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Analysis, design & implementation of sensor less control of induction motorby V/F Method

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ABSTRACT: *The controlling of Induction motor drives. Because of low maintenance and robustness, Induction motors have many applications in industries. Speed control of induction motor is more important to achieve maximum torque and efficiency. Various control techniques such as scalar control, vector control, Sensor-less control are used. Induction motor characteristics are well suited for Adjustable or Variable Speed Drive, which is, nowadays, preferred over Constant Speed Drive In this paper, Variable Voltage-Variable Frequency (V/f) base torque-speed control of three phase induction motor fed by a PWM Voltage Source Inverter will be simulated using MATLAB SoftwareThe comparison analysis is performed between various modulation techniques in quasi z sourceInverter. The modulation techniques are simple boost control, maximum boost control, and maximum constant boost control. From the study maximum constant boost control technique was found to be better than other sinusoidal pulse width modulation*

KEYWORDS: *Induction motor, variable speed drive, simple boost control, maximum boost control, space vector control, etc.*

I INTRODUCTION

The speed of the Induction motor can be changed by various technique such as hydraulic or eddy current coupling, but most efficient one method is change the supply frequency and voltage to the motor. ADUSTABLE SPEED DRIVE are broadly used for speed control induction motor. Since in the improvement of fast switching semi-conductor power device, many kinds of pulse width modulations (PWM) technologies are used for control circuit.
A number of pulse width modulations (PWM) schemes are used for three phase voltage source inverter carrier based sinusoidal PWM and space vector PWM (SVPWM).PWM strategies not only care of primary issues e.g. less THD,better voltage utilization but also addresses the secondary issues like switching loss, better harmonic spreading over the spectrum. SPWM can realize easily in circuit but in SPWM is low voltage utilization so now SVPWM technique are most often used for control circuit. Simulated using MATLAB software and its performance are showing relationship between SPWM and SVPWM.The simulation study reveals that space vector control PWM less THD, better voltage utilization and higher modulation.

II INDUCTION MOTOR

In the induction motor, the field circuit on the stator and armature circuit on the rotor, and the rotor poles are induced by transformer action.

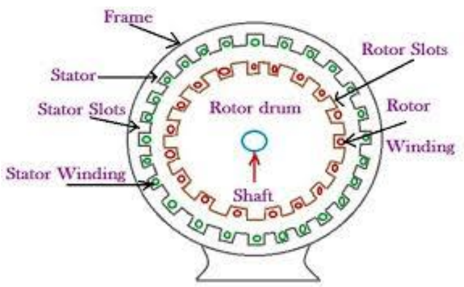


Fig 2.1 Induction Motor

Both the stator poles and the rotor poles rotate at the synchronous speed, so the speed of the induction motor is changed by frequency and pole. The relationship between frequency and sychrouns speed is given by below equation.

$$N_s = \frac{120f}{P}$$

But the rotor rotates physically at a speed slightly less than a synchronous speed and slows down as the load torque and power requirements increase.
These different between actual speed and sychrouns speed is called slip.

$$\% \text{ S}=\left(\frac{N_s - N}{N_s}\right)\times 100$$

So, N $\propto f$ or N $\propto$ 1/P

So it clear that the running speed of induction motor directly proportional to frequency. So for the purpose of speed control, frequency changer are required for the speed control of induction motor. VARIABLE FRQUENCY DRIVE will be used for speed control in electrical motor drive.

2.2 VARIABLE FRQUENCY DRIVE

VFD converts the supply frequency and voltage to the frequency and voltage required to drive a motor at a desired speed other than its rated speed.

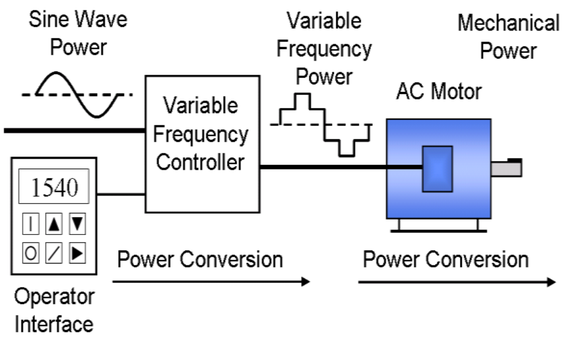


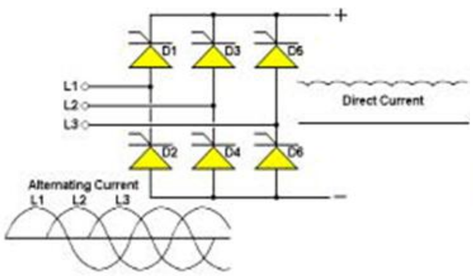
Fig 2.2: VFD System

Components of VFD

Basically the adjustable speed drive consists of rectifier, inverter and control components.

Rectifier: - A rectifier is an electrical device composed of one or more diodes that converts alternating current (AC) to direct current (DC).A full-wave, solid-state rectifier converts three-phase 50 Hz power from a standard 220, 440 or higher utility supply to either fixed or adjustable DC voltage.

Inverter: - Electronic switches - power transistors or thyristors - switch the rectified DC on and off, and produce a current or voltage waveform at the desired new frequency. The amount of distortion depends on the design of the inverter and filter.



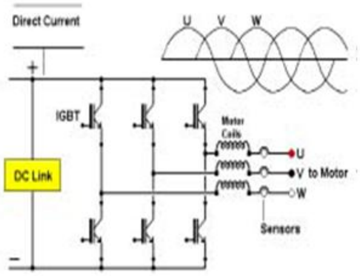


Figure 2.3 Rectifier Circuit

Fig 2.4 Inverter Circuit

Most currently available inverters use pulse width modulation (PWM) because the output current waveform closely approximates a sine wave. Power semiconductors switch DC voltage at high speed, producing a series of short-duration pulses of constant amplitude. Output voltage is varied by changing the width and polarity of the switched pulses. Output frequency is adjusted by changing the switching cycle time.

III DIFFERENT CONTROL TECHNIQUE

3.1. Simple sinusoidal pulse width modulation

In the simple boost pwm method gating signal are generated by comparing the sinusoidal reference signal

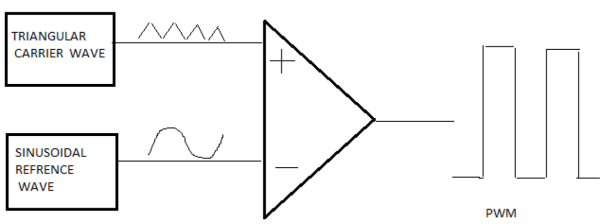


Fig 3.1.Simple SPWM Technique

Pulse width modulation is a technique in which a fixed input dc voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is most popular method of controlling the output voltage and this method is termed as pulse width modulation technique. PWM is an internal control method and it gives better result than an external control methods.

3.1.2 Maximum boost pulse width modulation

In this technique, there are five modulation curves: two shoot through envelop signal Vp andVn, and three modulating reference sinusoidal signal Va, Vb andVc. The amplitude of shoot through envelop signal should be greater than or equal to peak value of modulating sinusoidal reference signal. By comparing dc signal with the high frequency triangular carrier, shoot through switching pulses are generated. Therefore when triangular signal is greater than upper envelope Vp or less than lower envelope Vn, the circuit enters into ST state.

MBC can reduce the voltage stress across the switch and voltage boost can be obtained by turning all traditional zero state into shoot through state. Without distorting output waveform the maximum To and B can be obtained for any modulation index.

To increase the modulation index range third harmonic injection is commonly used in three phase inverter system. This is used here too, to increase the modulation index range thereby to increase the system voltage gain. The maximum modulation index that can be achieved is (2/ √ 3) .which can be achieved at third harmonic injection.

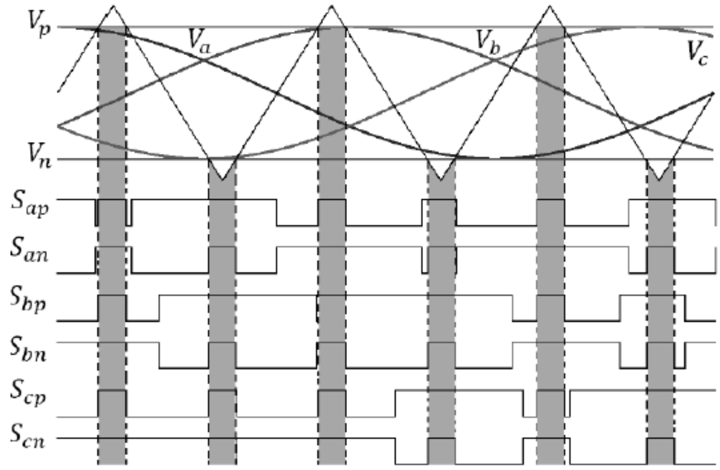


Fig 3.4: Maximum boost control

3.1.3 Third harmonic injection method

To reduce the volume and cost, the shoot through duty ratio should be kept constant and greater voltage boost for the given modulation index is required to reduce the voltage stress across the switch. There are five modulation curves for this control which include three

Reference signals and two ST envelope Vn and Vp. When carrier signal is greater than upper envelope signal or less than the lower envelope signal shoot through state is generated

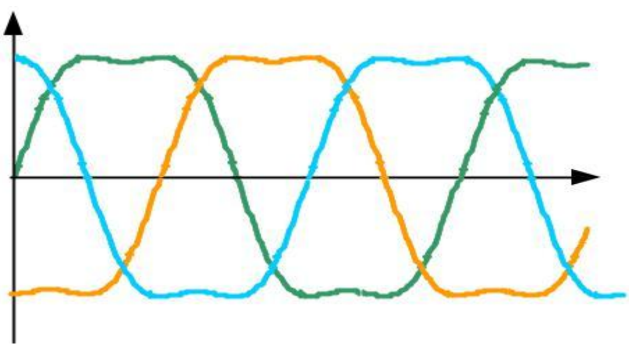


Fig 3.5 THIPWM Modulated Wave

3.1.4 Field oriented control

The field-oriented control method is widely used for induction motor drives. In these applications, a rotational transducer such as a shaft encoder is used. Several field-oriented induction motor drive methods without rotational transducers have been proposed**.** These methods have a disadvantage that the rotor resistance variation causes an estimation error of the motor speed

In the below fig the diagram shows field oriented control system.

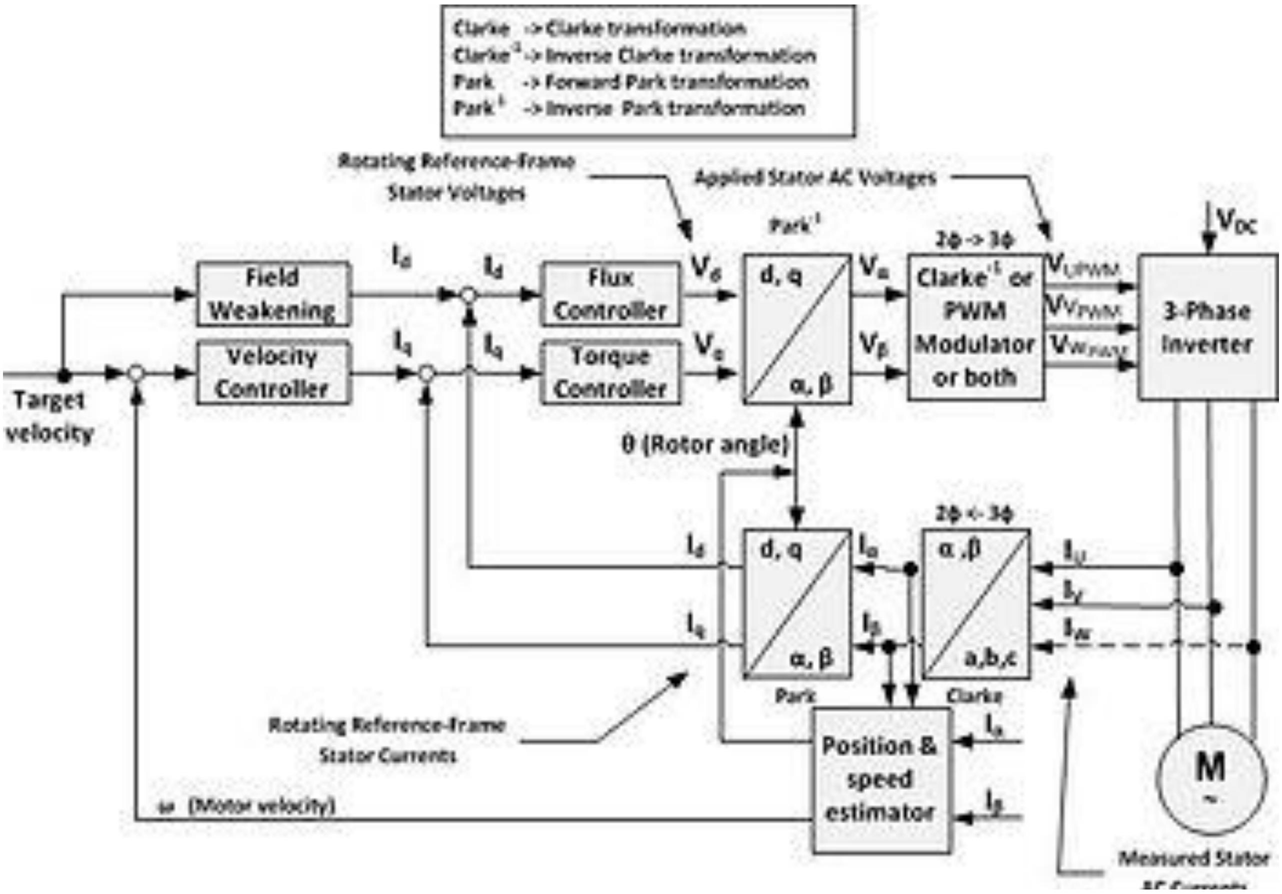


Fig 3.3 Field Oriented Control System.

Advanced control strategies can be implemented to decouple the torque generation and the magnetization functions in an AC induction motor. This **decoupled torque** and **magnetization flux** is commonly called rotor **Flux Oriented Control (FOC)**.

The **field oriented control** consists of controlling the stator currents represented by a vector. This control is based on projections that transform a three phase time and speed dependent system into a two coordinate (d and q frame) time invariant system. These transformations and projections lead to a structure similar to that of a DC machine control. FOC machines need two constants as input references: the torque component (aligned with the **q coordinate**) and the flux component

It needs to be transformed into a two time invariant coordinate system. This transformation can be divided into two steps: (a, b, c) → (α, β) (the Clarke transformation), which outputs a two coordinate time variant system. (a, β) → (d,q) (the Park transformation), which outputs a two coordinate time invariant system.

FOC for the induction motor drive can be broadly classified into two types: Indirect FOC and Direct FOC schemes. In DFOC strategy rotor flux vector is either measured by means of a flux sensor mounted in the air-gap or by using the voltage equations starting from the electrical machine parameters. But in case of IFOC rotor flux vector is estimated using the **field oriented control** equations (current model) requiring a rotor speed measurement. Among both schemes, IFOC is more commonly used because in closed-loop mode it can easily operate throughout the speed range from zero speed to high-speed field-weakening

Advantages of Field Oriented Control

- Improved torque response.
- Torque control at low frequencies and low speed.
- Dynamic speed accuracy.
- Reduction in size of motor, cost and power consumption.
- Four quadrant operation.
- Short-term overload capability.

IV. SIMULATION AND RESULT

4.1 Modelling & simulation of SIMPLE PWM using MATLAB

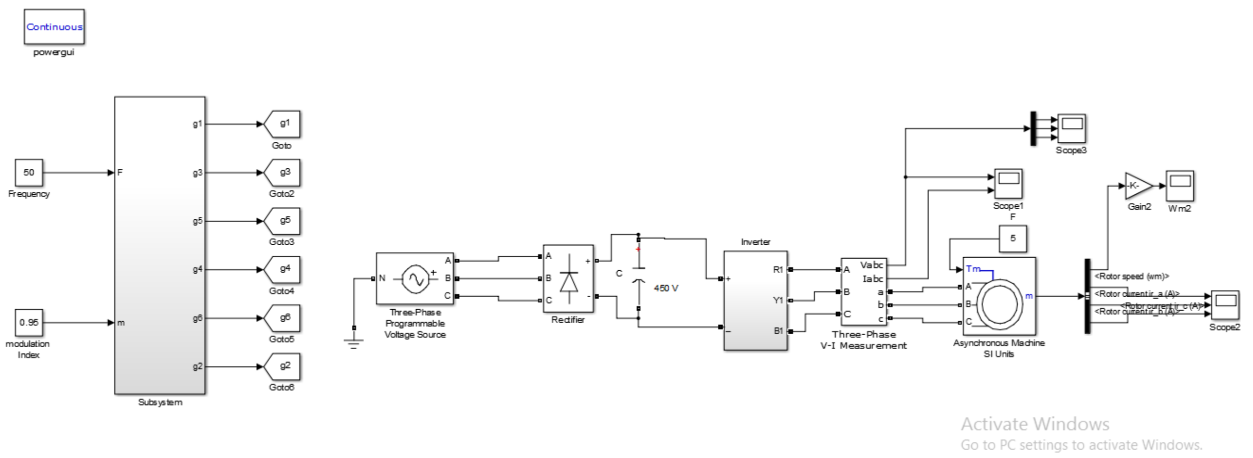


Figure: 4.1 simulation simple sinusoidal PWM method

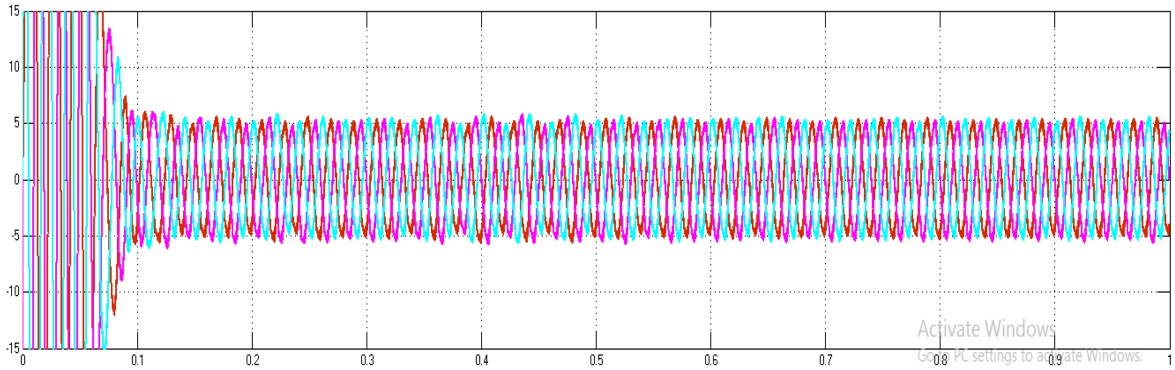


Figure: 4.2 output current simple sinusoidal PWM method

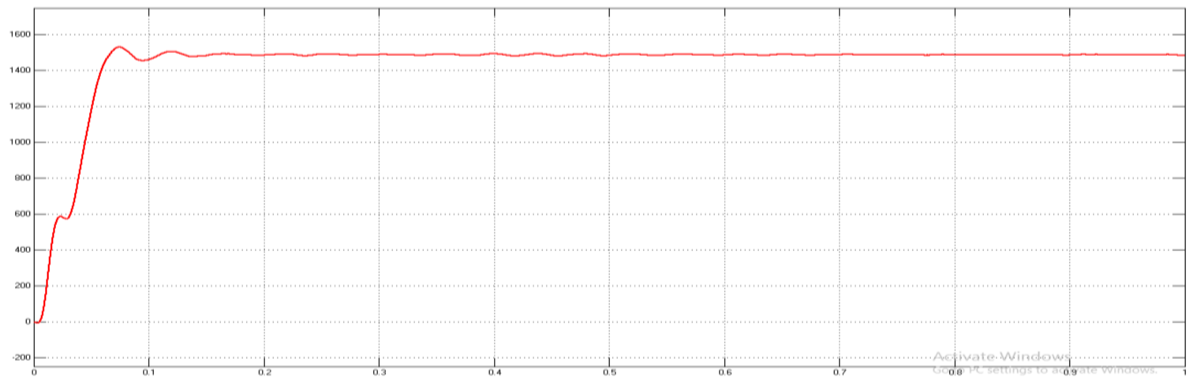


Figure: 4.3 output rotor speed simple sinusoidal PWM method

Set Speed RPM	THD VOLTAGE %	THD CURRENT %	O/P SPEED RPM
1500	71.75	30.12	1480
1000	71.30	21.17	970

Table 4.1 Analysis SPWM Method

4.2 Modelling & simulation of Maximum Boost PWM using MATLAB

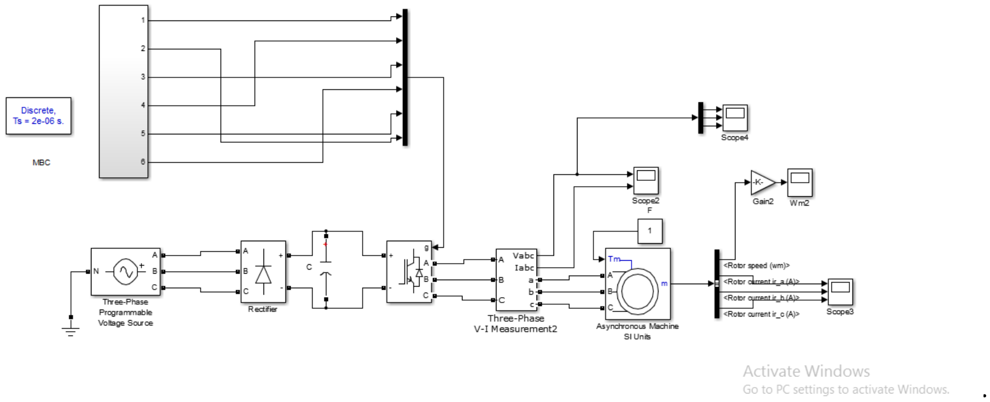


Figure: 4.4 simulation MAXIMUM BOOST PWM method

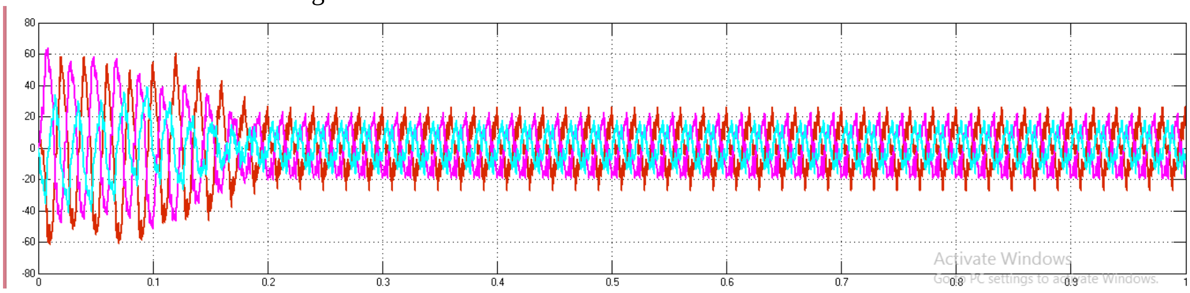


Figure 4.5. Output current

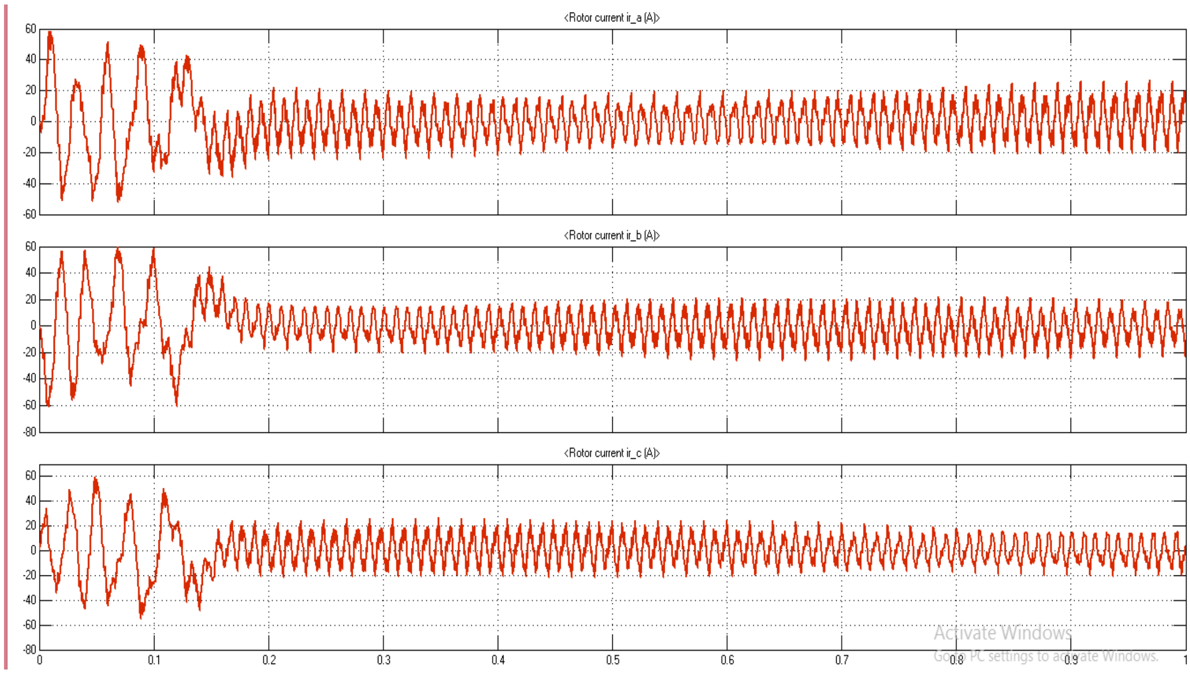


Figure 4.6 Output Rotor current

Set Speed RPM	THD VOLTAGE %	THD CURRENT %	O/P SPEED RPM
1500	62.24	10.29	1480
1000	59.18	59.27	970

Table 4.2 Analysis of Maximum Boost PWM control

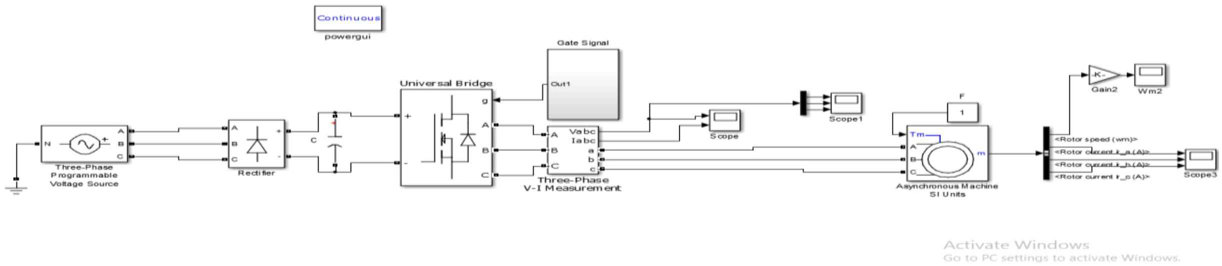


Figure 4.7 Third Harmonic Injection method

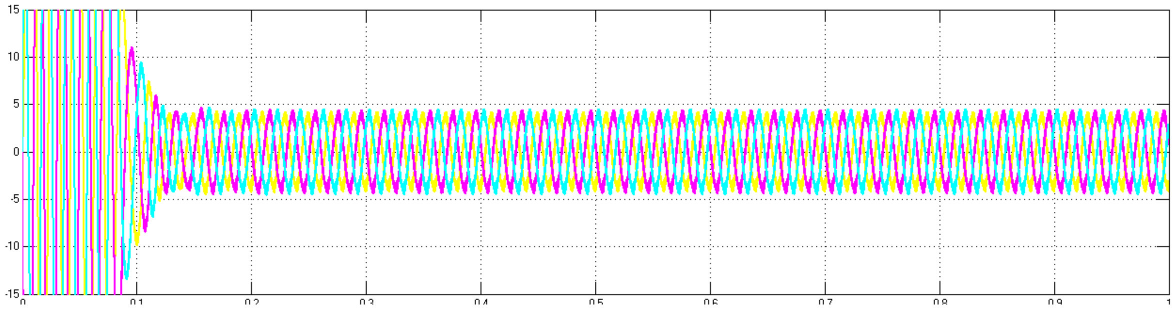


Figure 4.8 Output current Third Harmonic Injection method

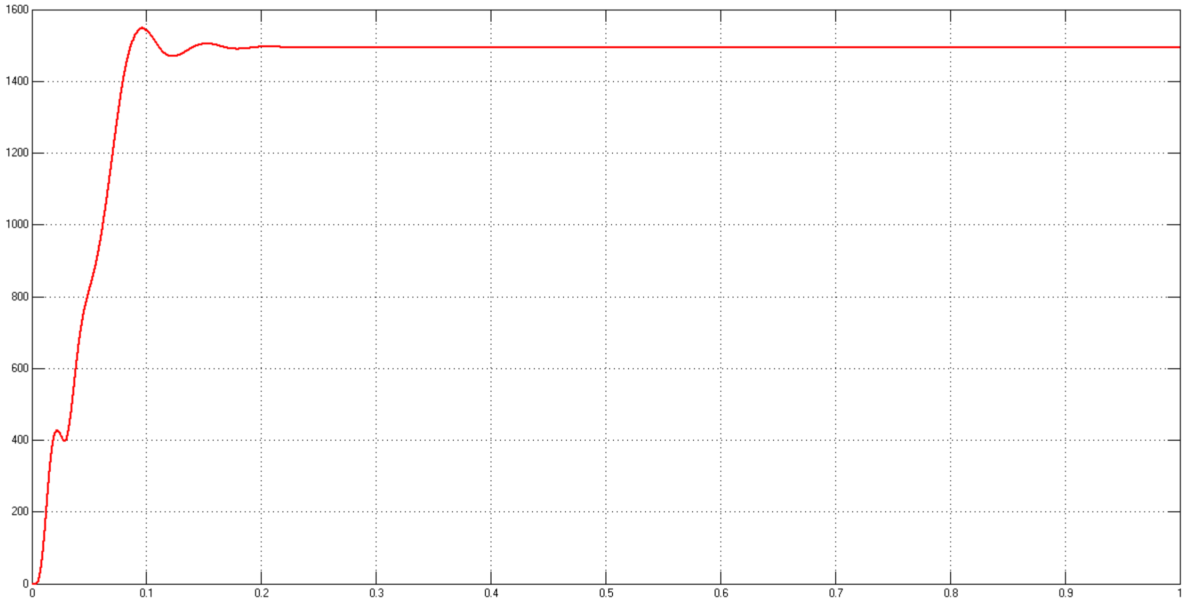


Figure 4.9 Output Rotor Speed Third Harmonic Injection method

Set Speed RPM	THD VOLTAGE %	THD CURRENT %	O/P SPEED RPM
1500	74.72	9.34	1480
1000	74.05	9.02	970

Table 4.3. Analysis of Third Harmonic Injection PWM control

V. The Space Vector Pulse Width Modulation

The Space Vector Pulse Width Modulation (SVPWM) method is an advanced, computation-intensive PWM method and possibly the best among all the PWM techniques for variable frequency drive application.The SVPWM method of generating the pulsed signals fits the above requirements and minimizes the harmonic contents.The vectors divide the plan into six sectors. Depending on the sector that the voltage reference is in, two adjacent vectors are chosen. The binary representations of two adjacent basic vectors differ in only one bit, so that only one of the upper transistors switches when the switching pattern moves from one vector to the adjacent one.

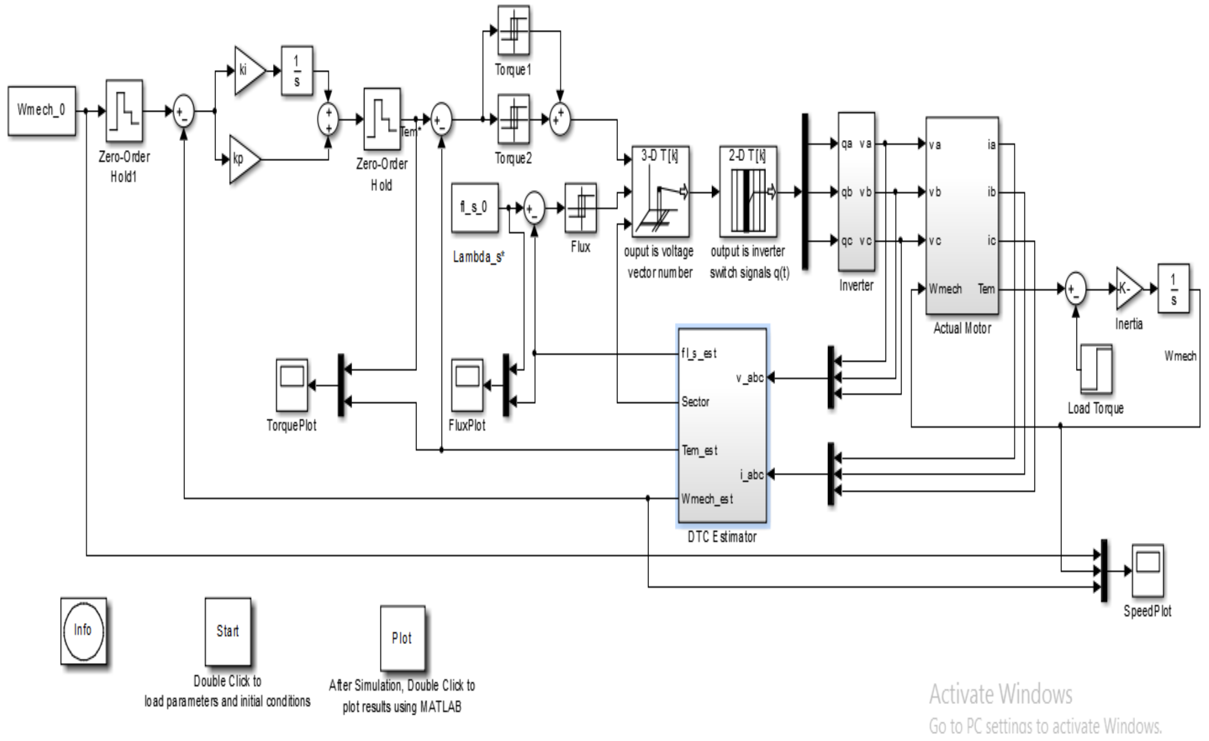


Figure 5.1 Model of SVPWM

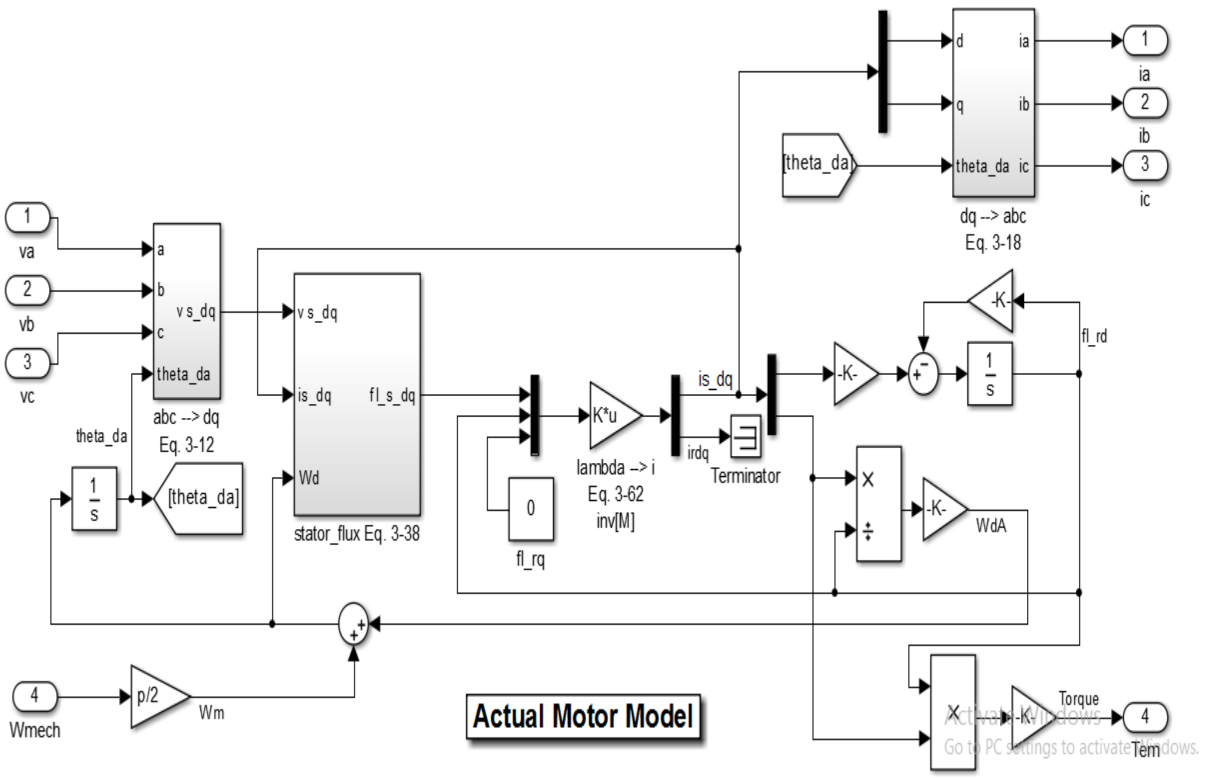


Figure 5.2 Model of MOTOR

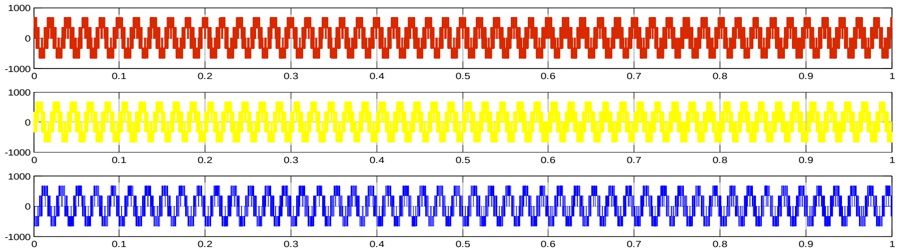


Figure 5.3 Output voltage SVPWM method

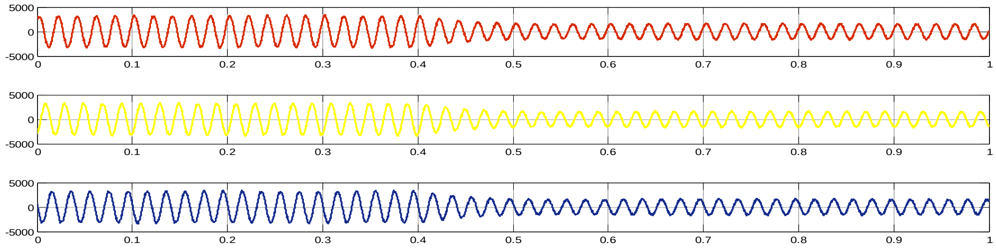


Figure 5.4 Output current in SVPWM method

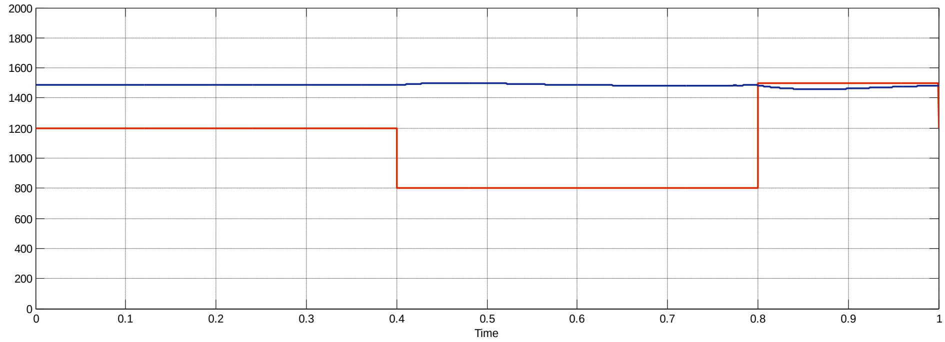


Figure 5.5 Motor speed and load variation

Time	Torque	Speed	THD voltage	THD Current
0 to 0.4	12000	1480	55.45 %	4.56 %
0.4 to 0.8	8000	1480	56.15 %	6.01 %
0.8 to 1	15000	1470	56.62 %	6.40 %

Table 5.1. Analysis SVPWM control.

CONCLUSION

Here we concluded that the sensor less speed control using open loop pwm method will simple, accurate and fast. And Critical investigation on various modulation techniques is performed. Proper control method should be selected according to the requirement of Different load.
The results of various control methods are performed for same input and system parameters. The performance of Different method is better obtained for Third Harmonic injection Method.
Implementation of motor speed control with FOC is completed and results are attached in the report. Motor data is important to improve the control response. Control algorithm will control the speed in our control region and speed remains same while change accurse in load.

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