Study on the functions and characteristics of interfaces in CBTC

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Abstract—Based on the analysis of three kinds of interfaces, this study discusses the application of interfaces technology on trainborne automatic train control systems. It proposes an interface system design for a train-borne CBTC (Communication Based Train Control) system. We study the interfaces functions and characteristics on physical attributes, protocol and transmission rate. And the paper proposes the method for verifying and testing.

Keyword: interface technology; CBTC; wireless communication

I. INTRODUCTION

CTBC (Communication Based Train Control) based on wireless communication has become a main trend of modern automatic train control system. CTBC based on communication consists of various subsystems, thus how to integrate all the subsystems of different functions and features into a stable system that is safe and reliable has become an important issue of vehicle facility integrations in railroad transportation. Interface technology is a vital part of large complex system integration, what follows is a set of interfaces relation and a reference scheme of onboard CTBC subsystems with the focused exploration of three interface types that have been widely used recently.

II. MAIN INTERFACE

With the rapid development of computer technology, computer interfaces tend to be uniform and unitary. It's very hard for the comprehensive structures in the industrial control field to be united because of their different applied occasions, nowadays the most versatile interfaces are: RS-232, RS-422, RS-485 and Fast Ethernet interface, etc. Here are their respective analyses.

A. RS-232

RS-232, an interface standard of serial data communications which is developed by the American Electronic Industries Association (EIA) is most commonly used in serial port of PCs and telecommunications and applied to connect peripheral devices of computer serial ports. Normally the maximum baud rate is limited to 20kb/s and the transfer distance to 15m. It's defined as a single-ended standard adopting an uneven transfer method, in which the allowed cable length can be spanned if the communication speed is reduced, known as the single-ended communication.

In the pin assignment, RS-232 often applies PIN25, DB-25 and DB-9.

B. RS-485

RS-485 is a two-wire, full-duplex, multipoint serial communication standard subordinated to OSI physical sub-layer. It is a serial port standard of balanced transmission modes that is compatible with RS-422 and expand the functions of RS-422. RS-485 allows multiple transmitters in a circuit, so it's a standard for multi-transmitters/receivers. RS-485 enables a transmitter to drive several load devices, which can be hung everywhere on the balanced wire of transmitters, receivers and combined transceivers so as to realize the multipoint applications of several drivers and transceivers sharing the same transmission line during data transfer.

RS-485 only specifies electrical characteristics of the driver and the receiver, it doesn't specify or recommend any data protocol. It enables the configuration of inexpensive local networks and multidrop communication links sent by single transmitters.

RS-485 has characteristics as follows:

1. The adoption of balanced transmission/differential receives results in high common mode rejection ratio (CMRR) and strong immunity of noise.
2. High communication speed, the allowed maximum speed is up to 10Mbit/s; Small swing amplitude(200Mv).
3. Long transmission distance (referring to none-modem direct transmission), offers 1.2km with the speed of 100Kbit/s and a longer distance with a relatively low speed.
4. It can be used point to point, point to multipoint, multipoint to multipoint communication.
C. Fast Ethernet Interface

Fast Ethernet is also called 10M/100M adaptive Ethernet, "fast" means its transmission rate can reach 100Mbps, which is 10 times the rate of standard Ethernet. The bus type of fast Ethernet is PCI and its network standards accord with IEEE802.310BASE-TX, IEEE802.3u 100BASE-TX, IEEE802.3x. Its interface type is RJ-45 and its transmission medium type is 10BASE-T(10-metre mode), 100BASE-TX(100-metre mode) of cat 3, cat 4 or cat 5, full/half duplex of cat 5, its maximum transmission distance is 100 meters with the application of UTP cat 5 cable. Ethernet adopts asynchronous operation mode, which is suitable to deal with IP emergency data stream, thus is very widely used in most cases of communication and other electrical systems.

III. THE RESEARCH OF ONBOARD CTBC INTERFACE

CTBC refers to the interactions of information stream and control stream by means of two-way mega-capacity communication between train and ground and between train and train so as to ensure the safe operation of a train under the corresponding block system. Reliable train-ground communication is an important technique support of CTBC. This article explores the interfaces of subsystems in the light of train control system based on wireless communication. Fig2 shows the interfaces on CBTC.

A. VOBC-Onboard communication control unit

1. Interface function

With the interface, VOBC can realize:

(1) The train-ground communication with regional control system, transmitting control and status information that is related to train safety, via two-way transmission of onboard computer--onboard communication control unit--ground communication control unit--regional computer.

(2) The train-ground communication with central control system, transmitting diagnostic information of onboard control system, via one-way transmission of onboard computer--onboard communication control unit--ground communication control unit--central diagnose computer.

2. Interface characteristics

(1) Type: RS-232 serial port
(2) Transmission rate: 38400bps
(3) Transmission mode: Asynchronous Transfer Mode(ATM)

B. Train positioning system-onboard communication control unit

1. Interface function

Onboard positioning system sends the train positioning information from onboard communication control unit to ground monitoring center ATS through wireless communication.

2. Interface characteristics

(1) Type: RS-485 Synchronous Serial Port
(2) Transmission rate: 512kbps
(3) Master and slave relation: Onboard communication control unit as the master and onboard positioning unit as the slave
(4) Direction flow of message:

Each synchronous port has quad messages.

- Timing
- Request signal of onboard communication control unit
• Gating signal of onboard positioning system
• Data.

Timing and request signals are sent to train positioning system from onboard communication control unit;
Gating and positioning data are sent to onboard communication control unit from train positioning system.

(5) Interface information frame
Apply character-oriented transmission protocol:

<table>
<thead>
<tr>
<th>Frame-Start Signal</th>
<th>Content</th>
<th>Check</th>
<th>Frame-End Signal</th>
</tr>
</thead>
</table>

During the data transmission, right-shifting mode is applied, also called little-endian.

C. Onboard positioning system-onboard computer

1. Interface Function

Train positioning information sent by onboard positioning system to onboard computer is an important data for CTBC to realize train control and to ensure safety.

2. Interface characteristics
(1) Type: RS-232 serial port
(2) Transmission rate: 38400bps
(3) Transmission mode: Asynchronous Transfer Mode(ATM)

D. Driver console-onboard computer

1. Interface function

The driving display provides the interfaces of onboard computer and automatic monitor ATS, the information includes the allowed maximum speed, the current detected speed, the distance from next stop, train operation mode and system error message, etc.

The output signal of onboard computer mainly includes:
(1) ATC operation mode selection:
• Automatic mode ATO, security signal;
• Manual mode ATP, security signal;
• Restricted manual mode, security signal;
• Resection(Bypass ATC function), security signal.
(2) Direction control:
• Going forward, security signal;
• Staying put, security signal;
• Stepping back, security signal;
(3) Emergency breaking, security signal:

Emergency breaking is operated by drivers. ATC will accept the ESD request under any operation mode. This is a safety circuit, any related interface or circuit breakdown will be regarded as an ESD request.

(4) Automobile door operation mode selection switch (To choose automatic or manual door operation), security signal:
• Automatic door opening/Automatic door shutting;
• Automatic door opening/Manual door shutting;
• Manual door opening/Manual door shutting.
2. Interface characteristics
(1) Type: Fast Ethernet, physical port: RJ-45
(2) Transmission rate: 10/100M Adaptive
(3) Information frame formation

Character-oriented transmission protocol is applied, the communication formation is as follow:

<table>
<thead>
<tr>
<th>Frame-Start Signal</th>
<th>Content</th>
<th>Check</th>
<th>Frame-End Signal</th>
</tr>
</thead>
</table>

E. Train Diagnostic Computer-Onboard Communication Control Unit

1. Interface function

It is used to transmit the diagnosed information between train diagnostic computer and onboard communication control unit. The onboard communication unit will then send the information to the ground ATC control system.

2. Interface characteristics
(1) Type: Ethernet port
(2) Transmission rate: 10/100M Adaptive
(3) Socket connector: Industrial RJ-45
(4) Information frame formation

Character-oriented transmission protocol is applied. The communication formation is as follow:

<table>
<thead>
<tr>
<th>Frame-Start Signal</th>
<th>Content</th>
<th>Check</th>
<th>Frame-End Signal</th>
</tr>
</thead>
</table>

F. Train operator/Passenger voice communication system-onboard wireless operation control unit

1. Interface function

It is used to conduct operator/passenger voice communication, providing help to the passengers while waiting for and taking a train.

2. Interface characteristics
(1) Type: ISDN port(Standard 2B Channel)

ISDN, the abbreviation of integrated services digital network, is the combination of digital switching and transmission. It provides all kinds of existing services in the communication networks in a rapid, accurate, economic and
effective way. Besides, it associates communications with data processing. Any signal that can be converted into digital signal, regardless of its original form, can be transmitted in ISDN networks, including voice, script, data and image. ISDN has connecting ports of two different rates, one is ISDN BRI (Basic rate interface) and the other is ISDN PRI (Primary rate interface).

(2) Transmission rate: 128kb/s
(3) Information frame formation
Character-oriented transmission protocol is applied. The communication formation is as followed:

<table>
<thead>
<tr>
<th>Frame-Start Signal</th>
<th>Content</th>
<th>Check</th>
<th>Frame-End Signal</th>
</tr>
</thead>
</table>

G. Train information control system interface

1. Interface function
A two-way communication connection is built between train information control system and signal system. The information transmitted includes:
- Current train number;
- Name of stops;
- Name of destination;
- The opening side of stops;
- ATC alarm information;
- Train information control system provides alarm information to onboard ATC system, who receives the messages and reports to the control centre.

2. Interface characteristics
(1) Type: Fast Ethernet, physical port as standard RJ-45
(2) Transmission rate: 10M/100M adaptive
(3) Information frame formation
Character-oriented transmission protocol is applied. The communication formation is as follow:

<table>
<thead>
<tr>
<th>Header</th>
<th>Content</th>
<th>Last Message</th>
</tr>
</thead>
</table>

IV. CHECKING AND TESTING PROGRAM

All the transmission protocol of interfaces between equipments/subsystems and integrated systems need to have three elements: Grammar, meaning and time sequence rules. Grammar decides the message formation during the communications, meaning makes clear the content while time sequence rules point out the interaction order of both sides, such as connection establishment, data transmission, data retransmission and connection cancellation, etc.

In the aspects of interface-checking technologies, the basic requirement is that the communication should be instant and reliable. The railroad transportation has a stricter requirement on this so that interface-checking should given emphasis during the interface design of railway vehicles. However, reliability and instantaneity are incompatible. A higher speed will result in shorter time, narrower waveform and less energy of a single data code element, in that way the possibility of information error will increase after information being interfered and mitigated and the reliability will decrease, so the transmission rate will descend if there is a higher demand of communication reliability. We need a reasonable solution to this problem. At present there are a couple of error controlling coding methods, but the main codes recommended by related standards of data and computer communications are: parallel parity code, vertical parity code, parallel vertical parity code and cyclic redundancy code, etc.

In the aspects of interface-testing technologies, to realize the interface of integrated programs there are a variety of links such as the purchase and installation of facilities and the development of software and hardware. Any problem of one single link will lead to the failure of interface function. Only through repeatedly customized tests can the interface function be carried out in an orderly fashion. Normally there are visual tests, communication tests, point to point tests, port to port tests, functional tests and performance test, etc.

V. CONCLUSION.

Based on the research of modern interface technologies that are commonly used, this article brings up the program of connecting interfaces of all the subsystems in railway CTBC system. In the light of the exploration of different interface functions and characteristics of each subsystem, the article also proposes checking and testing programs for CTBC vehicle port systems as a directional guide for the future researches. Interface technology integrates multiple complex systems, increases the integrity of complex systems and enhances transmission efficiency. Meanwhile, with the development of technologies, interfaces will gradually grow from complex and multiformal to simple, unitary and standard. Besides, all the control systems will evolve from using interfaces into seamless connection and the future railway vehicle system will become simple, stable and reliable.

REFERENCES