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RESEARCH ON FAULT DIAGNOSIS AND MAINTENANCE TECHNOLOGY OF POWER MARKETING SYSTEM BASED ON CENTRALIZED CONTROL MODE

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Abstract: Fault diagnosis operation and maintenance technology of power marketing system is the key technology for the normal operation of power marketing system, which can ensure the accuracy and effectiveness of fault diagnosis. However, traditional power marketing system fault diagnosis operation and maintenance technology is limited by the transformation of mode, resulting in low reliability and small diagnosis range of fault diagnosis. Therefore, the fault diagnosis and maintenance technology of power marketing system based on centralized control mode is proposed. The fault diagnosis and maintenance model of the power marketing system is constructed, and the centralized control mode is introduced to carry out special operation and maintenance processing for the observer and actuator faults of the power marketing system, so as to realize the fault diagnosis of the power marketing system with the centralized control mode. Experimental data show that compared with the traditional fault diagnosis and maintenance technology, the proposed fault diagnosis and maintenance technology of power marketing system based on the centralized control mode has higher reliability and a breakthrough in the diagnosis range.

1.Introduction

Power marketing is that power enterprises in the changing market environment, in order to meet people's power consumption needs for the purpose, through a series of market-related business activities of power enterprises, to provide power products and corresponding services to meet consumer needs, so as to achieve the goals of enterprises[1]. The essence of the electric power marketing is to adjust the level of demand of electric power market, demand time, by the good quality of service meet the requirements of users reasonable utilization, realize the interaction between the electric power supply and demand, the partnership established between electric power enterprises and users, prompting the user take the initiative to change consumer behavior and the way of power consumption, improve the efficiency of electricity, thus increasing the benefit of the enterprise. Power enterprises achieve their goals by satisfying consumers' needs[2]. However, over the years, the "seller's market" in which the demand of electric power enterprises exceeds the supply has led to the employees of electric power enterprises not paying attention to the needs of users, resulting in the production-oriented concept of electric power marketing in enterprises. At the same time, the marketing management concept is weak, the department mechanism is not perfect; Power sales channels are not smooth, power supply services lag behind the user's demand for electricity; The construction of power grid lags behind, and there are some phenomena that power cannot be delivered or used, which seriously affects the power supply. The formation mechanism of electricity price is not scientific, and the excessively high electricity price level restrains the electricity demand of users, etc. Although the power system operating unit constantly takes measures to enhance the reliability of system operation and improve the safe operation level of the power system, the fault diagnosis and operation and maintenance technology of the power marketing system based on the centralized control mode is studied[3].

2.Fault diagnosis and maintenance technology of power marketing system based on centralized control mode

2.1 Fault diagnosis and maintenance model of power marketing system

After decades of development, fault diagnosis of power system equipment and fault diagnosis of power station level have been relatively mature both in theory and in practice. System-level fault diagnosis has only recently started[4]. At present, in the theoretical research. More attention is paid to a single specific equipment, less attention to the comprehensive failure of equipment or system-level failure; In the aspect of alarm information, quantitative information is more used, while qualitative information or uncertain information is less used. In terms of technology utilization, it relies more on single intelligent technology and less on multi-source hybrid technology and collaborative technology. The rapid development of computer technology, communication information technology and artificial intelligence technology provides opportunities and challenges for the study of power system fault diagnosis. Problems in the application of power system fault diagnosis include:

(1) Expression and maintenance of rules -- acquisition and management of knowledge. How to acquire the knowledge of high accuracy and adaptability according to the change of system scale and operation mode, build the corresponding knowledge base quickly, and at the same time automatically check the consistency and completeness of knowledge to eliminate the redundancy and contradiction of knowledge is the primary problem that needs to be solved[5].

(2) Online application of fault diagnosis. The off-line fault diagnosis conclusion can not guide the system operators to control the power system in real time. Therefore, online diagnosis can help the system operation and maintenance personnel to timely grasp the actual fault situation of the system so as to make control decisions.

(3) Dynamic analysis of fault diagnosis[6]. Power system operation is a dynamic operation system. Static analysis ignores a large number of dynamic useful details of the fault process. For large or high-voltage backbone systems, high-speed protection is often adopted, so it is more necessary to analyze the dynamic process.

(4) Logical correlation, display and filtering of alarm signals. Real-time signals collected in time sequence cannot be all displayed to operators, so it is necessary to filter out signals that do not need to be displayed. The signal to be displayed needs to be considered in what manner. How to describe and label the importance of all warning signals uniformly; Which warning signals are interrelated needs further study.

(5) Most of the existing studies focus on equipment or substation layer, and there are few studies on fault diagnosis of dispatching center and centralized control center connected between dispatching center and substation. As the complex faults of interconnected power system often involve multiple substations and multiple lines, the fault diagnosis under the substation layer is powerless when encountering complex faults.

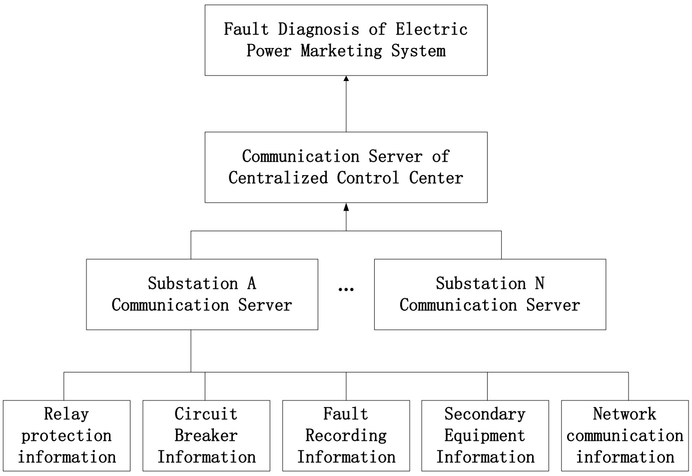

Figure 1. Fault diagnosis and maintenance model of centralized power marketing system

As shown in figure 1, all the information of the fault diagnosis operation and maintenance model of the centralized power marketing system is uploaded to the centralized control center, and then the centralized control center carries out alarm processing and fault diagnosis. The operation personnel of the centralized control center in this mode can master the detailed information of the actual operation of each unattended substation and have a comprehensive grasp of the actual situation on site. The disadvantage is that too much information is too complex, which increases the workload of operation monitoring personnel[7]. Some of the fault information in the operation and failure of the power system needs to be directly uploaded for the operator to master, and some of it is the internal information of the equipment that does not need to be uploaded immediately. All the information uploaded together is not conducive to the monitoring of the operator.

2.2 *Observer performance operation processing*

Since there are uncertainties in the actual power marketing system, the robustness of model-based fault detection and diagnosis technology to these uncertainties is a critical issue. The study on improving the robustness of fault detection and diagnosis techniques is currently focused on the observer-based FDI method. The method based on sliding mode, because of its robustness, can deal with uncertain problems in the system and reduce the possibility of false alarm[8]. So it's widely used. The concept of sliding mode observer is introduced into fault detection, but it is limited to linear systems. A sliding mode neural network observer is designed for a class of nonlinear systems. Before the fault occurs, the existence of the sliding mode is guaranteed, and based on this condition, whether the residual signal is in the specified sliding zone is detected, so as to determine whether the fault occurs. When the criteria are not met, the sliding mode state is destroyed, indicating that a fault occurs, the "fault estimator" in the observer is started, and the online fault morphology is identified by the neural network. The stability of the method was proved by lyapunov theory[9].

According to the fault diagnosis and maintenance model of the centralized power marketing system, the observer is proposed:

$$\mathrm{x}(\mathrm{t}) = A\mathrm{x}(\mathrm{t}) + \mathrm{f}(\mathrm{x}, \mathrm{u}) + L(\mathrm{y}(\mathrm{t}) - C\mathrm{x}) + S(\mathrm{x}(\mathrm{t}), \mathrm{y}(\mathrm{t})) \quad (1)$$

$$\mathrm{y}(\mathrm{t}) = C\mathrm{x}(\mathrm{t}) \quad (2)$$

Where x is the state estimator, y is the output estimator, and $L \in R^{n\times q}$ is the observer gain matrix.

At this point, the adaptive rate of network weight W is set as:

$$W_{\mathrm{i}} = D^{*}\delta_{\mathrm{i}}\sigma_{\mathrm{i}}^{T}(\mathrm{x}, \mathrm{u}) \quad (3)$$

When the system is in normal operation, $\mathrm{t} < T$, $B(\mathrm{t} - T) = 0$ and $\phi(\mathrm{x}, \mathrm{u}) = 0$ fail. You don't have to estimate the failure. Define $D^{*} = 0$. At this point, according to formula (1) and formula

(2), the error is:

$$e（t）=（A-LC）e（t）+f（x，u）-f（x，u）-S（x，y）\quad（4）$$

According to the above analysis, the observer designed according to equations (1) and (4) can ensure the arrival of the sliding mode. In this way, the designed observer is robust, and the estimation error of the sliding mode observer remains within the sliding mode boundary layer when the system is fault-free. Once the system fails, the deviation between the actual system and the estimation model will exceed the matching range, and the sliding mode will be static. Therefore, according to whether the estimation error exists in the boundary layer, the fault can be detected.

2.3 *Fault diagnosis operation and maintenance of actuator*

Considering the uncertain system in which the centralized power marketing system fails, the discrete difference equation is used to describe the process model as follows:

$$\begin{cases} \{X（k+1）=AX（k+1）+\sum_{i=1}^{N}A_{d_i}X（k-di）+a（CX（k），U（K））+\eta+\beta（\vartheta） \\ Y（k）=CX（k）+\mu（X（k），U（k），k） \end{cases} \quad（5）$$

Where, $X\in R^n$ is the state of the system, $U\in R^m$ is the system input, $Y\in R^p$ is the system output, and d_i is the time delay. α is a non-linear function that depends only on the state and the output. $\eta\in R^n\times R^m\times N$ is the uncertain part of the system state, including the uncertain part of the actuator, and $\mu\in R^n\times R^m\times N$ is the uncertain part of the system output, including the uncertain part of the sensor. $A\in R^n\times R^n$ is the coefficient matrix of the non-delay partial state, $A_{d_i}\in R^n\times R^n$ is the coefficient matrix of the system delay partial state, and $C\in R^p\times R^n$ is the coefficient matrix. ϑ fault is mutations, β（k−K） is a function of failure occur at K time[10]. The observer is designed as:

$$\begin{cases} X（k+1）=AX（k）+L（Y（k）-Y（k））+\sum_{i=1}^{n}A_{d_i}+\vartheta（k+1） \\ Y（k）=XC（k） \end{cases} \quad（6）$$

Its initial condition is: $e_x(0)=X（0）$, $L\in R^{n\times p}$ makes $A_0=A+LC$ stable.

When no fault occurs, the diagnostic model has absolute stability. When the fault occurs, the diagnosis scheme is condition stable, and the condition is $\|e_y(k)\|_2\geq\|v_3(k-1)\|_2$.

Therefore, when there is no failure, $D[e_y(k)]=0$,

$\Delta W（k+1）=\dfrac{b（\|v_1(k-1)\|_2+\|v_2(k-1)\|_2）}{\phi_0+1}\leq 0$, satisfies the stability condition.

When there is a failure, $D[e_y(k)]=e_y(k)$, when

$\dfrac{\dfrac{2a^2}{b}e_y(k)^Te_y(k)}{\phi_0+1}-\dfrac{ae_y(k)^Te_y(k)}{\phi_0+1}-\dfrac{2av_3(k-1)\ e_y(k)}{\phi_0+1}$, then in $\|e_y(k)\|_2\geq\dfrac{2}{1-\dfrac{2a}{b}}\|v_3(k-1)\|_2$,

in $\Delta W（k+1）\leq 0$, meet the stability conditions.

The adaptive tracker is:

$$\vartheta（k+1）=\vartheta（k）+\frac{C^TD[e_y(k)]}{\phi 0+\|C\|_2^2}\quad（7）$$

Where, $A_0 = A + LC$, ϕ_0 is an adjustable positive number.

Suppose a failure occurs at step k+1, then:

$$\left\| \mathrm{e_y}(\mathrm{k}+1) \right\|_2 \geq \left\| \vartheta \right\|_2 - \left\| C_{\mathrm{e_x}} + \mu, \ U, \ \mathrm{k}+1 \right\|_2 \geq \left\| \vartheta \right\|_2 - \varepsilon \quad (8)$$

Because, when $\left\| \mathrm{e_y}(\mathrm{k}+1) \right\|_2 \geq \varepsilon$, the fault can be detected, so, when $\left\| \vartheta \right\|_2 \geq 2\varepsilon$, the fault detection can also be completed.

3.Simulation experiment

In order to verify the effectiveness of the fault diagnosis and maintenance model of centralized power marketing system, the following comparative experiment is designed. Taking the range and reliability of power marketing system diagnosis as the experimental object, the system was divided into two groups. The centralized control power marketing system fault diagnosis operation model was the experimental group, and the traditional diagnosis method was the control group. Under the premise of controlling a single variable, the range and reliability of power marketing system diagnosis of the two groups were recorded respectively. The corresponding conditions were set for the experimental data of the two groups. In order to ensure the fairness of the experiment, the parameters of the experimental group and the control group were always consistent. In order to verify the difference between the scope and the reliability of the power marketing system diagnosis, the experimental group will use the centralized control power marketing system fault diagnosis operation and maintenance model to operate according to the requirements, while the traditional method adopts manual processing.

3.1 Reliability comparison of fault diagnosis

In the process of experiment, the hypothesis space is no longer composed of content and time interval, but simply the event content, which avoids the dimension disaster of the hypothesis space. The reliability of alarm nodes is evaluated one by one. If the reliability is greater than the set alarm reliability threshold, it is judged that the occurrence of the alarm is reasonable, and it is marked as a credible alarm node. In this way, the evaluation of alarm node from the cause node is avoided and the misjudgment of tail node is reduced. For simple faults, the alarms are not misreported or missed, and the occurrence time of each alarm is at the midpoint of time sequence constraint. But the actual power system failure is not all simple fault, especially because of the impact of communication conditions and other aspects of the alarm leakage, false alarm time occurs, at the same time the randomness of the alarm time can not be determined. Therefore, by comparing the fault diagnosis operation and maintenance model of the centralized power marketing system with the traditional fault diagnosis model, the results are shown in table 1:

Table 1. Results of different diagnostic models were compared

	The control group	The experimental group
The diagnosis	Line L15 is down	Line L15 is down
	Circuit breaker K24 will not operate	Circuit breaker K24 will not operate
	Circuit breaker K35C phase trip signal not received	Circuit breaker K35C phase trip signal not received
	Circuit breaker K33C phase trip signal misreported	Wrong timing mark for circuit breaker K23C phase trip signal
		Circuit breaker K33C phase trip signal misreported
Time	251s	127s

In terms of diagnosis time, the diagnosis model of the control group needs to establish a fault hypothesis for all the alarm signals received, so the optimization process consumes more time than the diagnosis model of the experimental group. As shown in figure 2 and 3:

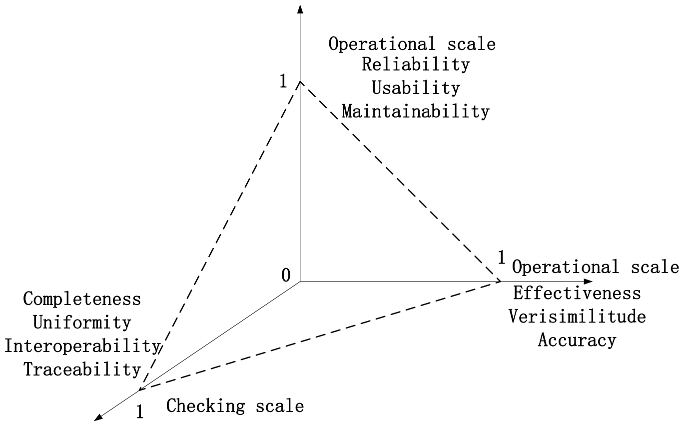

Figure 2. The credibility of the experimental group was evaluated

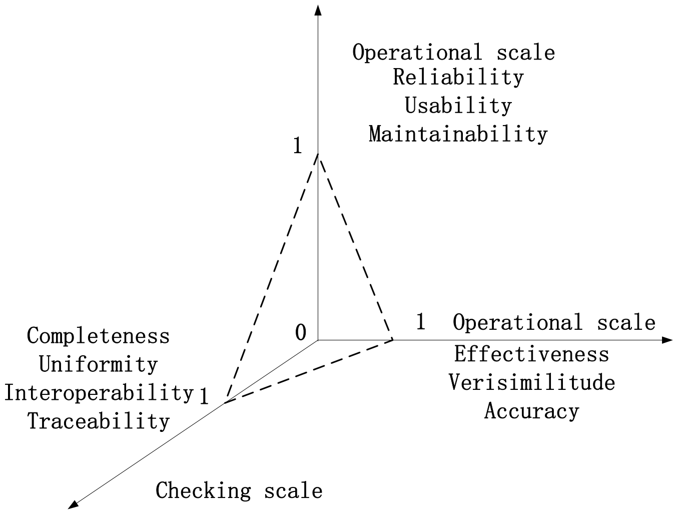

Figure 3. Control group credibility assessment

To sum up, the diagnosis model of the experimental group is much better than the fault diagnosis model of the control group in terms of the accuracy and speed of diagnosis, which overcomes the two shortcomings of the fault diagnosis model of the control group. Reliability analysis above knowable electric power marketing system of fault diagnosis in the contrast experiment, under the same numerical parameters, assessment of the credibility of the experimental group, the integrity of its operation scale, consistency, maneuverability, the accuracy of the authentication system, effectiveness, lifelike, and availability, reliability and maintainability of the running scale values are higher than the control group such as the overall value. Therefore, it can be proved that compared with the traditional fault diagnosis model, the power marketing system fault diagnosis reliability can be effectively improved.

3.2 Comparison of operation and maintenance detection of fault diagnosis range

At the same time, the experimental group and the control group conducted experiments on the fault diagnosis range of the power marketing system, and recorded the fault diagnosis range of the experimental group and the control group 12, 24, 36, 48 and 72 hours later, respectively. In order to avoid the interference of unexpected events on the experimental results, the treatment parameters of the experimental group and the control group were the same, and the specific results were as follows:

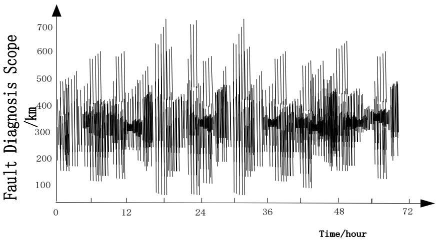

Figure 4. Fault diagnosis range of the experimental group

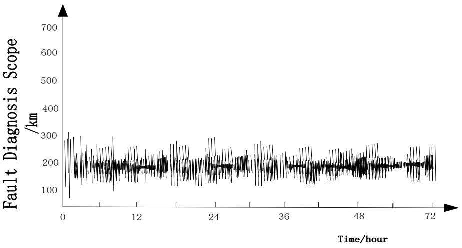

Figure 5. Control group fault diagnosis range

Compared with the above experimental results, the range of fault diagnosis in the control group and the experimental group was introduced for testing, but the range of fault diagnosis in the experimental group was far better than that in the control group. Observation of the figure above shows that the detection range of the control group is constant within the range of 350km, and the detection ability of the control group is weak if the weak signal exceeds the range. Moreover, with the increase of time, the detection ability of the control group becomes worse and worse. The detection range of the experimental group was up to 800km, and the weak signal strength of the reaction was very large, and the detection ability was always strong.

4.Conclusions

In the process of studying the fault diagnosis and operation technology of power marketing system based on the centralized control mode, a fault diagnosis and operation model of centralized power marketing system is proposed according to the time-delay phenomenon of the original system to different degrees. An actuator and sensor fault diagnosis scheme is proposed, in which state and output are estimated by constructing an observer. When a fault occurs, an adaptive tracker is used to track the fault. Because in the practical application process, the control object of power marketing system is often a complex large system, which has serious nonlinear characteristics such as hysteresis, strong coupling, and parameter time-varying, etc. In addition, the mathematical model is not too complex, the statistical characteristics of noise are not ideal, and there are factors such as process uncertainty and external interference, etc., so the diagnostic problems are very complex, and it is impossible for any single method to solve all the diagnostic problems. Therefore, in order to ensure the validity of the model, the model credibility and detection range are finally tested through simulation.

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