Computing, Performance and Communication Systems (2024)
Clausius Scientific Press, Canada
DOI: 10.23977/cpcs.2024.080106
ISSN 2371-8889 Vol. 8 Num. 1

Research on Communication Technology Security Strategies for Power Systems and Automation in the Information Age

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Keywords: Power Systems, Automated System, Information Age, Power Communication Technology

Abstract: In today's rapid development of information technology, the scope of power system and its automatic communication technology is expanding day by day, and it is more and more closely related to human's daily life. With the development and improvement of power automation technology, the demand for power equipment is increasing. As one of the important infrastructures of the country, the power system can realize the automatic transmission of data through the use of computer network technology. This not only greatly improves the transmission speed of information, but also relieves the original heavy workload of maintenance personnel, which plays a pivotal role in the development of the power industry. However, due to the fact that the power automation system has encountered many new problems in practical applications, such as network loopholes and network attacks in the process of information transmission, the power grid is prone to errors and control instability in actual operation. How to ensure the security of communication technology in the power industry has become a concern for people in the power industry. Based on the above reasons, from the perspective of electric power automation technology, this paper discusses the information security problems in electric power automation technology, in order to provide useful reference for the information security work in electric power automation technology. The research results show that the security of the communication technology of the automated power system was only about 87% originally, but it can reach about 96% after the reform. This has also directly increased user satisfaction to 97% or more, and at the same time, the operational stability of the power system has also undergone a qualitative leap, an increase of nearly 15% compared to the original.

1. Introduction

With the development and construction of the economy, the speed of urbanization in our country is getting faster and faster, the use of various electrical equipment is increasing, and the demand for

the power system is also increasing, but at the same time, it also brings huge pressure to the power grid. During the operation of the power system, due to the addition of automatic communication technology, the entire system has been scientifically and reasonably used, thus achieving the purpose of the power automation system. However, from the practical application of technology, due to some technical problems, the standardization level of automation systems has declined, which will cause great security problems to enterprises to some extent, resulting in economic losses and even personal safety. The application of power system and its automation technology, especially the application of network communication technology, can better solve the problem of power grid construction and play a positive role in the development of power communication. However, with the wide application of power automation technology in power grid communication, it has caused a great negative impact on the data content of the power grid, especially the security of data and information. Due to the use of automation technology, there will inevitably be some losses or even data leakage in the transmission of technology and information in the network. There is another situation, which is human-caused. In the case of improper operation, man-made leakage, data loss, etc., corresponding preventive measures should be actively taken. With the promotion of China's power automation technology, the power grid level of the entire country has been improved. At the same time, with the development of the economy, the development of automation technology is becoming more and more important. At present, China's electricity market is in great demand, which has a certain impact on the safe operation of automatic communication technology. If the safety management of automation is not paid attention to, it will cause the failure of the power grid, thus affecting people's normal life.

Therefore, this paper believes that we should not only pay attention to the security of power grid communication technology, but also study how to prevent errors and risks in the process of automation, so as to ensure the safe development and application of the power system, and promote the automation technology of the power system to a new level, reduce the error rate in operation, avoid potential safety hazards in operation as much as possible, and promote the development of automation, lay a solid foundation for the development of the power system, ensure the optimization and promotion of the power grid, and continuously improve the degree of automation of the power grid.

2. Related Work

With the continuous progress of society, the power system and its automatic communication technology have played a great role in promoting the work efficiency of the national power system. It not only promotes economic development, but also improves the safety of power system operation. With the increase of electricity consumption in China, the impact on automation technology is also increasing. If automation technology cannot be used effectively, it will lead to power grid interruption, thus affecting the normal life of the people. With the expansion of the scale and service mode of power terminals in our country, there are many problems in the current terminal communication access network. The wireless access network developed by the State Grid will help to solve this problem. Liu H analyzed the current situation of the power grid in Hebei Province, and at the same time predicted and analyzed the business needs, determined the wireless private network technology system, and gave the technical principles and solutions [1]. Electrified transport and the grid are an interconnected network. On this basis, Amini M provides a new architecture for an enterprise power and transportation system. He uses the Dijkstra algorithm to reduce the total travel cost by inputting the battery management system, the electricity price of the charging station, the efficiency of the powertrain components, and the flow of the transportation network[2]. In the power grid, scientific and accurate identification of abnormal power consumption

is the key to improve the level of power grid operation and management. Tian L found that using the percentage of abnormal scores can quickly and reliably identify abnormal information about power consumption. The experimental results simulated by him show that this method can better detect abnormal power consumption, and can improve the discrimination rate of abnormal power and the analysis accuracy of power consumption [3]. The power system is a multi-disciplinary, multi-domain system that combines a variety of different energy technologies. Simulation packages for evaluating component systems integration typically include only one sub-area and simplify others. Co-simulation is the use of specific solvers and proven analogy models combined with subdomain models described and solved in the local environment. Palensky P discusses current technologies and conceptually addresses the significant challenges in simulating smart power systems [4]. The power terminal communication access network is a key link in the power system, and it is the extension of the power grid backbone network. PI A uses the method of combining subjective preference and objective mathematical analysis to optimize the communication technology, so that the performance of the terminal communication access network has been greatly improved [5]. In modern power communication system, automatic communication system is widely used, it is an important part of realizing complex demodulation processing, and power consumption is an important factor restricting its performance. Ellaithy D M adopts the method of logarithmic operation in the realization of the sine function, which simplifies the generated program, reduces the power consumption, reduces the cost, and is based on the Taylor polynomial approximation, instead of the expensive multiplier and squarer [6]. Jimada-Ojuolape B found that there has been progress in integrating information and communication technology (ICT). ICT has played a pivotal role in people's daily life, and its integration with the power grid is particularly important. ICT provides efficient integration for all stakeholders of the power system, making it more economical and sustainable. In the power system, aspects such as intelligent monitoring, two-way communication between stakeholders and various components of the power system, power supply security, and self-healing are all manifested. However, in addition to the great advantages brought by ICT, its application to the power system also has many shortcomings, which may adversely affect the reliability of the power system [7]. Aalamifar F proposed a different communication technology for smart grid communication network. Among them, power line communication (PLC) has been widely used because of its large coverage and the ability to directly connect to remote areas through existing infrastructure. On this basis, he established a mathematical model of an advanced metering infrastructure for distribution networks based on PLC technology [8].

3. Power System and its Automation Communication Security

3.1 Problems Existing in Power System and its Automatic Control

At present, domestic experts, scholars and power system staff have taken corresponding management and control measures for the related problems of power system and its automation safety, but the results obtained in practice are not very good. There are many problems in the design of power systems and automatic control systems, and automation is involved in many places. Therefore, the application of power system is very extensive. In many places, many buildings, there will be power systems, and these power systems are interconnected, not isolated, and they have good compatibility [9]. Therefore, in the design and construction, the safety of electricity should be considered, and scientific and reasonable design methods should be adopted. In general, the content of the design must be extensive, so as to ensure the normal progress of the project. However, according to the analysis of the data on the installation and construction of the power system and automation equipment, it is found that the design of the electrical equipment and automation equipment in some buildings is not reasonable enough, causing many problems and inconveniences.

In addition, from the relevant data (as shown in Table 1), it can be seen that in some enterprises, the automation design and construction of the power system cannot be adapted to the latest design. The backward design scheme has many problems, such as the unreasonable design, which leads to many problems in the security control of the power grid [10]. If a safety management problem occurs, the entire power grid will be paralyzed, which will have a great negative impact on human life. Table 1 shows the relevant impact data for the power system mentioned above.

Table 1: Relevant impact data on the power system

Power Systems	degree of design	stability	communication security	running speed	degree of automation
traditional power system	72%	83%	88%	slower	75%
automated power system	94%	98%	97%	faster	96%
Semi-automatic power system	85%	90%	92%	generally	88%

Secondly, the problems of the power system and automation equipment must be solved to ensure the safe operation of the power system and the stability of the power operation. This not only puts forward higher requirements for skilled workers, but also strictly controls the quality of equipment. All equipment must meet the requirements of automation. If there is a problem, it will not only affect the automation of electricity, but also pose a great threat to the security of automatic communication technology [11]. The equipment in the power system has a lifespan. If it is not repaired in time, it is likely to cause system failures, and even endanger human life and property safety [12].

3.2 Differences Between Traditional Power Systems and Automated Power Systems

In the traditional power system, single resources and distributed resources are mainly connected with the power system through a large number of matching and transmission, which is a natural network foundation. Moreover, in the traditional power system, the terminal power consumption has already achieved "plug and play", and users do not need to know which power plant the power they use comes from, and each obtains power from it according to their own needs, so it has the characteristics of sharing and openness [13]. This is a concept that has been realized after several years of hard work. However, the traditional power system cannot realize the secondary conversion or replenishment of various power sources, nor can it meet the intervention of clean energy. This makes the sustainable development and comprehensive utilization of energy too limited. Moreover, the traditional power system management, dispatching and control systems cannot meet the needs of large-scale distributed generation and integrated systems that use electricity and energy efficiently.

In addition, traditional power systems cannot fully support decentralized users' access to energy and electricity markets. However, with the continuous development of China's electric power industry, the requirements for electric energy are also getting higher and higher. Therefore, under the premise of ensuring the safety of power system operation, it is necessary to exploit its advantages as much as possible [14]. The digitization of information means that the collected information reflects the real operation status of the power system as much as possible, so as to make scientific decision-making and management of the power grid. At the same time, information technology can also complete the collection and arrangement of three-dimensional and two-dimensional information. The informatization development of the automatic dispatching

system has greatly improved the transmission speed of information and commands between various substations and equipment in the power system. On the basis of digital technology, automatic dispatching system can effectively monitor the operation of power system and improve the monitoring and management level of power system communication security [15].

3.3 Development Status of Power System Automation Technology

In the development of electric power engineering, automation technology has been widely used and developed. Centered on computer technology, it has played a great role in promoting the development of the entire system. The application of this system can effectively carry out the operation and processing of various data, thus ensuring the reliability of the power system operation. Under this development trend, the real-time monitoring of the power system is an important guarantee for the safe and reliable operation of the power system [16]. With the advent of the information age and the rapid development of society, automated communication technology is gradually developing towards networking in the entire system, mainly including the main station, the sub-station and the terminal. Through the application of the network, the communication speed of the power system is improved, and the realization of various functions of the automation system is ensured. At the same time, in power engineering, communication and computer technology are used, and in the case of secondary processing of equipment, the monitoring and measurement of technology have played a great role. Figure 1 shows the data processing flow of the power communication system.

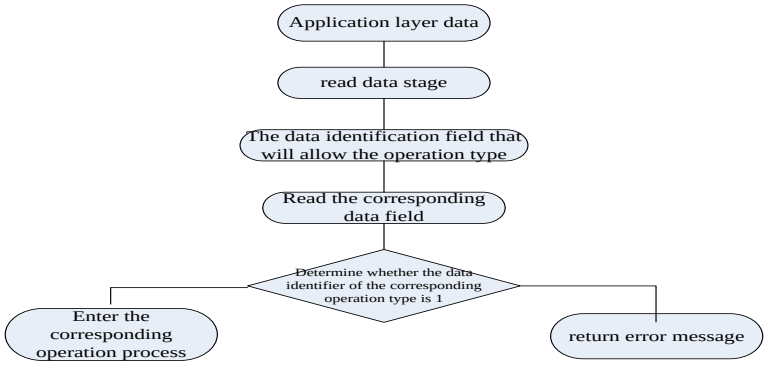

Figure 1: Data processing flow of power communication system

In addition, the current design of automated communication technology in China's power system needs to be further improved. The development of various equipment is of great significance to the safety management of the power system. However, due to the level limitation of power equipment, the automatic management of the power grid becomes more difficult, and with the increase of electricity consumption, the difficulty of equipment operation will also increase [17]. If it is not updated and maintained in time, it may cause the entire power grid to fail. In addition, due to the progress of the times, even if the automatic communication technology is used in the new generation, it has high technical requirements for its safety management. If it cannot be adapted, it may directly lead to the paralysis of the power system, thereby affecting the safety of human property. At the same time, the automation technology of China's power grid needs to be further improved. In the automation application of China's power grid, the increase of power supply will make the power grid load unreasonable, thus affecting the normal operation of the power grid [18]. In addition, in some remote areas, due to the constraints of economic, environmental and other factors, the design level of the power system is not advanced enough to achieve seamless connection with automatic communication technology, which will also affect the normal operation of the power system. At present, the development and construction of China's power system still

needs to be continuously improved to solve the safety problems in the operation of the power system [19]. In the existing research on automation technology, it is necessary to continuously strengthen the research on automation technology to reduce its problems, and improve the maintenance ability of employees at work, prevent major power accidents caused by technical problems, and prevent problems before they occur [20].

3.4 Power System and its Automation Technology Security Control Countermeasures

According to the security risks and problems of the actual power system and its automatic communication technology, the corresponding solutions are proposed. We have discussed the safety of automatic communication technology in power system from the following aspects. First, the design of the power system and its automation is optimized and analyzed from a safety point of view. For example, for the entire construction project, the relevant personnel should fully consider the actual condition of the building when designing the power system and automation [21]. Although there is still a big gap between domestic power system and automatic communication technology compared with foreign countries, we can make it conform to the overall system by constantly improving the design.

In addition, the automation level of each link can be properly enhanced, so as to make the operation of the power system more convenient, thereby improving the safety and automation of the power system. Of course, for the optimization and automation of the power grid, it is necessary to have specialized technical personnel to constantly think and explore, and constantly absorb, learn from, and innovate to make the design scheme more perfect [22]. Secondly, in order to ensure the safe control of the power system and automation technology, a series of measures can be taken to increase the investment in equipment. At the same time, it can increase the investment of power system and automation system. As long as there is sufficient funds, a batch of high-quality instruments that meet the quality requirements of power system and automation system can be purchased. Then, strictly reviewing the purchased power supply system and automatic control, put an end to shoddy, fake and unqualified equipment, ensure the quality of the equipment, and strengthen the safety control and management of the power grid and automation technology. In addition, in order to ensure the quality of the equipment, it should also be properly preserved.

3.5 Power System Automation Communication Model

In recent years, with the continuous development and breakthrough of information technology and automation technology, the use of power automation devices has become increasingly popular, and the communication security control system of power automation devices has become increasingly mature. In the design of the power control system, it is necessary to strictly monitor each link to minimize the internal differences, maximize the overall performance of the control system, and ensure the safe transmission and utilization of electric energy, so as to achieve the purpose of controlling energy consumption. Achieving this control requires specialized, experienced technicians to coordinate it with various power control systems, which makes adjustment and setup difficult. Therefore, it is necessary to optimize the PID controller parameter adjustment and setting process. Chaos search is a new optimization method of safety control system, which is essentially a search method that combines disordered and uncertain data. In recent years, chaos theory has been widely used to solve and discuss various practical problems, and it has also been used in the design of power communication security control systems for power automation devices. The design of chaos theory is based on ergodicity. It gives the following definitions: a certain mapping on chaos is $G(x)$, then the calculation formula is as follows:

$$\lim_{n\to\infty}\frac{1}{N}\sum_{n=1}^{N}G(X_n)=\int\rho(x)G(x)d(x) \tag{1}$$

Among them, $\rho(x)$is the application of the probability distribution density function in this theory.

$$\rho(x)=\lim_{n\to\infty}\frac{1}{N}\sum_{n=1}^{N}\delta(x-x_n) \tag{2}$$

In a probability density distribution, the mean time of an object is the mean state of the object. Taking the IOGISTIC mapping as an example, the mapping is defined as:

$$\mathrm{Y(k+1)=\mu y(k)[1-y(k)]} \tag{3}$$

Among them, μ=4, and $\mathrm{y(k)\in(0,1)}$

After conversion from the above provisions, we can obtain:

$$\mathrm{y(k)=\sin^2(\frac{\pi t(k)}{2})},\mathrm{t(k)\in(0,1)} \tag{4}$$

Among them,

$$\mathrm{\sin^2(\frac{\pi t(k+1)}{2})=\sin^2[\pi t(k)]} \tag{5}$$

Then formula (3) can be expressed as:

$$\mathrm{t(k+1)}=\begin{cases}\mathrm{2t(k),0\le t(k)\le 0.5}\\ \mathrm{2-2t(k),0.5<t(k)<1}\end{cases} \tag{6}$$

As shown in Figure 2, the flow of the algorithm is given, which mainly includes the description of the problem, the transformation of variables, the global rough search and the local fine search.

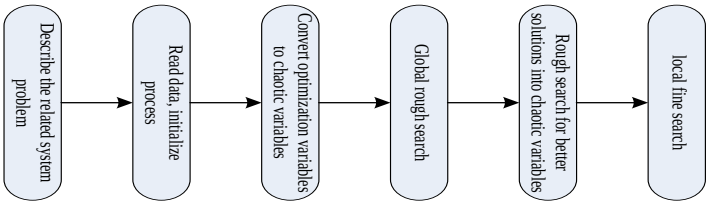

Figure 2: Algorithm flow

The chaotic sequence is not repeatable. According to this law, it can traverse all states in a specific area, which is called trajectory ergodicity, which is the most basic chaotic function optimization. In the electric power automation device, the PID controller has the advantages of simple structure, convenient adjustment of various values, and strong adaptability. Figure 3 shows the structure of the PID controller.

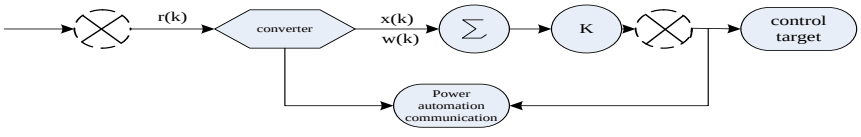

Figure 3: PID Controller Block Diagram

In Figure 3, the input signal $r(k)$ of the inverter is the relevant process and operating state of the automatic communication technology. After passing through the inverter, the signal $r(k)$ is converted into the state quantity x_i, and the state quantity x_i is x_1, x_2, and x_3 respectively.

$$x_1(k) = e(k) \tag{7}$$

$$x_2(k) = e(k) - e(k-1) \tag{8}$$

$$x_3(k) = \Delta^2 e(k) = e(k) - 2e(k-1) + e(k-2) \tag{9}$$

In addition, $\omega_i(k)$ is the weighting coefficient corresponding to $x_i(k)$, K is the neuron proportional coefficient, and K is greater than 0, and the control signal is generated by the neuron through the association search. On this basis, by adjusting the weighting factor to make it adaptive and organized, and monitored by the HEBB learning criterion, the weighting factor is adjusted as follows:

$$\Delta\omega_{ij}(k) = \sigma O_j(k) \tag{10}$$

Through the adjustment of the weight factor, it is correlated with the incentive value and combined with the monitoring mechanism to form the HEBB learning criterion. The calculation formula is:

$$\Delta\omega_{ij}(k) = \sigma[d_j(k) - O_j(k)]O_j(k)O_i(k) \tag{11}$$

With the popularization of power automation communication technology, the production efficiency of the power industry has been greatly improved, and the design of the power communication security system of the power automation device is particularly important. Using the chaos principle to design the power system not only saves the calculation amount, but also has good operability, which makes the parameter setting of the PID controller simple. The design method has certain scientificity and can be widely used in the safety automatic control system of the power system. The promotion of this design method will make its theory more perfect and more scientific.

4. Comparison of Traditional Power System and Automated Power System

Because the communication security of the traditional power system is not high and cannot meet the needs of decentralized clean energy, the traditional intensive management, dispatching and control system can no longer meet the integrated system access of large-scale distributed generation, electricity consumption and energy consumption, and cannot meet the needs of scattered users. If the technical management of the power grid is not regulated, or its deficiencies cannot be fully considered, the role of its safety management will be weakened. In order to solve this problem, it is necessary to strengthen technical management and improve the application of automation technology in the power grid. By training technical personnel and giving full play to the role of automation technology in safety management, the safety management of automation technology can be better achieved, the safety and stability of the power system can be ensured, and the long-term stable development of the power grid can be promoted. It has great changes in terms of user satisfaction, communication security, operation stability, energy utilization, and system operation speed. Figure 4 shows the speed comparison of the two systems.

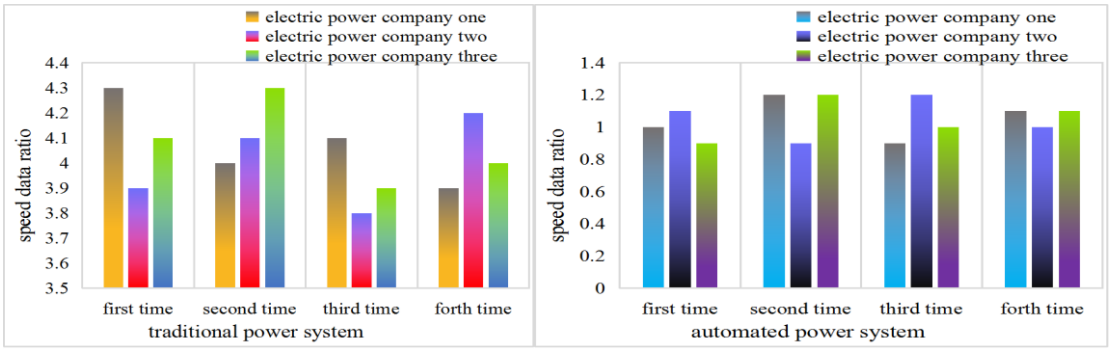

Figure 4: Comparison of operating speeds of the two systems

By using two kinds of power system simulation operation data in different power companies, it can be seen that the traditional power system operation speed, which can also be said to be the data processing speed, is generally maintained in the state of three or four seconds. If there is an emergency, it is easy to get out of control, which will have a great adverse impact on human life. On the contrary, the automatic power system has solved such problems well, making it twice or more faster than the original, laying a foundation for the better development of the automatic power system. Figure 5 shows the comparison of user satisfaction.

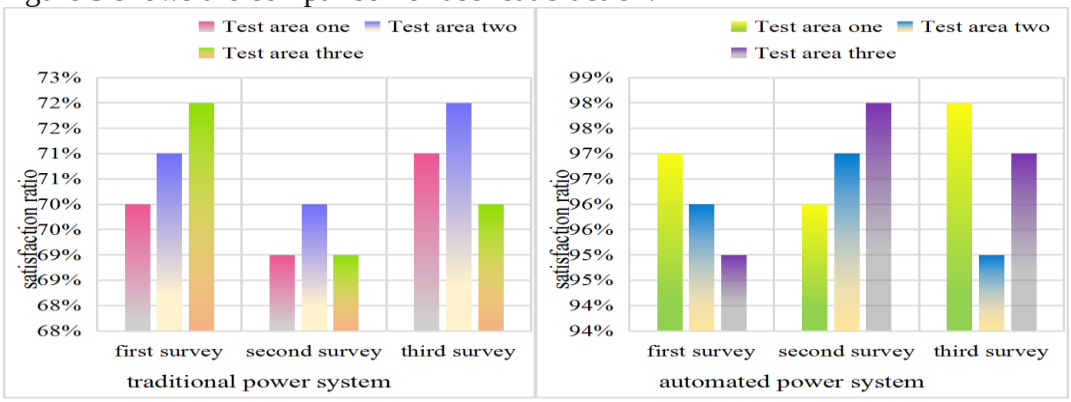

Figure 5: Comparison of user satisfaction

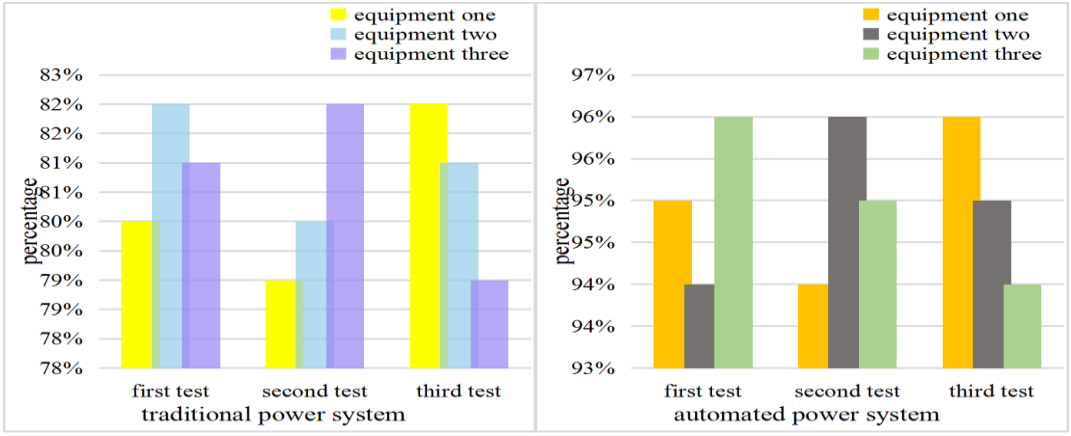

Figure 6: Comparison of operating stability of different systems

In the user satisfaction survey of traditional and automated systems in different regions visited three times, it can be found that although most regions still follow the traditional power system, after all, it also brings great convenience to human beings, but it does not mean that it does not defect. Judging from the survey, user satisfaction is maintained at around 70%, and if there is no

reform, it may show a downward trend. The emergence of automated communication technology systems has solved many problems that traditional power systems cannot handle, and user satisfaction has reached as high as about 97%, reaching full value. We have reason to believe that the future will definitely develop better. As shown in Figure 6, it is a comparison of the operating stability of different systems.

From the comparison of the operating stability of different equipment, it can be seen that the traditional power system may experience faults or short circuits or even large-scale power outages during periods of high electricity demand during use, which seriously affects human life, which is the so-called poor stability. The automated power system has been reformed and updated in all aspects, making its stability increased by 15% or even higher than the original, and has made outstanding contributions to the further development of human society. Figure 7 shows the comparison of communication security.

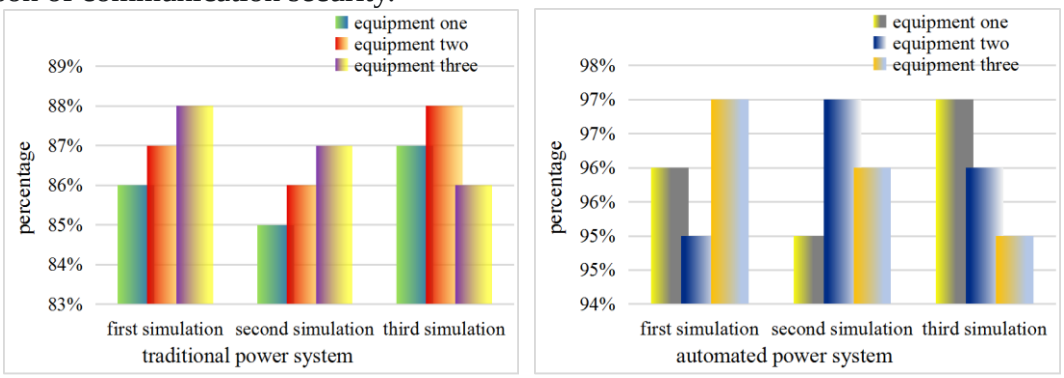

Figure 7: Communication security comparison

With the development of communication technology, the requirements of users are getting higher and higher, and ensuring the security of data and information is a prerequisite for the development of current communication technology. The traditional power system communication technology has problems of information leakage and insufficient signal strength in the development process, and its security is found to be about 87% through testing, which is above the average. But for humans, the safety is far from enough, so the popularization of new technologies is imminent. Only by developing the technology and security of power automation communication technology and doing relevant management and maintenance work can we improve the user's sense of use and solve the security problems in the communication process in a timely manner.

5. Conclusion

The communication technology security strategy of the power system and its automation mentioned in this paper also has some limitations, but its goal is to provide a reference for the relevant personnel and work units of the power system. The safety management of power system and its automatic communication technology is a long-term and systematic work. It is necessary for all power departments to improve their awareness and awareness, strengthen the research on problems in safety management work, and make full use of existing resources to find the optimal solution. In order to realize the safety of power system and its automatic communication technology, in addition to corresponding technology, special operators must also be required. The requirements for equipment are also very high, and the strict control of it is to make it closely connected with our life, and there is no room for loss. To achieve this goal, the relevant personnel must be strictly and carefully trained to ensure the safe operation of the power system. In short, with the wide application of power automation technology, the safe, stable and reliable use of power systems has become an important issue in the power industry. In order to ensure the intelligence and

standardization of the power system, it is necessary to formulate corresponding strategies and working methods based on the actual development of technology, so as to continuously improve the management level of the automation and communication technology of the power system, and lay the foundation for the safety management of the automation technology of the power system.

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