

Implementation of Induction Machine Model using Simulink a Step by Step Approach –A Review

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Abstract:- In this paper induction machine model Implement using Simulink is describe in step approach. In modular system each block solves one of the model equations and all machine parameters are available for control and verification purposes. Induction machine model used in different drive application after implementation such as open loop constant V/Hz control and indirect vector control. Finally model work as an induction generator is proved.

Keywords—Component; simulink, d-q model, voc.

I. INTRODUCTION

An electricis simulated in circuit simulators and its steady state model is used but in case of electrical drive the transient behaviour is important. Advantage of Simulink is an interactive tool for modelling, simulating, and analysing dynamic, multi domain systems. It allows the user to build a block diagram, simulate the system's behaviour, evaluate its performance, and refine the design .To start, Simulink provides a graphical user interface (GUI) for easy modelling. Using simple method as click and drag, the user can easily create block diagrams. Blocks represent elementary dynamic systems that Simulink knows how to simulate.

In this paper induction machine model Implement using Simulink is describe in step approach. In modular system each block solves one of the model equations and all machine parameters are available for control and verification purposes.

II LITERATURE REVIEW

The induction motor drive is a dynamic, recurrent, and non-linear system. Despite the great efforts devoted to induction motor control, many of the theoretical results cannot be directly applied to practical systems due to the following difficulties: 1) complicated computations involved; 2) nonlinearity of the system; and 3) uncertainty in the machine parameters. Using Simulink software, three induction motor models (current-input model, voltage-input model, discrete-state model) are built for the simulation studies of the controller.

It is well known the advantages of induction motors over traditional dc motors include simpler and cheaper mechanical structure and easy maintenance [3, 1]. The complicated control issues associated with the

adjustable speed drives applications of induction motor drives are solved by recent developments in the theory of vector oriented control, or vector control, fast digital processors and power devices. Vector oriented-control (VOC) is one of the most excellent control strategies of torque control in induction machine [3], both control strategies are different on the operation principle but their objectives are the same. They aim to control effectively the torque and flux [2and 1].

In early years, DC motor had significant advantages over other types of ac induction machine. The primary advantage is due to the torque control that can be provided by DC drives through the direct control of the armature current. In contrast, the early generation of AC drives, used pulse width modulation (PWM) to provide adjustable frequency sinusoidal currents to the AC machine stator, which was best suitable for speed control but did not have direct torque capability. DC motor drives provides instantaneous torque which is proportional to the product of the armature current and the field current while ac motor, on the other hand, involves complex, nonlinear relationship between voltages, current, flux and torque [4], After some development, the AC induction machine could nearly achieve torque control but was limited due to the limitation of microelectronic devices and unknown model parameters. However the progress in the field of power electronics, microprocessors and control theory have made it possible to overcome the difficulty of control AC motors and to apply AC drives for high performance variable speed applications.

III INDUCTION MACHINE MODEL

Dynamic equivalent circuit of induction machine is shown in fig.1. Induction machine model is derived from Krause's model. As per this model, the modelling equation in flux linkage form are as follows[1,2].

$$F_{qs} = \omega_b \psi_{qs} = X_{ls} i_{qs} + X_m \quad (a)$$

$$F_{qr} = \omega_b \psi_{qr} = X_{lr} i_{qr} + X_m \quad (b)$$

$$F_{qm} = \omega_b \psi_{qm} = \quad (c)$$

$$F_{ds} = \omega_b \psi_{ds} = X_{ls} i_{ds} + X_m \quad (d)$$

$$F_{dr} = \omega_b \psi_{dr} = X_{lr} i_{dr} + X_m \quad (e)$$

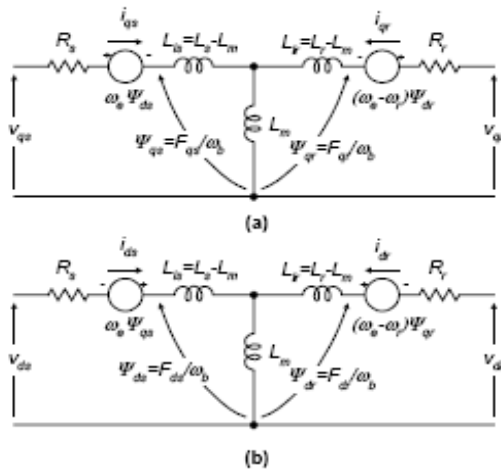


Fig. 1. Dynamic or d-q equivalent circuit of an induction machine.

Where,
and

From Equation (a) to (k), the currents can be expressed in terms of the flux linkage as[1,2]

$$i_{qs} = \frac{F_{qs} - F_{qm}}{X_{ls}}$$

$$i_{qr} = \frac{F_{qr} - F_{qm}}{X_{lr}}$$

$$i_{ds} = \frac{F_{ds} - F_{dm}}{X_{ls}}$$

$$i_{dr} = \frac{F_{dr} - F_{dm}}{X_{lr}}$$

Substituting Equation

$$F_{qm} = X_m \left[\frac{(F_{qs} - F_{qm})}{X_{ls}} + \frac{(F_{qr} - F_{qm})}{X_{lr}} \right]$$

$$F_{qm} = \frac{X_{ml}}{X_{ls}} F_{qs} + \frac{X_{ml}}{X_{lr}} F_{qr}$$

$$X_{ml} = \frac{1}{\left[\frac{1}{X_m} + \frac{1}{X_{ls}} + \frac{1}{X_{lr}} \right]}$$

Similar derivation can be made for F_{dm} as follows:

$$F_{dm} = \frac{X_{ml}}{X_{ls}} F_{ds} + \frac{X_{ml}}{X_{lr}} F_{dr}$$

Which can be expressed as

$$\frac{dF_{qs}}{dt} = \omega_b [v_{qs} - \frac{\omega_s}{\omega_b} F_{ds} - \frac{R_s}{X_{ls}} (F_{qs} - F_{qm})] \tag{1}$$

$$\frac{dF_{ds}}{dt} = \omega_b [v_{ds} + \frac{\omega_s}{\omega_b} F_{qs} - \frac{R_s}{X_{ls}} (F_{ds} - F_{dm})] \tag{2}$$

$$\frac{dF_{qr}}{dt} = -\omega_b \left[\frac{(\omega_s - \omega_r)}{\omega_b} F_{dr} + \frac{R_r}{X_{lr}} (F_{qr} - F_{qm}) \right] \tag{3}$$

$$\frac{dF_{dr}}{dt} = -\omega_b \left[\frac{(\omega_s - \omega_r)}{\omega_b} F_{qr} + \frac{R_r}{X_{lr}} (F_{dr} - F_{dm}) \right] \tag{4}$$

Finally, from Equation

$$T_e = \frac{3}{2} \left(\frac{P}{2} \right) \frac{1}{\omega_b} \left(i_{qs} i_{dr} - i_{ds} i_{qr} \right) \tag{5}$$

Where $V_{qr} = V_{dr} = 0$ Figure shows the corresponding equivalent circuits. As mentioned before, in the stationary frame, the variables appear as sine waves in steady state with sinusoidal inputs.

Let's define the flux linkage variables as follows: flux linkage = base angular electrical base frequency x flux

IV SIMULINK IMPLEMENTATION

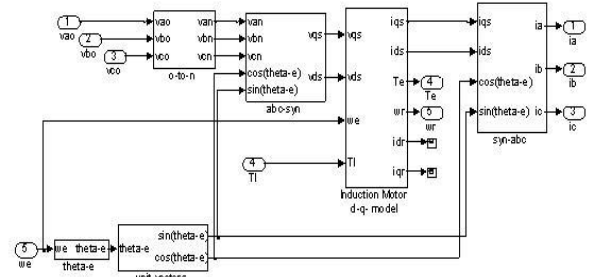


Fig. The Complete Induction Machine Simulink Model

The d-q model requires that all the three-phase variables have to be transformed to the two-phase synchronously rotating frame. The induction machine model implemented in this paper is shown in Fig. it consists of five major block transforming the three-phase voltages to the d-q frame and the d-q currents back to three-phase[2].

1. o-n conversion block

This block is used for isolated neutral system, otherwise it can be by passed. The transformation done by this block can be represented as follows. This is implemented in Simulink by passing the input voltages through a Simulink "Matrix Gain" block, which contains the above transformation matrix.

$$\begin{bmatrix} v_{an} \\ v_{bn} \\ v_{cn} \end{bmatrix} = \begin{bmatrix} \frac{2}{3} & -\frac{1}{3} & -\frac{1}{3} \\ -\frac{1}{3} & \frac{2}{3} & -\frac{1}{3} \\ \frac{1}{3} & -\frac{1}{3} & \frac{2}{3} \end{bmatrix} \begin{bmatrix} v_{ao} \\ v_{bo} \\ v_{co} \end{bmatrix}$$

2. Unit vector calculation block

The unit vectors are obtained simply by taking the sine and cosine of θ_e , $\cos\theta_e$ and $\sin\theta_e$ are used in vector rotation blocks, "abc-syn conversion block" and "syn-abc conversion block". The angle, θ_e is calculated by integrating the frequency of the input three-phase voltages, we.

$$\theta_e = \int \omega_e dt$$

3. abc-syn conversion block

To convert three-phase voltages to voltages in the two phase synchronously rotating frame, they are first converted to two-phase stationary frame using and then from the stationary frame to the synchronously rotating frame using.

$$\begin{bmatrix} v_{qs}^s \\ v_{ds}^s \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -\frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} \end{bmatrix} \begin{bmatrix} v_{an} \\ v_{bn} \\ v_{cn} \end{bmatrix}$$

$$\begin{cases} v_{qs} = v_{qs}^s = \cos\theta_e v_{ds}^s - v_{ds}^s \sin\theta_e \\ v_{ds} = v_{ds}^s \sin\theta_e + v_{qs}^s \cos\theta_e \end{cases}$$

Where the superscript "s" refers to stationary frame.

4. syn-abc conversion block

This block does the reversal of the abc-syn conversion block for the current variables.

$$\begin{cases} i_{qs}^s = i_{qs} = \cos\theta_e + i_{ds} \sin\theta_e \\ i_{ds}^s = -i_{qs} \sin\theta_e + i_{ds} \cos\theta_e \end{cases}$$

$$\begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_{qs}^s \\ i_{ds}^s \end{bmatrix}$$

Fig. shows the induction machine model is implemented in different block.

First consider the flux linkage state equations because flux linkages are required to calculate all the other variables. These equations could be implemented using Simulink "State-space" block[2].

V CONCLUSION

SIMULINK is a powerful software package for the study of dynamic and non linear syste. Using SIMULINK, the simulation model can be built up systematically starting from simple submodel.

In this paper, implementation of a modular Simulink model for induction machine simulation have been introduced. SIMULINK is a powerful software package for the study of dynamic and nonlinear systems.Using SIMULINK, the simulation model can be built up systematically starting from simple sub-models. The induction motor model after the implementation, examples are given with the model used in different drive applications, such as open-loop constant V/Hz control and indirect vector control are given. Finally, the use of the model as an induction generator is demonstrated.

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