The construction of soft servo networked motion control system based on EtherCAT

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***Abstract*—The paper presents a novel method for constructing soft servo networked motion control system via EtherCAT network. The EtherCAT network performance is analyzed in detail through comparison of it by other several industry Ethernet protocols. We give out the application PLC program flow chart of synchronous control. The experiment results show that the soft servo networked motion control system can realize the Multi-Axis high precision synchronization control for servo motors.**

Keywords-EtherCAT; soft PLC;industry Ethernet;servo motor

I. INTRODUCTION

Servo motion control technology has been widely used in various automation fields like factory automation, test stand, process control, machine vision, auto-identification, pressroom and wind power systems,etc[1-2]. However, traditional point-to-point motion control method can not meet the distributed motion control need. Consequently, networked control technology is introduced into the motion control field and builds networked control system. A networked control system is a control system wherein the control loops are closed through a real-time network[3].It can eliminate unnecessary wiring thus, reducing the complexity and the overall cost in designing and implementing the control systems. Several industry Ethernet technologies for motion control systems were developed in recent years[4]. SynqNet networked technology was presented by Danaher company in 2001.It connects motion controllers to drives and I/O devices with a single cable and provides new levels of speed, diagnostics, and safety[5].But a special motion control card which is inserted into the PCI slot of control computer is adopted. As International Standard IEC 61491 and European Standard EN 61491, the SERCOS protocol was introduced by the Interests Group SERCOS interface e. V. (IGS) in 1995[6].As well the special control card must be used for connecting the control computer with servo driver via SERCOS bus. Allowing for the disadvantages we select a novel industry Ethernet network protocol named EtherCAT constructing the soft servo networked motion control system with low cost and high performance. This paper is organized as follows, section II gives a brief overview for EtherCAT and comparison between the protocol and the above mentioned three protocols, section III describes the whole system design in detail, section IV gives the tested results to the system. Finally section V give our conclusions.

II. A BRIEF OVERVIEW OF ETHERCAT AND COMPARISON FOR THE ABOVE MENTIONED PROTOCOLS

A. A brief overview of EtherCAT protocol

EtherCAT is the new open real-time Ethernet Master/Slave network developed by Beckhoff. It incorporates some new features[7]:

- High usable data rate—a single standard Ethernet frame is used to transfer up to 1486 bytes of process data from almost 12000 digital inputs and outputs.
- Extremely fast—a dedicated interface chip makes sure that the telegram passing through the slave station is read and written in a few nanoseconds.
- Flexible topology structure — EtherCAT supports almost any topology including Line, tree or star.
- Extremely accurate synchronization performance—a very precise network-wide timebase with a jitter of significantly less then 1 microsecond is available.

Several mainstream servo motion networked control protocols are listed in Table I.

B. The comparison for several typical industry Ethernet protocols being used in servo motion control system

As we see in Table I, the SynqNet and EtherCAT are the best selection for servo motion control in view of the comprehensive performance. But SynqNet is not a open protocol and the master controller must be installed a special hardware control card. It adds significantly the system cost. In contrast, EtherCAT master only needs a general Ethernet network interface card. More important, EtherCAT protocol

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TABLE I. THE COMPARISON FOR SEVERAL PROTOCOLS

Protocol Names / Comparison Items	SynqNet	EtherCAT	SERCOS III	Powerlink	Profinet IRT
Master control requirements	Hardware Control Card	General NIC Card	Hardware Control Card	Special NIC Card	Hardware Control Card
Max.Inter-Node Distance	100m	100m	40m	100n	100m
Min.Cycle Time Delay	<25μs	125.250μs	125.250μs	400μs	1ms
Bandwidth	100Mbit/s	100Mbit/s	100Mbit/s	100Mbit/s	100Mbit/s
Transfer Mode	Full-Duplex	Full-Duplex	Half-Duplex	Half-Duplex	Half-Duplex
Max.jitter	<1μs	1μs	1μs	1μs	1μs

is fully open. No doubt the servo motion control system based on EtherCAT network protocol has the highest cost performance.

III. THE WHOLE SYSTEM DESIGN

The system includes a master station and n slave stations, as seen in Fig.1.Both soft PLC program and master program code which run in the windows achieve the master station function. The Beckhoff TwinCAT software system can turn almost any compatible PC into a real-time controller with a multi-PLC system. So we need only write the application PLC program code which finishes the motion control function.

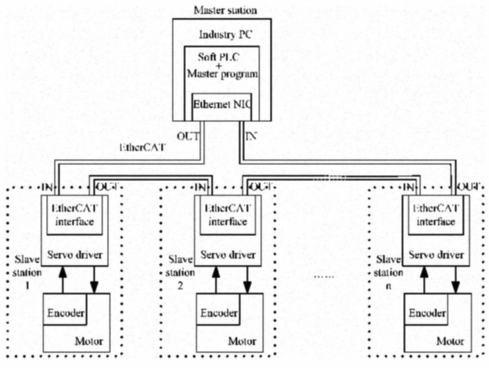

Figure 1. The system structure.

We design the master station program code of motor synchronization control. The program flow chart is given in Fig.2.

Soft PLC program is responsible for receiving a list of parameters including actual positions, actual velocity, current status of motor from the master program interface function.And then the program calculates the output values based on the set velocity and position values and send them to servo motor drivers through EtherCAT network.

Moreover, the program realizes the complex synchronization control algorithm.

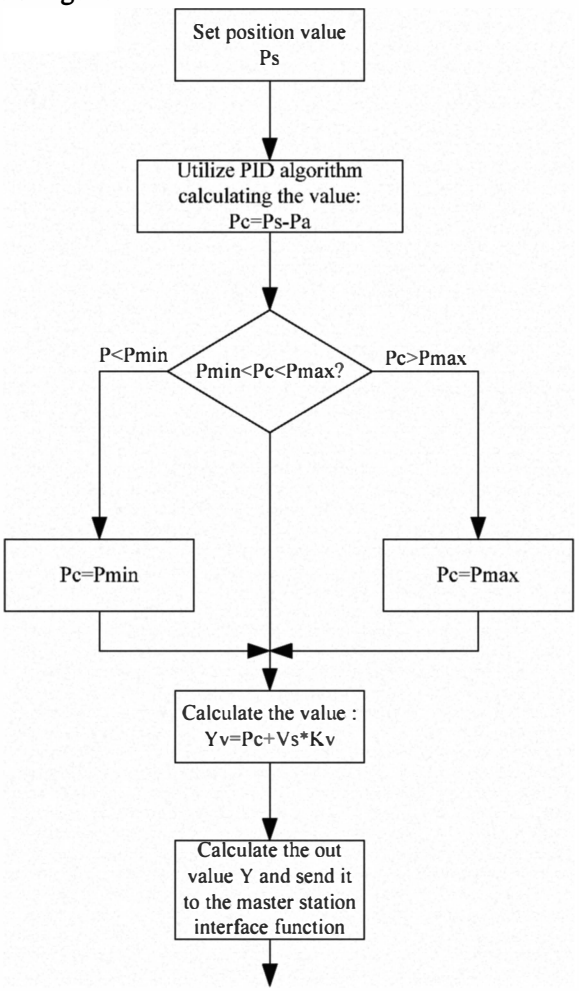

Figure 2. The PLC program flow chart

The control algorithm is packaged in a model. The input values of the model are the set position, velocity,

acceleration and actual feedback state values from motor. Using the algorithm the application PLC program calculates those order values which is sent to the motor,

IV. SYSTEM TEST AND ANALYSIS

First we test a set of data for the system with axis.

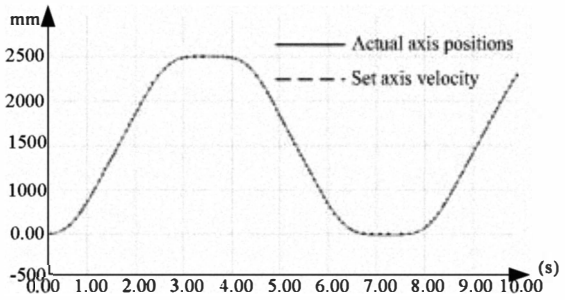

Figure 3. Actual axis positions and set axis velocity .

As we see in Fig.3 and Fig.4,the feedback data curve tested can almost completely follow the set curve.

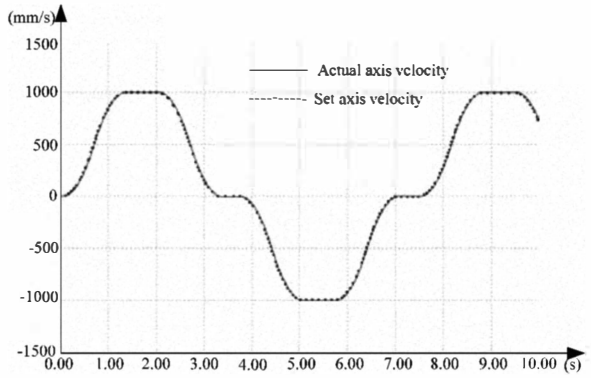

Figure 4. Actual axis velocity and set axis velocity

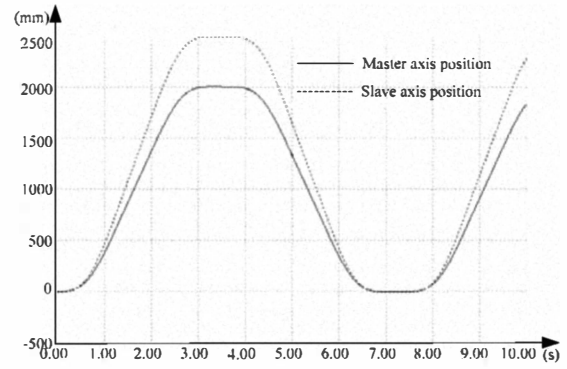

Figure 5. Master axis position and slave axis position

And then we test the system with a master axis and a slave axis.Fig.5 shows the position relation between master axis and slave axis.Fig.6 gives the axis velocity relation between mater axis and slave axis.The two pictures show the master axis can completely couple to slave axis.

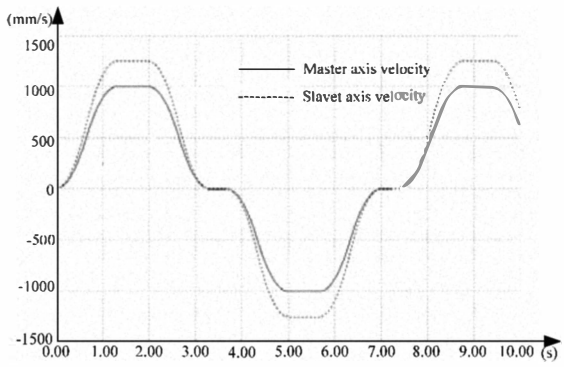

Figure 6. Master axis velocity and slave axis velocity

V. CONCLUSIONS

EtherCAT is a relatively new industrial protocol built on the Ethernet specifications; it incorporates some new features that make it adequate for real-time applications.It is believed that it is probably the industrial Ethernet solution that ensures the highest degree of communication efficiency.We construct the soft servo control system via EtherCAT network and acquire the highest cost performance. The test results show the system can cope with the multi-axis motion control requirement. The system has the high real-time capability and reliability.

REFERENCES

[1] SERCOS. S. Vitturi, "On the use of Ethernet at low level of factory communication systems," Computer Standards & Interfaces, vol. 23, pp. 267-277, 2001.

[2] R. M. Parkin, et al., "A PID servo control system experiment conducted remotely via Internet," Mechatronics, vol. 12, pp. 833-843, 2002.

[3] J.-D. Decotignie, "Ethernet-based real-time and industrial communications," Proceedings of the IEEE, vol. 93, pp. 1102-1117, 2005.

[4] P. Neumann and A. Poschmann, "Ethernet-based real-time communications with PROFINET IO," WSEAS Transactions on Communications, vol. 4, pp. 235-245, 2005.

[5] SynqNet. SynqNet users Web Site:www. SynqNet.org, 2001.

[6] SERCOS.SERCOS users Web Site:www.SERCOS.org,1995.

[7] EtherCAT.EtherCAT users Web Site:www.EtherCAT.org,2003.