

# Research on Challenges and Strategies of 5G Network Infrastructure Construction in China

Lijia Yang

Chongqing University of Posts and Telecommunications, China.

## Abstract

**4G changes our life. 5G, as a breakthrough information and communication technology, will change our society. However, with the large-scale deployment of 5G, from the perspective of development status, the network infrastructure construction of 5G in our country is still facing problems such as large investment demand, high operating costs, high energy consumption, and competition for spectrum resources. Therefore, this article analyzes the difficulties in China's 5G network construction, and specifically proposes to attract social capital and local governments to participate in the construction of 5G network infrastructure, cooperate with power grids and other cross-industry to further promote network construction and sharing. The article also recommends multi-purpose smart tower, Power line Communication and to promote the rational construction of 5G network infrastructure.**

## Keywords

**5G, Network infrastructure, Co-construction and sharing.**

## 1. Introduction of 5G Network Infrastructure in China

In December 2008, 3G license was issued, and in December 2013, 4G license was issued. On June 6, 2019, the Ministry of industry and information technology officially issued 5G business license to China Telecom, China Mobile, China Unicom and China Radio and television. China officially entered the first year of 5G business. Compared with 4G, 5G has developed faster. In the past year, 5G network coverage has spread, terminals have come into the market, and applications have emerged.

### 1.1. China has the most NSA 5G base station.

Base station is the cornerstone of communication network. Up to now, China has built 250000 5g base stations and there are more than 55 million 5g users in China. Miao Wei, Minister of the Ministry of industry and information technology, said during the two sessions of the National People's Congress this year, "we need to add more than 10000 5g base stations every week now." On May 17, 2020, world telecom day, the four major mobile operators (China Mobile, China Telecom, China Unicom, China Radio and television) respectively demonstrated their achievements in 5g development in the past year. At present, China Mobile has built 140000 5g base stations, the number of 5g package users has exceeded 50 million, and 5g signal has covered Mount Everest. This year's goal is to build 300000 5g base stations, covering cities above prefecture level in China. China Unicom and China Telecom have jointly built 115000 base stations through the co construction and sharing of station sites and spectrum resources, and strive to complete the construction of 300000 5g base stations by the end of the year. China Radio and television will also plan to build about 50000 5g base stations.

The reason why China can take the lead in 5g new technology is due to the high support of domestic policies, the investment of operators and the efforts of terminal manufacturers. China's policies and the cooperation of operators make our 5g network scale and coverage faster than the United States and other countries in the same period. For example, Verizon, a

wireless operator in the United States, officially launched 5g commercial services in Los Angeles, Sacramento, Indianapolis and Houston in October last year. However, users' feedback is not very good. The fundamental reason is that the deployment scale is not large.

This also has something to do with the system. Most of the United States are private operators, which only build networks in dense urban areas. In the suburbs of the road, elevators and other remote sites, because of the cost of the relationship is not to lay 5g network. But as we all know, if the signal is lost in a certain area, the experience will be greatly reduced.

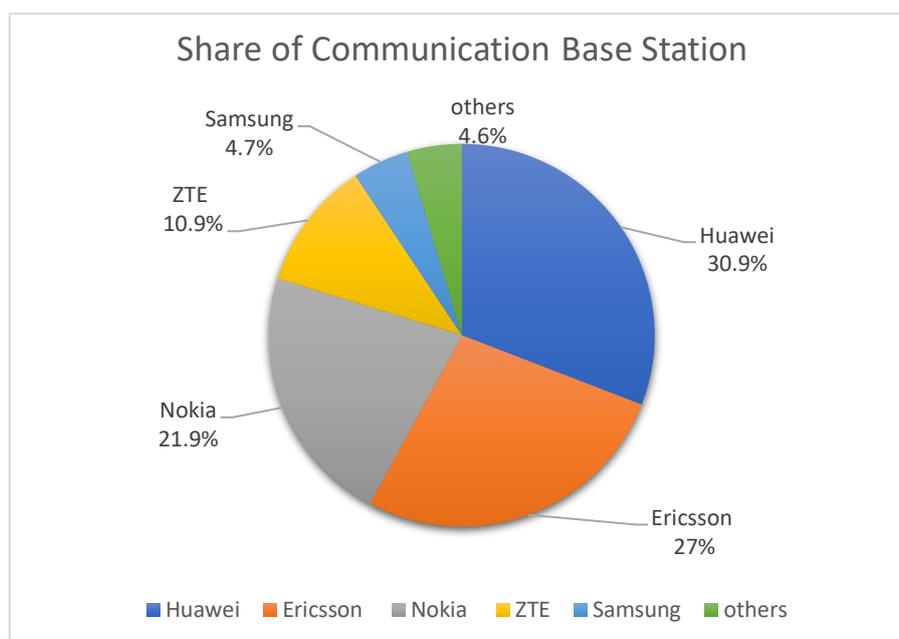


Figure 1: Proportion of communication base stations

### 1.2. Joint network construction

China Unicom and China Telecom reached an agreement on September 9, 2019. The two sides will cooperate to build a 5g access network and share 5g frequency resources across the country. Preliminary estimates show that the two operators can save about 10 billion yuan in investment cost by CO building and sharing. On May 20, 2020, China Mobile and China Radio and television signed a cooperation framework agreement on 5g co construction and sharing. The high-quality frequency band and content resources of China Radio and television, combined with the mature technology and equipment of China Mobile, have emerged.

So far, the domestic 5g network "2 + 2" competition pattern has been preliminarily determined. The innovative measure of joint network construction will help to build 5g network efficiently and form 5g service capability rapidly. While enhancing network quality and business experience, it will reduce network construction and operation cost, improve network efficiency and asset operation efficiency, and will be of great help to the overall development of 5g industry.

### 1.3. Leading in technology, patents, terminals and other fields

In terms of technology, China has organized large-scale 5g technology commercialization to promote the further maturity of 5g industrial chain. At present, 5g base station chips have been widely used in 7 nm technology, which greatly improves the performance, power consumption and stability.

In terms of standards, the German Federal Ministry of economic affairs and energy released the "Research on the fact finding of 5g standard essential patent declaration" report. As of January

2020, the total number of 5g patent claims in the world was 95526. China ranked first with 32.97% of patent holdings, ranking first in the global ranking list, while the proportion of patents in the United States was only fourth. Huawei's 5g standard essential patents (SEP) applications were 3147, ranking first. Compared with 7% of global SEP in 3G era and 20% in 4G era, China has made significant progress in intellectual property in 5g era [1].

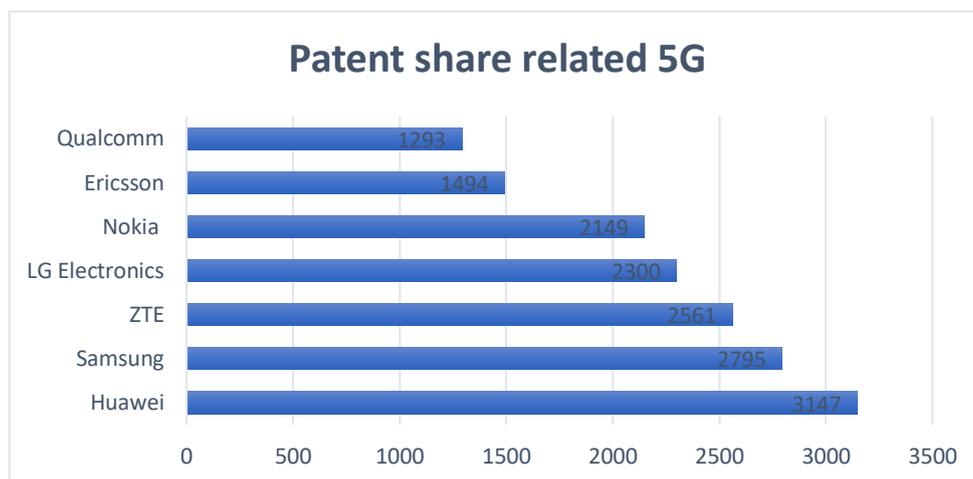


Figure 2: The ranking of patent share related 5G

In terms of terminals, Chinese manufacturers have been in the first camp in the global 5g intelligent terminal field. According to the list of 5g terminals released by GSA, as of April this year, a total of 283 5g terminals have been launched, of which 184 are from Chinese enterprises, accounting for 65% of the total number of 5g terminals in the world, and 108 5g mobile phones, with Chinese enterprises contributing 67%.

Huawei, vivo, oppo and other Chinese manufacturers have launched a number of mobile phones in Switzerland, the United Kingdom, the United States, the Middle East and other countries and regions, and successfully entered the first lineup of local 5g deployment. "5g" has become a new impression of China's mobile phones in the world.

## 2. Development Status of 5g Abroad

At present, the 5g development at home and abroad is in the early stage. The United States launched the "5g accelerated development plan" in September 2018, and major operators are eager to start 5g business, but the publicity significance is greater than the commercial significance. The 5g strategy with millimeter wave as the core makes the United States lose the first mover advantage; the application of 5g industry in the United States will focus on FWA in the early stage, and the overall situation is still in a very early stage; T-Mobile& The merger of sprint will have a significant impact on 5g network construction and market structure in the United States.

Three South Korean telecom operators officially launched 5g commercial services in 2019. On April 8, 2019, the South Korean government held a "5g + strategy" conference, announcing that it would promote the 5g strategy at the national level and create a world-class 5g ecosystem; Japanese operators planned to commercialize 5g in 2020, and are actively promoting the application research based on embB. The Ministry of general affairs of Japan has defined 13 kinds of 5g applications, focusing on the new business models of Internet of vehicles, telemedicine, intelligent factory, emergency relief and other applications; Switzerland Telecom officially launched 5g commercial services at the "5g business conference" held on April 11, 2019; the EU started 5g test in 2017, and plans to fully deploy 5g by 2025.

### 3. Challenges of 5g Network Infrastructure Construction in China

#### 3.1. Huge initial investment

The investment cost of 4G construction has not been recovered, and the cash flow situation still needs to be improved. Academician he Quan, the most senior academician in the field of communication, once provided such a set of data. China spent about 700 billion yuan to 800 billion yuan on the construction of 4G, and it took six or seven years to complete the construction, which is equivalent to more than 100 billion yuan invested by operators every year. But now, the huge investment cost of 4G has not been recovered. In the first half of 2019, the three operators achieved a total net profit of 76.849 billion yuan, which is difficult to support the huge capital demand of 5g construction. On the other hand, the telecom business income has also entered the bottleneck period, the growth of the number of users, dividend is gradually disappearing. In this context, we must grasp the pace and speed of 5g construction, and reasonably control the cost of 5g construction, in order to prevent excessive optimistic "aggressive behavior" of Japanese and British operators in 3G era, causing serious losses.

#### 3.2. The number of base stations has increased significantly

In order to develop 5g network, infrastructure must go ahead. Compared with 4G, 5g segment rate is higher and base stations are more intensive. With the development of 1g, 2G, 3G and 4G, the radio frequency used is higher and higher. The higher the frequency is, the more abundant the frequency resources can be used, and the higher the transmission rate can be realized. According to  $C = \lambda V$  light speed = frequency \* wavelength, if mobile communication uses high frequency band, then its biggest problem is that the transmission distance is greatly shortened and the coverage ability is greatly reduced. Covering the same area, the number of 5g base stations required will greatly exceed 4G.

In the future, 5g and even 6G base stations will have significant changes in quantity and quality, and it will become important whether the number of devices and related services can occupy an advantage. The transmission distance of 6G radio wave is only 100-200m. According to the estimation of Professor Kawabata University of Japan, "base stations equivalent to 10 times of the population will be needed". At present, there are about 600000 base stations in Japan, and one billion will be needed in the 6G era, and 100 billion in the world at most.

#### 3.3. The costs of single station construction, operation and maintenance has increased significantly

5g base station consumes a lot of power. At present, the number of 5g stations, the energy consumption of base stations and the price of single station are about three times of those of 4G mobile communication system. In the future, with the continuous surge of traffic and the gradual increase of network density, higher requirements are put forward for network planning, base station location, facility construction, power supply, etc., and the investment scale is also very large. The cost and network energy consumption problems will become more severe for operators. In addition, in the face of rich scenarios and customized requirements in the future, the network functions become more complex, the optimization parameters are numerous, and the operation and maintenance are more difficult. All of these put forward higher requirements for the intelligence of the basic network and the flexible personalized service.

#### 3.4. Higher requirements for indoor network coverage

In 5g era, indoor is the main application scene, and the proportion of indoor scene application is also increasing. 5g indoor application is more diversified, which also puts forward higher requirements for the network. Compared with 70% in 4G era, 80% of indoor traffic in 5g era, including voice and AR / VR applications, puts forward higher requirements for network delay.

However, 5g frequency band is very high, transmission loss and penetration loss are very large, it is difficult to transfer from outdoor to indoor, so indoor coverage is faced with this great challenge.

### 3.5. Competition for spectrum resource

In the future, 5g will develop into an era of interconnection of all things. It is predicted that by 2030, the number of electronic equipment access will exceed 125 billion, and machine communication will become the main communication mode of 6G. Such a huge number of access puts forward ultra-high requirements for network capacity. Assuming that the technical index of the future 6G network capacity is set at 10 million connections / km<sup>2</sup>, which is 10 times of the maximum access number of 5g. There is no doubt that the realization of such a large amount of Internet of things connectivity is a huge technical challenge. Due to the limited spectrum resources, there will inevitably be resource competition and signal interference, resulting in low transmission efficiency.

### 3.6. Increased energy consumption

The traditional 2g3g4g base station, because of the low computing power of the base station, usually the transmission power consumption is greater than the calculation power consumption. Because the 5g transmission rate will be doubled, the 5g base station will process massive data, and with the continuous development of 5g business, the computing power consumption of 5g BBU will gradually increase. 5g base station consumes a lot of power, and the single station power consumption is 2.5 ~ 3.5 times of that of 4G single station. The increase of AAU power consumption is the main reason for the increase of 5g power consumption. 5g technology requires large-scale broadband and large-scale antenna use, and the required performance will be improved accordingly.

## 4. Suggestions

### 4.1. Suggestions for large construction cost

In view of the high cost of 5g base station construction, this paper suggests that some base station operators build by themselves, some by tower, social capital, etc., and rent by operators. At the same time, financial institutions are encouraged to invest and the government should set up special funds to support. In the future, when 5g application is mature, operators will mainly compete in market operation and industrial cooperation to provide solutions for customers and become platforms and platforms when the base station providers are unified, the cost of the base station management should be unified [2].

#### 4.1.1. Infrastructure construction and sharing

Further promote the integration of the three operators, build and share the infrastructure such as iron tower, such a site only needs to build a set of equipment, both sides can share the cost. In terms of construction investment, the cost of base station equipment, antenna, design, construction and supervision can be saved, and the waste caused by repeated construction can be avoided. At the same time, operators can build a network. As mentioned above, at present, China Telecom and China Unicom jointly build a network, and mobile and radio and television co build a network. This not only meets the cost requirements, but also meets the consideration of information security, because at least two sets of domestic communication networks can be used at the same time. After all, information security is very important in both peacetime and wartime Yes.

For the problem of cash flow, operators can outsource the construction of specific infrastructure network facilities to iron tower, Zhongtong service, China Mobile Tietong and other enterprises, build some of them by themselves, and then integrate them according to the

operation situation in the later stage. For China Tower, with a large amount of capital investment before, the number of station sites with 1.94 million has surpassed the world. In this case, the same facilities are provided to more tenants, that is, to improve the sharing rate. On the one hand, for China Tower, the increase of income brought by the increase of sharing rate is much higher than the growth of unit cost, which will have an immediate effect on the improvement of revenue and profit. From the development of single tenant to multi tenant, the sharing site can effectively improve the marginal profit; on the other hand, the shared or independent service can be provided. The existence of commercial operators enables operators to share a single site fairly and efficiently, which can not only expand their own signal coverage, but also reduce the cost of construction and maintenance, and avoid the waste of resources caused by repeated construction.

#### **4.1.2. Attract social capital, local government and other subjects to participate in 5g Network Co Construction and sharing**

It is a feasible scheme to attract social capital to participate in the construction of 5g network under the condition of operators' financial shortage. By encouraging social capital to invest in the construction of infrastructure such as network base station, and then leasing the built infrastructure to operators, it can not only find a new investment channel for social capital, but also greatly reduce the initial construction capital investment of operators. The indoor distribution system, which is very important for 5g network application, can be constructed in cooperation with building operators and property management departments.

#### **4.1.3. Encourage financial institutions to actively support 5g construction**

Compared with 4G, 5g construction mode will have great innovation. The main body of investment, construction, operation and use will be diversified. It may be the subject of one aspect, such as the subject of professional investment, or the integration of multiple subject identities, such as integration of investment and construction, construction and operation, construction and operation, and use, etc., which requires financial innovation to support 5g construction. In view of the great significance of 5g to new infrastructure and the complexity of technology and business involved in it, it is suggested to set up professional departments related to 5g in financial institutions to provide financial support from the perspective of 5g whole industry chain. On the one hand, it can increase support through specialized finance, on the other hand, it can effectively control financial risks.

#### **4.1.4. Set up national 5g construction fund to support 5g construction**

It is suggested to set up a national 5g construction fund, led by the central government, to encourage local governments, social capital and other forces to participate in 5g construction through low interest long-term loans, renting self built base stations, and participating in 5g network construction enterprises, so as to solve the problem of lack of funds. In order to ensure the income of social capital, the fund can be set up in a structured way, and the income of central government is distributed after the inferior, the income of local government is distributed after the inferior, and the income of social capital is the highest priority distribution, so as to realize the driving role of social capital [3].

### **4.2. Suggestions for large demand of base stations**

#### **4.2.1. Make full use of the existing rods**

This year is the first year of 5g commercial use in China. In the future, the number of base stations will increase significantly, and the size of base stations will become smaller. The current base stations are the size of refrigerators. However, in the future, when the wavelength is shorter than 6G, the antenna will become smaller, which is only the size of a mobile phone. Lighting, billboards and passenger cars may also have the function of base stations. Therefore, the mode of "sharing all kinds of social resources + utilizing the old stock poles" is adopted to

cooperate with various social parties, such as electric power, railway, municipal administration, public security, transportation, property management, etc., to build and reconstruct base stations by using social resources such as power tower, street lamp pole, monitoring pole, billboard and water tower, which not only reduces the construction cost, but also shortens the construction period. Moreover, by optimizing the innovative scheme and reducing the weight, the relay mode of multiple rods is used to achieve continuous coverage effect for some rods without hanging high space. It can not only realize the rapid deployment of 5g network, save the investment cost and improve the efficiency and efficiency, but also avoid the waste of resources and unsightly phenomenon brought by the multi pole forest, reasonably and orderly use the urban space, beautify the road environment, and achieve the beautiful effect.

There is no doubt that under the co construction and sharing mode of integration of planning and construction, it is a means of reducing cost and increasing efficiency to fully rely on all kinds of tower resources in society to boost 5g economic, efficient and green development.

#### **4.2.2. Building a multi-purpose smart tower**

According to the dense distribution characteristics of 5g base stations, according to the idea of "macro micro integration, indoor and outdoor coordination", we explore multi department coordination mechanism, integrate social resources such as social poles, social management and social electricity across the border, and promote the two-way open sharing and overall utilization of tower resources such as tower base station, street lamp, monitoring, traffic indication, electric power and so on. Taking the smart street lamp as the carrier, integrating the intelligent lighting management system, video monitoring system, WiFi coverage system, information release system, emergency alarm system, etc., to create an overall solution of the Internet of things in smart city, not only can make people's life more convenient and safe, but also can reduce people's worries about the radiation and noise of the base station and prevent them from entering the community, because this is also about the base station A disguised camouflage.

Actively promote the mutual transformation of "communication tower" and "social tower", explore the "comprehensive sharing" mode, and promote the construction and transformation of Urban Smart tower with "one pole multi-purpose" function. The tower has multiple functions, which is a successful example of integrating information technology with traditional urban infrastructure, and achieves the goal of multi pole integration. Effective integration of 5g site resources can not only greatly save the construction cost, but also play a guarantee role for all systems through more in-depth integration and joint management.

#### **4.2.3. Power grid joint and sharing tower**

On April 24, 2018, China Tower and State Grid signed a strategic cooperation agreement, and the two sides started the strategic agreement of "sharing tower". As the construction cost of 5g network is much higher than that of 4G network, network densification is further strengthened, and multiple base stations are needed for support. The listing of China Tower and the addition of "sharing tower" cooperation mode with State Grid will accelerate the coverage of communication tower and small base station in China, and then accelerate the deployment of 5g network in China.

Power and communication sharing a tower can solve the problem of electricity and signal coverage, which is a cross-border development of sharing mode. "Sharing tower" fully enlivens the existing tower resources of the power grid, saves the communication operation cost and speeds up the network distribution progress [4]. The frequency of power grid operation is low-frequency band, while the transmission of communication base station belongs to high-frequency band. They are like parallel lines that never intersect. From the technical theory and communication equipment parameters, the electromagnetic field of power lines will not affect the communication equipment.

In fact, the power grid company into the communication tower has precedent. As early as July 15, 2017, Tokyo Electric Power Company publicly announced its support for 5g construction, opening power towers to operators to install 5g base stations and antenna equipment. Earlier, the UK's largest telecom operator, EE, also attached antennas and equipment to power towers. At & T's airgig project also uses off the shelf power infrastructure sharing to deploy 5g fixed wireless networks.

### 4.3. Power carrier technology

In addition to the 5g shared passive room technology previously developed by China Tower, the indoor shared coverage of various scenarios can be realized more economically and efficiently by combining active and passive, and power carrier technology can also be applied. At present, the tower has jointly promoted the construction of 34 5g indoor coverage projects with telecom enterprises in 24 cities to verify the coverage effect of low-cost 5g indoor coverage schemes such as wide-angle leaky cable and passive distribution system, which can provide more economical and reasonable 5g indoor coverage scheme for telecom enterprises and effectively reduce the investment cost.

Power line carrier communication is a kind of power line communication technology which is specially used to transmit electric energy. With its low price, flexible and convenient use, broadband service and other advantages, it will have a huge development space [4]. The perfect combination of power carrier and 5g will greatly provide the commercial promotion and user experience of 5g application, meet the commercial application in many fields, and easily cover the whole room with 5g signal.

At present, power carrier has been applied in smart home. The power carrier technology is integrated and embedded into various electrical appliances, and the existing power line is used as carrier communication medium to realize the communication and control between intelligent devices. Query the status of all electrical appliances at any time; centralized control of all intelligent electrical equipment in the home by any switch; group on and off designated electrical appliances, such as scene lights; master the home security situation at any time, such as anti-theft, fire alarm, detection of gas leakage, etc.; remote control of home appliances through the Internet or telephone [5].

There are also industrial applications, because of the large number of equipment in the industrial field, most of the automation equipment is made of metal materials, so the shielding of wireless signal will greatly weaken the wireless signal. In order to better meet the industrial field communication, 5g + PLC technology is adopted to realize the industrial field communication through the power line on the site, which will greatly provide the network construction period and cost, and make the whole network more stable and safe.

## 5. Conclusion

The biggest feature of 5g is the Internet of things. The future world will be a community full of intelligence and ubiquitous connectivity. Based on the difficulties in the construction of 5g infrastructure, this paper puts forward some suggestions, such as co construction and sharing, construction of smart towers and so on, in view of the huge investment, large demand for base stations and transmission efficiency. In the future, operators will enter the field of system integration and become a platform and solution provider. They may develop just like the Internet industry, and the network infrastructure will be managed in a unified way. Some studies have even proposed the possibility of merging the power grid and the communication network in the future. However, the relevant theory and technology are not mature. If the future technology breakthrough, it will change the pattern of the whole communication industry.

It can be said that in the era of 5g, we have already reached the forefront of the world. However, the pioneers and leaders always have to bear more "sunk costs". Large scale construction of 5g not only reflects the driving force of commercial interests, but also reflects the will of the country. From this perspective, "exchanging money for time and casting advantages with time" is a national grand strategy. The construction of 5g in the future also needs the joint efforts of the whole country from top to bottom. The construction of communication infrastructure also needs researchers to continue to overcome difficulties and innovate continuously, so as to realize the vision of "thinking about heaven and earth, everything at will" in the future as soon as possible.

## References

- [1] Wu Hequan: The new characteristics of network society and the challenges faced by industry in 5g Era[J]. Journal of Chongqing University of Posts and Telecommunications(Natural Science Edition), 2020,32(02):171-176.
- [2] Wang Zhenzhen and Xu Yanjing: How do operators break through the 5g era? [J]. Communications World, 2020, (14): 18-20.
- [3] Li Yongjian and Xia Jiechang: Difficulties and suggestions of 5g construction[J]. China National Conditions and Strength, 2020, (06):47-49.
- [4] Keysight Technologies, Riscure to Advance Development of 5G Networks, Devices, and Services[J]. Telecomworldwire,2020.
- [5] Pang Fayu: Prospect of low voltage power line carrier communication technology[J]. Smart Factory, 2017, (11): 53-54+58.