Design Asynchronous Machine Modeling using Simulink by PWM Inverter

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Abstract— The number of industry applications in which induction motors are fed by static frequency inverters is growing fast and, although much has already been done within this field, there is still a lot to be studied/ understood regarding such applications. The advance of variable speed drives systems engineering increasingly leads to the need of specific technical guidance provision by electrical machines and drives manufacturers, in this paper we have studied and developed a Simulink model with PWM inverter and find out the various characteristics and analysis them. This paper presents control of a three phase induction motor using single phase inverter with constant volts hertz control (V/F) method and pulse width modulation. Frequency control with flux proportional to V/f and voltage proportional to the speed seems to be the best solution. PWM gives a high quality output voltage. Single phase inverter output gives a better feed to the induction machine without extra components needed on the motor and also produces a higher starting torque and reduced speed pulsation amplitude.

Key words: ASM (Asynchronous Machine), PWM (Pulse Width Modulation)

I. INTRODUCTION

In the present time, in the mainly of the applications, AC machines are preferable over DC machines appropriate to their effortless and most robust construction without any mechanical commutators [1].Induction motors are widely used in many residential, commercial, industrial and utility applications. This is because the motor have low manufacturing cost, wide speed range, high efficiency and robustness [2]. However the use of induction motors also has its disadvantages, these lie mostly in its not easy controllability, unpaid to its complex mathematical model, its nonlinear behaviour during saturation effect and the electrical parameter oscillation which depends on the physical force of the temperature. Induction motor is essentially a constant-speed motor. Its speed of rotation is determined by the synchronous speed. In many industrial applications wide variation in motor speed is required. This can be achieved next to varying the stator frequency of the motor thereby varying the synchronous speed. Therefore, Motor control is a significant [3]. There are various control techniques available for the speed control of inductor motor like changing stator poles technique.

In this paper design to present a V/f control technique for the control of three phase induction motor. For this we have to kept voltage and frequency ratio constant. There would necessary to increase the maximum allowed current of the speed control unit by this means making it possible to sell their products to a wider range of customers with dissimilar needs for example control of pumps and more powerful fans, so here it is important to minimize the losses created in the machine/motor. AC drives, inverters and adjustable frequency drives all requisites that are used to control the speed of AC motor. AC drives receive AC power and convert it to an adaptable frequency, adjustable voltage output for controlling motor operation. The three common inverter types are Current source inverter (CSI), Voltage source inverter (VSI), Pulse width modulation inverter (PWM).

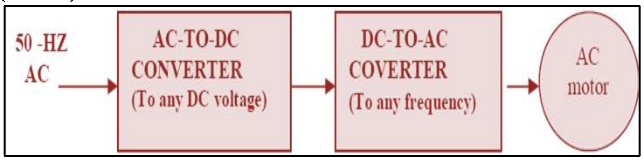

Fig. 1: Block Diagram of Speed Control Method

Output voltage from an inverter can also be adjusted by exercise a control within the inverter itself. The most efficient method of doing this is by pulse-width modulation control used within an inverter. In this method, a fixed dc input 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 the most popular method of controlling the output voltage and this method is termed as Pulse-Width Modulation (PWM) Control.

II. PREVIOUS WORK

Three phase induction motor and their Torque-Speed analysis induction motor can be categorized into two ϕ based on the construction of the rotor, 3- types: i. Squirrel Cage Induction Motor ii. Wound Rotor or Slip Ring Induction Motor The stator of both types of motors consists of a three phase balanced distributed winding with each phase mechanically separated in space by 120 degrees from the other two phase windings. This gives rise to a rotating magnetic field when current flows through the stator. In squirrel cage IM, the rotor consists of longitudinal conductor bars which are shorted at balanced ϕends by circular conducting rings. Whereas, the wound rotor IM has a 3- distributed winding even on the rotor side with as many number of poles as in the stator winding.

The applications of induction motors in various fields are increasing day by day because of the robustness and low maintenance cost. Maximum of these applications not only need fast response but also need intelligent speed control. To achieve high efficiency and maximum torque, speed control is the main concern of the induction motor. This paper introduces different classifications of speed control of an induction motor. Different characteristics of each speed control method will be described including performance, maintenance cost and area of applications. Finally based on different relative advantages and disadvantages comparison will be made among different types of speed control of induction motor as each type of control will be suitable for various applications.

Equivalent circuit-The advantages possessed by PWM techniques are as under:

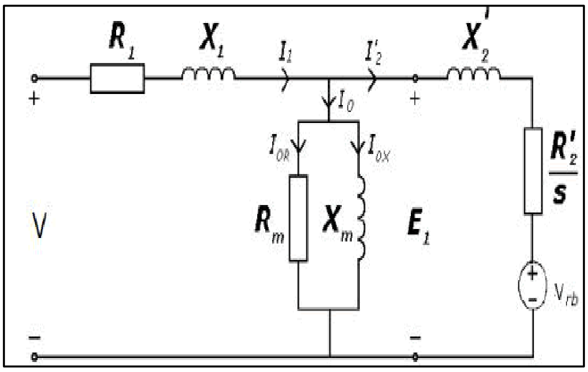

Fig. 2: Equivalent to Circuit of Poly Phase Induction Motor

V1= Stator Terminal Voltage
E1= Stator Emf Generated By Result
R1=Stator Effective Resistance
X1=Stator Leakage Reactance
R_M= Iron Core- Loss resistance
X_M= Magnetizing Reactance
R'_2 =Rotor Effective Resistance referred to stator
X'_2 = Rotor Leakage Resistance referred to stator
I_0= Sum of Magnetization
I_1= Stator Current
I'_2 = Rotor Current referred to stator
Vrb=emf due to the saturated iron bridges in the rotor slot

The output voltage control with this method can be obtained without any additional components. Through the method, lower command harmonics can be eliminated or minimized all all along with its output voltage control. As higher order harmonics can be filtered easily, the filtering constraints are minimized. The main drawback of this method is that SCRs are expensive as they must possess low turn-on and turn-off times.

The machine which we have simulated is a three phase induction machine having the subsequent details The Asynchronous Machine block operates in either producer or motor mode. The mode of operation is dictated next to the sign of the mechanical torque: If Tm is positive the machine acts as a motor. If Tm is negative, the machine do something as a generator. Inputs and Outputs of the machine Tm the Simulink input of the building block is the mechanical torque at the machine's shaft. When the input is a positive Simulink signal, the asynchronous machine behaves as a motor. When the input is a negative signal, the asynchronous machine performs as a generator. m The Simulink productivity of the block is a vector surround 21 signals. We can DE multiplex these signals by using the Bus Selector block. The stator terminals of the Asynchronous Machine block are identified by the A, B, and C letters. The rotor terminals are identified by the r. Note that the dispassionate connections of the stator and rotor windings are not available; three-wire Y connections are assumed

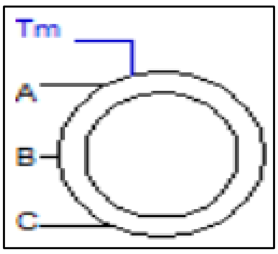

Fig. 3: ASM block

Lm	Magnetizing
Ls, L'r	Total stator and rotor inductances Vqs
Vqs, iqs	q axis stator voltage and current
V'qr, i'qr	q axis rotor voltage and current
p	Number of pole pairs
Te	Electromagnetic torque
Tm	Shaft mechanical torque
J.	Combined rotor and load inertia coefficient.
H	Combined rotor and load inertia constant
F	Combined rotor and load viscous friction coefficient

Table 1: Basic Parameter of Simulink for ASM Modelling

III. PROPOSED ASYNCHRONOUS MACHINE FOR SIMULINK MODELING

The ASM Current Controller implements discrete-time proportional-integral (PI) based asynchronous machine (ASM) current control in the rotor d-q reference frame. You typically use the ASM Current Controller in a series of blocks that make up a control structure. For example, to convert the dq0 reference frame output voltage to voltage in an abc reference frame, connect the ASM Current Controller to an Inverse Clarke Transform in the control structure. The basic block schematic of three-phase induction motor drive is shown in fig.3. It has 4 pulse discrete PWM Generator, Single phase inverter. In the proposed work the single-phase bridge inverter is designed using IGBT. IGBT switches are used because; they have high switching frequency [2]. Discrete Fourier is used to compute magnitude and phase of fundamentals. In this distorted current waveform convert into equivalent harmonic component. By which, we can find out THD. Output of inverter is feeded to three phase induction motor model for speed control. For creating 3rd phase adding a capacitor branch in series of 2nd phase this block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. Press Help for suggested snubber values when the model is discretized. For most applications the internal inductance Lon of diodes and thyristors should be set to zero. This block computes the fundamental value of the input signal over a running window of one cycle of the specified fundamental frequency. First and second outputs return respectively the magnitude and phase (degrees) of the fundamental. For the first cycle of simulation, the outputs are held constant to the value specified by the parameter "Initial input" Resistance. 1e5 this block computes the fundamental value of the input signal over

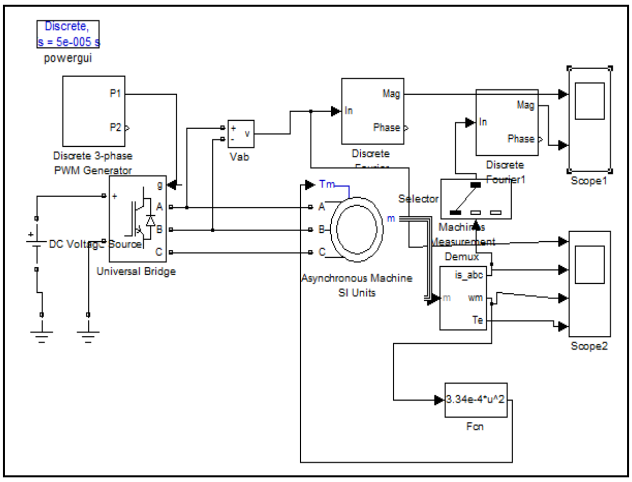

Fig. 3: Design Model

A running window of one cycle of the specified fundamental frequency. First and second outputs return respectively the magnitude and phase (degrees) of the fundamental. For the first cycle of simulation, the outputs are held constant to the value specified by the parameter "Initial frequency 60khz. The Discrete 3-phase PWM Generator block generates pulses for carrier-based Pulse Width Modulation (PWM) converters. The block can be used to fire the forced-commuted devices (FETs, GTOs, or IGBTs) of 2-level or 3-level converters using a single bridge or two bridges connected in twin configuration. Vectorised outputs P1 and P2 contain either 6 pulses (2-level) or 12 pulses (3-level). Use output P1 when operating in single-bridge configuration. The modulating signals can be applied at Input 1 (Uref) and the synchronization signal at input 2 (wt). Look under the mask' of the block to get a description of the pulse pattern.

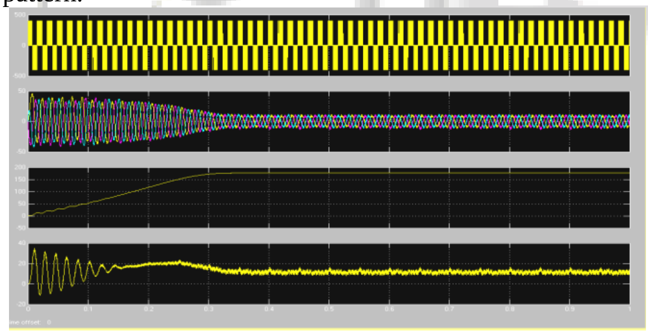

Fig. 4: Simulation Results of Main Winding Current & Simulation Result of Induction Machine Start

IV. Conclusion

Three phase induction motor control by using single phase inverter is very economical. Switching from "volt control" to "frequency control (volt / hertz)" method would make it possible to achieve the increase in current supplied to the induction machine, thereby decreasing heat inside the enclosure. The 3-phase output gives a better feed to the induction machine without extra components needed on the motor. It has been observed that 3-phase output from the PWM inverter will reduce speed pulsation and produce a higher starting torque. BY using single phase inverter instead of three phase inverter, reduces the total quantity of IGBT's .Hence, overall system cost reduces. There will be no need for manual adjustment of each unit, but the technical complicity is going in the wrong direction

References

[1] Vikas Shrivastava, "Industrial Design Aspects of High-Speed Electrical Machines among Active Magnetic Bearings designed for Compressor Applications" India. Int. Journal of Engineering Research and Application, ISSN: 2248-9622, Vol. 7, Issue 11, (Part -3) November 2017, pp.22-27

[2] M.S.Aspalli, Asha.R, P.V. Hunagund "three phase induction motor drive using igbts and constant v/f method" International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering Vol. 1, Issue 5,PP.230-235 November 2012.

[3] Shilpa V. Kailaswar, Prof. R.A.Keswani "Speed Control of Three Phase Induction motor by V/f Method for Batching Motion System" International Journal of Engineering Research and Applications (IJERA)" Vol. 3, Issue 2, pp.1732-1736. March –April 2013

[4] Vikas Shrivastava, Chris salter "Future Trend To Smart Grid Automation Architecture by IES 61850" Internatioal, Conference, Electrical, Electronic, Communication, Mechanical, Computing (EECCME)-2018, IEEE Madras Section, CFP18037, 978-1-5386-4303-7, Vellore District Tamilnadu India, January 2018

[5] Farzan Rashidi," Sensorless speed control of induction motor drives using robust and adaptive neuro-fuzzzy based intelligent controller",IEEE international

[6] Ku. Trupti Deoram Tembhekar "A constant v/f open loop and closed loop speed control of a three phase induction motor drive"

[7] Vikas Shrivastava, Seema Deshmukh "Analysis and Study Between Two Soft Swiching Techniques Used in Boost Converter Implementattion" Internatioal Conference, Electrical, Electronics, Communication, Mechanical, Computing (EECCME) -2018, IEEE Madras Section, CFP18037, 978-1-5386-4303-7 ,01-2018-1111,Vellore District Tamilnadu India, January 2018

[8] Mohan N, Undeland, T. M. and Robbins, W. P., "Power Electronics", John Wiley & Sons Inc., USA, (2003)

[9] Vikas Shrivastava, Seema Deshmukh "Utility Of Charge Controller With Maximum Power Point Tracker For Photovoltaic System" Internatioal Conference, Electrical, Electronics, Communication, Mechanical, Computing (EECCME)-2018, IEEE Madras Section, CFP18037, 978-1-5386-4303-7, 01-2018-1113, Vellore District Tamilnadu India, January 2018

[10] Ned Mohan, Tore M. Undelad, William P. Robbins, 1995, "Power Electronics Converters,Applications and Design", Wiley, New York

[11] Nisit K. DE ,Prashanta K.Sen " Electrics drives"Asoke K. Ghose Prentice Hall of india private limited

[12] Vikas Shrivastava, "Research on Structure for Flywheel Energy Storage System in Long Lifetime UPS", India. Int. Journal of Engineering Research and Application, ISSN: 2248-9622, Vol. 7, Issue 11, (Part -3) November 2017, pp.22-2

[13] Alfredo, Thomas A. Lipo and Donald W. Novotny, "A New Induction Motor V/f Control Method Capable of High- Performance Regulation at Low Speeds" IEEE Trans. Industry Applications, Vol. 34,PP.536-540 No. 4 July/ August 1998