The Vector Control of Induction Motor drives Speed Sensorless using a Fuzzy Algorithm

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Abstract

In this study, the estimate speed of rotor in the induction motor with Model Reference Adaptive control System (MARC) principle and to study that vector control system feedbacks speed estimated to speed control system and its result is as follows;

Considering with explanation an influence of speed estimation mechanism depend on error about the second resistance size established, it estimates the deviation of the second resistance establishment and exhibits a compensation method, what is more, it designs a reparation program using the fuzzy algorithm and testifies the result with the computer simulation. And besides, it composes the load torque estimation and estimates the load torque, as the result, feedback-compensating the result of estimation, it improves the efficiency. In consequence, it makes a good result for more powerful vector control system about the outside trouble.

I. Introduction

Recently, a variable driving system have widely application according to power transfer device of semiconductor or control in technology has been development. Representative of high performance control characteristic in the torque and speed sensorless of induction motor which is vector control. The speed of revolution information is occurred, that is the various kinds of tacho generator, pulse encoder and so on. However, in the actual control system, speed sensor problems occurred. Generally, price is expensive, structure is complexity and noise is weak. Therefore study has active executed. It is vector control that no using speed sensor estimated speed rotation from voltage, current, etc. The speed estimation is achieved to direct or indirect from information except speed, voltage or current of induction motor and that the motor factor. The speed sensorless vector system is proposed to speed control which is constitution for sleep frequency by means of estimation of induction motor factor. A speed control that constituted of estimation at sleep frequency that using the induction motor according to rotor slot high frequency voltage. The speed calculate of controller control system constituted to inner flux at same real quantity of induction motor. This study investigates these problems and propose solution to improve the accuracy speed controller in speed sensorless using a MRAC at one method. It is used to current and voltage model of output error. Generally, fixed-gain of PI speed controller have to control not get to satisfy control property. Flux calculation and vector convert of induction motor constituted observer. This torque is estimated which is feed-forward to compensated inner of speed controller. Therefore it is get inhibit effect of no concern load torque.

Ⅱ. Equivalent circuit or basic equation of induction motor

1. basic equation of induction motor

Equation of induction motor is theorem (1) for state solution

$$\frac{d}{dt}\begin{bmatrix} i_{qs} \\ i_{ds} \\ \Psi_{qr} \\ \Psi_{dr} \end{bmatrix} = A \cdot \begin{bmatrix} i_{qs} \\ i_{ds} \\ \Psi_{qr} \\ \Psi_{dr} \end{bmatrix} + B \cdot \begin{bmatrix} v_{qs} \\ v_{ds} \end{bmatrix}$$

$$= A_x \quad + \quad B_u \qquad ---(1)$$

Motor torque is shown times flux and current.

$$T = \frac{3}{2}\left(\frac{P}{2}\right) \cdot \overrightarrow{\Psi_r} \times \overrightarrow{i_{qs}}$$

$$T = \frac{3}{2}\left(\frac{P}{2}\right) \cdot (\Psi_{dr} - \Psi_{qr}\ i_{ds}) \qquad ---(2)$$

(induction motor is three-phase, P is pole number)

Load torque relation of equation(3)

$$T = J\frac{d\omega_r}{dt} + a\omega_r \qquad ---(3)$$

2. Rotor flux calculation

In equation (1), v_s is motor input, i_s is motor. It is state variable that output state observer system in relation of figure. 2-1 is used to, because flux is no determination.

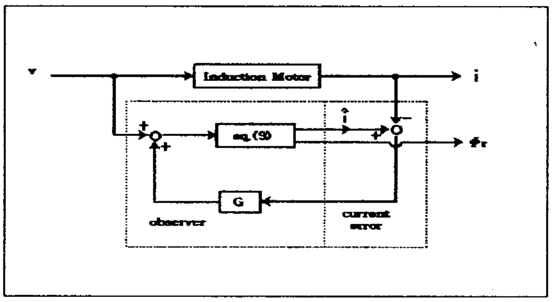

Fig. 2-1. The state observer

The ω_r is rotator angular velocity of motor. It is widely changed variable according to state of motor. Therefore ω_r is estimated that figure. 2-1 observer was possibility for observer system was application to relation of figure. 2-2.

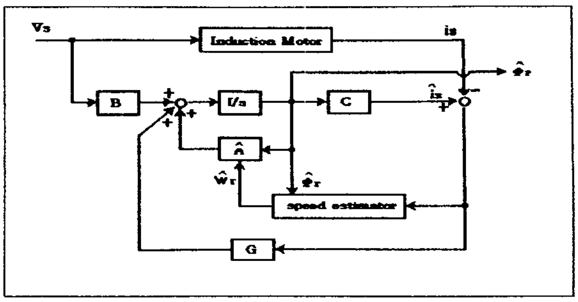

Fig. 2-2. The observer using the speed estimator

Response property of PI controller and fuzzy controller is shown to figure. 2-4, 2-5.

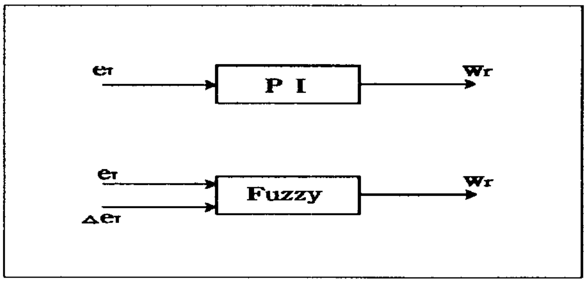

Fig. 2-3. The PI & Fuzzy controller

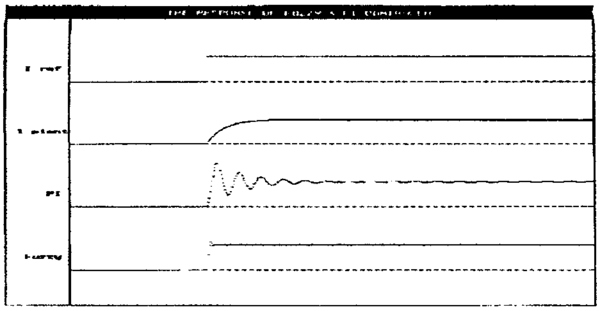

Fig. 2-4. The response comparison of PI and Fuzzy controller at variable step

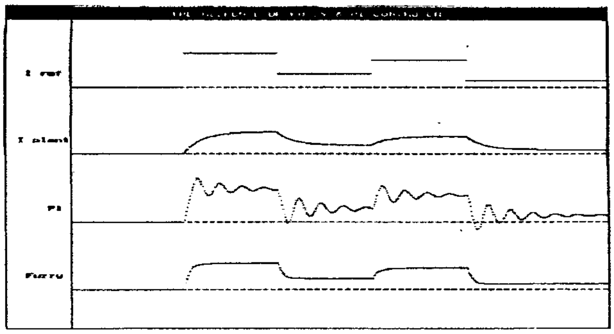

Fig. 2-5. The response comparison of PI and Fuzzy controller at variable input

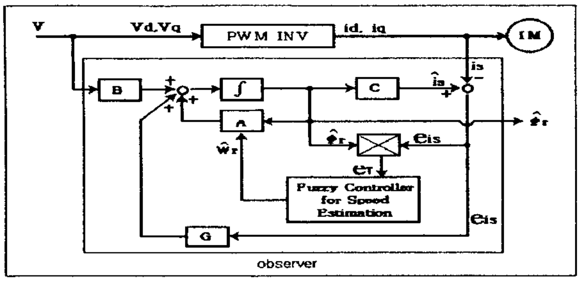

Fig. 2-6. The proposed flux observer system

The observer system for estimated flux is shown figure 2-6. In this system is designed to state variable error of system and state observer were minimum. Therefore, the observer designed is important to a suitable vector of gain G of error is possible to fast to zero

Ⅲ. Simulation and Experiment

1.motor parameter and block diagram

The completely block diagram is shown figure. 3-1 that motor rate is 2[HP], 220[V]/60[Hz], 4P, 1730[rpm], motor parameter is shown table 3-1.

Table 3-1. The motor parameter

rated output	2 HP	Rr	4.2 Ω
pole	4	M	0.165 H
J	0.02 kg · m²	Ls	0.178 H
Rs	1.73Ω	Lr	0.172 H

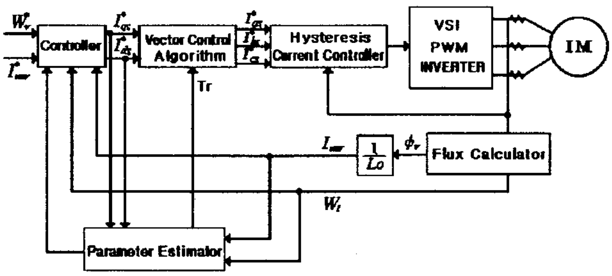

Fig. 3-1. Total Block Diagram of Vector Control System

2. Flux or speed simulation of observer system

Equation $\frac{d}{dt}\hat{x}=A\hat{x}+Bv_s+G(\hat{i}_s-i_s)$ is applied to state equation for computer simulation. Realization of figure. 2-6 observer system proposed in this study. Motor or observer response of q-axis current and speed shown figure. 3-2. It's frequency of voltage to input induction motor increased that speed of motor raised. Observer system is shown excellent estimation to transient state include input frequency variation of motor.

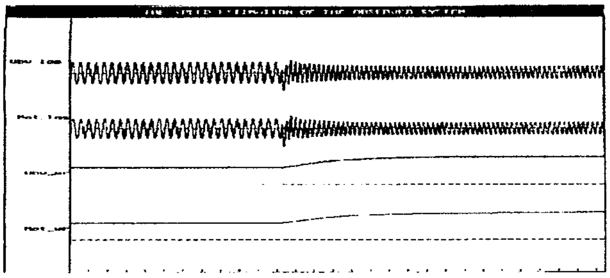
Fig. 3-2. The state estimation of the observer as the input frequency is step varied.

The q-axis current or speed response of motor or observer is shown which is load of direct current generator increasing figure. 3-3. Observer system estimated to excellent gave a state of motor during to the load increase.

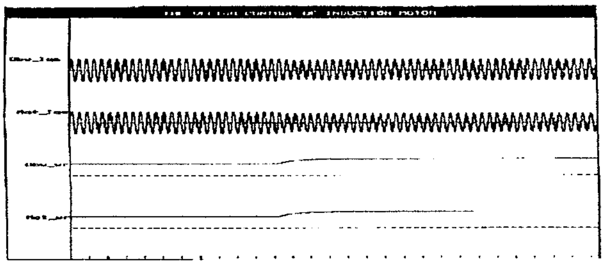
Fig. 3-3. The q axis current and speed response of the motor and observer as the load is increased.

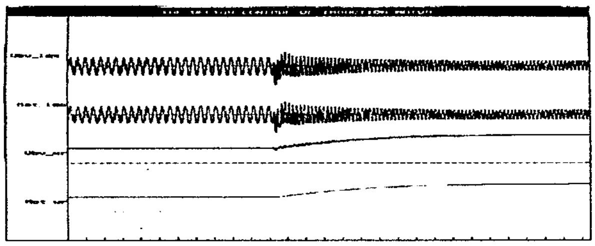
Fig. 3-4. The q axis current and speed response of the motor and observer as the Observer gain is 0 and frequency vary.

Figure. 3-5, 3-6 to voltage or current waveform shown no load and load. figure. 3-7 is speed maximum to load increased. This frequency of voltage and current is increased.

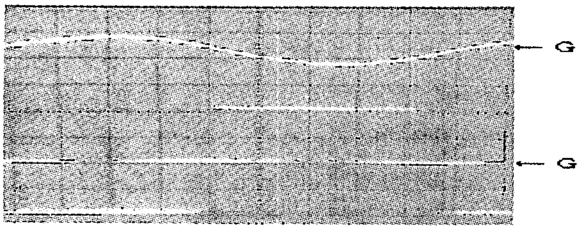

Fig. 3-5. The voltage and current waveform without Load 50V/DIV, 2A/DIV, 2ms/DIV.

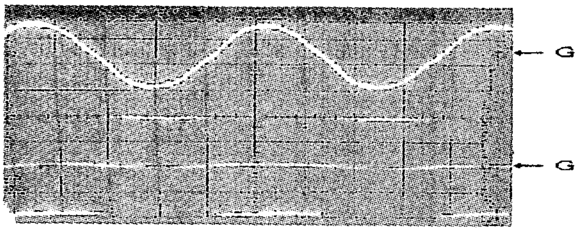

Fig. 3-6. The voltage and current waveform with 600[W] Load 50V/DIV, 5A/DIV, 2ms/DIV.

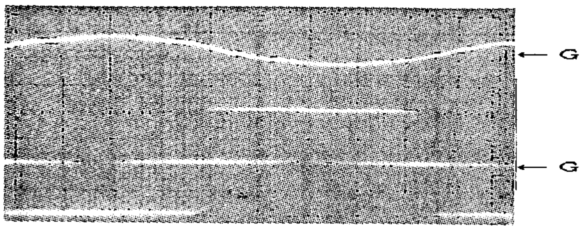

Fig. 3-7. The voltage and current waveform with 600[W] Load 50V/DIV, 5A/DIV, 2ms/DIV. (TOP:urrent,BOT:voltage)

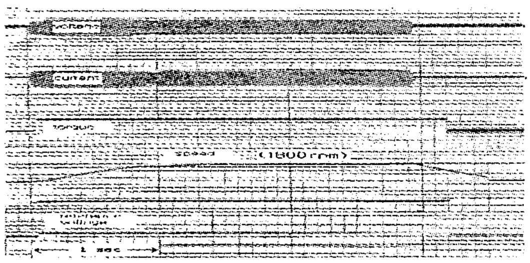

Fig. 3-8. The response at load

Action state of motor shown figure. 3-8 for using a photocorder. voltage, current, torque, speed rotation state variation is shown. It is varied to only voltage and current waveform but constant frequency.

Ⅳ. Conclusion

The results has been shown that proposed speed of motor estimated MRAC using a vector controller of speed sensorless is composed.

1.A speed estimation is occurred a number of error that time constant of secondary circuit to speed estimation different real value. The same flux calculation, flux calculation occurred error when R_s, σL_s is different real value.

2. The influence of noise measurement problem in program is occurred to delay error that according to input parameter which is considered to influence of resistance, etc. Because parameter of real motor is on present exactly arithmetic value.

3. Simulation and experiment results is proved superiority that efficiency of fuzzy system applied to vector controller speed sensorless of induction motor.

Adaptive control of fuzzy method when speed estimated using vector control to speed sensorless is executed. Therefore, in this system is obtained to excellent controller but it is necessary to measure of parameter setting error or noise.

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