

# Research on Development and Application of Low-Voltage and High-Speed Power Line Communication Technology

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**Abstract:** Low-voltage and high-speed power line communication (PLC) technology, as the main means of communication construction, enables the masses to obtain higher quality services and has attracted more and more public attention. This paper is divided into four parts: the introduction of PLC technology, the application significance of low-voltage and high-speed PLC communication technology, the characteristics of PLC channel and the application and comparison of high-speed PLC technology.

**Keywords:** Low-Voltage; High-Speed; Power Line Communication Technology; Application

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## Introduction

PLC technology is extensively distributed in 220V low-voltage transmission lines of urban and rural users because of its prominent advantages such as no wiring, wide coverage and convenient connection. On this basis, PLC technology is widely favored by the industry, thus providing the “last mile” solution of the Internet. As a result, PLC is regarded as one of the technologies with great application potential. At present, several programmable controllers have been tested in the field at home and abroad. The PLC access network usually includes two aspects, one is the public network (outdoor) from the substation to the household, and the other is the private network (indoor) in the user’s home, with a frequency range of 1-30MHz. Most systems can achieve a pure transmission rate of more than several Mbit/s. Therefore, the world has been ready for a wide range of applications of PLC technology.

## 1. Introduction of PLC technology

Power line for carrier communication is not a newly proposed technology. Since the 1940s, this technology has been used in long-distance transmission line communication in China. In the low-voltage power system below 220V, PLC technology can be applied to remote meter reading and household automatic control, with transmission speed usually below 1200bps<sup>[1]</sup>.

### 1.1 Basic principle of PLC technology

Power line communication (PLC) is a kind of communication means with power frequency electric energy as the carrier, and it is a special means of communication in power systems. Generally speaking, PLC is transmitted through the frequency of 1M-30M band. In the process of transmission, the signal from the user is processed by GMSK and OFDM technology, and transmitted through the power line. At the receiver, the original communication is obtained by first filtering the filtered signal and then demodulating it. Existing communication rates are in the range of 4.5M-45M depending on the specific device. In the communication process, the data input from the user is modulated by a modem. It is transmitted to the local device by the user’s distribution line, then demodulated by the local device and finally transmitted to the external network<sup>[2]</sup>.

## 1.2 Overview of PLC development

In China, the R&D of PLC technology lags behind, but it develops rapidly. China Electric Power Research Institute has been engaged in the research of PLC technology since 1997, and introduced domestic PLC chips in 2000. In late 2001, a small field test was conducted with satisfactory results. Tests on THE EPPLC-45M and EPL-14 were completed in 2003. The home network equipment based on 14Mbps programmable controller of Intellon, USA, developed by Shenzhen Guodian Technology Co., Ltd., has also been tested on a small scale. In the next stage, a 20Mbps home PLC network device will be developed using DS2's 45Mbps single chip microcomputer. Fujian Power Supply Company has developed a PLC household appliance controller that can achieve 10Mbps by using the 14Mbps single-chip microcomputer of American Tron, and has achieved good results in the residential area test.

## 2. Application significance of low-voltage and high-speed PLC technology

Power line communication (PLC), also known as PLT (hereinafter referred to as PLC), is a communication method for data and voice through wires. PLC is not a new technology; instead, its development dates back decades. As an important application means of PLC technology, medium and high voltage transmission network (35kV or above) transmits telecontrol data or voice at a low rate of 9-490kHz by using a power carrier device. "In low-voltage power systems below 220V, PLC technology is the first to be applied to load control, remote meter reading and home automatic control. Its transmission speed is usually below 1200 bps, which is called low-speed PLC. In recent years, the low-voltage transmission line communication technology of less than 1 Mbps is called "high-speed PLC" worldwide.

In recent years, Internet technology has developed rapidly, witnessing a geometric increase in the number of users accessing the Internet. However, which communication means should be used to connect the user's mobile phone with the adjacent broadband network connection device has become a difficult problem in the development of the network. This is also called the last mile by the industry. The 220V low-voltage transmission line, by virtue of its advantages of no wiring, wide coverage, and convenient connection, has become the most advantageous technology among the "last 300 kilometers" technologies recognized by the industry. At present, high-speed PLC can transmit 45Mbps data and realize data, voice, video, electricity and other transmission, which is expected to realize "integration of four networks (Internet + radio power grid + telecommunications network + power grid)".

PLC technology has broad development prospects in real life. Once the technology is put into commercial use, it will generate huge social and economic benefits, thereby promoting the reform of the telecommunications industry and providing a broad development space for the promotion of the network. In view of this, it is necessary to conduct in-depth research on high-speed carrier communication on low-voltage transmission lines.

## 3. Characteristics of PLC channel

When low-voltage power grid is used as a high-frequency carrier waveguide channel, it is imperative to figure out its complexity, which is quite different from other special communication channels. The electrical performance of the carrier communication system itself is also an important part of its work, which is characterized by the following aspects:

More attenuation: The loss degree in the low voltage line depends on the line and the load on the line. Due to multiple branches of low-voltage power lines and random entry and closure of different types of loads, a large multipath influence is caused.

High noise: The noise in high-voltage transmission lines comes from the short-term full load of several power grids, as well as radio broadcasting, sky power, etc. The noise types are: colored background noise, narrow-band noise and sudden noise. The burst pulse signal has a high signal concentration, usually 10dB higher than the background signal, sometimes reaching 50dB, which seriously interferes with the carrier signal transmission.

Strong interference: There are two situations of artificial interference and non-artificial interference in low-voltage lines. Non-artificial interference is a natural phenomenon such as power grid disturbance caused by lightning. Artificial interference is the biggest interference source in the power line, which is connected with the power supply line.

## 4. Application and comparison of high-speed PLC technology

### 4.1 Application of PLC technology

Fast commercial access to the Internet: Every household has a power distribution transformer. In this way, a low-cost looped network can be easily achieved by using power lines, and users can quickly access the Internet by connecting to the conventional main line or public telephone network with PLC routers or gateways. There is a router or a gateway next to the distribution transformer, where the backbone network and the power line local looped network exchange data, see Figure 1. PLC provides a solution for users to access the Internet that does not require additional wiring, avoids low commercial efficiency, and realizes the “last mile” from the original network distribution to an independent network for each household. Home/office network: It can realize home/office network for printers, scanners, fax machines, modems, and digital TVs without connecting lines, and facilitate multiple entertainment modes such as “simultaneous multi-user Internet access”. Besides, the cost of purchasing computer accessories can be saved, the inconvenience of cable connection among various devices can be reduced, and plug-and-play high-speed Internet access can be enjoyed, providing users with more comfortable and convenient living and working conditions. See Table 1. PLC technology will become a strong competitor of home/office telephone lines and home/office wireless networks.

### 4.2 Comparison of PLC technology

Table 1 shows the comparison of several broadband access schemes, and Table 2 shows the comparison of current main PLC products.

Table 1 Comparison between high-speed PLC technology and other broadband technologies

Communication mode	Rate (bps)	Physical medium	Comparative result
Telephone Mod	56K	Twisted pair	Widely used, but with low speed
ISDN	128K	Twisted pair	Not widely used, with slightly higher cost
XDSL	2-8M	Twisted pair	Dedicated frequency band and limited by distance
Limited television network	10M	Coaxial line	It is necessary to use ready-made network access, which is costly
PLC	14M	Power line	Wide distribution, convenient intervention and low cost

Table 2 Comparison of PLC products

Company name	Product	Rate (bps)
ASCOM, Switzerland	APA-45 series	4.5M
Siemens, Germany	SpeedStream25 series	14M
Intellon, USA	INT51 series chips	14M
Connex, USA	CXP series	14M
Phonex, USA	X-20x series	14M
DS2, Spain	DS4200 chip	45M
Fujian Electric Power Institute	FDDTP-MODEM	10M
Electric Power Research Institute	EPL-14M, EPL-45	14M

## Conclusion

PLC, as a cheap, flexible and convenient broadband service that can eventually provide telephone, Internet access and other services, will have a broad application prospects. However, considering the harsh power grid environment, immature technology, lack of legislation to allow Internet services and communication services to run on the power grid, unrecognized technical specifications, etc., the development of PLC technology is a systematic project that cannot be completed in a short time. Today, with the development of science and technology, multimedia communication with the integration of “four networks (Internet + broadcast network + telecommunication network + power grid)” can be achieved through power lines.

## References

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