Harmonic distortion analysis of SVPWM based Induction Motor

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ABSTRACT: **This** paper represents the analysis and simulation of SVPWM based induction motor drive. Total harmonic distortion analysis has been done of voltages and currents at different conditions. Due to simplicity of space vector pulse width modulation. The proposed method use a control system to generate a better power quality with lesser value of harmonic distortions. The simulation is done on a MATLAB software and the simulation results obtained and analysed. The most commonly used PWM schemes for three-phase voltage source inverters (VSI) are sinusoidal PWM (SPWM) and space vector PWM, (SVPWM). There is an increasing trend of using space vector PWM (SVPWM).The simulation is done on a MATLAB software and the simulation results obtained and analysed.

KEYWORDS:*Space vector pulse width modulation (SVPWM), Pulse Width Modulation (PWM), Insulated gate bipolar transistor (IGBT), Total harmonic distortion (THD), STATCOM (static synchronous compensator), SVC (static VAR compensator), and UPQC unified power quality conditioner*

I.INTRODUCTION

During the last few decades, the feasible control of induction machines receives a lot of attentions due to the extension of power electronics. With the development of power electronics, the power semiconductor devices are being broadly used in the power electronic converters, which convert power from one form to another. Many advanced semiconductor devices are existing today in power electronics market like BJT, MOSFET, IGBT, etc. The fast-switching devices and the techniques of Digital Signal Processor (DSP) provide the suitable ways to realize the complex control algorithms such that the induction machines can be controlled in different ways to satisfy certain requirements [1].

A Sinusoidal Pulse Width Modulation technique is also known as the triangulation, sub oscillation, sub harmonic method is very popular in industrial applications. In this technique a high frequency triangular carrier wave is compared with the sinusoidal reference wave determines the switching instant. When the modulating signal is a sinusoidal of amplitude Am, and the amplitude of triangular carrier wave is Ac, then the ratio m=Am/Ac, is known as the modulation index. It is to be noted that by controlling the modulation index one can control the amplitude of applied output voltage. [2]

For wide variation in drive speed, frequency of the applied AC voltage needs to be varied over a wide range. The applied voltage also needs to be varying almost linearly with the frequency. The harmonic content in the output of the inverter can be reduced by employing pulse width modulation (PWM). Sinusoidal PWM (SPWM) is affecting in reducing lower order harmonics while varying the output voltage and gone through many revisions and it has a History of three decades. Some of the following constraints for slow varying sinusoidal voltage be considered as the modulating signal are:

1. The peak magnitude of the sinusoidal signal is less than or equal to the peak magnitude of the carrier signal. This ensures that the instantaneous magnitude of the modulating signal never exceeds the peak magnitude of the carrier signal.

2. The frequency of the modulating signal is several orders lower than the frequency of the carrier signal. For example 50 Hz for the modulating signal and 20 KHz for the carrier signal. Under such high frequency ratio's the magnitude of the modulating signal will be virtually constant over any particular carrier signal time period.

3. A three phase Sine-PWM inverter would require a balanced set of three sinusoidal modulating signals along with a triangular carrier signal of high frequency.[2]

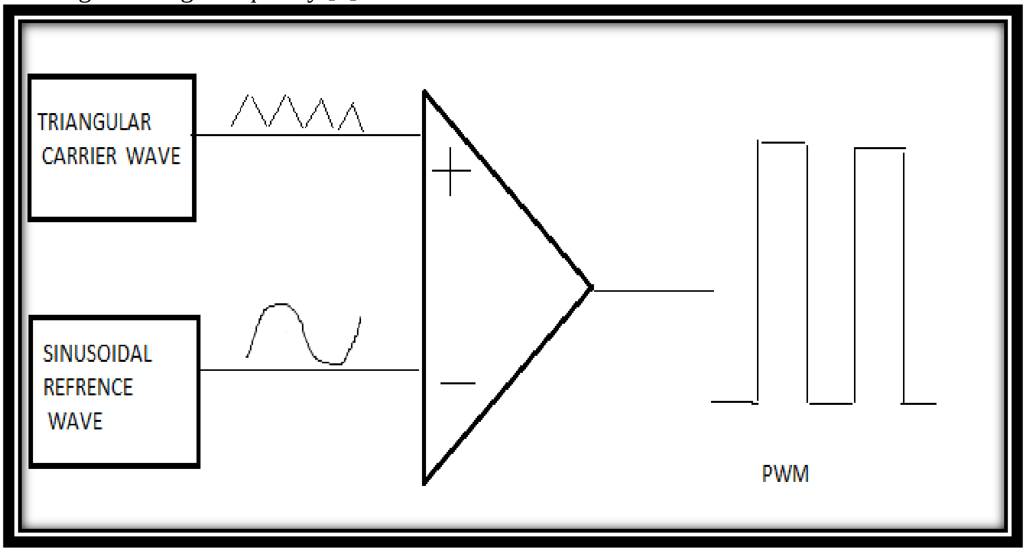

Figure 1: Sinusoidal Pulse width modulation

Following are the requirements of reactive power compensation: (1) it is required to supply/absorb reactive power to maintain the rated voltage to deliver the active power through the long transmission lines. This Voltage support helps in (a) reduction of voltage fluctuation at a given terminal of the long transmission line. (b) An increase in transfer of active power through a long transmission line (c) increases the stability. (2) Many Loads like motor loads require reactive power for their proper operation. This Load compensation helps in (a) improvement of power factor (b) balancing of real power drawn from the supply (c) better voltage regulation due to large fluctuating loads. (3) The modern industries use electronic controllers which are sensitive to poor voltage quality and will shut down if the supply voltage is depressed and may mal-operate in other ways if changes of the supply voltage is excessive. Many of these modern load equipment's itself uses electronic switching devices which then can contribute to poor network voltage quality [3]

II. INDUCTION MOTOR

The Induction Motor has a stator and a rotor. The stator is wound for three phases and a fixed number of poles. It has stampings with evenly spaced slots to carry the three-phase windings. The number of poles is inversely proportional to the speed of the rotor. When the stator is energized, a moving magnetic field is produced and currents are formed in the rotor winding via electromagnetic induction. Based on rotor construction, Induction Motors are divided into two categories. In Wound-Rotor Induction Motors, the ends of the rotor are connected to rings on which the three brushes make sliding contact. As the rotor rotates, the brushes slip over the rings and provide a connection with the external circuit. In Squirrel-Cage Induction Motors, a "cage" of copper or aluminium bars encase the stator. These bars are then shorted by brazing a ring at the end connecting all the bars. This model is the more rugged and robust variant of the Induction Motor.

Working

When the stator winding is energized by a three-phase supply, a rotating magnetic field is set-up which rotates around the stator at synchronous speed Ns. This flux cuts the stationary rotor and induces an electromotive force in the rotor winding. As the rotor windings are short-circuited a current flows in them. Again as these conductors are placed in the stator's magnetic field, this exerts a mechanical force on them by Lenz's law. Lenz's law tells us that the direction of rotor currents will be such that they will try to oppose the cause producing them. Thus a torque is produced which tries to reduce the relative speed between the rotor and the magnetic field. Hence the rotor will rotate in the same direction as the flux. Thus the relative speed between the rotor and the speed of the magnetic field is what drives the rotor. Hence the rotor speed Nr always remains less than the synchronous speed Ns. Thus Induction Motors are also called Asynchronous Motors. [4]

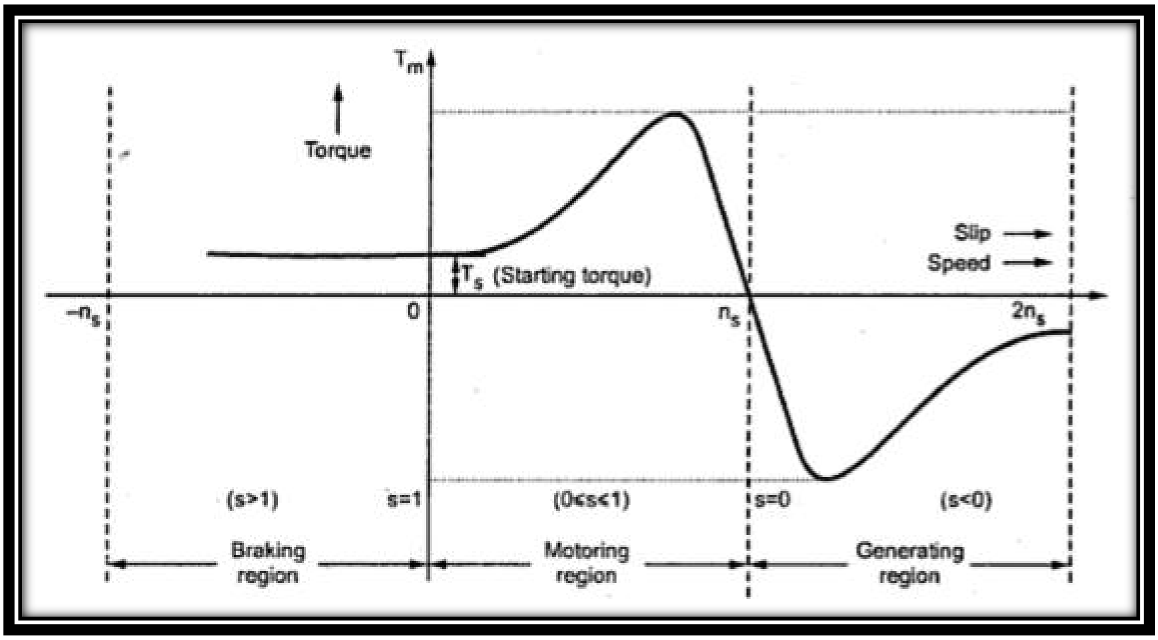

Fig. 1 Torque slip characteristic of induction motor

III. INVERTER

In an Inverter we require Forced commutation for thyristor, therefore we can use other self-commutating device like GTO, MOSFET, and other Transistors to avoiding the commutation circuit. But for high power application we must use thyristor along with the forced commutation circuit. [5]

There are major four techniques to reduce the Total Harmonic Distortion in Inverter:

1) Sinusoidal Pulse Width Modulation
2) Third Harmonic Injection Method
3) 60° Pulse modulation
4) Space Vector Pulse Width Modulation

SPACE VECTOR PULSE WIDTH MODULATION (SVPWM)

This technique is very useful for reducing the Total Harmonic Distortion. This technique is characterized by the constant amplitude pulse. And the width of these pulse is modulated to get Inverter output Voltage control and to reduce its harmonic content. The topology of three leg Voltage Source Inverter because of the constraint that the input line must never be shored and the output current must be always be continuous a Voltage Source Inverter can assume only eight distinct sectors. Six out of these eight sectors produces a non-zero output voltage and are known as non-zero switiching states and the remaining two sectors produces zero voltage are known as zero switching states.[5]

IV. INVERTER CONTROL

To control induction motor drives PWM inverters are very popular. Voltage source inverters mostly used to control both frequency and magnitude of voltage and current applied to motors. PWM fed induction motor drives gives better performance as compared to the fixed frequency induction motor drives.

Conversion of AC source from DC sources is achieved by a device known as inverter. Starting from a small power application device to large electricity applications like bulk power transmission inverters are extensively used. Pulse width modulation is a powerful technique for controlling analog circuits with a processors digital output. [3] [4]

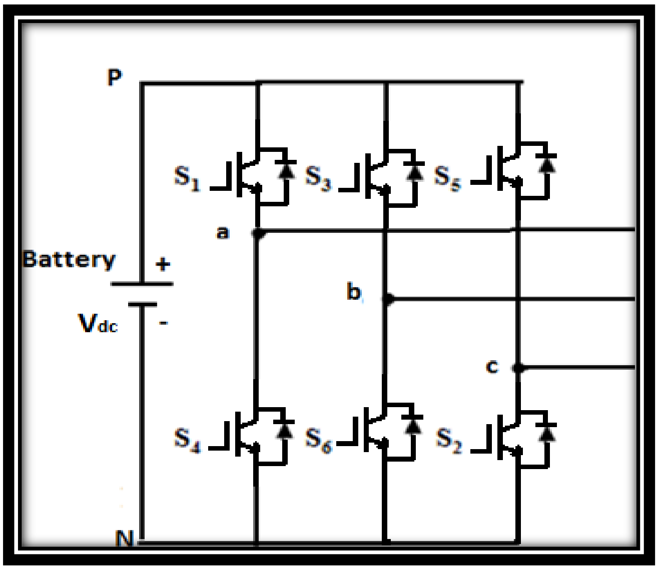

Fig. 2**Six switch composition of converter**

A number of Pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency from a Inverter to control IM drives But most widely used PWM techniques for three-phase VSI are Sine PWM (SPWM) and space vector PWM (SVPWM). But to reduce harmonic content & increase magnitude of voltage space vector PWM (SVPWM) is better than SPWM. Also space vector PWM technique (SVPWM) instead of sine PWM technique (SPWM) is utilized 15% more DC link voltage. So using SVPWM techniques for 3 phase inverter switches & Output of inverter is fed to speed control of IM drives. Simulation is done in a MATLAB/ SIMULINK.

The circuit model of a typical three-phase voltage source

Bridge inverter is shown in Figure, S1 to S6 are the six power switches that shape the output, which are controlled by the switching variables a, a‟, b, b‟, c and c‟. When an upper switches is switched on, i.e., when a, b or c is 1, the Corresponding lower switches is switched off, i.e., the

Corresponding a‟, „b or c‟ is 0.Therefore, the on and off states of the upper transistors S1, S3 and S5 can be used to Determine the output voltage. [4]

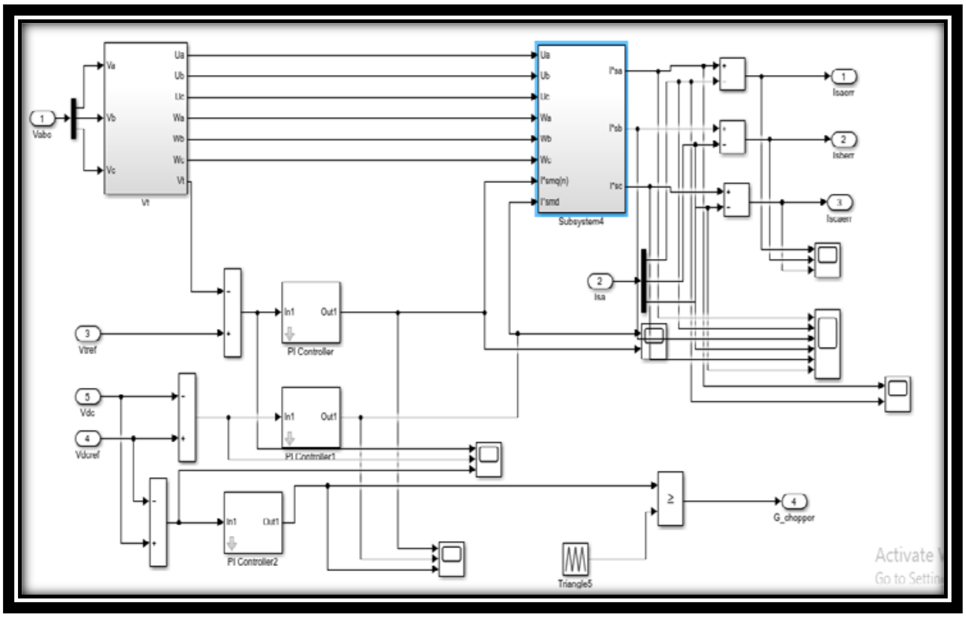

Fig. 3Inverter Control Subsystem

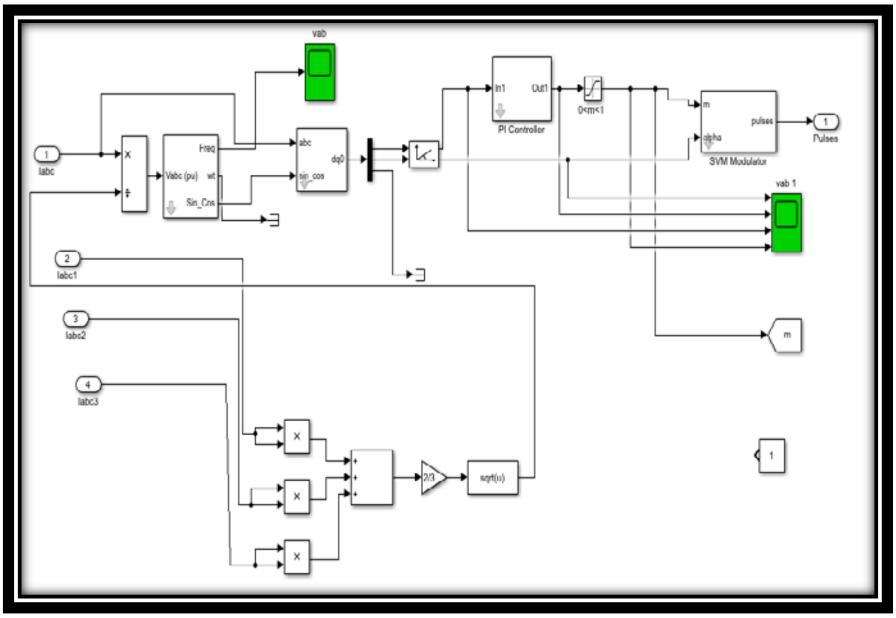

Fig. 4 Subsystem Of gate pulse generation

In this model we use a technique where the load which is variable is connected to the inverter, so if there is a variation in voltage it can be normalized by control methodology process. The voltage which is at the output of the inverter is fed back again to the controller and then it is compared with the reference bus voltage. The error is then controlled and normalized through PI controller. The tuning should be proper and proportional and integrator gain is done by initial assumptions.

V.CHOPPER

The method used in the motor control is to establish a power switching device to chop the source voltage. The process will make the pulse width of AC input voltage to change accordingly. This process is named as symmetrical pulse width modulation (PWM). This current has an inductive load and always having a continuous path to flow. The three modes for operating are proposed active mode, freewheeling mode and dead time mode. This AC chopper has the ability to control amounts of power low waveform distortion, high power factor and high response.

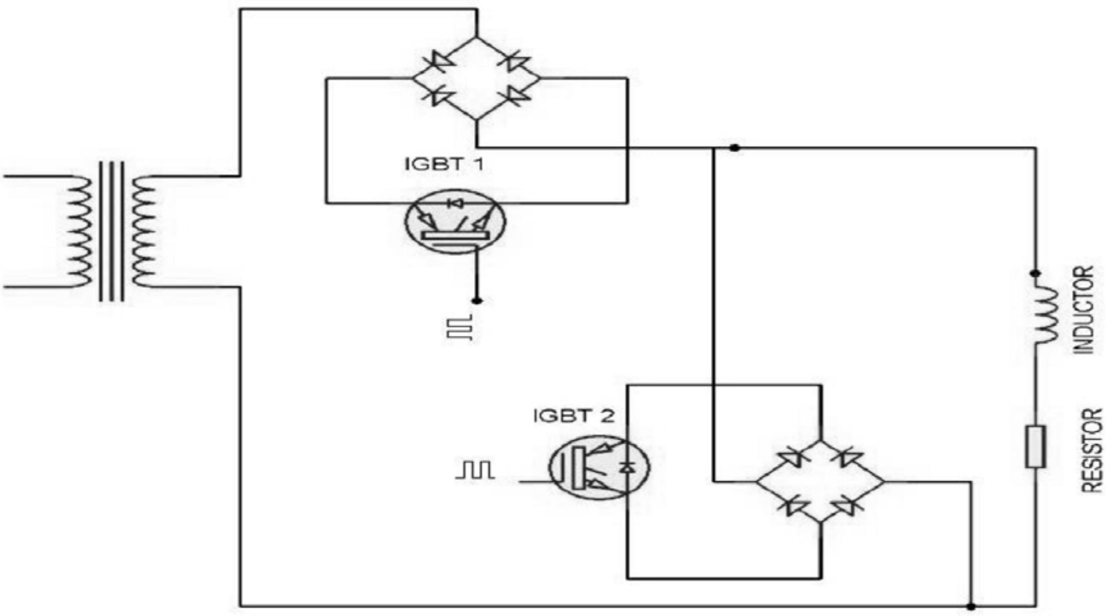

Fig. 5Chopper Circuit diagram

Parameters	
Induction motor	Power= 7.5 KW Stator resistance = 0.8ohm Inductance = 3 mH Rotor resistance = 0.8ohm Inductance = 3 mH
Connected load	Phase to phase voltage = 400 Frequency = 50
Inverter	Universal bridge = IGBT 3 arms

Table 1 Parameters Used

VI.RESULT AND DISCUSSION

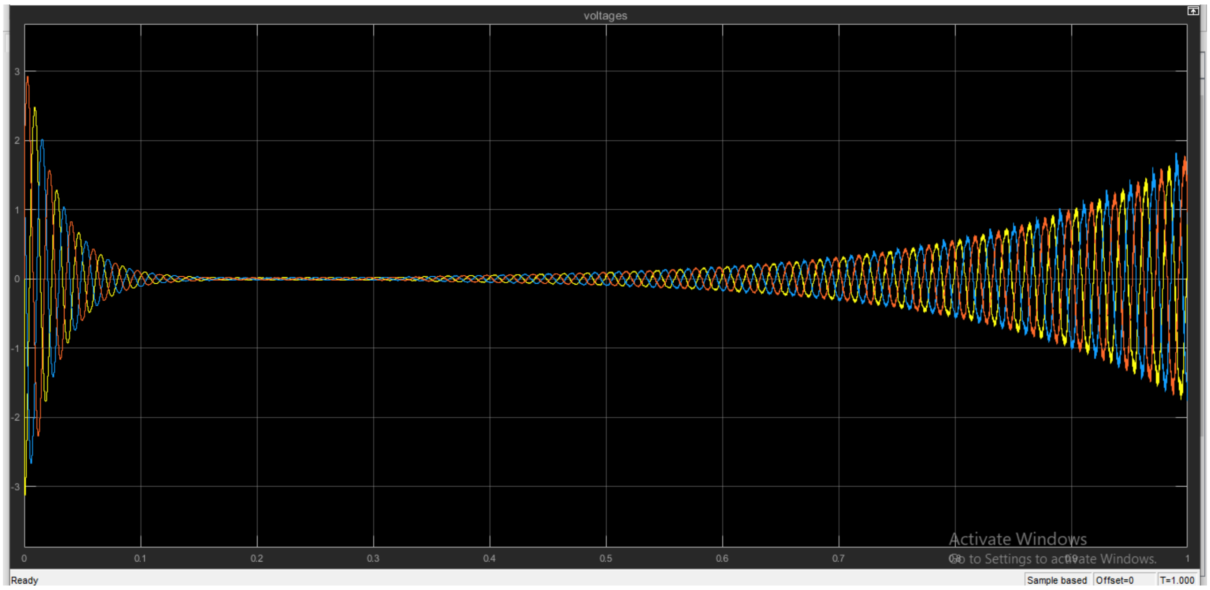

Fig. 5 Voltages after synchronous machine

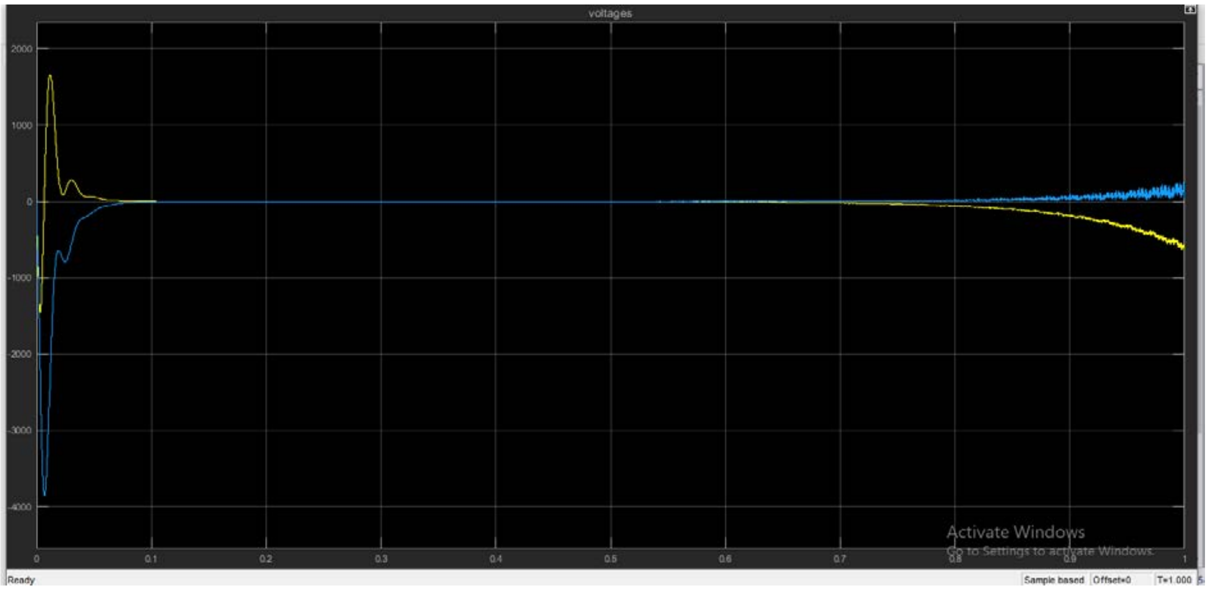

Fig. 6 Active and reactive power

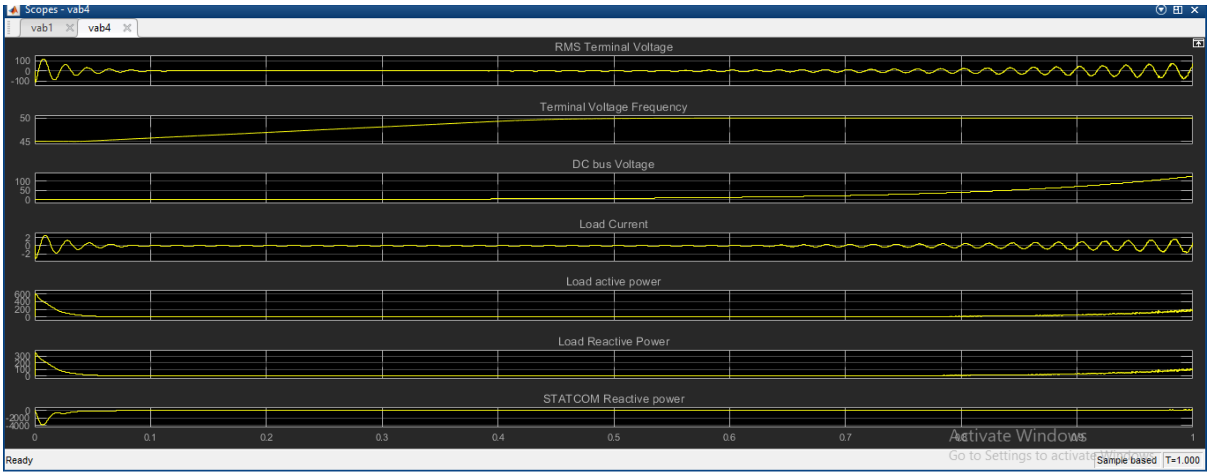

Fig. 7 Various Parameters

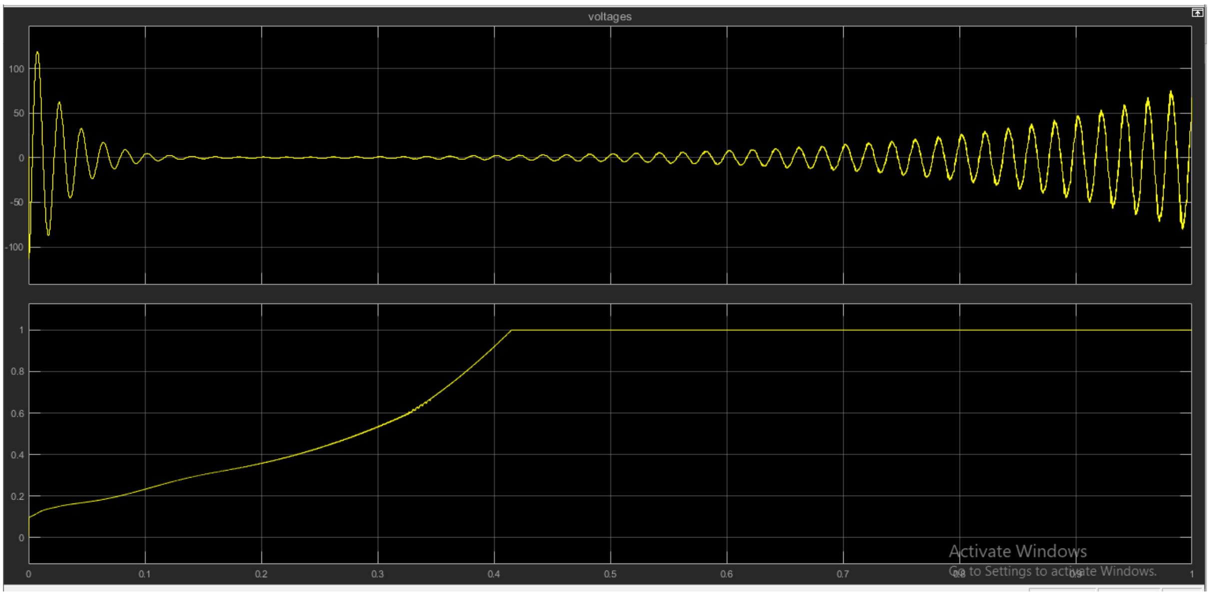

Fig -8 Voltage and m after Induction machine

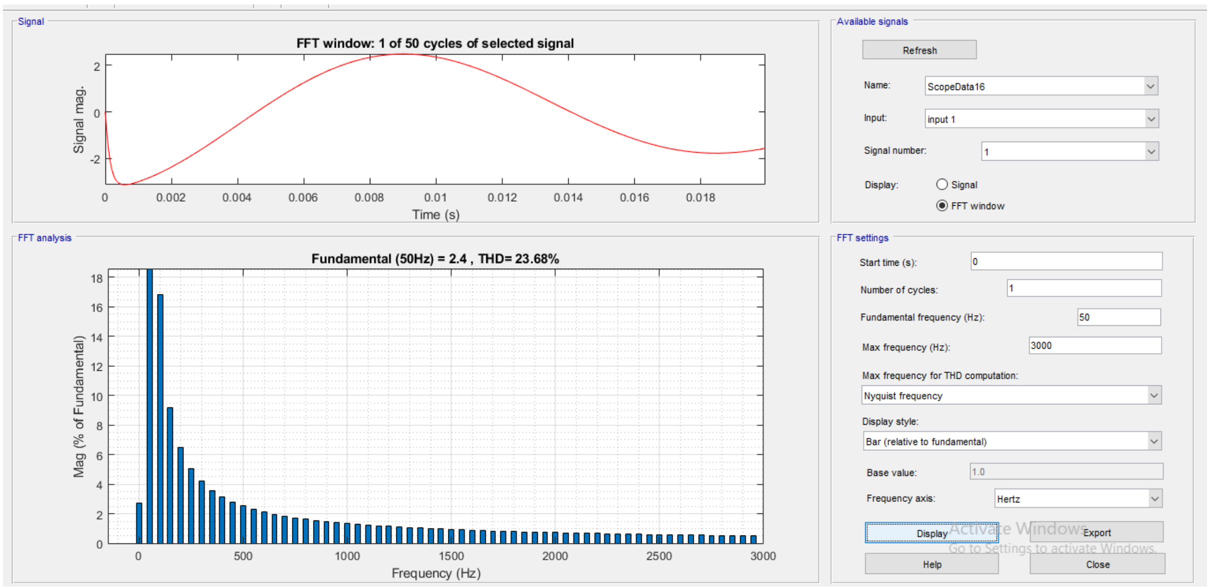

Fig -9: Voltage harmonics

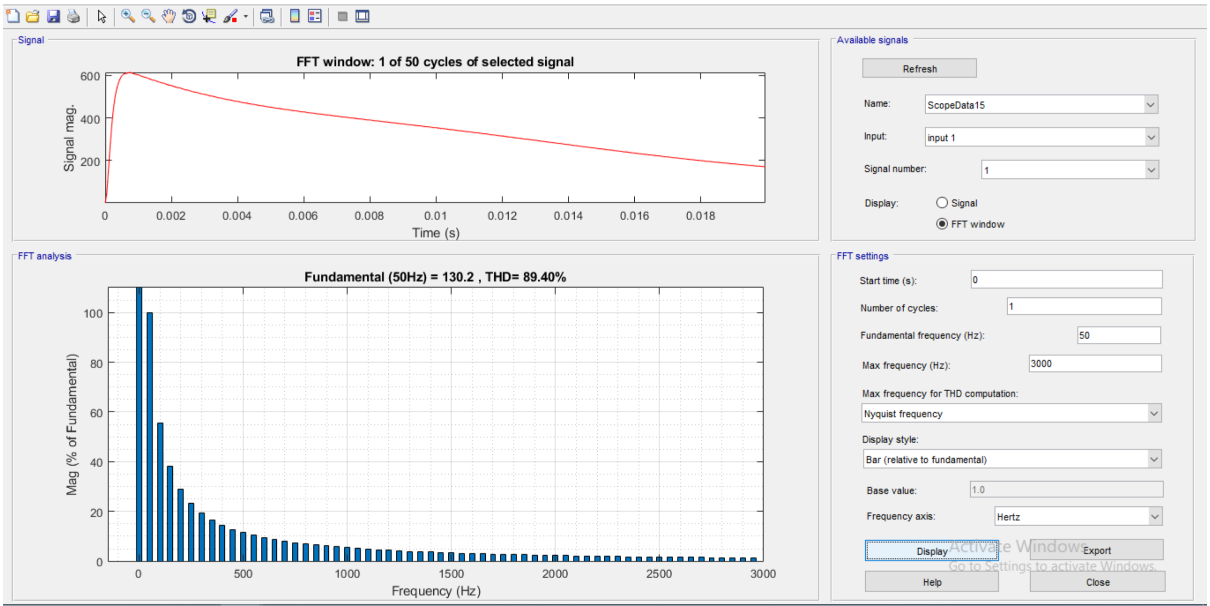

Fig -10: Current harmonics

VII.CONCLUSION

Modelling and simulation has been done on Matlab software of space vector pulse width modulation based induction motor drive and after simulation various parameters has been plotted. By using this control system voltage harmonics is in a desirable stage near about 23%.Further work can be done in future to reduce this harmonics by designing much better compensating device.Parameters taken has been described in the above table and the results are as shown in the above figures almost sinusoidal some more filtration has to be done accordingly to get the smooth output.

REFERENCES

[1] Venkata. Anil Babu Polisetty, B.R Narendra, "Enhanced performance of multilevel Inverter fed Induction Motor Drive", International Journal of Advanced Research in Electrical Electronics and Instrumentation Engineering, 2(11),2013, 5655-5661

[2] C.S.Sharma, Tali Nagwani "Simulation and Analysis of PWM Inverter Fed Induction Motor Drive" International Journal of Science, Engineering and Technology Research (IJSETR).

[3] Priyanka , Sunitha., Tanuja.T., Swathi.B.Power Quality Improvement in Power Distribution System using D-STATCOMVolume 7 Issue No.6 IJESC

[4] Ms. Neetu Khute Mr. Abhijeet lal, Mr. Abhishek Agrawal "Analysis and Simulation of asynchronous machine connected with load accomplished with Chopper control and PWM based Inverter International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume: 3 | Issue: 2 | Jan-Feb 2019 Available Online: www.ijtsrd.come-ISSN: 2456 - 6470

[5] Sandeep Ojha, Ashok Kumar Pandey Close Loop V/F Control of Voltage Source Inverter using Sinusoidal PWM, Third Harmonic Injection PWM and Space Vector PWM Method for Induction Motor, International Journal of Power Electronics and Drive System (IJPEDS) Vol. 7, No. 1, March 2016, pp. 217~224

[6] Neha Jain ,N. H. Funde). "Speed Control of Single Phase Induction Motor using AC Chopper by Asymmetrical PWM Technique" GRD Journals- Global Research and Development Journal for Engineering | Volume 1 | Issue 4 | March 2016 ISSN: 2455-5703

[7]] Mr. Sandeep N Panchal, Mr. Vishal S Sheth, Mr. Akshay A Pandya " Simulation Analysis of SVPWM Inverter Fed Induction Motor Drives," International Journal of Emerging Trends in Electrical and Electronics (IJETEE) Vol. 2, Issue. 4, April-2011

[8] http://www.rroij.com/open-access/power-quality-improvement-usingstatcom-with-different-control-algorithms.php?aid=44553 Power Quality Improvement using STATCOM with Different Control Algorithms
[9] Kantaria R, Joshi SK. A review on power quality problems and solutions. Power electronics NationalConference 2008.
[10] Omarand R, Rahim NA. Mitigation of Voltage Sags/ Swells Using Dynamic Voltage Restorer (DVR). 2009 4(4)ISSN 1819-6608.
[11] Kumar C, Mishra MK. A Control Algorithm for Flexible Operation of DSTATCOM for Power Quality Improvement in Voltage and Current Control Mode. 2012 IEEE International Conference on Power Electronics, Drives and Energy Systems,December16- 19@ .
[12] V. J. Sivanagappa1, R. Ranjani2, R. Suganya3, K. Sumath4, R. Yamuna, “Voltage Control of AC-DC Converter Using Sliding Mode Control,” International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 4, April 2013.
[13] N. N. Bengiamin and W. C. Chan, 1982, “Variable structure control of electric power generation,” IEEE Trans. Power Apparatus Syst., vol. PAS-101, no. 2, pp. 376-380, 1982.
[14] ANALYSIS OF VARIABLE FREQUENCY THREE PHASEINDUCTION MOTOR DRIVE” Thida Win, Nang Sabai, and Hnin NandarMaung. World Academy of Science, Engineering and Technology 18 2008.
[15] Dr.T.Govindaraj, and B.Gokulakrishnan, “Simulation of PWM based AC/DC Converter control to improve Power Quality,” International Journal of Advanced and Innovative Research.ISSN: 2278-7844, Dec-2012, pp 524-533.