

# Design and Implementation of a Maintenance Training Simulator for a Certain-type of Equipment

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**Keywords:** maintenance training; simulator; design and implementation.

**Abstract:** In order to improve training efficiency and cut down abrasion of equipment, the overall solution design of the maintenance training simulator for a certain-type of equipment is implemented based on functional analysis. The specific design and realization from both hardware and software is done to ensure the accordance of the internal and external structure, the mode of faults and the methods for removing the faults between the real equipment and the simulator. The training simulator provides training and evaluation platform for equipment operation and maintenance.

## 1. Introduction

A certain-type of equipment is typical information equipment, which has the characteristics of complex structure, high price, high degree of information, and multiple specialties. It requires high comprehensive maintenance support technology and has many difficulties in actual maintenance support. At present, the training of maintenance and support technicians in the army and schools is based on actual equipment, which is limited by the small amount of equipment and training scale and low training efficiency; In addition, training based on actual equipment can easily damage equipment, affect equipment life, and reduce equipment use efficiency. Practice has proven that developing a maintenance training simulator based on actual equipment is an effective way to solve the problems in the actual equipment training. Based on this, the maintenance training requirements of a certain-type of equipment is analyzed in this paper, a general plan for the maintenance training simulator is proposed, the specific design plan and implementation of hardware and software systems is presented, the training ability of equipment maintenance and support is improved through the construction of the training simulator.

## 2. Requirement analysis and overall scheme design

### 2.1 Requirement analysis

A certain-type of equipment is a typical command and control system which need interconnect with front-end information acquisition equipment and back-end weapon terminal equipment. In order to meet the maintenance training requirements and comprehensive maintenance support teaching ability of this type of equipment, the simulation trainer should have the following functions.

1. The simulation trainer can not only perform maintenance ability training, but also equipment operation training. Therefore, the design and implementation process should be close to the actual installation, and the operating steps and methods of the simulator should be consistent with the actual installation.

2. This type of equipment mainly implements network communication through two methods, wired and wireless. The wireless method is the main method, the simulation trainer needs to build a software and hardware platform for wireless communication for the training of the entire system.

3. As a maintenance training system, it is necessary to re-install the typical faults, provide training personnel with fault setting and detection functions, and automatically evaluate the training effect after the trainees finish the training subjects to improve the specificity of the next training.

## **2.2 The design of overall scheme**

The structure of the simulation trainer is basically the same as the installed structure. It mainly includes the following sub-system.

1. Information processing Sub-system, the information processing sub-system mainly includes computer hardware and command decision-making and control software to implement functions such as integrated information processing, command control, combat intelligence admission.etc.

2. Wireless communication sub-system, the wireless communication sub-system mainly includes a wireless data transmission device simulation trainer to realize the interconnection of the entire system. It can realize the communication between the radio data and the communication gateway under the management of the host computer.

3. Network control sub-system

The network control sub-system mainly includes simulation trainers for communication gateway and network switch. The communication gateway simulation trainer is the core device of the entire simulation training system. The network switch adopts TL-SF1008 and adaptive Ethernet switching module which contains eight 10 / 100Mbps adaptive ports to provide an interface for the self-organized local area network of terminal equipment.

4. The power supply sub-system

The power supply sub-system is a simulation trainer of Installed integrated power supply. It has the leakage protection function of AC input and provides uninterrupted DC and AC power for the equipment.

5. The fault setting sub-system

The fault setting sub-system realizes the remote setting and troubleshooting of the equipment simulation trainer fault. It is realized by the main control computer controlling multiple single-chip microcomputers through RS-485 bus or CAN bus, and the single-chip microcomputer controlling relays.

The technical difficulty of the simulator system development lies in the design of the single device and the development of the fault setting system. The main single devices include computers, network switches, communication gateways, and wireless data transmission equipment. Computers and network switches are realized by purchasing finished products.

## **3. The design and implementation of hardware**

### **3.1 The communication gateway**

The main functions of the communication gateway simulation trainer are: 1) with Ethernet communication function; 2) with serial communication function, the maximum number of channels is 8; 3) with real-time status indication function; 4) with data forwarding function. Structure principle block diagram of communication gateway simulation trainer is shown in Figure 1.

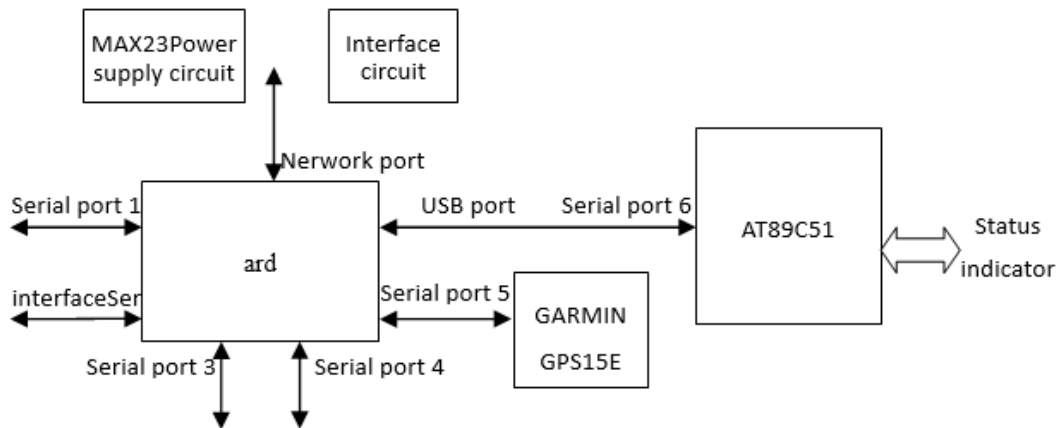


Figure 1 communication gateway schematic diagram

The communication gateway simulation trainer uses the embedded computer system ENC-LX800 as the core which has rich interfaces, including a CF card interface, 6 serial ports, 1 network port, and 2 USB ports. The communication gateway simulation trainer uses ENC-LX800 motherboard as hardware, which can be realized by developing software on it. The status indication is realized by a single-chip microcomputer which controls the on / off status of the status indicator. A USB interface in the ENC-LX800 motherboard is converted into an RS-232 serial port. The single-chip computer system is composed of AT89C51, crystal, serial interface chip and LED indicator.

### 3.2 The wireless data transmission equipment

The wireless digital transmission equipment simulation trainer simulates the operation of the radio station. The main functions include: 1) LCD Chinese character display; 2) keyboard input; 3) wireless data transmission 4) wireless data and voice transmission. The block diagram design of the digital transmission equipment is shown in Figure 2.

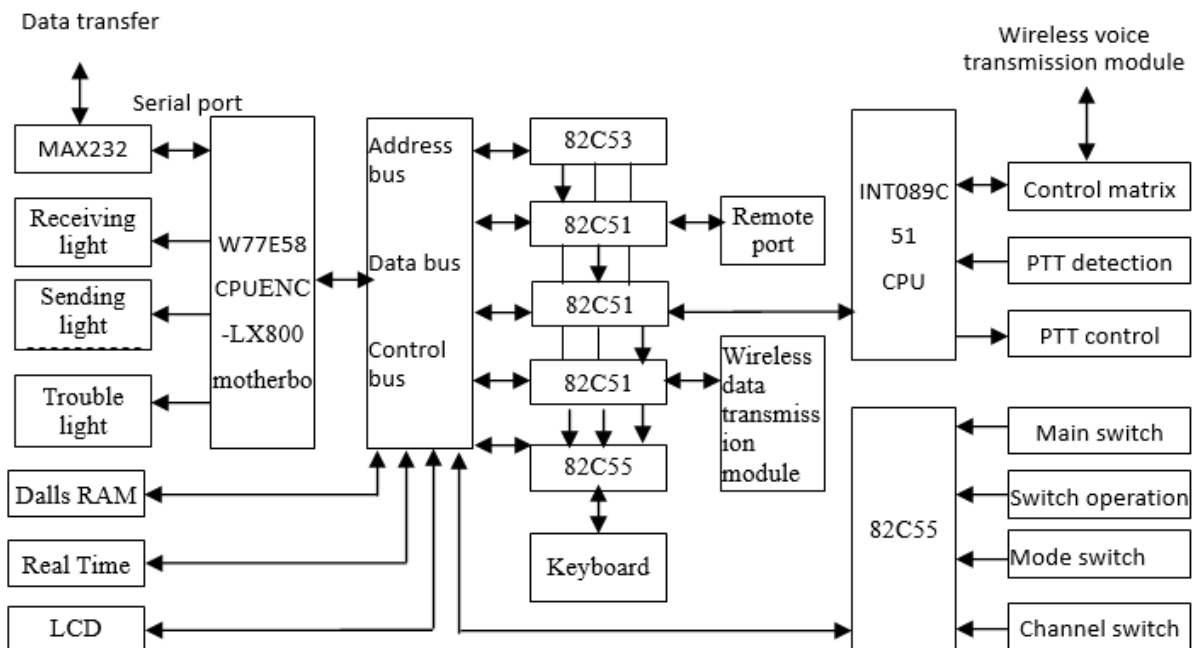


Figure 2 Data transmission equipment schematic diagram

The wireless data transmission equipment simulation trainer uses the W77E58 CPU board as the core plate to realize the whole machine management and data transmission functions. The level conversion of the data transmission interface is carried out through the MAX232 chip; the PTT handle is under the control of the AT89C51 microcontroller to implement the wireless speech

transmission function. There are many interfaces of digital transmission equipment including main switch, operation switch, mode switch, channel switch, mode indicator, keyboard, LCD, remote control and data interface (serial port), audio interface, antenna port, etc. Each interface realizes data exchange with W77E58 CPU core plate under the control of single chip microcomputer.

## **4. The design and implementation of software**

### **4.1 The control software of computer**

The main control software running on the computer mainly contains the following sections.

#### **1. The system status acquisition and monitoring module**

The data acquisition system collects the status information of each device through the serial acquisition module, and uploads it to the main control computer through the Ethernet port. The system status acquisition and monitoring module software can always monitor the data uploaded by the serial port acquisition module on the Ethernet through the corresponding port, analyze the received data, determine the device status on each node, and display the status information on the system flowchart; Green means unblocked, red means different. The software also needs to monitor the status information of the LAN and the gateway at any time. If the status of the LAN or the gateway is abnormal, it will be displayed on the process block diagram.

This software is a Windows application written in C # language. Through the Socket technology in C #, it can listen to the data uploaded by the serial acquisition module. Through the Com technology in C #, it can send status confirmation instructions to each switch and gateway device in the system.

#### **2. The fault setting module**

The software can set various hardware faults by sending hardware fault instructions to the corresponding fault setting board. After the fault setting board receives the fault command, it will simulate and display the fault effect in the device; the fault command is sent to the corresponding device fault monitoring software by software. After receiving the fault command, the device fault monitoring software will modify the corresponding software configuration file and simulating the effect of software failure.

The functions of the fault setting module mainly include: 1) Software setting fault function, pre-set fault setting code, when the user clicks on a certain fault point as requirement, the software sends the fault code of the fault point to the corresponding fault setting board through serial communication to set fault. 2) Status display function, the software can monitor whether each fault setting board has fault, or whether the fault is eliminated. 3) Status query function, the software can send status query instructions to each fault setting board regularly, so as to grasp the status of each fault setting board at any time. 4) Fault setting and saving function, when the fault is set and not eliminated due to time, power failure or other reasons, after the next boot, the previous state can still be obtained and the previous fault state can be continued. 5) Setting the fault at the specified fault point by sending fault code to the fault setting board through the fault setting module which can set communication gateway equipment, network switch equipment, wireless data transmission equipment. 6) Status display function, the software can display the status of various settings according to the status type, such as fault display, no fault display or fault display.

This software is a Windows application written in C # language. After clicking the fault button in the software interface, if it is a hardware failure, the software will send a fault instruction to the corresponding serial port through the Com technology in C #. After the fault setting board receives the instruction, the failure effect of the hardware will be simulated and displayed in the device; if it is a software failure, the software will send a fault instruction to the fault monitoring software in the corresponding device through the Socket technology in C #. After receiving the fault instruction, the device fault monitoring software will modify it. The corresponding software configuration file simulates the effect of software failure.

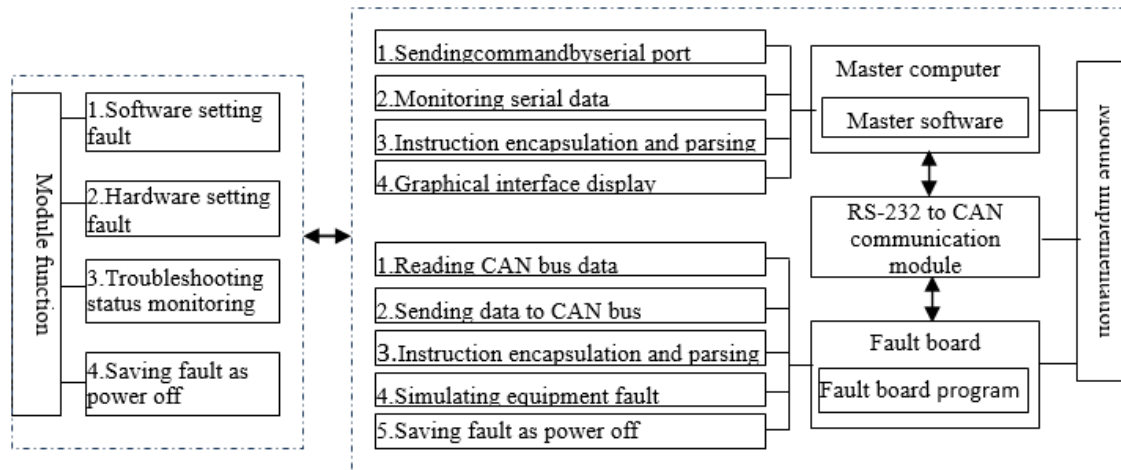


Figure 3 fault setting and monitoring module function implementation diagram

### 3. The maintenance process monitoring and maintenance effect evaluation module

This software is a Windows application written in C # language. The software sends instructions to the video matrix through the serial device, which can control the video matrix to switch the maintenance process screen shot by the surveillance camera to a large screen, providing a basis for the instructors to evaluate and score the students' operations. After the maintenance is completed, the maintenance effect evaluation according to the troubleshooting situation is performed.

The main functions of this module include: 1) Maintenance scene monitoring, monitoring each maintenance scene and maintenance process through video. 2) Maintenance scene display and switching, each maintenance scene screen can be displayed on a large screen, and multiple maintenance scenes can be switched and displayed according to the maintenance situation or maintenance process for the instructor to evaluate the maintenance process. 3) Evaluation of maintenance effect. The software can evaluate the maintenance effect according to the situation before and after the maintenance and troubleshooting, and give the maintenance results. The assessment is based on the time spent in the repair process, the number and effectiveness of troubleshooting. Instructors can combine the results of manual evaluation and software evaluation to comprehensively evaluate the students' maintenance practice performance.

In the simulation maintenance assessment, the teacher needs to start the simulation maintenance examination monitoring program in the software which can receive the hardware status information of the device through the serial port and record it in the database. The keyboard and mouse operation monitoring software on each device will record all keyboard and mouse operations of the students on the computer, and will save them to the database of the main control computer when the students complete the maintenance tasks. When the teacher ends the simulated maintenance test in the software, the software reads the records in the database, sorts them according to time, and compares them with the preset standard maintenance operations, and finally gives an evaluation score based on the similarity of the comparison.

### 4.2 .The software of communication gateway

The communication gateway software is mainly programmed in C # language, and uses Windows Socket and Com technology to convert the transmission protocol and perform corresponding distribution processing on different data packets.

Similar to the real communication gateway in the installed system, the combination of the Ethernet interface and the serial communication interface is used to realize the conversion between the Ethernet data packets and the serial communication data packets which are sent and received by the PC operating software. The communication gateway mainly realizes the conversion from computer network protocol to serial protocol, that is, the conversion from UDP data packet to RS232 data stream. All network communication data packets do not carry the receiver's IP address when they are sent by the initiator. Instead, they carry an internal address code which is a 2-byte

hexadecimal number and provided by the address book. All communication gateways and seats must keep the same address book; otherwise, normal communication will be impossible.

## **5. Conclusion**

The simulation trainer designed and implemented in this paper provides a simulation platform for certain types of equipment to carry out professional training, and adapts to the needs of information, network, and simulation teaching, improves the training conditions for equipment maintenance support, and will improve the training quality and the training content of this type of equipment and enrich the information-based teaching methods. This simulation trainer provides demonstration effects for colleges and troops to carry out similar types of construction, and further enhance the ability to serve the army.

## **References**

- [1] Weixin Zhang, Jiwen Hu, Yi Liu, et al. Design of Data Acquisition and Communication in Weapon Simulator[J], Measurement & Control Technology, 2016.
- [2] Fuqi Qu, Jianhua Tu, Xianglin Tan. The Design and Implement of A Maintaining Training Simulator for A Certain Geographical Network of Command System[C]. Proceedings of the Seventh China Command and Control Conference, 2019.
- [3] Zhen Fu. The Design and Realization of a Certain-type Commanding Machine Simulator [D]. Harbin Institute of technology, 2012.
- [4] Yu Lei. the Design and Implementation of the Multifunctional Gateway for Embedded Marine Communication [D]. Dalian Maritime University, 2016.