Three-dimensional cruise-control system design based on PLC

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Abstract. PLC is widely applied to cruise-control system owing to its merits. With the development of transducers, servo-control and step-by-step control system, PLC plays a greater role in accurate positioning. Combining with PC and touch screen, this kind of controller becomes more convenient in human-computer interface and management. The three-dimensional cruise-control system designed in this paper uses PLC to control transducers as to ensure the start-stop stability in transverse shift and uses stepping motor to make sure the accurate positioning in longitudinal shift. And this system utilizes servo-motor to make vertical lifting easy. Then it is expedient and flexible to achieve the remote control by PC or touch screen.

System Configuration

This system, known as three-dimensional cruise-driving, consists of longitudinal shift subsystem, transverse shift and vertical lifting subsystems.

Longitudinal Shift Subsystems (for carts). This subsystem adopts AC frequency-conversion electric drive in which the driving motor is three phase asynchronous reduction motor and transducer selects Siemens Micro Master 440 Inverter with power of 0.37KW. In both sides of tracks there are optoelectronic switch where signals enter to PLC and participate in control and position switch as the mechanical limiting position and not in participation in control. Rotary encoder in this system does feedback for cruise longitudinal shift. In this way, the mechanical control part in this system is simplified greatly.

Longitudinal Shift Subsystems (for cars). This system adopts stepping motor drive which mainly is made of 110BYG250B stepping motor, mating supporting driving power supply and driver module, proximity switches as well as position switches, in which proximity switches participate in PLC control and position switches do not just as mechanical limiting. Tooth shape guide rail damping in this system ensures the accurate positioning.

Vertical Lifting Subsystems. The lifting subsystem utilizes AC servo-control, which mainly composes Mitsubishi MR-E-40A, mating servo-motor and up-position switch which participates in PLC control. This subsystem adopts positional control mode and its mechanical part is very simple and reliable.

The Hardware Design of this Control System

Cruise system PLC selects Siemens S7-200 series having CPU226DC/DC/DC unitary PLC 24-channel input and 16-channel transistor output. In this system there are master (force control) control which is in charge for control switching and field (touch screen) control.

Resource Allocation in PLC as Tab.1

Table 1.Resource Allocation in PLC

I/O resource		I/O resource		Internal resource	
Designations	Functions	Designations	Functions	Designations	Functions
I0.0	Longitudinal encoder	Q0.4	Longitudinal running speed	M0.6	Winch in PC Inching up
I0.1	Winch type encoder	Q0.5	Servo motors Dropping	M1.0	HMI Inching left of longitudinal displacement
I0.5	Longitudinal left limit	Q0.6	Servo motors raising	M1.1	HMI Inching left of longitudinal

					displacement
I0.6	Longitudinal right limit	Internal resource		M1.2	HMI Moving forward horizontally
I0.7	Pre-limit of horizontion	Designations	Functions	M1.3	HMI Moving forward horizontally
I1.0	Post-limit of horizontion	M0.0	Inversion of Control	M1.4	Touch panel winch dropping P'tP
I1.1	Up-limit of winch	M0.1	PC moving left longitudinally P'tP	M1.5	Touch panel winch raising P'tP
Q0.0	transverse operating pulse	M0.2	PC'S longitudinal inching right	RS485 communication port	
Q0.1	Directions of transverse movement	M0.3	PC'S longitudinal inching left	Designations	Functions
Q0.2	Longitudinal left	M0.4	PC'S longitudinal backward	PORT0	PC communication
Q0.3	Longitudinal right	M0.5	winch dropping	PORT1	HMI communication

The Design of Main Circuit

This design includes converter, servomotor stepping-driven circuit and 24V DC power source etc.

Setting the Equipment Parameter. Parameter setting of stepping motor driving.1, 2, 3 positions are dialed into 0, 1, 1 to set subdividing numbers. And 4 and 5 positions are dialed into 1, 0 positions which are designated as horizontal working-pattern. And then 6-position is empty and useless. Finally, 7、8、9、10 positions are dialed into 1,1,0,0 positions and are set its working current respectively.

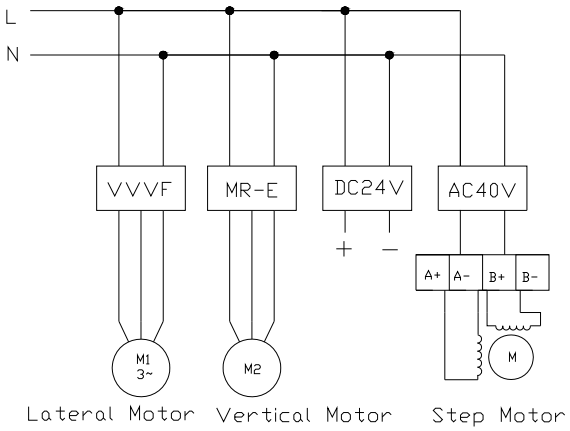

Fig. 1 System Main Circuit

Parameter Setting of Servo-driven. Make parameter P00 as 2002 which adopts positioning control mode. Then make parameter P08 as 500 which have 500 pulses per second.

Parameter setting of transducer

Table 2.Parameter setting of Siemens MM420 transducer

Parameters	Values	Functions	Parameters	Values	Functions
P0010	30	Factory Reset	P0702	2	Connecting and reversal movement
P0970	1		P0703	15	Fixed frequency setting value
P0003	3	Scope	P1000	3	Fixed frequency setting
P0300	1	asynchronous motor	P1003	40	operating frequency of the transducer
P0310	50	rated frequency	P1120	5	Rise time
P0700	2	Terminal board input	P1121	5	Fall time
P0701	1	Connecting	P2179	0	Without detecting load

The PLC Program Design.

In this system, the start-stop control and position control are not complicated .The system's point lies in high-speed pulse output.

PLC has the functions of outputting and receiving high-speed pulse. With its corresponding transducer and servo device, PLC can achieve intelligent control based on digital data. The function of PTO square wave pulse train with designated number of pulse, the periodic scope of which is 2~65535ms (ms is the periodic unit), and the counter range of which is 1~4294967295. If the period is lower than 2 units of time, and then 2 units of time is defaulted as the period. If the designated number pulse is 0, and then the pulse count is defaulted as 1.

PTO idle position in status byte (SM66.7 or SM76.7) indicates the ending of outputting of programmable pulse train. At the ending of pulse train, start interrupt routine. If we use multistage operation, interrupt routine is started while the accomplishment of envelope. PTO function permits pulse train queuing. When the activated output of pulse train is finished, start outputting of new pulse train instantly. In this way, the continuity of pulse train is guaranteed.

Optical-electricity encoder is a new kind of sensor for rotating speed and positioning control. This encoder uses motor shaft to move disk and then generates electrical signal with pulse-strings. These signals are amplified reformed as to use them to measure rotating speed and displacement. For optical-electricity encoder, obviously the more perforations mean the higher controlled resolution ratio.

Put this kind of pulse into PLC high-speed counter, and use comparison order do accurate positioning control. By ladder diagram or guide, this aim is accomplished.

Design of Man-machine Interface.

Upper Computer Interface. Force control monitoring configuration software makes developing environment, different kinds of projects, picture template more flexible and convenient. Development time and effort are also reduced greatly in this software. The on-line and history database with high performance is established. There is a strong distributed alarm and event processing functions. This software supports graphical cell in different chart-layers.

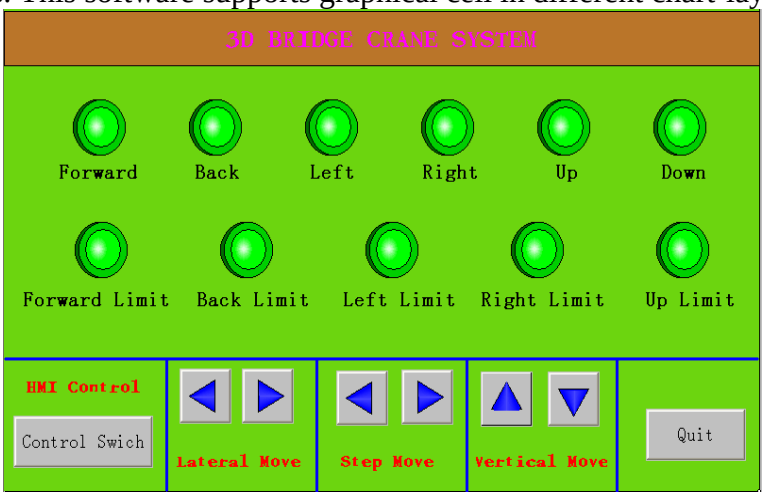

Fig.2 the interface of upper computer control

By controlling scripts, the showing and hiding of these chart-layers is realized flexibly, and object's properties and methods are callable. There is bran-new and nimble report design tool which can provide abundant sets of functions for reporting operations, and support complex scripts control. The figure 2 is the surface of this system design with flexible control and powerful function which can increase more management function according to user requirements.

Touch Type Human-computer Interface. WEINVIEW MT500 Serial touch screen is a new kind of human-computer interface aiming specifically at PLC applications. The users can freely assemble graphics, characters, buttons and numbers to process and monitor random information in multifunction display screen. If control power is switched to “site control”, then the touch screen control is effective. Figure 3 is the diagram of touch screen control, where the six buttons control Longitudinal left and right, transverse forward and backward, as well as winching up and down respectively. The indicator light above the diagram stand for the running state of the cruise.

Operational controls.

The crane control system falls into site control (touch screen control) and main control room control (force control), which is in charge for the switching control.

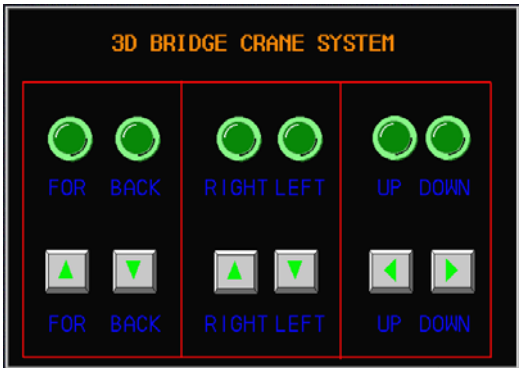

Fig.3 interface touch

Start force-control monitoring project, and click the 3D-Crane button on the diagram. Then the system comes into monitoring interface. On the top of interface is status display and at the bottom is the control zone. Switching control is used to change the operation, which switches between site control (touch screen control) and main control room control (force control). The six buttons control longitudinal left and right, transverse forward and backward, as well as winching up and down respectively. When operating state in left corner is in the control of main control room control, the operation is performed by computer and now the buttons on the screen is invalid. When the control power is switched into site control, the operation is done by touch screen and in this time the buttons on the computer is invalid.

Improvement measures.

Through production practice in recent two years, PLC applications are fairly successful and satisfy technical characteristic in cruise. Compared with the pristine relay control system, faults are reduced greatly. With further understanding of this technology, we have worked out flow chart according to the recent characteristics. We also can use test lamp to judge failure and eliminate failure quickly and accurately. On user requirement this system can increase different management functions such as statistics, log-in permission, alarming and gang piece work system etc.

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