

The Application of Quantum Communication Technology used in Electric Power Information & Communication System Confidential Transmission

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Abstract—Electric power information system is related with the safe operation of power grid. To ensure the data of electric power information will not be eavesdropped or deciphered, we need a strict way of encryption. With the improvement of computing capacity, traditional encryption algorithms are at high risk of crack. Quantum communication technology is an absolute security encryption mode, which can significantly improve the safety of electric power information system. For the particularity of electric power production and management data by analysing the principle of quantum communication technology, we have put forward implementation plan of electric power information system data encryption scheme and quantum communication network.

Keywords—Electric Power, Security Challenge, Encryption Algorithm, Quantum Communication, Security Encryption Principle

I. INTRODUCTION

The power industry is related to the national economy and the people's livelihood. Modern power system and information & communication system have been gradually integrated into a fusion hybrid system. With the continuous expansion of power system, business is more and more depended on information & communication technology. The safe transmission of sensitive data requires more strict security encryption. In the event of security attack or data leakage, it will have catastrophic consequences for the entire power system. The current security policies for information system communication, such as VPN, digital signature and so on, rely more on the time complexity of computing. However, with the rapid increasing of computing capacity, all policies are at risk of cracking [1] theoretically. Different from these, the security of quantum communication technology is guaranteed by the principle of quantum physics. It is by far the only strictly proven policy which ensures the unconditional security of encrypted communication technology [2]. The application of quantum communication technology in data encryption of power information system can provide an extremely reliable way for secure data transmission. In the paper, the principle of quantum communication technology and application conditions are discussed. The technical implementation

scheme for power information system and the planning of power quantum communication network are also proposed, which can provide directions for the following practical application.

II. RESEARCH BACKGROUND

In 2013, the United States CIA former employee Snowden detonated the spread of the global "prism door" incident which push the importance of network security and information security to the national strategic level. And recent accident and attacks in Ukraine and Israeli against power grid make the electric power information security situation more serious. China power industry is very important to the country's energy security and economic development. With the development of China electric power information system in recent years, it has reached a certain level. These policies for the information system security concentrate mainly on hardware and software system protection. However the secure communication protection, especially in electric power information transmission, is insufficient. It also has some limitations in the basic support technology and the future development. With the expansion of electric power, we will face more and more security risks with different scope and depth which make us to do more advance researches on new information security technologies.

In view of the current situation, quantum communication technology can be used in national defense, government affairs, finance, energy and so on. This technique has been widely concerned, which will greatly improve the information and communication security. Quantum communication technology has been a kind of strategic technology related to national security. We can construct a whole new electric power information & communication system protection hierarchy. At present, the technology has been tested in the financial, banking applications. China is now carrying out relevant research of quantum communication researches, and carried out experiment projects, such as the quantum Beijing-Shanghai trunk line, the Hefei and Jinan Quantum Security Communication Experiment Network and the Shanghai Quantum Communication Industrial Park. Especially in August 6th 2016, China launched the world's first quantum

satellite. With a wealth of fiber optic cable resources and communication stations, the application of quantum communication technology in electric power information system has the technical feasibility and the demand of the industry.

III. TECHNICAL PRINCIPLE

A. Principles of Quantum Communication

Quantum communication is based on the quantum key distribution technology, which utilizes the single-photon non-divisible and non-replicable quantum state to realize the secure key distribution between two communicating parties. Combined with "one-time-one- encryption", non-conditional secure encrypted for information transmission can be achieved[3][4]. Along its propagation direction, light vibrates in a vertical direction at the same time, which is also a quantum state. Different from traditional digital optical communication, quantum communication can encode and load information into the direction of single photon. According to the single photon inseparability, quantum state cannot be replicated. The quantum state also cannot be accurately replicated. In the process of quantum encryption transmission, any eavesdropping behaviour will cause disturbance to the quantum state. Thus the transmission of quantum states between the two sides will be monitored well. Therefore, through quantum state transmission with the agreement of two sides, the quantum state can be converted into a binary number, which can form a completely random encryption key for encryption protection of original data [5]. Even if the encrypted data is stolen during transmission process, eavesdropper cannot calculate the complete random key. This approach can be used to protect data security maximally [6].

B. Quantum Cryptography System

The basic model of quantum secure communication system is shown in Fig.1. The system requires two kinds of channels. One type is the classical channel used for the original transmission of cipher-text data; the other is the individual channel used for quantum key transmission. The key generator of two parties converts the quantum state into a binary code according to the rule of negotiation by judging the single photon quantum state. Because single-photon state transmission is completely random and cannot be stolen during transmission, both can eventually generate the same random binary key exactly. Through the quantum encryption machine, the original data and the key are encrypted and transmitted over the classical channel. Relevant receiver can decrypt the cipher-text use the key which has been synchronized.

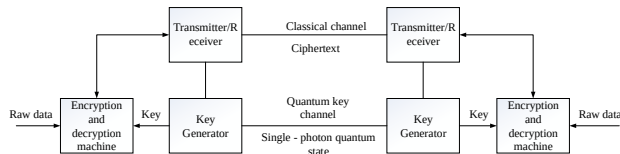


Figure 1. Quantum encryption System basic model

IV. APPLICATION

A. Application Scenario

The application of quantum communication technology in electric power information system can realize the protection of electric power production business and management information data transmission services. First of all, it can be used in the electric power production business data encryption transmission, such as protection, security control, dispatching telephone, dispatching automation, etc., which is very important to power production safety. The services mentioned above carry the real-time status and control instructions of grid production operation, which is of great significance to the safe operation of electric power. Using the quantum communication protection of electric power dispatching data network, distribution automation, can realize the safety of the electric power production information transmission. Secondly, electric power enterprise management information system, such as enterprise human resources, office system, E-mail system, TV phone system, and marketing system, to carry the important sensitive information on the stability of power grid operation also plays an important role in supporting; these data reveal that will lead to the risk of power system. In this case, using quantum encryption technology for data transmission protection is also feasible. Finally, power data disaster recovery of information is the last line of defence to ensure that the electric power security. When natural or man-made factors to paralyse the power system data, the information data disaster recovery plays an important role. And data recovery can guarantee the normal operation of power system. So for the power system remote data disaster recovery, still need high-reliability encryption to achieve data security protection. The same quantum secure communication system can be applied in these scenarios.

B. Physical Architecture Deployment

From second chapter description, we can see that for the current quantum secure communication system, we need two channels, one is a classic for cipher-text transmission channel, and the other is quantum key channel for quantum key transmission. Due to the limitations of technology development, the restrictions on the channel performance are very strict. First of all, the quantum key channel must be bare fiber, which means the optical fiber between two points cannot be transmitted through optical amplifier, optical switch, router or other equipment transfer. It can only be physically jumped, and cannot be shared with other transmission services. Therefore, if the quantum communication technology applied in power industry, it is necessary to consider whether quantum channel has the necessary fiber resources in advance. Secondly, the fiber distance between two sites is about 50km and the total loss must be less than 13dB. If the distance is much larger than this, the quantum key will lose the precision due to excessive loss. In order to realize long - distance quantum communication, it is necessary to set up relay station to realize the quantum key transmission, and ensure that the originating and receiving ends can generate the same

encryption / decryption key. Figure 2 shows the deployment of the device environment between sites.

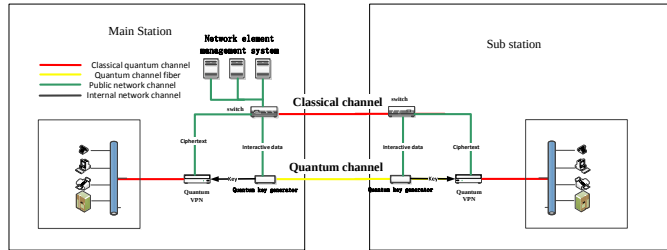


Figure 2. Quantum secure communication physical deployment

C. Quantum Communication Network Planning

The quantum communication technology of China is developing rapidly. It has been used in the financial business field for application testing. But it has not been used in electric power industry. Considering the future demand and the power industry has deployed rich fiber resources, quantum trunk and communication network can be built for electric power production and enterprise management service safe transmission.

First, quantum scientific experimental satellite is used to establish long distance, large area, and even across the continent of the international quantum communication Internet for power grid. According to the current deployment of quantum satellite ground receiving station, we can consider the west station and the east receiving station as inter-provincial internet pilot, to achieve the eastern and western power transmission, and as a collection of other metropolitan area network access points in the east and west. At the same time, using the Beijing-Shanghai trunk line, the access of electric power services between Beijing and Shanghai can be realized. And the provinces along Beijing-Shanghai line can also be accessed through the quantum communication.

Second, we can establish the quantum communication experimental network in the metropolitan area. Important validation and application of the electric power business protection for quantum communication was then used in electric power industry to provide experimental basis. Through the above inter-city and metropolitan area experimental network, we can gradually achieve power system interconnection, that is the north and south through the star and a trunk network, as well as the trunk network in the form of point-and-surface diffusion. So the distribution of LAN will gradually form a large-scale, high-density group network.

Based on the above issues, the power industry can make full use of existing resources and advantages, to establish electric power communication laboratory, in some technical problems in the study of quantum communication. Including polarized feedback of overhead lines, channel multiplexing of quantum key, long-distance transmission and power for the development of specific quantum devices. From the future perspective, to establish a wide range of quantum communication network in power system, as the industry can be used as a quantum communication resources, on the other hand can also be used as a quantum communication network

running open resource Implementation of national electric power industry vigorously support the development of quantum communication.

D. Suggest

Quantum communication is still in the development stage, many of the technologies in the study is not fully mature. Thus the application of quantum communication in the power industry there will be some problems [7][8].

First of all, the independent channel used for quantum key transmission is a waste of resources for the core; fiber resources are tight, difficult to solve the problem of redeployment difficult. The quantum bit rate, transmission distance and anti-jamming performance of the quantum signal on the commercial fiber have certain limitation, which cannot satisfy the transmission distance of single fiber long-distance transmission in single station. Secondly, the quantum key in quantum communication is mostly buried or pipeline fiber environment, however the power systems are mostly aerial cable. The complexity of the external environment will have some impact on the transmission of quantum key. Thus we need to modify equipment, to extend the transmission distance and to fight against polarization feedback at high altitude. In addition, the current quantum device is too large; the placement of the inconvenience, photon emission characteristics, and spectral monochromatic control immature aspects of the problem also limits the technology in power applications.

V. CONCLUSION

As an important development direction in the field of information communication, quantum communication technology is very meaningful and prospective to explore its application in power information system. In the paper, the quantum communication technology is applied to data transmission process of electric power information system by analysing the principle and application status of quantum communication technology and combining with the security transmission demand of important data in power industry. With the help of the high reliability and robustness of quantum communication, it provides an applicable solution for electric power information system data security transmission. Based on the analysis of the electric power industry, the application scenario of the quantum communication in the power industry is put forward, which provides direction for the follow - up construction and verification. At the same time, the follow-up suggestions and the construction plan of the quantum communication network are given for the existing problems.

REFERENCES

- [1] Z.W.Zhou, W. Chen and D. W. Sun, "A Survey of Quantum Information Technology," Chinese Science Bulletin, 20012, 12: 10-12.
- [2] Gisin N, Thew R. *Quantum communication*. Nature photonics, 2007, 1(3): 165-171.
- [3] H.J.Cao. "Theoretical Study of Quantum Communication," Dalian University of Technology, 2007.
- [4] P.Huang. "Study on quantum cryptography communication schemes and transmission characteristics of quantum channel," Shanghai Jiao Tong University, 2013.
- [5] F.G.Deng. "Study on the theory of quantum," Tsinghua University, 2004.
- [6] D.Wang. "The Study of Some Problems in Quantum Communication," Xi'an University of Posts & Telecommunications, 2012.
- [7] N.Gisin, R.Thew. *Quantum communication*. Nature photonics, 2007, 1(3): 165-171.
- [8] [15] H.Buhrman, R.Cleve, A.Wigderson. *Quantum vs. classical communication and computation*, Proceedings of the thirtieth annual ACM symposium on Theory of computing. ACM, 1998: 63-68.



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