Speed Control of a Three Phase Induction Motor Using PWM Inverter

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Abstract— **There are different method of speed control of three phase induction motor and to control the speed of three phase induction motor generally using V/F control strategy. Out of the a number of methods of speed control of an induction such as pole changing, frequency variation, variable rotor resistance, variable stator voltage, constant V/f control, slip recovery method etc., the constant V/f speed control method is the majority generally used. In this method, the V/f ratio is kept constant which in turn maintains the magnetizing flux constant so that the maximum torque remains unchanged. Thus, the motor is totally utilized in this method.**
This paper include with simulation of V/F speed control of three-phase induction motor using PWM inverter strategy. The simulation work proves the idea of V/F control using PWM inverter and the software used for simulation is PSIM (Powersim).The performance of the volt per hertz strategy were evaluated through simulation shown in results. In constant V/F control, by use PWM inverter, we can vary the supply voltage as well as the supply frequency such that the V/F ratio remains constant so that the flux remains constant too. So, we can get different operating zone for various speeds and torques and also we can get different synchronous speed with almost same maximum torque. Thus the motor is fully utilized and also we have a good variety of speed control. It is effortless, cost-effective to easier to design in open loop. But the drawbacks of open loop is it doesn't correct the change in output also it doesn't reach the steady state quickly.

Index term— **Induction motor, Speed control, V/F method , PWM Inverter**

I. INTRODUCTION

Engineering drive applications are usually classified into constant speed and variable speed drives. typically AC machines have been used in constant speed applications, whereas DC machines were chosen for changeable speed drives. DC machines have the disadvantages of higher cost and protection problems with commutators and brushes. Commutators and brushes do not permit a machine to operate in unclean and explosive environment. An AC machine overcomes the problem of DC machines. Although at present, the bulk of variable speed drive applications use DC machines, they are more and more being replaced by AC drives. While there are different methods of speed control of induction motor, Variable Voltage Variable Frequency or V/F is the most ordinary method of speed control. This method is most suitable for applications with no position control requirements or the need for high precision of speed control. Examples of these applications include heating, air conditioning, fans and blowers.

Be present it household application or engineering, motion control is required all over the place. The systems that are working for this idea are called drives. Such a system, if makes utilize of electric motors is known as an electrical drive. In electrical drives, use of different sensors and control algorithms is done to control the speed of the motor use suitably speed control method. Past only dc motors were effective 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, present trends and increase of speed control methods of an induction motor have improved the use of induction motors in electrical drives broadly.[1]

II. DIFFERENT METHOD OF SPEED CONTROL

A three phase induction motor is mostly a constant speed motor so it's fairly not easy to control its speed. The speed control of induction motor is done at the price of reduce in efficiency and low power factor. Before discussing the methods to control the speed of three phase induction motor one should know the necessary formulas of speed and torque of three phase induction motor as the methods of speed control depends upon these formulas [7]

Synchronous speed , $Ns = \frac{120f}{p}$ (2.1)

Where f = frequency and P is the number of poles

The speed of induction motor is given by, N = Ns (1-s) (2.2)

Where, N is the speed of rotor of induction motor

N_s is the synchronous speed

S is the slip

Stator and Rotor both side changed the speed of Induction motor . [12]

(I) The stator side speed control are further classified as:

1. V/F control or frequency control
2. changing the number of stator poles

3. controlling supply voltage
4. adding Rheostat in the stator circuit

(II) The rotor side speed controls are further classified as:
1. Adding external resistance on rotor side
2. Cascade control method
3. Injecting slip frequency emf into rotor side

III. V/F CONTROL OR FREQUENCY CONTROL

Whenever three phase supply is given to three phase induction motor rotating magnetic field is produced which rotates at synchronous speed given by in(2.1)

$$Ns = \frac{120f}{p}$$

In three phase induction motor emf is induced by induction like to that of transformer which is given by

$$E \text{ or } V = 4.44ØKT.f \text{ or } Ø = \frac{V}{4.44KTf} \qquad (3.1)$$

Now if we modify frequency ,synchronous speed changes but with reduce in frequency & flux will increase and this vary in value of flux causes saturation of rotor and stator cores which will further cause increase in no load current of the motor. Its key to maintain flux Φ constant and it is only achievable if we change voltage . i.e if we reduce frequency, flux increases but at the same time if we decrease voltage, flux will also decease causing no vary in flux and hence it remains stable.

Here we are keeping the ratio of V/F as constant. Hence its name is V/F method. For controlling the speed of three phase induction motor by V/F method we have to supply variable voltage and frequency which is easily obtained by using converter and inverter set.

IV. PULSE WIDTH MODULATED (PWM) INDUCTION MOTOR DRIVE OVERVIEW

The initiation of high power, fast switching devices and fast microprocessors has facilitated the expansion of variable speed induction motor drive systems. An induction motor drive system is comprised of a changeable frequency converter, a controller and an induction machine. The block diagram in Figure:1 demonstrates how the most important components of an induction machine drive system work mutually.

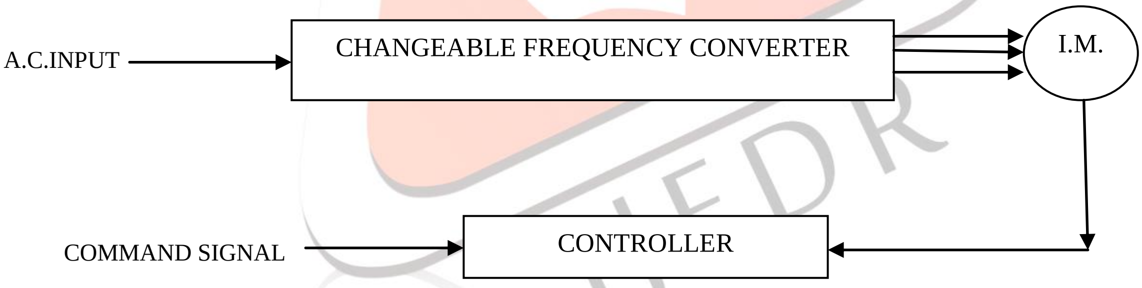

Fig :1 Block Diagram of An Induction Motor Drive scheme

Designed for constantly variable speed control the excitation frequency must be varied and the air gap flux have to be kept constant by controlling the magnitude of the applied voltage in a linear quantity to the excitation frequency. Supplying a voltage of changeable magnitude and frequency to the induction motor requires a variable frequency converter.
Classic variable frequency converter consists of a rectifier, DC link, and inverter. There are two fundamental classifications of inverters used in variable speed induction motor drives: current-source inverters and voltage-source inverters. A current-source inverter is more suitable to high power levels. Most smaller drives utilize a voltage-source inverter, of which the pulse width modulated (PWM) inverter is popular.[6]

- Speed Control of Induction motor using Microcontroller Based PWM Inverter.

The present job makes use of Microcontroller, in order to activate induction motor using V/F method. The various factors which make the microcontroller based system smart are,

(1)Simplicity of execution in variable speed drives
(2)Better reliability and bigger flexibility.
(3)Little cost and high precision
(4)Possible to adjust torque speed characteristics of drive by software adjustment.[1]

- Advantage of using Microcontroller based PWM inverter for Induction motor speed control

(1) Change of PWM frequency at any time
(2) The speed of the motor can be controlled smoothly.
(3) 50 Hz and 60 Hz base frequency both are equally applicable for constructed inverter.
(4) Motor acceleration or deceleration can be controlled and can change the direction of motor at any time.
(5) In online and off line it is possible to change the modulation index and voltage boost therefore it is achievable to control the output voltage.
(5) It is possible to monitor the dc bus voltage of the inverter.
(6) In the projected circuit facility of resistive breaking, fault monitoring [3]

V. PWM INVERTER FOR SPEED CONTROL OF INDUCTION MOTOR

The V/F method of speed control is simulated on PSIM software. The real system can be simulated with a high degree of correctness in this package. It provides a user interactive platform. This Chapter discusses the realization of V/F control using Simulink block.

The Fig:2 shows the simulation diagram of open loop V/F control of three-phase induction motor. It consists DC source (amplitude is 500), three -phase PWM inverter and three phase induction motor. Dc source is connected to the dc side of the converter. In this the reference speed is set. From that reference speed frequency is determined using the formulae illustrated in the equation (2.1). This frequency and amplitude are used to update the PWM duty cycle. MOSFET based converter gives the supply of the induction motor.

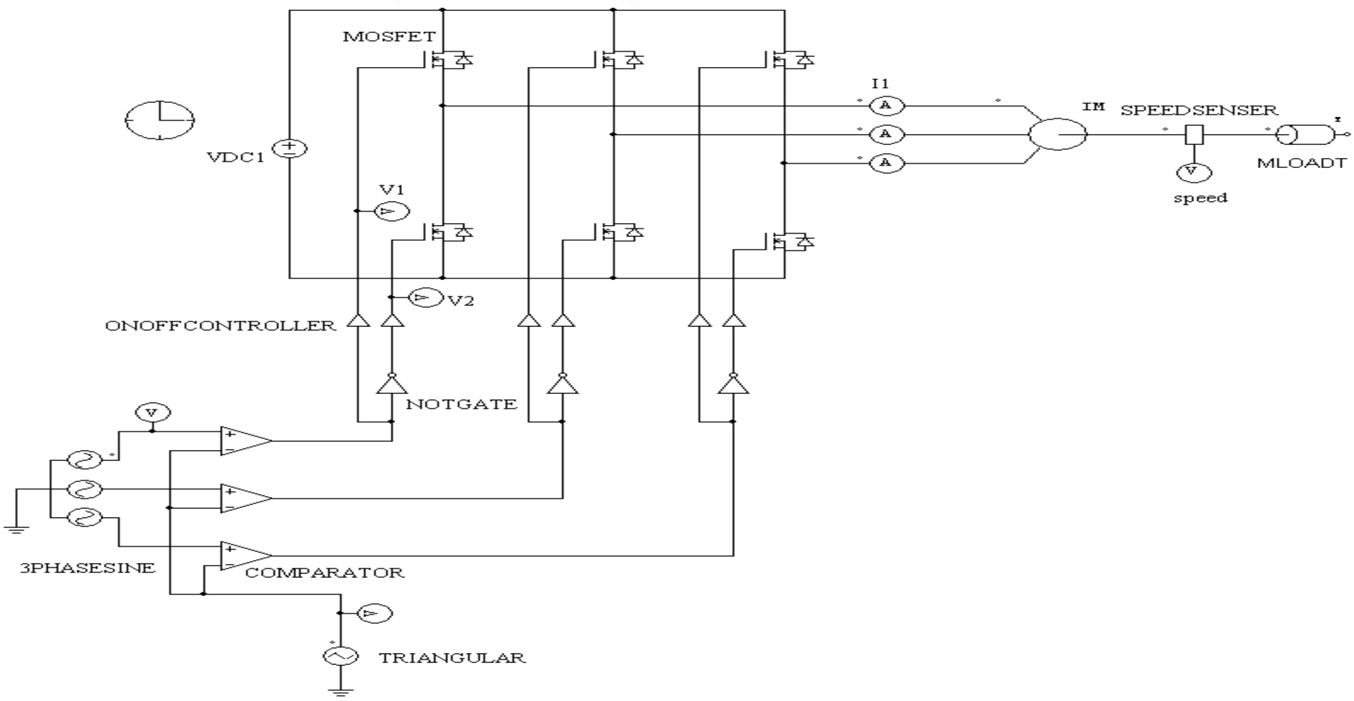

FIG:2 Simulation Diagram of Open Loop V/F Control of Three-Phase Induction Motor

VI. SIMULATION RESULTS

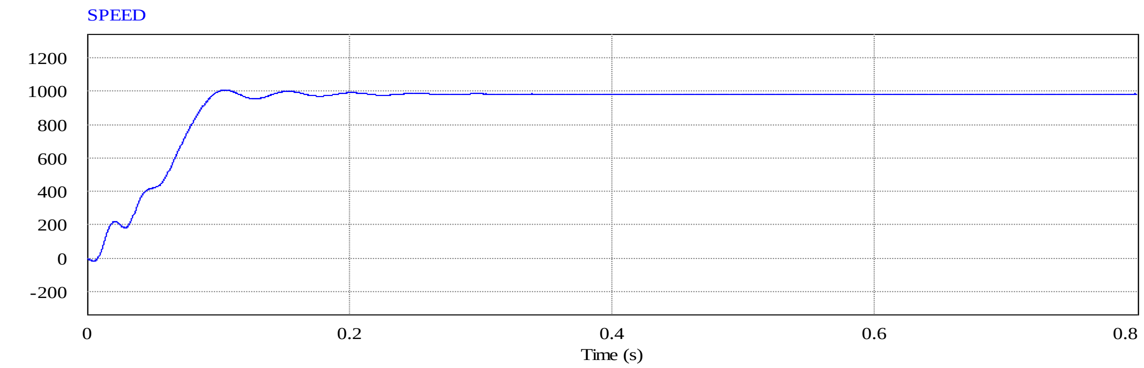

Fig : 3 Output Speed Waveform

The Fig:3 shows the simulated speed waveform of open loop V/F control of three-phase induction motor. Speed reaches the steady state at 0.3 second.

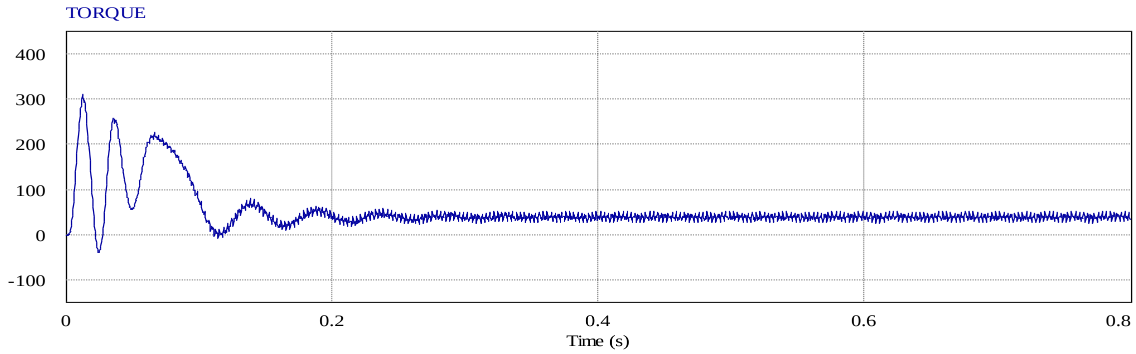

Fig : 4 Torque waveform

Figure:4 shows torque waveform .The mechanical load constant torque is set 40 and amplitude of the D.C source 500

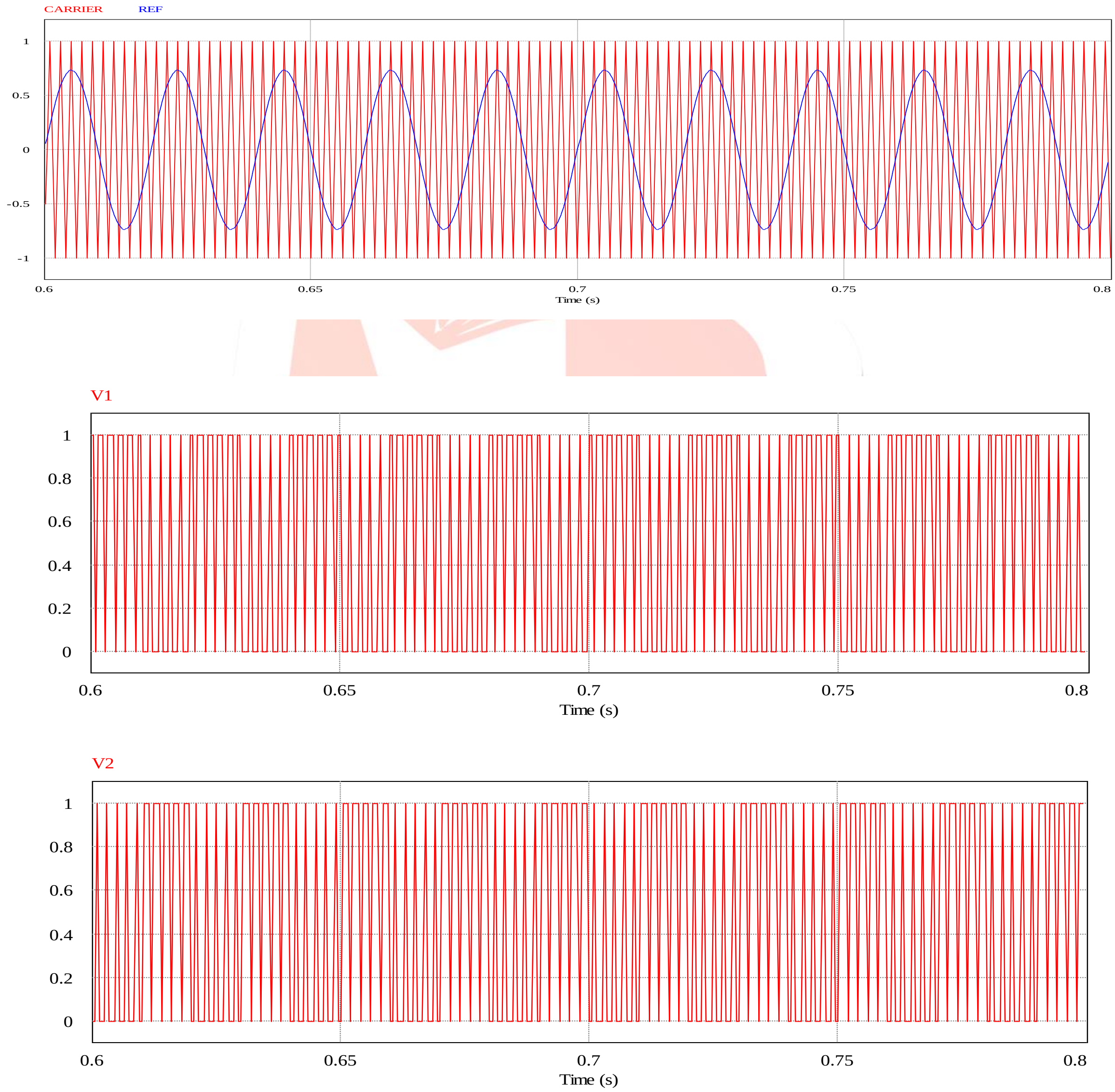

FIG : 5 Comparison of Carrier Wave And Reference Wave And Gate Pulse V1 & V2

The comparison between the carrier and reference wave form are shown in figure:5 and also shows the generating V1 (gate pulse 1) and V2 (gate pulse 2) wave form.

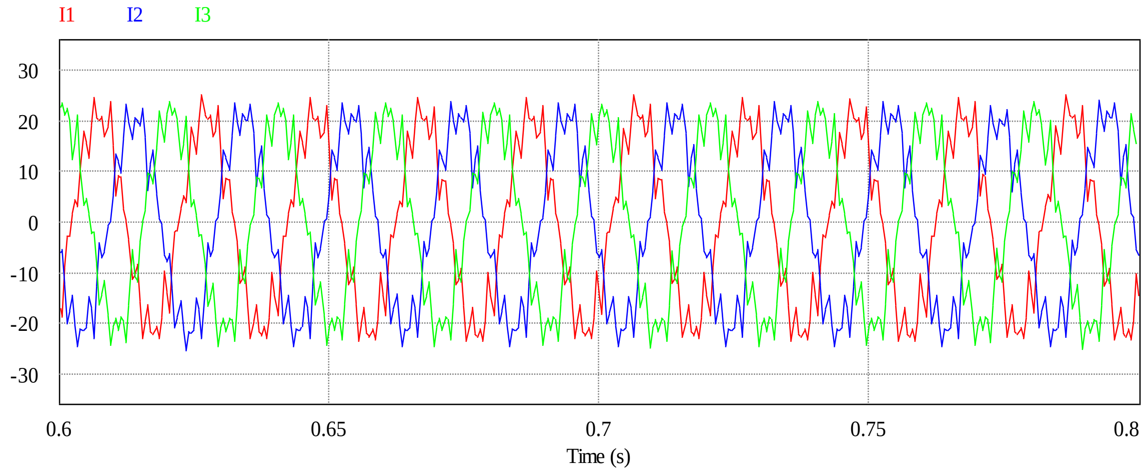

Figure : 6 Current Wave Form I1, I2 ,I3

Finally, we show the current waveform in figure:6 which measure by current prob I1, I2 ,I3 in the simulation diagram . I1 represent the phase 1 and I2 ,I3 represent the phase 2 and phase 3 respectively

This paper describes the simulation of V/F control of induction motor using PSIM and simulation results were presented. From the outputs obtained it is clearly observed that the time taken for speed waveform for open loop control reaches the steady state in 0.3 second.

VII. CONCLUSION

In this paper, constant V/F control, by use of PWM inverter, we can vary the supply voltage as well as the supply frequency such that the V/F ratio remains constant so that the flux remains constant too. we can obtain different operating region for various speeds and torques and also we can get different synchronous speed with approximately same maximum torque. It is uncomplicated, economic to easier to design in open loop. But the drawbacks of open loop is it doesn't accurate the change in output in addition it doesn't attain the steady state rapidly. From the Results clearly observed that the time taken for speed waveform reaches the steady state in 0.3 second.

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