Proceeding of the 13th International Forum of Automotive Traffic Safety, 2016, pp140-142
No.ATS.2016.304

Speed Sensorless Vector Control System Simulation Design

Liu xiangjun

Nanyang City, the first secondary school nanyang china 473000

email:zhoujimen@163.com

Abstract: AC induction motor speed control system in the accuracy and speed of identification and other issues. Using the model reference adaptive theory (MRAS) and ultra-stability theory of control system design.Obtained from the operating voltage and current measurements to estimate the inductio n motor end the motor speed, the speed sensorless vector control algorithm, using the current model and the voltage model flux estimate and simulation in Simulink software environment. The simulatio n results show that: the system has good dynamic and static characteristics and stability.

Keywords: speed sensor; vector control; model reference adaptive system; Speed Identification

1 Preface

Induction motor vector control (vector control, VC) has high control accuracy, low-frequency characteristic s, static and dynamic torque response and fast control performance, so widely used in high-performance AC motor drive system. But the speed feedback signal obtained with the conventional vector control speed by inst alling speed sensor, which not only increase the cost of the system, but also reduce the reliability of the syst em, limiting the scope of application of the system, affecting the performance of the speed control system. N o speed sensor vector control technology it is to obtain the stator voltage and current quantities from the mot or, estimated by calculating the motor speed, it eliminates the hassle of speed sensor hardware detection, redu cing system cost and improve system stability. Speed Identification of the time-varying nonlinear systems with simple algorithm, a small amount of calculation, real-time and good stability model reference adaptive control (model reference adaptive system, MRAS) based in many areas has been widely used. So I use MRAS to es timate the motor speed.

2Vector control

2.1 Fundamentals

Asynchronous motor vector control principle simulates asynchronous motors as DC motors to get better control performance, according to the dynamic mathematical model of the motor,and taking advantage of PARK transformation and CLARK transformation. Under the premise producing the same rotation MMF, stator currents i_A, i_B, i_C in the ABC three-phasecoordinate system can be converted to currents iα,iβ in α β two phase static coordinate system,through CLARK transformation(3s/2s), and then α β two phase static coordinate system can be convertered to dq two phase rotating coordinate system through PARK Transform (i.e. 2s / 2r transform), as a result, the stator current of the motor is decomposed into orthogonal excitation current id and the torque current i_q. In this way, when observer rotates with the coordinate standing on the core, the AC motor can be equivalent to a DC motor . Therefore, we can control the AC asynchronous motor with the method of controlling the DC motor. The schematic diagram is shown in Figure 1. i_A, i_B, i_C is the three-phase AC input current, ωr is the output speed.

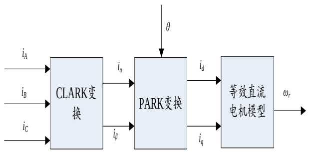

Figure 1. Vector control schematics

2.2 The current model rotor flux

According to the mathematical model of induction motor, we can conclude: the motor is a multi-variable, nonlinear, strong coupling system, want to be like as DC motor control AC motor control, we must transfor m vector.

Through vector transformation, we can get the motor in the dq coordinate system voltage equation is:

$$\begin{bmatrix} u_{s\alpha} \\ u_{s\beta} \\ u_{r\alpha} \\ u_{r\beta} \end{bmatrix} = \begin{bmatrix} R_s + L_s p & 0 & L_m p & 0 \\ 0 & R_s + L_s p & 0 & L_m p \\ L_m p & \omega_r L_m & R_r + L_r p & \omega_r L_r \\ -\omega_r L_m & L_m p & -\omega_r L_r & R_r + L_r p \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \\ i_{r\alpha} \\ i_{r\beta} \end{bmatrix} \quad (1)$$

After correlation can be drawn in terms of derivation induction motor rotor flux of the current model eq uation:

$$\psi_{r\alpha} = \frac{1}{T_r \rho + 1}(L_m i_{s\alpha} - \omega T_r \psi_{r\beta}) \quad (2)$$

$$\psi_{r\beta} = \frac{1}{T_r \rho + 1}(L_m i_{s\beta} - \omega T_r \psi_{r\alpha}) \quad (3)$$

Therefore, the rotor flux in the two-phase rotating coordinate system of the current modelequation:

$$\psi_r = \frac{L_m i_{sm}}{T_r \rho + 1} \quad (4)$$

Motor slip formula is:

$$\omega_s = \omega_1 - \omega = \frac{L_m i_{st}}{T_r \psi_r} \quad (5)$$

2.3voltage model rotor flux

After the same number of columns under coordinate conversion can be obtained rotor flux voltage equati on.

$$\hat{\psi}_{r\alpha} = \frac{L_r}{L_m}[\int (u_{s\alpha} - R_s i_{s\alpha})dt - \sigma L_s i_{s\alpha}] \quad (6)$$

$$\hat{\psi}_{r\beta} = \frac{L_r}{L_m}[\int (u_{s\beta} - R_s i_{s\beta})dt - \sigma L_s i_{s\beta}] \quad (7)$$

3 MRAS Speed Identification Based rotor flux

MRAS basic principle is: to build a mathematical model and the parameter or variable is not completely measurable system input error to use a reference model and an adjustable model to design a system can be changed in one or some of the parameters adaptive structure, adjusted by the variable parameter or action to change the output value of the adjustable model, so that the output of the reference model and adjustable model error is zero [3]. According to Popov super stability theory can be derived from the motor speed formula:

$$\begin{aligned} \omega_r &= \left(K_p + \frac{K_i}{p}\right)\left(e_{\psi\alpha}\hat{\psi}_{r\beta} - e_{\psi\beta}\hat{\psi}_{r\beta}\right) \\ &= \int_0^t K_i (e_{r\beta}\hat{\psi}_{r\alpha} - e_{r\alpha}\hat{\psi}_{r\beta})d\tau + K_p (e_{r\beta}\hat{\psi}_{r\alpha} - e_{r\alpha}\hat{\psi}_{r\beta})(K_i \geq 0, K_p \geq 0) \end{aligned} \quad (8)$$

4 System Simulations

4.1 Simulation Model

Based on Matlab/Simulink7.11.0 (R2010b), this paper simulate the MRAS speed calculation system of the asynchronous motor. Simulation motor parameters are: u=260v， f=50Hz， np=2， Rs=0.435Ω，Lls=0.002mH， Rr=0.816Ω，Llr=0.002mH，Lm=0.069 mH，J=0.19kg.m2. Stator and rotor winding resistor inductance is 0.071mH, leakage coefficient is 0.056, the rotor time constant is 0.087. Emulation circuit is shown in Figure2.

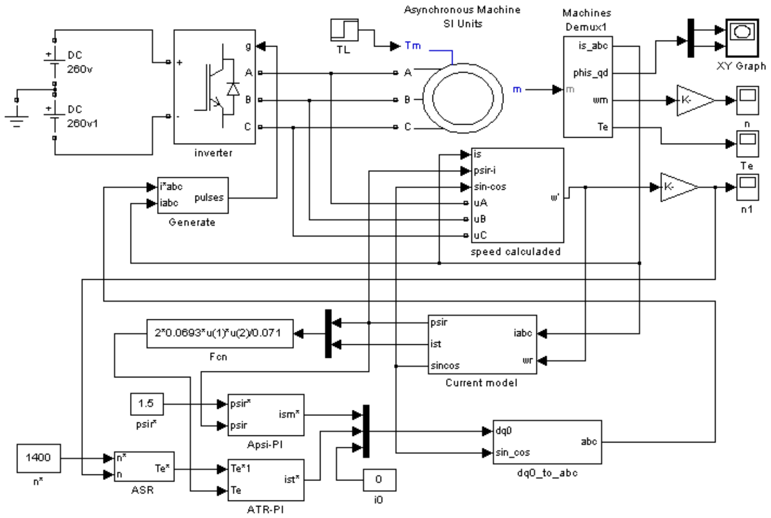

Figure 2 System Simulation Model

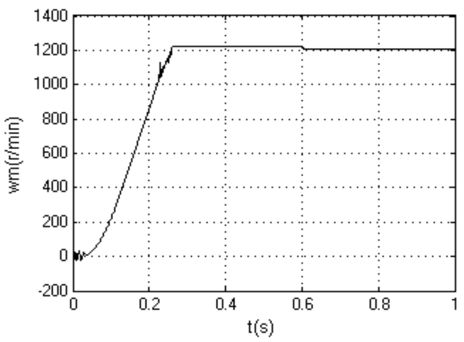

Figure 3 the actual speed

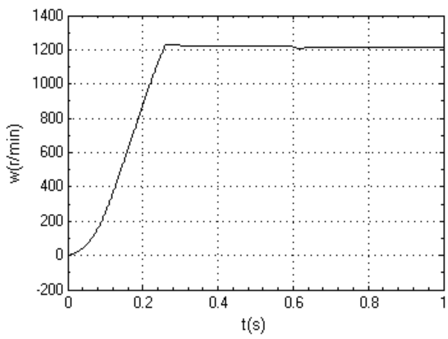

Figure 4 estimated speed

Figure 3 Figure 4 is the actual motor speed and the estimated speed waveforms. 6 in conjunction with Figure 7 shows that in the initial stage of starting the motor 0 ~ 0.22s motor rotation speed gradually increases, and consistent with the actual situation, the speed error is smaller, at 0.22 ~ 0.6s this stage, the motor speed is always in the set given the speed of 1200r / min, although the estimated speed fluctuations, ups and downs, but smaller, more stable system, in the 0.6s, outside the system load is added, the estimated speed fluctuations, but soon to return to the set speed 1200r / min. Whereby the entire simulation time can be learned: The system of the motor speed estimation error is very small, very small fluctuations, the system is always in a relatively stable state.

5 Conclusions

The simulation results show that the speed sensorless vector control system is robust, fast and accurate identification of the motor speed, has good dynamic and static performance and stability, has a guiding theory for the actual project.

References

[1] Li D H, Bai Jing, Li Z M, Li Qing, *AC Speed Control System*, Beijing, Electronic Industry Press, 2002.92-150.
[2] Xia C Y, *Adaptive control of AC and DC transmission system*, Beijing; Machinery Industry Press,2005,100-120.
[3] Li Zhen. *Sensorless field orientation control of induction machines based on a mutual MRAS scheme*[J].IEEE Trans on IE ,1998,45(5)

.