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Single Phase 5-Level Inverter Switching Pulses by Interfacing Arduino Uno with MATLAB

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Abstract:
Inverters are nowadays very much in demand due to their serviceability. Based on the area of application there are various types of inverters available among them Cascade H-bridge multilevel inverter is very useful in every industrial applications, power system and home appliance. There are numerous limitations of conventional two level inverter like presence of harmonics and high rate of change of voltage that is caused in output. The elimination of presence of harmonics in the inverter output involves various techniques. Cascade connection of H bridges is one of the very efficient ways to eliminate the presence of Harmonics and high change in the output voltage. The cascade connection of H bridges provides very less or negligible change in voltage between two levels that is ultimately solution for two level inverter. In this project we are studying Cascade H bridge multilevel inverter where due to presence of multiple DC source and large number of switches change in output voltage from one level to other will be less. Cascade H-bridge inverter and their harmonics elimination using PSIM/MATLAB, the output of the cascade H bridge multilevel inverter will approach sine wave as the level increases.

Keywords: MATLAB, DSO, Arduino Uno, TDH analysis, Sinusoidal pulse width modulation.

1. INTRODUCTION

From last few decades the requirement of low power electronic devices has been increased. People are selecting devices which have low power consumption with good efficiency. And also industrial applications have begun to required higher power instrument in recent year. Some medium voltage motor drivers and utility application required medium voltage and megawatt power level. The concept of multilevel converters has been introduced since 1975. 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. When the level of inverter is increased the output voltage waveform will be ripple free and harmonics will be reduced. The harmonics is mainly caused due to low switching losses.

This results in high output voltage with the harmonics, there are many type of techniques can be done to analysis the harmonics and to get a pure sinusoidal waveform. In our project we are studying the 3-level single phase H-Bridge inverter with various sinusoidal pulse width modulation techniques. The harmonics has been decreased up to a certain level and the output waveform has been measured in a digital oscilloscope. The details of the analysis are presented in the form of graph pulses can be given to the power semiconductor switches in the form of analog design, this increases the complexity of circuit. In our project, we are using an Arduino Mega 2560 microcontroller for generating the pulses. The pulses have been generated using MATL AB/PSIM Simulink for our purpose and it is loaded in to the microcontroller.

II. MULTILEVEL INVERTER:

The recently trained used of multilevel inverters in Industry, home appliance, railway, power system and some others application due to their advantages including produce high voltage level, increase efficiency, reduce switching stress on device, reduce filter and semiconductors switch cost and generated output voltage is staircase waveform.
The features of multilevel inverters are:-
[1] It is suitable for high-voltage and high-power application.
[2] It reduces TDH.
[3] It reduces switching stress.
[4] It is very easy to made packing layout for inverter.
[5] It switches each device only once per line cycle and generated a staircase waveform to reach a pure sinusoidal output voltage by increasing the number of levels. The cascade H-bridge output of 5-level inverters are more reliable and have the best reduced the switching stress and fault sustain as compared to the others two topologies. The multilevel inverter topologies which in indicated the area of power conversation shown below in Fig1

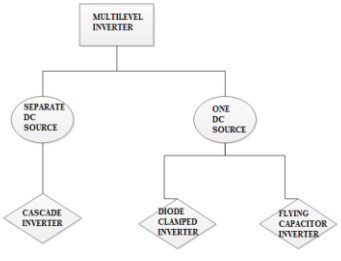


Figure.1. which is indicated the area of power conversation.

A. CASCADEDE H-BRIDGE MULTILEVEL INVERTER

Fig2: Show a five level cascaded H-bridge multilevel inverter.[4] The inverter consist of two H-bridge with series connection and each H-bridge having separate dc source. Which is fed by self-sufficient dc voltage source. In this figure two H-bridge consist of 8-MOSFET switches each H-bridge having 4-MOSFET switches. This two H-bridge switches are worked as two H-bridge series connection. So, first H- bridge switches are S1, S4 and second H-bridge switches are S1', S4' open at time S2, S3 same as second bridge S2', S3' are off. So output will be wave form of staircase. If number of level increase the number of dc source increases. It will be effect on cost of dc source and switches with complexity of inverter design circuit. This is disadvantages. The multilevel inverter are used where the demand of high power and power quality are essential, for example UPS, photo voltaic power conversion and hybrid power trains. Fig3 show the methodology of 5-level inverter analysis in matlab. First we have taken modulation index that is indicates of the ratio of peak magnitude of the modulation waveform and carrier waveform. It is relates the inverter dc-link voltage output of inverter. The modulation signal and magnitude of triangular signal vary between the peak magnitude and lower magnitude. The ratio of peak magnitude of modulation wave and the carrier wave is define as modulation index. Then comes to comparison of sine and triangular wave. In this comparison sine wave is fixed and four triangular wave vary by the modulation index. It will be given wave form of pulses. Then comes to PWM (pulse with modulation) generation .That is indicates comparison of sine and triangular wave form and it gave wave form of pulses that is given to switches. After then comes to FFT analysis.

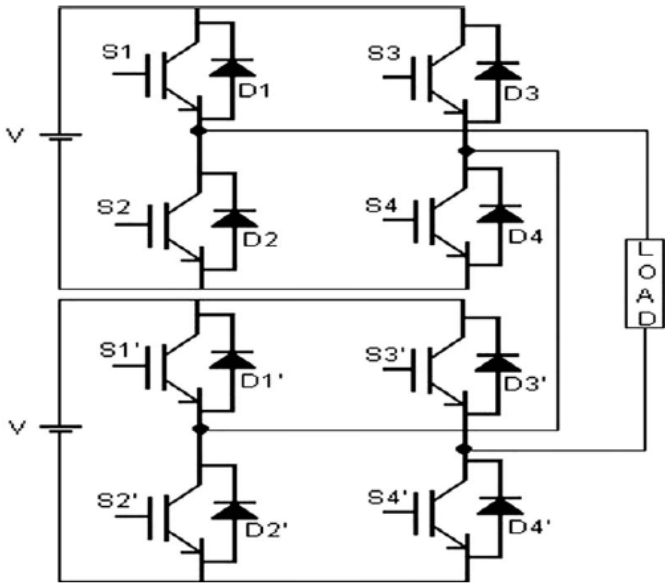


Figure.2. Five level cascaded H-bridge multilevel inverter. [4]

FFT analysis is the reduction techniques of harmonic content and fundamental component required. FFT analysis also carried out of output waveform of voltage. That FFT source the reduction of 5,7,13, level and fundamental component is higher value. Harmonic content reduces by the FFT analysis.

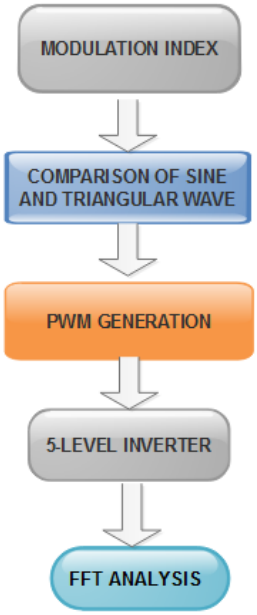


Figure.3. Methodology of Five level cascaded H-bridge inverter

III. SIMULATION RESULTS

The bridge circuit for 5-level inverter is shown below in Fig3

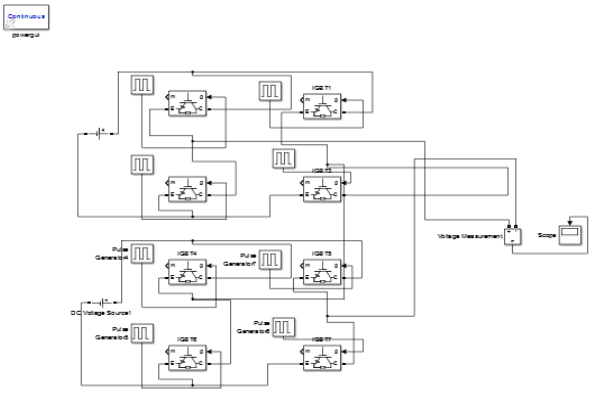


Figure.3. Simulation circuit for 5-level inverter.

The output waveform of 5-level inverter is shown below in Fig4.

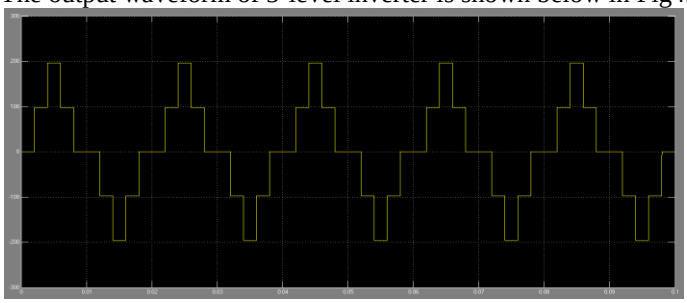


Figure.4. the output switching pulse of 5-level inverter.

The simulation circuit for 3-level inverter is shown below in Fig5.

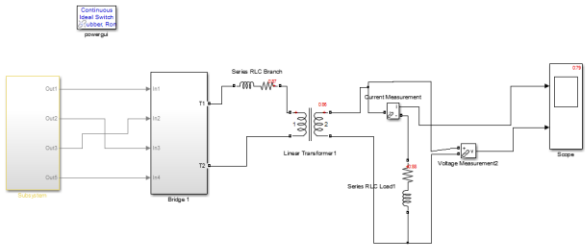


Figure.5. Simulation circuit for 3-level inverter.

The comparison of sine wave and triangular wave for 3-level inverter is shown below in Fig6.

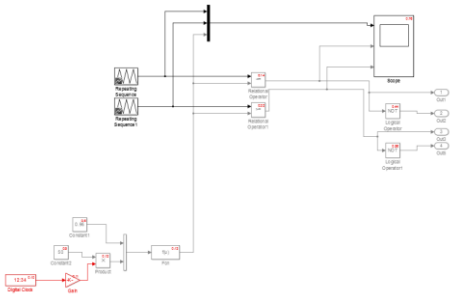


Figure.6. The comparison of sine and triagular wave.

The bridge circuit for 3-level inverter is shown below in Fig7.

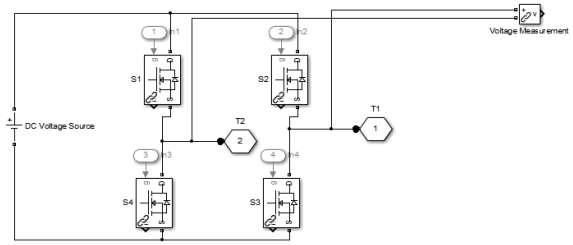


Figure.7. the simulation of bridge circuit for 3-level inverter.

The output waveform of 3-level inverter is shown below in Fig8.

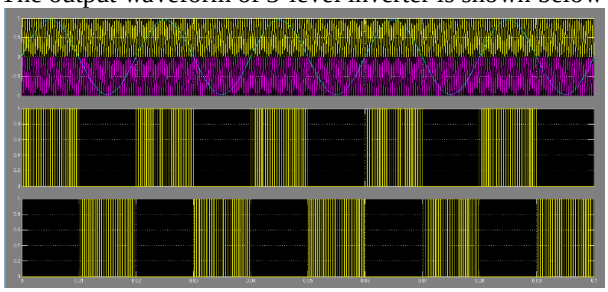


Figure.8. The results of comparison sine and triangular wave.

The switching pulse of 3-level inverter is shown below in Fig9.

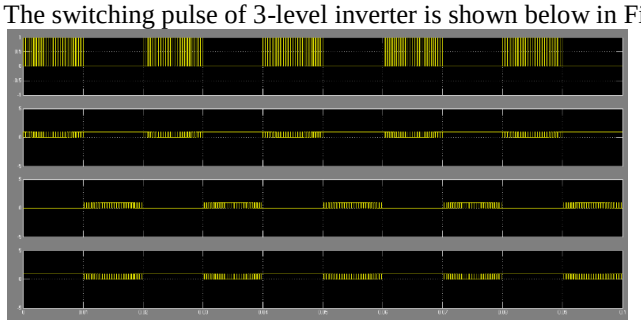


Figure.9. The output waveform of switching pulse for 3-level inverter.

The simulation power circuit for 5-level inverter is shown below in Fig10.

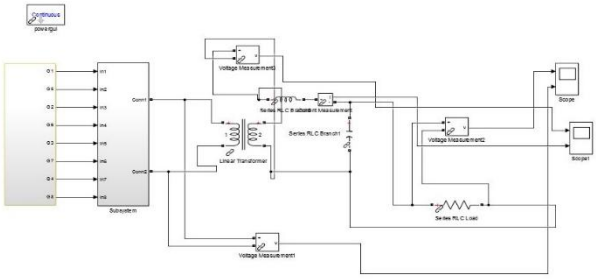


Figure.10. The simulation power circuit for 5-level inverter.

The simulation of switching circuit for 5-level inverter is shown below in Fig11.

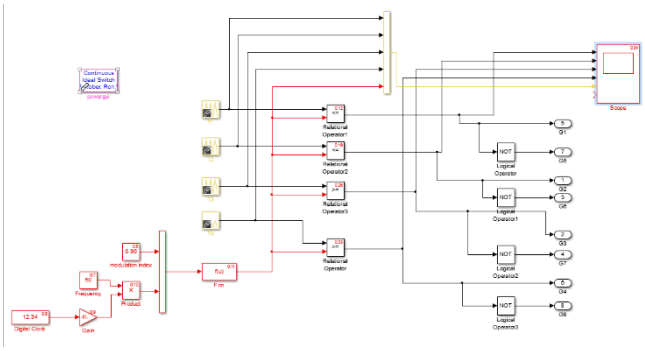


Figure.11. The simulstion of switching circuit for 5-level Inverter.

The comparison of sine and triangular wave for 5-level inverter is shown below in Fig12.

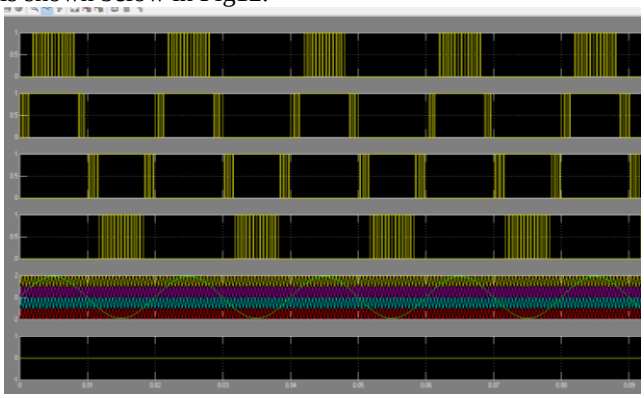


Figure.12.The results of cmaprison sine and triangular wave for 5-level inverter.

The comparison one sine and four triangular wave for 5-level inverter is shown below in Fig13.

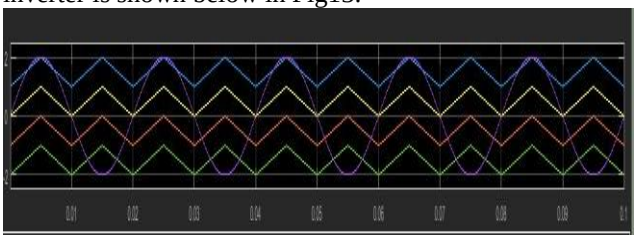


Figure.13. The result of comparison one sine and triangular wave.

The waveform of voltage and current for 5-level inverter is shown below in Fig14.

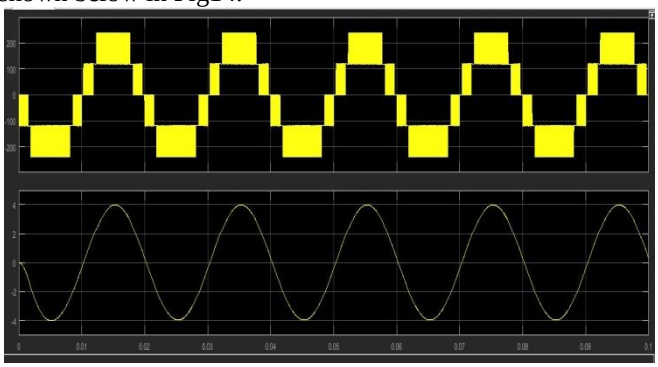


Figure.14. The results of voltage and current .

The experiment setup for 5-level inverter is shown below in Fig15.

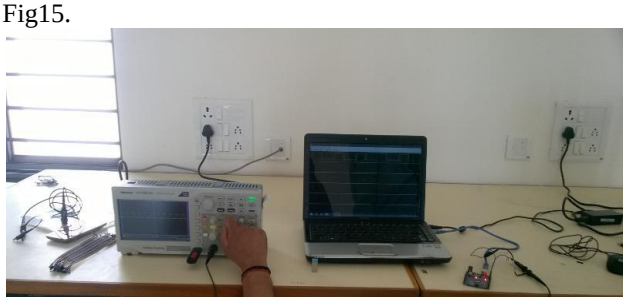


Figure.15. The experiment setup of to mesure the wave form by DSO.

The experiment setup of arduinouno interface with matlab for 5-level inverter is shown below in Fig16.

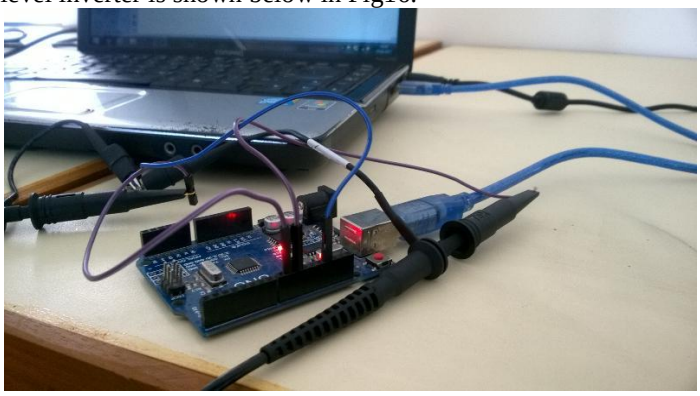
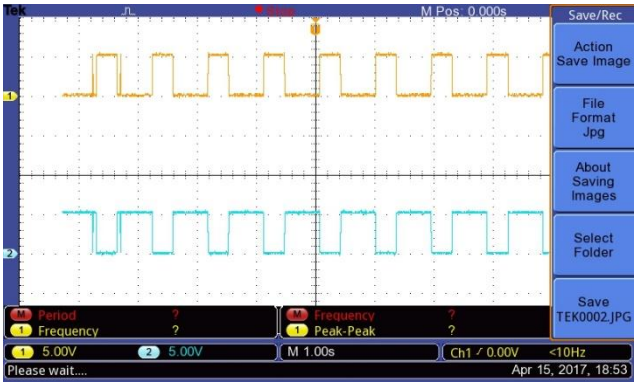
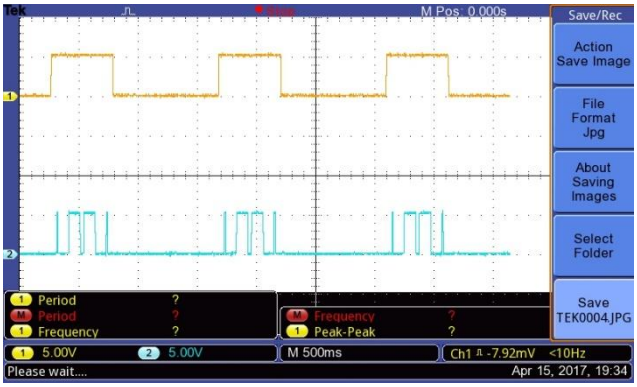
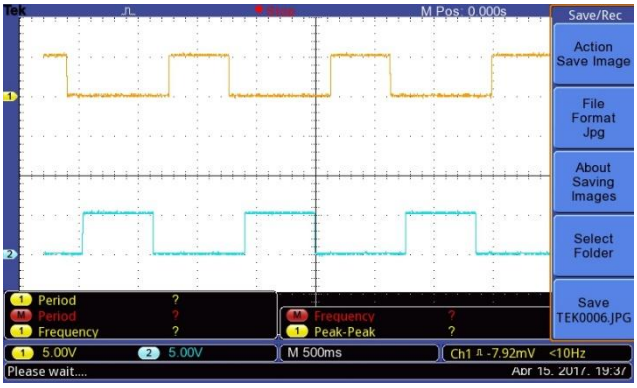


Figure.16. The experiment setup of arduino uno interface with matlab.







4. CONCLUSIONS

In this paper, the cascade H-bridge multilevel inverter from its name suggest that output will be of multilevel in the form of staircase. The Cascade H-Bridge multilevel inverter is the series connection of H-bridges which is combination of eight power switches. The output level depends on the number of H-bridge use in inverter circuit and also the number of available DC sources. Cascade H-bridge require separate DC sources. As the number of switches are more in cascade multilevel inverter the voltage stress on individual switch will be less. Here we are used SPWM techniques. In this techniques we have used comparison of sine and triangular wave to generated switching pulses by matlab simulation. The obtained switching pulses in Matlab is interfaced with arduino Uno to produce same pulses on the arduino Uno pin to measured wave form by DSO.

5. ACKNOWLEDGMENTS

Our experience of writing the pepper on “single phase 5-level inverter switching pulses by interfacings Arduino uno with

matlab" has successful, thanks to the support of many with our gratitude, we wish to thanks all of them. It is our little effort towards end. We would like to thank our Project guide "M.D.SOLANKI" who has been and will be the source of inspiration to us. We are very grateful for his support and encouragement without which this successful guidance of ours would not have been possible. We are grateful to others who contributed a major share in completion of our pepper.

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