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Research in Sensorless Vector Control of Induction Motor based on MRAS Technique

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***Abstract*—**Model Reference Adaptive System (MRAS) represents one of the most attractive and popular solutions for sensorless control of AC drive. According to the principle of asynchronous motor vector control，taking two phase rotating coordinates current model as the adjustable model and improved voltage model as reference model， a speed sensorless vector control system is built The model reference adaptive system (MRAS) method is used to identify system speed .Model reference adaptive system method is applied to asynchronous motor speed estimation and achieves speed sensorless control of asynchronous motor. The approach is implemented on Matlab /Simulink software. The simulation results show that the system has good control performance and accuracy. It proves the feasibility and practicability of the system.

***Keywords*—**motor; speed sensorless, model reference adaptive system, SVPWM, vector control

I. INTRODUCTION

This With the continuous improvement of power electronics technology and control theory, pay flow motor speed control system increasingly towards high performance. Ac asynchronous power machine speed sensorless speed control system to speed identification algorithm instead of sensing the speed of the detection device, to avoid speed sensor detection errors caused poor and sensor installation and maintenance of the difficulties, and has the price the advantages of the project has an important application of significance, is a modern communication important research direction. In induction motor speed sensorless control technology, the motor turns speed identification method after another, such as: extended kalman filter [1-4] neural network [5-8], pi adaptive method[9-11] and so on. The model reference is self-adaptive the theory of MRAS (model reference adaptive system)[12-14] is in recent years, speed sensorless induction motor vector control more good application of speed identification technology, which is characterized by guaranteed parameter estimation the gradual stability of the same time, changes in motor parameters and external disturbances has strong robustness. With the microcontroller, digital signal processor such as the continuous improvement of microprocessor performance, MRAS speed identification technology in the field of speed sensorless ac speed has a very good application prospect.

In this paper, the speed sensorless motor control, the introduction of model parameters Self-adaptive speed identification theory, through the rotor speed estimation the system can accurately identify the actual speed, the experimental results verify the propose a strategy of feasibility and effectiveness.

A. *Vector Control System*

a. Control System Program

The system measures the current iA, iB from the stator side of the motor And voltage uA, uB, Converted to isα, isβ by Clarke And usα, usβ, Into the rotor fluxThe observer model calculates rotor flux linkage angle and flux linkage values. The actual rotation of the motor The speed n is obtained by MRAS model estimation, according to the speed command value nref And the difference between the feedback value n, the speed regulator output corresponding electromagnetic torque The current value of the component isTref, And then with the system given excitation current componentisMrefUsT ref through the current regulator together And usMref, through Park inverse transform voltage us α ref This scheme can make the torque and flux completely decoupled, very good To estimate the motor speed, speed, current closed-loop control.

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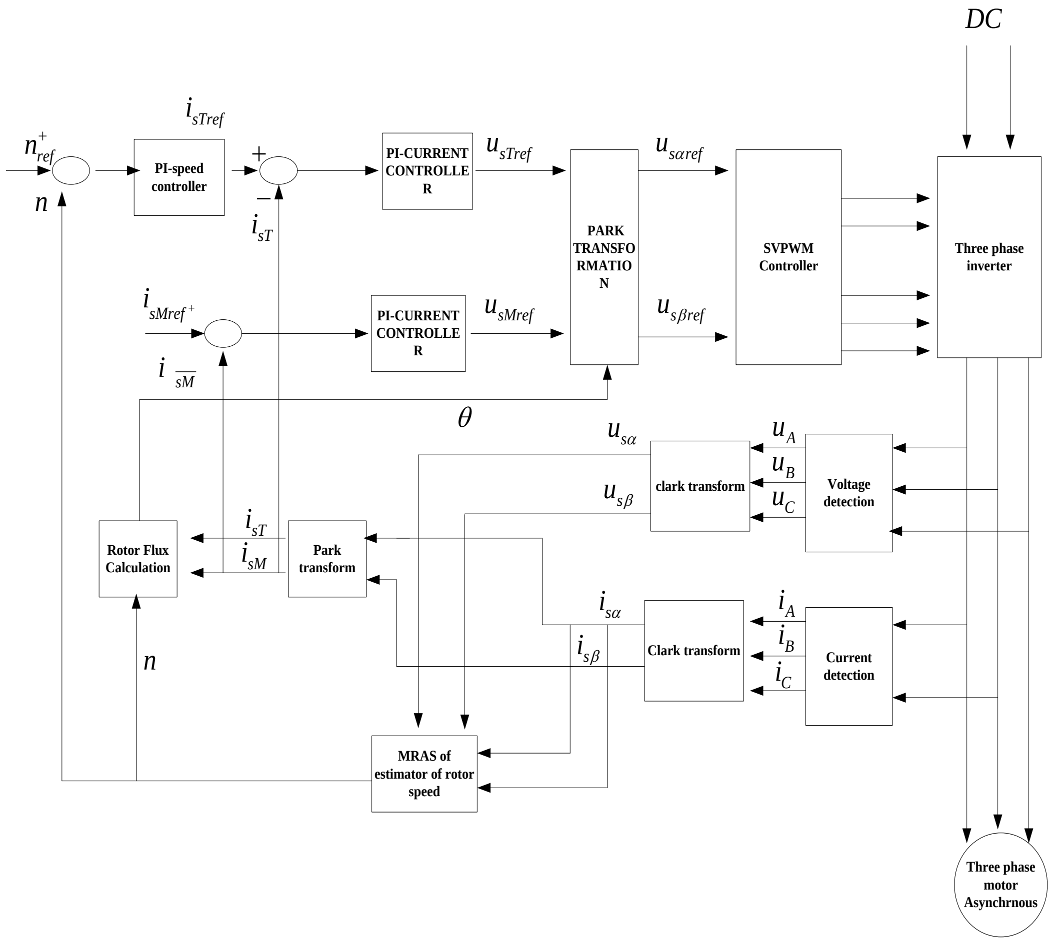

Figure 1. Speed sensorless vector control system block diagram

b. Router flux Observer

In the sensor less vector control [15], rotor flux linkage observation Sub-important. Using the voltage model as a reference model, the current model can be adjusted Model of the program to calculate the flux linkage.

Fluc Linkage Model:

Stator current by 3s / 2r transform excitation componentism And the torque component ist, the motor vector control equation is

$$T_e = n_p \frac{L_m}{L_r} i_{st} \psi_r \tag{1}$$

$$\omega_s = \frac{L_m i_{st}}{T_r \psi_r} \tag{2}$$

$$\psi_r = \frac{L_m}{T_r p + 1} i_{sm} \tag{3}$$

Where, Te For torque; Lm For mutual inductance; Lr For the rotor inductance; ψr For the rotor Flux; ist is the torque current component; Tr For the time constant. According to formula (1) ~ (3) can calculate the motor slip frequency ωs, the stator current frequency ω1 (ω1 = ωs + ωr) and ψr [4].The two-phase rotating coordinate system rotor flux linkage model can be adjusted Model to stator current and speed ωr As an input to calculate the rotor flux, the mathematical model as shown in (4), (5) below.

$$\psi_\alpha = \frac{L_m}{T_r} i_\alpha - \frac{\psi_\alpha}{T_r} - \omega_r \psi_\beta \tag{4}$$

$$\psi_\beta = \frac{L_m}{T_r} i_\beta - \frac{\psi_\beta}{T_r} - \omega_r \psi_\alpha \tag{5}$$

Compared with two-phase stationary coordinate flux model, two-phase rotation coordinate Flux model more suitable for computer real-time computing, easy convergence, more accurate Indeed However, Eqs. (4) and (5) also show that the current and speed are used as input The current model relies heavily on the rotor Tr If Tr There is deviation, will directly lead to the magnetic field is not allowed to be allowed to cause rotation between the axis of the system Strong coupling, so the current model cannot be used alone without speed sensing Vector control, the need to use together with the voltage model [5].

B. Fundamentals

Asynchronous motor vector control theory, is to produce the same spin The stator current iA, iB, iC in the three - phase coordinate system are the criterion By 3s / 2s transformation, can be equivalent to two-phase static coordinate system under the electricity Flow iα, iβ, And then through the synchronous rotation transformation, the motor stator current decomposition Into each other perpendicular to the excitation current iM And torque current ir. When observing Standing on the core, and with the coordinate system with the rotation, the AC motor will be equivalent Become a DC motor, it can imitate the DC motor control method to achieve the control of asynchronous motor. Among them, the AC motor rotor total magnetic Pass ψr It becomes equivalent to the DC motor flux, M winding is equivalent to DC motor excitation winding, i M Equivalent to the excitation current, T winding quite In the static winding, i r Equivalent to the armature current proportional to the torque. To On these equivalence relations can be expressed in Figure 1, the figure iA, iB, iC for Three-phase AC input, ωr For speed output.

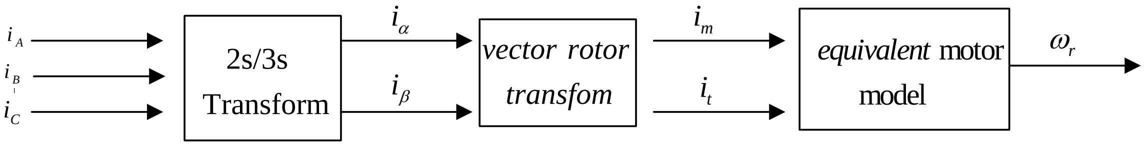

Figure 2. Vector control schematic

c. Mathematical model of asynchronous motor

From the asynchronous motor in the three-phase coordinate system can be seen in the mathematical model. The motor is multivariable, non-linear, strongly coupled system. To obtain the speed-regulating performance similar to that of DC motor, vector control must be carried out. Mathematics of Asynchronous motor in two-phase synchronous d-q coordinate system model.

Voltage Equation:

Stator Voltage Equcation

$$\left.\begin{aligned} u_{ds} &= R_s i_{ds} + \frac{d\varphi_{ds}}{dt} - \varphi_{qs}\frac{d\theta_s}{dt} \\ u_{qs} &= R_s i_{qs} + \frac{d\varphi_{qs}}{dt} + \varphi_{ds}\frac{d\theta_s}{dt} \end{aligned}\right\} \tag{6}$$

Rotor Voltage Equation

$$\left.\begin{aligned} u_{dr} &= R_r i_{dr} + \frac{d\varphi_{dr}}{dt} - \varphi_{qr}\frac{d\theta_r}{dt} \\ u_{qr} &= R_r i_{qr} + \frac{d\varphi_{qr}}{dt} + \varphi_{dr}\frac{d\theta_r}{dt} \end{aligned}\right\} \tag{7}$$

Flux linkage equation:

Stator flux equation

$$\left.\begin{aligned} \varphi_{ds} &= L_s i_{ds} + L_m i_{dr} \\ \varphi_{qs} &= L_s i_{qs} + L_m i_{qr} \end{aligned}\right\} \tag{8}$$

Rotor flux equation

$$\left.\begin{aligned} \varphi_{dr} &= L_r i_{dr} + L_m i_{ds} \\ \varphi_{qr} &= L_r i_{qr} + L_m i_{qs} \end{aligned}\right\} \tag{9}$$

Torque equation

$$T = \rho L_m (i_{qs} i_{ds} - i_{qr} i_{ds}) \tag{10}$$

In the above formula, uds Uqs, Udr, Uqr Respectively, set, the rotor voltage d - q axis component; ids, Iqs , Idr , Iqr Respectively, the rotor current d - q axis Component; , Φqs , Φdr , Φqr Respectively, fixed, rotor flux d - q axis points Quantity; , Lr For the d - q coordinate system, the rotor is equivalent to the two - phase winding Feeling; For the d - q coordinate system between the stator and the rotor coaxial equivalent winding Mutation; p is the differential operator; θ is the rotor a axis and α - β coordinate system α The angle between the axes; ωr For the rotor angular velocity, ωr = dθ / dt; θs For the d axis with Two - phase stationary α - β coordinate system α axis between the angle; ωs Rotate for the stator Magnetic field synchronous angular velocity, ωs = dθs / dt; θr For the d axis and the rotor a axis

The angle of θr = θs - θ.

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II. MODEL REFERENCE ADAPTIVE SYSTEM DESIGN

The model reference adaptive speed[16,17] is calculated using the rotor flux. The pressure equation and the current equation are respectively calculated for the rotor flux due to the voltage model Does not contain the speed signal, while the current model contains the speed signal, so the voltage model As the output of the rotor flux, the current model of the output as The calculated value of the rotor flux, to calculate the motor speed. Model Reference adaptive principle shown in Figure 2, Figure 3 shows.

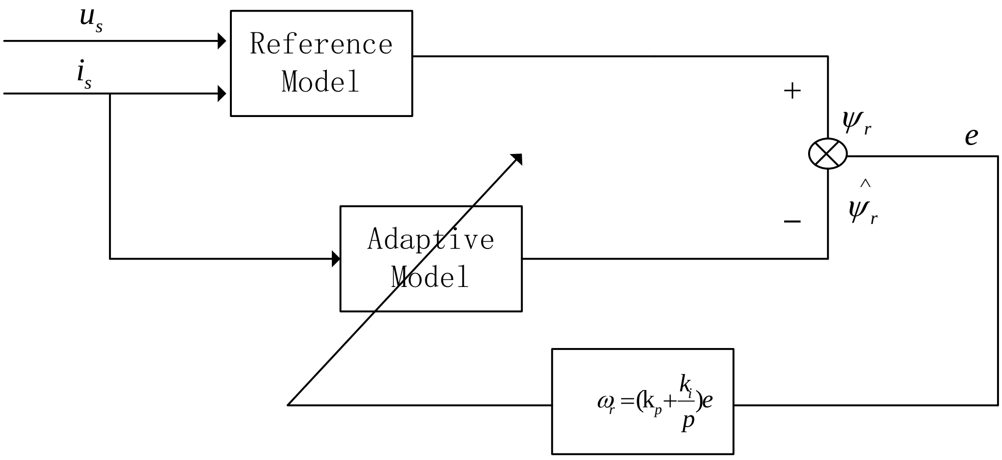

Figure 3. Model reference adaptive angular velocity identification algorithm

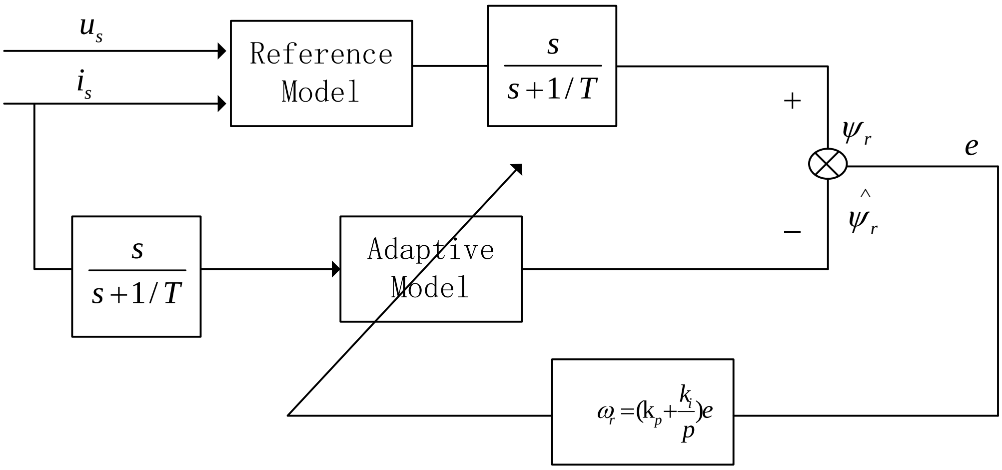

Figure 4. MRAS angular velocity identification algorithm with filter link

As the MRAS shown in Figure 2 is prone to error accumulation and DC Offset problem, so the traditional MRAS to improve, as shown in Figure 3. After the improved algorithm, to a certain extent, can improve the pure integral band To the impact of the choice of adaptive law can make the system gradually stable

III. SIMULATION SYSTEM

A. Simulation Model

This paper is based on Matlab/ simulink for Asynchronous motor MRAS the speed calculation system is simulated and simulated induction motor parameters show in table1 .

Parameters	**Values**
Stator resistance(Rs)	0.435Ω
Rotor resistance(Rr)	0.816Ω

Stator self inductance(Lls)	0.002 mH
Rotor self inductance(Llr)	0.002 mH
Magnetizing inductance(Lm)	0.067 mH
Rotor inertia	0.18 kg · m2
No pole	2
DC voltage	510V
voltage	380V
frequency	50Hz

B. Simulations Results

1) Figure 6 to Figure 9 are simulated according to the simulation model shown in Figure 5

2) Simulation results shown. System given speed of 1 200 r / min, no load start, in the vector

3) Under control, the speed rise steadily, after loading, a slight decline but then recovered,

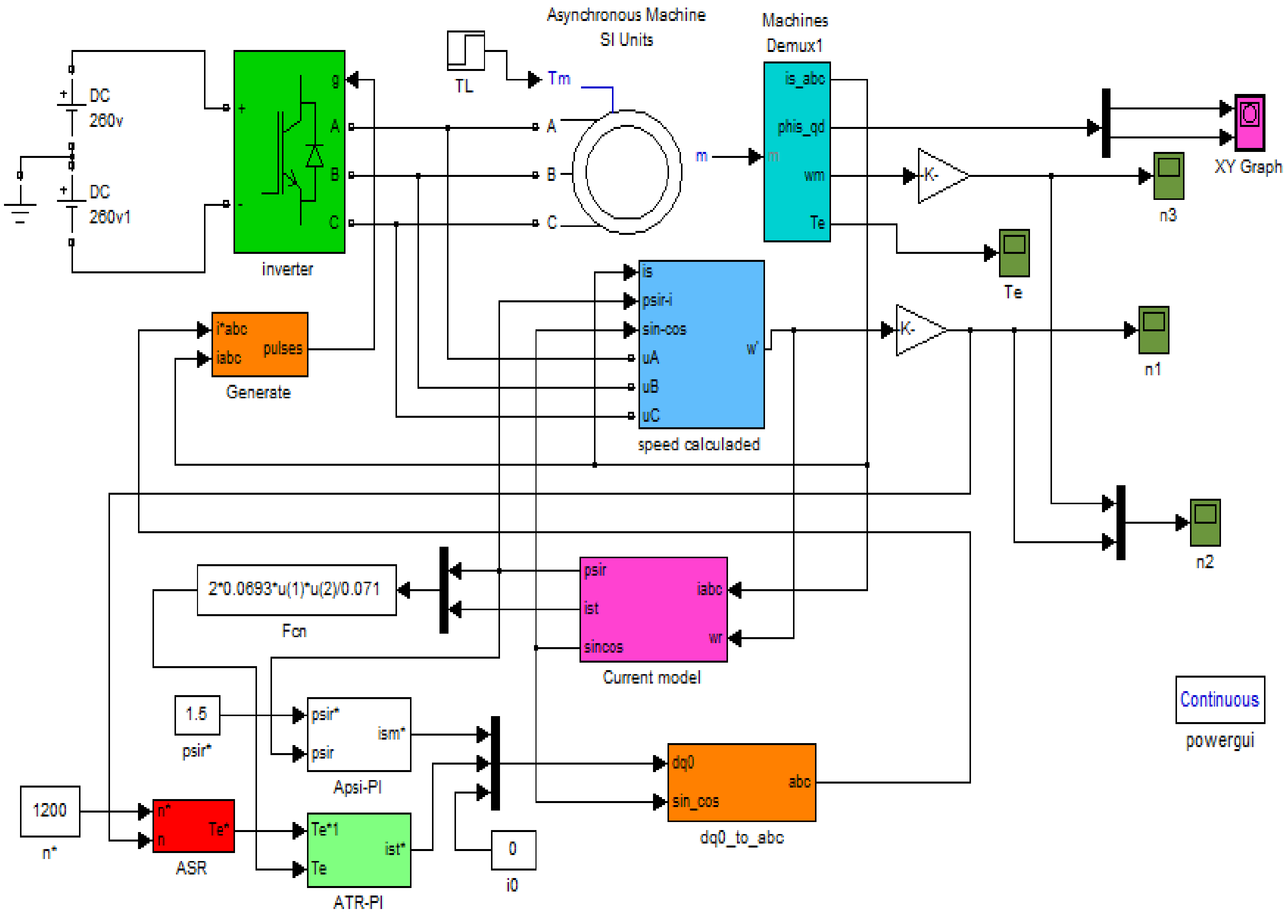

Figure 5. System simulation Model

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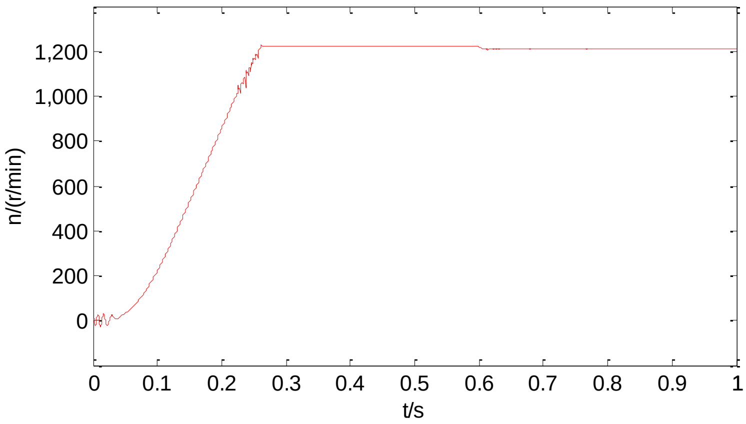

Figure 6. Estimated speed

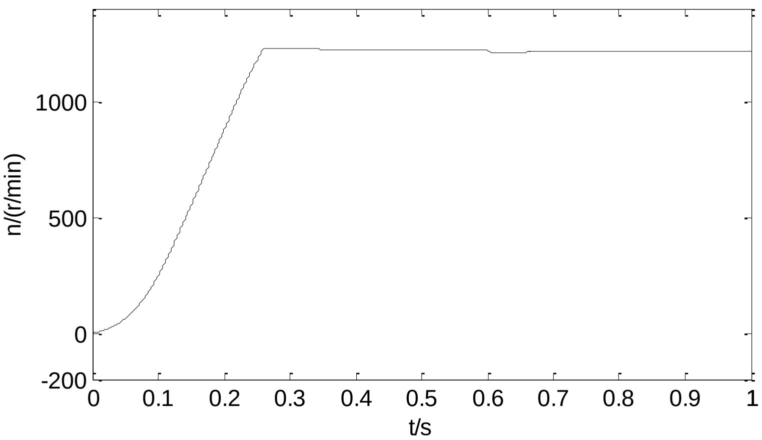

Figure 7. Actual speed

At a given speed of 0.26 s and a load of 0.6 s, the system regulator And the torque has a corresponding response. The rotor speed is at t = 0.26 s at start-up Has stabilized state, the stator flux at the start of a large change, electricity The magnetic torque has overshoot at the start and the given speed command change, but soon Tends to be stable, the stator flux amplitude gradually becomes constant, the system estimates the

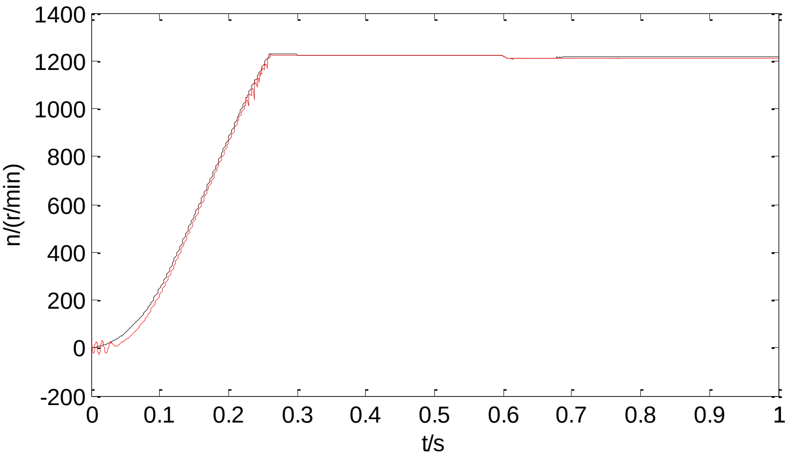

Figure 8. Estimated and actual speed at the same coordinate

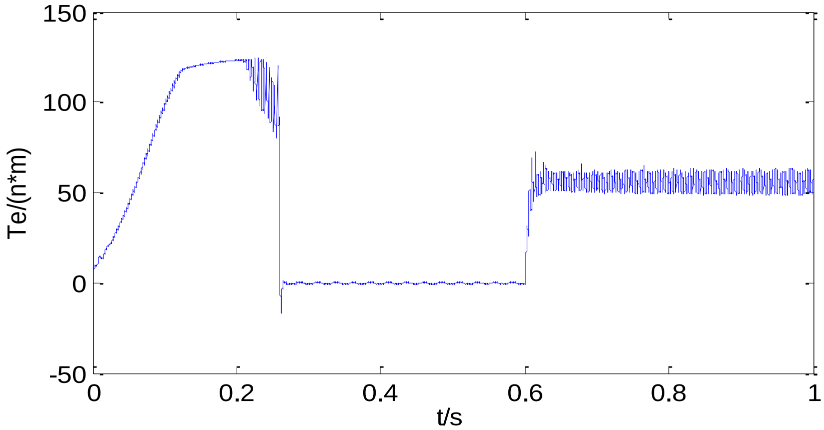

Figure 9. Motor output torque

Figure 11 to Figure 14 are simulated according to the simulation model shown in Figure 10 Simulation results shown. System given speed of 700r / min, no load start, in the vector Under control, the speed rise steadily, after loading, a slight decline but then recovered,

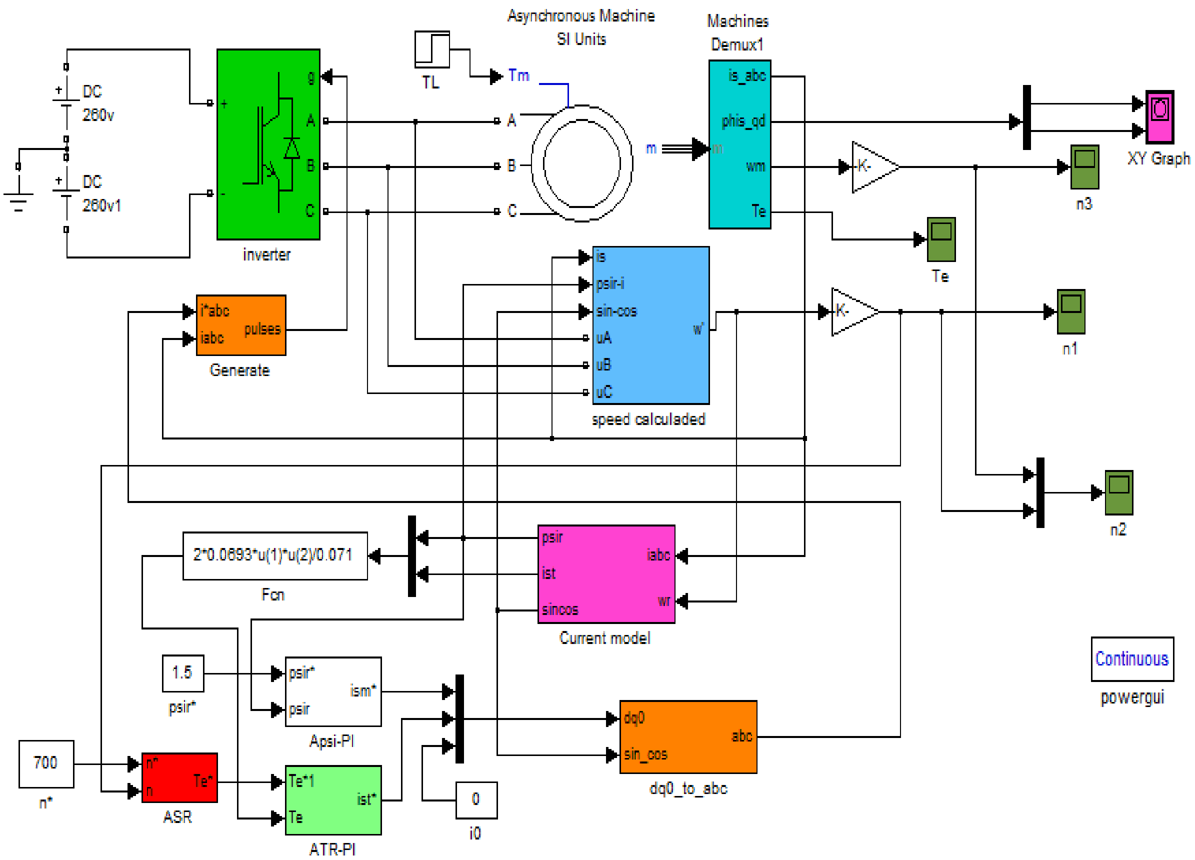

Figure 10. System simulation Model

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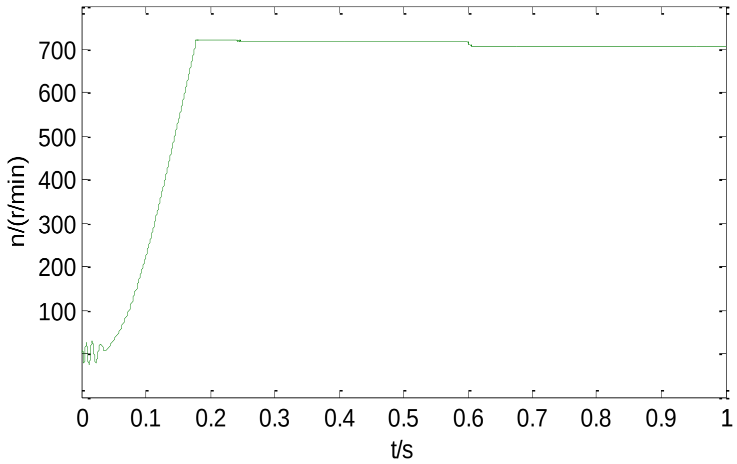

Figure 11. Estimated speed

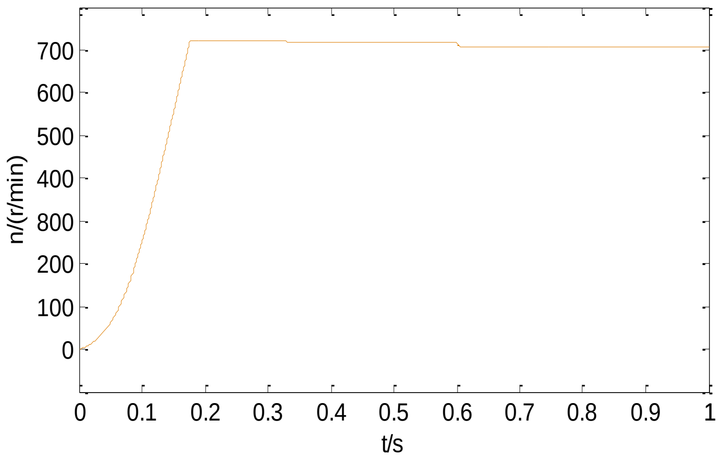

Figure 12. Actual speed

At a given speed of 0.26 s and a load of 0.6 s, the system regulator And the torque has a corresponding response. The rotor speed is at t = 0.26 s at start-up Has stabilized state, the stator flux at the start of a large change, electricity The magnetic torque has overshoot at the start and the given speed command change, but soon Tends to be stable, the stator flux amplitude gradually becomes constant, the system estimates the

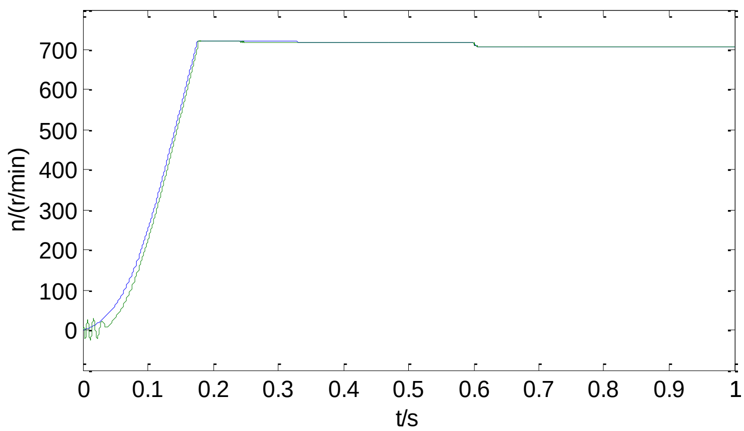

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Figure 13. Estimated and actual speed at the same coordinate

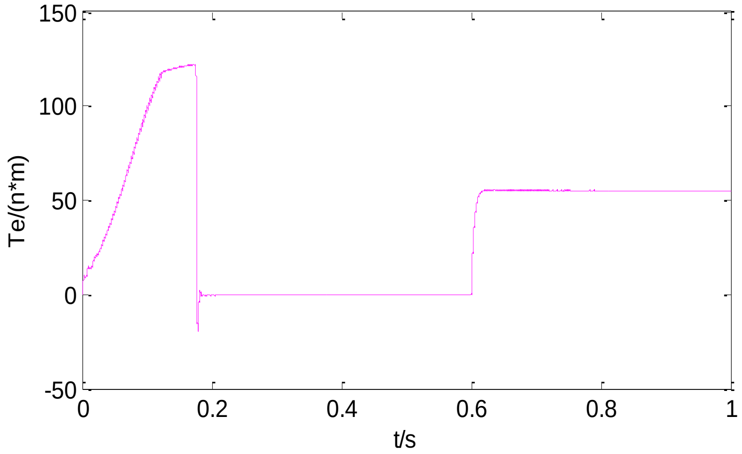

Figure 14. Motor output torque

Figure 16 to Figure 19 are simulated according to the simulation model shown in Figure 15 Simulation results shown. System given speed of 150 r / min, no load start, in the vector Under control, the speed rise steadily, after loading, a slight decline but then recovered.

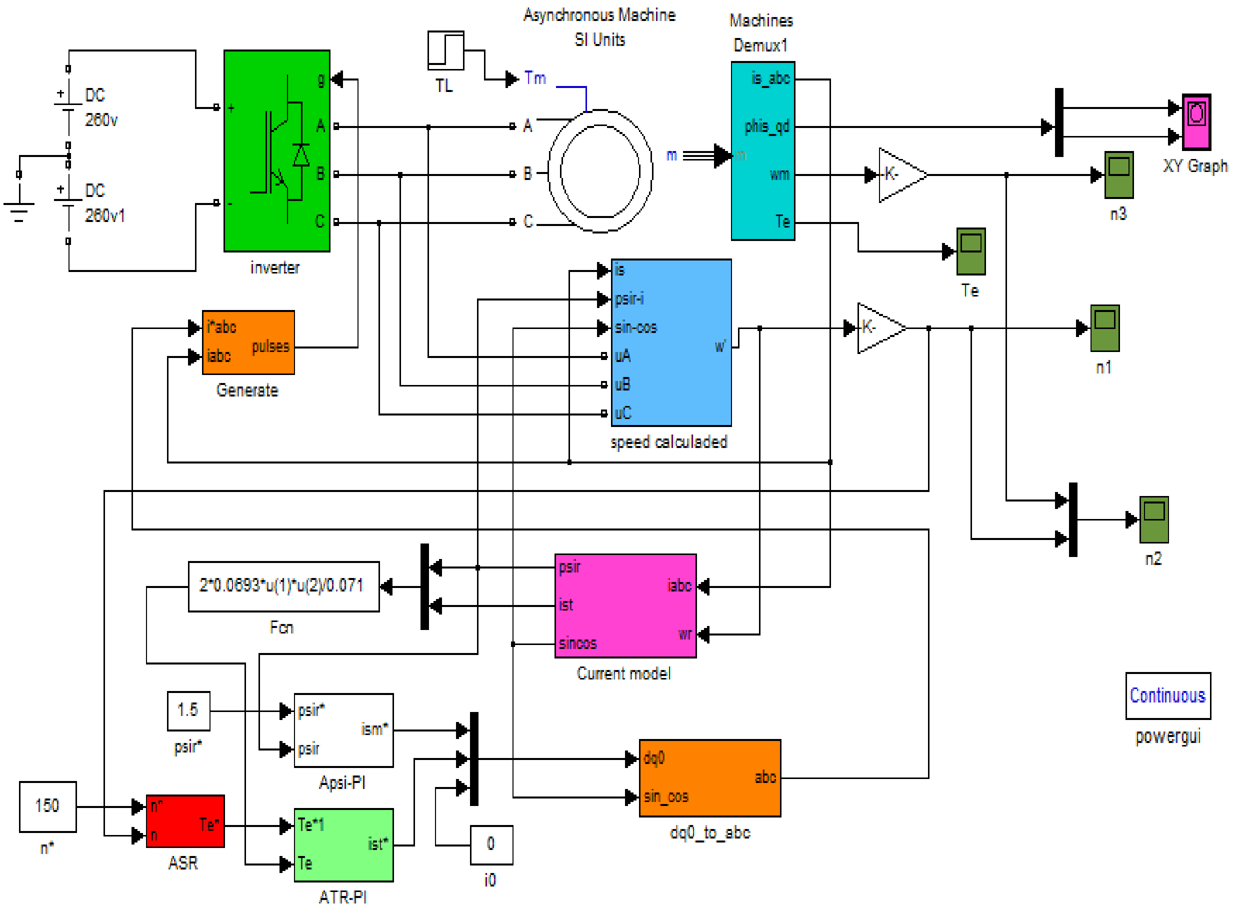

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Figure 15. System simulation Model

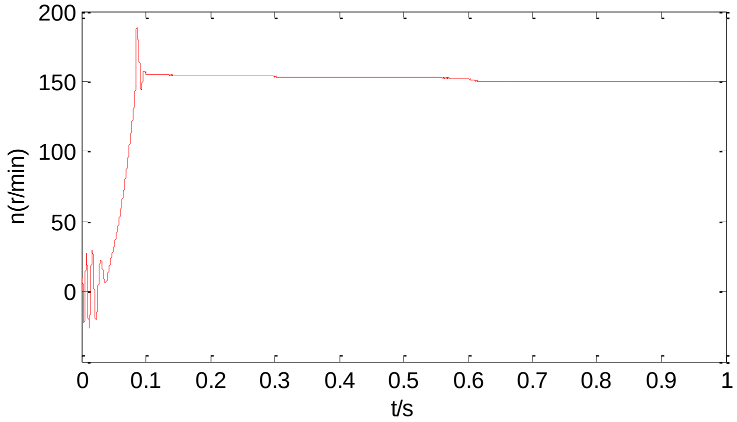

Figure 16. Estimated speed

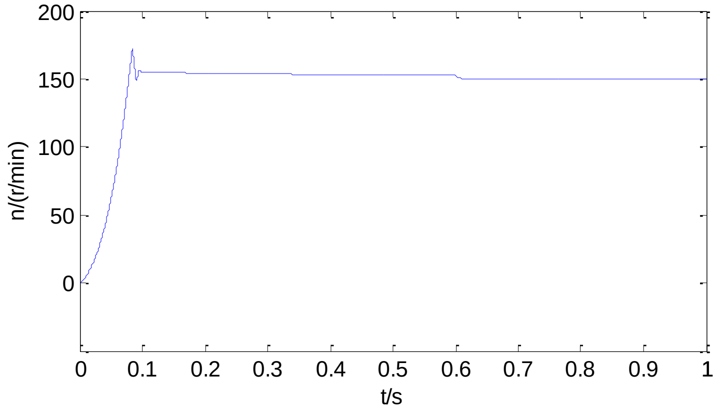

Figure 17. Actual speed

At a given speed of 0.26 s and a load of 0.6 s, the system regulator and the torque has a corresponding response. The rotor speed is at t = 0.26 s at start-up has stabilized state, the stator flux at the start of a large change, electricity The magnetic torque has overshoot at the start and the given speed command change, but soon Tends to be stable, the stator flux amplitude gradually becomes constant, the system estimates the

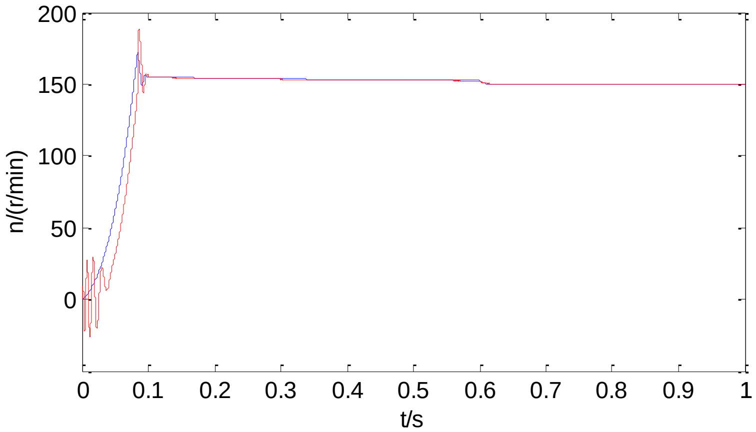

Figure 18. Estimated and actual speed at the same coordinate

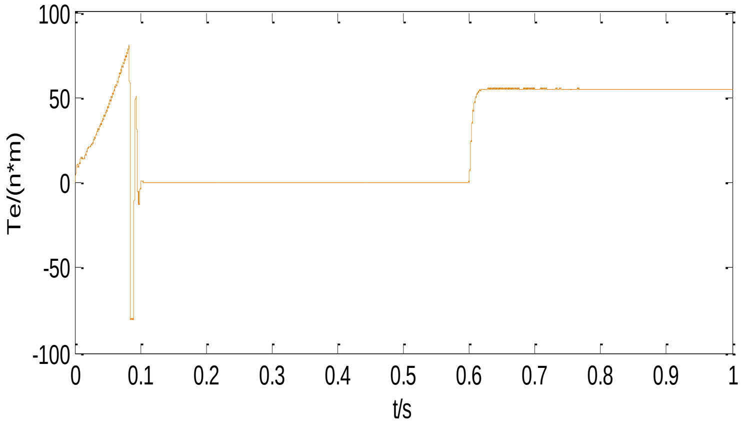

Figure 19. motor output torque

CONCLUSION

Neural network has a certain degree of ascension, can be considered as a control System strategy applied to the practical application. While the reality of the car temperature in the fine The degree does not need to do very high, mainly taking into account the cost of research and development. This limits the application of neural network control in the car, but according to the future The direction of development, people for the comfort and rapid response requirements are not Improve the control, neural network control will have a great development prospects

REFERENCES

[1] Zerdali E, Barut M (2016) Novel version of bi input-extended Kalman filter for speed-sensorless control of induction motors with estimations of rotor and stator resistances, load torque, and inertia. Turk J Electr Eng Comput Sci 24 (5):4525-4544. doi:10.3906/elk-1408-136

[2] Usta MA, Okumus HI, Kahveci H (2017) A simplified three-level SVM-DTC induction motor drive with speed and stator resistance estimation based on extended Kalman filter. Electr Eng 99 (2):707-720. doi:10.1007/s00202-016-0442-x

[3] Kung YS, Thanh NP, Wang MS (2015) Design and simulation of a sensorless permanent magnet synchronous motor drive with microprocessor-based PI controller and dedicated hardware EKF estimator. Appl Math Model 39 (19):5816-5827. doi:10.1016/j.apm.2015.02.034

[4] Inan R, Barut M (2014) Bi input-extended Kalman filter-based speed-sensorless control of an induction machine capable of working in the field-weakening region. Turk J Electr Eng Comput Sci 22 (3):588-604. doi:10.3906/elk-1208-31

[5] Venkadesan A, Himavathi S, Muthuramalingam A (2013) Performance comparison of neural architectures for on-line flux estimation in sensor-less vector-controlled IM drives. Neural Comput Appl 22 (7-8):1735-1744. doi:10.1007/s00521-012-1107-y

[6] Gutierrez-Villalobos JM, Rodriguez-Resendiz J, Rivas-Araiza EA, Martinez-Hernandez MA (2015) Sensorless FOC Performance Improved with On-Line Speed and Rotor Resistance Estimator Based on an Artificial Neural Network for an Induction Motor Drive. Sensors 15 (7):15311-15325. doi:10.3390/s150715311

[7] Maiti S, Verma V, Chakraborty C, Hori Y (2012) An Adaptive Speed Sensorless Induction Motor Drive With Artificial Neural Network for Stability Enhancement. IEEE Trans Ind Inform 8 (4):757-766. doi:10.1109/tii.2012.2210229

[8] Mouna B, Aicha A, Lassaad S (2011) Neural Network Speed Sensor less Direct Vector Control of Induction Motor Using Fuzzy Logic in Speed Control Loop. Int Rev Electr Eng-IREE 6 (5):2237-2246

[9] Mishra RN, Mohanty KB (2017) Implementation of feedback-linearization-modelled induction motor drive through an adaptive simplified neuro-fuzzy approach. Sadhana-Acad Proc Eng Sci 42 (12):2113-2135. doi:10.1007/s12046-017-0741-6

[10] Kilic E, Ozcalik HR, Yilmaz S (2016) Efficient speed control of induction motor using RBF based model reference adaptive control method. Automatika 57 (3):714-723. doi:10.7305/automatika.2017.02.1330

[11] Wang SY, Tseng CL, Chiu CJ (2015) Design of a novel adaptive TSK-fuzzy speed controller for use in direct torque control induction motor drives. Appl Soft Comput 31:396-404. doi:10.1016/j.asoc.2015.03.008

[12] Zbede YB, Gadoue SM, Atkinson DJ (2016) Model Predictive MRAS Estimator for Sensorless Induction Motor Drives. IEEE Trans Ind Electron 63 (6):3511-3521. doi:10.1109/tie.2016.2521721

[13] Holakooie MH, Taheri A, Sharifian MBB (2015) MRAS Based Speed Estimator for Sensorless Vector Control of a Linear Induction Motor with Improved Adaptation Mechanisms. J Power Electron 15 (5):1274-1285. doi:10.6113/jpe.2015.15.5.1274

[14] Brandstetter P, Dobrovsky M, Kuchar M, Dong CST, Vo HH (2017) Application of BEMF-MRAS with Kalman filter in sensorless control of induction motor drive. Electr Eng 99 (4):1151-1160. doi:10.1007/s00202-017-0613-4

[15] Kumar R, Das S, Syam P, Chattopadhyay AK (2015) Review on model reference adaptive system for sensorless vector control of induction motor drives. IET Electr Power Appl 9 (7):496-511. doi:10.1049/iet-epa.2014.0220

[16] Dehghan-Azad E, Gadoue S, Atkinson D, Slater H, Barrass P, Blaabjerg F (2018) Sensorless Control of IM Based on Stator-Voltage MRAS for Limp-Home EV Applications. IEEE Trans Power Electron 33 (3):1911-1921. doi:10.1109/tpel.2017.2695259

[17] Kumar R, Das S (2017) MRAS-based speed estimation of grid-connected doubly fed induction machine drive. IET Power Electron 10 (7):13. doi:10.1049/iet-pel.2016.0768

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