An Overview on Investigation of Speed Control Techniques of Three Phase Induction Motor Drives

Abhishek Sharma[1] Pawan Kumar Choudhary[2] Bheru Das Vairagi[3] Monika Vardia[4]
[1,2]M.Tech Student [3]Assistant Professor [4]Assosiate professor
[1,2,3,4]Department of Electrical Engineering
[1,2,3,4]GITS, Udaipur, Rajasthan

Abstract— This paper detail about the performance analysis of the speed control techniques of three phase induction motor drives by stator voltage control. The flow of power to the induction motor is controlled by switching action of the power switches, which thereby control the speed of the induction motor. Switching devices are now widely used in many power electronics and motor drives applications. This is due there many advantages such as compact size, low losses, ease availability, less cost and important low losses. The System consists of six bidirectional switches. In this paper the various techniques description given that is generally used to control the speed of three phase induction motors.

Key words: Smart grid, Features, capabilities of the smart grid, Smart home, Renewable energy, Consumer engagement, Distribution intelligence

I. INTRODUCTION

Induction motors are the most widely used electrical motors due to their reliability, low cost and robustness. However, induction motors do not inherently have the capability of variable speed operation. Due to this reason, earlier dc motors were applied in most of the electrical drives. But the recent developments in speed control methods of the induction motor have led to their large scale use in almost all electrical drives.

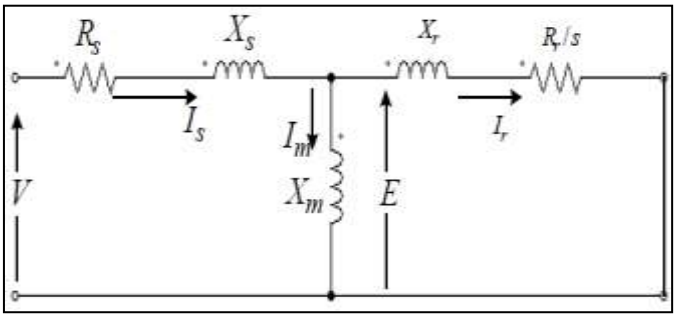

Fig. 1.1: Equivalent Circuit of Three Phase IM

Three phase induction motor is basically a constant speed motor and hence it becomes quite difficult to control its speed. The speed of induction motor can be controlled but can be achieved at the cost of decrease in efficiency and low power factor. Before studying the methods of speed control of three phase induction motor, let us look at the basic formulae of speed and torque of three phase induction motor as the methods depends upon them.

$$Ns = 120f/P$$

Where,
Ns = synchronous speed f = frequency and P = number of poles.
The speed of induction motor is given by,

$$N = N s (1- S)$$

Where,
N is the speed of rotor of induction motor, S is the slip.
The torque produced by three phase induction motor is given by-

$$T = (3/2\pi Ns)\times sE2R2/R2+X2$$

When the rotor is at standstill, slip s is one. So the equation of torque becomes,

$$T = (3/2\pi Ns)\times E2R2/R2+X2$$

Where,
E2 = rotor emf, Ns = synchronous speed, R2 = rotor resistance, X2 = rotor inductive reactance.
The various methods of speed control through semiconductor devices are as under:-

1) Stator Voltage Control
2) Stator Frequency Control
3) Stator Current Controls
4) Static Rotor Resistance Control
5) Slip Energy Recovery Control

The motion control is required everywhere (domestic as well industry). The system that is employed for this purpose is called drives. In electrical drives, use of various sensors and control algorithms is done to control the speed of the motor using suitable speed control methods.

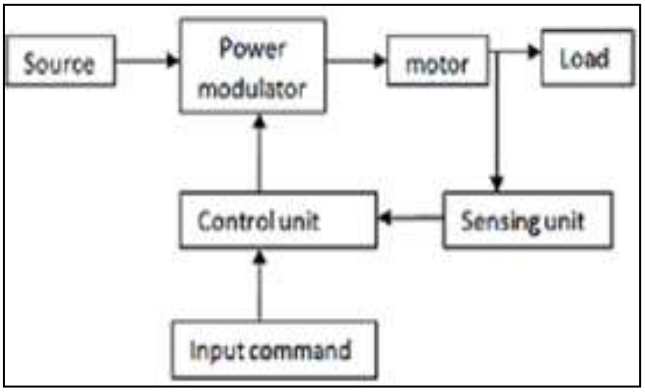

Fig. 1.2: Block Diagram of Electric Drive

Earlier only dc motors were employed for drives requiring variable speeds due to ease of their speed control methods. The conventional methods of speed control of an induction motor were either too expensive or too inefficient thus restricting their application to only constant speed drives. However, modern trends and development of speed control methods of an induction motor have increased the use of induction motors in electrical drives extensively.

II. METHODOLOGY

A. Three Phase AC Voltage Controller:

In phase control the Thyristors are used as switces to connect the load circuit to the input ac supply, for a part of every input cycle. That is the ac supply voltage is chopped using Thyristors during a part of each input cycle. The thyristor switch is turned on for a part of every half cycle, so that input supply voltage appears across the load and then turned off during the remaining part of input half cycle to disconnect the ac supply from the load. By controlling the phase angle or the trigger angle „α" (delay angle), the output RMS voltage across the load can be controlled. The trigger delay angle „α" is defined as the phase angle (the value of wt) at which the thyristor turns on and the load current begins to flow. Thyristor ac voltage controllers use ac line commutation or ac phase commutation.

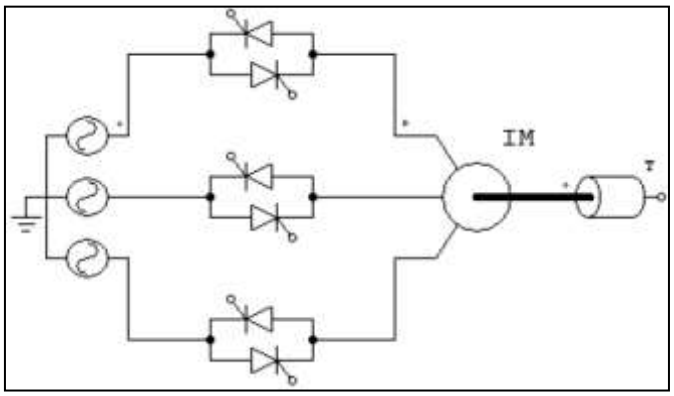

Fig. 2.1.1: Three Phase AC Voltage Controller

The Torque-Speed Characteristics of the three phase Induction motors for varying supply voltage by three phase AC Voltage method as:

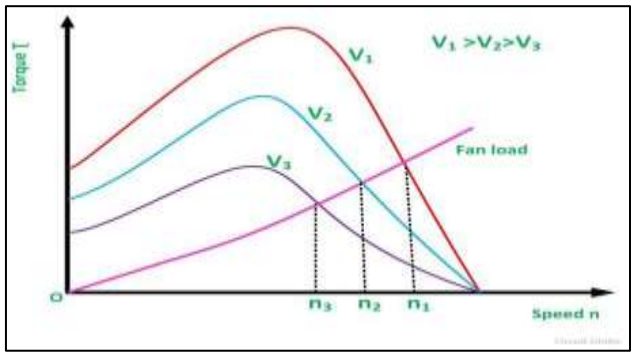

Fig. 2.1.2: Torque Speed Characteristics

B. Field Programmable Gate Arrays:

The availability of microprocessors, microcontrollers, and digital signal processors (DSP) facilitates the digital implementation of control system of electrical machines. The DSP is the most commonly used device for such applications. The DSPs are highly optimized specific microprocessors designed to process signals, including control signals. With the increasing density and complexity of field programmable gate arrays (FPGAs), programmable architectures are becoming more attractive for implementing embedded system designs. FPGAs are increasingly coming into their own as a way to achieve application specific integrated circuits (ASIC) like performance-levels with hardware that has off-the-shelf convenience similar to traditional DSP processors. Sophisticated control algorithms become easier to be implemented with FPGAs. One of the fundamental advantage of FPGA over DSP or other microprocessors is the freedom of parallelism. Since different parts of FPGA can be configured to perform independent functions simultaneously, its performance is just not tied to clock rate as in DSPs. The FPGA provides a low cost control for induction motor by many control strategy

Three-phase ac chopper is one of the simplest ways to control the speed of induction motor. AC choppers have been used to control both static and dynamic loads. Three phase ac chopper has been used to feed three phase induction motor. Single-phase and three-phase ac choppers are showing cost reduction and effective control. The main problems associated with the ac choppers are the high harmonic contents in the supply and motor currents, very poor power factor especially at light loads, and low efficiency. Modern PWM techniques can help in modifying these performance parameters. Using FPGA can generate the required PWM switching function easily and economically. The essence of this paper is to explain the design of digital speed control strategy of three phase ac chopper under three-phase induction motor load by using FPGA.

C. Sinusoidal Pulse Width Modulation (SPWM):

The most common PWM approach is sinusoidal PWM. In this method a triangular wave is compared to a sinusoidal wave of the desired frequency and the relative levels of the two waves is used to control the switching of devices in each phase leg of the inverter. Carrier frequency is preferred for complementary waveform, because it is necessary to keep the symmetry of the output voltage.

D. Space Vector Pulse Width Modulation (SVPWM):

Space vector PWM refers to a special switching scheme of the six power semiconductor switches of a three phase power converter. Space vector PWM (SVPWM) has become a popular PWM technique for three-phase voltage-source inverters in applications such as control of induction and permanent magnet synchronous motors. The mentioned drawbacks of the sinusoidal PWM and hysteresis-band current control are reduced using this technique. Instead of using a separate modulator for each of the three phases (as in the previous techniques), the complex reference voltage vector s processed as a whole. Therefore, the interaction between the three motor phases is considered. It has been shown, that SVPWM generates less harmonic distortion in both output voltage and current applied to the phases of an ac motor and provides a more efficient use of the supply voltage in comparison with sinusoidal modulation techniques.

SVPWM provides a constant switching frequency and therefore the switching frequency can be adjusted easily. Although SVPWM is more complicated than sinusoidal PWM and hysteresis band current control, it may be implemented easily with modern DSP-based control systems.

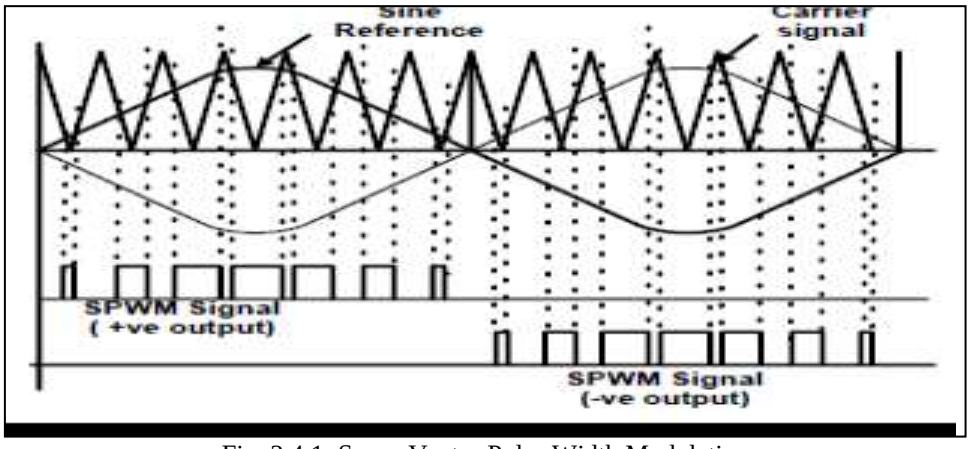

Fig. 2.4.1: Space Vector Pulse Width Modulation

III. RESULTS

By using AC Voltage control Method, if we change the firing angle the voltage will change for different values of torque. Similarly with change in firing angle speed variation for different values of torque, power factor variation for different values of torque, Motor efficieny for different values of torque as:

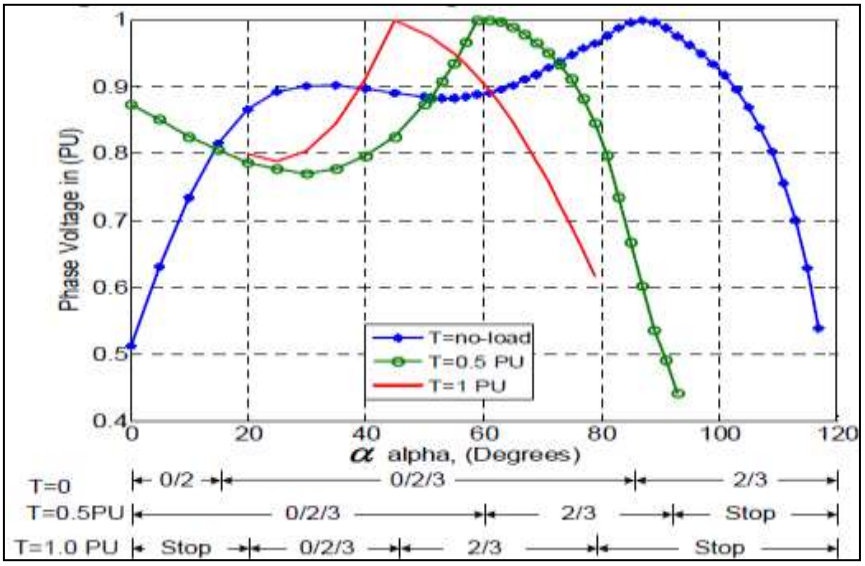

Fig. 3.1: Phase Voltage Variation of different values of Torque

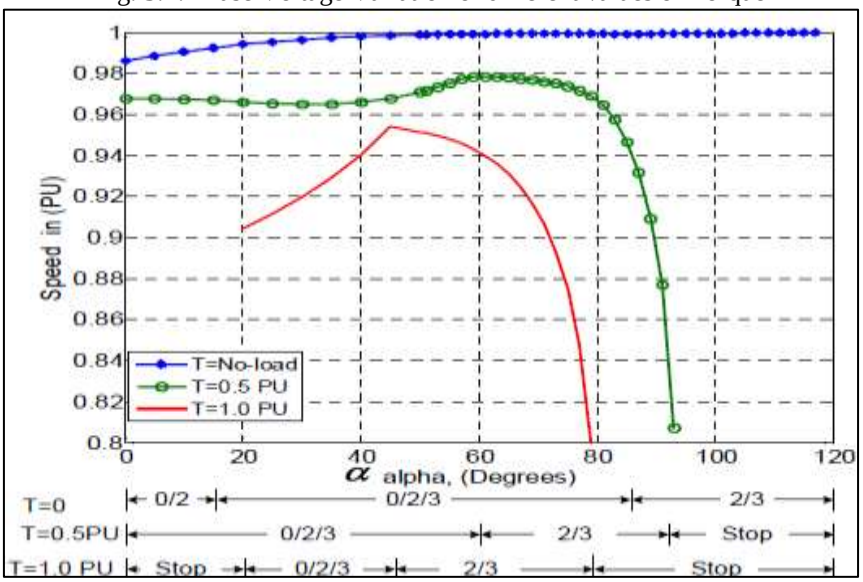

Fig. 3.2: Speed Variation of different values of Torque

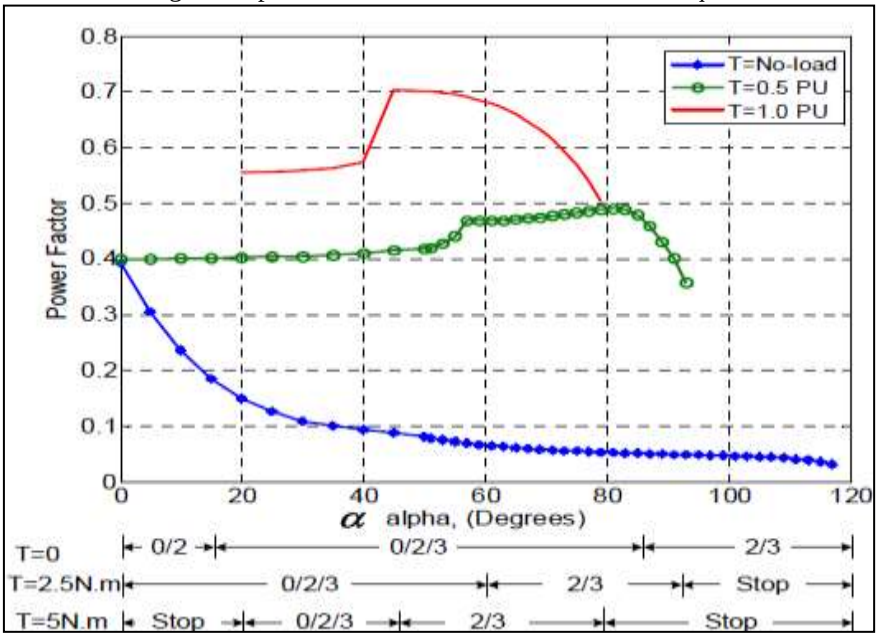

Fig. 3.3: Power Factor Variation of different values of Torque

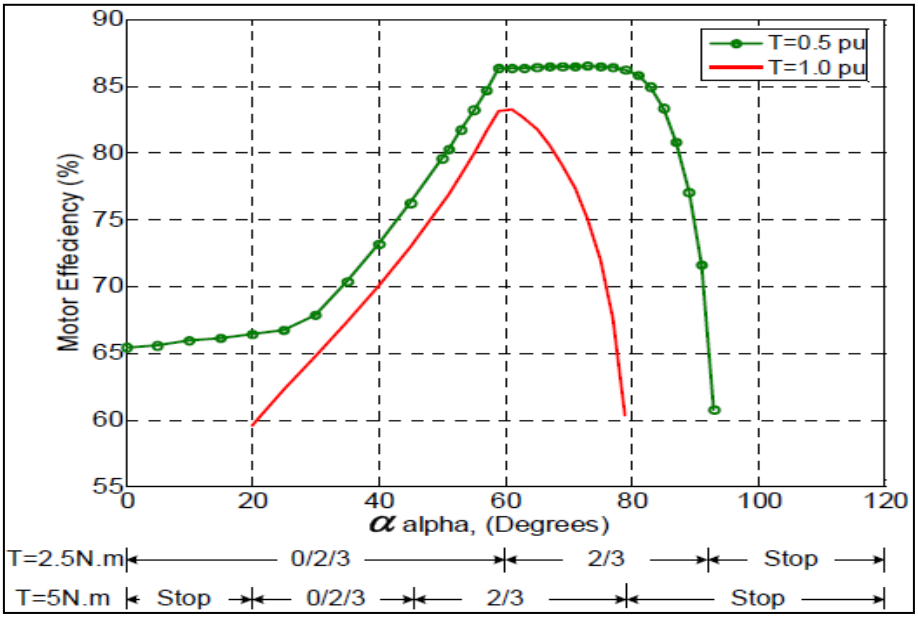

Fig. 3.4: Variation of different values of Torque

IV. CONCLUSION

The speed control of the induction motor is achieved by controlling the firing angle. The relation between the speed of the motor and the firing angle depends on the mode of operation. So, the speed control system has to identify the mode of operation to send a correct value of firing angle to switches otherwise the system will get out of control.

FPGA is used in producing the required switching signal in efficient manner. The FPGA provides a digital control for the induction motor. The digital control system provides a speed control and soft starting technique for the induction motor. The SPWM technique used for speed control of three phase induction motor based on microcontroller which is programmed by 'C' programming.

REFERENCES

[1] A. I. Alolah **"**Control Limits of Three Phase AC Voltage Controller under Induction Motor Load**"**
[2] Ali M. Eltamaly "FPGA Based Speed Control of Three-Phase Induction Motor Using Stator Voltage Regulator".
[3] Prabaharan.V "Microcontroller based Speed Control of Sinusoidal PWM Inverter fed Three Phase Induction Motor"
[4] Mohamed Y. Tarnini "Microcontroller Based Low Power Three Phase Induction Motor Frequency Drive"
[5] A K Bhardwaj "Speed Control of Three Phase Induction Motor using Space Vector PWM Method"
[6] V.V. Shrikant "Speed Control of 3 Phase Squirrel Cage Induction Motor by 3-Phase AC Voltage Controller Using SPWM Technique"
[7] Pragati S. Ramteke " Speed Control of Three Phase Induction by Phase Angle Control of TRIAC"
[8] Nisha Gurle "Speed Control of Three Phase Induction Motor by Stator Voltage Control"