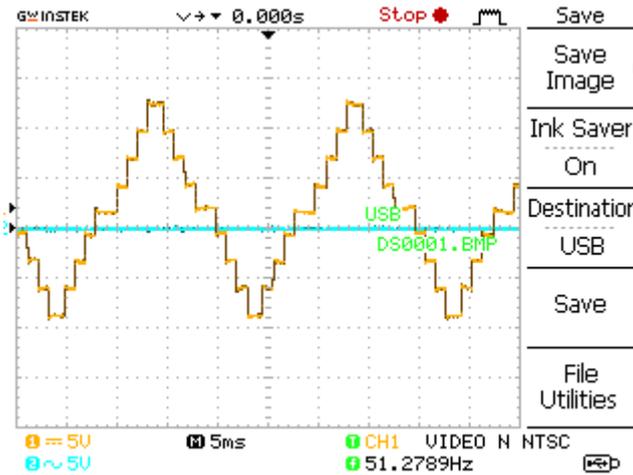
Fig-11: Total Harmonic Distortion Evaluation Using FFT analysis THD is 8.22%

### 5. HARDWARE IMPLEMENTATION

The hardware is implemented for nine level inverter, using IRF840 – MOSFET which has high voltage and current carrying capability. Gate Driver circuits are used for boosting the pulses which we get from a microcontroller. AT89C52 is used for generating required pulses. The hardware Setup for MSPWM based nine Level Inverter is shown in fig.12. And the output waveform for MSPWM based nine Level Inverter is shown in fig.13.



Fig-12: Hardware Setup for SPWM based nine Level Inverter



**Fig-13:** Output waveform for SPWM based nine Level Inverter from DSO



**Fig-14:** Photo of the load arrangement (Load voltage =53.9 V)

## 6. CONCLUSION

This paper dealt with the classification of a multilevel inverter and focused on Modified cascaded H-bridge nine level inverter. The main advantage of this method is the reduced switches for the inverter circuit. Sinusoidal PWM technique (SPWM) used for producing low total harmonic distortion without the usage of the filter. The Modified multilevel inverter reduces the switching losses and improves output capability. It can be observed that modified cascaded H bridge inverter topology produces better fundamental output voltage and minimized total harmonic distortion. Thus by increasing the number of levels, the harmonics reduced further.

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