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Simulation and Prototype Design of Novel Control Scheme for Multi-Level Inverter

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***Abstract* — In power applications where high power and power quality is main requirement, Multilevel inverters are used as a power conversion system. The important features of Multilevel inverters are the minimal THD, smaller switch ratings, greater DC link voltages and weakens electromagnetic interference. The development of the multilevel inverter having transformer less topology which opens up the various schemes of PWM to control active devices switching in every multiple levels of voltages in the inverter. For industrial applications, multilevel converter structures are classified into three different structures such as, cascaded H bridge converter with individual dc sources, diode clamped inverter, flying capacitor inverter.**

In this paper, a comparison between a simulation model and their results with the hardware implementation of the Multi-Level Inverter with Control Method having Predictive Model Control to maximize the Multi-Level Inverter and gives waveform in the form of Sinusoidal AC Waveform.

***Index Terms* — PWM, Power conversion, Multi-Level Inverter, THD, Predictive Model Control, Sinusoidal AC waveform.**

I. INTRODUCTION

IN high voltage and power applications, broadly used inverters are MLI [1]. It discussed the importance and features in detail along with the application due to the minimal THD, smaller switch ratings, greater DC link voltages and weakens electromagnetic interference and it has some disadvantages which limits the performance such as more components, difficult PWM control technique and problem in voltage balancing.

In power applications where high power and power quality is main requirement, Multilevel inverters are used as a power conversion system. The simulation environment is discussed for CHB-MLI topology having minimum amount of switches with various control and SPWM schemes. A comparison is presented in terms of THD and power devices utilization. After comparison, it is analyzed that smaller THD is present in SPWM-PD scheme having magnitude with variable carrier **[2].**

[**3]** represents a novel scheme in frequency operation with variable frequency as a control scheme for buck-boost DC to AC converter. For applications of variable frequency. A delta modulator with dual slope is proposed to minimize the harmonic distortion in the output voltage which is called a voltage-controlled modulator. The regardless of the frequency, an almost sinusoidal voltage having constant magnitude is generated from this suggested scheme. The suggested scheme gives THD within 4% which is under Voltage Harmonic Limits IEEE Std 519.

[4] presents the technique which the combination of two techniques, PWM control technique and hybrid control and nearest level control technique. The renewable energy generation systems which are connected with grid and industrial drives are areas where MLIs are very common. In **[5]** Karnaugh-Veitch maps technique is discussed to achieve the controlling technique for the three-level neutral point clamped and flying capacitor inverters. The logical functions strategy is utilized to control the individual switch of the inverter.to analyze the output voltage of the inverter. The Karnaugh-Veitch maps technique is used to reduce the logical functions. Due to the developing of control algorithm for the switches of inverter, Voltages across the capacitors are balanced.

II. SYSTEM MODEL

The figure 1. Shows the CHB circuit for five level inverter.

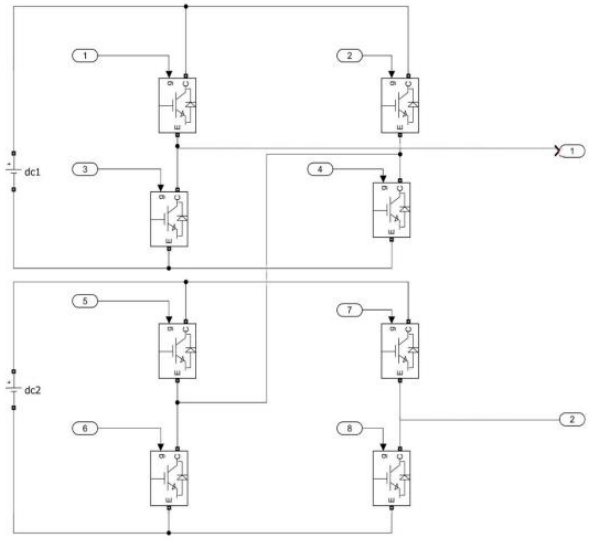

Figure. 1. CHB circuit for Five Level inverter

III. Simulation Model

The circuit diagram of physical model of CHB MPC Model is shown in figure. 2.

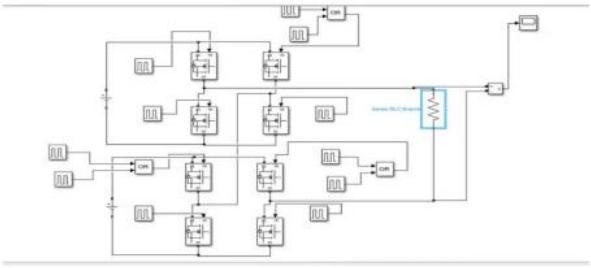

Figure 2. Circuit diagram for Physical Model of CHB MPC Model

The circuit diagram is explained in Figure. 3.

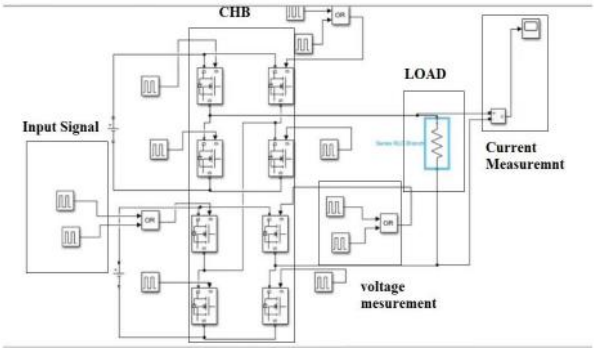

Figure 3. Labeled diagram for the Physical Model

As we can see from the above circuit, it consists of 8 Input Signals for each of the MOSFET Semi-conductor circuits to their Gates to turn them on and off for the running of the operation of Multi-level Inverter. The main CHB circuit and the load to be applied.

The switching states for the semi-conductor switches are given as in Table 1

	0	V	2V	V	0	-v	-2V	-V
S1	1	1	1	1	1	0	0	0
S2	1	0	0	0	1	1	1	1
S3	0	0	0	0	0	1	1	1
S4	0	1	1	1	0	0	0	0
S5	1	1	1	1	1	1	0	1
S6	1	1	1	1	1	1	1	1
S7	0	0	0	0	0	0	1	0
S8	0	0	0	0	0	0	0	0

Table1. Switching States.

From the above table we can see the at which voltage levels which of the Semi-Conductor switches are active.

IV. Hardware Implementation

The physical model consists of the An Arduino, 2 H-bridge cells of MOSFETS, also external battery is connected for the load as shown in Figure. 4.

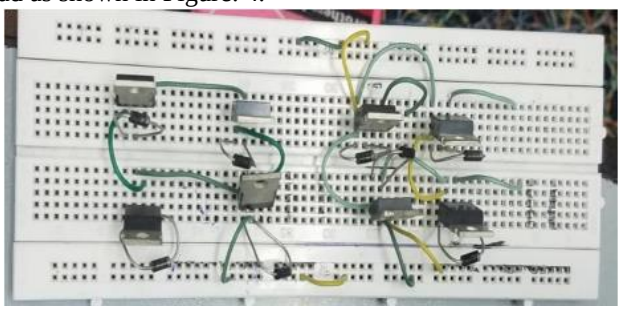

Figure 4. Hardware Model 5 Level Cascaded H-Bridge Multilevel inverter

The logic applied to the Prototype is based on Figure 5.

Switch	Delay	Pulse Width	OR Operation
S1	(0.02/8)*0	(5/8)*100	No
S2	(0.02/8)*0	(1/8)*100	Yes
S3	(0.02/8)*5	(3/8)*100	No
S4	(0.02/8)*1	(3/8)*100	No
S5	(0.02/8)*0	(6/8)*100	Yes
S6	(0.02/8)*0	(2/8)*100	Yes
S7	(0.02/8)*6	(1/8)*100	No
S8	(0.02/8)*2	(1/8)*100	No

Table2. Logic of the Prototype.

From the above table we can see the time at which gate signal is applied to the switches and for how long. For Example: Switch 1 (S1) is given Gate Signal instantly and remains turned on for 5 Cycles.

At No Load:

The figure. 5 shows the hardware model consists of 2 Arduinos.

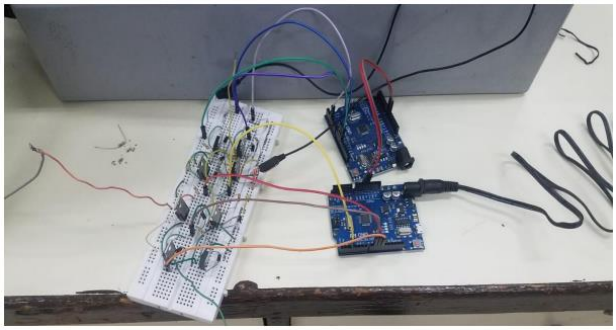

Figure 5. No Load Hardware Model

At Load:

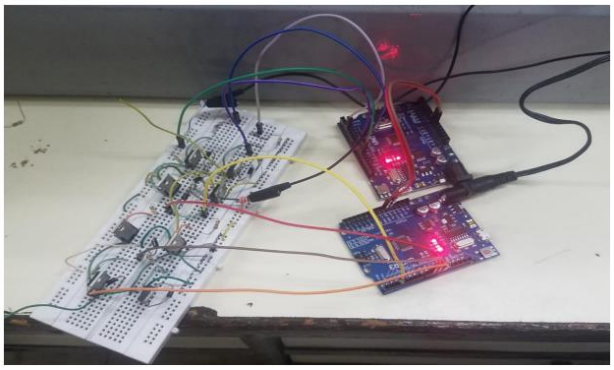

Figure 6. At Load Hardware Model

V. RESULTS

The results are obtained through simulation using MATLAB/Simulink environment and hardware circuit implementation. The Simulations of Cascaded Multilevel inverter were carried by using model predictive control in MATLAB Simulink. Resistive load is also connected at the output of inverter which consists of 1000ohm. Two Bridges or cells were considered for the observation connected to VDC 12V for each cell. The output of inverter is recorded through the performance of the circuit and evaluated with the voltage and current waveforms. Figure. 7 shows the output of the voltage that we get from the H-bridge output. As the inverter consists of 5 levels of the voltage therefore the waveform consists of five discrete magnitudes of the voltage. The resultant voltages then is passed through the RL filter known as low pass filter to the load consumption

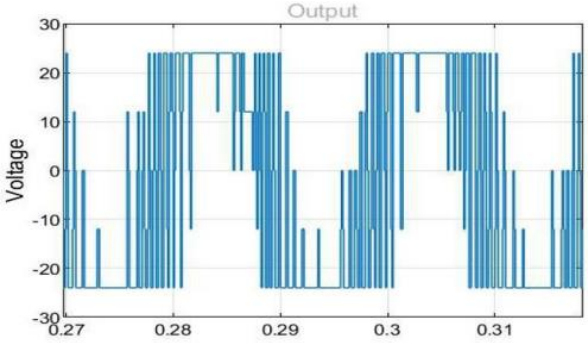

Figure 7. Inverter output voltage V

Inverter voltage is then passed through the filter to rectify the waveform when the voltage is rectified and free from noise then this voltage is then supplied to load. The given figure .8 shows the voltage at the end of the filter that will be supplied to load connected at the end of the circuit.

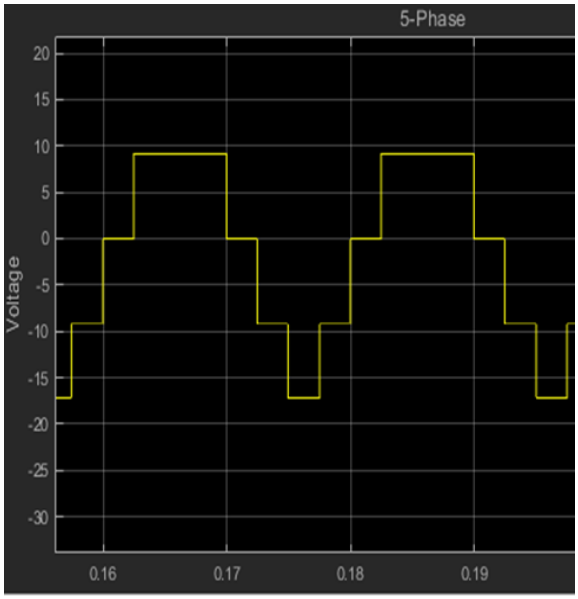

Figure 8. Load waveform

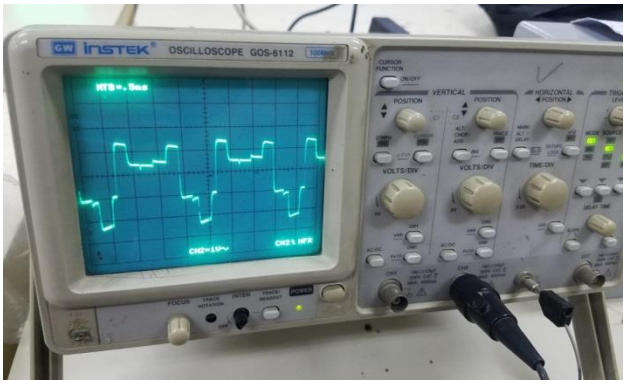

Figure 10. Hardware circuit output

As we can see from the above figure, the result is given on the oscilloscope which is similar to the simulation waveform. Switches are turned on by supplying them with gate signals at a fixed interval and for a fixed time based on the logic given in Table 2 to give output which is similar to the output gained in the simulation.

VI. FUTURE WORKS

Future work could be done based on the following topics:

- A Control Method could be developed for Current Constant Inverter as the one used for the Research Paper was a Voltage Constant Inverter.
- Fault Analysis and Solving could be incorporated into the model.
- More study could be done on the Control Scheme to program a Control Scheme which is able to handle Transient better.
- Try to use the Control Logic on Motor Drives.

VII. CONCLUSION

In this Research paper, A Control Scheme was developed for the 5-Level Cascaded Multi-Level Inverter which would reduce Total Harmonic Distortion, increase efficiency and allow for reduction of error in the operation of 5-Level CHB. The logic along with the 5-Level CHB was simulated first on MATLAB / SIMULINK and was found to be working satisfactorily in the simulation. A prototype was created based on the findings of the simulation. Based on the results of the prototype, it was found to be acceptably similar to the simulation thus justifying the simulation.

VIII. AUTHOR CONTRIBUTIONS

Azan Shah put forth innovative points and helped in writing the paper, Ghani Zaur , Zain ul Abdin did the experiments.

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