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PID control of STM32 serial port based on Simulink

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Abstract

In order to connect Simulink with STM32 as a simple upper computer to control the actual system model, the serial port transmission module between Simulink and STM32 is introduced, and the discrete PID module is used to calculate and output the data. Using this model, it is easy to adjust the PID parameters in the actual system without modifying the STM32 internal program. At the same time, a more advanced algorithm can be designed inside the Simulink instead of STM32The system control strategy can be changed more easily to further improve the control scheme.At the same time, the change of the controlled object can be shown in the form of curve by the upper computer of Simulink, which is convenient for the controller to observe the internal changes of the system and formulate further control strategies.

Keywords

PID control, temperature control, Simulink, serial port debugging.

1. Introduction

PID control is the abbreviation of proportional integral differential control. In the development of automatic control of production process in this century, PID control is the basic control mode with the longest history and the strongest vitality. It has the advantages of simple principle, convenient use, strong adaptability and strong robustness[1]PID is the abbreviation of proportional, integral and differential. As the name suggests, PID control algorithm is a combination of proportional, integral and differential control algorithm. It is the most mature technology and the most widely used control algorithm in continuous system. The control algorithm appeared in the 1930s to 1940s, which is suitable for the situation that the controlled object model is not clear. The practical operation experience and theoretical analysis show that this control law can be used to control many industrial processes with satisfactory results. The essence of PID control is to calculate according to the deviation value of input and the functional relationship of proportion, integral and differential, and the operation result is used to control the output.

Simulink is a kind of visual simulation tool in MATLAB, which is produced by MathWorks company of America. Simulink is a module diagram environment for multi domain simulation and model-based design. It supports system design, simulation, automatic code generation and continuous test and verification of embedded system. Simulink provides graphic editor, customizable module library and solver, which can be used for dynamic system modeling and simulation. Simulink can model with continuous sampling time, discrete sampling time or two kinds of mixed sampling time. It also supports multi rate system, that is, different parts of the system have different sampling rates. In order to create a dynamic system model, Simulink provides a graphical user interface for building a block diagram of the model. The creation process can be completed by clicking and dragging the mouse. It provides a faster, direct and clear way, and users can see the simulation results of the system immediately.[2]

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2. Methodology

2.1. Construction of Simulink project

Take the temperature control box controlled by STM32 (control the temperature by controlling the heating duty cycle) as an example. The model of this kind of temperature control box has the characteristics of large delay, unfixed system model, long cycle and being greatly affected by the environment, so it is a typical large delay model.

The data frame sent by STM32 is received and unpacked by byte unpacking module. After obtaining the data sent by STM32, the difference between the data sent by STM32 and the given value is calculated into the discrete PID module. Through the data type conversion module, the calculated data is converted into int32 type, and packaged into STM32 frame format which can be read by byte packet. After being sent through the serial port, PWM is assigned to complete the temperature control. Figure 1 is the flow chart of the whole system.

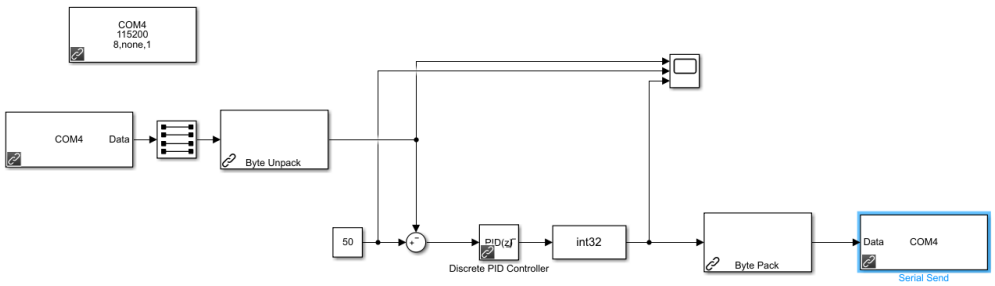

Figure 1: the flow chart of the whole system

2.2. Basic configuration of serial communication

Taking STM32 as the research object, this paper defines the data frame format that STM32 can send and receive correctly as: header = $, terminator = Cr / LF ('\ R ′), data type = uint8, data bits = 8, stop bits = 1, and configures the serial port receiving and sending module in Simulink as the data frame that STM32 can receive and send correctly. Figure 2 shows the serial port configuration information.

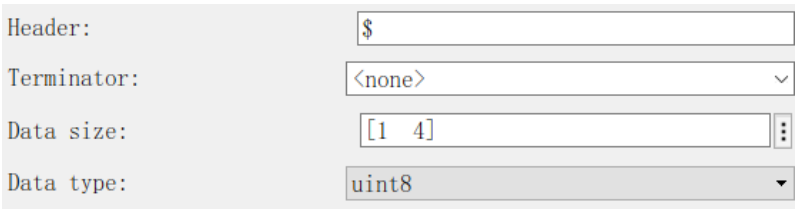

Figure 2 : the serial port configuration information.

Similarly, in STM32, the data frame formats sent to and received from Simulink are defined to establish normal serial communication between the two computers.

2.3. Selection of control scheme

In this paper, PID control and bang bang control as examples, In Simulink， Discrete PID Contorller's Compensator formula(1)is a positional algorithm, that is, the output is related to the whole past state, and the accumulated value of error is used.

This system focuses on the PWM output calculation using Simulink as the controller, so only the PID control strategy model is designed. If you need to set a more advanced control strategy, just modify the PID control module to other control strategies in the system engineering.

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$$PID(z) = P + IT_S \frac{1}{Z-1} + D \frac{1}{T_S} \frac{Z-1}{Z} \tag{1}$$

2.4. data type conversion

Because the program of STM32 is programmed by C language, and the data sent by STM32 is of float type, which corresponds to single type in Simulink, the input and output of the whole system can work normally only when they are all defined as single type, and then the data type conversion module is used to convert the data of single type into int32 type, Finally, the data frame packed as uint8 type is sent to STM32 for reading. that is: 1. Receive the data of float (single) type sent, 2. Process the operation with single type in Simulink, 3. Send the single to be output

2.5. Tuning of PID parameters

Because the temperature control system is a system with large delay, and the system control requires no static error, so PID adjustment is selected. At the same time, the system is a follow-up system. In a certain temperature, it is regarded as a fixed system, and the flight curve is obtained by making step disturbance to the given value. The approximate transfer function of the system is obtained by fitting the curve with MATLAB, then according to the transfer function in Simulink for rapid simulation, using the attenuation curve method to get the approximate PID parameters, this parameter is written into the program for actual control, and then according to the control target fine-tuning PID parameters, finally get the discrete PID control parameters, as shown in Figure 3.

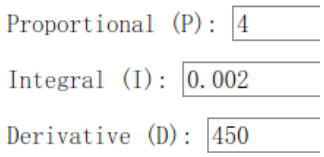

Figure 3: Discrete PID control parameters

3. Results and discussion

3.1. Overall structure design of program

Upload the collected information to PC; At the same time, Simulink running on PC processes the collected information, calls PID control or other control algorithms, gets PWM control value and sends it to control the controlled object. At the same time, the controlled value is sent to the oscilloscope interface for monitoring the working state.

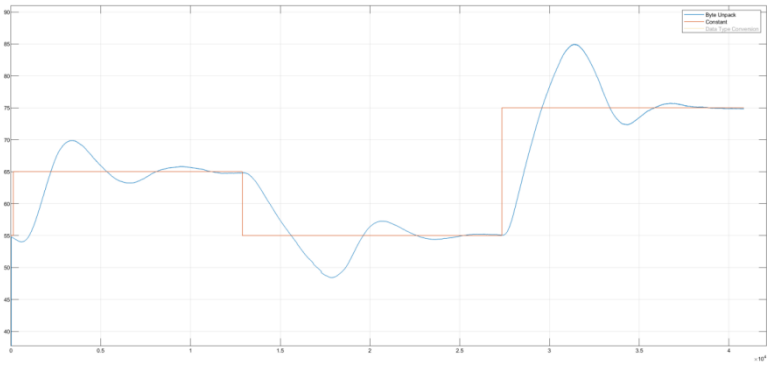

Figure 4:Curve of target temperature and measured temperature

The system is tested by heating twice and cooling once. The test results are shown in Figure 4. It can be seen from the figure that the output PID control effect of Simulink joint debugging control is good.

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3.2. Change of PID parameters and given value

In the process of Simulink and STM32 joint debugging, open the discrete PID control module, which can modify the three constant terms of P, I and D in the PID algorithm. Click apply to modify the PID parameters and put them into control directly， By using the constant module in Simulink, the system can directly click to modify the given value.

At the same time, set Simulink, you can see the difference between the input PID and the output PID control in the process of operation, as shown in Figure 5

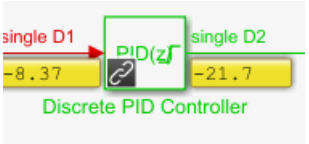

Figure 5: input and output of discrete PID module

3.3. Change of PID control strategy

In Simulink, you can create modules with different logic functions by yourself. The system control strategy can be modified by replacing the designed control module with the discrete PID module in Figure 1. Taking the easy to design bang bang control as an example, the designed bang bang control module is replaced by the discrete PID control module, and the system runs normally.At the same time, the output control value is changed between 100 and - 100, and the bang bang control of the system is carried out successfully

4. Conclusion

As a popular research technology, automatic control technology has been widely used in various fields. Because it is difficult to implement the complex algorithm directly on the single-chip microcomputer, and the parameters need to be downloaded again each time. Therefore, the serial port joint debugging based on Simulink is very helpful for beginners to design and understand the advanced algorithm and set the control parameters.

References

[1] Y.H.Jin :Process Control(Tsinghua University Press, China 1993), p.31.

[2] Information on https://ww2.mathworks.cn/help/simulink/.