Modeling And Simulation of Speed and flux Estimator Based on Current & voltage Model

Prof. Hemant chouhan
Dept. of Electrical & Electronics Engineering
SVITS, Indore MP (India)
hemant_chouhan31@yahoo.com

Prof. Dinesh Chandra Jain
Dept. of Comp Sc. & Engg
SVITS, Indore MP (India)
dineshwebsys@gmail.com

Abstract: This paper introduce a estimator based on and current & voltage model used in induction motor (IM) drive. The rotor speed estimation is based on the model reference adaptive system (MRAS) approach. The closed loop control mechanism is based on the voltage and current model. The control and estimation algorithms utilize the synchronous coordinates as a frame of reference. A speed sensor less induction motor (IM) drive with Robust control characteristics is introduced. First, a speed observation system, which is insensitive to the variations of motor parameters.

Keywords: MRAS, Speed & flux Estimators, FOC

Table:1 - NOMENCLATURE

L_s, L_m, L_r	Stator, mutual, rotor inductance
R_s, R_r	Stator, rotor Resistance
P	no. of Pole
V_{dS}, V_{qS}	d-axis and q-axis component of stator voltage vector V_s
V_{dr}, V_{qr}	d-axis and q-axis component of rotor voltage vector V_r
i_{dS}, i_{qS} & i_{dr}, i_{qr}	d-axis and q-axis component of stator/rotor current vector I_s
T_e, J ,	Exciting torque, moment of inertia
ω_e, ω_r ω_{sl}	Synchronous, rotor, slip speed
ψ_{ds}, ψ_{dr}	Stator and rotor leakage flux

I. Introduction: Field oriented control (FOC) has been recognized as the algorithm that gives the induction motor (IM) drives fast dynamic response. Implementation of such scheme requires precise knowledge of both the machine flux and rotor speed[1]. Direct measurement of these quantities increases the system cost and reduces its reliability[2]. A lot of research efforts have been done to determine the machine flux and rotor speed indirectly from the stator terminal quantities (voltages and currents) using estimation techniques[3]. Elimination of the flux and speed sensors has the advantages of low cost, reduced size and increased reliability. For instance the performance of the model-based speed estimation schemes at low speeds is limited by the observability problem and the machine parameter variations[4].

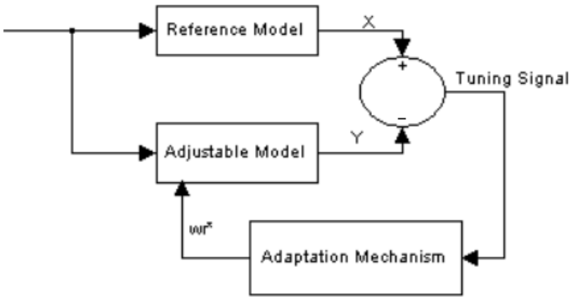

Fig.(1) Basic Block Diagram of Estimator

The above given fig.(1) shows the block diagram of the estimator. The estimator calculates the speed ωr* from the stator voltage and current components[5].

II. Basic Current and Voltage Model Equation:

The control and estimation of induction motor drives constitute a vast subject, and the technology has further advanced in recent years. Induction motor drive with cage type machine have been the workhorses in industry variable speed application in wide power range that covers from fractional horse power to multi-mega watts. In addition to process control, the energy saving aspect of variable frequency drive is getting a lot of attention nowadays[6].

III. Speed &Flux estimation:

Current Model: In the low speed region, the rotor flux component can be synthesized more easily with the help of speed of and current signals. The rotor circuit equation of (d^s-q^s) equivalent circuits can be given as:[7]

$$\frac{d}{dt}\Psi_{dr}^{s} + R_r i_{dr}^{s} + \omega_r \Psi_{qr}^{s} = 0 \qquad (1)$$

$$\frac{d}{dt}\Psi_{qr}^{s} + R_r i_{qr}^{s} - \omega_r \Psi_{dr}^{s} = 0 \qquad (2)$$

Adding term $(L_m R_r/L_r) i_{ds}^s$ and $(L_m R_r/L_r)\, i_{qs}^s$ respectively, on both sides of the above equation ,we get.

$$\frac{d}{dt}\Psi_{dr}^{s} + \frac{R_r}{L_r}(L_m i_{ds}^{s} + L_r i_{dr}^{s}) + \omega_r \Psi_{qr}^{s} = \frac{L_m R_r}{L_r} i_{ds}^{s} \qquad (3)$$

$$\frac{d}{dt}\Psi_{dr}^{s} + \frac{R_r}{L_r}(L_m i_{qs}^{s} + L_r i_{qr}^{s}) + \omega_r \Psi_{qr}^{s} = \frac{L_m R_r}{L_r} i_{qs}^{s}$$

where $T_r = L_r/R_r$ is the rotor circuit tie constant.

Voltage Model: In this method, the machine terminal voltages and currents are sensed and the fluxes are computed from the stationary frame (d^s-q^s). These equations are:[8]

$$i_{qs}^{s} = \frac{2}{3} i_a - \frac{1}{3} i_b - \frac{2}{3} i_c = i_a \qquad (4)$$

$$i_{ds}^{s} = -\frac{1}{\sqrt{3}} i_b + \frac{1}{\sqrt{3}} i_c \qquad (5)$$

$$= -\frac{1}{\sqrt{3}}(i_a + 2 i_b) \qquad (6)$$

since $i_c = -(i_a + i_b)$ for isolated neutral load.

$$v_{qs}^{s} = \frac{2}{3} v_a - \frac{1}{3} v_b - \frac{1}{3} v_c$$

$$= \frac{1}{3}(v_{ab} + v_{ac}) \qquad (7)$$

$$v_{ds}^{s} = -\frac{1}{\sqrt{3}} v_b + v_c$$

$$= -\frac{1}{\sqrt{3}} v_{bc} \qquad (8)$$

$$\psi_{ds}^{s} = \int (v_{ds}^{s} - R_s i_{ds}^{s})dt \qquad (9)$$

$$\psi_{qs}^{s} = \int (v_{qs}^{s} - R_s i_{qs}^{s})dt \qquad (10)$$

$$\Psi s = \int \psi_{ds}^{s2} + \psi_{qs}^{s2} \qquad (11)$$

$$\Psi_{dm}^{s} = \Psi_{dm}^{s} - L_{ls} i_{ds}^{s} = L_m(i_{ds}^{s} + i_{qr}^{s}) \qquad (12)$$

$\Psi_{qm}{}^{s} = \Psi_{qm}{}^{s} - L_{ls} i_{qs}{}^{s} = L_m (i_{ds}{}^{s} + i_{qr}{}^{s})$ (13)
$\Psi_{dr}{}^{s} = L_m i_{ds}{}^{s} + L_r i_{dr}{}^{s}$ (14)
$\Psi_{qr}{}^{s} = L_m i_{qs}{}^{s} + L_r i_{qr}{}^{s}$ (15)

Eliminating i_{dr}s and i_{qr}s from equation (14)-(15) with the help of equations (12)- (13), respectively, gives the following:

$\Psi_{dr}{}^{s} = \frac{L_r}{L_m} \Psi_{dm}{}^{s} + L_{lr} i_{ds}{}^{s}$ (16)
$\Psi_{qr}{}^{s} = \frac{L_r}{L_m} \Psi_{qm}{}^{s} + L_{lr} i_{qs}{}^{s}$ (17)

which can also be written in the following form with the help of equation (12)-(13):

$\Psi_{dr}{}^{s} = \frac{L_r}{L_m} (\Psi_{ds}{}^{s} - \sigma L_s i_{ds}{}^{s})$ (18)
$\Psi_{qr}{}^{s} = \frac{L_r}{L_m} (\Psi_{qs}{}^{s} - \sigma L_s i_{qs}{}^{s})$ (19)

where $\sigma = (1 - \frac{L_m 2}{L_s L_r})$

Since the voltage model flux estimation is better at higher speed ranges, whereas the current model estimation can be made at any speed. Where the voltage model becomes effective at higher speed ranges, but transition smoothly to the current model a lower speed ranges.[9,10] All used nomenclature shown in table.(1)

IV. Simulink current and voltage Model:

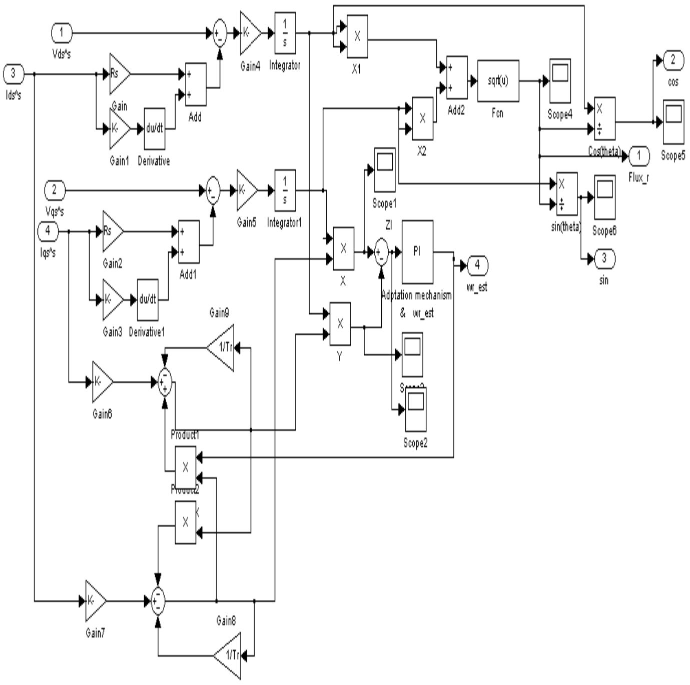

Fig.(2) Rotor Flux & Speed Estimation Model

V. Simulink Results:

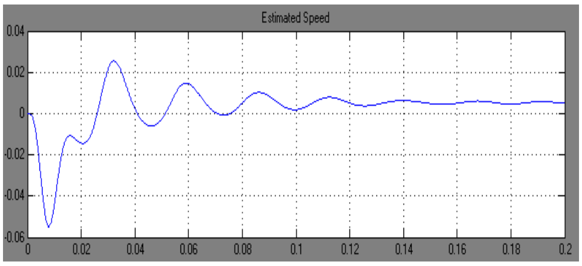

Fig.(3) Estimated speed through Estimator

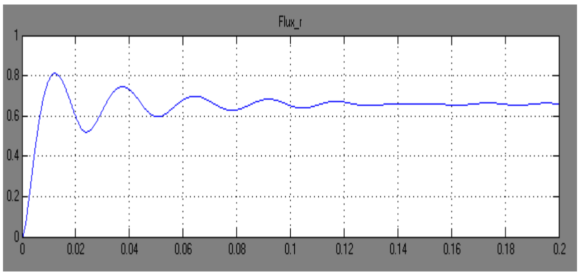

Fig.(4) Rotor Flux Estimated

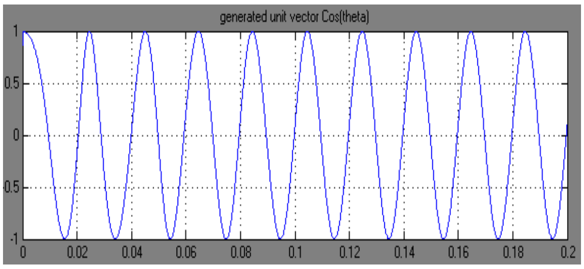

Fig.(5) Generated unit Vector {Cos(θ)}

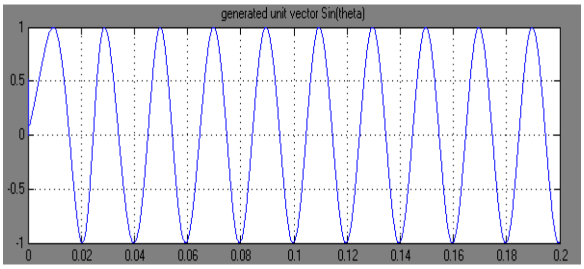

Fig. (6) Generated unit Vector {Sin(θ)}

Conclusion: The mathematical model and control design methodology for the sensorless vector control of induction motor drives, In which provided a detailed description of both inverter-machine and controller systems, Sensor less indirect field oriented control has been realized. The motor speed is estimated & based on the difference between the outputs of two flux's simulators. This scheme of vector control based on The voltage and current model, and constructs a hybrid model. Sensor less control with rotor resistance adaptation gives better performance with respect to the one without this adaptation. The rotor speed is estimated by using the adaptive method with a model reference approach and the stator currents are controlled by using PI regulators.

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Hemant Chouhan received the B.E. .degree and M.E.(Power Electronics) Degree with in in Electrical engineering (with first Division) in 2007 and 2010 both from Rajiv Gandhi Technical University, Bhopal, Madhyapradesh, India. In 2010 become a Asst. Professor in Electrical and Electronics Engineering Dept. of SVITS Indore, MP India.

Prof. Dinesh Chandra Jain received M.Tech (IT) degree from BU and B.E(Computer Science) degree from RGPV –University Bhopal. He has published many Research Papers in reputed International Journal. He is a member of ISTE, IACSIT, IETE and many Engineering Societies. **He is pursuing PhD in Computer Science** and Presently working as a Assistant Professor in SVITS-Indore (India).