Research on Dual-Mode Communication Technology Based on Power Line Carrier and Micro Power Wireless

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Abstract. At present, the power meter reading system mainly uses the single power line carrier meter reading mode or the single micro power wireless meter reading mode. Due to the disadvantages of the two modes, the single meter reading mode cannot meet the meter reading under different environmental conditions. In order to improve the success rate of communication, this paper puts forward the dual-mode communication technology of power line carrier and micro power wireless integration, which is based on the power line carrier. It overcomes the defects of single meter reading mode and improves the real-time performance, reliability and success rate of meter reading.

Keywords. Power line carrier; micro power wireless communication; dual mode communication.

1. Introduction
With the development of global energy Internet construction, especially the increasing requirements of smart grid for access network communication technology, the existing single power line carrier and micro power wireless communication cannot meet the requirements in coverage, bandwidth rate, communication delay, system stability and other aspects [1].

As a kind of communication medium network, power line has obvious economic benefits and production efficiency. However, due to the complexity of low-voltage power network structure and the serious attenuation of high-frequency signal, the distributed capacitance, distributed inductance, load property, load impedance value and noise of power network are dynamic rather than constant [2]. Especially with the development of economy and the improvement of people’s living standard, the number of various electrical appliances increases sharply, and this kind of random and irregular interference is becoming more and more serious. Although the manufacturers have developed a variety of anti-interference technology to deal with, the inherent problems of power line carrier technology have been affecting the development of automatic meter reading technology [3].

Micro power wireless communication transmits data over the air and is not affected by power line environmental noise. However, due to limited power, wireless communication performance is easily affected by wall blocking, metal shielding and weather environment [4, 5]. Although this influence can
be reduced by multi frequency point, automatic frequency modulation and other technologies, the improvement of wireless performance is restricted by bandwidth limitation.

Generally speaking, power line communication makes full use of the existing power line resources, and has the advantages of convenient use, economy and reliability [6]; wireless communication has the characteristics of flexible networking [7]. Based on the characteristics of the two communication modes, this paper proposes a dual-mode communication technology based on the integration of power line carrier and micro power wireless. The dual-mode module chooses the optimal communication channel according to the actual situation of power line channel and wireless channel to build a heterogeneous network, which can effectively eliminate the communication Island, realize the complementary advantages of PLC and wireless in the whole network, and improve the communication efficiency the real-time, reliability and success rate of meter reading.

This paper is organised as follows: a dual-mode communication technology is proposed based on the integration of power line carrier and micro power wireless and the characteristics of power line carrier and wireless channel, which are presented in Section 2. Section 3 presents power line carrier and micro power wireless communication fusion technology. Section 4 presents the test results. Moreover, some conclusions are discussed in Section 5.

2. Characteristics of Power Line Carrier and Wireless Channel

2.1. Power Line Channel Characteristics

One of the key problems of power line carrier communication is its transmission characteristics. The environment of power line channel is bad, which is characterized by large signal attenuation, large impedance variation, strong noise interference and time-varying. At present, the use of power line for data transmission and the establishment of PLC network technology has made great progress, but still faces great challenges. There are strong signal attenuation, a lot of interference, unpredictable noise and variable impedance in PLC channel, which are determined by the characteristics of PLC channel itself [8].

Power line channel has the following characteristics [9]:

1. Impedance matching problem: due to the constant access or pull-out of equipment, the input impedance and output impedance of low-voltage power line often change dramatically, so how to design a reasonable circuit to make the input and output impedance match is a difficult problem;

2. Noise interference problem: compared with other communication channels, power line channel has the following noise interference besides background noise interference: narrow band noise, periodic noise synchronized with power frequency, periodic noise asynchronous with power frequency, sudden noise, etc;

3. The problem of large signal attenuation: there is a certain signal attenuation on the power line channel. Attenuation is related to distance and communication frequency.

4. The broadband power line communication system operating in the frequency band of 2mhz-30mhz may cause electromagnetic interference to the existing shortwave radio services due to the poor shielding of the power line.

2.2. Wireless Channel Characteristics

The influence of wireless channel on signal transmission mainly includes transmission attenuation, frequency selective fading caused by multipath propagation, time selective fading caused by time-varying and spatial selective fading caused by angle expansion [10, 11].

1. Frequency selective fading

Multipath propagation of signal will lead to time delay spread, or time dispersion, which is frequency selective fading in frequency domain. Two important parameters describing multipath effect are delay spread and coherent bandwidth. From the perspective of time domain, the time delay is different because each path component of the transmitted signal arriving at the receiving antenna experiences different propagation paths, which makes the energy of the received signal expanded in time.
(2) Time selective fading

The time-varying of wireless channel is caused by the relative motion of transmitter and receiver or the motion of other objects in the channel. When the transmitter and the receiver make relative movement, the frequency of the received signal will shift, which is called Doppler effect. Time varying leads to time selective fading, which is reflected in the frequency domain, that is, the signal spectrum is broadened, also known as frequency spread. Two important parameters describing time-varying are Doppler extension and coherent time.

3. Power Line Carrier and Micro Power Wireless Communication Fusion Technology

In general, the power line communication makes full use of the existing power line resources, without any wiring, and has the advantages of convenient use, economy and reliability; the micro power wireless communication has the characteristics of flexible networking, high communication rate and strong real-time performance [12]. The integration of the two technologies can give play to the technical advantages of heterogeneous network, expand the coverage of communication network, and make the network more flexible Stronger scalability, improve network stability.

3.1. Physical Layer Integration of Power Line Carrier and Micro Power Wireless Communication

The development of microelectronics and software radio technology makes it possible to integrate power line communication and wireless communication in physical layer. The core idea of power line and wireless physical layer integration is to use high sampling rate digital to analog converter, use digital devices for most of the physical layer processing, carry out modular and parametric design in the digital domain, reuse the common or similar algorithms and operations of the two communication modes, and choose between the two communication modes through software. For the analog part, due to the difference of frequency and communication medium, different analog front ends need to be used, and the software is used to switch between different analog front ends.

The physical layer of power line carrier and wireless communication can be easily integrated through software radio technology. As shown in figure 1, for the same technologies of power line carrier and wireless communication, such as channel encoding and decoding, OFDM, the same module can be used in the digital domain for seamless integration, and the parameters of each module can be configured by software to adapt to power line communication or wireless communication, such as OFDM length, code block length, etc.

![Figure 1. Power line carrier and wireless integration.](image-url)
end is used to up convert the OFDM signal to if, and then transmit it to the RF front-end through the digital to analog converter.

In the analog part, the ADC and DAC reuse the same device, while the power line communication and wireless communication use independent analog front-end module respectively, and switch through software control.

3.2. Analog Front End and Coupling Circuit of Power Line Carrier
The power line carrier signal coupling and analog front-end processing circuit is a very important link in the medium and low voltage power line carrier communication system. It realizes the safe isolation and matching between the carrier communication device and the high-voltage power grid, the injection and extraction of high-frequency carrier signal, the filtering and amplification of high-frequency analog signal, and so on. It prevents and attenuates the noise and interference signal as much as possible. As shown in figure 2, it mainly includes transmitting filter, power amplifier, line filter, coupling and impedance matching circuit, receiving amplifier, filter, AGC, sampling filter, ADC and other circuits.

![Figure 2. Power line carrier analog front end and coupling circuit.](image)

3.3. Analog Front End and Antenna System of Wireless Communication
Different from the analog front-end and coupling circuit of power line carrier signal, the analog front-end of wireless communication needs to up convert the analog signal of digital if to the high frequency point used, thus figure 3 up conversion circuit, transmitting filter, power amplifier, low noise amplifier, receiving filter, down conversion circuit, transceiver switching and antenna system.

![Figure 3. Wireless communication analog front end.](image)
3.4. Power Line Carrier and Micro Power Wireless Integration Module
This paper proposes a dual-mode communication technology of power line carrier and micro power wireless. The carrier in this technology uses high-speed digital processing technology, supports dual frequency parallel receiving, multi frequency transmission, and supports FSK, PSK and other modulation modes. The radio uses 470MHz radio frequency technology, multi band frequency hopping technology, long byte data packet mechanism, network adaptation, automatic relay, interference source processing and other technologies. Both technologies ensure the stability, reliability and accuracy of the system.

The dual-mode module can effectively eliminate the communication Island, realize the complementary advantages of PLC and wireless in the whole network, eliminate the communication blind spot, and solve the problems of low communication performance and reliability.

4. Test results
Test the sealed chip, mainly test the maximum transmitting power and receiving sensitivity of the micro power RF part. Table 1 shows the test results. The results show that PLC has little influence on the micro power, and the performance of micro power wireless communication is within the technical requirements, which shows that the dual-mode mode can work normally under the condition of meeting the conditions, and under different environmental conditions, the two modes can complement each other, improving the success rate of communication, faster meter reading speed and stronger adaptability.

The test results show that, in the dual-mode technology proposed in this paper, PLC has little influence on the micro power, does not affect the normal operation of each other, and can complement each other.

Table 1. RF performance test.

| Parameter                | Technical requirement | Test result |
|--------------------------|-----------------------|-------------|
| Maximum transmitting power | ≥17dBm               | 18.2 dBm    |
| Receiving sensitivity    | ≤-106dBm              | -108 dBm    |

5. Conclusion
This paper proposes a dual-mode communication technology based on the integration of power line carrier and micro power wireless. The dual-mode module chooses the optimal communication channel to build a heterogeneous network according to the actual situation of power line channel and wireless channel by balancing the transceiver and no main and auxiliary. The two modes can complement each other, effectively eliminate the communication Island, realize the complementary advantages of PLC and wireless in the whole network, and improve the efficiency of meter reading the real-time performance, reliability and success rate of the system are improved.

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