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Design of composite digital filter with least square method parameter identification

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ABSTRACT*:*Motor control operation in the process of parameter identification precision is susceptible to interference signal power frequency and high order harmonic, the influence of the commonly used filter is often only filter out of some interference, lead to identification of parameters is not precise control and ultimately affect the system running effect, this paper puts forward the compound digital filter and the recursive least square method combining algorithm was applied to parameter identification of induction motor, designed a least squares parameter identification of compound digital filter, and using S - function in MATLAB programming simulation validation. The simulation results show that the design of the least squares parameter identification compound digital filter can effectively improve the precision of parameter identification, improve performance of vector control system.

Keywords: recursive least square method, parameter identification, composite digital

I. INTRODUCTION

For asynchronous motor with vector control system, the accuracy of the motor parameters has a great influence on motor's control performance. These parameters mainly include motor stator resistance, stator inductance , rotor resistance, rotor inductance and mutual inductance. When the parameters are not accurate, the parameters of the motor performance will be led to degraded or even out of control. It can be seen that the accurate identification of motor parameters is particularly important to the vector control of asynchronous motor.

Parameter identification of asynchronous motor are mainly off-line identification and online identification method. Online identification method is mainly to identifystator and rotor resistance which have large time-varying during motor running process. Online identification method mainly includes model reference adaptive, full order observer method, the least square method, etc. Online identification [2] is advantageous to the performance of the control system, so the corresponding real-time is needed to be joint to realize algorithm. In order to prevent and eliminate the influence that the interference of processor power produced on microprocessor control system [3]. Not only the hardware filtering can be used, but alsosoftware filtering can employed. In many control systems with slow signals [4]. The conventional hardware RC filter is hard to be used to deal with the interference of low signal (the hardware circuit is requiring not too big), just as power frequency. Thus, with the help of the processor's fast operation. Using software filtering method may produce more obvious effect [5].

In this paper, a recursive least square method based on composite digital filter is proposed to identify the parameters of asynchronous motor. The RC low-pass digital filter and arithmetic average filter are used in Compound digital filter. In reference [1], recursive least squares algorithm formula is as follows [6]:

$$\begin{cases} \hat{\theta}(N+1) = \hat{\theta}(N) + K(N)\left[y(n+N+1) - \phi^T(N+1)\hat{\theta}(N) \right] \\ K(N) = P(N)\phi(N+1)\left[1 + \phi^T P[N]\phi(N+1) \right]^{-1} \\ P(N+1) = \left[E - K(N)\varphi^T(N+1) \right] P(N) \end{cases} \quad (1)$$

II. THE DESIGN OF COMPOUND DIGITAL FILTER

As the arithmetic mean filter has a good effect on filter, so the arithmetic mean filtering is adopted in this paper. The sampling number N in arithmetic mean filter is larger; a lot of harmonic interference signals will be produced. The low-pass filtering method should be considered so that for more than one frequency signal is suppressed and attenuated. Therefore, the compound digital filter is combined by low pass filter and arithmetic average filtering, the relationship between input and output is shown in figure 1.

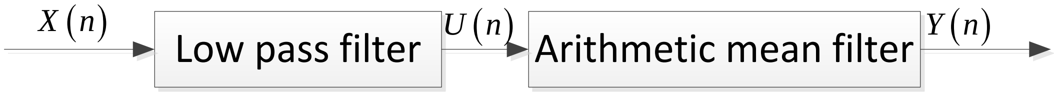


Fig.1 The relationship between input and output in compound digital filter

2.1 RClow-pass digital filter algorithm

The digital filter is adopted to realize low-pass filtering. Not only can achieve filtering effect and PCB layout space can be saved, but also the cost can be reduced. RC low pass filter is shown in figure 2.

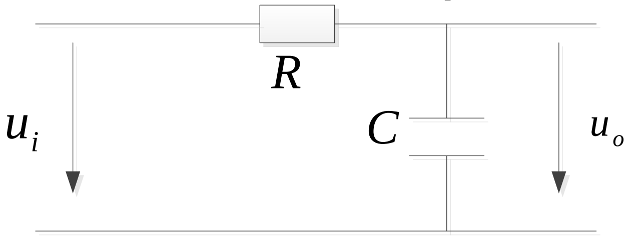


Fig.2 RC low pass filter

RC low-pass filter is simulated by digital,and the transfer function is as follows:

$$G(s)=\frac{Y(s)}{X(s)}=\frac{1}{\tau s+1} \quad (2)$$

Formula (2), τ is the time constant of the RC filter， $\tau = RC$.By the formula can be seenRC low pass filter is actually a filtering system with a first order lag.
Will the discretization, available

$$Y(kT)=(1-\alpha)Y(kT-T)+\alpha X(kT) \quad (3)$$

Formula(3), $X(kt)$ is the k TH sampling values; $Y(kT)$ is k times the filter output value structure; α isfiltering smoothing coefficient; $\alpha = 1 - e^{-T/\tau}$, T is the sampling period. Type (3) to simulate RC digital low-pass filter, can use the program implementation.

2.2 The arithmetic mean filtering algorithm

Arithmetic average filtering is to find a $Y(k)$, so that the value of the error between the sampling value of the square of the smallest,

$$s=\min\left[\sum_{i=1}^{N} e^2(i)\right]=\min\left\{\sum_{i=1}^{N}\left[Y(u)-X(i)\right]^2\right\}$$

A function for extremum principle

$$\bar{Y}(k)=\frac{1}{N}\sum_{i=1}^{N} X(i) \quad (4)$$

In formula (4), $\bar{Y}(k)$ is k times N sampling arithmetic mean value; $X(i)$ is the i TH sampling values; N is the sample number.

III. MATLAB SIMULATION AND ANALYSIS

According to the vector control of asynchronous motor, we can obtain transfer function

$$\frac{i_{s\alpha}}{u_{s\alpha}}=\frac{p+\frac{R_r}{L_r}}{\sigma L_s p^2+\left(R_s+\frac{L_s}{L_r}R_r\right)p+\frac{R_s R_r}{L_r}} \quad (5)$$

Formula (5) on both sides of Laplace Transform

$$\frac{i_{s\alpha}}{u_{s\alpha}}=\frac{s+k_0}{k_1 s^2+k_2 s+k_3} \qquad (6)$$

Among them $k_0=\frac{R_r}{L_r}$, $k_1=\sigma L_s$, $k_2=R_s+\frac{L_s}{L_r}R_r$, $k_3=\frac{R_s R_r}{L_r}$

Make $Z=u_{s\alpha}/s$,formula (5) written about the form of transfer function

$$Z=\frac{u_{sd}}{s}=-\frac{u_{s\alpha}}{s^2}k_0+i_{s\alpha}k_1+\frac{i_{s\alpha}}{s}k_2+\frac{i_{s\alpha}}{s^2}k_3 \qquad (7)$$

Formula (7) Z transform

$$Z(k)=-Z(k-1)k_0+U(k)k_1+U(k+1)k_2+U(k+2)k_3 \qquad (8)$$

Least squares identification of recursion method of MATLAB/S-function of the program flow chart is shown in figure 3.

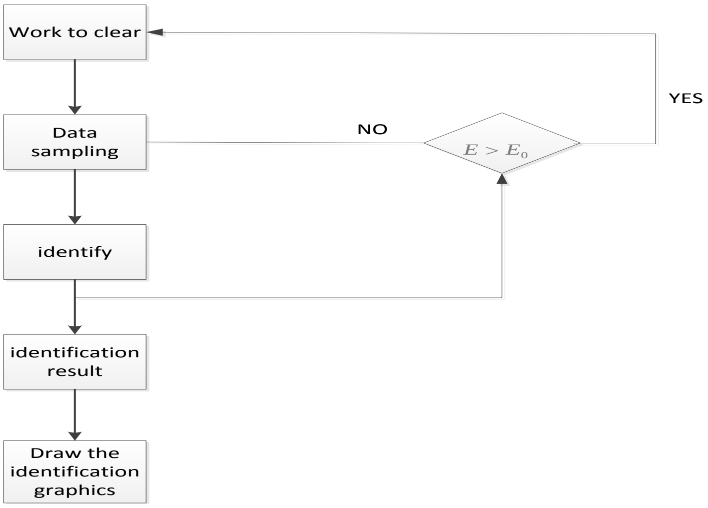
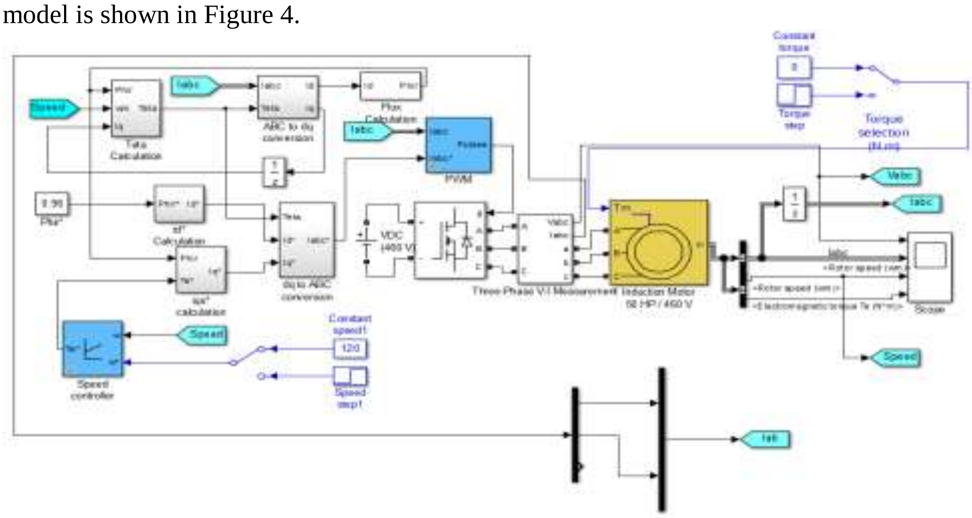


Fig.3 s-function programming flow chart

The simulation model is built on the basis of the model of the motor inside the MATLAB, Motor parametersare as followsRatedpower $P_N=3.73kw$ Ratedvoltage $U_N=460V$, $f_N=50Hz$, $R_s=0.087\Omega$, $R_r=0.228\Omega$, $L_{ls}=L_{lr}=0.8\times10^{-3}H$ and $L_m=34.7\times10^{-3}H$.

For asynchronous motor vector control system simulation is as follows, the simulation time is set to 1s, In order to achieve the best simulation results, the simulation step is s, which is 50001 points, and the simulation model is shown in Figure 4.



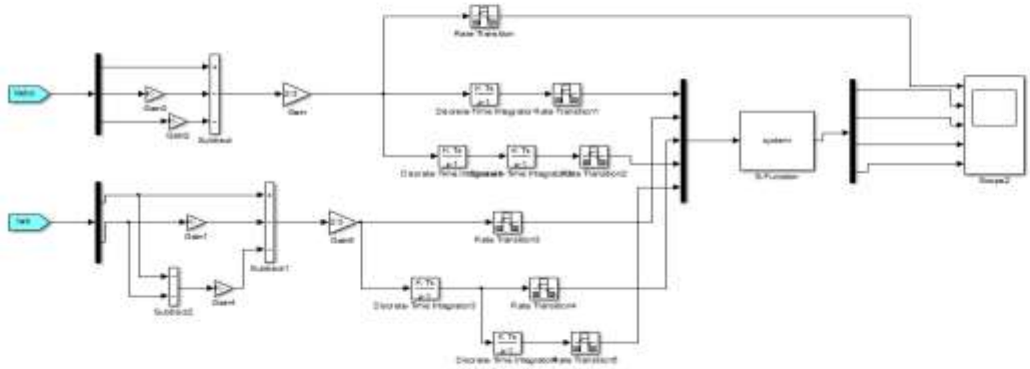
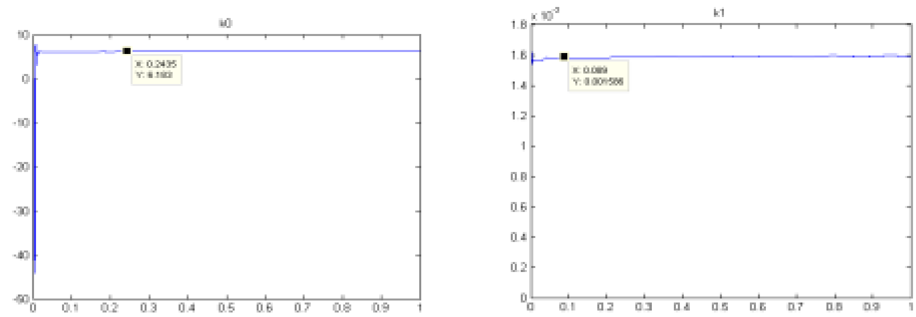
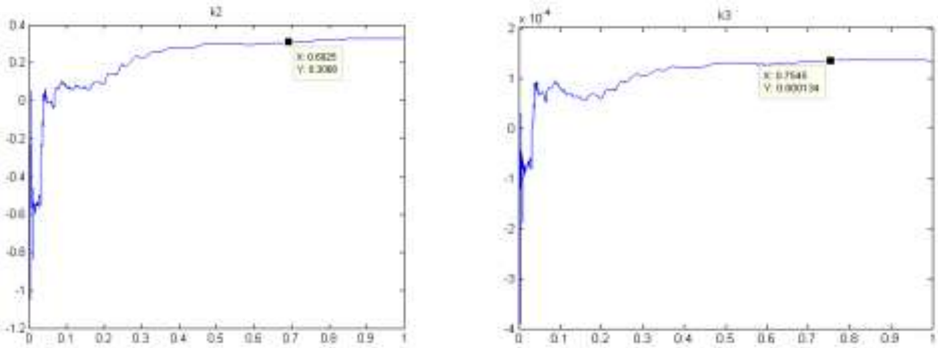


Fig.4 Simulation model of asynchronous motor parameter identification

The simulation waveform is shown in figure 5



Identification coefficient of k_0 Identification coefficient of k_1



Identification coefficient of k_2 Identification coefficient of k_3

The coordinate values indicated in the above four maps indicate that the value of each coefficient is stable at a certain moment, that is, the final identification of the coefficients, where K0 in 0.2435 s stable value of 6.183; K1 in 0.089s stable value of 0.001586; K2 in 0.6925s stable value of 0.3068; K3 in 0.7545s stable value of 0.000134. To get the identification error, with each coefficient comparing the actual calculation of the comparison results as shown in table 1:

Tab.1 the error of the value and the actual value of the coefficient.

Coefficient	K0	K1	K2	K3
actual calculated value	6.3225	1.582e-3	0.3068	1.376e-4
Identification value	6.183	1.586e-3	0.315	1.34e-4

Error（%）	2.2	0.25	2.3	2.6

Known from the table 3-1, the identification error of the four coefficients is less than 3%, so this set of data can be extracted for motor parameter calculation, According to the type (6) and (7) in the motor parameters and coefficients k_0、 k_1、 k_2 and k_3, the mathematical relationship between be able to get the parameters of the motor, the calculation results are as follows：

$$R_s = \frac{k_3}{k_1} = 0.084\Omega \ R_r = k_2 - R_s = 0.231\Omega$$

$$L_s = L_r = \frac{R_r}{k_0} = 36.3\text{mh} \ L_m = \sqrt{L_s^2 - L_s k_1} = 35\text{mh}$$

The above calculated motor parameter value and the actual parameter values to compare results as shown in table 2:

Tab.2error factors level

parameter	R_s / Ω	R_r / Ω	$L_r = L_s / \text{m}H$	L_m / H
Actual motor parameter values	0.087	0.231	35.5	34.7
Identification of parameter values	0.084	0.228	36.3	35
error（%）	3	1.3	2.25	0.86

From the table 2 can be obtained through identification of motor parameter value and the actual parameter values of error is less than 3%, , we can think that the use of the least square method to identify the motor parameters is very accurate, at the same time also is very fast.

IV. CONCLUSION

Based on vector control of induction motor, the rotor resistance R_r , stator resistance R_s , rotor inductance L_r and rotor mutual inductance L_m are identified by using MATLAB tool.According to the section on data analysis to identify convergence faster, better stability. Obtained with the identification of stator rotor parameters of the error and the error of stator resistance identification is not big. That the least squares parameter identification method of compound digital filter can be individually to identify motor parameters [7.8] and the parameters of identification is fast accurate. This article deficiency is not generic simulation identification of induction motor under different environment in the aspects to be improved.

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