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PWM Techniques for driving cascade multilevel inverter

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ABSTRACT: In terms of electricity generation, electricity conversion and storage demanding more developed method in low and medium level applications. The stored electricity or generated through conventional methods like solar, need to be inverted in to alternating form to drive devices available in daily usage or for specific purposes. The inverters are build using various technique and methods with advance algorithm to enhance the efficiency and usage. The inverters design includes multilevel inverter and having various another methods as its subtypes, in this paper we shown the results of cascade multilevel inverter which is single phase and can be utilized for low and medium power requirement. The MOSFETs are used to form two H-bridge which interns maintain or form levels and convert into alternating form. The driving of MOSFETs are done using microcontroller which will generate pulse width modulation(PWM). The sequences of switching action are prepared using observation by slowing the PWM signals. The system designed gives 5 levels output and achieved the task of inversion with good efficiency.

KEYWORDS: Actuator, Cascade, Conventional, Efficiency, Electricity conversion, Inverters, Microcontroller, MOSFET, Multilevel, Pulse width modulation.

I. INTRODUCTION

The renewable energy sources are enhancing the system with greater precision and fewer power losses. Solar cells are a distributed energy source that may be mounted on any consumer location, such as the roof of a house. These photovoltaic cells convey the electricity using a converter to convert the dc voltage of the cells to ac voltage [1-3]. The power and harmonics of the two-level inverter are both high. A multi-level inverter is a power electronics circuit that can provide a desired alternating supply voltage at the output with variable voltage and frequency from a single dc voltage or multiple lower level dc voltages as input, and it has been suggested as the best choice in several medium and high voltage applications [1]. Multilevel inverters have gained popularity in recent years.

A traditional inverter can operate at two voltage levels. Multilevel inverters have several voltage or current sources and can switch their outputs between voltage or current levels. A multilayer inverter can be built in a variety of topologies [6-11], each with its own set of benefits and drawbacks. To construct the inverter, the simplest way is to connect regular inverters in parallel or series. More complex structures involve, inserting inverter within inverter to form a multi-level inverter. A multilayer inverter's primary function is to generate a desired ac voltage level from dc voltage sources. This dc voltage source could be equal to or different from one another. The ac voltage that this dc voltage generates looks to be sinusoidal. One disadvantage of deploying a multi-layer inverter is that it approximates sinusoidal waveforms, which is problematic because of harmonics.

Sharp transitions can be found in the staircase waveform produced by a multilayer inverter. By converting power in small voltage steps and resulting in lesser harmonics, the multilayer inverter improves ac power quality. As a result, multilevel inverter research has gotten a lot of attention in recent years. Various classifications of multilevel inverters with diverse topologies, such as diode clamped, flying capacitor, cascaded H-bridge, hybrid H-bridge, and novel hybrid H-bridge multilevel inverters, have been created based on a significant number of research works [7-23]. The Electrical Engineer has been particularly interested in the cascaded H-bridge multilevel inverter among these topologies. The cascaded H-bridge multilevel inverter is a serially connected H-bridge with a separate dc supply. The voltage on each dc source in this setup is the same [1,2]. The multilayer inverter, on the other hand, has disadvantages such as difficulty boosting voltage levels in power switching devices, switching losses, circuit complexity, and economic considerations.

In addition, as the number of switching devices grows, the power converter's overall reliability and efficiency suffer. The major goal of this research is to build and execute a multilayer inverter with four H-bridge units in order to reduce the number of switching devices while maintaining low overall energy loss and total harmonic distortion.

II. TYPES OF MULTILEVEL INVERTERS

- Diode clamped multilevel inverter
- Flying capacitor multilevel inverter
- Cascaded H-bridge multilevel inverter

Diode Clamped Multilevel Inverter

The main concept of this inverter is to use diodes and provides the multiple voltage levels through the different phases to the capacitor banks which are in series. A diode transfers a limited amount of voltage, thereby reducing the stress on other electrical devices. The maximum output voltage is half of the input DC voltage. It is the main drawback of the diode clamped multilevel inverter. This problem can be solved by increasing the switches, diodes, capacitors. Due to the capacitor balancing issues, these are limited to the three levels. This type of inverters provides the high efficiency be-cause the fundamental frequency used for all the switching devices and it is a simple method of the back to back power transfer systems.

Flying capacitor Multilevel Inverter

The main concept of this inverter is to use capacitors. It is of 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. Clamping diodes are not required in this type of multilevel inverters. The output is half of the input DC voltage. It is drawback of the flying capacitors multi-level inverter. An electric battery is a device consisting of one or more electrochemical that converts stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode and a negative terminal, or anode. Electrolyte flow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

Cascaded H-Bridge Multilevel Inverter

The cascaded H-bride multilevel inverter is to use capacitors and switches and requires less number of components in each level. This topology consists of series of power conversion cells and power can be easily scaled. The combination of capacitors and switches pair is called an H-bridge 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. One of the advantages of this type of multi-level inverter is that it needs less number of components com-pared with diode clamped and flying capacitor inverters. The price 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. Multilevel cascade inverters are used to eliminate the bulky transformer required in case of conventional multi-phase inverters, clamping diodes required in case of diode clamped inverters and flying capacitors required in case of flying capacitor inverters. But these require large number of isolated voltages to supply each cell.

III. PRAPOSED TECHNOLOGY

The N-level cascaded H-bridge, multilevel inverter comprises (N-1)/2 series connected single phase H-bridges per phase, for which each H-bridge has its own isolated dc source.

Three output voltages are possible, ±Vs, and zero, giving a total number of states of 3(N−1)/2, where N is odd. Figure 1 shows one phase of a 5-level cascaded H-bridge inverter. Its main limitation lies in its need for isolated power sources for each level and for each phase, although for VA compensation, capacitors replace the dc supplies, and the necessary capacitor energy is only to replace losses due to inverter losses. Its modular structure of identical H-bridges is a positive feature.

- The number of levels in the line-to-line voltage waveform will be k = 2N −1.
- While the number of levels in the line to load neutral of a star (wye) load will be p = 2k −1.
- The number of capacitors or isolated supplies required per phase is Ncap = (N −1)/2.
- The number of possible switch states is nstates= Nphases.
- The number of switches in each leg is Sn= 2(N −1).

Due to the advantages, the cascaded inverter bridge has been widely applied to such applications as HVDC, SVC, stabilizer, high power motor drive and so on. This topology of inverter is suitable for high voltage and high power inversion because to itsability to synthesize waveforms with better harmonic spectrum and low switching frequency.

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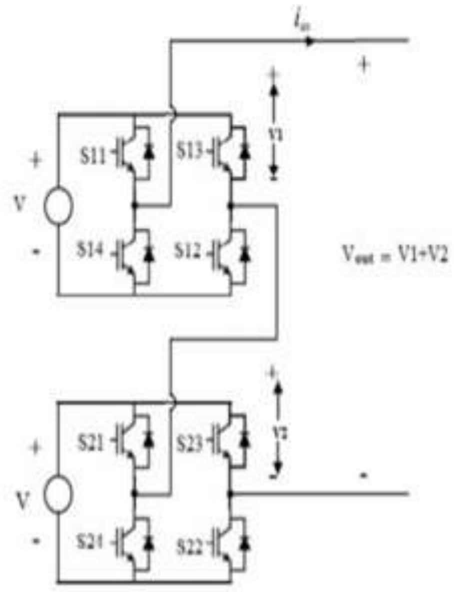

Fig.1 Single Phase Cascaded H-Bridge 5 level MLI

Advantages:

- The number of possible output voltage levels is more than twice the number of dc sources (m = 2s + 1).
- The series of H-bridges makes for modularized layout and packaging. This will enable the manufacturing process to be done more quickly and cheaply.

The 5 level inverter consists of two H-bridges shown in Fig.1, which are fed by Separate DC sources. There are four switches namely and S1, S2, S3, S4 in the first H-Bridge and there are four more switches namely S5, S6, S7, S8 in the second H-bridge. The load is associated between the terminals A and B.

Principle of operation: Let us consider names of the switchesof each bridge as S11, S12, S13, and S14 for first bridge, S21, S22,S23, S24 for second bridge switches. Consider the three voltagesources are equal as V1=V2=V.

TABLE 1

s1	S2	S3	S4	S1	S2	S3	S4	OUTPUT
1	0	0	1	0	0	0	0	V
1	0	0	1	1	0	0	1	2V
0	0	0	0	1	0	0	1	V
0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	N-V
0	1	1	0	0	1	1	0	N-2V
0	0	0	0	0	1	1	0	N-V
0	0	0	0	0	0	0	0	0

Switching statesof a 5 level inverter

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IV. IMPLEMENTATION STAGE

Hardware implementation

The figure represents the system we developed for multilevel cascaded inverter. The microcontroller is used to control the PWM. The controlled sequential signal then transferred to MOSFET connected in H-Bridge format. The isolation will be provided by using opto-isolater which in terms isolate the microcontroller from high current drain in to it. The H-Bridge will convert this PWM sequences into levels of volt-ages to form a sinusoidal waveform. This waveform will be having same parameters as pure sine wave but instead of linear it will be in staircase type waveform.

Software implementation

The table one shows the sequential sequences need to be applied. the microcontroller provides sequences with respect to logic and the switching frequency which is nothing but the driving signals for MOSFET. The figure with having flowchart for the program execution.

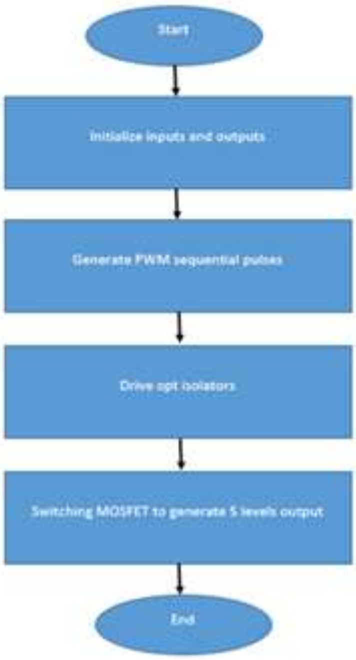

Fig.2 Single Phase Cascaded H-Bridge 5 level MLI flowchart

V. RESULTS

The five level cascade multilevel inverter is implemented and the results are up to mark and hence using few more technique the output of system can also use as commercial product for low and medium application for inverter. The figure below represents the output waveforms reaching to approximation of sinusoidal waveform of supply.

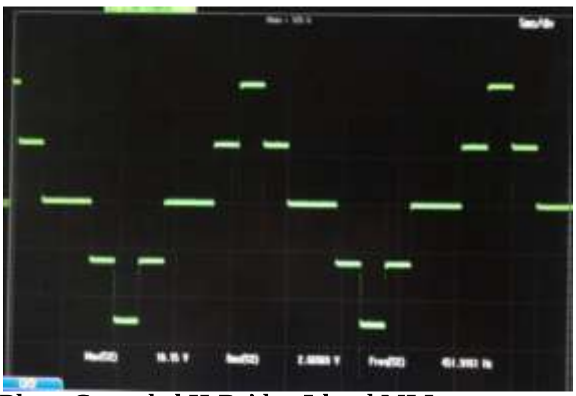

Fig.3 Single Phase Cascaded H-Bridge 5 level MLI output wave-form

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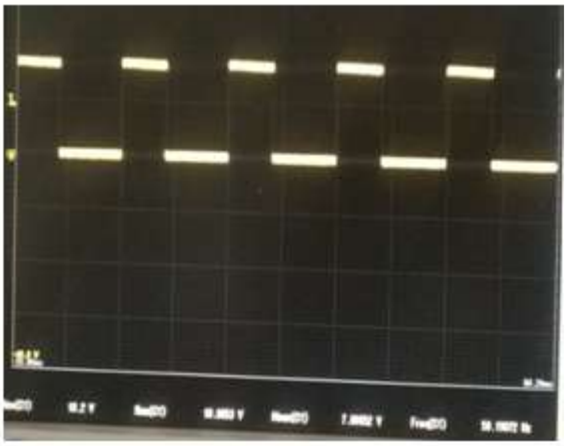

Fig.4 Single Phase Cascaded H-Bridge 5 level MLI PWM

VI. CONCLUSION

In this paper, experimental implementation of 5 level inverter with single phase resistive load has been proposed and the hardware prototype of 5 level inverter with resistive load using microcontroller ARDUINO UNO is implemented. Future work will be towards the implementation of 7, 9 and 11 level inverters. As the levels of output increases, nearly sinusoidal waveform will be obtained, this results in reduced THD. So the benefits of mutilevel inverter include, lower transient power loss due to low frequency switching, less THD, reduced ac filters, and possibility to replace MOSFETs with IGBTs, and thereby providing copact power conversion. it is necessary to replace the conventional drives with 2 level inverters by multilevel inverters.

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