Design of Model Predictive Torque Control (MPTC) for Speed Control 3 Phase Induction Motor with Robust Stator Flux Observer

Halim Mudia[1], Mochammad Rameli[1], Rusdhianto Efendi[1]

***Abstract** - The induction motor is a desirable alternative to the direct current motor in many applications because it is rugged, reliable and economical. However, control of the induction motor is more complex than the direct current motor, this is caused by the complexity of the dynamics of the induction motor, so the algorithm of induction motor is more complex. Based on these problem, author conducted a study on the induction motor using Model Predictive Torque Control (MPTC) with robust stator flux observer, in which robust stator flux observer is designed to overcome the shortcomings in the Direct Torque Control (DTC) conventional which can cause high fluctuation in flux ripple and torque ripple when reach steady state condition. So from the purpose of the proposed method, the results of the designed system can adjust the rotating speed of the induction motor in accordance references given at 120 rad/s with a settling time is 0.753 seconds, and also can minimize fluctuations in flux ripple and torque.*

***Term Index** - Direct Torque Control, Induction Motor, Model Predictive Control, Robust Stator Flux Observer.*

INTRODUCTION

In this research, the propose of design speed control of induction motor 3 phase is equipped with three main parts, controller (model predictive control and propotional-integral), direct torque control, robust stator flux observer, and induction motor model, depicted in Fig. 1.

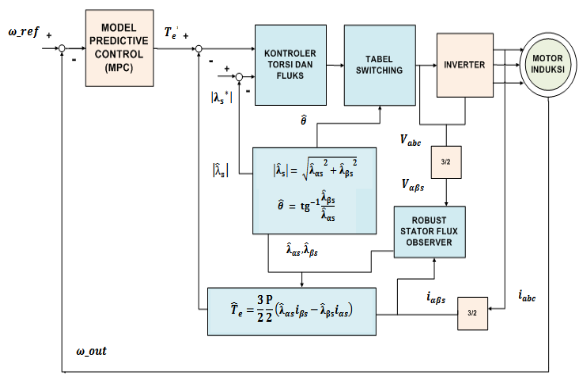

Figure 1. Block diagram of the system induction motor.

Based on system induction model, the control strategy Single Input Single Output (SISO) is designed and realized with Model Predictive Torque Control (MPTC) with robust stator flux observer to control the speed of three phase induction motor using matlab, where robust stator flux observer can be designed with the following equation:

$$\hat{x}(k+1) = (A_n + \Delta A)\hat{x}(k) + Bu + H(\hat{\imath}_s(k) - i_s(k))$$

$$\hat{\imath}_s(k) = c\hat{x}(\text{k}) \qquad (1)$$

Where the mathematical model of the induction motor is expressed by:

$$\begin{bmatrix} V_{qs} \\ V_{ds} \\ V_{qr} \\ V_{dr} \end{bmatrix} = \begin{bmatrix} R_s + pL_s & \omega_e.L_s & pL_m & \omega_e.L_m \\ -\omega_e.L_s & R_s + pL_s & -\omega_e.L_m & pL_m \\ pL_m & (\omega_e - \omega_r)L_m & R_r + pL_r & (\omega_e - \omega_r)L_r \\ -(\omega_e - \omega_r)L_m & pL_m & -(\omega_e - \omega_r)L_r & R_r + pL_r \end{bmatrix} \begin{bmatrix} i_{qs} \\ i_{ds} \\ i_{qr} \\ i_{dr} \end{bmatrix} \qquad (2)$$

The mathematical model of the induction motor load is expressed by the equation:

$$\tau_e - \left(\frac{N_1}{N_2}\right)^2 \left(B_b\omega_m + J_b\frac{d}{dt}\omega_m\right) - B_r\omega_m = J_r\frac{d}{dt}\omega_m \qquad (3)$$

RESULT AND DISCUSSION

Results of design speed Control 3 phase induction motor with robust stator flux observer can be seen in the following figure:

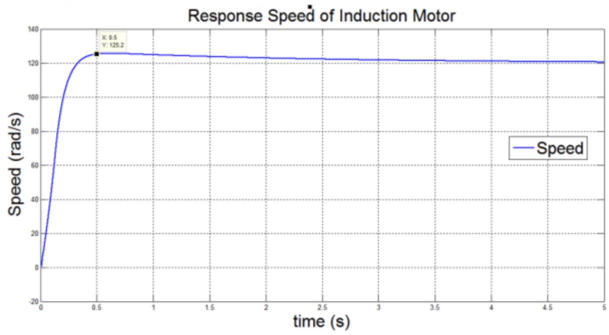

Figure 2. Response Speed of Induction Motor Using controller proportional-integral Direct Torque Control with load (Reference = 120 rad/s)

In figure 2. It can be seen that the value of the response speed by using a load at the time of t = 0.5 second is 125.2 rad /s

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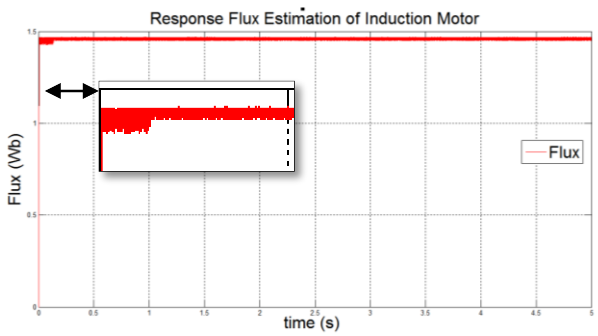

Figure 3. Response flux Estimation of Induction Motor using controller proportional-integral Direct Torque Control with load

Based on the results in figure 3 and figure 5 that the Direct Torque Control (DTC) with robust stator flux observer can minimize ripple fluctuations flux in the steady state, and the results in figure 2 and figure 4 that the Model Predictive Control (MPC) can keep speed in accordance with the speed reference.

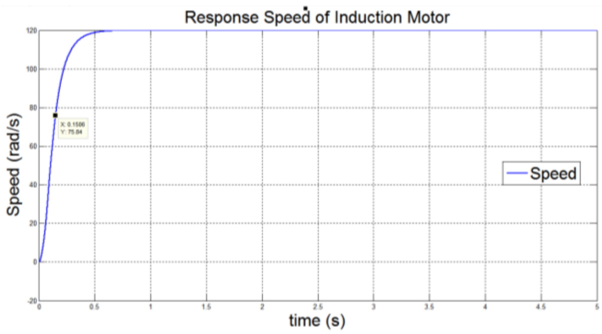

Figure 4. Response Speed of Induction Motor using model predictive torque control robust stator flux observer With Load (Reference = 120 rad/s)

In Figure 3. After using the Model Predictive Torque Control (MPTC) with robust stator flux observer, the response speed can reach the specified reference value of 120 rad/s with the value of the time constant (τ) to speed response in Figure 4.15 is 0.1506 seconds, and settling time obtained for 0.753 seconds.

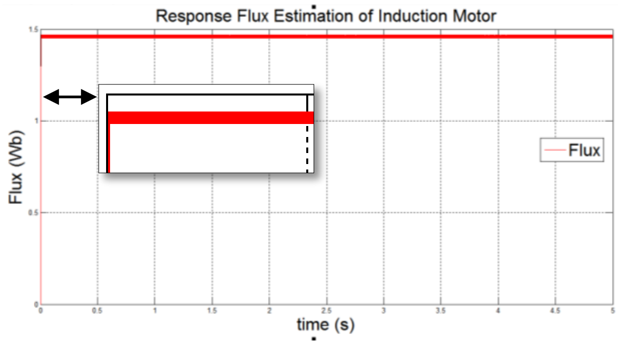

Figure 5. Response flux Estimation of Induction Motor using model predictive torque control robust stator flux observer With Load.

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