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Designing and Simulation of Five Level Single Phase Inverter based Water Pumping Unit for Irrigation System

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Abstract - *This paper proposes a five level inverter system for water pumping system in rural areas. The proposed inverter system is designed by multilevel topology. Proposed multilevel topology reduces the harmonics in output of the inverter. In some rural areas where renewable energy is more concentrated, this inverter comes into play. Reduction of number of switches and voltage divider system make the system efficient and simple. Multilevel inverter is efficient for light load. In this topology a sine wave is generated with the help of five different level dc voltages which give more accurate sine wave and less harmonics generation.*

Key Words: Water pumping system, Multi level inverter, Harmonics reduction, FFT

1. INTRODUCTION

One of the most efficient methods to convert DC to AC is solid state device based inverter. MOSFET has lower conduction loss than BJT. In inverter system for high frequency switching MOSFET is used. In primary stage inverters are square wave based which have high THD(Total Harmonics Distortion) now by using PWM technique the THD can be reduced. In PWM inverter the output pulse width changes with respect to time so average value of the output is like a sine wave. Generation of signal for PWM based inverter is too much complicated that it needs one or more carrier signal and one reference signal. But multilevel inverter does not require this type of signals. It operates on switching principle in particular switch at a particular instant of time. In multilevel inverter output is generated by the combination of various dc voltages where the voltage changes from one level to another by steps. So generated sine wave for this case is accurate. Without using any filter this inverter can be designed. Our proposed multilevel inverter is designed by H bridge topology. A voltage divider system is proposed by using series combination of two capacitor. A capacitor never allows a DC current for a long time but in these cases the switches are operated at very high frequency so for the small amount of time capacitor allows current to flow through. When two capacitor are in series combination they behave like two cells and they have charged from the main source. Hence main supply voltage is divided in two parts. By switching various voltages waveform is generated. This proposed inverter is suitable for small and medium load application. Nowadays renewable energy is more concentrated. Most of the cases PV arrays are used. PV array output is DC but AC motors are the most efficient one than DC. To make the overall system efficient we have to convert PV array output to AC so this type of inverter comes into play. In rural power distribution power requirement to each consumer is very low and the area is of low density. So transmission loss is higher and due to low density initial installation and maintenance of supply is very difficult. By using PV array and proposed multilevel inverter topology each consumer can feed according to the requirement of power and no need of transmission. Nowadays water pumping is more concentrated by PV array. Small water pumping stations are used but they are located in remote areas so supply the electrical power is not safe and transmission loss is very high. By using PV array system and this proposed multilevel system this problem can be solved.

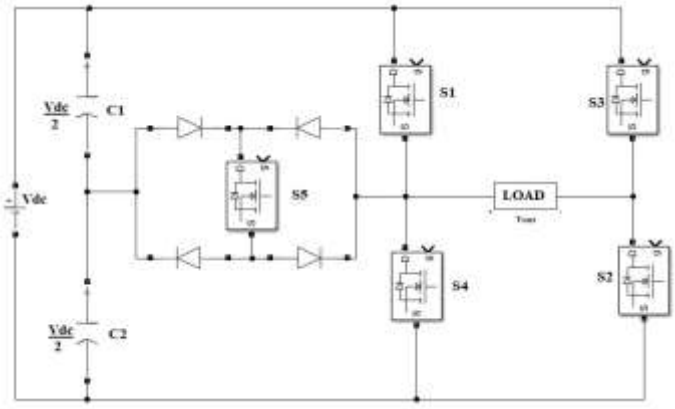

Fig -1: Circuit diagram of single phase five level inverter

2. WORKING OF THE SYSTEM

Two series connected capacitors are connected in parallel with the main supply which divides the voltage Vdc in two equal parts.

a) Fig -2 shows the supply of the voltage +Vdc across the load. In this condition S1 and S2 are active and other switches are turned off. S1 connect load +ve terminal to Supply +ve terminal and S2 connects load –Ve terminal to load –Ve

terminal. So +Vdc is supplied across the load. Current conduction has been shown with the help of bold line.

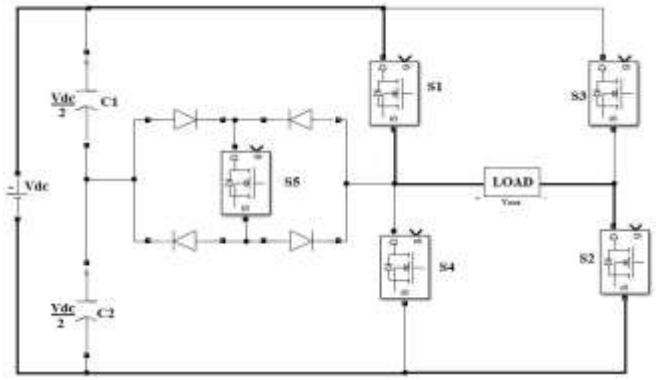

Fig -2: circuit to generate voltage Vdc across the load

b) Fig -3 shows the supply of voltage Vdc/2 across the load. Voltage drop across the capacitor is Vdc/2. Load is connected by two switch S5 and S2. S5 connect load +ve to C2 +ve and S2 connect load –ve to C2-ve. Current conduction has been shown bellow by the bold line. With the help of four diodes switch S5 working as a bidirectional switch.

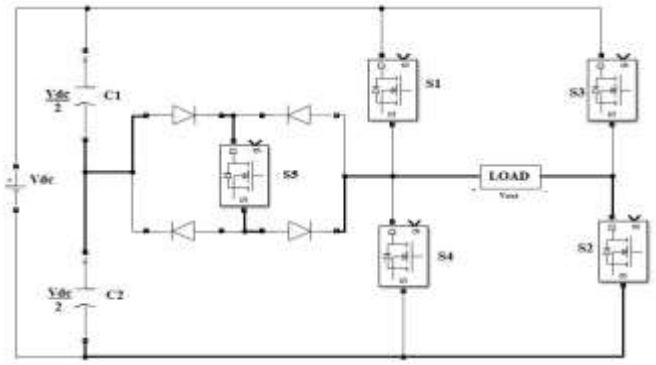

Fig -3: circuit to generate voltage Vdc/2 across the load

c) To supply zero voltage across load we have to short circuit the load terminals. In fig-4 this mechanism has been shown. To short circuit the load terminal S1 and S3 are turned on and other switches are turned off. Current conduction path has been shown in this figure with the help of bold line.

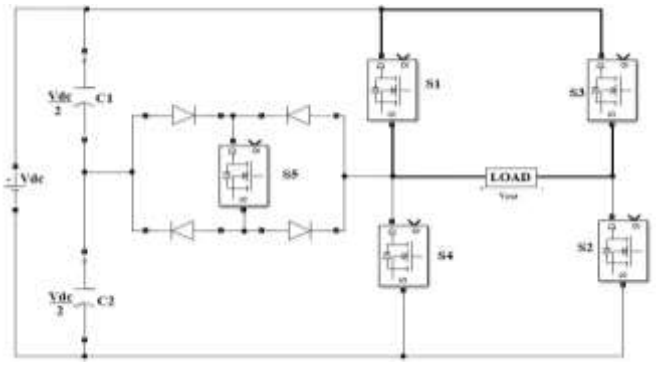

Fig -4: circuit to generate voltage 0 volt across the load

d) Fig -5 shows the supply of –Vdc voltage across the load. In this instant of time switch S3 and s4 are turned on and other switches are turned off. S3 connects the load –Ve terminal to supply +ve terminal and S4 connects the load +Ve terminal to –Ve terminal of the supply. With the help of bold line current conduction path has been shown.

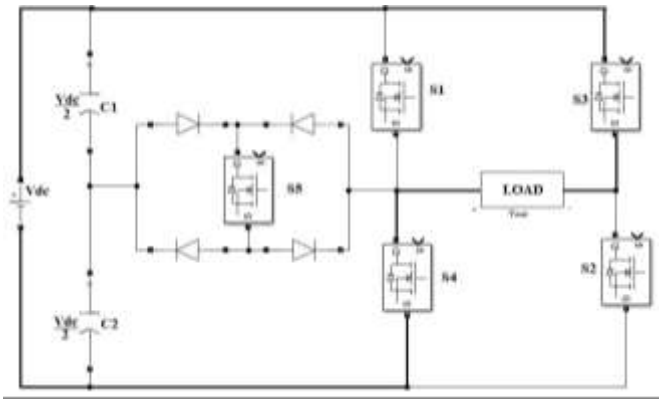

Fig -5: circuit to generate voltage -Vdc across the load

e) Fig-6 shows the supply of –Vdc/2 to the load. From the voltage divider system Voltage across the capacitor C1 is Vdc/2. In this instant of time S3 and S5 are active and other switches are turned off. S3 connects load –ve terminal to capacitor +Ve terminal. S5 combination of four diodes work as a bidirectional switch connects load +Ve terminal with capacitor –Ve terminal. Current conduction path is shown with the help of bold line.

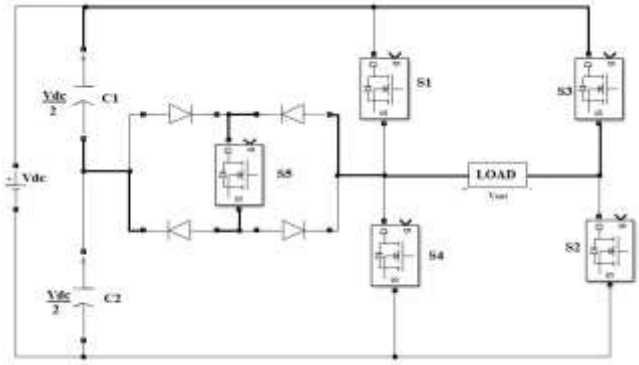

Fig -6: circuit to generate voltage –Vdc/2 across the load

3. RESULT AND DISCUSSION

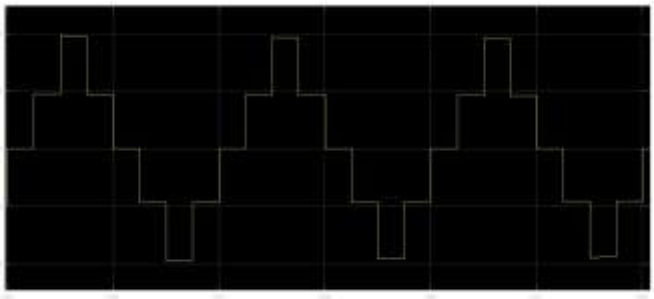

Fig -7: Output waveform of the inverter

The proposed inverter system is simulated in MATLAB simulink and the output waveform of the proposed five level inverter is shown above. It has been observed that if the rating of the inverter is high then we have to use higher value capacitor to get proper output. This proposed inverter is helpful for rural water pumping system because these are not in large rating. The output waveform looks like a stepped sine wave. Machine life and output is fully dependent on the supply. If square wave is supplied to the motor the motor output will be affected so the proposed inverter output is very helpful to overcome the problem. Total harmonics distortion (THD) is a major point to analyse the quality of an inverter .THD can be determined from the First fourier transform (FFT).From the output waveform FFT has been done in the MATLAB simulink for 1cycle and 4 cycle respectively. For one cycle THD is 30.13% and for four cycles THD is 30.07%.

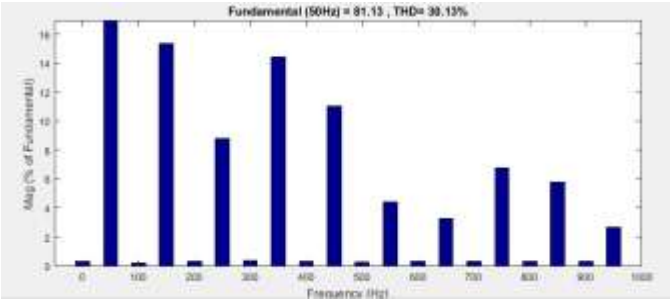

Fig -8: FFT of inverter output for 1 cycle

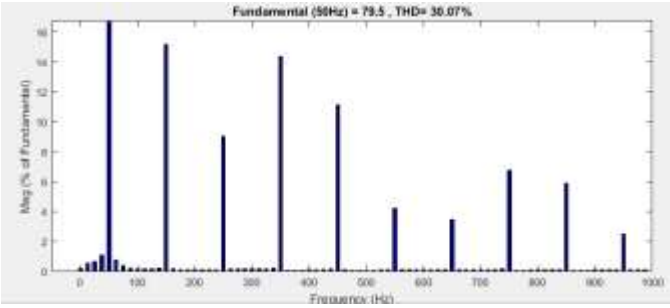

Fig -9: FFT of inverter output for 4 cycle

4. CONCLUSION

This paper introduces a proper application of H bridge multilevel topology in five level inverter. Voltage divider system using capacitor reduces the number of external sources. This proposed multilevel topology has reduces the number of switches which decreases the losses of the inverter. This inverter is very helpful for low power water pumping and domestic application. Rating of the inverter can be changed by changing the rating of the switching devices. For the development of the inverter PWM can be used for reduction of THD and better accuracy of the output sine wave. By using some different topology it will be possible to connect the inverter to the micro grid by auto synchronization.

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