Implementation and Analysis of A Three-Phase Inverter using Different Modulation Techniques (SPWM and SVPWM)

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***Abstract*— The aim of this paper is to design a Three Phase Inverter through which Modulation Techniques can be implemented. The proposed system will enable the user to get an idea about how different modulation techniques can have different results when they are implemented. Two modulation techniques are being compared on the basis of the waveforms that obtained as output. Overall, the system enables the user to determine which modulation technique should be implemented for better results and better performance.**

***Keywords*— Inverter, Modulation**

I. INTRODUCTION

Most appliances and machines today run on AC power. If the AC power is not available, then there must be a way to convert the DC power to AC power. This conversion is performed by a power electronics circuit called an inverter. The primary function of the power inverter is to change a DC input voltage into a symmetrical AC output voltage of the required magnitude and frequency. These devices include uninterruptible power supplies (UPS), variable speed AC drives, induction heating and backup power supplies aircraft power. In recent years, the industry has started demanding more powerful equipment and is now reaching the megawatt level. AC controlled drives in the megawatt range are usually connected to medium voltage networks. It is difficult today to directly connect a single power semiconductor switch to a medium voltage network. For this reason, a new family of multilevel inverters has emerged as a solution.

A multi-level inverter includes an array of power semiconductors and a capacitive voltage source that produces a step-wave voltage at the output. Capacitor voltage can be added through switching to achieve higher output voltages, while power semiconductors need to withstand only lower voltage.

In sinusoidal PWM, the width of each pulse changes proportionally to the amplitude of the sinusoid evaluated at the center of the same pulse. The gating signal is generated by comparing the sine wave reference to triangular carrier wave. SVPWM is a modulation technique used in FOC to determine pulse width modulated signals for inverter to get the desired voltage as output.

A. Background of Study

The need for inverters has been always been there in the industry. Many modifications have been done on the design of inverters to get a better output. Modulation techniques are used to get a better output to serve the purpose in the industry. The purpose of the modulation circuit is to convert the reference voltage into a series of switching signals to obtain this reference voltage at the converter output.

II. LITERATURE REVIEW

Medium voltage motor drives and utility applications require medium voltage and megawatt power level. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter not only achieves high power ratings, but also enables the use of renewable energy sources. Great amounts of study related to various types of inverter topologies of multilevel inverter have been studied.

The inverter is used to convert DC to AC. The device is used extensively; it has a wide range of application in high power medium voltage apparatus. The inverter can be obtained from different topologies. The commonly used topologies are Cascaded H-bridges inverter with separate dc sources, Diode-Clamped Multilevel Inverter, Flying Capacitors Multilevel Inverter. However, the Cascaded H-bridge inverter is the most popular topology. The advantages are that, the number of possible output voltage levels is more than twice the

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number of dc sources. Series of H-bridges makes for modularized layout and packaging. This will enable the manufacturing process to be done more quickly and cheaply. This topology provides flexibility for expansion of the number of levels easily without introducing undue complexity in the power circuit. The major disadvantage of the topology is that even levels cannot be obtained. This leads over specification of the system, leading to increase in cost and low efficiency. This disadvantage can be overcome by a new topology. The new topology is composed of the full bridge and a half bridge. The result is a H-bridge which gives four level output. The new topology hence overcomes the constraints of H-bridge cascaded inverter. This new topology has been simulated using MATLAB and also implemented in hardware.

A space vector PWM and SPWM method for a 3-level inverter can easily be introduced in the proposed method to minimize the output harmonic distortion voltage, limit the minimum pulse width, and balance the DC link capacitor bank voltage. The resulting solution is a simple algebraic equation that directly relates the width of the gate signal pulse to the reference phase voltage. Based on the computer simulation results, the main features of the proposed method are shown.

The SVPWM method for multilevel cascaded bridge is explained in [3]. The inverter designed in this topology gives rise to a large number of problems because of voltage vectors and its complexity. SVPWM method is basically proposed to approximate the reference vector. The simulation results are based on the multilevel cascaded H-bridge inverter and they are compared with the theoretical results. The fabrication and implementation of a 50Hz SPWM inverter for DC to AC conversion can be performed with different topologies [2]. For example, one that can be serialized from a standard wall outlet. There are generally three types of general-purpose inverters: modified sine wave, pure sine wave, and square wave. Considering output power, efficiency, and harmonics, pure sine wave inverters have the highest quality among these three types of inverters. The main goal of this article is to generate pure sinewaves.

DC/AC converters can be used for low voltage DC power sources such as solar panels or fuel cells. The battery must be converted for the device to operate on AC power. In our article, an inverter converts low-voltage DC power to high-voltage DC power. It then uses PWM to convert the high DC source into an AC signal equal to a sine wave. This inverter circuit provides a pure sine wave at all frequencies with low distortion. Modelling is initially done by Proteus software. Finally implemented and tested in real time.

III. *CONTROL AND MODULATION STRATEGIES*

In power inverters it is essential to control the output voltage. This can be done by internal or external control. Internal control can be done within the inverter itself using different PWM techniques. In pulse width modulation technique, more specifically sine PWM, the reference wave i.e. a sine wave is compared with a triangular wave. The generated pulses are then further given to the gate terminal of power switches. By proper modulation, desired output level can be obtained. Further the harmonics can also be reduced.

Pulse width modulation (PWM) strategies used in a conventional inverter can be modified to use in multilevel converters. The modulation methods used in multilevel inverters can be classified according to switching frequency. Method that works with high switching frequencies has many commutations for the power semiconductors in one period of the fundamental output voltage. A very popular method used in industrial applications is the classic carrier based sinusoidal PWM (SPWM) that uses the phase-shifting technique to reduce the harmonics in the load voltage.

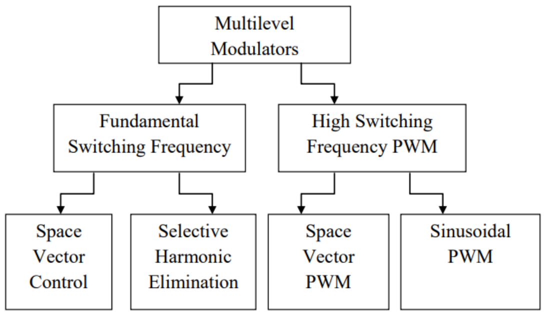

Fig 3.1: Classification of Multilevel Modulation Methods

IV. *PROPOSED WORK*

A. *Requirements*

An inverter is a device which is used to Alternating Current (AC) to Direct Current. The most important aspect about any inverter is the switches that are going to be used. Depending on the needs and requirement either IGBTs or Mosfets could be used. The switch rating would differ from application to application.

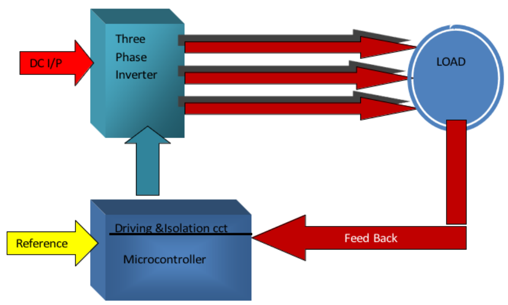

Fig 4.1: Proposed System

B. Application Architecture

The proposed system is designed to be used and studied as a prototype. The switches that are used can be replaced with switches of higher or lower ratings. The selection of switches will depend upon the required output and the application for which the inverter is being used. By the implementation of Modulation techniques better results can be achieved. This would be beneficial in any application.

V. RESULTS AND ANALYSIS

VI.

A. Software Results and Analysis

In this study, MATLAB was used for software implementation of the processed study. The tools were selected for their capacity to simulate and model electronic circuits, enabling the design testing.

The inverter design was tested for two modulation techniques- SPWM and SVPWM. The output for both were recorded in the form of waveforms. The waveforms were taken as the basis of comparison to determine which modulation technique is better.

The inverter circuits and the waveform results/outputs are given below in the figures.

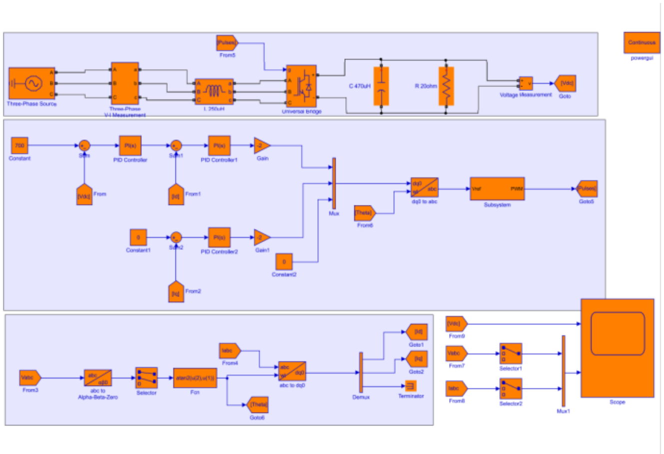

Fig 5.1 PWM Simulation

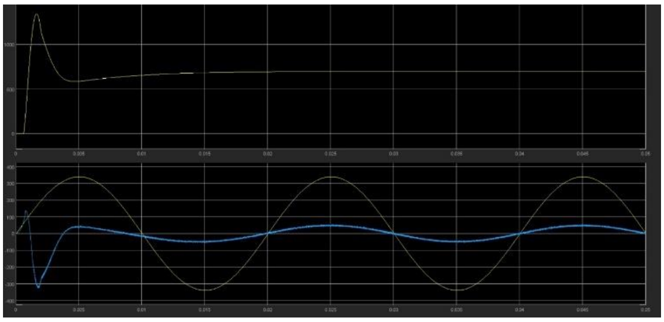

Fig 5.2 PWM Output

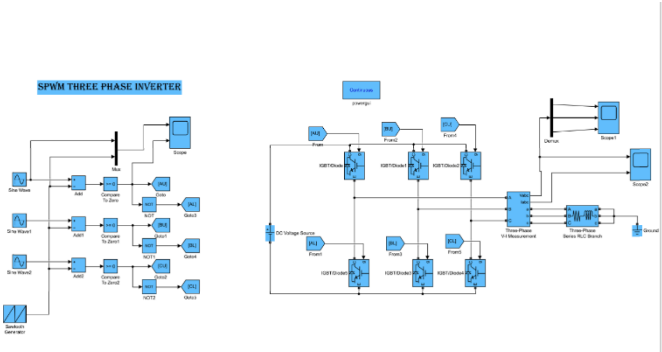

Fig 5.3 SPWM Simulation

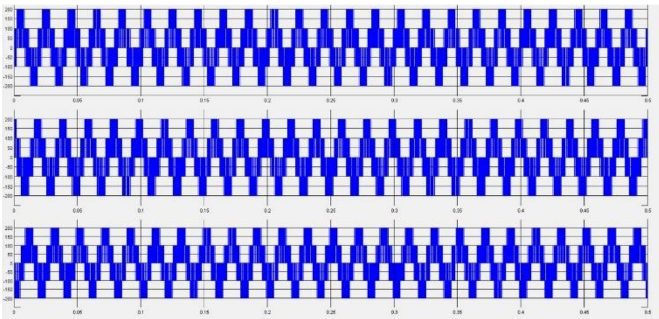

Fig 5.4 SPWM Simulation Output

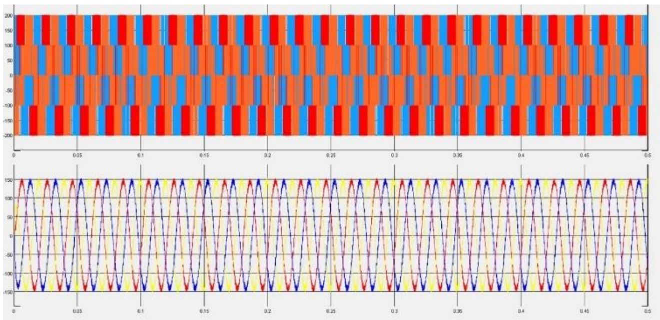

Fig 5.5 SPWM Simulation Output

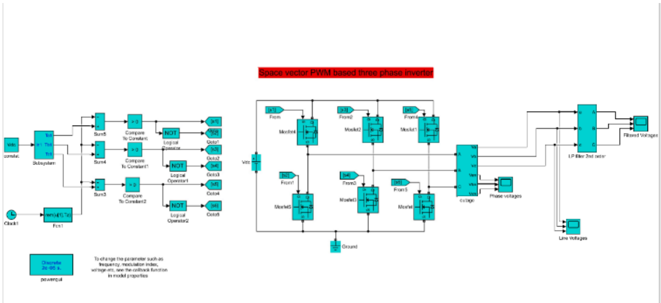

Fig 5.6 SVPWM Simulation

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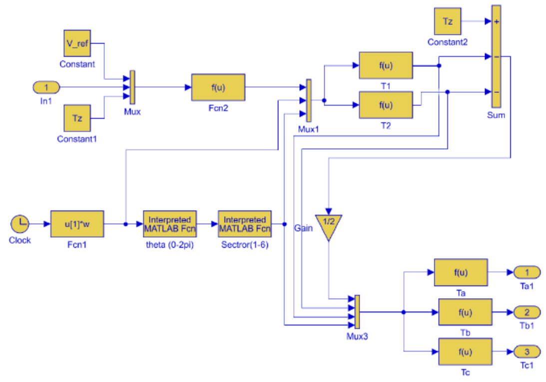

Fig 5.7 SVPWM Simulation Sub- Systems

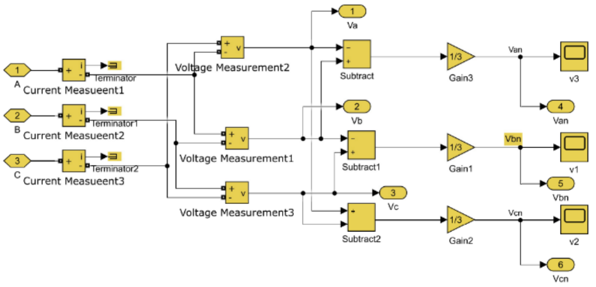

Fig 5.8 SVPWM Simulation Sub- Systems

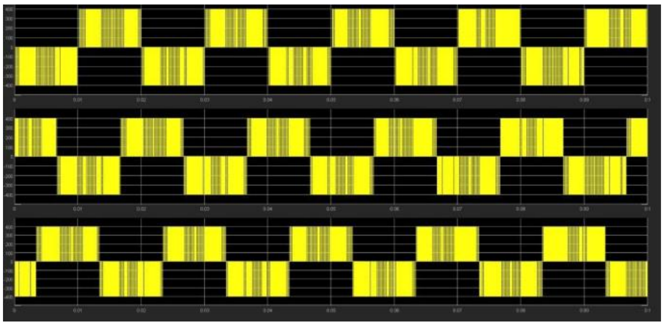

Fig 5.9 Phase Voltage

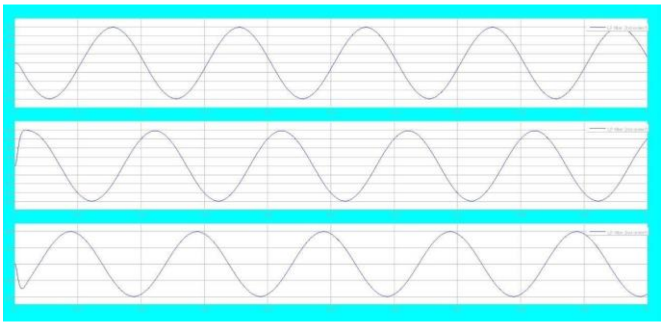

Fig 5.10 Filtered Output Voltage

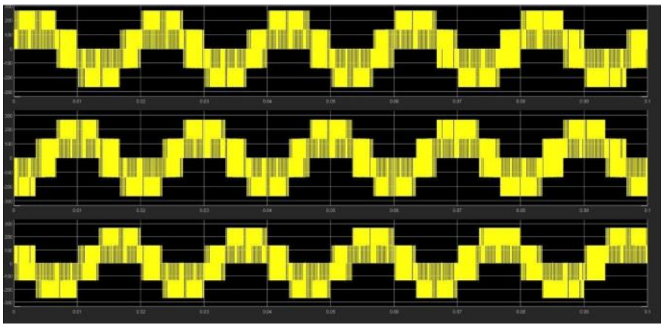

Fig 5.11 Line Voltage

B. Hardware Analysis

Hardware implementation aims at cascading two single level inverters to obtain a three level inverter. The key components in the hardware implementation are:

- Power MOSFETS
- IR2110
- ATMEGA 8
- IN 4148
- µf 4007

Power MOSFETs are used as switching devices, NOT Gate is in a single level inverter to give signal to negative half inverse to that of the positive half and the IR 2110 is to give gating pulses of modulated pulse width and also for phase shifting.

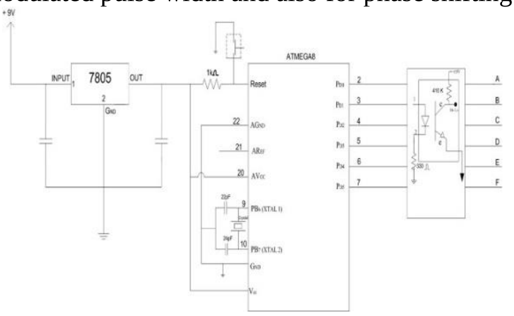

Fig 5.12: Controller Diagram

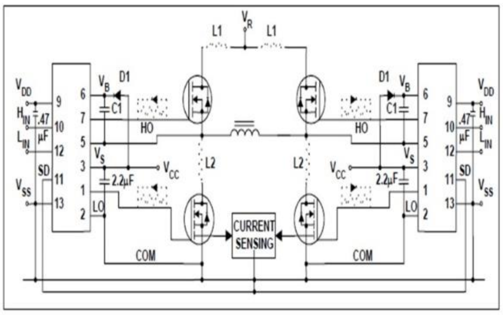

Fig 5.13: Connection of Inverter

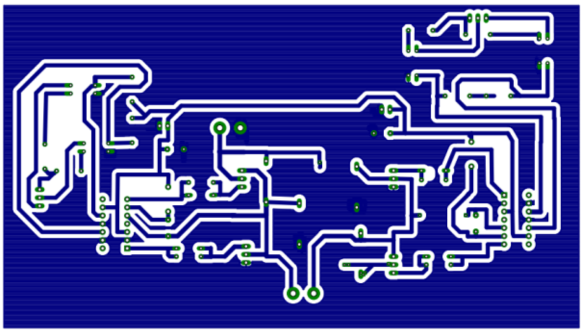

Fig 5.14: PCB of Inverter

VII. CONCLUSION

In conclusion, this proposed project is designed to give an analysis about the working of a three-phase inverter. It also covers the aspect of different modulation techniques- SPWM and SVPWM. Both these modulation techniques are compared on the simulation software and their respective results are obtained. This project is basically a prototype whose limits could be extended to a very higher range. It could be used in the industries depending upon the application. By the implementation=ion of modulation techniques the desired output can also be achieved as these modulation techniques enhance the quality of the output.

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