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Integrated Linear Motor Motion Control System based on B&R PCC

Rongrong WU
Department of Electronic Engineering
Tianjin University of Technology and Education
Tianjin, China

Shengli LU
Engineering Training Center
Tianjin University of Technology and Education
Tianjin, China

***Abstract*— In view of the automatic control principle course, there are many questions which have theory over practice, limit experiment from experiment box, complicated and scattered experiment system and not enough enthusiasm and initiative from students. The integrated linear motor motion control system is put forward and analyzed based on PCC. It expounds detailedly the characteristics of PCC, the overall design framework of motor motion control system, software design and PID control and man-machine interface. This design makes the motor motion control system in PCC used to be an organic whole to facilitate direct control. The students make study in theory. At the same time, they pay attention to the operation of the experiment. It has broad application prospects.**

Keywords—PCC; Motor Motion Control System; Automation Studio

I. INTRODUCTION

With the development of industrial technology, motion control in the field becomes more and more important. Automatic control principle as a classic course of motion control, its theory is very perfect, but practice is lacking. Combining theory and practice has become the trend of the times in order to meet the needs of curriculum reform. Through the analysis of the motor motion control system, the students can feel intuitively and theory is applied to practice. Automatic control principle test chamber ZY13001B2 can do several commonly experiments, while B&R PCC can do more related experiments. B&R PCC can meet all kinds of complex, high dynamic motion control. Automation Studio which is programming software has automatically generating the C code, programming, simulation, control, network communication and man-machine interface for itself to make the control more convenient and efficient. The whole control system perfectly is shown in front of students to make students more profoundly understand and master knowledge[1].

II. THE PROGRAMMABLE COMPUTER CONTROLLER

Austrian B&R Programmable Computer Controller PCC (Programmable Computer Controller) includes logic control, process control, motion control, data processing, networking and communication and so on, it is a true multi-functional controller. But from its essence, the PCC is still a programmable logic controller PLC. Compared with the traditional PLC, the PCC uses the advanced time-sharing multitasking operating system, has the formidable floating point arithmetic function, supports ladder diagram and all kinds of high-level programming languages, so it is a higher PLC[2]. In short, PCC not only can reduce the hardware investment and reduce cost, but also can improve the reliability of the system.

Automation Studio developed by B&R company is an integrated programming environment. It can be in a PLC use a variety of programming languages to write programs at the same time, meets the requirement and programming manner of different writers. Since all of the programming language in Automation Studio is used in the unified compilers, diagnostic tools and treatment, and makes the programming work is simple and efficient. The connection of Simulink of MATLAB software and programming software Automation Studio has the advantages of other software can't match. Based on the research of the mathematical model for motor, the motor control system in Simulink automatically generated C code in the Automation Studio. And then through the design of software and hardware configuration makes the motor run according to the requirements of control. The code automatically generated, programming, simulation, control and network communication can be completed in Automation Studio "ALL In One" kit, the whole motor motion control system is integrated as a whole, these provides a complete platform for motor motion control system which has a variety of control requirements.

III. MOTOR CONTROL SYSTEM

A. The Advantages of Linear Motor

Linear motor converts electrical energy directly into linear motion, compared with "the rotary motor + ball screw ", eliminating all intermediate transmission mechanism, not only to ensure the control precision and response speed, but also because of less parts, simple maintenance, greatly reducing the parts wear, improve the motion stability and so widely used in all kinds of high speed and high precision processing equipment[3]. The performance comparisons are shown in table 1.

TABLE I. THE PERFORMANCE COMPARISON OF DIRECT DRIVE AND INDIRECT DRIVE

Category	Linear motor	Rotary motor + Ball screw
Speed(m/min)	300	120
Maximum acceleration(m/s^2)	10g	1.5g
Precision(μm)	0.1-1	2-5
Servo system	Simple	Complex

B. The main technical indexes of Linear Motor

TABLE II. THE MAIN TECHNICAL INDEXES

Working voltage	DC 12V
The maximum current	6
Working stroke	40mm
Continuous thrust	6N
Positioning accuracy	0.0005mm
Working mode	position, velocity, force, parallel
Acceleration	0-10G

C. The control system

Motion control is a movement according to the idea operation based on the current, speed and position of real-time acquisition and through feedback and parameters setting. Motion control system is mainly composed of control model, a signal amplification, a motor parts and feedback. Small signal can be amplified through signal amplification part, it provides enough power to motor. The output can be compared with the input through the feedback part, operation will be more accurate after adjustment.

For motor motion control system has good dynamic performance and wide frequency band, control system uses current loop, speed loop and position loop servo control, ensuring the driving mechanism has high precision tracking requirements for position and speed[4]. Three-ring servo control system is cascading a position ring outside based on the double closed loop control system, it has stronger anti-interference function, making the system run more smoothly. The structure of the linear motor control system includes linear motor, motor control chip, a bipolar type reversible PWM control, linear displacement detection device. Position deviation is reference displacement compared with the actual displacement measured by linear displacement detection device in feedback loop, output value obtained after PID arithmetic is the linear motor control voltage. Linear motor control system structure diagram is shown in Figure 1.

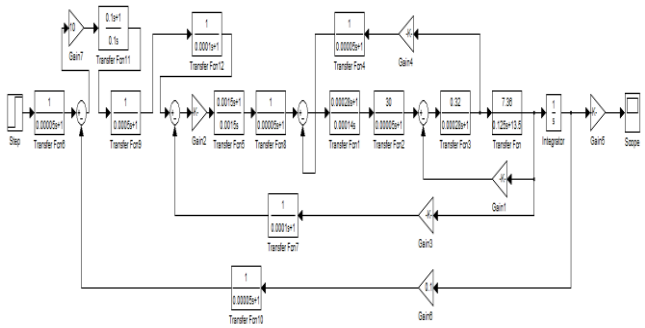


Fig. 1. Linear motor control system structure diagram.

Current loop: including current regulator, PWM circuit, power drive circuit, Hall current sensors. Hall current sensor detects armature current of voice coil motor, and then it is sent to the current regulator compared with input reference value, the output can be used to generate the PWM waveform. At the same time, the upper limit of the current limited in order to prevent damaging the motor when working current increases suddenly.

Velocity loop: including displacement sensors, capture unit, signal processing circuit, the speed regulator. Velocity loop feedback can be determined by the displacement of the displacement sensor in unit time, and then it is sent to the speed regulator compared with input reference value and exports a control voltage which as reference input signal current loop after speed regulator processing.

Position loop: including displacement sensors, capture unit, signal processing circuit and the position regulator. The current displacement of voice coil motor as position loop feedback value is detected by displacement sensor and the input position command as given reference value, the output of the latter two by position adjustment processing as input reference values of speed loop. speed regulator processing. Position loop step response is shown in Figure 2.

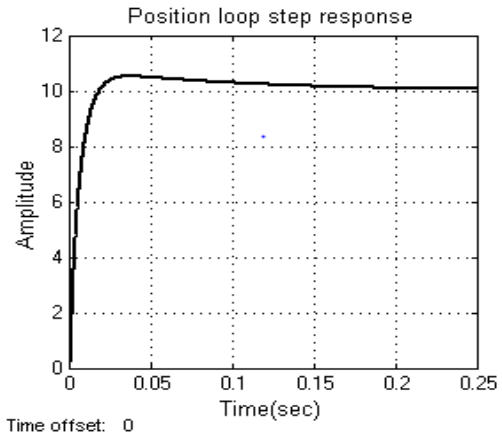


Fig. 2. Position loop step response.

IV. THE GENERATED CODE

Simulation tool BR Automation Studio Target for Simulink is will installed under the Matlab software interface. After the installation, Simulink Library directory menu will appear B&R Automation Studio toolbox subdirectory. The subdirectory contains B&R set block, B&R input block, B&R output block, B&R parameter block and so on[5], the function block will replace the original modules, added to the motor control system simulation model. The input signal converts input module, the output signal replaces the output module, PID parameters needed to adjust will be replaced by the parameter module, this is conducive to real-time adjust the parameter in the PLC. After finishing model in Matlab/Simulink, openning the Automation Studio software, configurating a series of related parameters in the Matlab and AS, configuration parameter map is shown in Figure 3. C code automatically generated and implanted into the programming environment AS by starting the C code generation button. The interface automatically generated code is shown in Figure 4.

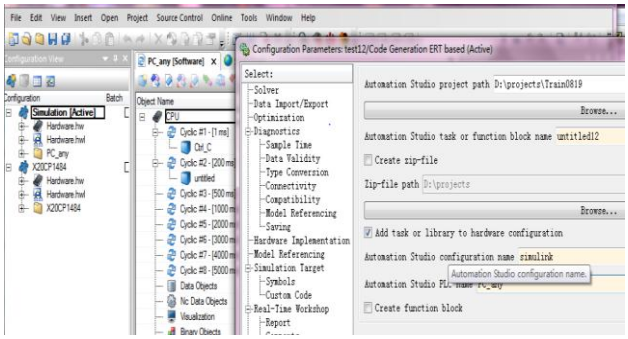


Fig. 3. The interface automatically generated code.

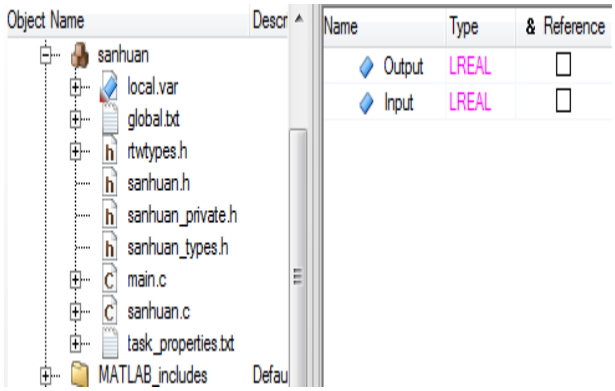


Fig. 4. The interface automatically generated code.

V. PID CONTROL

Controlled quantity is constituted with proportion, integral, differential of the deviation by a linear combination[6]. Controlled quantity controls the controlled object, the controller is known as the PID controller. PID control principle diagram is shown in Figure 5.

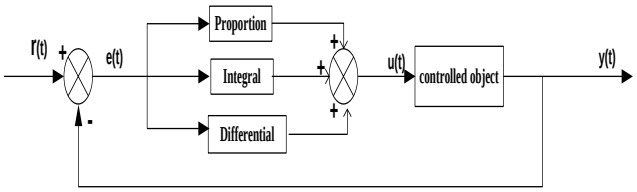


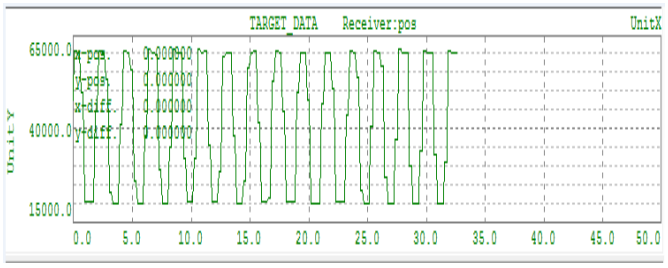
Fig. 5. PID control principle diagram.

In the PID controller, proportion link's role is to respond instantly to deviation. controller will immediately act once deviation, making the controlled quantity change to reduce the deviation. Proportional coefficient Kp choose must be appropriate to the less transition time, less static error and stable effect.

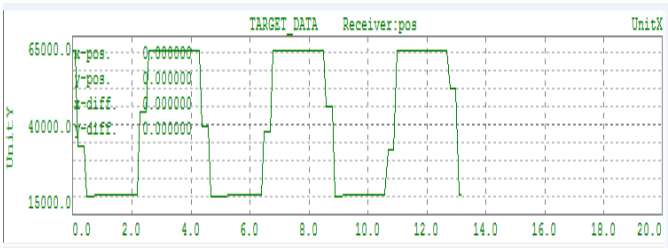
The regulatory role of integral part will eliminate the error, but can reduce the response speed of system and increase the system overshoot amount. So integral parameter must be determined according to the specific requirements of actual control.

The role of differential part is to prevent the change of deviation. It is based on the change trend of deviation control. The change of deviation is greater, the output of differential controller is greater, and can be revised before the deviation value becoming bigger. The introduction of derivative action will help to reduce the overshoot, overcome the oscillation and make the system stable. But the role of the differential is sensitive to noise of input signal. So differential not needed in general, or the input signal is filtered before the differential effect.

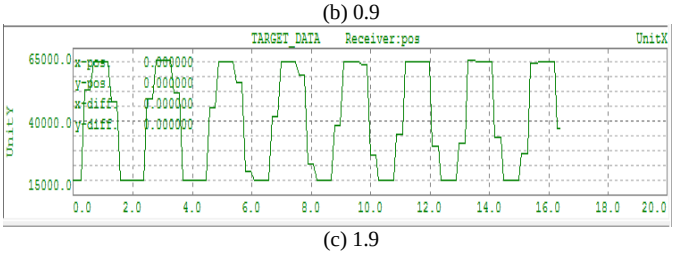
The complete AS project is downloaded to PCC hardware for controlling the actual system[7]. The Running of the machine is realized by specific software seting and hardware connection. The running position of the machine can be real-time monitored from the programming software AS. Different PID parameters influence on motor running effect. Motor proportion parameter is respectively 0.5, 0.9, 1.9, the corresponding performance record is shown in Figure 6. Motor integral parameter is respectively 0.005, 0.01, 0.07, the corresponding performance record is shown in Figure 7. Motor differential parameter is respectively 0, 5, 10, the corresponding performance record is shown in Figure 8. Through comparing parameters, the best parameters are respectively 0.9, 0.01, 5, and then the motor position operation is smooth and response is fast.



(a) 0.5

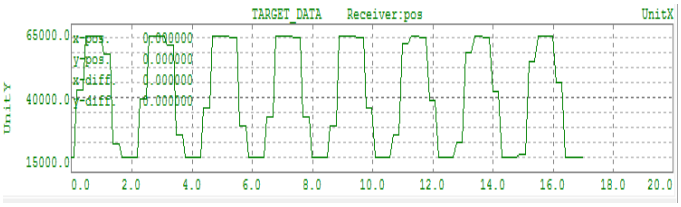


(b) 0.9

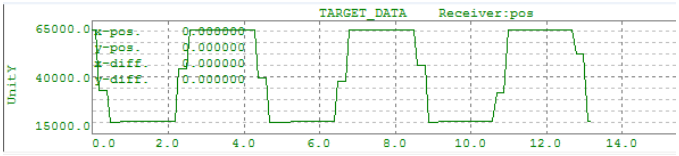


(c) 1.9

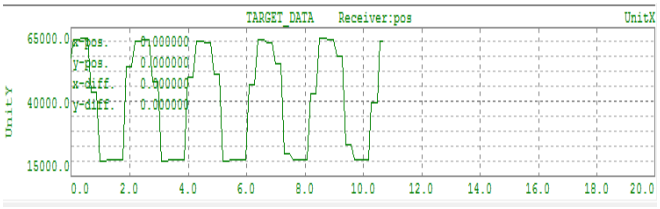
Fig. 6. The motor proportion parameter diagrams.



(a) 0.005

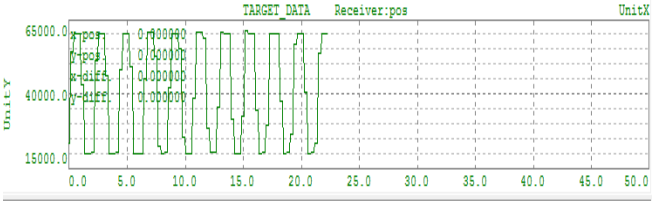


(b)0.01

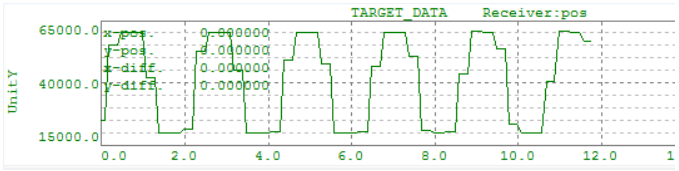


(c) 0.07

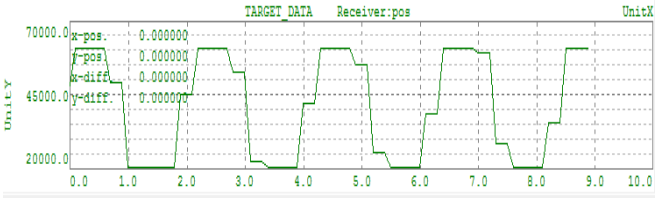
Fig. 7. The motor integral parameter diagrams.



(a) 0



(b)5



(c) 10

Fig. 8. The motor differential parameter diagrams.

VI. MAN MACHINE INTERFACE

Operate interface is interactive interface which the user and the application[8]. The operation of the interface is selected and designed which a user's most familiar with will show to the user a friendly feeling, and to reduce the distance with the user, user use the program correctly and conveniently.

B&R Visual components provide the application environment for creating Visual interface. Visual components integrated in the AS is a visual environment. This means that the visualization and control engineering is managed, edited, and executed together.

Images can be displayed on a target system with display, or a remote terminal (such as: Power Panel) independent of the controller, or Virtual VNC display (Virtual Network Computing).

Common picture is independent of the control unit, numerical display is dependent on the communication of controller. Different from ordinary picture program, B&R visual communication is integrated in the task of the controller.

When inserting a new object in the visual component, there are a lot of are available for everyone to use in engineering. For example, predefined elements have the starting page, fonts, and two languages (English and German), unit group, all controls the predefined style classes, touchpad buttons configuration, basic alarm system, touching pictures group and the border of the plate and alarm systems, buttons and so on. For motor motion control system, receive and send data is displayed at the same time in the interface to easy to control. Send data can change at any time, in order to meet the needs of different users. Receive data real-time displayed in the interface can be easy to observe. Man-machine interface diagram of motor motion control system is shown in Figure 9.

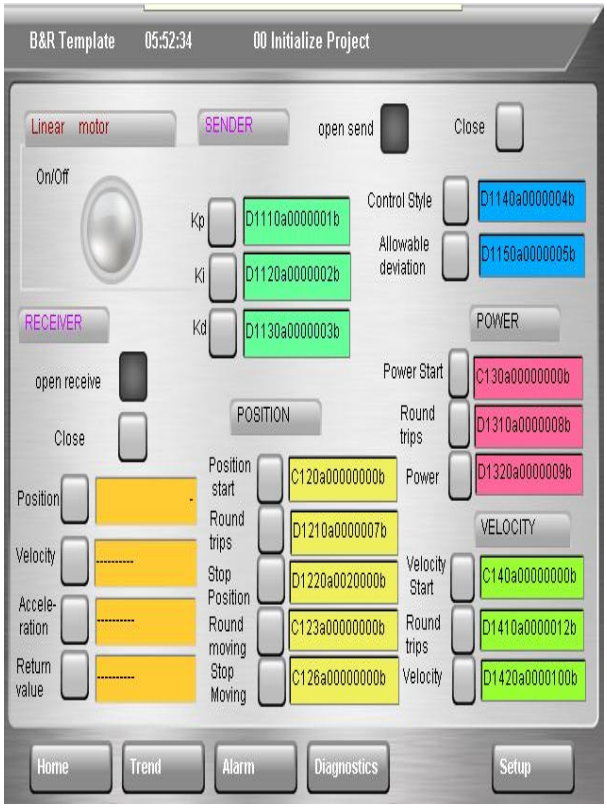


Fig. 9. Man machine interface diagram of motor motion control system.

VII. CONCLUSION

This paper presents a motor motion control system based on PCC and experimental results are obtained. In this experiment, the motor motion control system simulation model is replaced by the module of B&R Automation Studio Target for Simulink in Matlab. It is imported into the AS, automatically generated C code. After the simulation, the motor running is stable and efficient. Through the reasonable configuration of hardware and the success of the communication connection, the operation of the motor is normal and realizing the control function. Design of Man-machine interface make control become more intuitive and convenient. The experimental is concrete and feasible, so that

the students can set out from actually and validate their learned knowledge. Integrated equipment allows students to operate easily and control online, making up for the limitation of limit experiments from traditional test chamber. It has broad application prospects.

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