MATLAB Simulation for Speed Control of Three Phase Induction Motor Drive using V/FControl

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Abstract

As the subject of the paper, the speed control of induction motor fed by a three phase voltage source inverter has been done using PWM. To control the peak dc link voltage of the VSI, a PI controller was designed. This model uses the bode diagram. Based on the required dynamic specifications, the parameters of the PI controller were calculated. The speed control method adopted was compared with the adjustable speed drives. The comparison was done to change the motor speed from 0 to the rated speed (N_s) with the rated load torque. MATLAB simulation of the proposed speed control method for 1HP induction motor was done to verify the performance of the proposed method.

Keywords:*Induction motor, Mathematical model, Volt-per-Hertz Controller, Control, MATLAB Simulink. D space*

I. INTRODUCTION

The industrial need to improve the quality of the product can be fulfilled by the application of constant and variable speed drive systems. Until 1980s, DC motors were the choice of variable speed drive. Control of DC motor running at constant speed at any load was achieved by Devangan et.al.[1].

Latter on the induction motor became the workhorse in the industries. Low cost, high efficiency, high robustness, reliability and low maintenance are some the advantages of the induction motors over DC motors. When mechanical loads are changed the speed characteristics for induction motor also changes. The induction motors do not have the constant speed characteristics. There are many control methods the induction motor to provide it with the constant speed characteristics. Some of the prominent methods are scalar control, vector control etc. [2-5]. The popular V/F method of induction motor operation has been known over decades [6]. It uses the stator flux and torque error to generate the stator voltage and frequency [7-10]. In order to increase the reliability, flexibility and simplicity of controlling the error and therefore to provide constant speed characteristics to induction motor drives, microcontrollers are being used. In the present work, a model of a three-phase induction motor wasdone using the mathematical modeling principles. The speed of three-phase induction motor was then controlled using six switches. The D-space was used for controlling the speed. The error signal is generated bycomparing fundamental component of input line to line voltage of motor with reference voltage. The model was executed using MATLAB software.

TABLE I Nomenclature

V_{ds}	Voltage of stator on direct axis	V_{qs}	Voltage of stator on quadrature axis
L_a	Total self-inductance	L_{ad}	Self-inductance on direct axis
L_{aq}	Self-inductance on quadrature axis	$\square_{ds}$	Mutual-inductance of stator on direct axis
$\square_{qs}$	Mutual-inductance of stator on quadrature axis	$\square_{dr}$	Mutual-inductance of rotor on direct axis

$\square_{qr}$	Mutual-inductance of rotor on quadrature axis	$\square_{mq}$	Mutual-inductance of main winding
Ls	Self-inductance of stator	Lr	Self -inductance of rotor
T_e	Electrical torque developed	j	Moment of inertia
T_l	Load torque	$\square_r$	Speed of rotor

TABLE II **PARAMETERS OF THE INDUCTION MOTOR FOR THE SIMULATION STUDY**

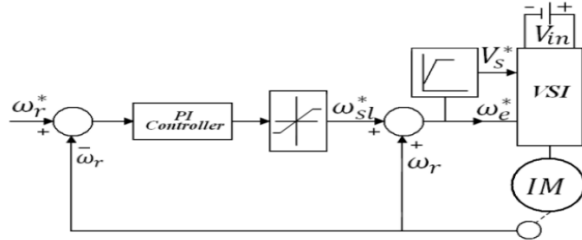|	
Source voltage : 415 volt	Frequency: 50 Hz
Stator Reactance: 0.0412henry	Rotor reactance: 0.0412henry
Power: 1 hp	Speed: 1415 rpm
Rotor resistance: 12.53 ohm	Stator resistance: 2.3 ohm

II. *Drive System Configuration*

Fig.1. Block diagram of V/F control

The block diagram of system configuration is shown in Fig. 1. An error signal obtained by the difference between the actual speed and reference speed.The error was then processed in a controller.The output then sets the inverter frequency as well as the modulation index. The slip speed command ω_{sl}, is regulated by a slip regulator.The PWM based three phase inverter frequency was determined from the synchronous speed. The synchronous speed was calculated by summing actual speed ω_f to the slip speed ω_{sl}.,Frequency ω_s generates the reference signal for the V/F control of the induction motor terminal voltage V_s. The drive finally gets settles at slip speed (motor torque balances the load torque).

III. *Modeling and Simulation of Drive System*

A.Induction motor modeling

   The mathematical model for induction motor in the stationary reference was obtained on the basis of applied stator voltage and flux linkage using the following sets of equations:

$$v_{ds} = v_{an}$$

$$v_{qs} = (v_{bn} - v_{cn})/\sqrt{3}$$

$$L_a = (1/L_m) + (1/l_{ls}) + (1/l_{lt})$$

$$L_{ad} = L_{aq}$$

$$d\Psi_{ds}/dt = V_{ds} + (R_{s/}/L_{ls})(\Psi_{md} - \Psi_{ds})$$

$$d\Psi_{dr}/dt = (R_s/L_{lr})(\Psi_{md} - \Psi_{ds}) - \omega_r\Psi_{qr}$$

$$d\Psi_{qr}/dt = (R_s/L_{lr})(\Psi_{mq} - \Psi_{qs}) - \omega_r\Psi_{dr}$$

$$\Psi_{md} = L_{ad}((\Psi_{ds} + /L_{lr}) + (\Psi_{dr}/L_{lr}))$$

$$\Psi_{mq} = L_{aq}((\Psi_{qs}/L_{ls}) + (\Psi_{qr}/L_{lr}))$$

$$i_{ds} = (\Psi_{ds} - \Psi_{md})/L_{ls}$$

$$i_{qs} = (\Psi_{qs} - \Psi_{mq})/L_{ls}$$

$$T_e = (3P/4)(i_{qs}\Psi_{ds} - i_{ds}\Psi_{qs})$$

$$d\omega_r/dt = 1/J\{p/2(T_e - T_l) - b\omega_r\}$$

B. Modelling of Controller

The design of controller was done using the following equations

$$y(t) = k_p e(t) + k_i \int_0^t e(k)$$

$$y(k) = k_p error + k_i \sum_0^k error(n)$$

   Where, k_p and k_i are proportional and integral gain constant.

IV. D -Space Implementation for V/F Speed Control

   In the recent scheme we have selected VSI for the squirrel cage Induction motor through D-Space. Now a day's D-Space replaces microcontroller where inverter receives firing pulses from D-Space. The motor has been operated under variable speed mode at rated speed. The speed can be risen higher than the rated speed using D-space.

A.MATLABSimulation/Simulink Model

   MATLAB simulation controlled the speed of induction motor making useof thecontrol circuit and power circuit with implementation of D-Space as shown in Fig.2
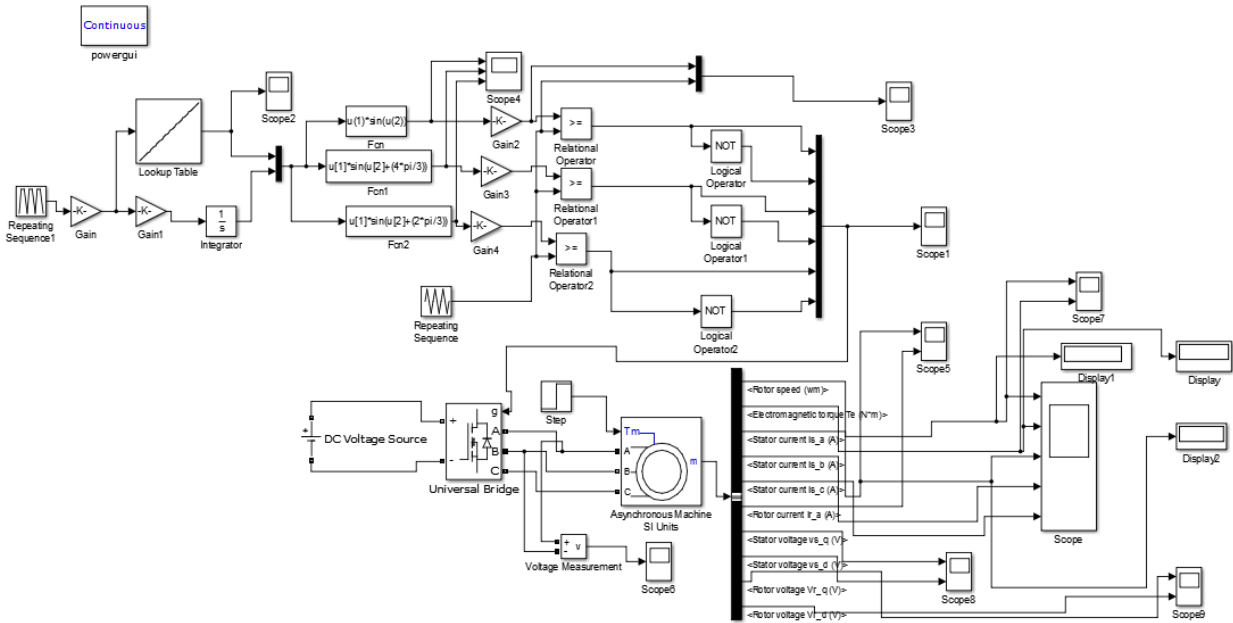
Fig. 2 Simulation model of V/F speed control of induction motor

V RESULT

The simulation results were obtained when rotor is rotated for 10 seconds. Initially rotor at standstill condition at t=0 and it reached speed of

150 rad/sec at t = 10 seconds. Load torque, T_L = 0.5 N-m was applied. The output of control circuit or VSI output is shown in figure 4.

When the output of VSI was fed to squirrel cage induction motor, then electrical torque was found to increase and after some time it became constant. Output depends on the PI controller value. Fig. 4 shows the simulation results giving the variation of three phase current and torque in accordance with the speed.
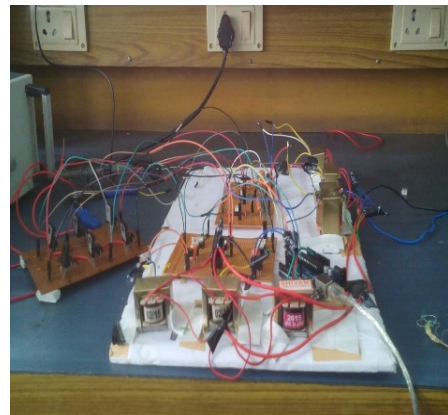

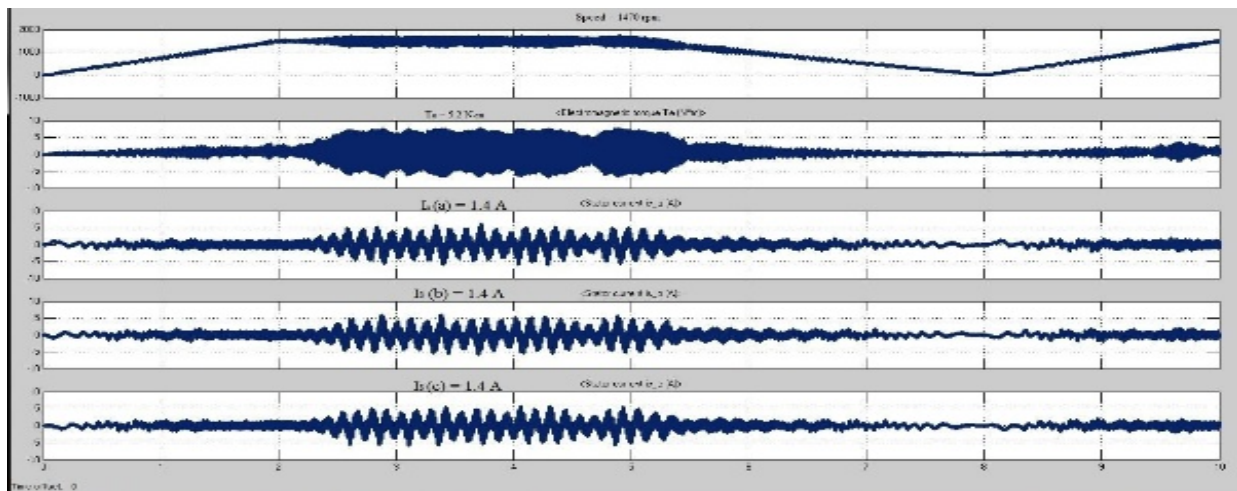**Fig. 3** Hardware of power circuit and firing circuit of voltage source inverter

Fig. 4 Simulation result of line voltage of VSI, stator direct axis and quadrature axis current

VI. CONCLUSION

This paper presented a new V/F control of induction motor through D-Space fed by voltage source inverter based on V/F control. Speed is controlled by interfacing of D-Space. The validity of speed control method were verified from the simulation results and input voltage change and also verified that the speed control through D-Space is very efficient compare to microcontroller.

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