



Comprehensive Intelligent Training Simulation System for Power Communication Transmission Network

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Abstract. The simulation effect of AE system in power communication network data transmission is poor, and the effect of intelligent training decreases accordingly. For this purpose, a comprehensive intelligent training simulation system for power communication transmission network is designed. The POWER chip designed on the hardware has 30 channels, and the AD sampled values are forwarded to the opposite side CPU board to realize the AD re-sampling of the dual CPU boards; 10 independent Ethernet control effects can be realized by using the GOOSE processor; the training simulation of the power grid is analyzed on the software. According to the requirements, the functional modules of the system are established to realize the intelligent simulation of power network data. The system test method is used to verify that the simulation effect of the designed comprehensive intelligent training simulation system for power communication transmission network is better, which is of great promotion value.

Keywords: Power communication · Transmission network · Comprehensive · Intelligent training · Simulation

1 Introduction

With the continuous and rapid development of power industry and the gradual standardization of power market, power system puts forward higher requirements for the security, stability and economy of power grid operation. The quality of power system management and operation personnel is an important factor to ensure the stable and safe operation of power grid. Therefore, training the technical quality of power system operators is an important topic of power system [1]. Since the 1990s, with the rapid development of many high-tech fields such as computer, network image technology, information processing, software engineering, database technology and expert system, China's relevant scientific research institutions and colleges and universities have successively developed and issued characteristic power communication transmission network operator training simulation software system in cooperation with operation units, Raise the technology of simulation training system to a new course [2]. In order to train power system operation and management personnel, colleges and universities and scientific

research institutions have developed dispatcher simulation training system, centralized control station simulation training system and power communication transmission network simulation training system according to different needs to train the technical ability of operators [3]. At present, the simulation training of power communication transmission network, power grid dispatching system and centralized control station have made great development, but there are many problems. Although the simulation system has been continuously developed and improved with the wide application of computer, multimedia and database technology, the application of simulation system in college teaching is very limited [4]. Therefore, if the combination of simulation training system and theory can be used in college teaching, give full play to the advantages of simulation training system, so that electrical related professional employees can quickly integrate into their work roles after entering their posts, meet the needs of the unit and become qualified professional operators, it is a major breakthrough in teaching work.

Today's simulation training system has been widely used in the training of operators of power enterprises and employees majoring in electrical engineering in Colleges and technical secondary schools [5]. Based on the teaching requirements, I want to use the existing simulation system framework and functions to establish a regional power grid power communication transmission network system. However, in the process of project implementation, there are some problems, such as slow calculation speed after switching operation and non convergence of power flow, which can not meet the simulation requirements of normal operation conditions of power grid and power communication transmission network. Secondly, the existing simulation system also needs to be upgraded and improved in terms of operation ticket rule maintenance, operation training mode and evaluation. Finally, the data model of the existing simulation system is converted from the EMS data model by manual + software semi-automatic mode, so it is difficult to add new functions, and more work needs to be done to transplant it into the data model [6]. Therefore, it is urgent to re research and develop the intelligent evaluation function of normal operation condition simulation and operation training of power communication network.

2 Hardware Design

2.1 POWER Chip

The POWER chip designed in this paper has 30 channels (15 channels AD sampling and 80 point sampling rate for a single CPU board). At the same time, the AD sampling value (the first 15 channels) is forwarded to the opposite CPU board using the State Grid extended FT3 motherboard to realize ad re acquisition of Dual CPU boards. Receive the State Grid extended FT3 message forwarded by the opposite CPU board through the motherboard (AD recovery of Dual CPU board) [7]. 2-way point-to-point FT3 reception, receiving 1 OMbps national network extended FT3 protocol (80 point sampling rate) or SMbps standard FT3 protocol (80 point sampling rate) according to the configuration. 2-way point-to-point SV reception (80 point sampling rate) and message analysis. After synchronous processing of time interpolation, ad local sampling, ad re sampling, FT3. SV sampling values are interpolated into an 80 point sampling value data set. In addition to sending it to PowerPC, the data set is also assembled into SV (only one ASDU) message

and FT3 message (1 OMbps national network extension FT3 or SMbps standard FT3) according to the configuration and sent to other chips in groups (Note: the data source of FT3 message does not contain SV sampling value). The AD local sampling and AD opposite side re acquisition data contained in the SV and FT3 messages sent to other chips need to be de zeroed. PowerPC is responsible for calculating the zero drift value, and FPGA is responsible for deducting the zero drift value from the sampling value [8]. Receive the external time synchronization signal to realize time synchronization and synchronization. At the same time, convert the time synchronization signal on this side into 1PPS pulse and forward it to the CPU board on the opposite side through the motherboard [9]. The external timing synchronization signal source includes optical 1PPS, optical B code, 1588 timing 1PPS and 1PPS forwarded by the opposite CPU board. If the timing synchronization signal is optical B code, the FPGA will store the absolute time in the register after decoding, and generate a second pulse signal with a pulse width of 1 OMS, and the falling edge of the second pulse signal corresponds to the whole second time. PowerPC can realize accurate timing according to the absolute time and second pulse. It has synchronous punctuality function and meets the accuracy requirements of 10 min and 4 microseconds [10]. Therefore, a high-precision constant temperature crystal oscillator needs to be provided on this board. It has PT parallel and PT switching functions (when SV and FT3 message framing, copy the sampling values of some sampling channels to specific sampling channels according to the configuration). It has the function of zero sequence self production (when SV and FT3 message framing, vector sum the data of three sampling channels according to the configuration and fill in the specific sampling channel).

2.2 GOOSE Processor

The GOOSE processor designed in this paper can realize 10 independent Ethernet control effects, of which 8 are connected with 8 Ethernet optical ports of the small panel, one is connected with the fast bus and the other is connected with the internal bus of the board [11]. The eight Ethernet on the small panel are used for GOOSE transceiver with external devices, the Ethernet connected to the fast bus is used for GOOSE transceiver between two CPU boards in the device, and the Ethernet connected to the internal bus of the board is used for GOOSE transceiver with PowerPC [12]. According to the principle of shared memory switch, the translucent forwarding of GOOSE message between any Ethernet controller is realized (“translucent” means that the source address of GOOSE message can be modified according to the configuration during GOOSE message forwarding without changing other contents of the message). When processing Comtrade data, because the sampling message sent by the process layer equipment is of fixed frequency, interpolation processing is required [13]. The usual interpolation methods include Lagrange interpolation, Newton interpolation, difference quotient interpolation. Different interpolation methods have different effects on the operation speed and accuracy of the program. This paper adopts the linear Lagrange interpolation method [14]. Assuming that the original sampling data of power communication data is the original simulation signal, then:

$$S = \sum_{k=0} A^{kw} \sin(kwt + \theta_k) \quad (1)$$

$$x(nT'_s) = x\left(n\frac{f_s}{f'_s}T_s\right) \quad (2)$$

In formulas (1) and (2), S is the original simulation signal; k and w are constants; t is the sampling time; θ is the operation effect index; T'_s is the signal acquisition cycle; $x(nT'_s)$ is the signal acquisition sequence; f_s and f'_s are two adjacent sampling points respectively; n is the number of samples, so $n\frac{f_s}{f'_s}T_s$ is the processing cycle of communication data and can only be an integer. Assuming that n' is the maximum integer less than $n\frac{f_s}{f'_s}T_s$, the processing interpolation effect of the hardware is as follows:

$$P_n(x) = \sum_{k=0} \left(\prod_{\substack{j=0 \\ j \neq k}}^n \frac{x - x_j}{x_k - x_j} \right) y_k \quad (3)$$

$$R_n(x) = \frac{f_n + 1(\xi)}{(n + 1)!} \quad (4)$$

$$\omega_{n+1}(x) = (x - x_0)(x - x_1)(x - x_2)\dots(x - x_n) \quad (5)$$

$$y_n = x(m)(m + 1 - n') + x(m + 1)(n' - m) \quad (6)$$

In formulas (3) to (6), $P_n(x)$ is a data processing expression; x , x_j , x_k and y_k are linear interpolation parameters; $R_n(x)$ is the remainder expression of data processing; f_n is the n data sampling point; $\omega_{n+1}(x)$ is the multiple expression of communication data; Assuming that data interpolation processing is performed in x_m and x_{m+1} , y_n is an interpolation linear expression; n' is a constant; Let $n = 1$, from which:

$$R_1 = \frac{f^2(\xi)}{2!} \omega_2(x) \quad (7)$$

$$\omega_2(x) = \left(n\frac{f_s}{f'_s}T_s - m \right) \quad (8)$$

$$y_2 = \left(n\frac{f_s}{f'_s}T_s - m - 1 \right) * T_s^2 \quad (9)$$

In formulas (7) to (9), m is a constant; The resulting interpolation error is as follows:

$$R = \frac{x(\xi)}{f_s} T_s^2 \quad (10)$$

In formula (10), R is the interpolation processing error; Through the processing of the processor, the simulation effect of the system will be improved to the greatest extent.

3 Software Design

3.1 Analyze the Training and Simulation Requirements of Power Grid

According to the demand analysis of the system, the functions and requirements of the power grid normal operation and operation simulation training system are described as follows: the simulation function and requirements of normal operation conditions can simulate the following situations under normal conditions. The load of power system changes with time, and the power distribution, power loss and power supply power in the power grid change with the change of load; During the maintenance of power equipment in the power system, manually operating the switchgear, exiting the maintenance equipment or putting the maintenance equipment into operation will change the operation mode of the power system; In case of fault of power equipment, the protection acts, the switchgear will automatically disconnect and automatically exit the fault equipment; The regulation of reactive power distribution in power system involves the input and exit of regulating transformer tap and reactive power compensation equipment. In the above cases, the power flow distribution of the power grid changes after operating the equipment, and the measured values of the system change accordingly. The normal operation condition simulation function shall meet the following requirements under the data test of Beijing power grid. Under each normal operation condition, the calculation time response is between 0.51.5 s. This calculation time includes system wiring analysis, power flow calculation, measured value calculation and interface measured value display; The response time of operating the switchgear is also between 0.51.5 s; Under each normal operation condition, the power flow of the system can converge. Switching operation training is a very important part of the simulation training function. It is mainly a series of operations that comply with the operation procedures and operation procedures according to the operation tasks, combined with the operation mode of the system and the operation state of electrical equipment. Compiling correct operation ticket is the core content of switching operation training and an important link to improve the professional quality of employees. In order to make the process of staff writing operation ticket can be tracked, guided, assessed and evaluated by computer, the system training process is designed in this paper, as shown in Fig. 1.

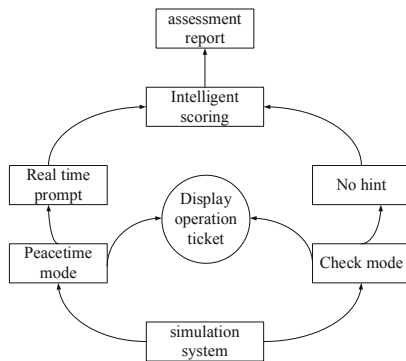


Fig. 1. System training process

As shown in Fig. 1, the training mode is divided into normal training mode and examination mode, which are set at the beginning of training. Set the operation task function in scheduling terms. Select the equipment to be operated, use scheduling terms such as operation / hot standby / cold standby / maintenance / operation on ## bus, set the operation mode of initial state and target state, and automatically generate the initial state, target state and connection relationship of all equipment related to the operation task according to different equipment types (circuit breaker, transformer, line and bus). Operation task management function. Including: delete and create operation tasks; View the evaluation report generated by the operated task; Check the specific details of the operation task, etc. According to the type and current status of switchgear selected according to the point diagram, in addition to providing general operation modes (on / off, check off / on, etc.), other possible operation modes are automatically provided. If the secondary plug-in is selected, two operation modes of “up” and “down” will be provided; Select the trolley switch to provide the operation modes of “working position”, “test position” and “maintenance position”. Real time intelligent checksum prompt function. This is a function used for employees’ daily training. The system tracks and verifies each step of employees’ operation in real time. If there is an error, it will prompt the employees to violate the specific rules. If it is correct, the operation will be output to the operation ticket currently being written. Display and management functions of operation ticket contents currently being written. You can modify and delete the steps that have been operated. In the examination mode, you can delete any operation item that has been operated. In the normal training mode, only the last operation item can be deleted. Intelligent scoring function. According to the content of violation of rules, the evaluation criteria set in advance according to the degree of harm shall be used for score evaluation. After the operation, the system generates an evaluation report. The evaluation report includes all operation steps of employees, contents of violation of rules, scores deducted according to the degree of harm, etc.

3.2 Establish the Functional Modules of the System

This paper designs a simulation training system for normal operation and operation of power grid. Under normal operation of power grid, the response of operating switchgear meets the requirements, power flow convergence and short output time. An intelligent evaluation function system for switching operation of dispatching power communication transmission network is developed by using Visual C++ and database, which can track and remind users of operating rules violated in real time, Give the final evaluation report score. The main functions of the power grid normal operation and operation simulation training system are divided into two parts: the data model conversion of the power grid normal operation and operation simulation training system. The lowest raw data comes from the model of EMS primary equipment data in dispatching automation. The data required in this system is only a part of it, so only the useful data is screened, One part of the secondary equipment data is generated by the program, such as CT and Pt tables generated in the program, and another part is expanded manually. The figure middle module is the core of the system. It is based on data and realizes the following two functions. When the equipment value on the interface changes, the program receives the changed equipment label and the changed value. The system performs topology

analysis, power flow calculation and measured value calculation, and returns to the measured value on the monitoring interface, thus, as the basis of the system functional module, the overall structure of the functional module of the system is shown in Fig. 2:

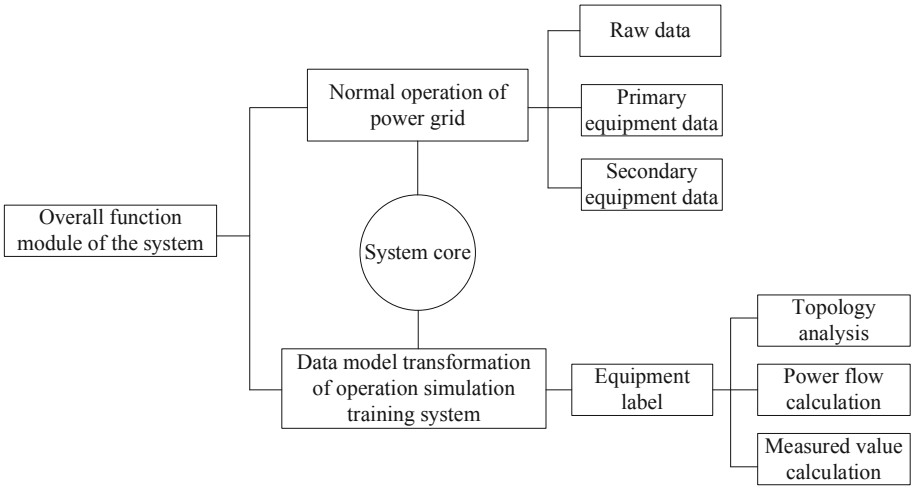


Fig. 2. Overall structure diagram of functional modules of the system

In addition to the Wizcon graphic interface, the operation interface of the system also has various dialog boxes designed by MFC. The maintenance and management of system data are completed by these dialog boxes. For example, operate the task attribute management window, which can add tasks, delete tasks and view task details. The operation is convenient and the human-computer interaction interface is friendly.

3.3 Intelligent Simulation of Power Network Data

In order to realize the intelligent simulation effect of power network data, the data sources of the simulation training system designed in this paper are obtained from the equivalent model. Manual + software semi-automatic equivalence is carried out from EMS. The manual equivalent data is huge and the workload is quite large. If this huge workload can be completed by the program, and the system can generate the equivalent model directly from the EMS data, it will enhance the universality of the simulation training system to various power grid data and improve the development efficiency of the system. This paper needs to develop such an automatic modeling software. The functions of EMS are different from those of the normal operation of power grid and operation simulation training system, so the required data information structure is also different. After the automatic modeling program obtains the EMS data, it needs to be transformed, filtered and expanded. The reasons are as follows: some equipment information required for the normal operation of power grid and operation simulation system cannot be obtained directly from the EMS data information, It can be used by the simulation program only after necessary data format conversion. For example, the branch

parameter information in the power grid normal operation and operation simulation system describes the equivalent power system model of primary equipment in the power system after equivalence and conversion. The “branch type” in the branch data table does not exist in the branch parameter attribute data of EMS data, so it must be based on other EMS data information, Generate data required for normal operation of the simulation system. The power grid normal operation and operation simulation system only needs part of the EMS data information, and other invalid data information to the system must be filtered and removed. For example, the data information of line parameters and line attribute information in EMS data are very comprehensive. For example, the “line status” and “related line name” information are line attribute information not required by normal simulation system, which should be removed. The normal operation and operation simulation system of power grid needs the basic information of transformer, but the configuration information of transformer is missing in the EMS data information, so it is necessary to expand the data not in the EMS data. When the interface operates the switchgear, the corresponding measured values change, so the system must configure the attribute information of the transformer.

The system designed in this paper can start directly from EMS, and the equivalence work is completed by program. Compared with manual equivalence, it shares data with EMS, and has the advantages of easy expansion and real-time updating data. Because the EMS data is different from the data structure required by the simulation function under normal operating conditions, the program will convert, filter and expand the EMS data after obtaining the EMS data. According to the analysis of operation simulation function under normal working conditions, most of the simulation data comes from EMS model data, and the program calculation needs to analyze, convert and modify the primary data to generate the required intermediate data. The extended switch knife switch parameter table is obtained by adding CT table to the original switch knife switch table. Adding current transformer equipment to the original main wiring is equivalent to a closed “switch”. The basic information of the data item is consistent with the switch switch parameter table. The starting and pointing element codes of CT correspond to the left and right end element codes of the switch and are set to the closed state. The branch parameter table is obtained by synthesizing the line parameter table, transformer parameter table, reactance parameter table and capacitance parameter table. Before power flow calculation, as long as the branch is equivalent, the equivalent parameters are obtained according to the equivalent models of different equipment and filled in the branch parameter table. In power flow calculation, branch parameters and node voltage information are called to generate power flow results. Therefore, the simulation results of the system designed in this paper can be guaranteed to be good.

4 System Test

In order to verify whether the system designed in this paper has practical effects, the above system is tested. In order to ensure the fairness of the experiment, the method in this paper and the traditional method are set to the same experimental environment. The test process and results are as follows.

4.1 Test Process

In the test process, first test the hardware of the system, and the test parameters are shown in Table 1.

Table 1. Hardware test parameters

Data item	Data type
CT coding	Character
CT name	Character
Voltage level	Integer
Starting element code	Character
Pointing component code	Character
Starting equipment code	Character
Meter current value	Float

As shown in Table 1, under this condition, the hardware of the system can be ensured to operate normally. At this time, the software is tested, and the login interface of the system is shown in Fig. 3.

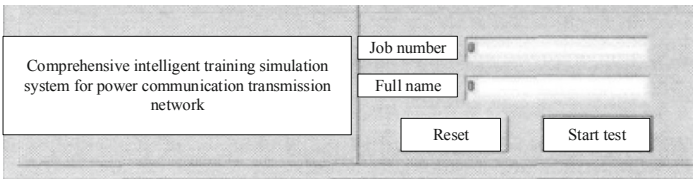


Fig. 3. System login interface

As shown in Fig. 3, when the above interface appears, it can indicate that the system is running normally.

4.2 Test Results and Discussion

Under the above test environment, compare the traditional AE system with the system designed in this paper to verify the simulation effects of the two systems, as shown in Table 2.

As shown in Table 2, the communication data transmission error of traditional AE system is more than 0.10, and the simulation effect is poor; The communication data transmission error of the system designed in this paper is less than 0.10, and the simulation effect is good, which is in line with the purpose of this paper.

Table 2. Test results

Number of experiments	Communication data transmission error of traditional AE system	The communication data transmission error of the system designed in this paper
1	0.67	0.06
2	0.36	0.03
3	0.28	0.02
4	0.12	0.01

5 Conclusion

The main achievements of this paper are as follows: the training mode of compiling operation ticket by point diagram in line with the actual workflow is designed, and the overall structure and function of power grid normal operation and operation simulation training are designed. The automatic data modeling function and normal operation condition simulation function based on EMS data and meeting the requirements of dispatching substation simulation training are studied and developed. The general judgment rules for automatic generation of operation tasks and the general verification method of hierarchical operation rules suitable for various wiring forms are studied and developed, which greatly reduces the system maintenance workload of intelligent operation training software. The intelligent operation evaluation function based on the above general rules is studied and developed to automatically generate the evaluation report, assist the superior leaders to objectively and comprehensively evaluate the employees' operation, and reduce the workload of the superior leaders. The function of power grid normal operation and operation simulation training system is verified by using an actual power grid data. The test results show that the simulation results of normal operation conditions are reasonable, the response time of operating equipment meets the design requirements, the switching operation can track and prompt in real time, and the final results are given in the form of report. The superior leaders can evaluate the employees according to the report information, which improves the training efficiency.

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