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Simulation based Analysis of Space Vector Pulse Width Modulation (SVPWM) in AC Drives

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Abstract:** Since a solid state transformer is a three stage AC/AC converter with a high frequency transformer and because of advanced features like high power density, on demand var support and frequency control, solid state transformer is an empowering innovation for the advanced power distribution systems. It can likewise discover application in high power density engine drives. The single stage solid state transformer considered in this work is equipped for bidirectional power stream and open loop power factor rectification. This topology utilizes a base measure of copper and has generally few semiconductor switches. In this work we exhibit a novel modulation SVPWM system utilizing Solid State Transformer for AC drives. Multilevel inverters produce sinusoidal voltages from discrete voltage levels, and pulse width modulation (PWM) methodologies achieve this assignment of creating sinusoids of variable voltage and frequency. Modulation techniques for Hybrid Multilevel Inverter can be according to the switching frequency strategies. A wide range of PWM techniques have been developed to accomplish the following: wide linear modulation range, low switching loss, diminished Total Harmonic Distortion (THD) in the spectrum of switching waveform: and simple usage and less calculation time. The most generally utilized methods for executing the pulse width modulation (PWM) procedure for multilevel inverters are Sinusoidal PWM (SPWM) and space vector PWM (SVPWM). The SVPWM is considered as a superior method of PWM usage as it has points of interest over SPWM as far as great use of dc bus voltage, diminished switching frequency and low current ripple is displayed. SVPWM can be effectively executed in a couple of microseconds, accomplishing comparative outcomes compared with other PWM strategies.

***Keywords:** SVPWM, SST, THD, AC Drives, VSI.*

I. INTRODUCTION

Power generation, transmission, and distribution are the three principle constituents of the present age power systems, in which the power transformer assumes a most basic part. Power transformers empower high-proficiency and long-distance power transmission by boosting the voltage to a higher one in the generation side. In the distribution network side, this high voltage is ventured down for commercial, industrial and residential purposes. The improvement patterns of the traditional power transformers are mostly centered around new magnetic materials, protection materials, manufacturing processes, and other monetary elements. Recently, together with other technological advancements, power electronics is by and large genuinely considered as one of the profitable advances that could enable future smart-grids, doing as such at all levels of electrical power frameworks. The powerful converter has discovered its wide application in both transmission and distribution power systems over the previous decades, for example, in high-voltage dc (HVDC) transmission frameworks, flexible ac transmission systems (FACTS) gadgets, for example, static Var compensator, static synchronous compensator (STATCOM), unified power flow controller (UPFC), and others, and sustainable power source frameworks, particularly in substantial infiltration of inexhaustible assets, for example, solar and wind. In the ongoing decade, another powerful converter, named solid-state transformer (SST) (also known as power electronic transformer), has grabbed much eye and been broadly examined for the distribution systems. In the course of recent years, a few endeavors have been made to convey a low-voltage and power SST prototype. However, SSTs right now are constrained by voltage and power rating of the power gadgets and accessible circuit topologies, and all things considered have not infiltrated into the appropriation frameworks [1]. The fundamental thought of the SST is to accomplish the voltage change by medium-to high-frequency confinement, hence to conceivably diminish the volume and weight of it contrasted and the conventional power transformer. In spite of the fact that the idea of SST is direct, the outline and execution are difficult. The SST is basically a high-voltage and high-control electronic circuit, of which the design and reliable operation are dependably a challenge. Likewise, SST contains numerous different parts other than the high-frequency transformer, for example, power devices, gate drivers, heat sinks, control circuits, cooling framework, auxiliary power, and other circuitry. All things considered, looked for bring down volume and weight decrease may not be ensured without a cautious plan [2]. Actually, the viable size and weight decrease of the SST contrasted and the conventional transformer can be accomplished just when the extent of the high-frequency transformer is sensibly bigger than whatever is left of the parts. Thus,

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awesome endeavors are as yet required toward the fast advancement of the SST [2,3]. To direct the plan of the SST in the power distribution networks, a survey of the best in class innovation of the distribution transformers, including proficiency, volume and weight, and cost, is at first introduced.

II. SPACE VECTOR MODULATION

The coveted three stage voltages at the yield of the inverter could be spoken to by a proportional vector V pivoting in the counter clock astute bearing as appeared in Figure 4.6.a. The greatness of this vector is identified with the size of the yield voltage as appeared in Figure 4.6.b and the time this vector takes to finish one upset is the same as the crucial day and age of the yield voltage.

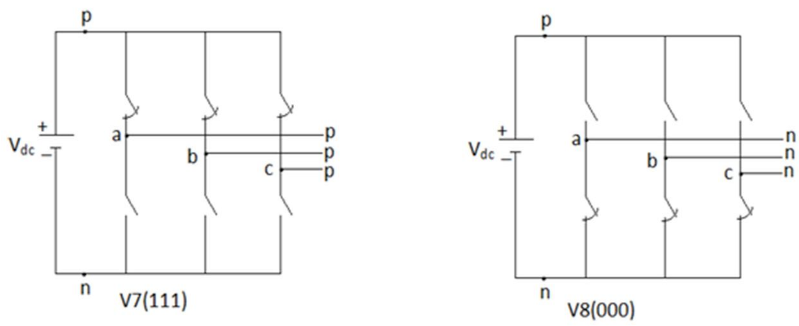

Figure 1 Zero Output Voltage Topologies

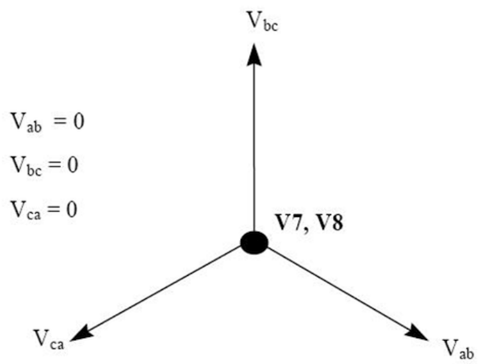

Figure 2 Representation of the zero voltage vectors in the α, β plane

At the point when the coveted line-to-line yield voltage vector V is in part 1 as appeared in Figure 4.7., vector V could be blended by the beat width balance (PWM) of the two contiguous exchanging state vectors V1 (pnn) and V2 (ppn), the obligation cycle of each being d1 and d2, individually, and the zero vector (V7 (nnn)/V8 (ppp)) of obligation cycle d0

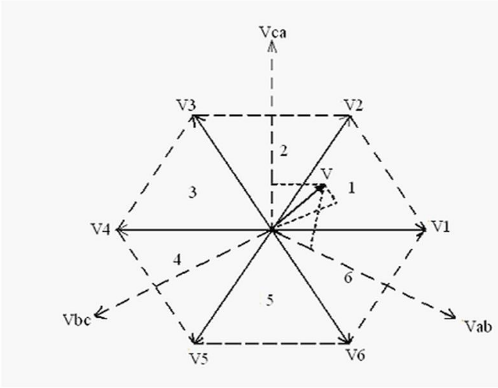

Figure 3 Output voltage vector in the α, β plane

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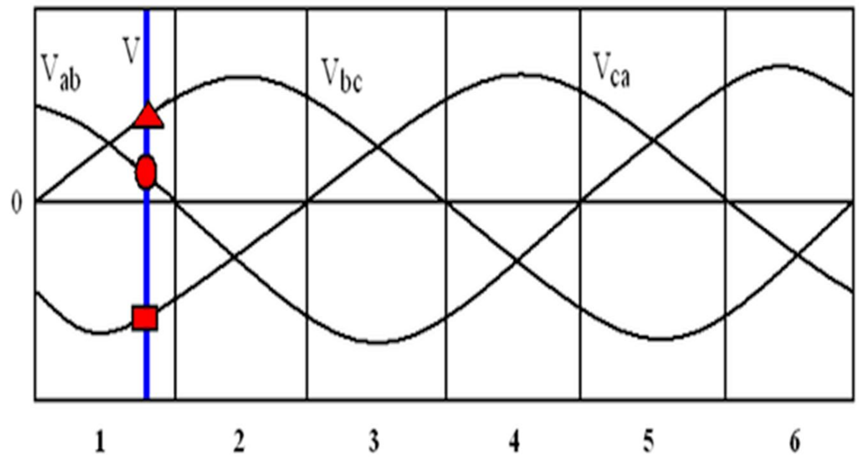

Figure 4 Output Line Voltages

Where, 0 m 0.850 is the adjustment file. This would relate to a most extreme line-to-line voltage of 1.0Vg, which is 15% more than customary sinusoidal PWM. All SVPWM plans and the greater part of the other PWM calculations, utilize the Equations 4.3 and 4.4 for the yield voltage blend [4]. The adjustment calculations that utilize non-neighboring exchanging state vectors have been appeared to deliver higher THD and additionally exchanging misfortunes. However, some of them, for e.g. hysteresis balance, can be extremely easy to actualize and can give quicker transient reaction. The obligation cycles d1 , d2 and d0 , are particularly decided from Figure 4.7, and the conditions of 4.3 and 4.4, the main contrast between PWM plans that utilization nearby vectors is the decision of the zero vector(s) and the arrangement in which the vectors are connected inside the exchanging cycle.

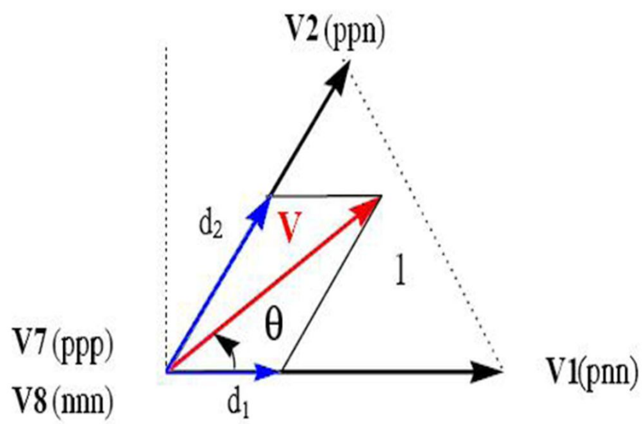

Figure 5 Synthesis of the Required Output Voltage Vector in Sector 1

A. *General Structure Of The Space Vector Modulation Algorithm*

The control preparing unit computes the essential parameters to apply an exchanging state. The info information to the control preparing unit is the reference space vector. Amid different cycles, the unit decides the division number, triangle number of the sub hexagon. The division number and triangle number distinguish the right exchanging grouping. The flowchart is given for a n-level inverter and can be utilized for any n-levels without change. The information supply is the sufficiency of the voltage steps and tweak list m, the underlying estimation of o. The stream graph of the proposed calculation to discover least THD is appeared in Figure 4.8. The regulation record mc is figured for different emphases [5]. The distinction between two regulation record terms is figured.

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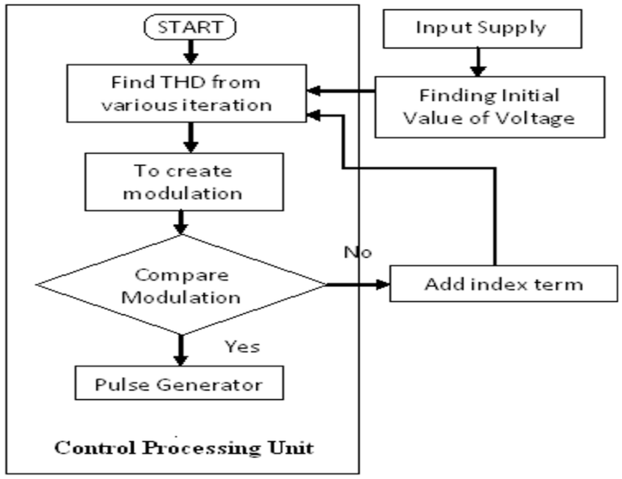

Figure 6 Flowchart of the Algorithm

$$|m-m_c| < \delta$$

where,

$\delta -$ Reference value increases (or) decreases the pulse generation in the pulse generator.

In the event that the contrast between the two regulation record terms is not as much as reference esteem , the proposed calculation yields the ideal exchanging edges. The cycle strategy is utilized to illuminate and discover minimization of the voltage THD.

III.SPACE VECTOR PULSE WIDTH MODULATION FOR SST

Staggered inverters create sinusoidal voltages from discrete voltage levels, and heartbeat width regulation (PWM) methodologies achieve this errand of producing sinusoids of variable voltage and recurrence. Balance techniques for Hybrid Multilevel Inverter can be ordered by the exchanging recurrence strategies. A wide range of PWM strategies have been created to accomplish the accompanying: Wide straight regulation range, less exchanging misfortune, diminished Total Harmonic Distortion (THD) in the range of exchanging waveform: and simple execution and less calculation time. The most generally utilized procedures for actualizing the beat with adjustment (PWM) technique for staggered inverters are Sinusoidal PWM (SPWM) and space vector PWM (SPWM). The SVPWM is considered as a superior procedure of PWM usage as it has favorable circumstances over SPWM as far as great use of dc transport voltage, decreased exchanging recurrence and low current swell [6]. SVPWM is viewed as a superior procedure of PWM execution, as it gives the accompanying points of interest,

1) Better key yield voltage.
2) Useful in enhancing consonant execution and decreasing THD.
3) Extreme straightforwardness and its simple and direct equipment execution in a Digital Signal Processor (DSP).
4) SVPWM can be productively executed in a couple of microseconds, accomplishing comparative outcomes contrasted and other PWM techniques.

In this part, a space vector is characterized in a two-dimensional (2-D) plane and a SVM is performed in the 2-D plane. Moreover, a three dimensional (3-D) space vector has been characterized in this part for fell H-connect staggered inverter. All the current space vector adjustment plans are executed in a two-dimensional, and are along these lines unfit to manage the zero-grouping part caused by unequal load [7]. Unpredictability and computational cost of conventional SVPWM procedure increment with the quantity of levels of the inverter as a large portion of the space vector balance calculations proposed in the writing include trigonometric capacity estimations or look-into tables. Be that as it may, unequal dc sources can't be connected to diode-clipped inverter. In the mean time, the initial 3-D space vector regulation for fell H-connect, which is equipped for managing zero-arrangement segment caused by uneven load. The three-dimensional space vector adjustment plans are supersets of, and therefore are perfect with, regular two-dimensional space vector regulation plans. Another upgraded 3-D SVPWM (3-D OSVPWM) is like effectively existing 3-D SVPWM introduced in, following a comparative documentation [8]. The proposed SVPWM method compute the closest changing vectors succession to the reference vector and the on-state lengths of the separate exchanging state vectors by methods for straightforward 63 expansion and examination activity, without utilizing trigonometric capacity figuring's, look-into tables or organize framework changes. Such low intricacy and computational cost make them exceptionally appropriate for execution in ease gadgets. Notice that these 3-D OSVPWM procedures can be connected with adjusted and lopsided frameworks. Execution of the 2-D SVPWM and 3-D OSVPWM methods is completed. Both SVPWM calculations are actualized into a Field Programmable Gate Arrays (FPGA) from Xilinx Foundation [9]. MATLAB Simulink is utilized to build up all recreation works. At long last, both algorithmic usages have been tried with a fell H-connect staggered inverter.

IV. RESULTS

MATLAB is a great dialect for specialized processing. The name MATLAB remains for Matrix Laboratory, since its essential information component is a lattice (cluster). It is fourth era of abnormal state programming dialect for math calculations, displaying and reproductions, information examination and preparing, perception and designs, and calculation advancement.

A. SST SVM Model

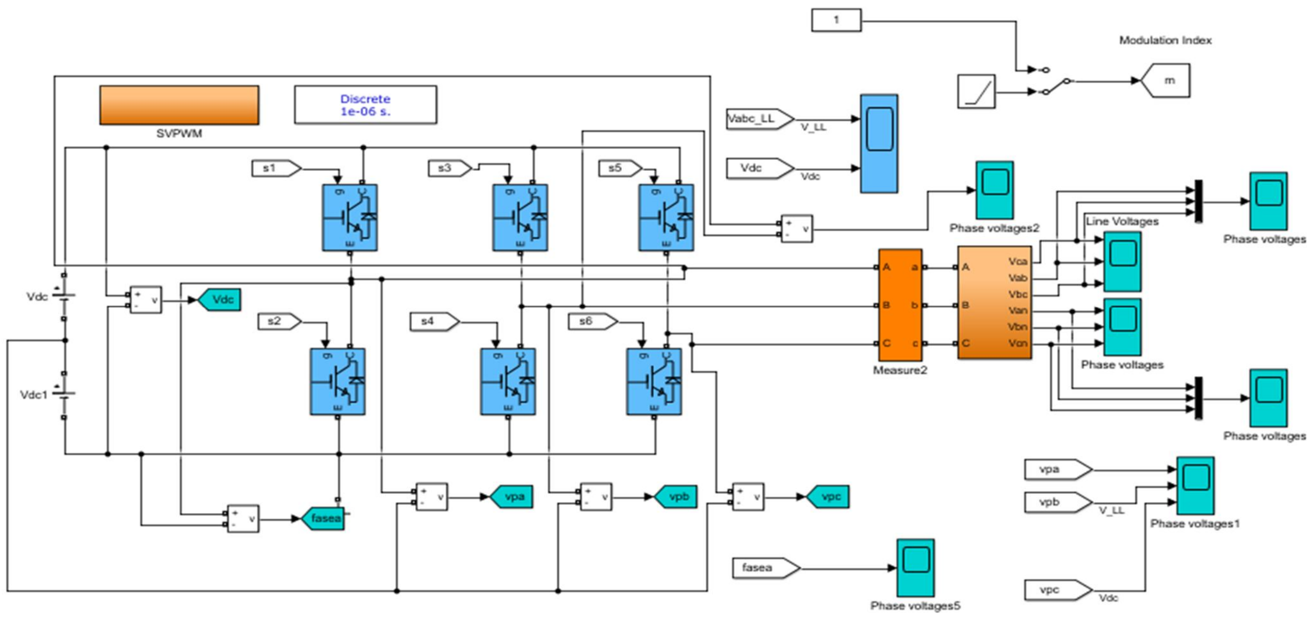

Fig 7 Design of Proposed scheme in Simulink with SVPWM

Fig 7 shows the simulink model of SVPWM ac drive. Model has been drawn on MATLAB. In the next stage output has also been shown.

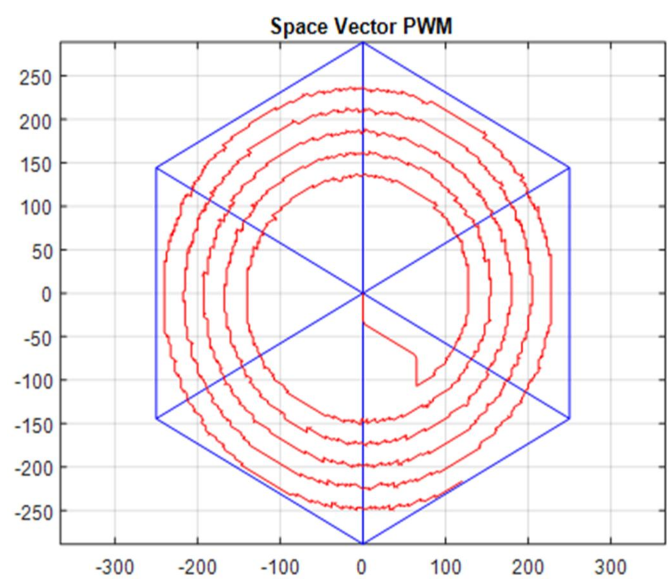

Fig 8 XY plot of SVPWM after completion of simulation

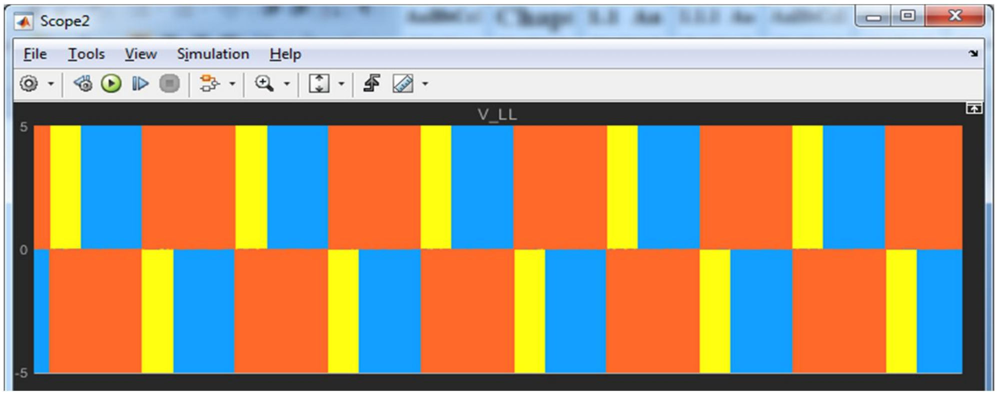

Fig 9 phase voltage of SVPWM for SST

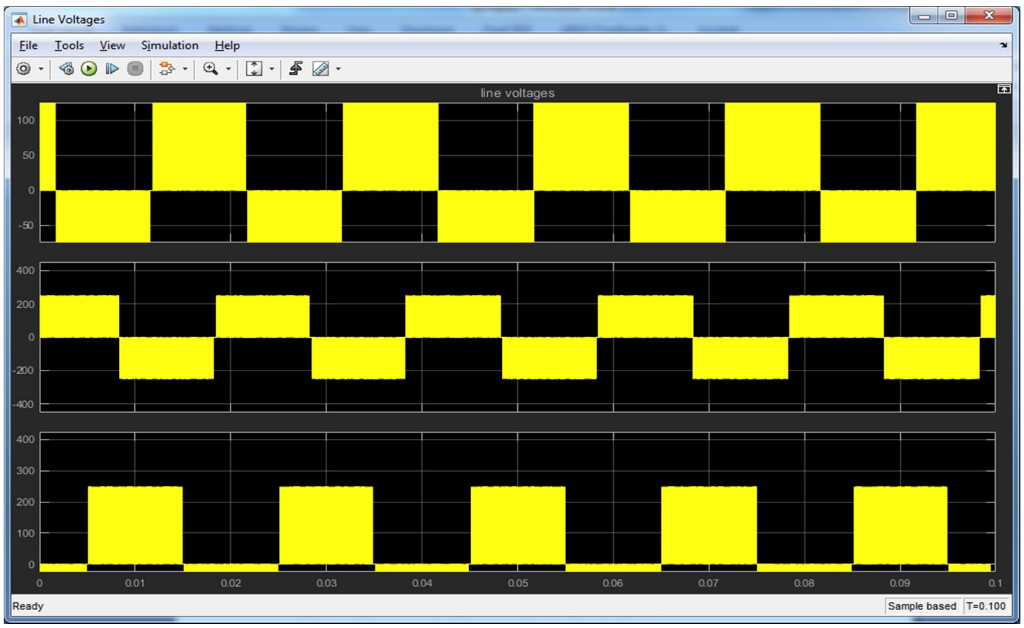

Fig 10 Line voltage of SVPWM for SST

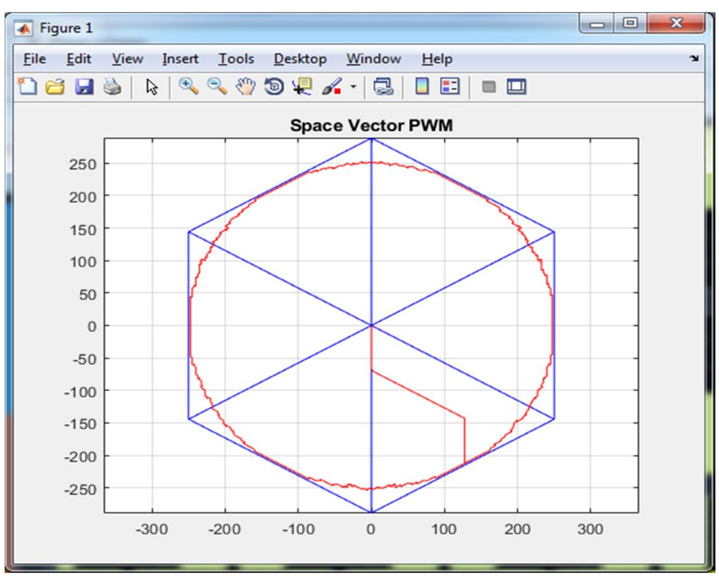

Fig 11 XY plot of SVPWM After switching modulation index to 1

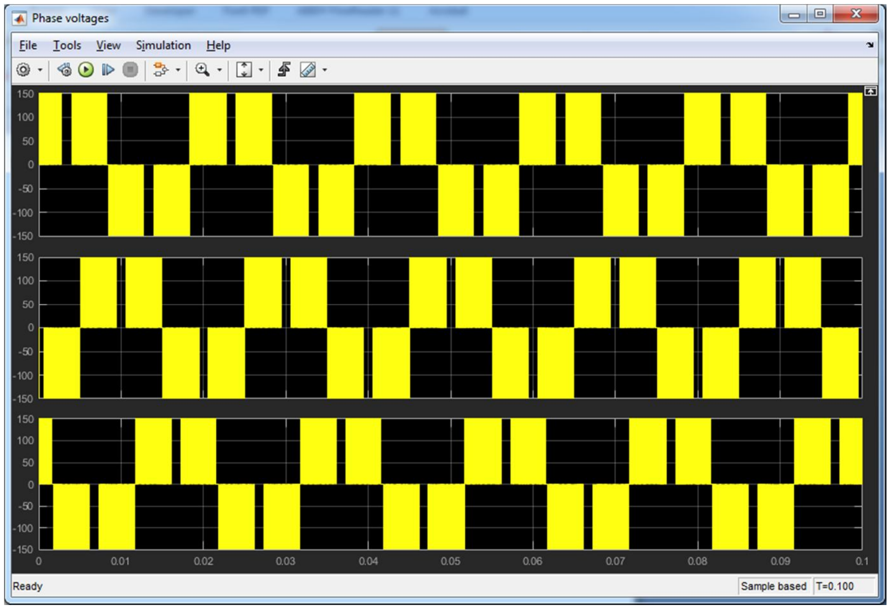

Fig 12 Phase voltage of SVPWM After switching modulation index to 1

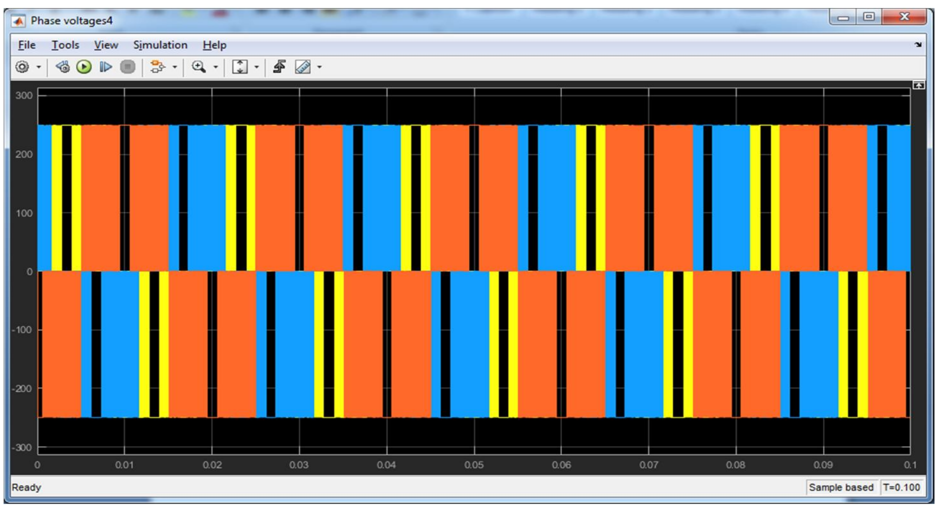

Fig 13 Line voltage of SVPWM After switching modulation index to 1

V. CONCLUSION

As a solid state transformer is a three stage AC/AC converter with a high frequency transformer. Because of cutting edge highlights like high power thickness, on request var support and recurrence direction, strong state transformer is an empowering innovation for the advanced power appropriation framework. It can likewise discover application in high power thickness engine drives. The single stage strong state transformer considered in this work is equipped for bidirectional power stream and open circle control factor remedy. This topology utilizes a base measure of copper and has moderately few semiconductor switches. Multilevel inverters generate sinusoidal voltages from discrete voltage levels, and pulse width modulation (PWM) strategies accomplish this task of generating sinusoids of variable voltage and frequency. Modulation methods for Hybrid Multilevel Inverter can be classified according to the switching frequency methods. Many different PWM methods have been developed to achieve the following: Wide linear modulation range, less switching loss, reduced Total Harmonic Distortion (THD) in the spectrum of switching waveform: and easy implementation and less computation time. The most widely used techniques for implementing the pulse with modulation (PWM) strategy for multilevel inverters are Sinusoidal PWM (SPWM) and space vector PWM (SPWM). The SVPWM is considered as a better technique of PWM implementation as it has advantages over SPWM in terms of good utilization of dc bus voltage, reduced switching frequency and low current ripple is presented.

VI. ACKNOWLEDGEMENT

I concede the way my guide Er. Navnidhi Sharma played an important role in carrying out this work and all those difficult times when it was looking like a blind alley. She gave me confidence and motivated me to take up this work. All my toiling efforts were based on her motivation. Finally, i would like to mention my parents which are the be-all and end-all inspirations and motivations to me.

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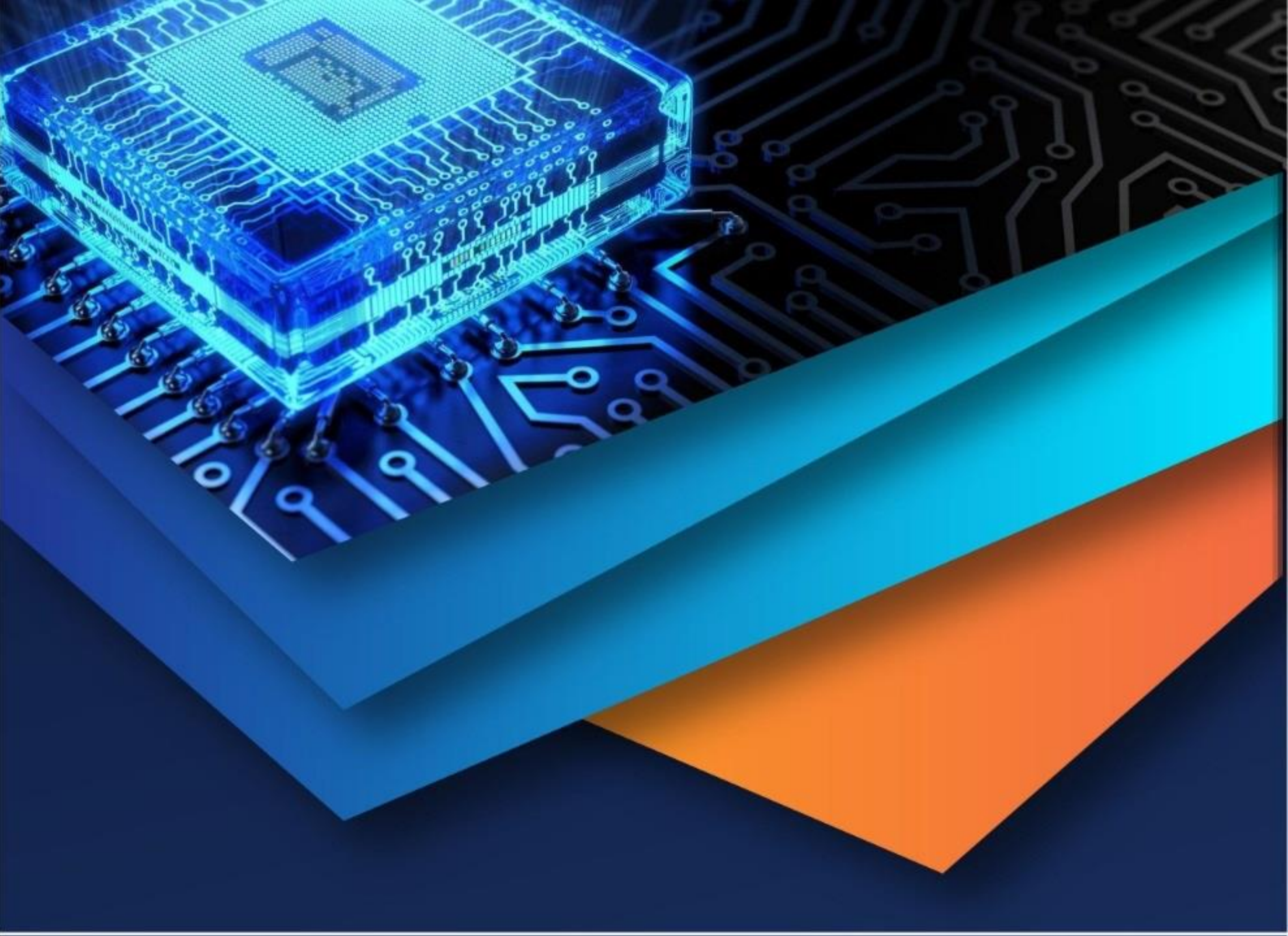

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