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Effective Application of IoT Power Electronics Technology and Power System Optimization Control

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Abstract: With the development of society, the power system plays an important role in the global energy structure. However, facing increasing energy demand and environmental pressure, improving power system efficiency, reducing costs, and ensuring reliability and safety have become key issues. The Internet of Things (IoT) power electronics technology, as one of the research hotspots, integrates IoT and power electronics technology to achieve intelligent and optimized control of power systems through sensors, communication, and control technologies. In order to meet current and future needs, it is necessary to optimize the operation and management of power systems using IoT power electronics technology. By analyzing the application of Internet of Things power electronics technology and the optimal dispatch of power systems, support vector machine algorithms are used to analyze and process equipment data, and perform data monitoring and anomaly detection to promote energy waste reduction and energy saving, and then start from operation and maintenance respectively. Comparative simulation experiments were conducted in five aspects: efficiency, effectiveness of power load prediction and optimization control, effectiveness of intelligent monitoring, operating costs, and data security. The experimental results show that the operation and maintenance efficiency of the power system using IoT power electronics technology has been improved to only 18 h for equipment fault handling. The accuracy of load forecasting optimization control based on IoT power electronics technology reaches 94%. The fault detection accuracy of intelligent monitoring of power equipment based on the power electronics technology of the Internet of Things has reached 96%. At the same time, the Internet of Things power electronics technology was used to improve the power operation mode, so as to promote the monthly electricity sales revenue of 2.77 million RMB. In addition, the effectiveness of IoT power electronics technology in power data security management has reached 95%. In summary, IoT power electronics technology can improve the stability, reliability, and security of power systems, reduce costs, improve efficiency and management level, and has broad application and promotion prospects.

Key words: power system; power electronics technology; Internet of Things; optimized control; support vector machine

1 Introduction

With the continuous development of the power system, the energy crisis, and the urgent need to increase environmental awareness, the optimal control of the power system has become the primary issue at the moment. The Internet of Things (IoT) power

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electronics technology is a new technology that applies IoT technology to the field of power electronics, which combines sensors, communication technology, cloud computing, and other technologies with power electronic products to achieve intelligent power management and control. The IoT power electronics technology, as a new type of power information technology, has broad application prospects and important driving effects. It connects the physical world with the digital world and achieves real-time monitoring, data collection, intelligent judgment, and automatic control of the power system through technological means such as sensors, intelligent devices, and the Internet, thereby effectively optimizing the operation and management of the power system. At present, there are many problems and challenges in the power system, such as supply and demand imbalance, load fluctuations, equipment aging, energy waste, and so on. The solution to these problems cannot be separated from the application of IoT power electronics technology. Through the IoT power electronics technology, the digitization, intelligence, and automation of power systems can be achieved, enhancing the reliability and efficiency of power system operation, reducing energy consumption and pollution emissions, and promoting sustainable development of the power industry. The application of IoT power electronics technology is of great significance for optimizing the operation and management of power systems. It can improve the intelligence level of the power system, optimize energy utilization efficiency, enhance the sustainable development ability of the power system, and promote the transformation and upgrading of the power industry, thereby achieving sustainable development of the power system and improving social and economic benefits. The Internet of Things power electronics technology can also achieve remote monitoring and control of power equipment. By interconnecting with intelligent devices, the operational status and fault information of the devices can be detected in a timely manner, and timely repairs and maintenance can be carried out. This can greatly improve the reliability and lifespan of the equipment, reduce maintenance costs, and reduce downtime.

The massive integration of power electronic systems poses new challenges to the stability and power quality of modern power grids. Wang and Blaabjerg[1] presented a systematic analysis of harmonic stability in future power systems based on power electronics. He firstly described the basic concepts and phenomena of harmonic stability, pointed out that harmonic stability is a class of small-signal stability problems, and then discussed the linearization model of the converter and the system analysis method[1]. Zhao et al.[2] provided an overview of the technical activities of the working group on power system dynamics and parameter estimation aimed at investigating the additional benefits of dynamic state and parameter estimation for improving power system reliability, safety, and resilience, and discussed in detail the motivation and engineering value of dynamic state estimation[2]. Tuttelberg et al.[3] presented a method for estimating the effective inertia of a power system from the ambient frequency and active power signals measured by a phasor measurement unit, and demonstrated that the inertia can be estimated from the ambient measurement data and not only from the disturbances. The method allowed dividing the system into multiple regions and estimating the effective inertia of each region as a separate quantity[3]. Shangguan et al.[4] designed a robust delay-dependent load frequency control scheme based on delay correlation for a power system based on sampled data control[4]. The above-mentioned scholars analyzed the load frequency related to power system stability, security, and robust delay, which to a certain extent improved the stability and power quality of modern power grids. However, these scholars have not yet conducted a deeper analysis of the optimization control of the power system.

With the increase of power electronics renewable power generation and the advancement of renewable energy integration trends, the control and stability of the power system have been seriously affected, and many researchers have conducted research on this issue. Given the urgent need to address inertial issues, Fang et al.[5] conducted a comprehensive review of inertial augmentation methods, including proven and emerging technologies, and studied the impact of inertia on frequency control[5]. Zhao et al.[6] outlined the application of artificial intelligence in power electronic systems and discussed four types of artificial intelligence applications, namely expert systems, fuzzy logic, meta heuristic methods, and machine learning[6]. The Industrial Internet of Things (IIoT) is a new paradigm for using different services to execute different healthcare applications in daily life. Healthcare applications based on the IIoT paradigm are widely used to track the health status of patients using remote healthcare technology. Complex biomedical sensors utilize wireless technology and remote services in industrial workflow applications to perform different medical tasks, such as heartbeat and blood pressure. However, existing industrial healthcare technologies still need to address many issues, such as security, task scheduling, and cost of processing tasks in IIoT based healthcare models. In response to the above issues, Lakhan et al.[7] proposed a new solution and proposed a blockchain based Deep Reinforcement Learning Task Scheduling (DRLBTS) algorithm framework with different objectives. DRLBTS provides security and effective scheduling for healthcare applications. Then, after initial allocation and data validation, it shares secure and effective data between connected network nodes. The statistical results indicate that DRLBTS has adaptability and meets the security, privacy, and shelf life requirements of distributed network traditional Chinese medicine healthcare applications[7]. Many disease detection and prevention applications in digital healthcare systems are widely used, but usually only focus on prediction and classification, neglecting processing performance and data privacy issues. This study investigates the offloading and scheduling issues of efficient distributed joint learning healthcare systems based on blockchain networks in healthcare applications. To address this issue, Abed Mohammed et al.[8] proposed an Efficient Distributed Joint Learning Offloading and Scheduling (EDFOS) system in blockchain based networks. EDFOS consists of different solutions, such as energy-saving offloading and scheduling, and meets the Quality of Service (QoS) of the application when executed in the system. The simulation results show that compared to existing healthcare systems, EDFOS reduces power consumption by 39%, training and testing time by 29%, and resource leaks and deadlines by 36%. The EDFOS platform is an effective solution to address the power consumption and data privacy issues of healthcare applications[8]. However, these scholars did not analyze the effective application of IoT power electronics technology and power system optimization control, but only explored it from a shallow perspective.

To enhance the efficiency of the power system, reduce operating costs, and ensure its reliability and safety, this article explored how to fully utilize the IoT power electronics technology to improve the optimization control efficiency in the power system. Through experiments on the optimization control of IoT power electronics technology in power systems, it has been found that the use of IoT power electronics technology has significantly improved and enhanced the operation and maintenance efficiency, load forecasting and optimization control, intelligent monitoring of power equipment, upgrading of power operation modes, and data security of the power system. It can provide important support for the reliable and stable operation of the power system.

2 Application Method of IoT Power Electronics Technology

2.1 Application scope of IoT power electronics technology

The IoT power electronics technology refers to the application of modern information technology, communication technology, and automation control technology in the power system to achieve digital, intelligent, and remote management and control of power equipment. The core idea is to use Internet of Things technology to build a data collection, transmission, processing, and analysis platform for the power system. Through cloud computing and big data technology, real-time monitoring and analysis of the operation status, load demand, and other data of power equipment and power system are carried out to improve the efficiency, safety, and reliability of the power system.

In the research of IoT power electronics technology, the following specific technologies can be used to achieve digitalization, intelligence, and remote management and control of power systems.

Sensor technology monitors the working status and environmental conditions of power equipment in real-time by installing various sensors on the equipment, such as temperature sensors, humidity sensors, current sensors, etc. Sensors convert the collected data into digital signals and transmit them to the control system. Communication technology utilizes wireless communication technologies such as Wi-Fi, Bluetooth, LoRa, etc., to transmit data collected by sensors to cloud platforms or control centers. This can achieve remote monitoring and control of power equipment, facilitating real-time management and scheduling of the power system by management personnel. Data storage and processing technology, through cloud computing and big data technology, stores the data collected by sensors in the cloud and utilizes powerful computing power for data processing and analysis. By using technologies such as data mining and machine learning, it is possible to predict power equipment faults and load demands, and take measures in advance to avoid potential problems. Intelligent control technology, based on the results of data analysis, intelligently controls and optimizes scheduling of power equipment. Through automated control algorithms, refined management of various aspects of the power system can be achieved, such as load balancing, supply and demand matching, thereby improving the efficiency and reliability of the power system.

The IoT power electronics technology can be applied to various aspects of the power system, including monitoring, control, and operation management of power equipment. Its main application areas include the following:

(1) Intelligent monitoring of power equipment. The application of IoT power electronics technology in intelligent monitoring of power equipment can achieve multi angle monitoring of power equipment, including real-time monitoring of parameters such as voltage, current, and power. Through IoT technology and big data analysis, it is possible to collect operational data of power equipment and analyze its health status. This can predict faults and abnormal situations in advance, develop corresponding maintenance plans, and avoid equipment damage or failures, thus improving the efficiency and life cycle of the equipment.

(2) Remote control of power equipment. The application of IoT power electronics technology has made remote control of power equipment possible. Remote control can avoid misoperation of power equipment and reduce equipment failures or safety risks caused by human factors. In addition, through remote control, real-time monitoring of the power system can be achieved, problems can be identified in a timely manner, and corresponding measures can be taken.

(3) Load forecasting and optimized scheduling. The application of IoT power electronics technology can make load forecasting and optimized scheduling of power systems more accurate and efficient. The load forecasting of the power system refers to predicting the electricity demand of the power system through big data analysis and model algorithms, combined with factors such as weather, season, and user behavior, to achieve optimal scheduling of the power system[9, 10]. Through load forecasting and optimized scheduling, unnecessary energy waste can be avoided, the operating costs of the power system can be reduced, and the efficiency and stability of the power system can be improved.

(4) Fault diagnosis and maintenance of power equipment. The application of IoT power electronics technology in power equipment fault diagnosis and maintenance has made the troubleshooting and resolution of power equipment faults faster and more accurate. Through various sensors and intelligent control devices, comprehensive monitoring and diagnosis of power equipment can be achieved, problems can be quickly identified, and maintenance and repair measures can be taken in a timely manner. This can significantly reduce the maintenance time and cost of power equipment, and improve the reliability and service life of the equipment.

(5) Power system data security. The application of IoT power electronics technology can ensure the security of power system data. Through real-time monitoring and anomaly detection, network attacks and information leakage events can be identified and responded to in a timely manner, and corresponding security measures can be taken to avoid illegal theft or abuse of power system data[11, 12]. In addition, remote upgrading and safe maintenance of power equipment can be achieved through IoT technology to ensure the normal operation of the power system.

2.2 Power system optimization scheduling and equipment operation and maintenance

The power system is composed of various power equipment and power networks, including power generation, transmission, transformation, distribution, and consumption. It is the infrastructure for achieving people’s electricity supply, providing necessary electricity resources for various industries and daily life. The operation, stability, reliability, and safety of the power system are related to the growth of the national economy and social stability[13, 14]. As shown in Fig. 1, it is the interface diagram of the operating status of the power system. The left side of Fig. 1 shows the status of the five city power systems of City A, City B, City C, City D, and City E, as well as the estimated cost and transmission distance. The right side is the transmission line model and specification, and

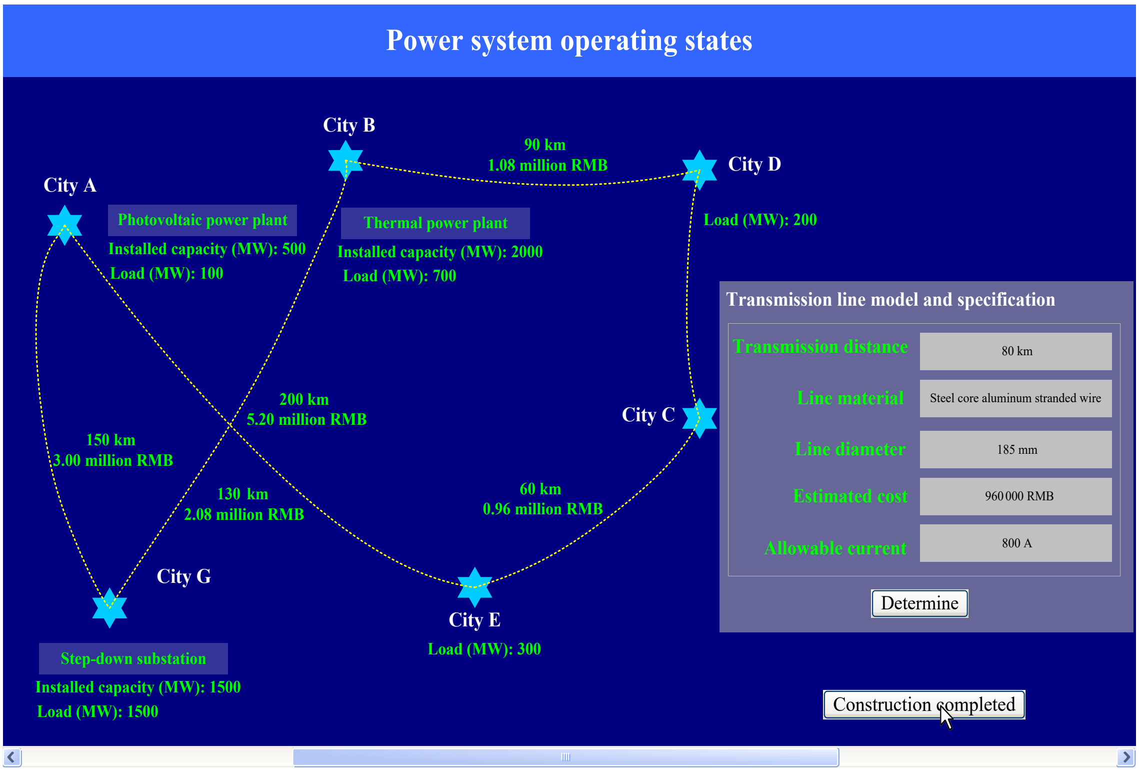


Fig. 1 Power system operation status.

the transmission distance can be set in sequence, line material, line diameter, estimated cost, allowable current, and other parameters. The power system has become one of the necessary infrastructures for socio-economic development and people's lives, and is also an important means to promote clean energy and sustainable development.

(1) Optimal dispatch of power system. Power system optimization scheduling refers to the scientific and reasonable allocation and scheduling of various resources in the power system, enabling the entire system to complete various tasks with the lowest cost, highest efficiency, and best security[15, 16]. The optimization and scheduling of the power system needs to consider multiple factors, including but not limited to power quality, energy consumption, equipment health status, user needs, and other aspects. Through the application of IoT power electronics technology, intelligent monitoring of power systems can be achieved, and problems can be identified and solved in a timely manner, thereby optimizing the operation and resource utilization of power systems.

(2) Equipment operation and maintenance. The operation and maintenance of power equipment is a very important link in the power system. Through the application of IoT power electronics technology, intelligent monitoring and fault diagnosis of power equipment can be achieved, and corresponding measures can be taken in a timely manner for repair and maintenance. By analyzing data on power equipment and predicting model algorithms, it is possible to prevent equipment failures and improve equipment reliability and stability.

2.3 Support Vector Machine (SVM) algorithm

SVM, as an adaptive nonlinear model, has a wide range of applications in IoT power electronics technology and power system optimization control. The basic idea of SVM is to map data into high-dimensional space and find an optimal segmentation hyperplane, so that samples of different categories can be correctly separated. Some samples closest to the segmentation hyperplane are called support vectors, which play an important role in classification.

The application of support vector machines in IoT power electronics technology mainly involves data analysis and processing of IoT devices, as well as energy-saving scheduling of IoT. SVM can be used for monitoring and anomaly detection of IoT device data. By learning and analyzing the historical data of IoT devices, constructing an SVM model can evaluate the normal operation status of devices, and provide early warning and processing in case of abnormal situations, ensuring the safe and stable operation of devices. SVM can be used for energy conservation scheduling in the Internet of Things. By learning and analyzing historical energy usage data, an SVM model is constructed for energy demand prediction and energy-saving scheduling, enabling various devices in the Internet of Things system to operate more efficiently, promoting the reduction of energy waste and energy conservation.

Given training set $\{c_o\}_{o=1}^{M}$, where the subscript o represents the o-th training sample, M represents the total number of training samples, and $c_o \in T^f$, in which T^f refers to an f-dimensional vector. Assuming that the training samples are mapped from the original space to the feature space, the mapping form is $\omega : c \to \omega(c)$, where ω refers to the mapping parameter. In the feature space, to find the hyperplane that separates the training samples from the origin at the maximum interval, the support vector machine needs to solve the following optimization problems:

$$\begin{aligned}&\min_{e,\sigma}, \epsilon \frac{1}{2}\|e\|^2 - \sigma + \frac{1}{bM}\epsilon_o,\\&\text{s.t., } e^Y \omega(c_o) \geqslant \sigma - \epsilon_o,\\&\epsilon_o \geqslant 0, o = 1, 2, \ldots, M\end{aligned} \tag{1}$$

where $e \in T^f$ is the weight vector and σ is the interval parameter. ϵ_o is a relaxation variable and $b \in (0, 1]$ is a percentage estimate. e^Y refers to the y-dimensional vector.

The original optimization problem is not easy to solve. Applying the Lagrange multiplier method, the following dual problems can be obtained:

$$\begin{aligned}&\min_{\beta} \frac{1}{2}\sum_{o=1}^{M}\sum_{k=1}^{M}\beta_o\beta_k l(c_o, c_k),\\&\text{s.t., } \sum_{o=1}^{M}\beta_o = 1,\\&0 \leqslant \beta_o \leqslant \frac{1}{bM}, o = 1, 2, \ldots, M\end{aligned} \tag{2}$$

where β_o is the Lagrange multiplier corresponding to the o-th sample and l indicates the weight parameter. In addition, the weight vector can be written in the following form:

$$e = \sum_{o=1}^{M}\beta_o\omega(c_o) \tag{3}$$

When $0 \leqslant \beta_o \leqslant \frac{1}{bM}$, the corresponding sample is called a support vector, and the interval parameter can be obtained by any support vector c_o:

$$\sigma = \sum_{k=1}^{M}\beta_k l(c_k, c_o) \tag{4}$$

Based on the obtained vector and interval parameters, the final discriminant function of the classifier can be obtained:

$$g(c) = \sum_{o=1}^{M}\beta_o l(c, c_o) - \sigma \tag{5}$$

For new test samples, their category labels are

$$u = \mathrm{sign}(g(c)) \tag{6}$$

where $\mathrm{sign}(\cdot)$ is the indicative function. When $u = 1$, the sample to be tested is normal data, and when $u = -1$, it is abnormal data.

Power equipment failures have a significant impact on the stability and reliability of power system operation. Using SVM models to diagnose power equipment failures can predict and identify equipment failures in advance, providing a basis for equipment maintenance and upkeep[17].

3 Optimization Control Effect of IoT Power Electronics Technology in Power System

As information technology represented by artificial intelligence and big data analysis continues to develop, the applications of IoT, power electronics, and other technologies begin to be widely used in the power system[18, 19]. This article aimed to explore how to fully utilize the IoT power electronics technology to enhance the optimization and control efficiency of power systems. This article designed five sets of experiments to simulate the application of IoT power electronics technology in power systems. These five experiments are: applying IoT power electronics technology to improve the efficiency of power system operation and maintenance, optimizing and controlling power load prediction based on IoT power electronics technology, applying IoT power electronics technology to intelligent monitoring of power equipment, upgrading power operation mode based on IoT power electronics technology, and applying IoT power electronics technology to improve power system data security. To ensure the accuracy of the experiment, this article designed two schemes (Scheme A and Scheme B), selecting 16 power systems. Among them, 8 systems adopt the operation mode of Scheme A, numbered 1–8, and the other 8 systems adopt the operation mode of Scheme B, numbered 1–8.

3.1 Applying IoT power electronics technology to enhance the efficiency of power system operation and maintenance

Experimental purpose: The application of IoT power electronics technology to improve the efficiency of power system operation and maintenance was explored.

Experimental Plan A: Traditional power system operation and maintenance methods were adopted for efficiency indicator data statistics.

Experimental Plan B: IoT power electronics technology was adopted to achieve equipment fault automatic detection and alarm, remote monitoring, and other functions.

Indicator 1: Equipment fault handling time (h).

Indicator 2: Average number of equipment repairs (times).

Indicator 3: Working hours of operation and maintenance personnel (h/month).

Figure 2 shows the application of IoT power electronics technology to enhance the efficiency of power system operation and maintenance. Figure 2a shows Scheme A, and Fig. 2b shows Scheme B.

From Fig. 2, it can be seen that the application of IoT power electronics technology in the operation and maintenance efficiency of the power system had an equipment fault handling time of 18 h, an average of 3 equipment repairs, and a working time of 133 h/month for operation and maintenance personnel. When using traditional power system operation and maintenance methods, the equipment fault handling time was 47 h, the average number of equipment repairs was 8, and the operation and maintenance personnel worked for 232 h/month. Scheme B adopted IoT power electronics technology to achieve equipment fault automatic detection and alarm, remote monitoring, and other functions. Compared to Scheme A, it can significantly reduce equipment fault handling time and maintenance frequency per month, and also shorten the working time of operation and maintenance personnel.

3.2 Power load prediction and optimization control based on IoT power electronics technology

Experimental purpose: The effectiveness of power load prediction and optimization control based on IoT power electronics technology was explored.

Experimental Plan A: Traditional power load forecasting methods and scheduling methods were adopted for efficiency index data statistics.

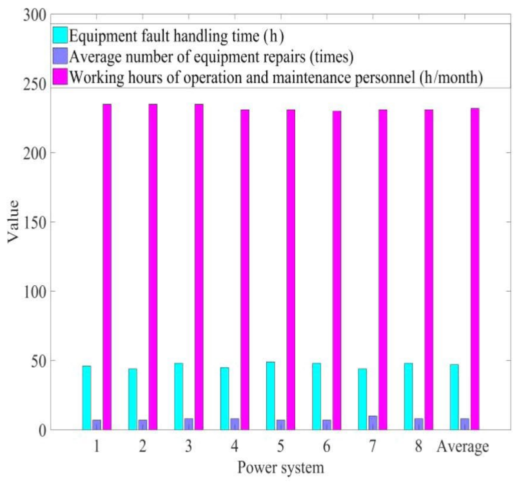
Experimental Plan B: The optimized control method for power load prediction based on IoT power electronics technology was adopted.

Indicator 1: Accuracy of load forecasting (%).

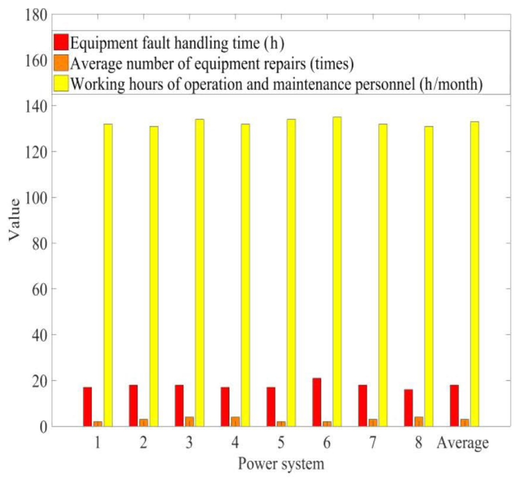
Indicator 2: Power system operation cost (10 000 RMB/month).

Indicator 3: Power loss rate (%).

Table 1 shows the analysis of power load prediction and optimization control based on IoT power



(a) Scheme A



(b) Scheme B

Fig. 2 Analysis of applying IoT power electronics technology to improve the efficiency of power system operation and maintenance.

electronics technology.

As can be seen from Table 1, when using the traditional power load forecasting method and dispatching method, the load forecasting accuracy is 81%, the power system operating cost is 1.121 million RMB/month, and the power loss rate is 3.9%; on the contrary, based on the Internet of Things power electronics technology, the accuracy of load prediction and optimization control is 94% and the effect is quite obvious. Compared with the traditional one, it has increased by 13%. The power loss rate is lower, only 1.8%, which has reduced by 2.1% compared with the traditional one. The operating cost of the power system is 0.950 million RMB/month, which is 0.171 million RMB/month less than the traditional one. This indicates that the use of IoT power electronics technology has achieved more accurate load forecasting and real-time control optimization, while ensuring power supply while reducing the operating costs and power loss rate of the power system.

3.3 Intelligent monitoring of power equipment using IoT power electronics technology

Experimental purpose: The effectiveness of intelligent monitoring of power equipment using IoT power electronics technology was explored.

Experimental Plan A: Traditional methods were used for regular maintenance of power equipment, and efficiency index data statistics were conducted.

Experimental Plan B: IoT power electronics technology was adopted to achieve real-time monitoring and fault prediction of power equipment.

Indicator 1: Accuracy of power equipment fault detection (%).

Indicator 2: Average maintenance time of equipment (h).

Indicator 3: Stability index of intelligent monitoring system (%).

Figure 3 shows the application of IoT power electronics technology for intelligent monitoring and analysis of power equipment. Figure 3a shows Scheme A, and Fig. 3b shows Scheme B.

From Fig. 3, it can be learned that the application of IoT power electronics technology for intelligent monitoring of power equipment had a fault detection accuracy of 96%, an average maintenance time of 19 h, and a stability of 98% for the intelligent monitoring system. By using traditional regular maintenance for power equipment, the accuracy of power equipment fault detection was 76%, the average repair time of the equipment was 34 h, and the stability of the intelligent monitoring system was 90%. This indicates that the use of IoT power electronics technology has achieved real-time monitoring and fault prediction of power equipment. Through the functions of automated detection and error elimination, the accuracy of power equipment fault detection can be greatly improved and the maintenance time of equipment can be reduced. At the same time, the stability and management level of intelligent monitoring can be greatly improved.

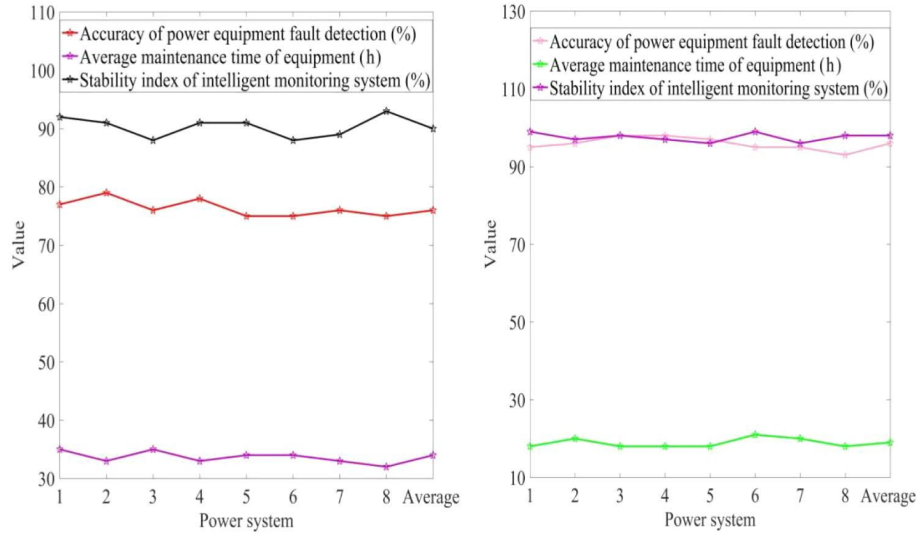
3.4 Upgrading of power operation mode based on IoT power electronics technology

Experimental purpose: The effectiveness of upgrading the power operation mode based on IoT power electronics technology was explored.

Experimental Plan A: The traditional power operation and management model was adopted for

Table 1 Analysis of power load prediction and optimization control based on IoT power electronics technology.

Number of tests	Adopting traditional power load forecasting method and scheduling method			Power load prediction and optimization control method based on IoT power electronics technology		
	Accuracy of load forecasting (%)	Power system operation cost (million RMB/month)	Power loss rate (%)	Accuracy of load forecasting (%)	Power system operation cost (million RMB/month)	Power loss rate (%)
1	79	1.106	3.9	94	0.953	1.6
2	82	1.128	3.8	93	0.945	1.9
3	83	1.125	3.9	94	0.942	2.1
4	80	1.121	4.0	93	0.949	1.6
5	84	1.126	4.1	92	0.955	1.8
6	81	1.120	3.8	93	0.960	1.7
7	82	1.124	4.0	93	0.940	1.9
8	80	1.115	3.9	96	0.958	2.1
Average	81	1.121	3.9	94	0.950	1.8



(a) Scheme A (b) Scheme B

Fig. 3 Analysis of intelligent monitoring of power equipment using IoT power electronics technology.

efficiency indicator data statistics.

Experimental Plan B: IoT power electronics technology was adopted to upgrade the power operation mode through real-time data supervision and automated management.

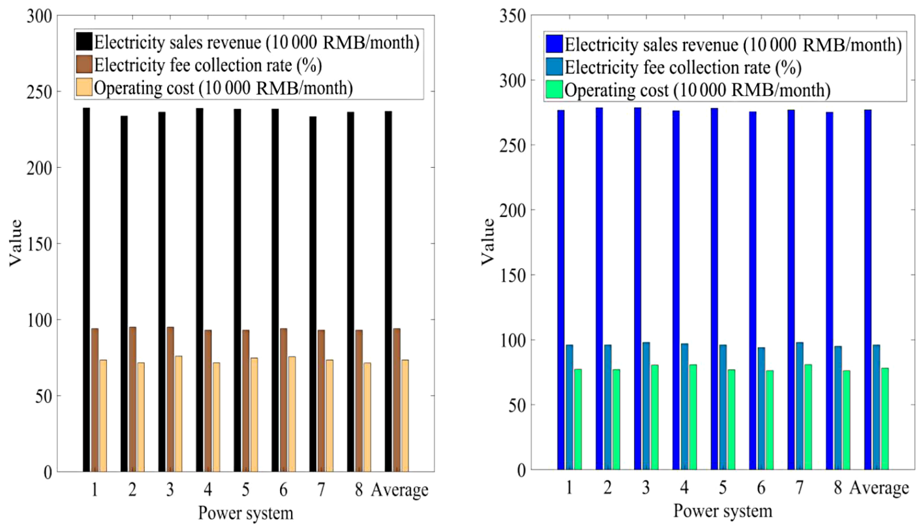
Indicator 1: Electricity sales revenue (10 000 RMB/month).

Indicator 2: Electricity fee collection rate (%).

Indicator 3: Operating cost (10 000 RMB/month).

Figure 4 shows the upgrade analysis of power operation mode based on IoT power electronics technology. Figure 4a shows Scheme A, and Fig. 4b shows Scheme B.

From Fig. 4, it can be learned that the use of IoT power electronics technology to upgrade the power operation mode resulted in a power sales revenue of 2 770 000 RMB/month, a power fee collection rate of 96%, and an operating cost of 782 000 RMB/month. Using the traditional power operation and management model, its power sales revenue was 2 371 000 RMB/month, the electricity fee collection rate was 94%, and the operating cost was 734 000 RMB/month. By applying IoT power electronics technology, electricity sales have significantly increased, and the collection rate of electricity bills has also increased, but operating costs have also correspondingly increased. Therefore, in terms of upgrading the power operation mode, IoT power electronics technology can play an



(a) Scheme A (b) Scheme B

Fig. 4 Analysis of power operation mode upgrade based on IoT power electronics technology.

important role.

3.5 Applying IoT power electronics technology to improve data security in power systems

Experimental purpose: The application of IoT power electronics technology to enhance the security of power system data was explored.

Experimental Plan A: Traditional power data security management methods were adopted for efficiency indicator data statistics.

Experimental Plan B: IoT power electronics technology was adopted to achieve real-time monitoring and anomaly detection of power systems.

Indicator 1: Incidence rate of information leakage events (%).

Indicator 2: Number of network attacks per month (times).

Indicator 3: Effectiveness of existing safety measures (%).

Among them, Table 2 shows the use of traditional power data security management methods, and Table 3 shows the use of IoT power electronics technology for power data security management methods.

From Table 2, it can be seen that using traditional power data security management methods, the occurrence rate of information leakage events was 9.5%, the number of network attacks was 20 per month, and the effectiveness of existing security measures was 86%. From Table 3, it can be learned that the power data security management method using IoT power electronics technology had a rate of 1.7% for information leakage incidents, 4 network attacks per month, and a 95% effectiveness of existing security measures. This indicates that the use of IoT power electronics technology has achieved real-time monitoring and anomaly detection of power systems, improving the reliability of power data, effectively reducing the incidence of information leakage events and the number of network attacks per month, and improving the effectiveness of existing security measures.

Table 2 Adopting traditional power data security management methods.

Number of tests	Incidence rate of information leakage events (%)	Number of network attacks per month (times)	Effectiveness of existing security measures (%)
1	9.2	19	86
2	9.7	22	84
3	9.4	17	87
4	9.9	17	85
5	9.7	21	87
6	9.1	21	88
7	9.2	21	84
8	9.5	23	85
Average	9.5	20	86

Table 3 Power data security management method using IoT power electronics technology.

Number of tests	Incidence rate of information leakage events (%)	Number of network attacks per month (times)	Effectiveness of existing security measures (%)
1	1.9	2	95
2	1.5	5	94
3	1.3	5	96
4	1.5	4	95
5	2.0	3	96
6	1.9	5	96
7	1.9	2	93
8	1.7	5	95
Average	1.7	4	95

4 Discussion

The emergence of IoT power electronics technology has brought new opportunities and challenges to the optimization and control of power systems. By adopting IoT power electronics technology, intelligent control and monitoring of all aspects of the power system can be achieved, including equipment operation and maintenance, load forecasting, and power sales. This article verified the optimal control effect of IoT power electronics technology in power systems through five sets of experiments, and obtained significant conclusions.

In terms of equipment operation and maintenance, the use of IoT power electronics technology can shorten equipment fault handling time and maintenance frequency. The processing time for equipment failure was only 18 h, a reduction of 29 h, and the maintenance frequency was reduced from the traditional average of 8 times to 3 times. Traditional troubleshooting of power equipment requires manual inspection or standby monitoring, which is not only time-consuming and laborious, but also prone to miss detections and misjudgments. The use of IoT power electronics technology can achieve real-time monitoring and remote control of equipment conditions. When there is an abnormality in the equipment, an alarm can be immediately issued and fault diagnosis can be carried out, greatly improving the efficiency of equipment operation and maintenance.

In terms of load forecasting optimization control, the use of IoT power electronics technology can improve the accuracy of load forecasting and reduce power loss rate. The load forecast accuracy reached 94%, and the power loss rate was reduced to 1.8%. Traditional load forecasting methods only rely on simple statistical analysis of past load data and cannot consider the impact of various complex factors. The use of IoT power electronics technology can achieve real-time monitoring and analysis of various environmental factors, resulting in more accurate load forecasting results, and adjust power output based on real-time data to reduce power loss rate.

In terms of intelligent monitoring of power equipment, the use of IoT power electronics technology can achieve real-time monitoring and control of power equipment. The fault detection accuracy is as high as 96%, which is 22% higher than the traditional one. Traditional power equipment monitoring requires manual inspection or installation of specialized monitoring equipment, which is not only time-consuming and labor-intensive, but also prone to miss detections and misjudgments. The use of IoT power electronics technology can monitor the condition of equipment in real-time, analyze and predict potential problems of equipment based on data, and take timely measures to prevent equipment failures.

In terms of upgrading the power operation mode, adopting IoT power electronic technology can increase power sales and electricity fee collection rate. Among them, the income from electricity sales reached 2 770 000 RMB/month, and the electricity bill collection rate reached 96%. The traditional electricity sales model mainly relies on manually filling out electricity meter readings or receiving customer reports for electricity fee calculation, which has significant loopholes and unfairness. The use of IoT power electronics technology can monitor power usage in real-time and calculate electricity bills based on actual electricity consumption, thereby avoiding errors and disputes in electricity bill calculation caused by human factors.

In terms of data security in the power system, the use of IoT power electronics technology can improve the security of power data. The incidence rate of information leakage is only 1.7%, which is 5.8% lower than traditional methods. Traditional power system data are mainly stored in hard drives and are susceptible to hacker attacks and virus infections, posing risks of leakage, tampering, and loss. The use of IoT power electronics technology can achieve encrypted storage and transmission of power data, ensuring the security of power data.

In summary, the IoT power electronics technology has broad application prospects in power systems, which can bring many advantages, including improving equipment operation and maintenance efficiency, reducing power loss rate, improving load forecasting accuracy, increasing power sales and electricity fee collection rate, improving power data security, and so on. Power enterprises should actively promote and apply the IoT power electronics technology to achieve the intelligence and digitization of power systems and better serve social development.

5 Conclusion

The IoT power electronics technology refers to the use of IoT technology to achieve intelligent control and monitoring of all aspects of the power system. Adopting IoT power electronics technology can shorten equipment fault handling time and maintenance frequency, improve load forecasting accuracy, reduce power loss rate, and monitor equipment status in real-time. According to data analysis, the potential occurrence of equipment failures is predicted, electricity sales and electricity fee collection rates are increased, and the security of electricity data is improved. The IoT power electronics technology has broad application prospects, which can help power enterprises achieve intelligence and digitization of power systems, further improving the efficiency and security of power systems, and also enhancing the competitive advantage of power enterprises.

This article has greatly improved the existing problems, but there are also some shortcomings. The power system data analysis and load prediction accuracy are not accurate enough, and the degree of intelligence and digitalization is not deep enough. In addition, with the rapid development of the Internet of Things, power electronics technology, and society, the safety level of the power system is not high enough, and will be further optimized through experiments in the future.

(1) More intelligent. With the continuous progress of technology and the deepening of data analysis, the power electronics technology of the IoT would become more intelligent and automated. The power system predicts load demand through more accurate data analysis, achieves flexible scheduling, and improves power output efficiency. At the same time, the power system can also automatically detect and handle faults, thereby reducing the need for manual intervention.

(2) More digital. The IoT power electronics technology can achieve comprehensive digitization of power systems. Electric power enterprises can establish a digital platform to comprehensively monitor and manage electricity sales, electricity bill settlement, etc., to help enterprises achieve a comprehensive digital transformation.

(3) More secure and reliable. With the popularization and application of IoT power electronics technology, the security of power systems has been further improved. Data security and network security have become important components in the intelligent construction of power systems. Through the application of security technology, the safety of the power system has been effectively guaranteed.

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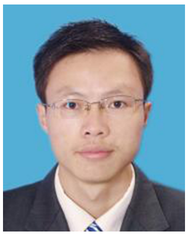

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