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Design and Realization of Tracking Autopilot for Leisure Yacht

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Abstract. On the basis of the autopilot control principle and the STM32F103RBT6 controller, an tracking autopilot for the leisure yacht was designed with manual steering and automatic steering function in this paper. The schematic circuit design and software design were detailedly described. Practical application confirmed that the autopilot has high reliability and good steering performance.

Introduction

With the rapid development of the yacht industry in recent years, leisure yacht become more and more popular with people of all ages. Because of wind, waves and currents and other interference factors in the yacht, the heading of yacht always change, continually. So the yachtsman need to keep steering. Although autopilot which can keep steering in the vast waters instead of sailors has been achieved on large ship, but because of the huge difference of the controlled object, these autopilots can not be used in the leisure yacht. The leisure yacht automatic steering system is developed based on the ARM controller.

System structure

Course autopilot, a steering gear, is designed as a summary of the steering law. In order to ensure the consistency of the actual course and given heading, control structure of the autopilots is closed-loop control [1, 2], the block diagram is shown in Fig. 1.

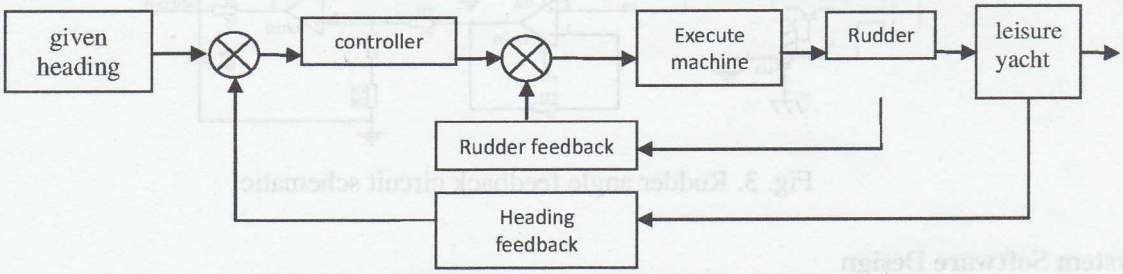

Fig. 1. Autopilot schematic block diagram

From Fig. 1, we can clearly see the heading autopilot is a second-order closed-loop system, which includes: given course cell, heading feedback cell, given heading and actual course compare cell, the controller, given rudder angle and the actual rudder angle compare cell, the execute machine, the rudder, rudder angle feedback mechanism. The performance of the autopilot depends on two important factors: the performance of steering gear itself steering as well as the control algorithm, which is more important.

Hardware Design

A. The steering unit

Gear for a yacht steering and the electric - hydraulic steering gear for a big boat is quite different. The total length of the yacht is small, and will not sailing in the big storm, a lot of leisure yachts use hydraulic lever as the main steering body, through the stretching of the hydraulic lever to drive the

rotation of the rudder. In this system, single-shaft stepper motor PK223PA-SG7.2 produced by Oriental Motor Corporation is used as the steering gear. The rotation of the stepper motor can be changed to the stretching of the hydraulic lever. Therefore, the control of the rudder becomes into the control of the stepper motor. The steering unit circuit diagram is shown in Fig. 2.

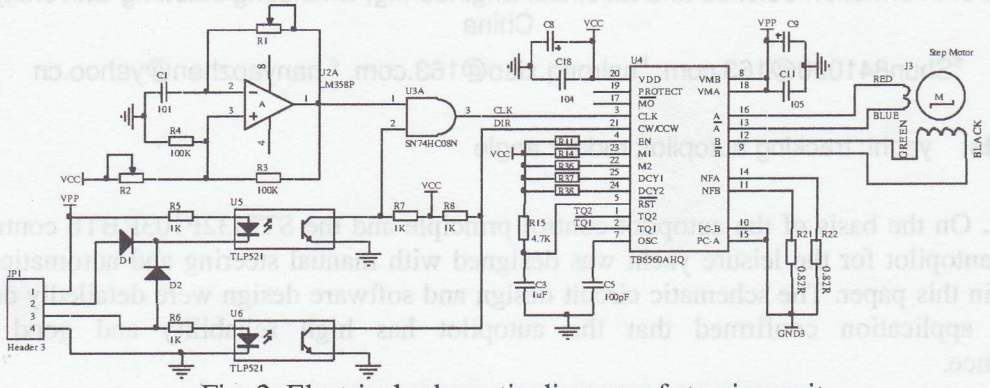

Fig. 2. Electrical schematic diagram of steering unit

B. The rudder angle feedback unit

Rudder angle is an important detection unit [3] for the autopilot, precision potentiometers is selected to detect the rudder angle. The potentiometer supply voltage is 3.3V. By adjusting the potentiometer installation location, the voltage on the center tap of the potentiometer is about 1.65V when the rudder is in the middle. When the rudder rotation within ± 36 °, the center tap output voltage of the potentiometer is between 1.32 and 1.98V. The Smaller output range, the lower detection accuracy of the rudder angle. To improve the resolving power, there is a 1:4 zoom to the output voltage with precision amplifier. And so the output range of the potentiometer become to 0.33-2.97V, which can effectively use the A/D converter sampling range and improve the rudder angle detection accuracy. The rudder angle feedback circuit diagram is shown in Fig. 3.

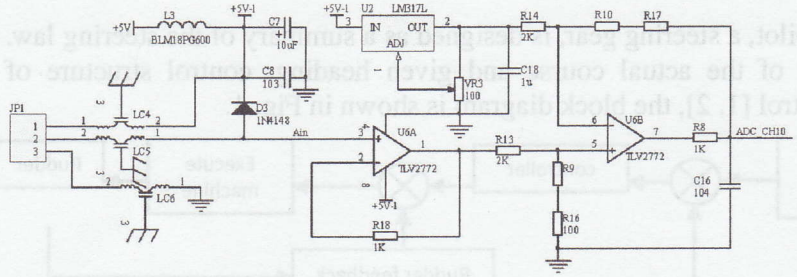

Fig. 3. Rudder angle feedback circuit schematic

System Software Design

The software design of the autopilot is to control the steering based on the yaw angle, and achieve the final course accordant to the set course. It can be divided into steering subroutine, rudder angle sampling subroutine, keyboard sampling subroutine, the display routines, information input and output subroutines. Due to space limitations, this article only describe the steering subroutines and rudder angle sampling subroutine in detail.

A. The steering subroutine

Steering subroutine is a core program of the autopilot. Steering subroutine flow chart is shown in Fig. 4. Program based on the deviation of the set heading and actual course, according to the control algorithm can calculate the current state of partial rudder angle [4, 5], then the program is based on the partial rudder angle and the actual rudder angle, the rudder leaves deflection to the specified rudder angle to complete the steering.

B. The rudder angle sampling

Rudder angle and the heading is the two most important feedback in the design of autopilot, so the precision and accuracy of sampling in the rudder angle has a very important impact to the autopilot control accuracy. The system choose a precision potentiometer as a core component of rudder angle sampling. In actual measurement, the microcontroller via A/D converter can get the location of the center tap of the potentiometer, we can draw the current value of the rudder angle [6] after linear transformation. Flow chart of the rudder angle calculation program is shown in Fig. 5.

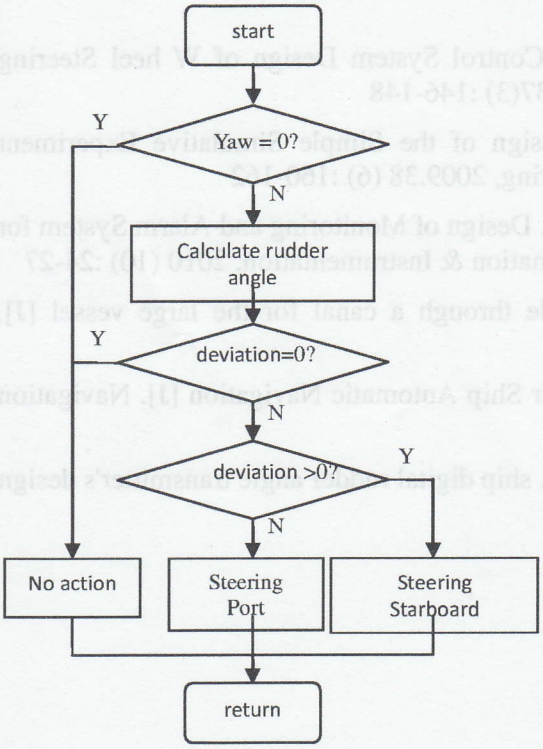

Fig. 4. The flow char of steering subroutine

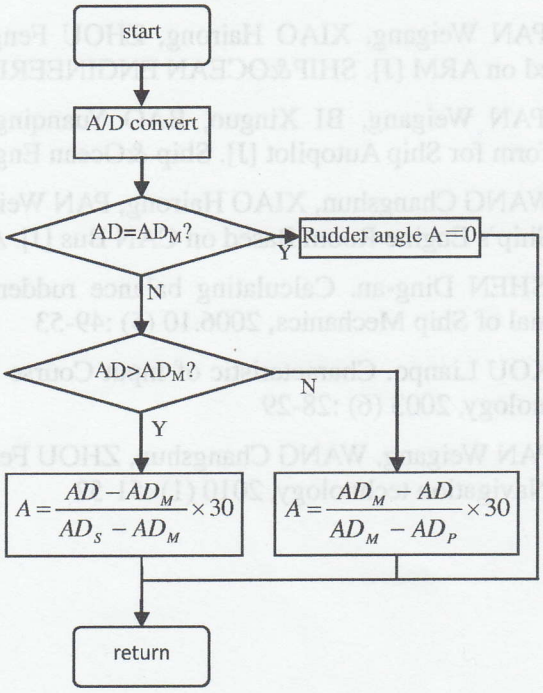

Fig. 5. The flow char of rudder angel Calculation

where A: rudder angle value;
AD: A/D convert value;
ADM: rudder 0 ° calibration value;
ADS: Starboard 30 °calibration value;
ADP: Port 30 ° calibration value.

The calibration value is set when the autopilot power on for the first time or there is an angle deviation. Calibration method of operation is as follows: when the rudder reach the middle position (0°), press the calibration button, the microcontroller will store the A/D conversion results ADM at this time into internal E2PROM; then control the rudder respectively go to the Port 30° and Starboard 30° position, press the calibration button, the corresponding A/D conversion results of the ADS, the ADP respectively stored in the E2PROM unit, and the calibration is complete.

Conclusion

The autopilot has been applied in a number of leisure Yacht in Zhejiang Province. Because of well steering performance and high reliability, the autopilot got the praise of lots of leisure Yacht design company and users. GPS system is not used in the autopilot, you can not get the the current location information of the leisure Yacht, so it can not achieve automatic control of the navigation path, we need to improve it next.

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