Design of a General Monitoring Host Machine for Railway Trackside Equipment

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Abstract. A large number of infrastructure and equipment are distributed along the railway, which will directly affect the safety and efficiency of railway transportation. In this paper, a general monitoring host machine for railway trackside equipment is designed to realize the power supply, automatic networking, logic operation centralized management, data collection, storage and processing of trackside equipment monitoring. The host machine consists of a CPU board, a interface board, a power board, several PLC (Power Line Carrier) communication boards and isolation transformers. It supports a variety of monitoring applications, and covers almost all monitoring requirements of trackside equipment. Based on the monitoring host machine, a monitoring system for trackside equipment of track circuit system is developed.

1. Introduction
Railway trackside equipment is of various types, large quantity and wide distribution, which is an important foundation to ensure the safety and efficiency of railway transportation and plays a key role in supporting railway development. Therefore, it is urgent to realize the functions of operation data acquisition, working condition monitoring, fault diagnosis positioning and maintenance prediction of trackside equipment by applying advanced technologies, which is of great significance to ensure safe and efficient operation of railway[1].

However, the monitoring of trackside equipment is faced with power supply, communication and other problems, which is hard to solve because of the restriction of cables and railway special environment.[2] A general monitoring host machine is designed in this paper, which can provide power supply and communication channels for the trackside equipment monitoring system. The massive monitoring data of the trackside will be collected by the host machine to achieve the centralized management, which supports the intelligent diagnosis, operation and management system of trackside equipment based on the railway Internet of things.

2. Architectural Design
According to the monitoring requirements, working environment, distribution condition, operation and maintenance of railway trackside equipment [3], the general monitoring host machine should provide the functions of isolated power supply, power conversion, operating system, protocol conversion, CAN communication, PLC communication, Ethernet communication, status monitoring and display, centralized management, etc [4]. Architecture of the monitoring host machine is shown in Figure 1.
3. Hardware Design

The hardware of monitoring host machine mainly includes a CPU board, a power board, an interface board, a mother board, several PLC communication boards and isolation transformers, etc. It occupies 3U high and 84hp wide space, which can be placed in a standard cabinet.

3.1. CPU board

3.1.1. CPU design. The core processor of the CPU board adopts am5716 of TI, supporting Linux operating system. The chip has dual arm-a15 core, dual floating point DSP c66x core, two dual core programmable real-time units and industrial communication subsystem, and integrates rich peripherals. The core circuit of am5716 includes power supply, reset, clock configuration, start mode configuration, memory, nonvolatile memory circuit, etc. Am5716 uses two off chip crystal clocks with frequencies of 20MHz and 22.58MHz to generate the internal clock frequency. Am5716 is started by chip pin configuration, and the supported starting modes are UART, SD, USB and QSPI.

3.1.2. Storage design. In order to ensure the processing performance and storage capacity of the monitoring host machine, two DDR3 chips with a total capacity of 1 GB and an EMMC with a capacity of 8 GB are configured. The circuits design are shown in Figure 2 and Figure 3.

Figure 1. Architecture of the monitoring host machine.

Figure 2. Circuit diagram of DDR3.

Figure 3. Circuit diagram of EMMC.
3.1.3. CAN interface design. The CPU board provides six independent CAN bus interfaces, two of which are the processor's own CAN interface, and the other four are converted through SPI interface. The interface circuit adopts MCP2515 of Microchip, and CAN data transmission and reception is realized by SN65HVD230 of TI. The circuit design is shown in Figure 4.

![Circuit diagram of CAN](image)

3.2. Power board
The power board converts 220VAC to 12VDC, 5VDC and 3.3VDC, supplying power for other boards in the host machine cage through the motherboard. The functions of lightning protection, rectification filtering and over-current protection are designed.

3.3. Interface board
The interface board provides two Ethernet ports, an USB port and two CAN ports from the CPU board, and the EMC protection circuit of the interface is considered.

3.4. Isolation transformer
Isolation transformer provides power (220 VAC, 50 Hz) for outdoor trackside monitoring equipment, and its capacity can be flexibly configured from 100W to 260W according to the power supply requirement.

- Transformer ratio: 1:1
- Insulation resistance: > 500m Ω
- Insulation withstand voltage: > 2000V

The schematic diagram is shown in figure 5.
3.5. PLC communication board

The broadband high-speed power line carrier communication is adopted, including carrier chip circuit, crystal oscillator circuit, FRAM circuit, can interface circuit, reset circuit, carrier receiving filter circuit, carrier power amplifier and transmitter circuit. The module has the following characteristics:

- The working frequency range is 2~12Mhz
- The OFDM physical layer broadband communication technology optimized for low-voltage distribution power line network is adopted
- The sub-carriers support BPSK, QPSK and QAM modulation
- Automatic and fast networking, supporting path maintenance and automatic relay technology
- Up to 1024 terminals

The carrier receiving filter circuit adopts the following 8-order filter, i.e. first through 5-order high pass filter and then through 3-order low pass filter.

4. Software Design

According to the requirements of monitoring track circuit system, the software function is developed based on the monitoring host machine. The software flow chart is shown in Fig. 6.
4.1. Application software threads
The application software structure design is divided into three threads, as shown in Figure 6. After the program is running, the main thread is first run to initialize the program, and then two threads are opened: the communication thread to the upper computer (host communication) and the communication thread to the lower computer (slave communication). The two threads are logically parallel to the main thread, and the main thread is responsible for ensuring the stable running environment and reasonable allocation of resources and exception handling.

4.2. PLC communication
Based on the limitation of cables, the real-time and reliability requirements of monitoring the trackside equipment, the monitoring host machine applies broadband PLC communication technology[5]. The PLC board starts the networking process as the master after power on. It sends the carrier message to the power line, which carries address information, network slot information and carrier frame transmission time stamp. After receiving the beacon frame, the slave calculates the time difference between the beacon frame and the network reference time of the master, and then calibrates it. At the same time, the signal quality of the message is evaluated, and an application for joining the network is sent to the master. The communication system is based on the white list network. The master judges whether to allow or refuse the slave to join the network through the white list.

On the communication line, the slave close to the master terminal first joins the network and becomes the first level node. After all the first level nodes enter the network, the master will arrange the first level nodes to send the carrier frame, and the further nodes will receive the carrier frame of the first level nodes and join the network as the secondary nodes, so as to cycle until all nodes join the network.

The whole network is a tree structure. The maximum level of network support is 15. The routing is self-maintenance without manual intervention. During the operation process, the master and slave will periodically send network maintenance messages, so that the slave can select the relay node with the best communication condition.

5. Summary
Facing the urgent requirements and difficult problems of monitoring railway trackside equipment, a general monitoring system host machine for trackside equipment has been designed in this paper, which provides stable power supply, anti-interference communication channel, data processing and centralized management capabilities for trackside monitoring equipment. Taking the outdoor equipment of track circuit system as an example, the software adaptation is carried out. The monitoring host machine also meets the monitoring requirements of switch machine, signal machine, compensation capacitor, choke transformer and other trackside equipment through adaptation development, which has good adaptability and expansibility.

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