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Design and Simulation of an Isolated Seven Level Three Phase Inverter

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Abstract: ***This paper proposes a seven level three phase inverter with PWM control scheme for better performance and magnitude control of output voltage. This proposed inverter offers a proper isolation between load and inverter circuit and different phases also. This inverter is capable of generating waveforms independently for different phases. By changing the reference signal frequency output frequency can be changed which is capable to make the system of variable frequency. Use of reverse voltage topology has increased the magnitude of output voltage. Proper application of diode makes the unidirectional switch bidirectional and decreases the number of switches.***
Keywords: Pulse width modulation, multi-level topology, bi-directional switches, isolation system

I. INTRODUCTION

Nowadays inverters are developing day by day. To reduce harmonics and increase the accuracy of inverter multi-level topology and PWM control has been implemented in this work. To overcome energy crisis, we are concentrating on renewable energy. Equipments used in AC are more preferred nowadays. Most of the generated power using renewable energy is DC. To convert DC power to AC inverter is needed. Major problem in conventional inverter is higher THD and less accuracy in output voltage. This inverter has been proposed using both multilevel and PWM topology which reduces the THD and increase the accuracy of output voltage. A multilevel topology has been developed using a series capacitor based voltage divider system which ensures lower loss and allow multilevel operation using a single voltage source. Three phase inverter has been developed from a single phase inverter. For different phases three different power circuits has been used having a common voltage divider system. Generated waveform in different phases is independent of each other. A Six winding transformer makes the power circuits for different phases isolated. This inverter is build up with the help of H-Bride topology. In this topology use of bridge can supply the maximum source voltage to positive half and negative half of the signal. This ensures peak to peak voltage which is twice of dc supply voltage. If the supply voltage is V the divided voltage should be V/3, 2V/3 and V, which can be applied in positive and negative half of the waveform. In this proposed inverter, voltage in different level is generated with the help of bidirectional switch and reverse voltage bridge. Use of PWM control topology in this inverter needs high speed of switching. To reduce the switching loss in the inverter MOSFET has been used. MOSFETs are made bi-directional by using diode bridge. Use of bi-directional switch reduces the total number of switches. Three different phases waveform is generated by the help of three reference signal. Output waveform is dependent on reference signal. So this inverter is independent of frequency.

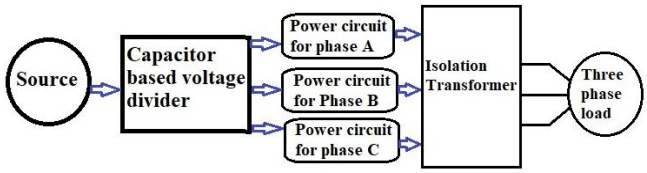

Fig. 1 Block diagram of the proposed seven level inverter

II. WORKING PRINCIPLE

This proposed multilevel inverter works on the basis of H-bridge topology and PWM control logic. For THD reduction and increase in the accuracy of the inverter multilevel topology and PWM control has been used. Both the topologies has some advantages as well as some disadvantages. For a PWM control logic magnitude of output voltage is reduced and a high quality filter is needed to get proper output. By using both multilevel and PWM topology this problem can be reduced. Power circuit is based on multilevel topology and control is based on PWM topology. In PWM topology high frequency switching is needed and for that reason MOSFET has been selected. To make S_5 and S_6 bi-directional, a diode bridge has been introduced. Switching sequence for each phase has described in the table given below.

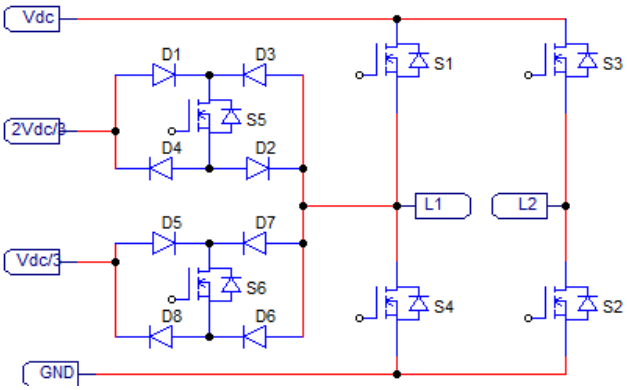

Fig. 2 Power circuit of the inverter for phase A

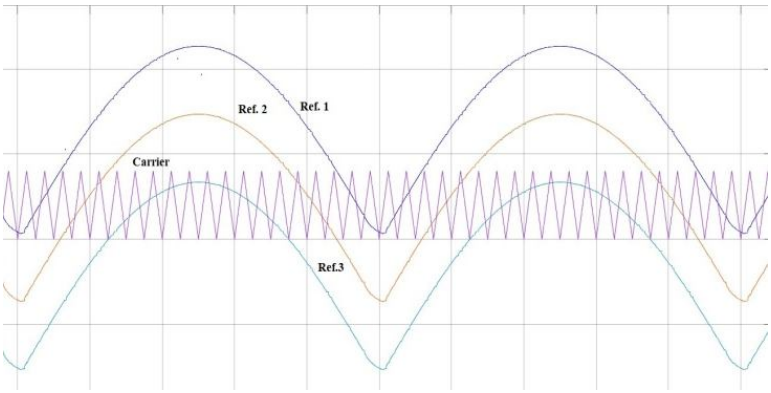

Fig. 3 Signals for controlling the inverter

Table 1 Switching sequence of the switches for phase A

Output voltage	S1	S2	S3	S4	S5	S6
V_{DC}	on	on	off	off	off	off
$2V_{DC}/3$	off	on	off	off	on	off
$V_{DC}/3$	off	on	off	off	off	on
0^-	off	on	off	on	off	off
$-V_{DC}/3$	off	off	off	on	on	off
$-2V_{DC}/3$	off	off	off	on	off	on
$-V_{DC}$	off	off	on	on	off	off
0^+	on	off	on	off	off	off

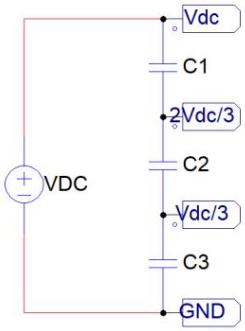

Fig. 4 Capacitor based voltage divider circuit

To reduce the number of voltage source in input side for different voltage level a capacitor based voltage divider circuit using three capacitors has been proposed. This circuit is able to divide the supply voltage into three parts as V_{DC}, $2V_{DC}/3$ and $V_{DC}/3$. Capacitor has been selected in voltage divider network because of its low power loss.

For a capacitor string equivalent capacitance C is given as

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Q=CV

If capacitance of each capacitor are same the voltage drop across each capacitor = $V_{DC}/3$. When two capacitors are connected in series output voltage is $2V_{DC}/3$.

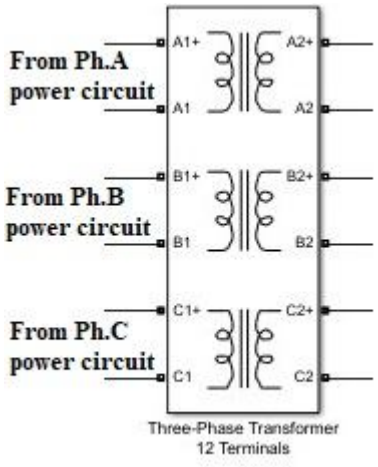

Fig. 5 Isolation transformer

Use of isolation transformer makes the system more efficient. By using this transformer it is possible to make a three phase inverter out of three single phase inverters. In conventional three phase inverter without isolation fault in any phase and unbalance condition can affect the output voltage of another phase. In those methods another problem is that maximum output voltage is less than DC supply voltage. In this proposed method it is possible to supply the total source voltage across the load. If the power circuit of any phase does not function properly, this does not affect the output voltage of other phase. By using this topology output voltage of this inverter can be increased.

III. RESULT ANALYSIS

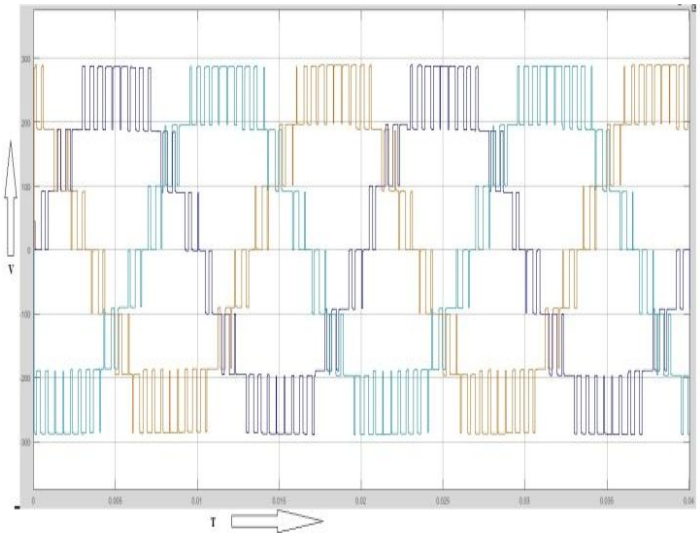

Fig. 6 Output voltage waveform for R-L load

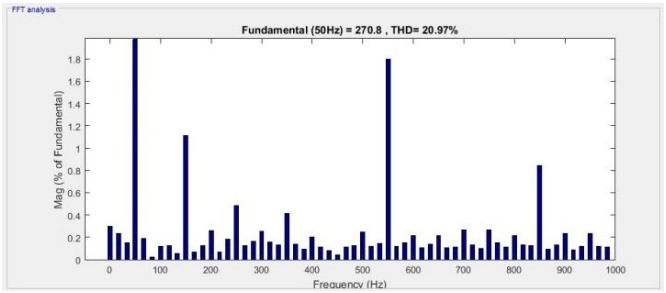

Fig. 7 FFT window for R-L load

This proposed inverter has been simulated in MATLAB Simulink model for different load condition with different types of load. Output waveform of this inverter is quite good. THD is an important parameter to judge the quality of an inverter. Less THD contained waveform is more preferred for better operation of equipments. This we can get from FFT analysis. Where the other conventional inverter contain higher THD for resistive load due to lack of filter, this inverter contain very less THD. In this simulation it is also observed that w.r.t. change in frequency of reference signal output waveform frequency is also changed. For the use of isolation transformer magnitude of output voltage waveform is increased.

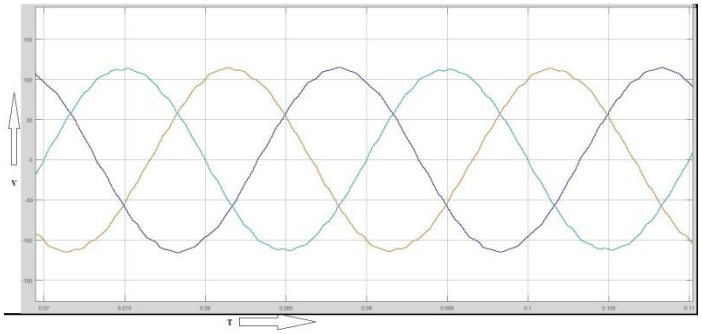

Fig. 8 Output waveform for R load

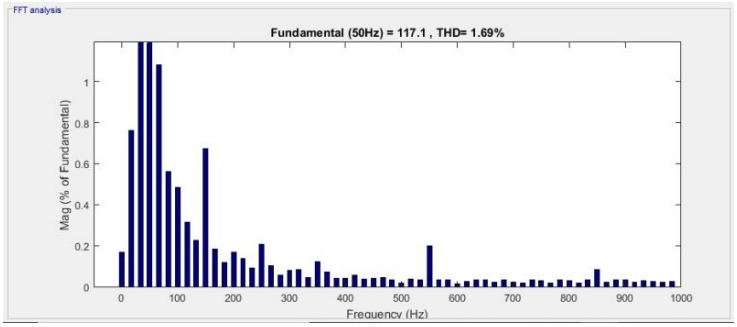

Fig. 9 FFT window for R load

IV. CONCLUSION

This paper proposes a designing and simulation of three phase seven level inverter with proper isolation. In this project a three phase seven level inverter has been simulated in "MATLAB Simulink" model. If this is implemented in hardware, it offers simplicity and ease of maintenance. By using this inverter output voltage can be increased because of its isolation transformer. Isolation transformer also gives a proper isolation between all the phases. This inverter is tested in different load conditions which offer a low THD and better accuracy in output voltage waveform. Use of diode bridge can make the unidirectional switch bi-directional. Inverter control is based on three reference signal. It can change frequency w.r.t. reference signal. This proposed inverter can be implemented for grid connection also due to its auto synchronization. Most of the conventional inverter contains higher THD in resistive load due to lack of filter than an R-L load. For resistive load this proposed inverter contains THD less than 2% which is very much low.

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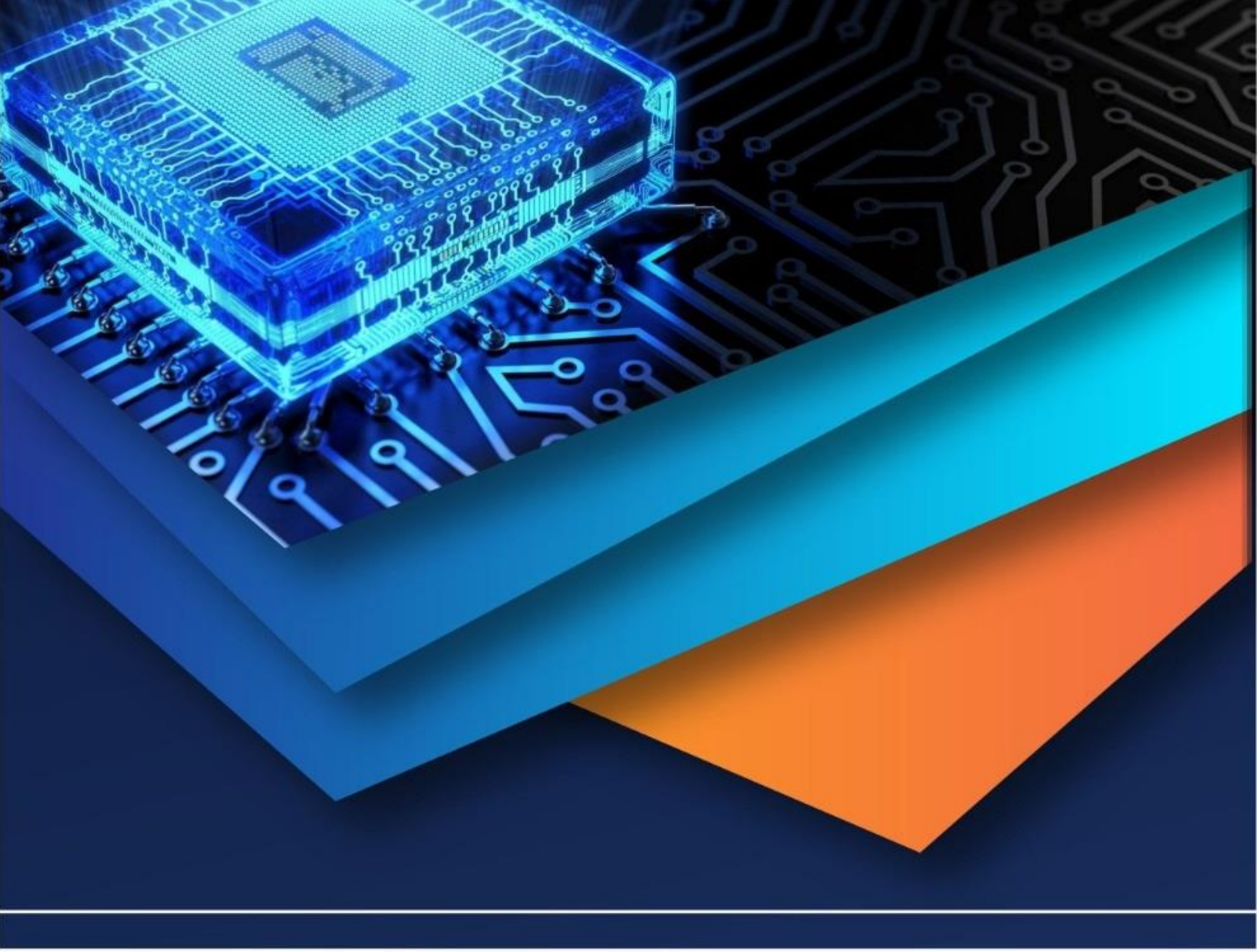

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