Three Phase Five Level T-Type Multi Level Inverter using Hybrid Sources

Ramya.G, P.Sathyanathan, A.G.Karthikeyan, R.Selvamanikandan, P.Suresh

Abstract: This paper presents a 5 level T-type multilevel inverter, to improve the performance of the hybrid system and then improved voltage is injected into the grid. Two three level inverter with common emitter and common collector configurations are combined to obtain a five level inverter. PV and wind energy is used as a source of energy to the five level T-type MLI. It has advantages such as low switching losses, lesser THD, less filter requirement and superior output quality when compared to 3-level T-type MLI. PWM technique is employed to generate output voltage. The Simulation is done using MATLAB Simulink.

Index Terms: T-type multilevel inverter, Photo voltaic, Wind energy and Total Harmonic Distortion.

I. INTRODUCTION

DC-AC converters play a prominent role in electrical field. The role of inverters has increased to a considerable extent with the introduction of power electronic devices, digital controllers, sensors etc. They are further divided into different types based on their output wave form [1]. Multilevel inverters are emerging as the new technology for high and medium power applications [2-3].They are found useful in pumps, fans, compressors etc. Recently, they have been introduced into renewable energy applications like wind, PV and fuel cells [4].They have also been used in low and medium voltage applications [1, 5-6]. Multilevel inverters consist of a cluster of semiconductors and capacitors, which produces output in the form of staircase voltage waveform [7].The application of switches in these devices allow as the addition of capacitor voltage reaching high voltage level while power semiconductors must withstand only reduced voltage [8-9]. Therefore, they provide improved output, lower electromagnetic interference, lower device stress, reduced size and cheaper [6, 10-14].They also generate smaller common mode voltage reducing stress in motor bearing [15]. Multilevel Inverters can be further classified as diode clamped, cascaded H Bridge and flying capacitor [16].The first topology to be introduced was H Bridge. However, it had a large number of isolated voltages to supply to each cell [17-19].Diode clamped multilevel inverters utilize a bank of series connection of capacitor switching cells [20]. Various control strategies and modulation techniques have been used to control them [21-23].To overcome the problems of basic multilevel inverter topologies, T type multilevel inverters were introduced [24].It begins with two level multilevel inverter. It has large capacity, more DC voltage usage, less bulky filters, lesser dv/dt ratio and lesser harmonics. They reduce conduction losses due to lesser number of series connection devices [25-27]. However, they are more advantageous due to better performance with lower loss and higher space utilization ratio [28].Two level inverters cannot be used in case of grid systems because they have quasi square wave output. In order to connect with grid, output voltage must be near sinusoidal. Three level Inverters provides high efficiency, low output harmonics, reliability compared to two level inverters. It can be used in PV, wind and fuel cells. It reduces the problem of lower conduction loss [29]. PV can be delivered to a power system through grid connected inverter [30]. In this framework, a five level T type multilevel inverter is used in a grid connected system to overcome the disadvantages of MLI. PV cell and wind energy is used as a source of energy to MLI. This is used to reduce THD and thereby increasing power quality. Section II explains the system description. Section III explains the results and discussions of the proposed 5 level T-type MLI with hybrid source. Section IV gives the conclusion of the findings.

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II. SYSTEM DESCRIPTION

In this paper, a hybrid source is fed to the inverter circuit. The output, in turn is fed to the load and grid connection thereby giving the total output to the resistive load. If the output produced is maximum, then the additional voltage produced is fed to the grid connection. If it is minimum, then the required amount of voltage is fed to the grid connection. Figure 1 shows the proposed T –type Multi Level Inverter using Wind and Solar Source. In this, input is fed from a hybrid system. The hybrid system consists of solar and wind sources. The power obtained is fed from the sources to the DC-DC converter which steps down the higher dc voltage to a lower one. This in turn is fed to the 5 level T type inverter which in turn is fed to the load and grid.

2.1. Hybrid system

Hybrid system has the advantage of combining different classes of system within its structure for increasing its flexibility. This system can be used in more than one power system. One of the important feature is that they can be used both in small systems and in larger ones.

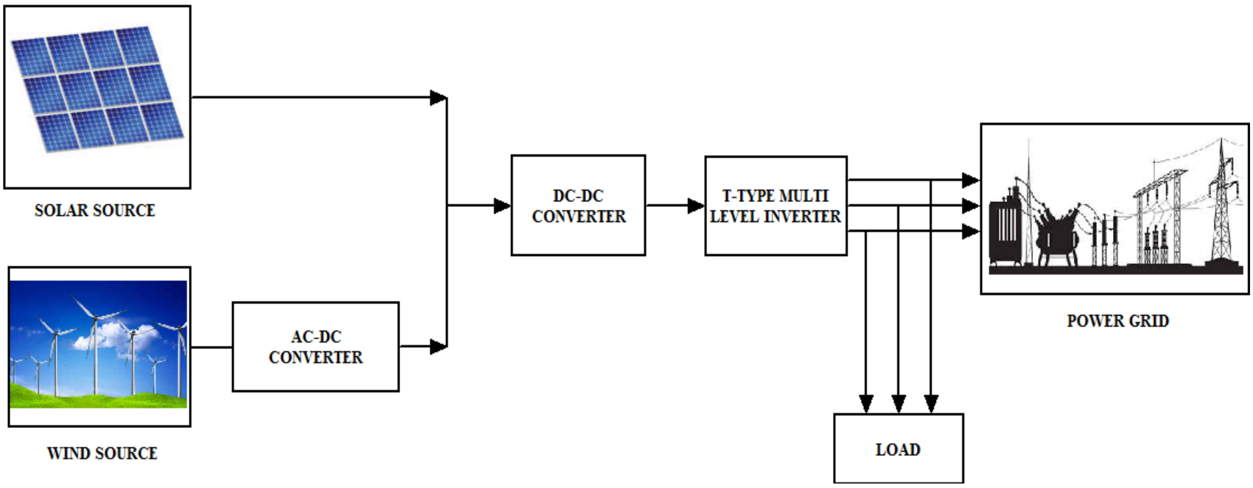

Figure 1. Block of proposed T –type Multi Level Inverter using Wind and Solar Source

They can be used for household applications. Hybrid system with alternating current sources are coming into existence in the recent period. They can be used for supplying power to remote areas. The power loss in this type of system will be low compared to primitive ones. In this framework, the hybrid system consists of a wind system and PV system. The wind and PV both produces an input of 500V. Both of them combine to give a total output of 1000V. The losses produced are reduced using slider compensator.

2.2. 5 level T- type multi-level inverter

The output of the hybrid system is connected to the five level T- type multilevel inverter. Here the DC input is converted in AC output. It reduces the power loss by lowering the operating frequency of some devices. In conventional system, the THD level and the power losses are higher. The THD value can be reduced for each higher level T-type inverter. The reduced THD level of the T-type inverter is compared between three level and five level inverters. Their characteristics has been studied in this paper and reaction has been discussed. This type of inverter is applied mainly to reduce the losses and THD level. This in turn is used in medium and high voltage application but cannot be used in low voltage application. Cascade is the inverter-type which precedes the T-type inverter. Both these types have almost similar properties. But, Cascaded inverter can withstand only 80% of total input voltage fed to it while T-type inverter can withstand 90% of input voltage. An input of 1000V is fed to the T-type inverter and 500V obtain as an output.

2.3. Grid System

Here the multi-level inverter is connected to the grid system. Grids are mainly used for compensating power in a system. Here the grid system is used for supplying the power to the load when the hybrid source fail to meet the demand and also when there is extra power in the system the extra power can be given to the grid to compensate the load voltage. At the grid, three phase AC source is available to provide and also to store the power. From the solar-wind hybrid system we will get the DC as the input, then that input will go to the five level T- type multi-level inverter where the DC is converted into the AC and `the harmonics present inside the currents will be eliminated and the total harmonic distortion (THD) will be less. In this circuit the THD can be reduced to a minimum level with lesser number of filters. The grid is connected in series with the multi-level inverter which provides the power to the load when the hybrid source fails to meet the demand of the load. When the power is more than the demand, then the extra power will be stored in the grid.

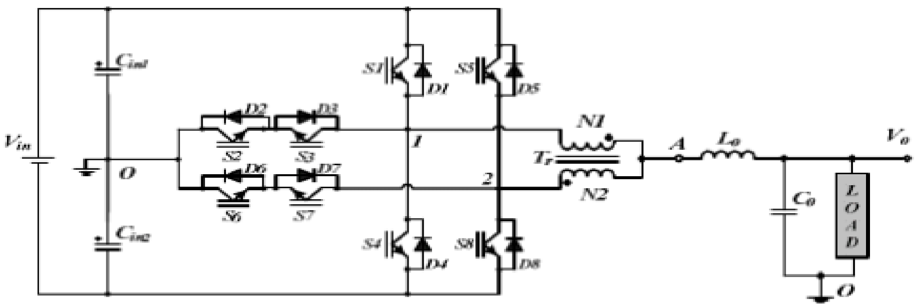

Figure 2. Proposed inverter topology

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III. SIMULATION RESULTS AND DISCUSSION

The simulation of the proposed system is done by using MATLAB Simulink. A three phase five level T type MLI topology has been implemented using a hybrid source based on the proposed topology. The simulations are divided into different parts in order to obtain the output at each level of operation. Figure 3 shows the simulation circuit of the hybrid source. The source is a combination of PV and wind source, each providing 500V input voltage. On combining these, we get a total output of 1000V as shown in Figure 4. This in turn is fed to the inverter circuit. Figure 5 shows the simulation diagram of five level T type MLI. The input of the multi-level inverter is connected to the hybrid source. The 1000V output of the hybrid source is fed as input to the T type MLI. When 1000V DC is fed to the multilevel inverter, it converts the DC voltage in to AC voltage. The output voltage of five level T-Type MLI is shown in Figure 6. Thereby the AC voltage obtained is 250V.The 1000V input supplied to the system is obtained as an output of 250V due to the losses that happen in the circuit during the conversion of DC-AC. Hence, the final output is 250V and 10A. The output from the inverter is connected to the grid system and the resistive load. The grid is connected in series with the multilevel inverter to compensate the power in the system. Figure 7 shows the Simulation diagram of the grid system.. It can supply 250V and 6A to the system. It can be used for both supplying power and absorbing power from the system .

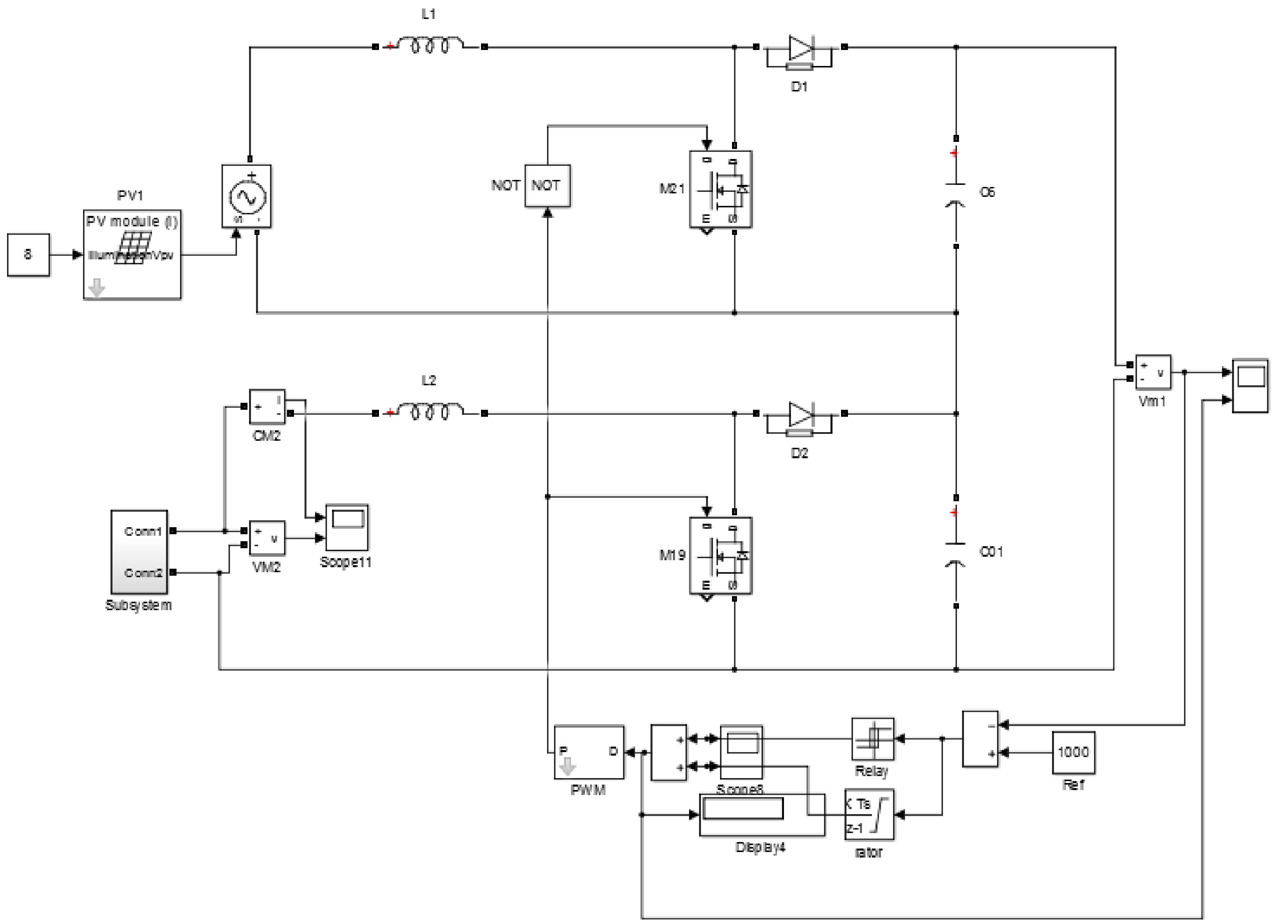

Figure 3. Hybrid source simulation circuit

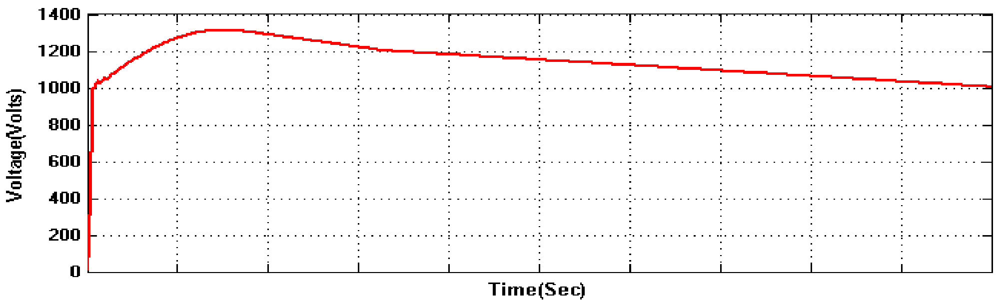

Figure 4.Output voltage of hybrid source

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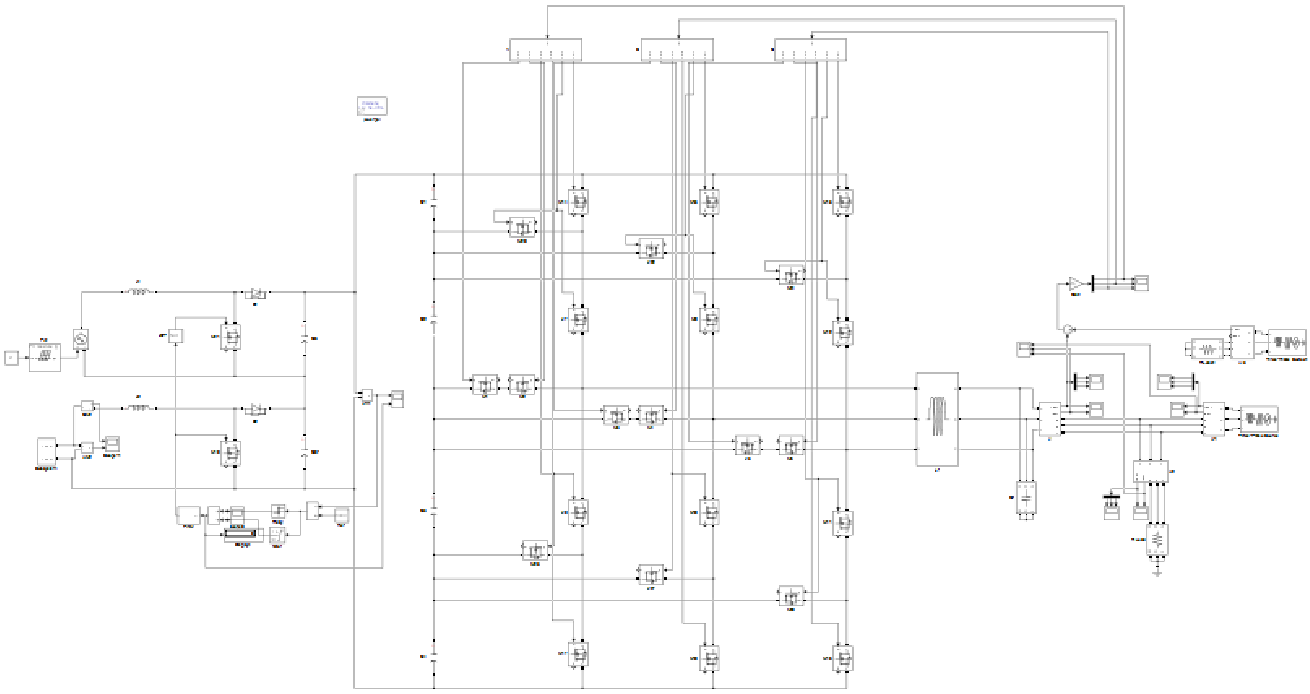

Figure 5- Simulink Diagram of Five level T- type MLI using Hybrid Sources.

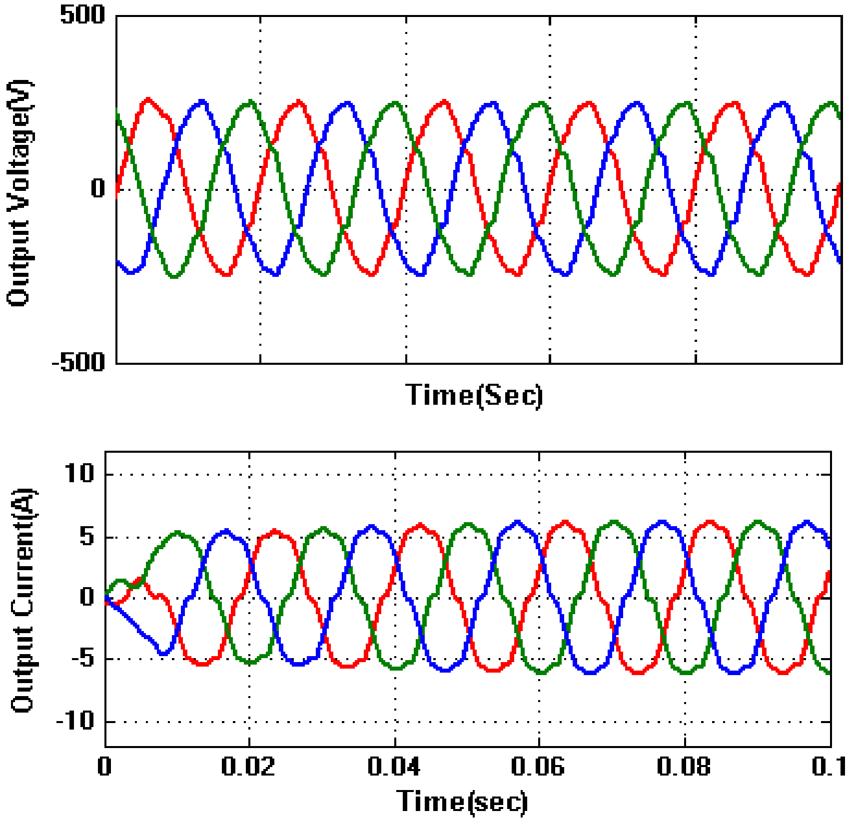

Figure 6-Output of Five level T- type MLI.

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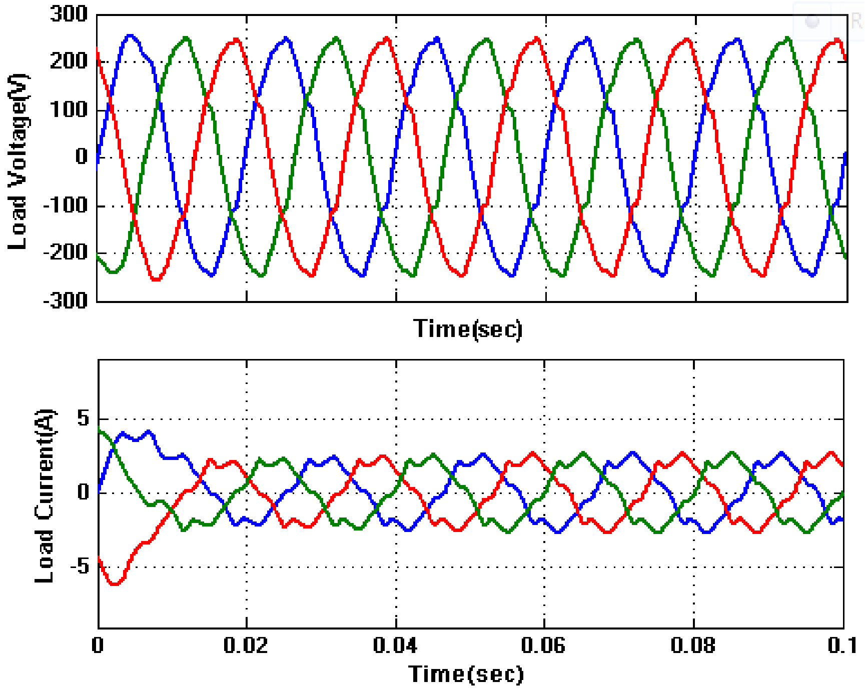

Figure 7- Load voltage and load current of the five level T- type MLI connected to Grid system

Apart from this, THD plays an important role in this system. THD is the disturbance present inside the current that should be reduced to get the pure current when the conversion of DC-AC happens. The Figure 8 shows the THD present in the system. In this system, the THD level has been reduced to 4.82% which is acceptable by IEEE standard.

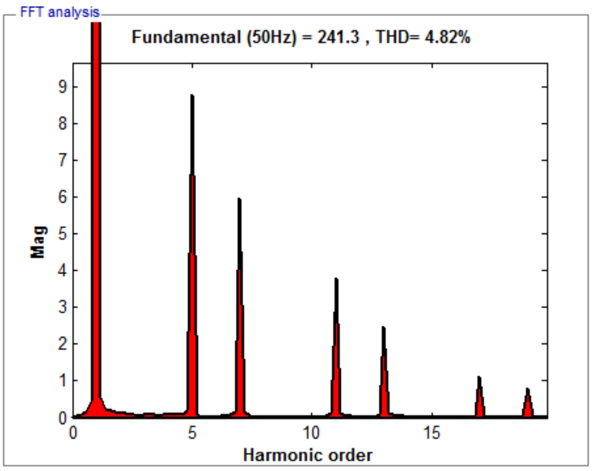

Figure 8-Total Harmonic Distortion of five level T-type MLI.

IV. CONCLUSION

The 5 level T type MLI has been derived from three level T-type topology. Hybrid system is successfully applied to the five level T type MLI. It produced better output with lesser THD. The output of the system can be further improved by the incorporation of H-bridge cells at both ends. The proposed topology can be a good solution for renewable energy source. Since solar and wind hybrid system has been used. Simulation studies have been performed on proposed structure. It has obtained output voltages with THD 4.82%, which is accepted by IEEE standard. The results are found to be satisfactory.

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