Application of PowerLink real-time network bus in elevator industry

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Abstract: In this paper, according to the characteristics of elevator electrical control system and the communication mechanism of PowerLink bus, a technical scheme of using PowerLink bus in elevator Internet of Things is proposed. The scheme includes elevator control system framework, core hardware design and software design, to achieve the elevator real-time monitoring system data transmission large and short transmission delay requirements, while improving the safety of data transmission, has the characteristics of short software development cycle and development costs, can be quickly applied to various brands of elevator Internet of things system.

Key words: PowerLink bus; Elevator control system; Internet of Things; Scheme design

Introduction

The core of Industry 4.0 lies in the interactive networking of production technologies by making full use of embedded control systems. Through the Internet of Things, we can build an intelligent system network covering the entire product life cycle, including the manufacturing process, installation and use, and post-maintenance. For elevator manufacturers, from simple manufacturing to manufacturing + service is a very important direction, in order to truly provide better and more accurate elevator maintenance services, the elevator of the Internet of Things is an inevitable trend.

I. Advantages of real-time Ethernet Powerlink

Compared with the traditional industrial field communication bus, the Ethernet Powerlink bus has the following advantages: (1) faster speed and greater transmission distance. (2) The topology is more flexible, the development cost is low and the development cycle is short. (3) Wider application, the application of Ethernet can be extended from the commercial network to the industrial network field. (4) In line with IEC61508 standard SIL3 level of openSAFETY technology, openSAFETY is based on Powerlink safety technology, the technology is also open source and free to use.

Table 1: Comparison between Powerlink and CAN fieldbus

Comparison items	CAN	POWERLINK
Transfer Rate	1-12Mbps	100Mbps
Minimum loop	1ms	0.1 ms
Node transmission distance	40m@1Mbps	100m@100Mbps
Number of nodes	32	239
Delay	100us	0.1 us
Data frame capacity	<=100Byte	<=1496Byte
Jitter	100us	50-80ns
Communication mechanism	CSMA/CA	CSMA/CD
Security Protocol	There is no	openSAFETY

II. The elevator electrical control system PowerLink implementation plan

1. Communication model of elevator electrical control system

Elevator control system by the main control system, car/car outside sub-system, host frequency conversion system, door control system, electronic safety device composition. The main control system is the brain of the elevator control system, which is responsible for the logic processing of the elevator operation and the control of the elevator operation under different states. The in-car/in-car foreign capital system is responsible for transmitting the call button signal of the outside call and the car to the main control system, and receiving the command of the main control system for floor/maintenance/overload/full load and other elevator real-time status display and button display instructions. The door control system receives the opening and closing instructions of the main control system, and controls the elevator to open and close automatically. The motor driving system and the gate control system will also feed back their own operating status information to the main control system. The electronic safety device can independently collect the real-time speed and position of the elevator, and perform safety actions to prevent accidents and send fault information to the main control system when the elevator is abnormal.

Each electrical subsystem of the elevator uses Powerlink to communicate with the main control system. The communication model is shown in Table 2 below.

Table 2: Communication model between Powerlink and main control system

Device Layer	Call system	Gating system	Mainframe drag system	Electronic safety system	Other
Protocol Application layer	CANOPEN Application layer: Object dictionary information SDO PDO structure data				
Protocol Transport layer	Powerlink Transport				
	Ethnet drive				
Hardware link layer	Ethnet controller				

Powerlink adopts a three-layer network from the perspective of OSI seven-layer network model, which specifies the physical layer, data link layer and application layer, and follows the CANopen standard at the application layer. It provides a unified interface for the application program, and different devices use a unified access method. There are three steps to adopting Powerlink communication design:

(1) According to DSP CiA417 standard in the main control system to develop all electrical subsystem data dictionary, add their own dictionary data object, generate configuration file, put in the main control system SD card.

(2) After the start of the master control system, read the set configuration file from the SD card, generate according to the data dictionary, and write to the dual-port RAM data area of the FPGA according to the agreed data area.

(3) The master sends configuration commands to each electrical subsystem, and each electrical subsystem sends/receives Powerlink Ethernet data to read and write the data dictionary of the master according to the configuration information.

2. The core hardware design

In terms of hardware design, considering the difference in real-time requirements of each subsystem in the system, it is convenient to unify the hardware design of the main control platform and each electrical subsystem, and adopt a dual-core design (FPGA+CPU) structure, as shown in Figure 1 below:

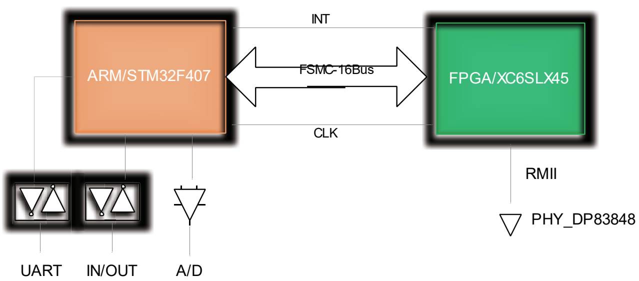

Figure 1: System hardware design

In Figure 1, Xilinx's XC6SLX45 is selected as the FPGA. The logical unit is 40000Les, the memory is 2088Kb, 2 CMT, the main frequency is 400MHz to 1,080MHz, and 2 Block RAM. The main CPU uses ARM Cortex-M4 STM32F407 with Cortex-M4 core, one FPU, 1MB FLASH, 512KB memory, 168M main frequency and one Flexible static memory controller (FSMC). The PHY chip of Ethernet uses DP83848 of ST, which uses RMII interface and FPGA connection.

The FPGA and the main CPU are connected through the asynchronous communication data bus FSMC of STM32, the data width is 16Bit, and the asynchronous static memory timing is adopted.

FPGA is designed as ARM external expansion bus device, FPGA is specially responsible for Powerlink communication, Powerlink protocol stack and a dual-port RAM are realized using HDL language in FPGA. After receiving the data, ARM parses the application layer data according to CANopen protocol. The ARM and the FPGA network processing unit (Powerlink_Dll) read and write the dual-port RAM separately.

Between FPGA and ARM, there are send and receive Buf, when the FPGA completes a frame Ethernet data reception, the data is written to the dual-port RAM receive Buf, at the same time in the status register to "receive flag" set, and the current FIFO address code modification, after the completion of the INT signal, ARM in the INT interrupt, Will in turn query whether there is a successful reception mark, according to the FIFO address area code read all the data inside the corresponding address. After receiving, reset the status register's "receive flag". During each Powerlink communication cycle, the FPGA and ARM refresh their respective RAM areas periodically.

3. Software scheme design

On the basis of the above hardware design, it is also necessary to design the communication software function, as shown in Figure 2 below.

In this scheme, the physical layer and data link layer of Powerlink are realized in FPGA, but the application layer of Powerlink is not realized. Application layer data to ARM controller processing.

Powerlink's IP core designed by Verilog HDL is used in FPGA, and the development environment uses ISE12.4.ISE to provide a large number of IP cores for use. Powrlink's IP adopts the existing mature IP core scheme, the IP core in addition to the realization of POWERLINK main battle/slave IP function, according to the current POWERLINK specification DS 301, to achieve all the functions of management node (MN) and control node (CN). The IP core also contains a standard Ethernet RMII controller.

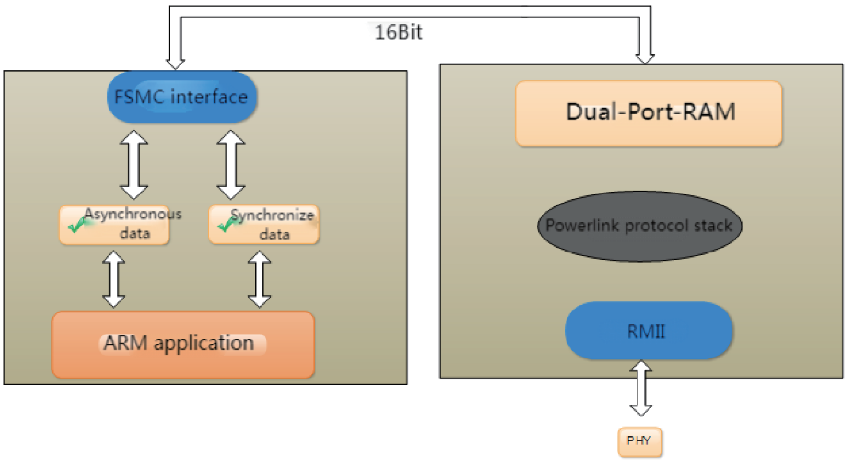

Figure 2: communication software function diagram

Powerlink application layer using CANopen protocol stack, from the type of synchronous data and asynchronous data, using PDO/SDO format data communication. The main control CPU uses CANopen protocol as application layer protocol.

According to the control function of the elevator, the software successively designs the elevator control function module, data communication module, parallel scheduling algorithm module, elevator input/output processing module, elevator anomaly detection and protection module on the main control system. The elevator control task is the main component of the elevator control application program. The elevator control task is divided into tasks that run in different cycles, and different cycles are executed according to the priority of the task. Elevator operation control tasks include: elevator operation mode processing (maintenance, fire, lock ladder, return level, etc.), call processing, door switch processing, real-time control of the speed curve of the drive subsystem, safety fault processing, etc.

All the electrical subsystems in this scheme use Powerlink to exchange data with the main control system. The master chooses the preset synchronization cycle data according to the current set number of elevator floors and elevator units. Each cycle to complete a subsystem synchronous data receiving and sending, and will complete an asynchronous data interaction with this subsystem.

The data communication module is the key to ensure that the elevator master control system can get the elevator information correctly, and the communication module mainly needs to deal with two kinds of data: SDO/PDO. PDO is used for the data with high real-time performance requirements and small payload, such as the floor display of outbound/car and various status display of elevator. SDO is suitable for data with large amount of data transmission but low real-time requirements, such as OD data sent by the main control system and historical fault records queried by the main control system. PDO data adopts the production/consumption mode, the receiver of data can not reply to the sender, and the receiver of SDO must reply to the sender according to the data protocol. Module according to the function is divided into: interrupt subtask, communication management subtask, data parsing subtask, sending data organization subtask, communication exception processing subtask. The communication module is designed to process by state machine. The communication management task switches the execution priority among these sub-tasks according to the current real-time state. The communication between tasks is all in the queue mode. Queues are divided into data queues and message queues. The data queue is mainly used as a buffer data area for exchanging data between different tasks, and the message queue is used for different tasks to transmit their respective states. In order to quickly query, unidirectional linked list data structure is used. PDO type data takes precedence over SDO data. In the interrupt subtask, first determine whether it is PDO data, if it is sent to the PDO data queue of the management task, at the same time determine whether the PDO data of periodic synchronization needs to be sent, if it is, write the processing result message to the dual-port RAM of the FPGA immediately, and send the message queue of the management task.

III. Conclusion

With the advent of the intelligent era, the elevator industry is facing a new technological revolution. The application of new technology in the elevator, especially the elevator operation monitoring system to meet the real-time, intelligent, network is the general trend of The Times, is the inevitable requirement for the high-quality development of the elevator industry. It is imperative to replace the traditional fieldbus such as RS232/RS485/CAN-Bus with real-time Ethernet bus. The design scheme proposed in this paper is based on the open source Powerlink real-time Ethernet technology. The software integration is simple, the development cost is low, and the application and promotion speed is fast. For the application of real-time Ethernet technology in the elevator industry to throw a brick.

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