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Research on Anti-vibration Control of Optoelectronic Servo System

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Abstract: Structural resonance may cause the system to be small and stable, limiting the tracking accuracy and dynamic response speed of the airborne photoelectric platform servo system. The anti - disturbance controller compensates the structural resonance of the stabilization ring of the servo system. The single-loop control structure and the multi-loop internal model control structure of the servo control system are described, and the error perturbation and model disturbance suppression performance are analyzed in depth. Then, in the multi-loop internal model control structure, the current loop, Speed loop and stable loop controller, and gives the hardware circuit design and software flow realization of servo control system based on double DSP. In order to improve the servo performance of the photoelectric stability tracking platform, a disturbing control servo system with integral compensation term is proposed according to the disturbance characteristics of the anti-interference control algorithm, and the system is used to arrange the transition process of the command signal.

Introduction

Optoelectronic servo system is a complex device including photoelectric detection, signal processing, control system and precision machinery. It has a wide range of applications in the field of field measurement and weapon control. With the development of modern technology, the demand for optoelectronic tracking servo system is getting higher and higher, requiring more response, stability and tracking accuracy.

The servo control system is a key component of the photoelectric stabilization platform. Its function lies in the isolation of the visual axis caused by the attitude and other interference moments in the inertial space, and the precise tracking of the target is realized on the basis of the stability of the visual axis. The main factors that affect the performance of the control system include: (1) system model uncertainty, such as motor and platform load changes, mechanical resonance, model approximation and inaccurate identification; (2) system internal disturbances, including: system electrical interference and internal (3) external disturbance of the system, such as carrier attitude interference, carrier vibration, wind load disturbance; (4) the external disturbance of the system, such as the carrier disturbance, the carrier vibration, the wind load disturbance, Sensor error, such as signal noise, gyro drift and so on [1].

Traditional servo control system design method using a single stable ring controller to suppress the above factors, it is difficult to achieve overall considerations, and it is difficult to achieve satisfactory results. Based on this, a stable loop control strategy based on multi - loop and double - mountain internal model control is proposed, and the controller design of error factors is realized. The motor is the direct control object of the servo control system, and the control of the tracking mirror is realized by the control of the motor. Torque motor has the advantages of low speed, large torque, small torque fluctuation, large output torque and good linearity. The design adopts DC torque motor as the driving element. Motor servo control includes two sets of azimuth and pitch systems, the structure is basically the same.

Servo Control Analysis

As the main technical indicators of the vehicle photoelectric stabilization platform is stable accuracy, that is, when the servo system is subjected to external disturbance torque, the aiming line deviates

from the original aiming target error. To some extent, the main control object of the servo system is inertial space position of the line of sight. Therefore, in the design of servo system, the auto-disturbance rejection control algorithm based on the model to increase the rate integral term. At this time, the steady state error of the step input system is zero, and the system error of the rate input is constant. The second order differential tracker is responsible for processing the automatic tracking angle difference signal or the single lever control signal, forming the position closed loop control, the third order state observer and the nonlinear combiner to complete the correction processing of the gyro signal to form the rate closed loop control [2].

Therefore, a fourth-order standard auto-disturbance-rejection controller can be used to control the stabilization ring. It consists of a fourth-order tracking differentiator and a fifth-order extended state observer. The experimental results show that the standard controller can make the stabilization ring of the servo system higher speed tracking accuracy. In order to simplify the design of the auto - disturbance - rejection controller, the number of adjustment parameters is reduced. According to the principle of zero - pole configuration, the auto - disturbance - rejection controller of the stabilization ring of the rotating frame servo system of the photoelectric platform is designed by nominal control. Fig.1 shows stable loop of the optoelectronic platform servo system.
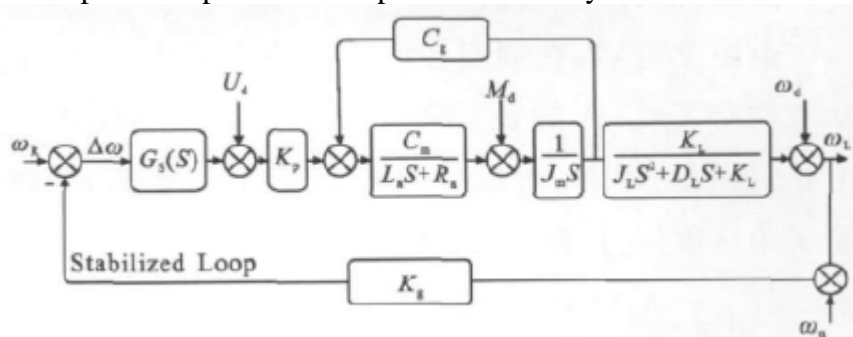

Fig. 1.The stable loop of the optoelectronic platform servo system

Through the analysis of system error perturbation and model perturbation, we can see that the multi-loop internal model control structure can achieve the hierarchical design of the error disturbance suppression function compared with the traditional single-loop control structure. The current loop controller is mainly used to suppress the noise of the electronic circuit and improve the motor characteristics. The speed loop controller is mainly used to suppress the friction, cable restraint and mass imbalance torque. The stable ring controller is mainly used to suppress the external disturbance of the system, Attitude disturbance, carrier vibration, wind load disturbance and gyro drift; the existence of speed loop controller makes the robustness of the system greatly improved [3].

Design of Anti-vibration Control

The main function of the current loop is to strictly follow the PWM input command, so as to precisely control the motor output torque, while suppressing system electrical interference (such as electronic circuit noise, armature current fluctuations, etc.) to improve the motor characteristics. The realization of the current loop can be divided into digital and analog, although the digital implementation has its flexibility, no temperature drift and other characteristics, but the processor chip processing speed determines the sampling rate can't be high. The system uses analog circuits to achieve current closed-loop. The controller design principle: the use of PI control offset the control object electrical time constant corresponding to the inertia link, the controller of the integral part of the control object to offset the differential items [5].

The main function of the speed loop is to improve the system stiffness, to suppress the internal torque interference (such as friction torque, cable restraint torque, mass imbalance torque, etc.), improve the robustness of the system. The speed loop in the system is digital implementation mode, and the dSPACE hardware-in-the-loop simulation system is used to design the controller by

combining experimental and theoretical analysis. The concrete steps are as follows: (1) Using the dSPACE sweep to obtain the open loop frequency characteristic of the speed loop, and realize the transfer function of the loop by Matlab identification toolbox. (2) Transfer function of the lag ahead of the correction design, so that the speed loop has good steady-state and dynamic performance.

For the high frequency band of the system, the noise band of the mountain control system mostly falls in the high frequency band. Therefore, it is hoped that the logarithmic frequency characteristic will drop as fast as possible, which will reduce the influence of noise on the system, but the high frequency characteristic Down too fast, and will reduce the phase margin of the frequency band, thus affecting the stability of the system. Therefore, it is necessary to consider indicators in the design process. Fig.2 shows ideal open loop frequency characteristics.
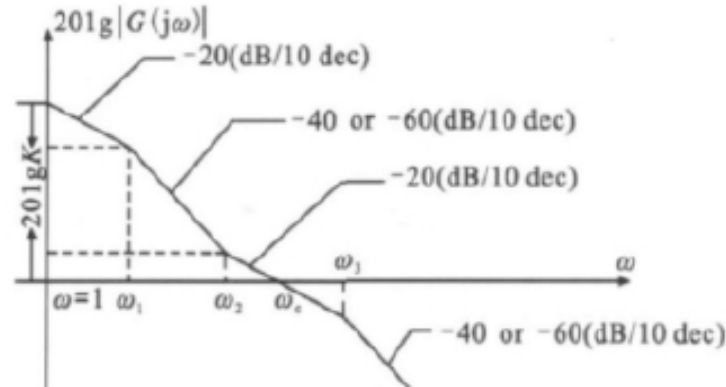

Fig. 2.The ideal open loop frequency characteristics

System Implementation

The servo control system processor to complete the above-mentioned multi-loop, dual-mountain internal model control algorithm, but also the implementation of sensor data acquisition, capture, tracking, targeting mode switching, and human-computer interaction and a series of operations, And real-time requirements are higher. The differential link of the system PID controller is more sensitive to the noise, so the PI controller of the differential part is used in the project. Hardware circuit mainly includes: DSP1 servo control circuit. Mainly complete the platform of the servo control, such as speed loop, stable ring, position loop and tracking ring controller algorithm implementation; and servo-related information interaction, such as control of each circuit to complete the speed signal, gyro signal, spin signal, image tracking off miss signal, limit signal read and PW M signal output, etc.Fig.3 shows system stability loop step speed tracking.
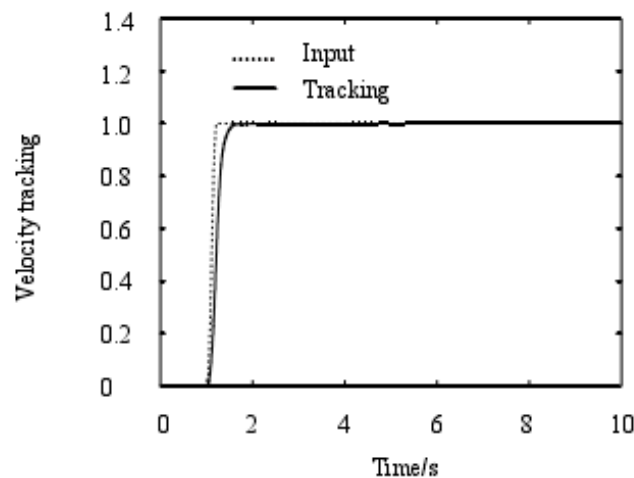

Fig. 3.The system stability loop step speed tracking

The design of the two control structures were tested for performance. Figure 7 shows the step response curve of the control system, in which the single-loop control structure is dashed line, the adjustment time is 35 ms, the overshoot is 60%; the multi-loop internal model control structure is

solid line, the adjustment time is 5 ms, The The introduction of multi-loop internal model control, improve the system's response speed and overshoot suppression. The stability platform is installed on the two-axis precision turntable, and the attitude disturbance of the turntable simulation carrier is controlled. Taking the sine disturbance of amplitude 10 and frequency of 1 Hz as an example, the carrier disturbance performance of the test system is tested. The servo system is capable of tracking the upper unit step signal in a limited time, i.e., within 2s without overshoot.

Mainly to receive the center of the console and control the handle of the signal to complete different modes work of switching, as well as CCD, IR, laser and other optical detectors integrated control and data exchange. The data acquisition circuit completes the sensor signal acquisition, such as the speed signal, the gyro signal, rotation signal and so on. I / O circuit to complete the platform limit, the motor is enabled; drive circuit according to DSP output PWM signal, control motor drive platform movement. The DSP output of the drive signal for power amplification; (6) RS422 / CAN communication circuit. RS422 mainly completes data interaction with image tracker, optical sensor (CCD, IR, laser); CAN is used to realize human-computer interaction with center console and manipulator.

Conclusions

Based on the background of the photoelectric stabilization platform, a stable ring controller design method based on multi - loop and double - mountain internal model control is proposed for the error factors in the servo control system. Current loop, speed loop, stable ring controller design method, and servo control system hardware and software implementation method, can be a good multi-loop internal model control structure. The experimental results show that it can suppress the influence of structural resonance on the servo system and improve the speed tracking accuracy of the stabilization ring of the photovoltaic platform, and it is robust to the large range of parameters in the structural resonance transfer function. The theoretical performance analysis and experimental verification of single - loop structure and multi - loop internal model control structure show that the latter has good instruction tracking accuracy, disturbance suppression performance and robustness.

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