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ORIGINAL CONTRIBUTION

Simulation and Analysis of Three Phase 7-level Hybrid Switched Capacitor Unit Based Multi-level Inverter

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ABSTRACT

Numerous industrial applications have begun to require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel converter system for a high power application. In this transaction a three phase 7 level hybrid switched capacitor unit based multilevel inverter topology is proposed. The inverter consists of three switched capacitor unit and a three phase two level voltage source inverter. In this proposed topology higher level of line voltage using less number of switches can be achieved. Thus switching loss will be lesser and efficiency will be higher. The said topology is simulated in MATLAB/SIMULINK using multi carrier based pulse width modulation and obtained the desired result.

KEY WORDS: Hybrid Muli/-level Inverter; SwitchedCapacitor Multi Level Inverter; Multi Carrier Based pwm

1. INTRODUCTION

One of the pioneering work in the field of power electronics and drives is the invention ofmultilevel inverter. In 1981 the first three level diode clamped multi-level inverter came in thepicture. Compared to classical 2 level inverter, multi-level inverter provides lesser total harmonicdistortion, lesser voltage stress across the switch, lesser EMI noise, and greater power handlingcapabilities. Since 3 decades there exists different research works on multi-level inverter to improvethe different drawbacks of classical multilevel inverter. Along with NPC other two types of classicalmulti-level inverters are flying capacitor (FC) and cascaded H-bridge(CHB). A detail comparisonbetween these three classical MLI's like structural difference, controlling difference,applicationdifference has been presented in the ref [16]. The main advantage of CHB compared to NPC & FCis that, it is easy to extend further level and easy to control but the main disadvantage is that it needsa no of isolated dc supply as the level of the inverter increases. On the other hand NPC need a largernumber of semiconductor devices, clamping diodes as the level increases. Further capacitor voltageunbalancing problem is another major drawback of NPC topology. As for result more than 3 levelNPC is not popular in the industrial application. Although the flying capacitor topology removes thecapacitor voltage unbalancing problem of NPC but needs large no. of flying capacitor as the no oflevel increases.result.To mitigate the different problems of classical multilevel inverter topologies, different hybrid inverter topologies have been introduced in literature. These hybrid topologies are produced by different possible combinations or connection between these classical multilevel converters. In this paper, a new hybrid inverter topology has been presented. The proposed topology is consists of a two level three phase inverter with switched capacitor cell in a series combination. Due to

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switched capacitor cell the output voltage level is increased.

Objectives

- Study of 3 phase multilevel inverter.
- Development of a three phase switched capacitor based hybrid multilevel inverter.
- Simulation and analysis of proposed topology.

2. LITERATURE REVIEW

Ahmed Salem,Emad M. Ahmed, Mohamed Orabi and Mahrous Ahmedin their paper [2] the author proposed A new modular multilevel inverter topology using two modulation control techniques is presented. The proposed has several advantages compared with existing topologies. A lower number of components count such as isolated dc-power supplies, switching devices, electrolyte capacitors, and power diodes are required. So it exhibits the merits of high efficiency, lower cost, simplified control algorithm, smaller inverter's foot print and increased the overall system reliability. Ebrahim Babaei and Saeed Sheermohammad zadeh Gowgani in their paper [1], two new topologies have been proposed for multilevel inverters. The algorithms for the determination of the dc voltage source values have been presented, and the optimal number of switches and dc voltage sources to produce the maximum number of voltage levels at the output has been obtained. The loss calculations have been done. The proposed topologies reduce the number of switches and isolated. Alessandro Luiz Batschauer, Samir Ahmad Mussa and Marcelo Lobo Heldwein in their paper [3] A novel hybrid multilevel converter able to achieve four, five or six level operation has been proposed. The main advantage for this solution is the possibility of reduction of the power ratings for insulated dc sources compared to the CHB and to other hybrid solutions such as the VSI cascaded with full bridge converters. The operation principle of the converter has been clarified and the achievable space vector spaces presented. A four-level hybrid modulation scheme has been presented, which allows unidirectional power flow in all dc sources for any modulation index and, thus, lowers the power demand on the insulated dc sources for high modulationindexes.Ebrahim Babaei Somayeh Alilu Sara Laali in their paper [8] basic topologies have been proposed for multilevel inverters to generate seven voltage levels at the output. The basic topologies can be developed to any number of levels at the output where the 31-level, 127-level, and general topologies are consequently presented. In addition, a new algorithm to determine the magnitude of the dc voltage sources has been proposed. Theproposed general topology was compared with the different kinds of presented topologies in literature from different points of view.S. Mondal, T. Roy, A. Dasgupta and P. K. Sadhu in their paper [18] proposed a new switched capacitor based single phase hybrid multilevel inverter.

3. CIRCUIT DESCRIPTION

The topology proposed in [18] shows us single phase unit of the hybrid multi level inverter.Here in this literature three switched capacitor unit is used for three phases and a three phase 2 level voltage source inverter is used. There is a 4 switch bridge in every switched capacitor unit. Each bridge has two legs. Total three switched capacitor unit along with a 4 switched bridge circuit is connected to a 3 phase two level voltage source inverter. From the midpoint of the three arms of 3 phase voltage source inverter a star connected load is connected. A single switched capacitor unit is shown below:

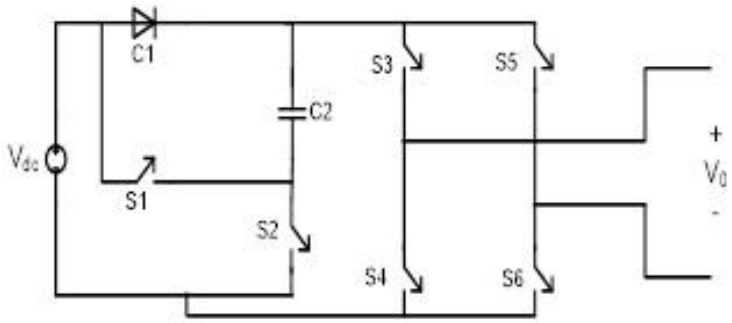


Fig 1: single switched capacitor unit

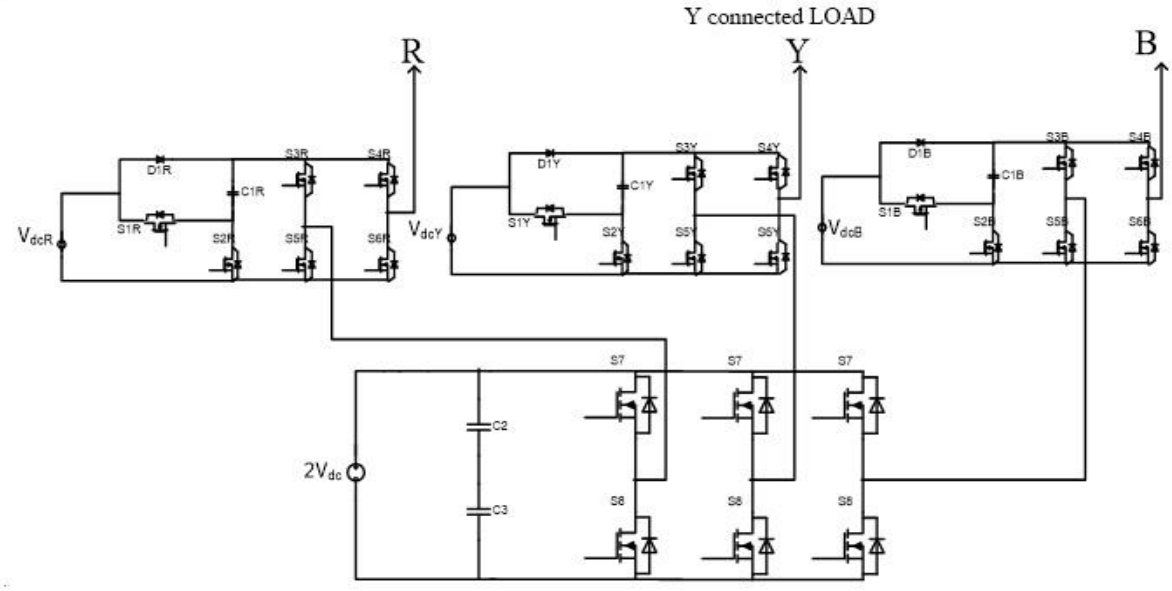


Fig. 2: Three phase 7 level switched capacitor hybrid multilevel inverter

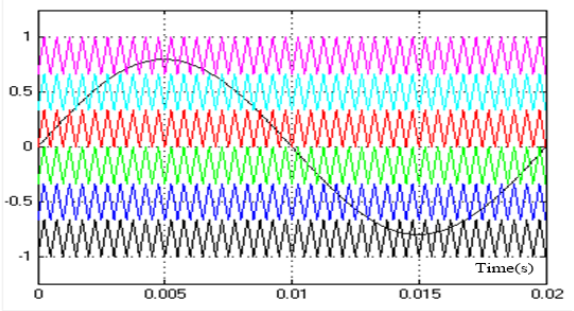


Fig. 3: STPWM with phase disposition

4. PULSE WIDTH MODULATION STRATEGY

In this simulation Sine Triangle Pulse Width Modulation technique has been used. Here three phase reference voltages have been compared to triangular carrier waves to generate gate signals. Phase Disposition multi carrier based STPWM is implemented here. As we know we can get 7-level output from the proposed inverter we have to take 6 carrier signals with which the sine signal have to compare to generate the signals. The comparison for R phase unit is shown in the fig 3.

are Here according to the rule of STPWM the the 50Hz ac signal is compared with the 2kHz triangular signal. The pulses generated from this pwm modulation also passed through a not gate to generate reciprocal signals. All the pulses generated here are shown in Fig: 4(a) and Fig: 4(b)

In order to create the switching pulses we need to create the V, -V,2V, -2V,3V,-3V pulses separately in MATLAB/SIMULINK some logic circuits have been created to generate pulses for the said voltage level. Now in the next process the generated voltages i.e. V, 2V,3V, -V, -2V, -3V are ANDed with STPWM generated signals. By AND operation of the said signals we can find the ultimate level voltages. Now according to the switching we have to OR the signals to generate the ultimate pulse which we have to give at the gate of mosfets. So, the pulse generated to operate the mosfets are shown in fig 5.The above process was for the Gate pulse generation for the switching in R phase switched capacitor unit. For other two phases i.e. for production of Y-Phase and B-Phase the other two sinusoidal reference should be $+180^{o}$ and $-180^{o}$from the 0 phasor. Rest of the process will be same for the signal generation of other semi conductor switches.

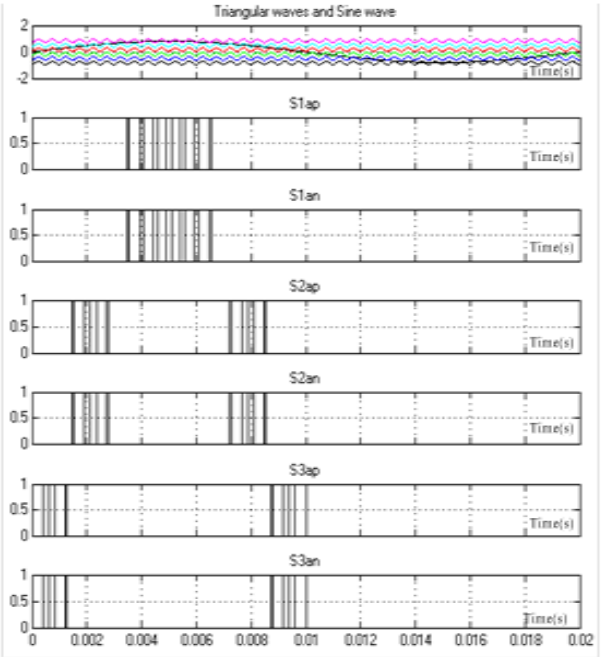


Fig. 4(a): Pulses from the PWM before inverting

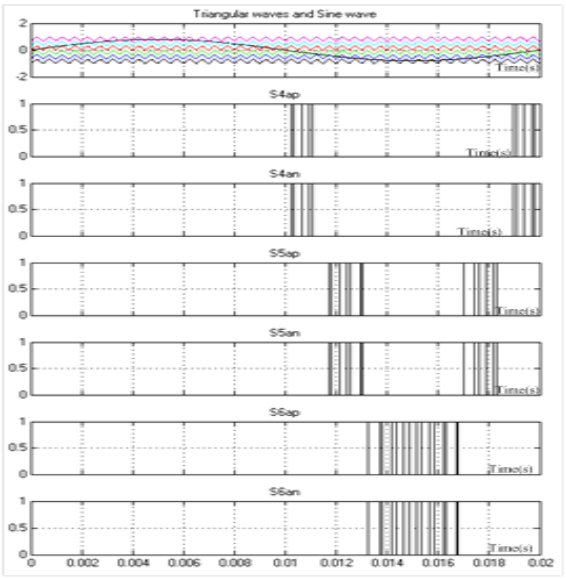


Fig. 4(b): Pulses from the PWM after inverting

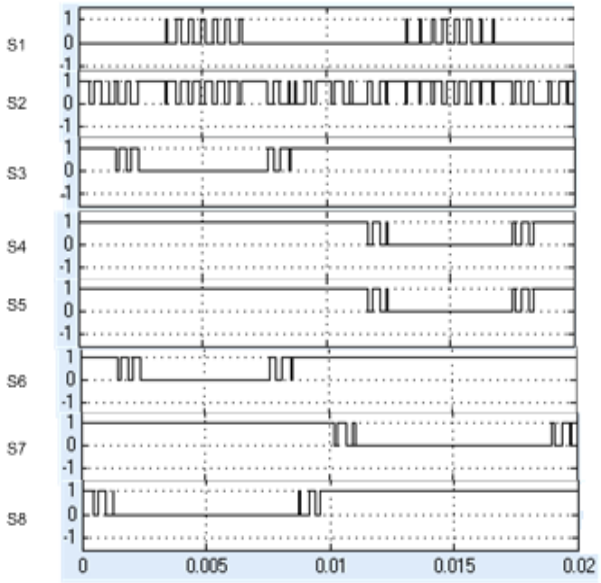


Fig. 5: Gate signal for the MOSFET of R phase unit

5. RESULT ANALYSIS

In this literature the circuit has been analyzed with R and R-L load. So the output load voltage and load current waveforms for R and R-L load are given below in fig 6& 7:

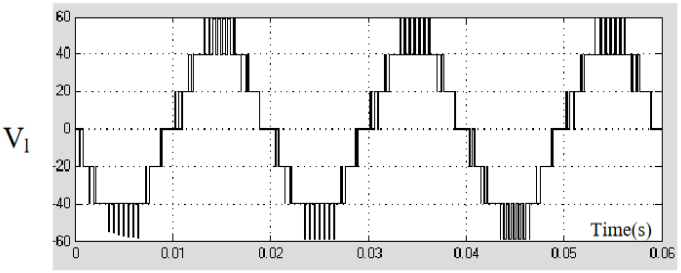


Fig. 6(a): Load Voltage Waveform for R-Load

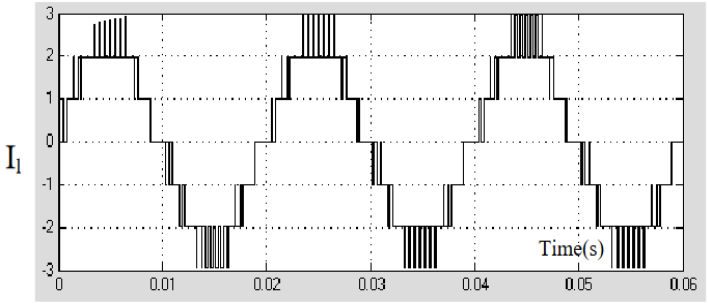


Fig. 6(b): Load Current Waveform for R Load

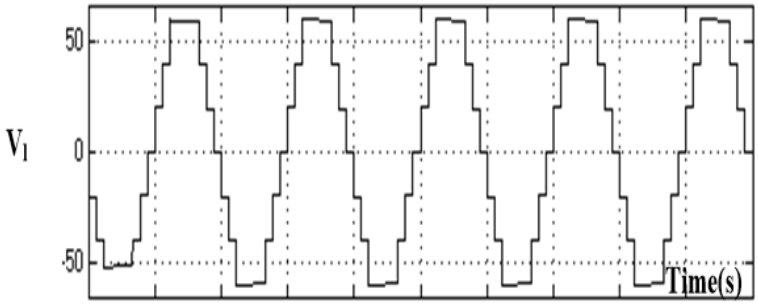


Fig. 7(a): Load Current Waveform for R-L Load

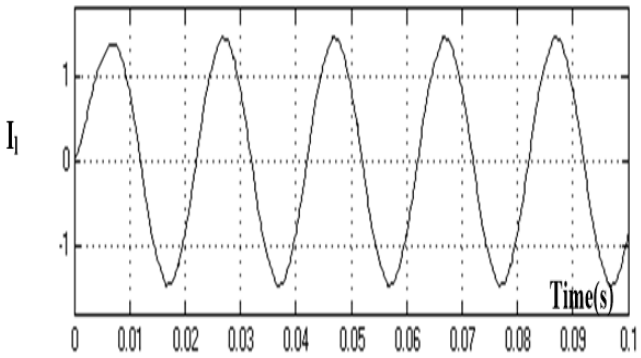


Fig. 7(b): Load Current Waveform for R-L Load

FFT analysis for the simulation of the said inverter is shown in Fig 8. Using R-L load and applying modulation index 0.8 we can achieve a %THD of 11.96% on Line voltage. By changing the amplitude modulation index we can vary the % THD.

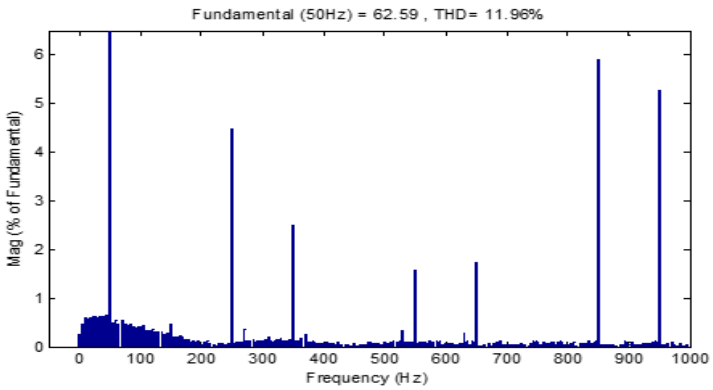


Fig 9 : FFT Analysis

6. CONCLUSION

Three phase 7 level switched capacitor unit based hybrid multilevel inverter has been implemented in this literature. This circuit is verified by MATLAB/SIMULINK simulation. It can be concluded that the proposed topology can generate more number of switching devices as the no of switching devices is less, switching loss is less and efficiency of the inverter is higher than other topologies. The main disadvantage of the proposed topology is the use of capacitor but here the voltage balancing of the capacitor is easy and stable voltage level can be generated. Capacitor acts as an alternative voltage source in this topology. So from this transaction it can be concluded that the switched capacitor unit uses a capacitor to store charge and then its acts as a different voltage source, so that we can achieve a boosted up voltage profile.

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