

# Design of FMEA Software for Marine Electric Propulsion System based on VB

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## Abstract

The normal operation of Marine electric propulsion system determines the vitality of the ship. To carry on the FMEA to the system, can analyze the type of failure that the system may occur, the influence and the solution method. To this end, the use of visual programming software Visual Basic specially designed a fault management and online detection software, and the use of Access to establish a fault database, by Siemens S7-1200 as the lower computer, control motor rotation. When a fault occurs, the fault mode, causes and solutions will be displayed on the software interface, so that the traditional sense of FMEA online.

## Keywords

Electric Propulsion of Ship; FMEA; Visual Basic.

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## 1. Introduction

Marine electric propulsion system is composed of many equipment, complex system composition, high degree of automation, once the failure will produce greater harm to the normal operation of the ship. The FMEA is introduced into the Marine electric propulsion system to predict and evaluate it quantitatively, and the necessary preventive measures are put forward. VB comes with MSCOMM serial communication control, has a perfect serial port data sending and receiving functions, suitable for the development of FMEA measurement and control software. The PC is used as the upper computer to establish communication with the Yokogawa WT333E digital power meter and the Qizhi 8902F2 three-phase digital electric parameter tester to realize the data acquisition of the electric propulsion system, and online monitoring. When the system fails, the fault mode, influence and cause will be suggested, and the report will be output as the FMEA data.

## 2. Marine electric propulsion system

### 2.1 Electric propulsion system

Marine electric propulsion system mainly consists of three parts: motion control system, electric power system and electric propulsion control system. Its structure is shown in Figure 1.

After the control console of the bridge issues the command of ship speed and course, the motion control system receives the command to implement control. The electric system, on the other hand, provides the power to drive the electric motors and other equipment through the grid. The electric propulsion control system includes transformers, converters, propulsion motors, etc., which can adjust the speed of the propulsion motors according to the ship's control instructions.

The research process usually starts from the following aspects:

1. The command controller sends the ship forward and backward instructions to the control device;
2. Control device, usually including speed closed-loop control and torque closed-loop control, to ensure the motor speed in the normal range;

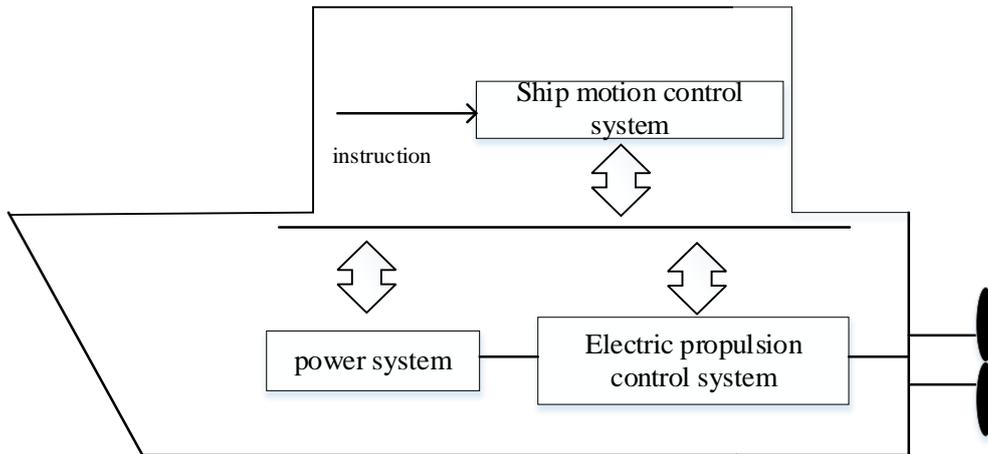


Fig. 1 Electric propulsion system structure drawing

3. Frequency converter, mainly to convert the input constant voltage constant frequency alternating current into voltage and frequency adjustable alternating output;
4. Propulsion motor, mainly permanent magnet synchronous motor, without DC power supply to provide excitation current;
5. Propeller, mainly studying mechanical stress and so on.

**2.2 Electric propulsion experimental platform**

The experimental platform uses 380V mains power simulation to supply power to the electric propulsion system of the whole ship. As the control system of the bridge, Yanxin IPC-710 IPC has built-in fault mode influence analysis software based on VB, and sends signals to ABB frequency converter through Siemens PLC S7-1200 to control the operation of the propulsion motor. The experimental platform is equipped with a yokogawa WT333E digital power meter and a qingchi 8902F2 three-phase digital electric parameter tester. The former displays the electrical parameters at the controller side in real time, and the latter displays the electrical parameters at the input side of the propulsion motor, so as to facilitate data recording and fault setting. Haiguang's three-phase permanent magnet synchronous motor ACW-8KW is used to simulate the propulsion motor, which can be used as either a load or a drag motor, while the three-phase asynchronous motor simulates the resistance of seawater to the propulsion motor.

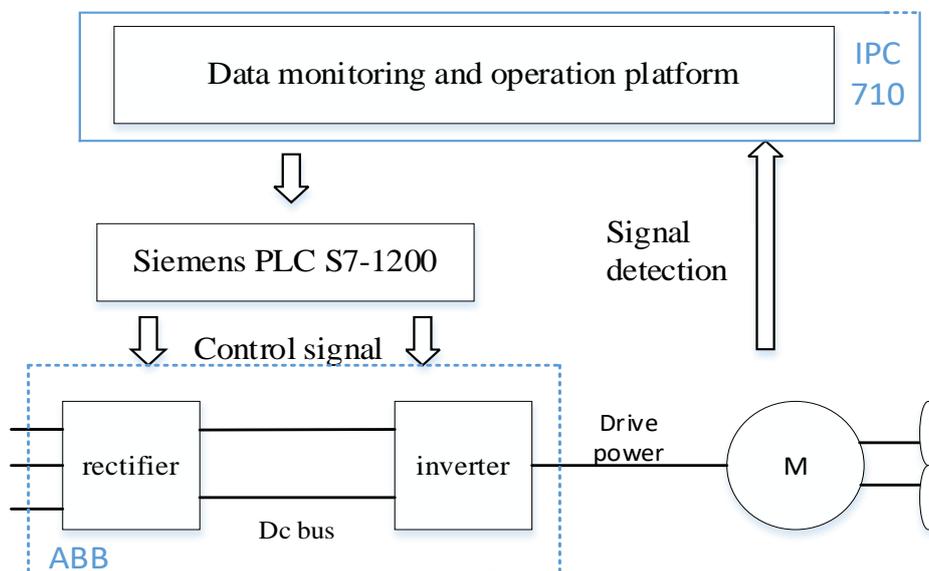


Fig. 2 Experimental platform structure drawing

### 2.3 Electric propulsion system FMEA

Failure mode impact analysis is an inductive analysis method that analyzes all possible failure modes of each product in the system and all possible impacts on the system, and classifies each failure mode according to its severity, detection difficulty and occurrence frequency.

In the 1990s, the International Maritime Organization (IMO) introduced the FMEA method into the shipping industry, and gradually applied this principle in the formulation of safety rules, ship design and ship operation management. In 1991, under the joint research of the Underwater Engineering Research Institute of Shanghai Jiao Tong University and the 701 Research Institute of China Ship, China made the first ship overall reliability model, which gradually put the ship reliability research work into the right track in China. In 2017, the China Classification Society issued a guidance document, "Guidelines for Failure Mode and Impact Analysis," which can be used as a reference for relevant research.

Marine electric propulsion system faults include electrical faults and mechanical faults. This paper mainly studies the electrical faults and carries out FMEA for them.

Table 1. FMEA

Items	Failure Mode	Reason	Solution
Propulsion motor	Motor stall	The motor is blocked due to overload or insufficient motor power	Check motor load and transmission rating
Propulsion motor	Motor overcurrent	The effective current limit is set too small	Reduce the stop torque correction factor
Frequency changer	PU internal communication	Communication error detection between transmission control unit and power unit	Check the connection between the drive control unit and the power unit
Frequency changer	I/O signal failure	I/O module failure or entry failure	automated repair
controller	short-circuit fault	wiring mistake	Check the wiring



Fig. 3 PID module parameters

## 3. Software development

### 3.1 Siemens PLC control

The experimental platform is programmed with STEPT7 software ladder diagram language to control the rotation of the propulsion motor. The input of the analog signal is voltage and current, and the

effective value of the input is within the range of 0 to 27648. In order to obtain the required values in the standard form, the integer type is output into the real type through the base conversion of MUL, SUB and Norm-X modules. Through its built-in PID-COMPACT instruction, it provides a universal PID controller with integrated self-regulation function in both automatic and manual modes. Realize the PID adjustment of torque, can be fixed torque and fixed speed test.

In the PID module of the program, the proportional, integral and differential parameters can be set by themselves. This time, the proportional gain is set as 5, the integral factor is set as 20, the differential delay coefficient is set as 0.2, and the algorithm sampling time is set as 1 second.

The following is the equipment diagram of Siemens PLC.

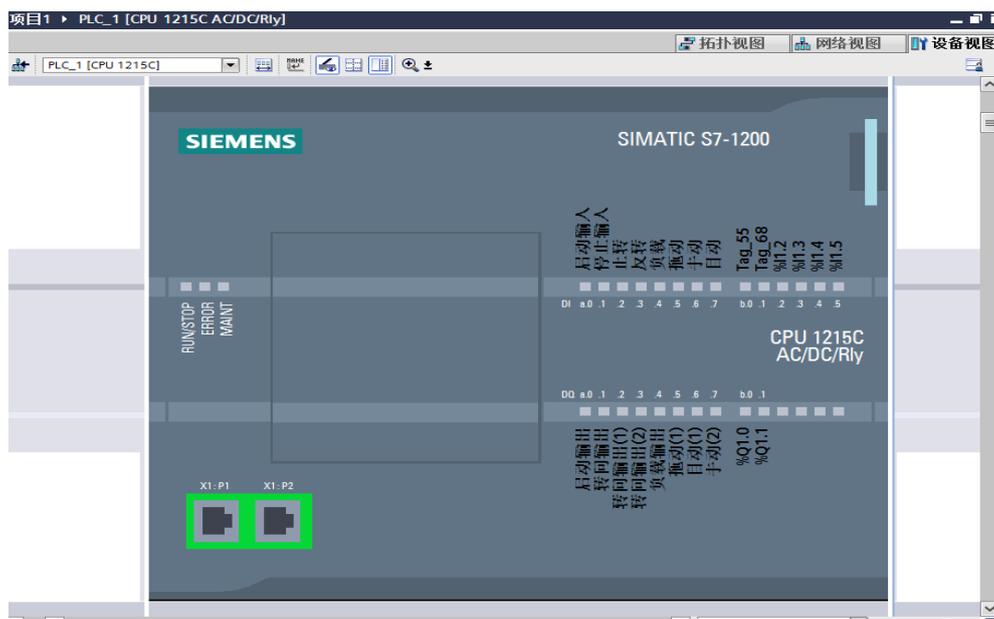


Fig. 4 PLC equipment

The Siemens PLC S7-1200 uses the CPU1215C and has a built-in dual port Ethernet switch. In order to realize the establishment of communication with IPC, the IP address is set as 192.168.1.7, and the subnet mask is 255.255.255.0.

### 3.2 Upper computer software design

VB is a Windows application development tool launched by Microsoft. It has the characteristics of simple and clear, high programming efficiency and short development cycle. At the same time, it has a friendly visual programming interface, convenient programming and strong function.

#### 3.2.1 Login form design

Login form primarily validated to try to use the software users and permissions, the distribution of the software only has an account and password, depending on the type of user different permissions assigned to users, ordinary users can't use FMEA modifying function of the database, and the administrator can change on software fault information within the database.

#### 3.2.2 Main interface

Online fault mode impact analysis can be realized in this window. After the detection starts, IPC will start communication and display the information of serial port on the interface. Electrical signals of the controller side and the propulsion motor side will be displayed in real time on the lower side, and the speed and torque information of the motor will be calculated. When the electric propulsion system is running normally, the signal light of each module is green, and IF Else statement is used to turn the indicator light to red in case of failure. At the same time, the fault mode, the cause and the solution at this time are called out from ACCESS.

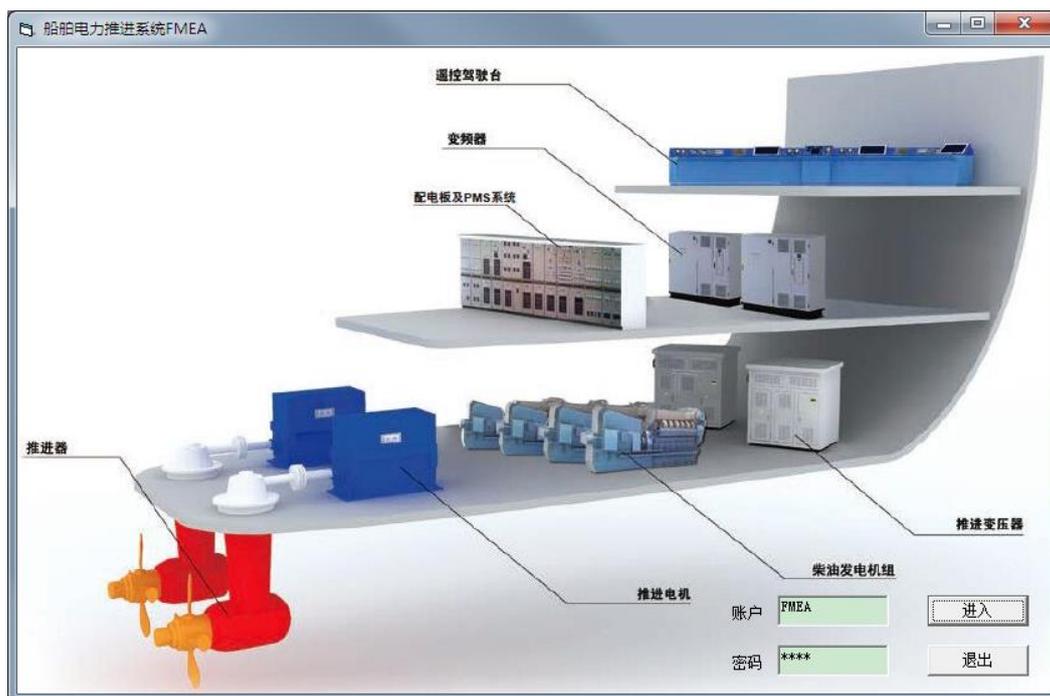


Fig. 5 The login form

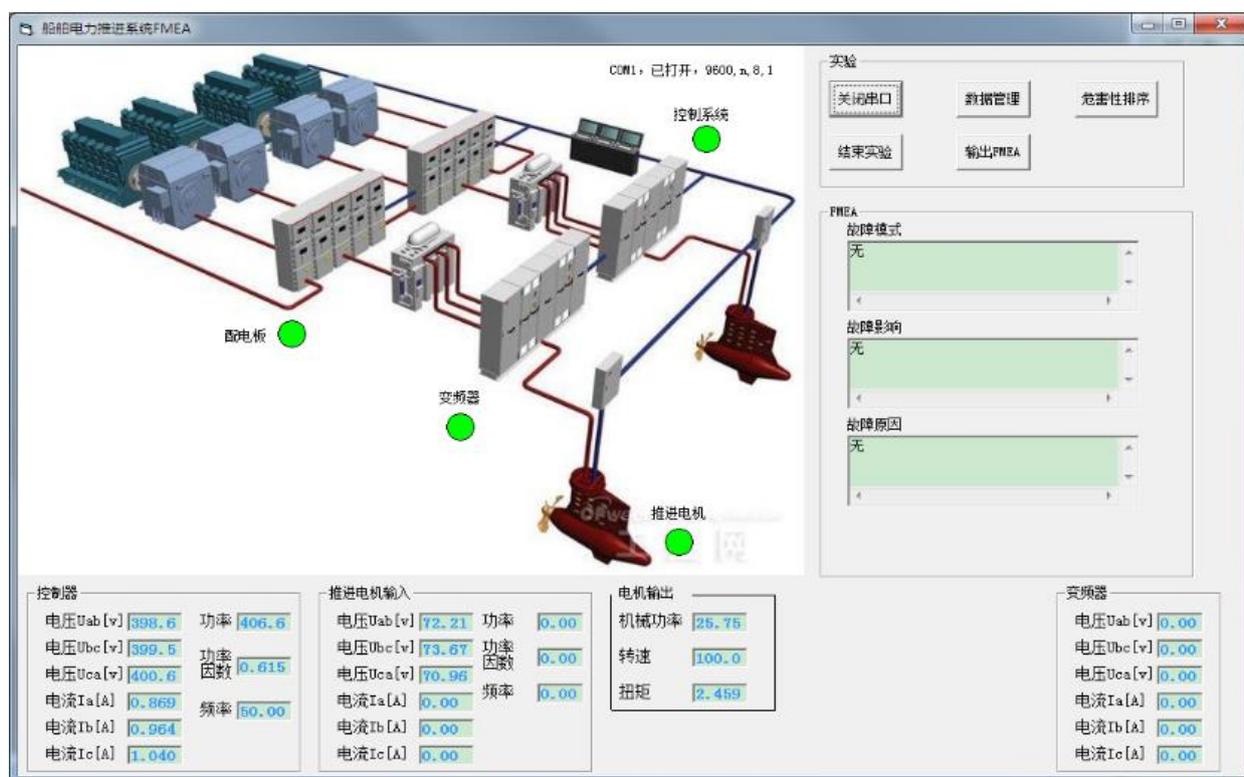


Fig. 6 Main interface form

Data management function can view or modify the FMEA database information, after the end of the experiment, automatically shut down communication, and can output the FMEA report.

### 3.2.3 Data management form

ADO Data control is ActiveX control, its usage and Data usage are similar, use it to connect the DataGrid with Access database. In the software interface, you can modify, add, delete FMEA information, modify the results of synchronization to ACCESS and save.



Fig. 7 Data management form

### 3.2.4 Data management form

Siemens PLC and digital instrument have RS232 serial interface, serial port communication mode is to split into byte transmit bit that one by one, the two sides to communicate, must abide by certain rules of communication, and should be carried out in accordance with the same rate, serial communication, namely and use the same baud rate, this equipment platform using 9600bit/s transmission rate, data bits is 8, a serial port using COM3, input and output range 3F8 to 3FF.

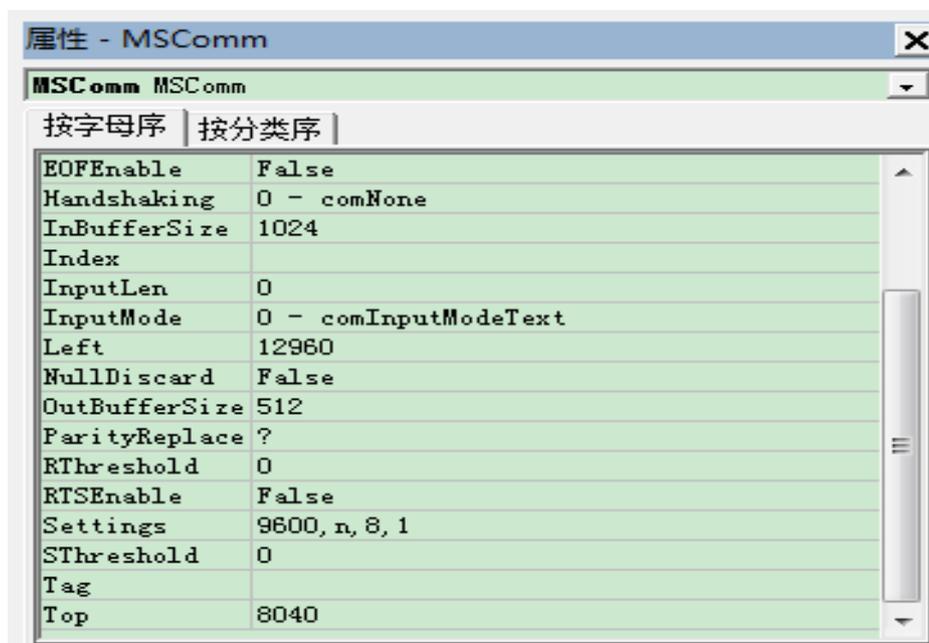


Fig. 8 MSComm control Settings

VB software bring MSComm control can provide a simple serial port communication function, sending and receiving command parameters, each byte is one start bit, 8 data bits, 1 stop bit, after the PC serial port to receive packets, trigger a VB MSComm\_OnComm events, direct call called VG\_QZ8902 and WT333 VB module file, make smart meter data displayed in the VB software, to realize the establishment of the communication.

### 3.2.5 Fault phenomenon

When the system runs normally, the interface displays normally. When the current of the propulsion motor is too large and exceeds the limit, the system reports a fault, the indicator light of the propulsion motor turns red, and the interface shows that the fault mode is motor overcurrent, and the influence is severe heating of the motor. The cause is that the effective current limit is set too small.

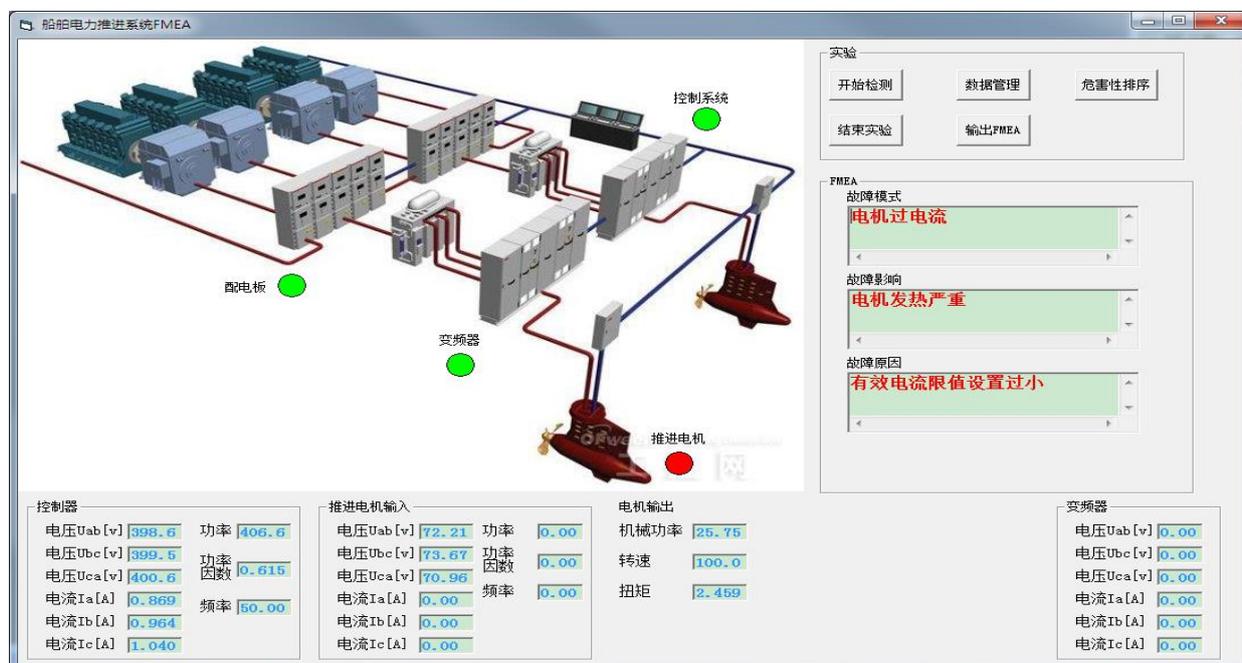


Fig. 9 Fault phenomenon

## 4. Conclusion

This study the advantages of using MSComm in Visual Basic and ADO controls, combined with the Access database to produce one for online FMEA research of PC software, can realize the real-time display of electric signal of the electric propulsion system, gives the switchboard, controller, inverter and propulsion motor, such as the red and green light, when the fault occurs, according to the green light and displayed in the TextBox failure mode, cause and solution.

## Acknowledgments

This works is supported by a fund project: The Shanghai Science and Technology Committee (STCSM) Project (Project Name: Research on Intelligent self-healing of ship regional distribution power system, Project No.:20040501200).

## References

- [1] Lyuben D. Ivanov. Reliability estimation of ship's hull girder in probabilistic terms when ultimate strength is used as a failure mode [J]. Ships and Offshore Structures,2013,8(2).
- [2] Dell Products L.P.; Patent Issued for Inter-Process Communication Fault Detection And Recovery System (USPTO 10,742,761) [J]. Information Technology Newsweekly,2020.
- [3] Infinidat Ltd.; Patent Issued for Clustered Disk Error Recovery (USPTO 10,698,779) [J]. Journal of Engineering,2020.
- [4] Electronics; Beihang University Researchers Have Provided New Study Findings on Electronics (Two-Stage Checkpoint Based Security Monitoring and Fault Recovery Architecture for Embedded Processor) [J]. Journal of Engineering,2020.
- [5] ZHANG Chun-ying LIU Feng-chun. Research of Visual Basic Programming Teaching Model Based on Project Development Teaching Method [J]. Computer Education 2010(5):105-108.