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Program design and implementation for servo system

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Abstract
The program design and implementation for servo optima control system is studied. A linear and discrete system of a servo control system is considered. The state variables are chosen for the servo control system and the system is rewritten in the state-space representation. Then, the performance index is chosen. In order to simulate the control effect of the optimal control system, Matlab program environment is employed and the program is design and implement for the servo system. The results of the program demonstrate the effectiveness of the servo optimal control system.

Keywords: program design, program implementation, servo system

1. Introduction

Servo system is an electronic control system in which a hydraulic, pneumatic, or other type of controlling mechanism is actuated and controlled by a low-energy signal [1]. The servo system makes the output of the object, the position, the state, and so on, which can follow the input target (or the given value) with any change of the automatic control system.

Its main task is to control and control the output power according to the requirements of control commands, amplification, transformation and control of power, so that the output torque, speed and position control of the driving device is very flexible and convenient. In many cases, refers to the servo system is to control the amount of (the system output) is a feedback control system of mechanical displacement or displacement velocity and acceleration, its role is to enable the mechanical displacement output (or angular displacement) to accurately track the input (or angle), a feedback control system and its structure and other forms of no the difference in principle [2, 3, 4]. Servo system was originally used for national defense industry, such as artillery control, ship's automatic driving and missile launching, and then gradually extended to many sectors of the national economy, such as automatic machine tools, wireless tracking control and so on [5, 6, 7].

Traditional AC servo motor has soft characteristics and its output characteristics are not single value [8, 9, 10]. Stepper motor generally unable to pinpoint for open loop control, speed of the motor itself and the resonance zone, PWM speed control system of position tracking performance is poorer, frequency control of motor speed is relatively simple but sometimes not enough accuracy, dc motor servo system, with its excellent performance has been widely used in the position servo system, but its disadvantages, such as complicated structure, the contradiction in dead zone in super-low speed and commutator brush will bring noise and maintenance problems. The new type of permanent magnet ac servo motor develops rapidly, especially from the square wave control to the sinusoidal wave control, the system performance is better, its speed range is wide, especially the low-speed performance is superior [11, 12, 13].

2. Servo system and optimal control

The servo system is mainly composed of three parts: the controller, the power drive, the feedback device and the motor. The controller of CNC system according to the given value and the actual operation of the feedback device detection value difference control; power driving device as the main loop of the system, on the one hand, according to control the amount of power to the motor function, adjust the torque of the motor, on the other hand, according to the requirements of the motor the power supply of constant voltage constant frequency conversion required for motor AC or DC motor; power supply according to the size of dragging machine operation.

Based on the control structure of the system, the position closed-loop system of CNC machine tool can be regarded as the position adjusting loop, speed regulation automatic control system of double closed loop, the actual working process of the internal control is the position input into the corresponding speed signal, and then through the drive servo motor speed control system, realize the actual displacement. The main motion of CNC machine tool requires high speed performance, so the servo system is required as a high performance wide speed control system. The control system is as following:

$$\begin{aligned} X(k+1) &= 0.5X(k) + 2U(k), \\ U(k) &= K_1 V(k) + K_2 X(k), \\ V(k) &= R(k) - Y(k) + V(k-1), \\ Y(k) &= X(k). \end{aligned} \tag{1}$$

Choose state variables for servo control system (1) in the following

$$X(k) = [X_1(k) \quad X_2(k)]^T, K = [K_1 \quad K_2]. \tag{2}$$

The system (1) is rewritten in the state-space representation:

$$\begin{aligned} X(k+1) &= GX(k) + HW(k), \\ W(k) &= -KX(k), \end{aligned} \tag{3}$$

in which:

$$G = \begin{bmatrix} 0.5 & 0 \\ -0.5 & 1 \end{bmatrix}, \quad H = \begin{bmatrix} 2 \\ -2 \end{bmatrix}.$$

Then, the performance index is chosen as following form:

$$J = \frac{1}{2}\sum_{k=0}^{\infty}\left[X^T(k)QX(k) + W^T(k)RW(k) \right], \tag{4}$$

in which:

$$Q = \begin{bmatrix} 100 & 0 \\ 0 & 1 \end{bmatrix}, R = 1.$$

3. Program design and implementation

The main indexes to measure the performance of the servo system are frequency band width and precision. Bandwidth is defined by the frequency response characteristic of the system, which reflects the fast tracking of the servo system. The greater the bandwidth is, the better of the speed is. The bandwidth of the servo system is mainly limited by the inertia of the control object and the actuator. The greater the inertia is, the narrower the bandwidth. The bandwidth of the general servo system is less than 15 Hz, and the bandwidth of the large device servo system is below 1~2 Hz. Since 1970s, due to the development of the torque motor and high sensitivity speed machine, the servo system realizes direct drive, get rid of or reduce the backlash and the elastic deformation of the nonlinear factors, the bandwidth of 50 Hz, and the successful application in long-range missiles, satellites, precise command instrument etc.. We design the Matlab program to simulate the control effect.

```
G = [0.5 0;-0.5 1];
H= [2;-2];
Q= [100 0; 0 1];
R= 1;
[K, P, e]= dlqr (G, H, Q, R);
K1=- K (2);
K2= K (1);
GC= G-H*K;
HC= [0; 1];
CC= [1 0];
DC= 0;
Figure (1)
V= [0 100 0 1.2];
[Y, X] = dstep (GC, HC, CC, DC, 1, 100);
KK = 1: length (Y);
% Output Y
Plot (KK, Y, 'Ok', KK, Y,' -W')
Axis (V)
xlabel ('Time/s')
ylabel ('Y')
figure (2)
%X1 and X2
plot (KK, X, 'Ok', KK, X, '-W')
xlabel ('Time/s')
ylabel ('X1,X2')
```

The precision of the servo system is mainly determined by the precision of the measuring element used. Therefore, high accuracy measurement elements must be used in servo system, such as precision potentiometer, synch, resolver, photoelectric encoder, grating, magnetic grid and ball grid. In addition, additional measures can be taken to improve the accuracy of the system. For example, the measuring shaft of the measuring element (such as synch) is connected with the rotating shaft through the reducer, so that the rotation angle of the rotating shaft can be enlarged to improve relative measurement accuracy. The servo system using this scheme is called the precision measurement system or the dual channel system. The precision reading channel is called through the angle measuring line meshed with the reducer and the rotating shaft, which is directly taken from the angle measuring line of the rotating shaft, which is called the rough reading channel.

In an automatic control system, the system that changes the output with a certain accuracy to follow the change of the input quantity is called a servo system, also called a servo system. The servo system of CNC machine tools refers to the automatic control system which takes the position and speed of the moving parts of the machine tool as the control quantity, also known as the servo system.

The servo system is composed of a servo drive device and a driving element (or executive element servomotor), and a high-performance servo system has a detection device, which feedback the actual output state. The optimal control output of the servo system is shown in fig. 1.

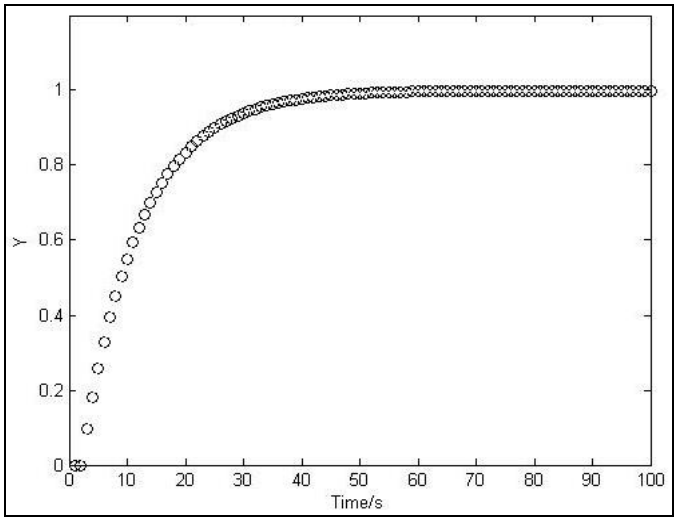

Fig 1: Curve of the output

As an open-loop control system, stepper motor has an essential connection with modern digital control technology. In the current domestic digital control system, stepper motor is widely used. With the emergence of digital ac servo system, ac servo motor is more and more used in digital control system. In order to adapt to the development trend of digital control, most of the motion control systems adopt stepper motor or full digital ac servo motor as the motor. Although the two are similar in the control mode (pulse train and directional signal), there are significant differences in performance and application. The performance of the two is compared.

The servo pulse depends mainly on the location, basically can be understood in this way, the servo motor receives 1 pulse, 1 pulse rotation angle will be corresponding, so as to realize the

displacement, because the servo motor itself has the function of a pulse, so the servo motor rotates one angle, will send a corresponding number of pulses, so the servo motor and accept pulse forming the closed loop, so that the system will know how much pulse to the servo motor, also received a number of pulse back, so you can control the motor rotation, very accurate, so as to realize accurate positioning, can reach 0.001mm. The states of the servo system are shown in fig. 2.

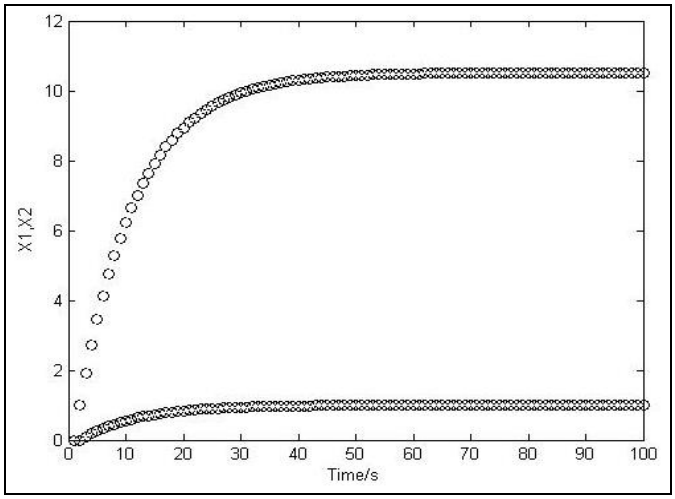

Fig 2: Curve of x_1 and x_2.

4. Conclusions

With the development of power electronic technology, high power motor drive technology, manufacturing technology and computer control technology and control theory, the development of high speed, high integration, low cost microprocessor and the advent of commercialization, the full digital AC servo system to enter the stage of comprehensive development. The servo system has a certain nonlinear and strong coupling and time-varying, and servo object has strong uncertainty and nonlinear, coupled with the operation of the system by varying degrees of interference, and the conventional control method is difficult to meet the control requirements of the high performance servo system. A linear and discrete system of a servo control system is considered in this paper. The program design and implementation for servo optima control system is studied. The results of the program demonstrate the effectiveness of the servo optimal control system.

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