[1]Zepeng Wu*

Design Of Ems Scheduling Strategy for Large-Scale Energy Storage Power Plant Based on High-Performance Computing and Its Enhancement of Power System Stability Research

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Abstract: - This paper designs the EMS scheduling strategy, and the EMS scheduling system consists of a central layer, a data layer, and an execution layer. The power operation state data are collected by terminal devices, the acquired data are imported into the central layer through the network, the data are pre-processed by SCADA, the network analysis and optimized dispatching are carried out according to the data, the state regulation module advances the order to be given, and the control order is executed by the terminal devices. A relatively safe power EMS network structure and power EMS network security protection system architecture are established, and the optimization system of power EMS network is set up to reduce power fluctuations. The results show that the node voltage MV probability obtained by the algorithm of this paper is 223, which is the closest to the actual power system trend change. The longest time of system transcription is 9.32s, the highest transcription space utilization is 0.0007%, and the Y value is proportional to the size of the transcription source. The system has the highest power scheduling efficiency and the highest point of scheduling efficiency reaches 50%. The proposed system has the shortest backup time, the smallest backup space usage, the highest predicted value of backup power scheduling data performance, and the best scheduling efficiency, which can effectively improve power stability.

Keywords: ems scheduling strategy; power operation state; data preprocessing; network structure; power fluctuation

1. INTRODUCTION

Power system is an important part of the national economy, but also the basis of the national economy and people's livelihood, at the same time as its scale has been expanded accordingly, the amount of relevant data has also gradually increased [1]. Power scheduling data is an intrinsic requirement of the rapid development of the national economy, in recent years, the progress of science and technology to promote the development of the power system, at the same time, the power system is working more and more widely, the workload is getting higher and higher, and at the same time the quality of power requirements are also getting more and more, so to improve the completeness of the scheduling data, the accuracy and the stability of the electric energy has become a key point of the power system's current work [2]. Improper operation, computer damage and flooding and other uncontrollable factors may cause power scheduling data is incomplete, when the data is incomplete in the case of the first priority is to consider how to modify the data, restoration, will not lead to the power system disorder [3]. In order to avoid the system failure caused by incomplete data, it is necessary to set up an automatic data transcription system, through which real-time scheduling data of the power system can be

[1] University of Sunderland, UK.Email:mreichel7@liberty.edu

transcribed, in order to avoid the abnormal operation of the power system caused by incomplete data [4].

In this paper, the EMS scheduling strategy for large-scale energy storage power plants is designed to apply vectorization technology to power system computation, which can greatly improve the program running speed and reduce the complexity of modeling and algorithm development. The basic principles of vectorization technology and its application in the field of high-performance power science numerical computation are introduced, and the relevant vectorization computational equations for tidal current computation in right-angle coordinates and polar coordinates are deduced to illustrate the feasibility of the application of vectorization in the modeling and algorithmic implementation of power systems. When designing the power EMS network security strategy, the network boundary of power EMS is firstly cleaned up, a relatively safe power EMS network structure is established, and zoning is carried out according to the security needs and characteristics of different parts. And isolation is carried out between different areas, and the security protection strategy design is carried out for the plant and station end network and the control layer network respectively, to obtain the power EMS network security protection strategy, so as to provide a better guarantee for the safe and stable operation of the power EMS.

2. RELATED WORDS

For the problem of energy storage and conventional electric energy allocation, literature [5] proposes that according to the energy storage capacity, the proportion of responsibility with the unit is agreed in advance, but the method ignores the actual participation of energy storage in the dynamic change of capacity characteristics. Literature [6] summarizes the research on energy storage system applied to secondary frequency regulation, using energy storage and wind power with the wind farm has a certain scheduling capacity, participate in the secondary frequency regulation, is a current research hotspot. Literature [7] proposes a power decomposition idea, the power demand signal is decomposed, and the energy storage and the unit bear different frequency components. Literature [8] studied the joint participation of electric vehicles and heat pump water heaters in the secondary FM method, also introduced the SOC feedback, the simulation results show that the energy storage has a superior FM effect, but the FM effect decreases when the energy storage capacity is larger. For the study of energy storage participation in the secondary frequency control strategy of high efficiency, literature [9] designed a distributed robust controller for energy storage frequency regulation, the load and renewable new energy fluctuations of the high-frequency part of the energy storage system by the energy storage system, the low-frequency part of the traditional unit, giving full play to the advantages of the fast speed of the energy storage, avoiding the disadvantage of its limited power. Literature [10] designed the energy storage control strategy of SOC to realize the smooth correction of energy storage system output.

3. EMS SCHEDULING DESIGN FOR LARGE-SCALE ENERGY STORAGE POWER PLANTS

3.1 Power EMS Functions

EMS is the core component of power system dispatching control, which is very important for the safe and stable operation of power system. The function of power EMS is shown in Fig. 1, and EMS mainly contains the center layer, data layer and execution layer. Firstly, the terminal devices such as RTU and PMU located in the plant and station layer perform data acquisition of power operation status and other data, and then upload the acquired information to the central layer on the basis of the dispatching data network, and then SCADA performs preliminary processing of the uploaded data. Then network analysis and optimized scheduling are carried out based on the uploaded data, and the ASC/AGC/AVC state regulation module completes the ordering, transmits the control commands through the power scheduling data network, and finally the control commands are executed by the terminal devices such as ASC/AGC/AVC at the plant and station layers [11-13]. The details are as follows:

(1) Remote Terminal Unit RTU is a monitoring device installed at remote sites, responsible for monitoring and controlling the field equipment, and converting the measured signals into a data format that can be transmitted on the power dispatching data network. At the same time, RTU can also execute the control commands issued by the dispatching layer, which is an important part of the power network. The realization of telemetry, remote control, telecommunication and other functions before each plant station and the dispatching office need to be completed by the remote terminal unit for information transmission [14].

(2) The power system synchronous phase measurement device is used to carry out the measurement and output of synchronous phase in the field equipment of the power system, and store the measurement data, and can transmit the measurement data to the master station in real time.

(3) The power dispatching data network is used to transmit communication monitoring data during power system production, real-time operation data of power dispatching, and so on.

(4) SCADA, also known as data acquisition and monitoring control system, can realize the functions of data acquisition, measurement and equipment control, and is the most important sub-system in power EMS. Through SCADA system, the uploaded data can be preliminarily processed, which enables the dispatching center to correctly grasp the information on the operating status of the power system, so as to carry out the monitoring of the operating status of the system, control decision-making and fault diagnosis.

(5) ASC/AGC/AVC state regulation module includes automatic stabilization control, automatic power generation control and AVC automatic voltage control, which are the three major control systems in the power system. The ASC/AGC/AVC state regulation module completes the power scheduling for decision-making and control, which can guarantee the safe and stable operation of the power system [15].

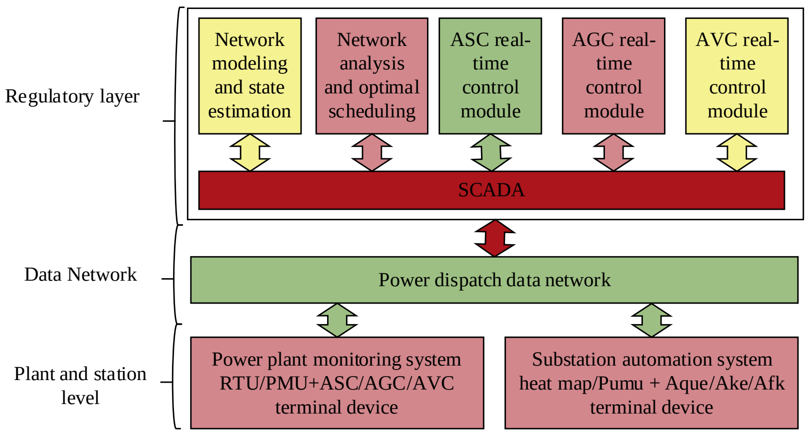

Figure 1 Power EMS functions

3.2 Power EMS network security protection system

EMS power dispatching system mainly contains three parts: the control layer, the data network, and the plant and station layer, so before constructing the electric power EMS network security protection system, it is necessary to fully take into account the relevant security needs analysis from these three aspects, and then design the EMS network security protection strategy according to the needs of the different levels respectively [16]. Before building the EMS network security protection system, the boundaries of the electric power EMS should be cleaned up, and the cleaned up EMS network is more simple and safe. And based on the security needs of the three parts of the regulation layer, data network and plant and station layer, the region is divided, and the security protection strategy design is carried out for the plant and station end network and the regulation layer network respectively, so as to get the electric power EMS network security protection strategy, so as to provide a better guarantee for the safe and stable operation of the electric power EMS.

3.2.1 Establishment of a relatively secure power EMS network structure

The power EMS network can be viewed as a ring network containing three parts: the regulation layer, the data network, and the plant and station layer, which is in a non-open state, so the design of the power EMS network lacks security considerations, resulting in the fact that as long as the network devices connected to the internal EMS can access the RTUs, which creates a security threat. Therefore, the security protection of power EMS networks starts with the establishment of a relatively secure power EMS network structure [17].

Fig. 2 shows a relatively secure power EMS network structure, where devices at the regulation and control layer only access the data at the plant and station level through the SCADA server system, and other EMS workstations indirectly access the data at the plant and station level and make decisions about RTUs and control them by connecting to the SCADA server system. Within the plant-station layer, only the plant-station layer control system is allowed to directly control RTUs and terminal units, and other equipment and computer pairs are not allowed to access RTUs [18]. In the plant-station layer, the RTU devices of the power plant monitoring system and substation automation system are responsible for monitoring and controlling the power plant and substation, and their security is very important for the power plant and substation. If the RTU devices are directly connected to the grid control layer, when the grid control layer is hacked, the hackers can easily monitor and control the RTU devices, threatening the security of power plants and substations. Therefore, the RTU devices are isolated from the grid control layer devices, the RTU devices only communicate with the SCADA server, the SCADA server is connected to the grid control layer, and the SCADA server collects the data from the RTU devices and sends the grid control commands to the RTU devices [19]. This network structure clarifies the power EMS network structure, reduces the number of EMS network boundaries, and can effectively isolate RTU devices, adding a barrier to improve the security of RTU devices.

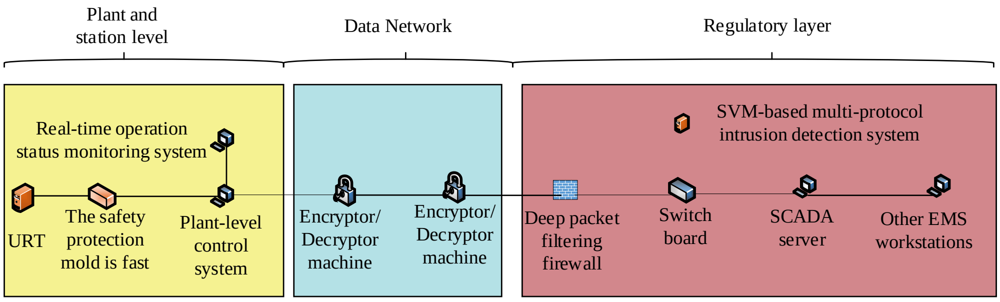

Figure 2 Relatively safe power EMS network structure

3.2.2 Power EMS Network Security Protection System Architecture

Based on the relatively secure power EMS network structure, this paper proposes a power EMS network security protection system, the basic idea of which is to place modules with similar and close security requirements in the same region. Firewalls or security isolation devices are used for protection between different areas, and protection can be disregarded or the means of protection can be reduced in the interior of the same security area. The number of security protection devices that need to be deployed can be as small as possible, thus reducing the cost of protection [20]. Moreover, the deployed security isolation firewalls and deep packet filtering firewalls are embedded in using the bridge mode, which will not destroy the original network topology.

Power EMS network security protection system architecture is shown in Figure 3, power EMS network is divided into plant and station layer network, scheduling data network and control layer network, in the relative security of the power EMS network structure on the basis of the diagram, according to the above analysis of the network security of the power EMS as well as the plant and station layer and control layer of the network security needs analysis, the paper for the different network areas to design the corresponding security defense Measures are as follows:

(1) In order to avoid the network security threat of the power EMS equipment at the plant and station level, use the security protection module to isolate the control system at the plant and station level from the RTU. And access control is carried out on the plant station layer control system to prevent unauthorized illegal access to the control system and to avoid illegal access and attack on the RTU as well as terminal equipment by attacking the control system [21]. The plant level control system is a very important device in power EMS, once the plant level control system is attacked, the RTU and terminal equipment will be greatly threatened. Setting up the security protection module is the threshold of communication between the plant level control system and RTU, and only by guaranteeing the network security of the power EMS plant level control system can the network security of the power EMS plant level equipment be truly guaranteed.

(2) Between RTU and SCADA system involves the transmission of scheduling data and control instructions, which requires high real-time communication, and is the focus and core of power EMS network security protection. As can be seen from the analysis of the security of power EMS in the previous section, the data transmission between the plant and station level and the control level is carried out through the power dispatching data network, and encryption and decryption have been carried out before and after the transmission of the dispatching data network, but the deceptive attack based on the vulnerability of the communication

protocol cannot be prevented. In this paper, based on the telecommunication protocol IEC60870-5-104 protocol and DNP3.0 protocol to protect the power EMS control layer network, in order to avoid the protocol vulnerabilities to the power EMS control layer network brings various security risks, in the control layer of the internal deployment of the depth of the packet filtering firewall for network security protection. At the same time, the communication traffic between RTU devices and SCADA servers is monitored, and a multi-protocol based abnormal traffic detection system is used to provide timely alarms and processing once abnormal traffic is detected. Through the combination of deep packet filtering firewall and intrusion detection system protection strategy for the control layer network security protection and detection, to prevent the communication between the plant station side and the dispatching master station from being attacked by deception [22].

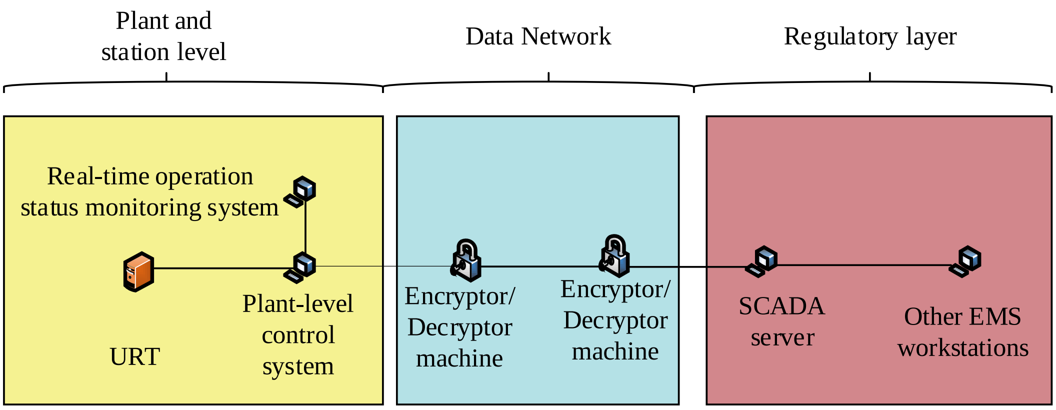

Figure 3 Power EMS network security protection system architecture

4. HIGH PERFORMANCE COMPUTING BASED ON VECTORIZATION TECHNIQUES

4.1 Principles of vectorization

The core purpose of adopting vectorization technology is to improve the running speed of the program, whether in a stand-alone or distributed environment, to improve the running speed of the program, it is necessary to optimize the various basic aspects of the fetch finger - decoding - fetch operand - execution. The basic idea of vectorization is to make full use of the hierarchical storage system of the computer, as far as possible, for the continuous data in the cache for the operation. At the same time, it is necessary to ensure that the computation applied in the Cache is independent of the data address in the storage unit, which can reduce the time of fetching instructions and calculating the operand address, and improve the CPU's efficiency in the execution of core computing tasks, such as floating-point operations. Computation-independence also ensures that symmetric multiprocessor systems, or distributed environments, can effectively increase the parallelism of program execution [23].

For example, A is a real matrix, and to take the trigonometric sine of all the elements in A, the nonzero elements of A can be taken into a contiguous block in Cache, and a separate trigonometric sine operation can be performed on each element of that block. $\sin(A)$ is a vectorized description of the above operation. Vectorization is supported by hardware platforms and compilers at both compile time and runtime.

4.2 Vectorized Description of High Performance Computing

4.2.1 Interpretation of meaning

Vectorization is a general processing method with universal applicability. The mathematical model of the power system determines that the basic equations of the power system can be vectorized [24]. The calculation of tidal currents in right-angle coordinates and polar coordinates will be analyzed as an example, and the meanings of vectorization symbols used in this paper are explained as follows for the sake of narrative brevity:

(1) $.\times$ denotes the new object obtained by multiplying the corresponding elements between 2 vectors or 2 matrices.

(2) $diag\left(e\right)$ is the conversion of vector e to a diagonal sparse matrix.

(3) $e\left(i\right)$ is to reorder vector e with integer vector i and return the sorted vector. $diag\left(A\right)$ means to take out the diagonal elements of matrix A to form a new column vector.

(4) $G\left(i,j\right)$ is for reordering matrix G with integer vector i,j, returning the sorted matrix.

4.2.2 High Performance Computing in Cartesian Coordinates

The HPC tidal equation in rectangular coordinates is:

$$\begin{cases} P_{Gi}-P_{Li}-e_i\sum_{j=1}^{n}\left(G_{ij}e_j-B_{ij}f_j\right)+f_i\sum_{j=1}^{n}G_{ij}f_j-B_{ij}e_j=0 \\ Q_{Gi}-Q_{Li}-f_i\sum_{j=1}^{n}\left(G_{ij}e_j-B_{ij}f_j\right)+e_i\sum_{j=1}^{n}G_{ij}f_j-B_{ij}e_j=0 \end{cases} \tag{1}$$

If the node voltage, supply power, and load power are written in the form of corresponding vectors, with G,B being the real and imaginary parts of the conductivity matrix, respectively, and noting $x=\left[e^T,f^T\right]^T$, the above equation can be written as:

$$h\left(x\right)=\begin{bmatrix} P_G-P_L-e.\times\left(Ge-Bf\right)-f.\times\left(Gf+Be\right) \\ Q_C-Q_L-f.\times\left(Ge-Bf\right)+e.\times\left(Gf+Be\right) \end{bmatrix}=0 \tag{2}$$

Due to the method of arranging the variables in groups, the Jacobi matrix is a chunked structure. Examining matrix $\frac{\partial\Delta P_i}{\partial e_i}$, the formula for the elements: when $i\neq j$, then there is:

$$\frac{\partial\Delta P_i}{\partial e_i}=-\left(G_{ij}e_i-B_{ij}f_i\right)-\sum_{j=1}^{n}\left(G_{ij}e_j-B_{ij}f_j\right) \tag{3}$$

The above equation can be expressed uniformly by a simple observation:

$$\frac{\partial \Delta P}{\partial e} = -\left(Gdiag\left(e\right) - Bdiag\left(f\right)\right) - diag\left(Ge - Bf\right) \tag{4}$$

Similarly, the equations for the remaining sub-blocks of the Jacobi matrix can be derived. The corrections for each variable can be obtained by choosing the appropriate coefficient matrix optimization ranking algorithm and numerical decomposition algorithm to solve the correction equations. The optimal ordering algorithm is transparent to the trending computation, and there is no need to employ a special strategy of arranging the variables throughout the computation in order to solve the equations efficiently [25]. The speed of global calculation can be ensured by applying the vectorization method, and the contact line power is calculated by the equation:

$$\begin{gathered} P_{ij} = \left[e(i) \times e(i) + f(i) \times f(i) - e(i) \times e(j) - f(i) \times f(j)\right] . \times \\ diag\left(G(i,j)\right) + \left[e(i) \times f(j) - e(j) \times f(i)\right] \times diag\left(B(i,j)\right) \end{gathered} \tag{5}$$

4.2.3 High Performance Computing in Polar Coordinates

The HPC trend equation in polar coordinates is:

$$\begin{cases} P_{Gi} - P_{Li} - V_i \sum_{j=1}^{n} V_j Y_{ij} \cos\left(\delta_{ij}\right) = 0 \\ Q_{Gi} - Q_{Li} - V_i \sum_{j=1}^{n} V_j Y_{ij} \cos\left(\delta_{ij}\right) = 0 \end{cases} \tag{6}$$

Eq. $\delta_{ij} = \theta_i - \theta_j - \alpha_{ij}$, where Y_{ij} and α_{ij} are the magnitude and phase angle of the corresponding elements in the conductivity matrix, respectively. If we write $x = \left[V^T, \theta^T\right]^T$, define $e = [1,...,1]^T$ and $A = \theta e^T - e\theta^T$, and the admittance matrix is $Y < \alpha$, then the vectorized form of the above equation is:

$$h(x) = \begin{bmatrix} P_G - P_L - V.\times\left(Y.\times\cos\left(A - \alpha\right)V\right) \\ Q_C - Q_L - V.\times\left(Y.\times\cos\left(A - \alpha\right)V\right) \end{bmatrix} = 0 \tag{7}$$

Examine the formula for the elements of matrix $\frac{\partial \Delta P}{\partial \theta}$: when $i \neq j$, then there is:

$$\frac{\partial \Delta P_i}{\partial \theta_i} = -V_i Y_{ij} V_j \sin\left(\delta_{ij}\right) \tag{8}$$

When $i = j$, then there is:

$$\frac{\partial \Delta P_i}{\partial \theta_i} = V_i \sum_{j \neq i, j=1}^{n} Y_{ij} V_j \sin\left(\delta_{ij}\right) \tag{9}$$

Remembering the symmetry of Y , the above equation can be expressed uniformly as:

$$\frac{\partial \Delta P}{\partial \theta} = -diag\left(V\right)\left(Y \times \sin\left(A^T - \alpha^T\right)\right)diag\left(V\right) + diag\left(V \times \left(Y \times \sin\left(A - \alpha\right)V\right)\right) \quad (10)$$

The formulae for the remaining sub-blocks can be derived in the same way. The formula for contact line power is:

$$P_{ij} = -V_i^2 Y_{ij} \cos\left(\alpha_{ij}\right) + V_i Y_{ij} V_j \cos\left(\delta_{ij}\right) \quad (11)$$

The corresponding vectorization is calculated as:

$$\begin{aligned} P_{ij} = -V\left(i\right) \times V\left(i\right) \times diag\left(Y\left(i, j\right)\right) \times \cos\left(dig\left(\alpha\left(i, j\right)\right)\right) + V\left(i\right) \times V\left(j\right) \times \\ diag\left(Y\left(i, j\right)\right) . \times \cos\left(\theta\left(i\right) - \theta\left(j\right)\right) - diag\left(\alpha\left(i, j\right)\right) \end{aligned} \quad (12)$$

Essentially, the process of forming vectorized formulas is actually the process of reconstructing the execution order of algorithmic instructions, and the use of vectorization methods can ensure the speed of global computation.

The high efficiency of system scheduling is the basis for ensuring the stability of electric power, and the power scheduling efficiency is the key index reflecting the EMS scheduling performance of the automated system, and the scheduling efficiency η can be derived by the following formula:

$$\eta = \frac{k^2 / \Gamma_S \Gamma_D}{\left(\sqrt{1 + k^2 / \Gamma_S \Gamma_D} + 1\right)} \quad (13)$$

Where, k is used to describe the coupling factor, which is a reflection of the transfer rate. $\Gamma_S \Gamma_D$ is used to describe the rate of energy dissipation in the power scheduling process, the higher the value of scheduling efficiency, the faster the power scheduling, the higher the scheduling performance of the automated system.

5. POWER SYSTEM STABILITY ANALYSIS

This experiment is conducted to verify that the high-performance computing large-scale energy storage power plant EMS scheduling strategy studied in this paper can improve the stability of the power system. The current calculation method based on the forest algorithm and the probabilistic current calculation method based on the DAEM algorithm for wind power grid-connected system are compared with the high-performance calculation based on vectorization technology in this paper, and the performance of EMS scheduling for new energy large-scale energy storage power plants is analyzed. At the same time, the backup sources of five types of data are obtained, and their backup source sizes are 1MB, 10MB, 100MB, 500MB, and 1000MB, respectively.In the process of verifying the power stability, the system in this paper is verified to contribute to the improvement of the power stability from three aspects: the analysis of the probability density of voltage amplitude, the analysis of the backup performance of the system, and the analysis of the system scheduling efficiency.

Due to the large number of operations involved in this experiment and the need to present the results of the study in the form of plots, MATLAB is used for the numerical analysis and calculation of this experiment. In the experiment, the random variable data are mainly read directly into the program by the MATLAB data read-in statement through the Excel table.

5.1 Voltage amplitude probability density

The current calculation method based on the forest algorithm, the probabilistic current calculation method based on the DAEM algorithm for wind power grid-connected system, and the high-performance calculation method based on the vectorization technique are compared, and the distribution of the voltage magnitude probability density is shown in Fig. 4. The measured value of the node voltage MV probability at the highest point of the voltage magnitude probability density is 225, the node voltage MV probability under the current calculation method based on the forest algorithm is 260, and the node voltage MV probability obtained by the probabilistic current calculation method of the wind power grid-connected system based on the DAEM algorithm is 248. Therefore, the current calculation method based on the forest algorithm and the probabilistic current calculation method of the wind power grid-connected system based on the DAEM algorithm have the same value as that obtained by the current calculation method based on the forest algorithm. Therefore, the node voltage MV probability obtained by the current calculation method based on the forest algorithm and the wind power grid-connected system based on the DAEM algorithm is overestimated, and the results cannot truly reflect the fluctuation of the node voltage after the new energy grid-connected system. In this paper, the high-performance calculation method of vectorization technology obtains the node voltage MV probability of 223, and the calculated probability distribution characteristics are closest to the actual power system trend changes. Therefore, it can be proved that the method of this research is more accurate in the measurement of voltage amplitude probability density distribution situation, and the system of this paper can effectively promote the stability of the power system.

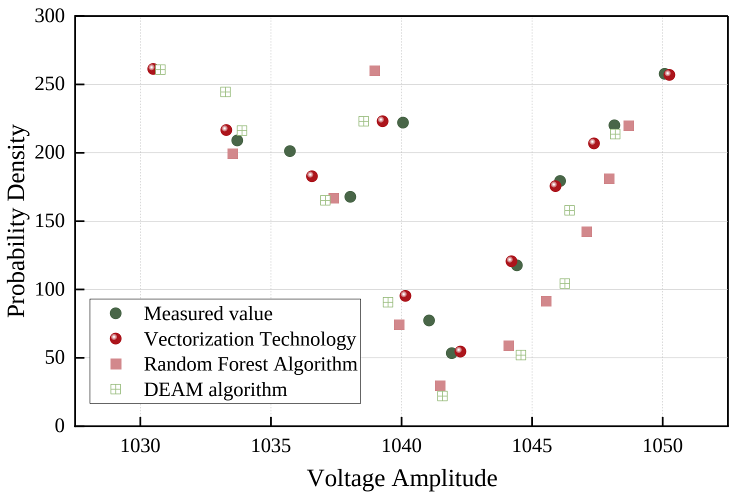

Figure 4 Voltage amplitude probability density distribution

5.2 System Backup Performance Analysis

For different sizes of power scheduling data backup sources, power scheduling data backup is carried out separately to compare the backup process of different systems, and the performance test results are shown in

Table 1. Where, Y value represents the predicted value of the performance of different systems for backing up power dispatching data. RF represents the random forest algorithm, D is the DEAM algorithm, and VT is the vectorization technique proposed in this paper.

Using the system of this paper to transcribe the scheduling data, and in order to ensure the comprehensiveness of the experiment, the size of the data transcribed varies, the backup time of the system of this paper is the longest of 9.32s, and the highest utilization rate of the transcription space is 0.0007%, and the Y-value is directly proportional to the size of the transcription source. Under the condition of the same backup source size, the time used for transcription and the transcription space utilization rate of the power dispatching system based on forest algorithm are higher than that of this paper's system, and there is no obvious regularity in the Y-value.In the process of backing up the backup source of the power dispatching system based on DAEM algorithm system, the time used for transcription is smaller than that of this paper's system when the source of transcription is not larger than 100MB, and the time used for backing up the source of transcription is not smaller than 100MB, showing a significant upward trend and higher than that of this paper's system. Shows a significant upward trend and is higher than that of the system in this paper. When the transcription source is not less than 100MB, the backup time shows a significant upward trend, which is higher than that of this system. The backup space occupancy rate is continuously higher than that of this system, and the Y-value decreases with the continuous improvement of the backup source size of the power dispatch data. Comprehensively, it can be seen that the backup function can be completed in the shortest time, and the predicted value of the backup power scheduling performance is the highest, which largely improves the reduction of the volatility of electric energy.

Table 1 Performance test results

Backup /MB	Backup time/s			Backup space usage/%			Y Value		
	RF	D	VT	RF	D	VT	RF	D	VT
1	1.96	1.31	1.43	0.0006	0.0007	0.0003	74.12	83.23	96.45
10	4.02	2.24	2.81	0.0006	0.0008	0.0003	72.01	80.08	96.48
100	7.93	3.87	4.06	0.0008	0.0010	0.0004	75.24	80.41	97.06
500	11.22	9.46	6.70	0.0012	0.0016	0.0005	74.18	79.23	97.17
1000	17.68	20.05	9.32	0.0017	0.0026	0.0007	74.55	77.34	97.72

5.3 System Scheduling Efficiency Analysis

With the gradual increase of scheduling distance, the power scheduling efficiency profile is shown in Fig. 5. With the gradual increase of scheduling distance, the overall scheduling efficiency curve of the forest algorithm-based power scheduling system shows a trend of rising and then falling, and the highest scheduling efficiency is 17%. The overall scheduling efficiency curve of the power scheduling system based on the DAEM algorithm also shows a rising and then falling trend, and the highest point of scheduling efficiency is 35% higher than the former. Compared with Random Forest and DEAM, the high-performance EMS power scheduling system based on vectorization technology in this paper has the highest power scheduling efficiency, and the highest point of scheduling efficiency reaches 50%. It shows that the high-performance EMS power scheduling system based on vectorization technology in this paper has high scheduling efficiency for power and also strengthens the stability of power.

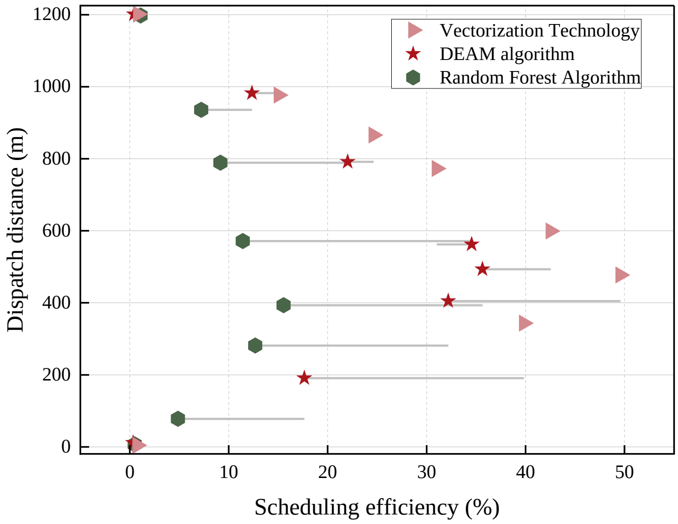

Figure 5 Comparison of power dispatch efficiency

6. CONCLUSION

In this paper, the design of EMS scheduling strategy for large-scale energy storage power plants is carried out, and vectorization technology is brought into the design process, through the basic principles of vectorization technology and its application in high-performance computing of power systems. Taking the trend calculation as an example, the state variables are arranged in chunks, and the vectorized formulas for the trend equations in right-angle coordinates and polar coordinates, Jacobi matrices, and the power calculation of the contact line are deduced. The system in this paper is verified to help improve power stability from three aspects: voltage magnitude probability density analysis, system backup performance analysis, and system dispatch efficiency analysis. The results show that the highest point of voltage magnitude probability density is 225 measured value, and the probability measurement value of this paper's method is 223, which is closest to the measured value. When this paper's system backs up the backup source, the backup time of 1.43-9.58s and the backup space occupancy of 0.0003%-0.0007% are the least, and the system performance is predicted to be the highest. The system in this paper has the highest power scheduling efficiency of 50%. Therefore, the proposed method can not only shorten the calculation time, but also improve the system scheduling efficiency and system stability.

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ABOUT THE AUTHOR

ZepengWu was born in Jieyang，GuangDong. China, in 1988. He obtained a master's degree from Sunderland University in UK. He currently working at the BYD Auto Industry Company in Shenzhen. His main research direction is electrochemical energy storage and analysis of the BESS application of strategies.

E-mail:mreichel7@liberty.edu