Simulation based V/F speed control of three phase induction motor

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***Abstract*—The three phase induction motors are the most widely used electric motors in industry .They run at a essentially constant speed from no-load to full -load. This report presents need of speed control in induction motor.Out of the several methods of speed control of an induction such as change of number of poles, variation in frequency, variable stator voltage, constant V/f control, variable rotor resistance, slip recovery method etc., the constant V/F control has proven to be the most versatile.One of the basic requirement of this scheme is PWM inverter. In this PWM inverter have been modeled their output is feed to the 3 phase induction motor.A MATLAB SIMULINK MODEL was designed to successfully implement Open Loop V/f Control on a PWM-Inverter fed three-phase Induction Motor, and the torque is observed to be constant for various rotor speeds. Then a MATLAB model for Closed-Loop V/f Control on a PWM-Inverter fed 3-phase Induction Motor. The microcontroller has used to minimize the size of system also speed of microcontroller allows complex control techniques to be used to build control system.**

***IndexTerms*—MOSFET,PWM,SPWM,V/F.**

I. INTRODUCTION

Induction Machines is the most widely used motor in industry. Initially induction motor are used for fixed application however in last two decade, due to evolution of power semi-conductor device and electronics converter induction motor are well established in industrial area. Various methods for the speed control of induction motor.These are Pole changing, variable supply voltage control, variable, supply frequency control,variable rotor resistance control,V/F control [1].Due to simple construction and almost maintenance free operation induction motor dominates DC motor. Theproblem of complex signal processing overcomes by microcontroller which performance related signal processing easily and quickly.Such that voltage frequency control can be realized. Microcontroller is used to adjust the speed of induction motor [2].Three phase diode bridge rectifier converts AC into DC. Three phase voltage inverter converts DC into AC based on PWM controller signal from PIC microcontroller.IGBT or MOSFET driver circuits is used to driver MOSFETS with minimum time from on to off state or off to one state.So, to control speed of induction motor using pic microcontroller [3&4].
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Pulse width modulation refers to a method of carrying information on train of pulses and the information be encoded in the width of pulses. The AC voltage is dependent on two parameters i.e. amplitude and frequency. It is essential to control these two parameters. The most efficient to control these parameters are by using Pulse Width Modulation techniques. In order to generate the gating signals using Pulse Width Modulation Techniques we compare the reference signal amplitude (Ar) with carrier signal amplitude (Ac). The fundamental frequency of output voltage is determined using the reference signal frequency. The ratio of Ar to Ac is called Modulation index. The Pulse width can be varied from 0 to180 (degrees) by varying Ar from 0 to Ac.

2.RELEVANCE:-

There are various methods for the speed control of induction motor.

1)pole changing
2)variable supply voltage control
3)variable supply frequency control
4)variable rotor resistance control

Out of which pole changing method reconstruction of stator for changing poles, variable supply voltage required large voltage deviation for small speed change, variable rotor resistance control causes power losses in external resistance. Frequency control has found widespread use in industrial and domestic application due to following advantages

a)Provides good range of speed.
b)The speed can control above and below rated speed.
c)The acceleration control by controlling rate of change of supply frequency[1].

3. LITERATURE REVIEW:-

I. "Various method of speed control of induction motor."

Prof.k.Vasudevan, Prof.G.Sridhara Rao, Prof.P.Sasidhara Rao

Various methods for the speed control of induction motor. These are Pole changing, variablesupply voltage control, variable supply frequency control, variable rotor resistance control.

II. . "DSP based V/F control of induction motor. "

Mr. C.S.Kamble, Prof. J.G.Chaudhari, Dr.M.V.Aware

The DSP based control systems have numerous advantages. The high processing speed of theDSP family allows sophisticated control techniques to be used to build a high precision control system.

III. . "Open loop V/F control of induction motor based hybrid PWM with reduced torque ripple."

M.H.V.Reddy, V.Jegathesan

Space Vector Pulse Width Modulation (SVPWM) has become the successful techniques toconstruct three phase sine wave Voltage Source Inverter (VSI) parallel to control three-phase induction motor using v/f control. The speed control of induction motor is more important to achieve maximum torque and efficiency. VSI fed induction motor produces a pulsating torque due to the application of non-sinusoidal voltages. Among the various modulation strategies Space Vector pulse width Modulation Technique is the efficient one because it has better spectral performance and output voltage is more closed to sinusoidal. Torque pulsation is strongly influenced by PWM technique used.

IV. "Microcontroller based control of 3 phase induction motor using PWM."

S.M.Wankhede, R.M. Holmukhe

The microcontroller based speed controlling system can be used various industries to operatemotor according to the desired speed this is completely closed loop system and the speed of the motor will be controlled automatically using feedback from motor in terms of
RPM.

V. "V/F control of induction motor drive."

Mr.D.Jee, Mr.N.Patel

One of the basic requirements of this scheme is the PWM Inverter. In this, PWM Invertershave been modeled and their outputs fed to the Induction Motor drives. The uncontrolled transient and steady state response of the Induction Motor has been obtained and analyzed. A MATLAB code was developed to successfully implement Open Loop V/f Control on a PWM-Inverter fed 3-phase Induction Motor, and the Torque was found to be constant for various rotor speeds. This was followed by a MATLAB model for Closed-Loop V/f Control on a
PWM-Inverter fed 3-phase Induction Motor. It was observed that using a Closed-Loop scheme with a Proportional Controller gave a very superior way of controlling the speed of an Induction motor while maintaining a constant maximum torque.

VI. "3 phase induction motor drive using IGBTs and constant V/F method."

. M.S.Aspalli, Asha R. P.V. Hunagund

It presents design and analysis of a three phase induction motor drive using IGBT"s at the
inverter power stage with volts hertz control (V/F) in closed loop using dsPIC30F2010 as a controller.It is a 16 bit high-performance digital signal controller (DSC). DSC is a single chip embeddedcontroller that integrates the controller attributes of a microcontroller with the computation and throughput capabilities of a DSP in a single core. A 1HP, 3-phase, 415V, 50Hz induction motor is used.

VII. "Designe of three phase voltage source converter with "ISPWM technique for performance analysis of three phase induction motor"

R.B.madke

This report work deals with the design,implementation and analysis of voltage source converter with ISPWM technique.These work will be consist of three phase voltage source converter.These converter based on new pulse width modulation technique is called as inverted sine PWM..

4. PROPOSED WORK:

4.1. Induction motor:-

The three phase induction motors are the most widely used electric motors in industry. They run at a essentially constant speed from no-load to full -load. Induction Motors account for more than 85% of all motors used in industry and domestic applications. In the past they have been used as constant-speed motors as traditional speed control methods have been less efficient than speed control methods for DC motor.

4.2. Control strategy for controller:-

The induction motor speed variation can be easily achieved for a short range by either stator voltage control or rotor resistance control. But both of these schemes result in very low efficiencies at lower speeds. The most efficient scheme for speed control of induction motor is by varying supply frequency. This not only results in scheme with wide speed range but also improves the starting performance.

If the machine is operating at speed below base speed, then v/f ratio is to be kept constant so that flux remains constant. This retains the torque capability of the machine at the same value. But at lower frequencies, the torque capability decrease and this drop in torque has to be compensated for increasing the applied voltage.

The EMF equation is given by,

$$E=4.44f \, \phi \, T$$

$$\text{Stator Voltage (V)} \propto [\text{Stator Flux } (\phi)] \times [\text{Angular Velocity } (\omega)]$$

$$V \propto \phi \times 2\pi f$$

$$\phi = V/F$$

The induction motor design to operate at particular value of flux known as knee point. If we varies only voltage or only frequency the value of flux also change .If flux increases above the knee point the core of the motor get saturated. If the value of flux decreases below knee point, the value of starting torque get reduces and speed get fluctuate.

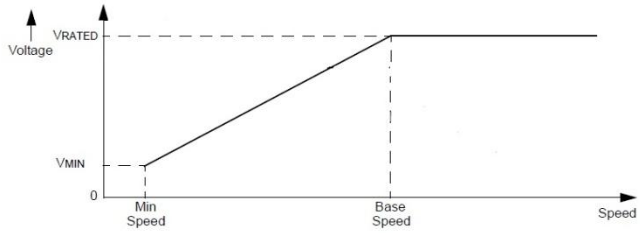


Fig 1. voltageVs Speed Characteristics

4.3. PWM INVERTER:-

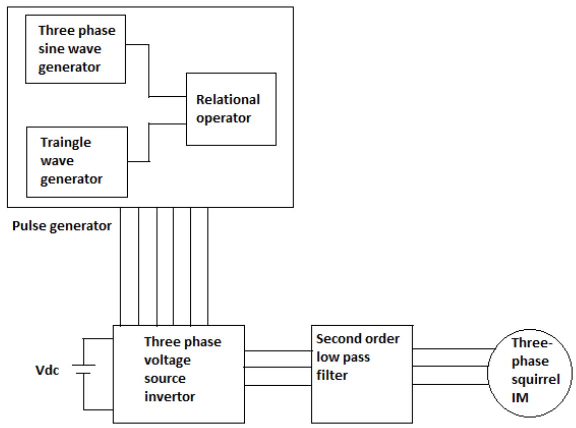


Fig 2.General Block Diagram

The PWM inverter converts DC supply to AC supply.From fig 10.1, the output voltage of inverter is controlled by Pulse Width Modulation. Hence no arrangement required for variation of input DC voltage. The input to the induction motor is controlled by controller unit by varying the pot.

5. SIMULATION WORK:-

For the open loop control of induction motor the voltage source inverter employing sinusoidal pulse width modulation technique is used, the output of inverter is feed to second order low pass filter prior to the motor.

As shown in above block diagram, gate pulses for the inverter are generated by comparing the sine wave and triangle wave by the relational operator. Whenever the sine wave amplitude is lessthan triangle wave it generates the output high otherwise low. For one leg of inverter the positive group switch is feed directly from output of relational operator and negative group switch is feed by NOT gate of same relational operator. Similarly for other two legs two more relational operators is used, in this way total six pulses are generated for six switches of inverter. Such, pulses which are feed to inverter.

5.1. PWM :-

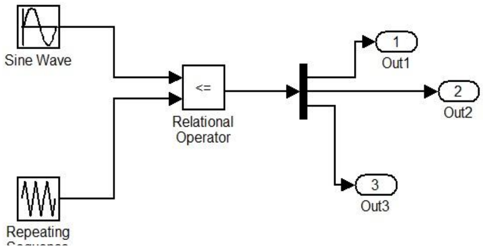


Fig 3. Simulink Model for SPWM Pulses generation

Above fig shows the Simulink Model for SPWM Pulses generation. The sinusoidal pulse-width modulation (SPWM) technique produces a sinusoidal waveformcompared with triangular waveform .Where sinusoidal waveformassumed as the reference waveform. The desired output voltage is achieved by varying the frequency and amplitude of a reference or modulating voltage. The variations in the amplitude and frequency of the reference voltage change the pulse-width patterns of the output voltage but keep the sinusoidal modulation.

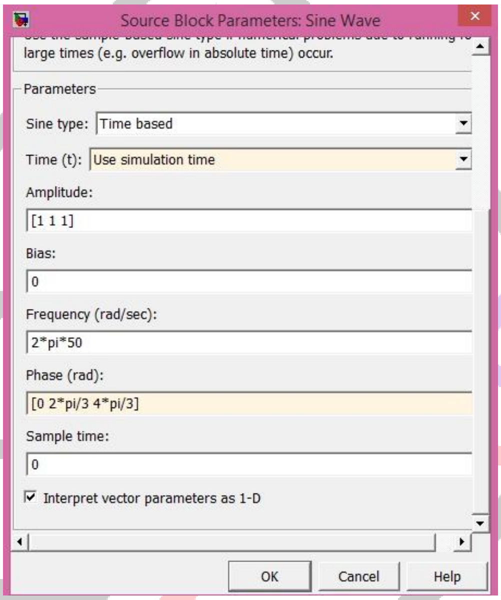


Fig 4.Selection parameter for sine wave generator

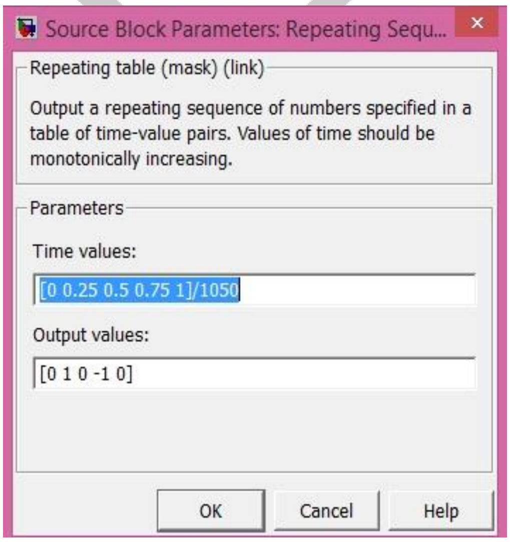
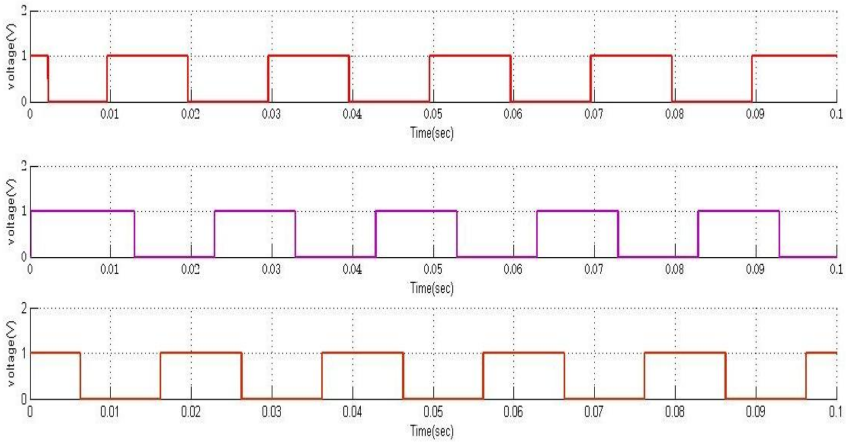


Fig 5. Selection parameter for triangular wave generator

A low-frequency sinusoidal modulating signal is compared with a high frequency triangular signal, which is called the carrier signal. The switching state is changed when the sine

waveform intersects the triangular waveform. The crossing positions determine the variable switching times between states. N three-phase SPWM, a triangular voltage waveform (VT) is compared with three sinusoidal control voltages (Va, Vb,



and Vc), which are 120° out of phase with each other and the relative levels of thewaveforms are used to control the switching of the devices in each phase leg of the inverter.The output of the PWM is shown in fig.

Plot 1.Output of the SPWM

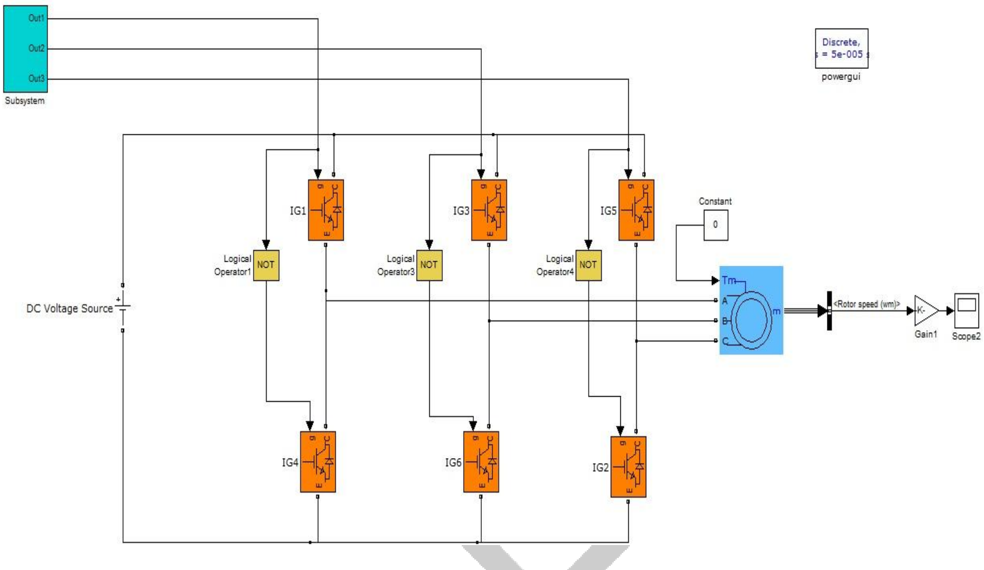


Fig 6.Simulink Model for SPWM Inverter fed Induction Motor

Above fig shows the Simulink Model for SPWM Inverter fed Induction Motor. Here we developed a DC to AC inverter fed to induction motor in Simulink / Matlab with a three phase PWM inverter controlling both the frequency and magnitude of the voltage output. For generation of PWM pulses the technique was used comparing sinusoidal control voltage (at the desired output frequency and proportional to the output voltage magnitude) with a inverted sine waveform at a selected switching frequency. For this simulation 20HP (15 KW),400V, 50Hz,1460 RPM squirrel cage Asynchronous motor is used. The speed of induction motor is in rad/sec. By multiplying negative Gain of 60/2*pi speed is converted into RPM.

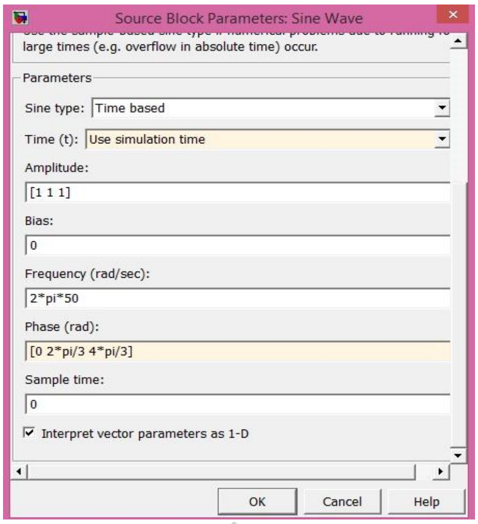
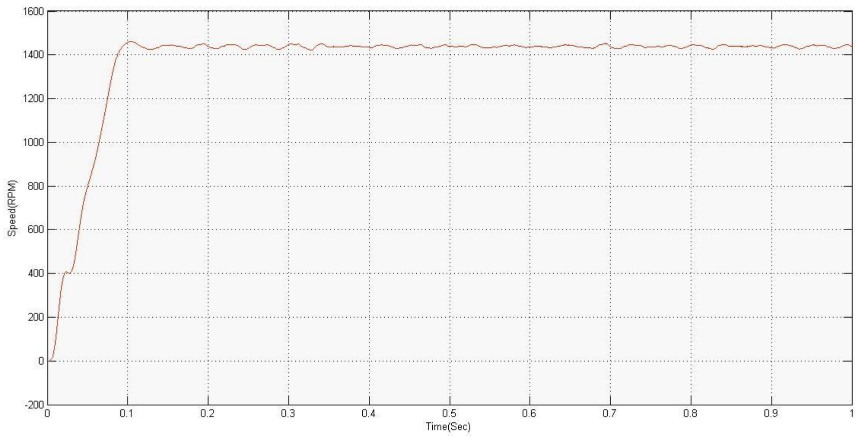


Fig 7.Selection parameter for rated speed



Plot 2. Speed Vs Time Characteristics for rated speed

Above fig. shows, the result obtained from the simulation for rated speed case .In this case the rated value of voltage 1(pu) and rated value of frequency 50Hz are given to the carrier wave. This gives us the V/F ratio 8.

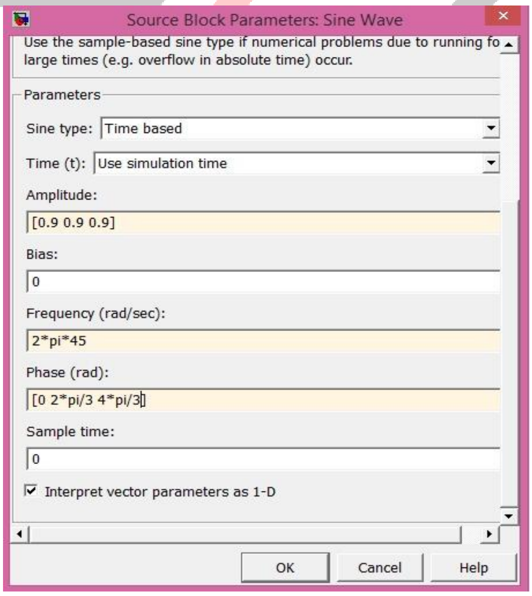
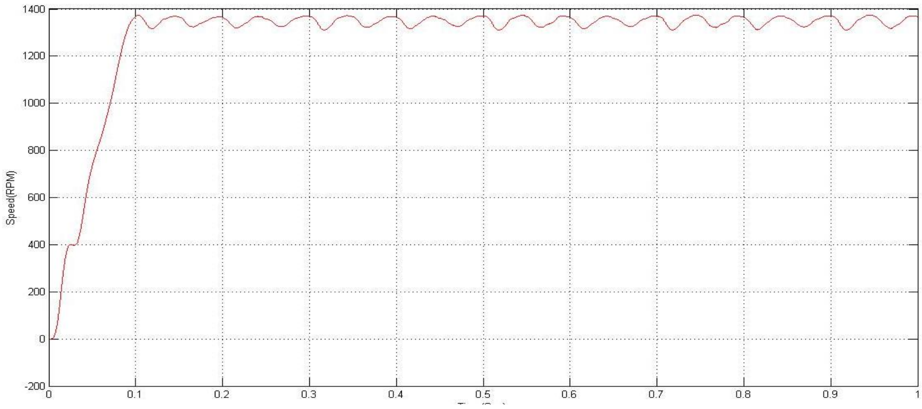


Fig 8. Selection parameter for below rated speed



Plot 3. Speed Vs Time Characteristics for below rated speed

Above fig. shows, the result obtained from the simulation for below rated speed case .In this case the rated value of voltage 0.9(pu) and rated value of frequency 45Hz are given to the carrier wave without changing the V/F ratio in previous case 8.

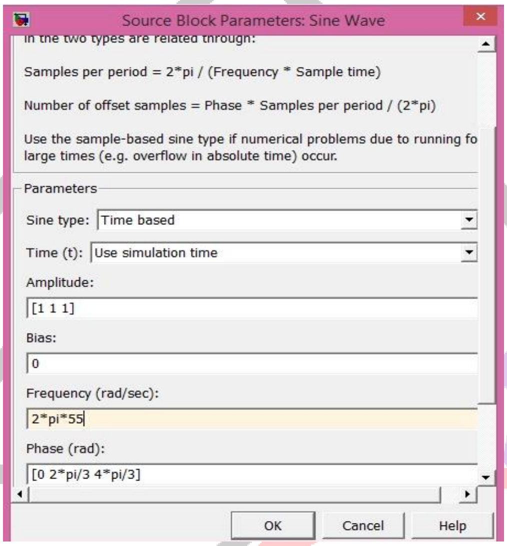
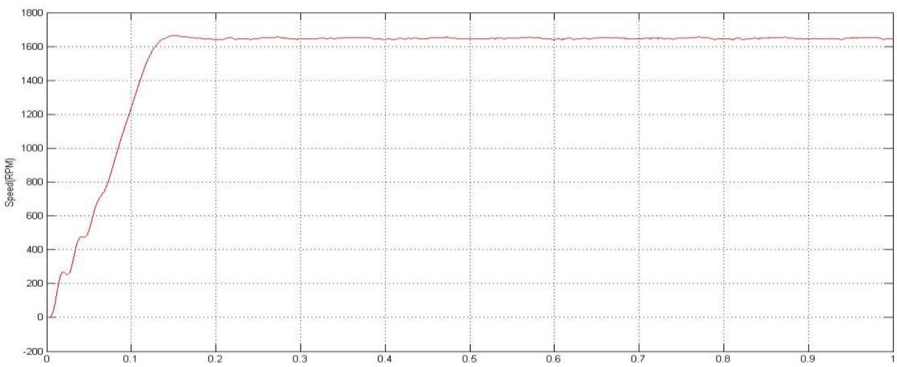


Fig 9.Selection parameter for above rated speed



Plot 4. Speed Vs Time Characteristics for above rated speed

Above fig. shows, the result obtained from the simulation for above rated speed case .In this case the rated value of voltage 1(pu) and rated value of frequency 55Hz are given to the carrier wave.

6. Conclusion:-

Speed of 3- phase Induction model is controlled successfully in open method. The PWM signals were generated in controlling technique by comparing either a triangular waveform with a sinusoidal waveform using relational operators. An Induction Motor was run with the help of a PWM Inverter for implementing the speed control mechanisms and the various characteristic curves were obtained. It was observed that there were a lot of transient currents in the stator and rotor at the time of starting and they took some time to settle down to their steady-state values. Open-loop V/f Control was implemented using MATLAB. The Voltage Source Inverter varied the magnitude of the terminal Voltage accordingly so that the V/f ratio remained the same. It was observed that again the maximum torque remained constant across the speed range. Hence, the motor was fully utilized and successful speed control was achieved.

REFERENCE:-

1. Prof.k.Vasudevan, Prof.G.Sridhara Rao, Prof.P.SasidharaRao,"Various method of speed control of induction motor." IIT madras, 2008.

2. Mr. C.S.Kamble, Prof. J.G.Chaudhari, Dr.M.V.Aware,"Digital signal processor based V/F control of induction motor drive." , IEEE, vol.no.10,10 Nov, 2009.

3. M.H.V.Reddy, V.Jegathesan "Open loop control of induction motor based on hybrid PWM with reduced torque ripple." IEEE, vol. no.11, 2010.

4. S.M.Wankhede, R.M. Holmukhe, "Microcontroller based control of 3 phase induction motor using PWM." ICEEN, 2011.

5. Mr.D.Jee, Mr.N.Patel,"V/F control of induction motor drive." NIT, May2013.

6. M.S.Aspalli, Asha R. P.V. Hunagund ,"3 phase induction motor drive using IGBTs and constant V/F method"IEEE, vol. no.1, Nov, 2012

7..R.B.madke"Design of three phase voltage source converter with "ISPWM technique for performance analysis of three phase induction motor".