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Implementation of Five Level Cascaded Hybrid Bridge Multilevel Inverter using SEPIC Converter

Senthil Kumar.R[1]

Assistant Professor, Dept of EEE, M.Kumarasamy College of Engineering, Karur, Tamilnadu, India[1]

ABSTRACT: The multilevel inverter has been accoutrement in many applications which ranges from high to medium levels of power like motor drives, power conditioning devices for both conventional and renewable energy distribution and generation. The types of multilevel inverter are H-Bridge cascaded multi level inverter, flying capacitor multi level inverter and diode clamped multi level inverter[4]. For better reliable and to achieve fault tolerance because of modularity, cascaded multi level inverters are used. The main feature of multi level inverter is to operate at low power levels even then cell failure. This modularity allows the multi level inverter to get stack for high voltage and power type applications. In multi level inverter the output side consists of many H-Bridge cells which are identical in nature are connected in series. This type of configuration is denoted as a cascaded H-Bridge multilevel inverter which are symmetrical when the DC bus voltage are equal in all series power cells. In case of asymmetrical cascaded multilevel inverter to get more levels in output, DC voltages are varied. In this thesis, two modulation techniques are used. 1) multi carrier phase shifted modulation 2) embedded matlab function. And also the THD level is compared.

KEYWORDS: Multilevel inverter, SEPIC converter, PWM techniques

I. INTRODUCTION

Power electronics is the major field in electrical and electronics engineering which are used in semiconductor devices to convert power from the source to the corresponding load requirement. The load may be differs according to its applications i.e DC or AC, single and three phase and also depends upon its isolation[1]. Mainly used power source are AC and DC source, batteries, solar panel, generators and also for commercial uses. Single and three phase are having line frequency about 50 or 60 HZ. Power converters are used here to convert the power from source to the form required by the load. The commonly used power converters are AC-DC converter, a DC-DC converter, a DC-AC inverter or an AC-AC converter depending on the application.

II. CASCADED H BRIDGE MULTILEVEL INVERTER

(A) INVERTER:

An electrical device that converts DC to AC current is called Inverter. In home inverter is used for back up process. It is also used in aircraft for converting direct current to alternative current. In general, AC power is commonly used in applications like radio, radar, motor etc.

(B)MULTILEVEL INVERTER

Now a days the industrial needs are raised to have high power in their applications. But still some appliances power requirement is medium or low to run their operation. By using high power in all industries load is good for only some motors which requires high power. But it will damage the other loads. Because applications that run on medium power source requires only medium voltage. Hence multi level inverter has introduced in 1975 to have both high and medium voltage. It is mainly used in industries.

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(C) DC-AC INVERTER

The basic need of multilevel inverter is to have high power output from medium voltage. Some of the medium voltage sources are batteries, super capacitors, solar panel are medium voltage sources[3]. These inverters consists of number of switches. These switches angle arrangement in an inverter is the most important while designing.

Multilevel inverters are three types.

1) Diode clamped multilevel inverter
2) Flying capacitors multilevel inverter
3) Cascaded H- bridge multilevel inverter

III. FIVE LEVEL CASCADED H-BRIDGE MULTI STRUCTURE

(A)DIODE CLAMPED MULTILEVEL INVERTER:

The diode clamped multilevel inverter provides multiple voltage level by the use of diode through the capacitor bank which are connected in series. The stress of the electrical devices are reduced by transferring limited level of voltage in diode. The input DC voltage is the half of the maximum output voltage. This is the disadvantage of the diode clamped multilevel inverter. This drawbacks can be overcomes by increasing the diode, switches and capacitors. The high efficiency is provided by this type of inverter due to the fundamental frequency for all switching devices. It is the easy method for the back to back power transfer topology. The five level multilevel inverter of diode clamped uses diode, switches, and one capacitor is used. So that the output voltage is half of the supply voltage DC. The 9 level inverter consists of elements like diodes, capacitors and switches. In this inverter the output voltage is more than five level inverter.

(B)FLYING CAPACITORS MULTILEVEL INVERTER:

The concept of multi inverter with flying capacitor use capacitors. It is connected in series with the switching cell of capacitor clamped. The capacitor will transfer little amount of voltage to electrical devices. The switching state of this inverter is same as the diode clamped multilevel inverter. The output voltage is determined by half of the input DC voltage. This is the disadvantage of multi-level inverter with flying capacitor. It balance the switching redundancy of the flying capacitor. It also controls active and reactive power which flows in a circuit. Switching losses occurs due to high frequency switching. Here switches and capacitors only used.

(C)CASCADED H-BRIDGE MULTILEVEL INVERTER*:*

In H-Bridge cascaded multi level inverter less number of switches are used and the inverter use capacitor and switches for the designing process[2]. This method in multi level inverter includes power conversion cells that are connected in series and power is scaled. The combined capacitors and switches makes H-Bridge. Each H-Bridge inverter supplied with separate DC supply. H-Bridge inverter consists of cells where each cell consist of zero voltage, positive DC voltage and negative DC voltage. Compared with other type multi level inverter like diode clamped and flying capacitor, H-Bridge has the advantage of having less components [2]. And also the price and weight is less compared with other inverters. Some of the new switching methods like soft switching is used in H-Bridge multi level inverter.

Multi level cascaded inverters are helping to eliminate components like bulky transformer in case of conventional transformer, clamping diodes in diode clamping inverters and flying capacitor in flying capacitor inverters. Each cell in H-Bridge require number of isolated voltages[5].Diode clamped inverter is same as H-Bridge multilevel inverter.

A separate DC supply is given to a single phase H-Bridge inverter. Every H-Bridge inverter cell generates there output voltage such as $+V_{dc}$, 0, and $-V_{dc}$ only when the DC supply converts into AC supply by using number of different combination switches. When the all switches are turns on, the output voltage is zero. Two switches are turned on for 2 level output to get a $+V_{dc}$. By turning on other two switches $-V_{dc}$ can be obtained. The obtained AC outputs from different H-Bridge inverter are connected in series so that the voltage waveform gives the sum of output produced by inverter.

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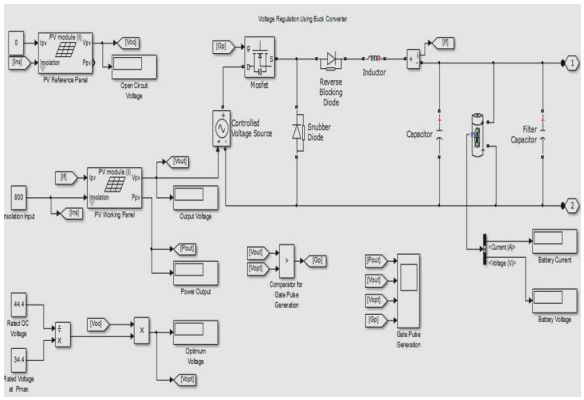

Fig.1 PV Block Diagram

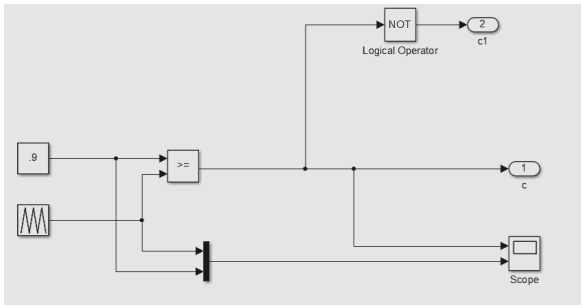

Fig.2 PWM Modulation

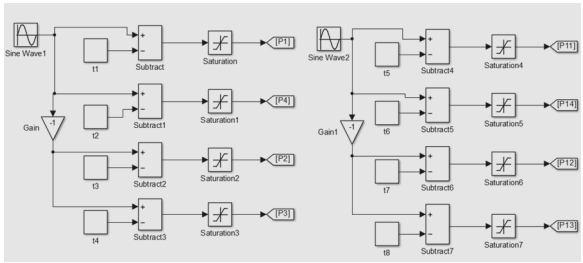

Fig.3 Pulse control given to the MOSFET

There is a PV panel block(Fig.1) which has a working panel with the total input of 800 radians. The output voltage of this working panel is about 87.91V dc and it is same as the open circuit voltage. The optimum voltage is of about 68.11V[5]. it also consists of a battery of 50V which is being charged from the panel through the buck converter. Then this total output of the panel is being given to the interleaved boost converter.

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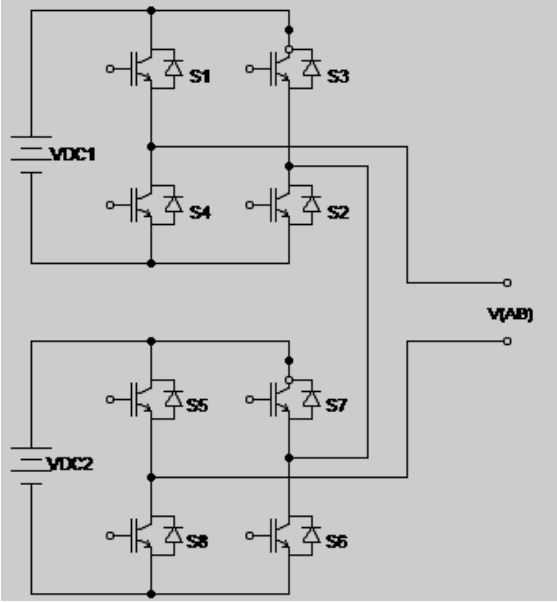

Fig.4 Five level CHB inverter

IV. THE PROPOSED SYSTEM - MULTILEVEL INVERTER

The proposed system consists of singe phase cascaded 5-level inverter. The circuit includes two H-Bridge inverters connected in series which has eight switches configured as S1-S4 and S5-S8. The output voltage of H-Bridge multi level inverter is calculated by V0=V1+V2 where two DC sources are applied. Comparing with square wave inverter, output waveform of multi level inverter of stepped waveform reduces harmonics[4]. H-Bridge inverter is supplied with separate Dc supply. Every H-Bridge inverter cell generates there output voltage such as + V_{dc}, 0, and – V_{dc} only when the DC supply converts into AC supply by using number of different combination switches such as S1, S2,S3, S4. Turning on the switch S1 and S2 results +V_{dc}. As like –V_{dc} is obtained by turning on S3 and S4 switches and the output voltage is 0. Turning on the switch S5 and S6 results +V_{dc}. As like –V_{dc} is obtained by turning on S7 and S8. The obtained AC outputs from different H-Bridge inverter are connected in series so that the voltage waveform gives the sum of output produced by inverter is given below

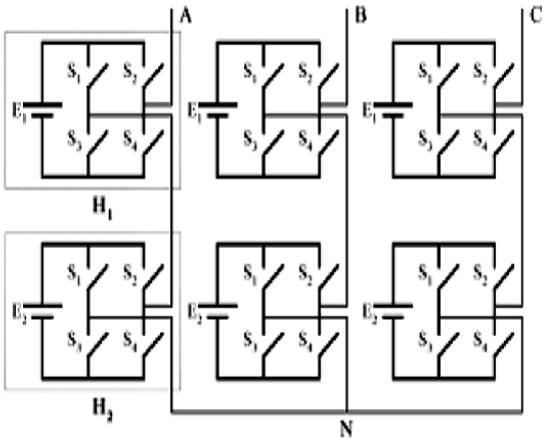

Fig.5 Topology for a 5 level three phase inverter

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(A) EXISTING SYSTEM

The existing system converter consists of H-Bridge inverter where the supply is given independently. The amalgam voltage waveform is obtained by sum of each cell outputs where they are connected in series. The output voltage of first cell is given by V1 and the output voltage of second cell is given by V2. The total output voltage is given by V=V1+V2. Output voltage has five levels such as 2V, V, 0, -V, -2V. The major advantage in the H-Bridge is requires only small amount of components and soft switching process which is employed in circuit. And major drawback is when the level of the voltage increase , usage of switches is also increased. The amount of source supplied is also greatly increased which leads to high cost and more weight. These inverters are suitable for high power applications like static synchronous compensators, active filter and reactive power compensation applications, photo voltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging. Moreover, in electric and hybrid power trains motors are used.

(B) PROPOSED SYSTEM

To overcome existing system, newly designed five level H bridge is implemented. This design includes single switching element and four diodes are added in H-Bridge inverter which connects to Dc power supply[7]. The switching control should be proper so that it can generate half of the input Dc supply voltage. The obtained corresponding five voltage output are V, V/2, 0, -V/2, -V.

The switches S1 and S2 are turned on to get voltage output V. Likewise, the switches S4 and S5 are turned on to get voltage output V/2. The switches S3 and S4 or S1 and S2 are turned on to get voltage output 0. The switches S2 and S5 are turned on to get voltage output –V/2. The switching combinations are shown in Table1.

(C) PWM MODULATION

In this method, to generate the switching pulses with PWM technique and embedded matlab functions are used. In multicarrier modulation, triangular waveform amplitude and frequency are same between adjacent carriers. Figure 2 and 3 shows multicarrier phase shifted PWM and embedded Mat-lab function.

(D) FIRING PULSE ANALYSIS

SPWM plays a major role in power electronics which helps to increase power so that the pulse voltage which are present in sequence are generated by ON and OFF switches. The pulse generated by SPWM is simple in nature and rugged. Because of this advantage it is used in industries application for more than decades. The characteristics of SPWM includes constant amplitude but with different duty cycle[6]. The main application of SPWM is to control motor and inverter operation. To obtain voltage control in output and to reduce the harmonics, width of the pulses are varied. Specifications: Type; SPWM Carrier frequency =3 KHz Operating Frequency=50Hz, Gain=K=6500 Phase delay= 0,-pi/3

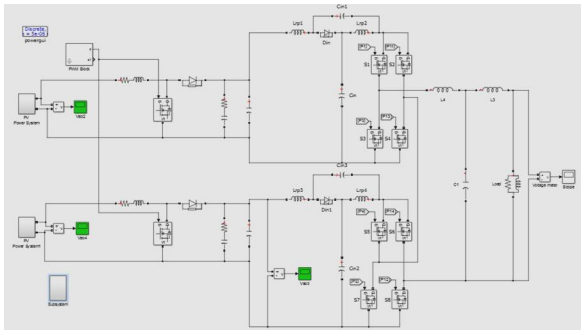

Fig 6 Simulation diagram of five level multilevel inverter

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(E) SIMULATION RESULTS

Mat lab/Simulink Model of five level Cascaded H-Bridge multilevel Inverter with DC/DC sepic Converter. Each H-bridge DC voltage is 12 V. Hence total input is 24volts

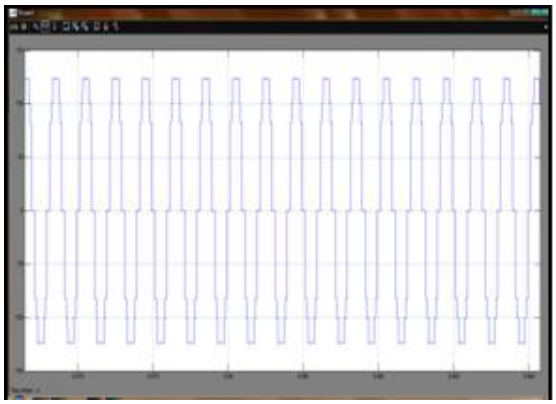

Fig.6. Output Voltage Waveform from Inverter

This waveform has been plotted between the voltage and the current.

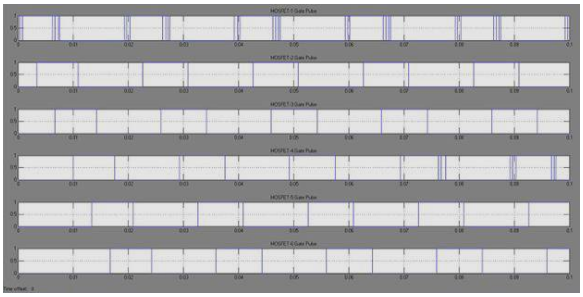

Fig.7 Output of Inverter Gate Pulse

The above figure shows, the output voltage waveform and voltage measurement waveform. It also shows voltage measurement block of three phase voltage. This block is used for measuring spontaneous voltage in a current circuit. The output of this block is voltage in per unit values. Voltage measurement block is connected in series with three phase so that it transfers phase-ground and phase-phase peak voltages.

V. CONCLUSION

From the results from simulation shows the Full efficiency of the proposed system five level hybrid inverter. It gives 95% of output efficiency compare to conventional direct current to alternative current inverter. The main advantage of this two level inverter is less cost and weight compared with other type inverters. Moreover, the THD level is very high. Practically, with high THD value the output voltage is not possible. But the design of this inverter have better performance than 9 level inverter. Due to the increase in levels, the cost and weight is greatly increased. This method is well suited only for industries drives. By having a filter circuit in a network we can reduce the THD value. This circuit implementation decrease the usage of switches.

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