OFDM Simulation and Its Application in Mobile Communication

Zhanyi Lu,Zhixi Xie,Haifeng Dou

Information Technology Engineering College, Foshan University of Science and Technology, Guangdong, China

Abstract: In recent years, with the rapid development of the economy, people rely more and more on mobile communication, and therefore greatly promoted the rapid development of modern mobile communications industry, efficient mobile communication system has gradually become a new generation the direction of development. This article describes the content of OFDM simulation and in mobile communications applications. This paper analyzes the principle of OFDM technology, establishes the simulation model of mobile communication system, writes the program code of the system, establishes the simulation model, analyzes the interference factors in the process of the mobile communication transmission, and completes the analysis of the simulation result through simulation. This paper also focuses on the realization of orthogonal frequency division multiplexing (OFDM) and the performance of sub-channels and other parameters and reduces the peak-to-average power ratio of OFDM systems. Finally, the application status and prospect of OFDM technology in the modern communication system are expounded.

Key words: Orthogonal frequency division multiplexing, communication system, sub channel, peak-to-average power ratio

1 Introduction

1.1 Introduction to OFDM

OFDM is called Orthogonal Frequency Division Multiplexing; the meaning of Chinese is orthogonal frequency division multiplexing technology. This technology is the foundation of the HomePlug Powerline Alliance industry specification, which uses a discontinuous multi-tone technique to combine a large number of signals in different frequencies called carriers into a single signal to complete the signal transmission. Because this technology can transmit signals under clutter interference, it is often used in transmission media that are susceptible to external interference or are less resistant to external interference.

In fact, OFDM is not now developed new technology, OFDM technology has been nearly 40 years of history, mainly for military wireless high-frequency communications systems. However, the structure of an OFDM system is very complex, thus limiting its further promotion. Until the 1970s, people use discrete Fourier transform to achieve multiple carrier modulations, simplifying the system structure, making OFDM technology more practical. In the 1980s, people studied how to apply OFDM technology to high-speed MODEM. Since the 1990s, OFDM technology research into the wireless FM channel on the broadband data transmission. At present, OFDM technology has been widely used in broadcast audio, video, and civil communication systems. The main applications include asymmetric digital subscriber loop (ADSL), ETSI standard digital audio broadcasting (DAB), digital video broadcasting (DVB), high definition television (HDTV), wireless local area network (WLAN) and so on.

OFDM is a multi-carrier modulation technique. The core is to divide the channel into several orthogonal sub channels and perform narrowband modulation and transmission on each sub channel, thus reducing the mutual interference between sub channels. The signal bandwidth on each sub channel is less than the associated bandwidth of the channel, so the frequency selective fading on each sub channel is flat, greatly eliminating intersymbol interference. In addition, since the carriers of the respective sub channels in the OFDM system are orthogonal to each other, their spectra are overlapped with each other, which not only reduces the mutual interference between the subcarriers but also improves the spectrum utilization rate.

1.2 The significance of OFDM research

Modern society has entered the information age, in a variety of information technology, information transmission that communication plays a supporting role. Countries around the world are committed to the research and development of modern communication technology, and wireless communication is an indispensable part of the modern communication system. Today, wireless communication has become one of the most important means of communication for people's daily life, and the rapid increase in the demand for wireless communication is the fundamental driving force of wireless communication technology. The Global System for Mobile Telecommunication (GSM) generated in the mid-1980s and the Code Division Multiple Access (CDMA) communication system proposed by the early 1990s were the second generation mobile communication technologies, to meet people's high-quality voice services and low-rate data business requirements. With the continuous expansion of the type of communication business requirements, the demand for communication rate continues to increase, the existing second generation mobile communication network has been unable to meet the new business needs; To this end, the beginning of this century, people developed a broadband CDMA Technology as the core of the third generation mobile communication network standard WCDMA, cdma2000, and TD-SCDMA. At present, the researchers focus on three generations later (Beyond 3G, B3G) and fourth generation (4G) wireless communication system technology research, research the main goal is high-speed Internet wireless access and high-quality digital multimedia information wireless transmission and other applications , And one of the commonalities of such business is the requirement for high-speed wireless information transmission. Orthogonal frequency division multiplexing (OFDM) and Quadrature Amplitude Modulation (QAM) have many advantages in high-speed wireless transmission. The B3G and 4G systems have listed OFDM technology as a backup. Election layer standard. In recent years, researchers have put forward many theoretical and technical bases for the application of OFDM technology in wireless communication systems.

OFDM technology is a multi-carrier transmission technology; the main feature is the high-speed information is divided into multiple orthogonal subcarriers and low-speed transmission; because sub-carriers overlap and orthogonal, they can independently transfer information symbols and Do not interfere with each other while maintaining high spectral efficiency. OFDM system on the one hand to improve the robustness of the time-domain impulse noise; the other hand, based on the block transmission technology OFDM technology between each OFDM information symbols plus the protection interval (Time Interval Guard, TGI), as long as the protection interval Is greater than the maximum delay spread of the Channel Impulse Response (CIR), and the orthogonality between all subcarriers of the system can be maintained after passing through the channel. OFDM is based on the block transmission orthogonal multi-carrier transmission so that it has anti-symbol inter-coding (ISI) capability, but also can be channel equalization from the complex time domain processing into a simple frequency domain deal with. In the OFDM system, the system can flexibly apply the adaptive modulation technology and the adaptive power distribution technology among the subcarriers according to the working environment of the subcarrier to further improve the transmission efficiency and transmission performance of the system.

With the development of modern mobile communication system, in order to achieve high-speed information transmission, people began to study multi-carrier modulation technology. People began to study multi-carrier modulation technology. Orthogonal frequency division multiplexing (OFDM) technology is based on the development of a digital signal processing technology based on the parallel digital transmission. OFDM technology with its high spectrum utilization and information transmission efficiency and strong anti-multipath fading ability in the field of wireless communications has been widely used. OFDM (Orthogonal Frequency Division Multiplexing) technology was first proposed in the 1960s when the practical application was a military wireless high-frequency communication link. In recent years, due to the rapid development of DSP (digital signal processing) technology, OFDM as a can effectively deal with inter-symbol interference, high-frequency utilization of high-speed transmission system, causing widespread concern. As one of the keys to OFDM technology, channel estimation directly affects the performance of the whole system. At present, the commonly used channel estimation algorithm mainly has two kinds of pilot channel estimation and blind channel estimation.

The channel estimation can be defined as a process of characterizing the effect of the physical channel on the input signal. If the channel is linear, then the channel estimation is to estimate the impulse response of the system. The so-called channel estimation is a mathematical representation of the influence of the channel on the input signal. And good channel estimation is an estimation algorithm that minimizes the estimation error. In summary, the channel estimation in OFDM systems is of great importance.

Although the OFDM system has many unique advantages, because of its special structure, making the system there are some shortcomings. One is the peak power ratio than the signal distortion, so that the superposition of the signal spectrum changes, resulting in the sub-channel signal between the orthogonality is destroyed, resulting in mutual interference, the system performance degradation; Second, OFDM system Timing and frequency offset sensitivity. When OFDM receives a signal with carrier frequency offset, carrier frequency offset can cause subcarrier interference (ICI), reducing the orthogonality between sub channels, thereby reducing overall system performance.

Due to the relatively poor wireless channel propagation environment, the complexity and diversity of the geographical environment, the randomness of user movement and multipath propagation, etc., will affect the OFDM signal transmitted through the channel, the signal amplitude attenuation, frequency offset and Phase rotation, destruction of the signal orthogonality, resulting in inter-symbol interference ISI and ICI. Increasing data transfer rates also provide higher data transfer requirements for wireless access systems such as anti-frequency selective fading, anti-symbol interference (ISI), and so on. Although OFDM technology itself has a mechanism to combat multipath fading, it is not enough to ensure that ISI and ICI are eliminated, and OFDM is very sensitive to system frequency offset, so that the received signal at the receiving end is distorted and cannot be demodulated correctly Transmit data, reduce the performance of the entire system.

In order to improve the performance of the system, it is necessary to ensure the orthogonality of the signal, to prevent ISI and ICI. There are usually three ways to resist ISI and ICI: one is data interleaving, the second is channel coding, and the third is channel estimation and equalization. This is usually used in the OFDM system; this paper is the third program to study. This is because the channel propagation environment is bad, will seriously affect the performance of communication systems, even if the system by adding data interleaving module and channel coding module, cannot eliminate the channel, especially mobile wireless transmission channel, it is a time-varying multipath The fading channel has a great influence on the transmission signal transmitted in the channel, which will greatly degrade the overall performance of the system. In order to make the transmission data through the channel after the attenuation, the receiver is correctly received, the data experienced by the channel fading impact should be reasonably compensated, the wireless communication system must join the channel estimation and equalization module. Channel estimation technology, as a means of obtaining channel fading parameters, is one of the key technologies to improve the performance of wireless data transmission. Therefore, the study of the estimation and equalization of the channel is very necessary and quite critical.

The significance of channel estimation is that the channel estimation method is used to obtain the impulse response of the channel in the time domain or frequency domain, and the channel information is correctly demodulated for the receiver to eliminate or reduce the influence of the time-varying multipath channel on the signal transmission. Compared with differential demodulation, data symbols with channel estimation can help increase the SNR gain of 2.5 ~ 3dB by using coherent demodulation and can also use multi-level modulation technology (such as M-QAM) with high band utilization. , Channel estimation can also provide the necessary information for space-time code decoding and multi-user detection, maximum ratio combining and other technologies. Especially in wireless data packet communication, since it is often necessary to obtain the channel state experienced by each packet, the channel estimation played a vital role.

Channel estimation is widely used in communication systems. Adaptive channel equalizers utilize channel estimation to counter the impact of ISI. The diversity technique utilizes channel estimation to achieve the best match with the received signal. The maximum likelihood detection is achieved by channel estimation Error probability minimization; the most important point is that the channel estimation makes the receiver coherent demodulation possible, compared with non-coherent demodulation, coherent demodulation can improve the overall performance of the system.

2. OFDM basic principles

2.1 Orthogonal frequency division multiplexing (OFDM) implementation and performance analysis

Method to realize:

In conclusion, OFDM can be divided into two types according to the baseband filter: one is a baseband filter with a time domain rectangle; one is a baseband filter that conforms to the Nyquist first criterion. , The baseband FIR digital filter g (m) conforming to the Nyquist first criterion for each sub channel can avoid inter-symbol interference in the case of channel bounds, especially in the case of high signal-to-noise ratios It is particularly important. The theoretical analysis shows that (1) the real part of the sub channel does not interfere with the imaginary part at the sampling point of the adjacent sub channel. (2) The real part of the sub channel does not have a real part at the adjacent sub channel sampling point after the time axis is staggered.

Performance analysis:

We compare the two ways of implementing OFDM from several aspects. The OFDM of the time domain rectangular baseband filter is called the mode I. The OFDM using the frequency domain cosine roll-off type baseband filter is called the mode II. From the occupied spectrum point of view, because the use of a time domain rectangular filter, the frequency of each sub channel is sin (f) f type, the amplitude spectrum shown in Figure 4 (unprotected interval). Since the spectrum of each sub channel itself is band limited, there is no serious waveform distortion and inter-symbol interference in the band-limited channel. The total bandwidth occupied by the same sub-channel number is smaller than the way. From the realization of complexity point of view, it should be said that the way is extremely simple, especially in the introduction of DFT technology; multi-channel modulation can be easily achieved. And no matter how much the number of sub-channels, the increase is only the amount of calculation only. Mode 2 can also be simplified with DFT technology, and the order of the baseband filter can be greatly reduced, but the baseband filter is still indispensable, that is, each sub-channel to have one, which in the sub-channel number of more occasions will be a lot of overhead. From overcoming multipath fading, the way in which a baseband filter is not, it is possible to leave a space in front of each symbol as a guard interval. So that it can have a long time in the multi-path delay, does not cause interference between adjacent symbols. For the second way, because of the shape of the baseband filter has more stringent requirements, so if you leave a part of the space as a protection interval will destroy the shape of the baseband filter, then can no longer guarantee inter-code interference, so this way cannot add Protection interval. Of course, since the two modes adopt multi-carrier modulation, the symbol interval is widened, and it is more resistant to multipath fading than a single carrier. That each symbol is more conducive to overcome the interference caused by their delay.

In the implementation of the first OFDM, the waveform formed by the DFT is not the same as the waveform formed by the orthogonal frequency division in the true sense. The reason is that the sampling point obtained by the DFT is too small to be it comes back to the analog signal. This difference is not sufficient to affect the reception of its sub-channel data, but for the presence of multipath interference, it will cause a large error matrix. It is necessary to increase the number of sampling points to form a real OFDM.

2.2 Sub-channel number and other parameters set

In the OFDM system, the OFDM modulator mainly modulates the OFDM data. OFDM modulator uses N = 120 data sub channels, 8 pilot channels. 120 data sub channels are QPSK channel modulation, 8 pilot channels using BPSK channel modulation. In order to use the baseband transmission, add zero processing (add 128 0), so that the band expansion 1 times. After reverse processing, the IFFT of 256 points is used for OFDM modulation. The system clock is 80MHz, with FPGA to complete the data encoding and modulation, and finally to read the clock at 500 kHz rate sent to D/A.

Before the dynamic sub-channel allocation, according to the size of each user's ferry to determine the number of sub-channel should be divided by the number of sub-channel, and then according to the user's instantaneous yu loser gain dynamic allocation of sub-Tao Road. This stage of the buffer modulation mode is fixed, and the user requires the same bit error rate. There is a better test algorithm to determine the sub-channel allocation; it is divided into two steps to achieve a better sub-channel dynamic allocation, that is, the initial distribution of secret iterative approximation. The initial distribution of the Phenomenon is given by the iterative exchange to continuously approximate the final result to minimize the transmission power. The sub channels of the sub channels or a K × N matrix are arranged according to the order of the gain of each sub channel in descending order of each user, and then the sub channels are assigned to the user from the first column of the matrix, If the sub channel has not yet been allocated and the user has not yet been assigned the required sub-channel, the sub-letter is assigned to the user, assigned 1 at the corresponding position of the allocation matrix, and the remaining position of the column is 0, At the same time, the power of the flower is the least. To the variable rate of production, the use of water 'program distribution power secret: the link gain of the user distribution of large power, the link gain of small user allocation of power is small so that the priority of the power to get the maximum boiled system capacity Cuan. If the link gain is not within the given range of values, then the sub channel beyond this range does not allocate power.

2.3 Reduce the peak-to-average power ratio of OFDM systems

Orthogonal frequency division multiplexing (OFDM) technology is considered to be very suitable for the next-generation mobile communication system in the wireless channel high-speed transmission technology, this technology has high band utilization, and single carrier modulation technology can be more for effective against multipath interference in the wireless channel. However, one of the major drawbacks of OFDM systems is that the transmit signal at the transmitting end has a large peak-to-average power ratio (PAPR), which limits the wide application of OFDM technology. The reason of the high peak of the signal is analyzed, and the data sequence is shifted to find the lowest sequence transmission of PAPR. The simulation shows that there is a certain effect on improving PAPR.

The main reason for the high PAPR in the OFDM system is that the OFDM signal is superimposed on the quadrature subcarriers in the time domain. When the number of subcarriers reaches a certain degree, the waveform of the OFDM symbol will be one according to the central limit theorem Gaussian stochastic process, the envelope is unstable, and when the IV subcarriers are the same, they will produce the largest peak when they are added to the peak. This phenomenon causes the OFDM signal to be easily distorted by the amplifier, destroying the orthogonality between the subcarriers, thereby deteriorating the transmission performance. For multicarrier systems, the peak-to-average ratio depends on the number of subcarriers, which increases as the number of subcarriers increases and is not sensitive to the modulation scheme used. The most serious impact of high PAPR is on the transmitter and the receiver's power amplifier. Since the general power amplifier is not linear, and its dynamic range is limited, so when the OFDM system within a wide range of changes in the signal through the non-linear components (such as access to the amplifier's non-linear region), the signal will produce non-linear distortion, resulting in harmonics, resulting in more pronounced spectral spread and in-band signal distortion, resulting in degraded overall system performance, while also increasing the complexity of ~ D and D/A converters and reducing their accuracy. In order to reduce the signal PAPR value, many people have studied this. Up to now, some methods have been proposed to reduce PAPR values. These methods are mainly divided into the following categories: clipping class technology, coding class, multi-signal representation technology.

2.3.1 Limiting technology

Of these technologies are: limiting filtering, peak windows, and peak offsets. Where the clipping filter and the peak window are non-linear processes, and the peak offset is a linear process.

2.3.1.1 Clipping filter

In the OFDM signal, since the probability of a large peak is very small, the clipping is a very direct and effective technique to reduce the peak-to-average ratio. However, the limiting is a non-linear process, thereby reducing the overall system's bit error rate performance and spectral efficiency. Clipping filtering can reduce the out-of-band spectrum, but this, in turn, leads to peak regeneration. If the digital signal is directly clipped, the clipping noise will all fall within the band, and the noise cannot be reduced by filtering. To avoid this aliasing, you can fill the input data and use a longer IFFT process to sample the original data block. Similarly, after limiting the need to filter to eliminate out-of-band limiting noise. When the clipping technique is used to reduce the PAPR of the signal, the signal amplitude will be filtered once it exceeds the set threshold.

2.3.1.2 Peak Window Technology

Although the simplest and most straightforward way to reduce the PAPR of a signal is to limit the signal peak directly so that its signal amplitude is limited to the desired maximum amplitude. But the limiting is a non-linear process, which will bring in-band and out-of-band radiation. The limit function can be seen as a process in which the 0FDM signal is multiplied by a rectangular function. When the amplitude of the OFDM signal is less than the given threshold, the rectangular function is 1, and when the amplitude of the OFDM signal exceeds the given threshold, the rectangular function the value is less than 1. The spectral range of the OFDM signal after the clipping of the OFDM signal and the convolution of the window function spectrum. The characteristics of the out-of-band spectrum are mainly determined by the larger frequency bands in the two spectra, that is, the spectrum of the rectangular window function. The spectrum has a very slow roll-off coefficient, and the roll-off coefficient is inversely proportional to the frequency. In order to reduce the extra-band problem caused by direct limiting, the larger signal peak can be multiplied by the appropriate non-rectangular window function. In fact, as long as better spectral characteristics can be obtained, any window function can be In addition, the ideal window function should have as narrow bandwidth as possible. On the other hand, the window function should not be too wide in the time domain because the wider window in the time domain means that more signal samples will be affected, thereby increasing the bit error rate of the system. The better window functions are cosine, Kaiser, and Hamming windows.

2.3.1.3 Peak Offset

All of these techniques are focused on directly reducing the power of more than a given threshold signal samples of the amplitude-frequency selective mapping to reduce the OFDM system peak-to-average power ratio research. For direct slicing and peak windowing techniques, the OFDM signal is directly operated to reduce the PAPR of the signal so it will bring considerable out-of-band. The use of linear peak cancellation technology can avoid this unwanted out-of-band. Appropriate selection of the reference function to have a substantially equivalent bandwidth to the transmitted OFDM signal. In this way, this peak offset technique does not bring any out-of-band. For example, the sync function is a more appropriate reference function. Some function of the shortcomings is that it has unlimited corresponding. Therefore, in practical application, should be used in a way to cut its short time limit. One way is to multiply it by a window function, such as a cosine window, which does not cause unwanted out-of-band interference. If the window function is the same as the 0FDM symbol window function, the reference function has the same bandwidth as the 0FDM symbol. In this way, the peak offset does not destroy the out-of-band spectral characteristics. If the reference signal window is narrowed, the computational complexity of the peak offset will be reduced, but the out-of-band will increase, so there is a trade-off between the smaller computational complexity and the larger out-of-band. Peak offset can be processed directly on OFDM time domain symbols. It contains a power peak detector and a comparator that reduces the peak and the amplitude of the signal around the peak when the power of the signal is detected to exceed the set threshold. The incoming data is first coded, and the string is transformed to construct the OFDM time domain signal. Then, with the cyclic prefix, the signal symbol is extended to the symbol of the IV + IVG signal samples. After the parallel-to-serial transformation, the peak cancellation process is performed to reduce the PAPR value of the signal. It is also possible to perform a peak offset process directly before adding a cyclic prefix to IFFT. In addition to the peak offset module, the transmitter is no different from the standard OFDM transmitter, and there is no difference between the receiver and the conventional OFDM receiver so any standard OFDM receiver can be used.

2.4 String and transform

The typical form of data transmission is the serial data stream, the symbols are transmitted continuously, and the spectrum of each data symbol can occupy the entire available bandwidth. However, in the parallel data transmission system, many symbols at the same time transmission, reducing those in the serial system problems. In the OFDM system, the size of each transmission symbol rate of about tens of bits/s to several tens of Kbit/s between, so must be serial and parallel conversion, the input serial bit stream can be converted into OFDM symbols can be transmitted. Since the debug mode can be adaptively adjusted, the modulation mode of each subcarrier can be varied because the number of bits that can be transmitted per subcarrier can also be changed so that the length of the data to be allocated to each subcarrier is Different. In the receiver to perform the opposite process, from the sub-carrier out of the data length is not the same. The opposite process is performed at the receiving end, and the data from the respective subcarriers is converted back to the original serial data.

When an OFDM symbol is transmitted in a multipath radio channel, frequency selective fading causes some subcarriers to receive a significant attenuation, causing a bit error. These zero points at the channel frequency response cause the information transmitted on the adjacent subcarriers to be destroyed, resulting in a series of bit errors in each symbol. Most forward error correction (FEC) works more effectively if both error distributions are associated with a large number of consecutive occurrences of errors. Therefore, in order to improve the performance of the system, most systems use data scrambling as part of the string and transform work. This can be achieved by randomly assigning each successive data bit to each subcarrier. At the receiver side, a corresponding inverse process is performed to solve the signal. In this way, not only can the original order of the data bits be restored, but also a series of bit errors due to signal fading can be distributed so that they are distributed evenly in time. This randomization of bit error locations can improve the performance of forwarding error correction coding (FEC), and the overall performance of the system is improved.

2.5 Subcarrier modulation

The orthogonal frequency division multiplexing (OFDM) technique is to divide a given channel into a number of orthogonal sub channels in the frequency domain, modulate on one subcarrier for each sub channel, and transmit each subcarrier in parallel. Although the total channel is non-flat, frequency selective, but each sub channel is relatively flat, narrowband transmissions are performed on each sub channel, the signal bandwidth is less than the corresponding bandwidth of the channel, thus greatly eliminating the interference between signal waveforms The And the carrier of the sub channel is orthogonal to each other, an OFDM symbol includes a plurality of synthesized signals of PSK modulated or QAM modulated subcarriers, the spectra of each subcarrier being overlapped with each other, thereby increasing the spectral utilization. (I = 0, 1, ..., N - 1) is the data symbol assigned to each sub channel, fi is the carrier frequency of the i-th subcarrier, and the number of subcarriers is denoted by N, The equivalent baseband signal of the OFDM symbol starting from t = ts can be expressed as (analog signal expression):

The real and imaginary parts of s (t) correspond to the in-phase and quadrature components of the OFDM symbol, respectively. In the actual system, the cosine and sine components of the corresponding subcarriers can be multiplied to form the final sub channel. The k (k = 0, 1, N - 1) samples of the transmit rate are expressed as follows: Let ts = 0 and the sampling rate be N/T.

(1-2)

It is clear that the expression of IDFT is exactly the expression of IDFT. It can be seen that modulation and demodulation of OFDM can be realized by IDFT and DFT or (IFFT and FFT). As shown in Figure 1.2, an instance of four carriers is included in an OFDM symbol. Of these, all subcarriers have the same amplitude and phase, but in practical applications, it is not possible for each subcarrier to have the same amplitude and phase according to the modulation of the data symbols. It can be seen from Figure 1.2 that each subcarrier contains an integer multiple times in an OFDM symbol period and that one of the adjacent subcarriers is different by one cycle. This characteristic can be used to explain the orthogonality between subcarriers, namely:

(1-3)

Such as the jth subcarrier in Equation 1-3, and then integrates into the time length T, i.e.

As can be seen from Equation 1-4, the demodulation of the Jth subcarrier can restore the desired symbol. For other carriers, the frequency difference (I-J)/T can produce an integer multiple of the period due to the integration interval, so the integration result is zero. This orthogonality can also be explained from the frequency point of view. According to Equation 1-2, each OFDM symbol contains a plurality of non-zero subcarriers within its period T. So its spectrum can be seen as a convolution of the spectrum of the rectangular pulse with period T and a set of δ functions located at each subcarrier frequency. The rectangular pulse spectrum amplitude value is the sinc (T) function, and the zero point of the function appears at a position where the frequency is 1/T integer multiple.

Figure 1.3 OFDM subcarrier spectrums

This phenomenon can be seen in Figure 1.3, which shows the sinc function of the symbols obtained by rectangular waveform-shaping in each sub channel that covers each other. At each subcarrier frequency maximum, the spectral values of all other sub channels are exactly zero. Since the maximum value of each subcarrier frequency corresponding to these points needs to be calculated during the demodulation of the OFDM symbols, the symbols of each sub channel can be extracted from a plurality of overlapping sub channels without receiving Interference of other sub channels. As can be seen from Figure 1.3, the OFDM symbol spectrum can actually satisfy the Nyquist criterion, that is, there is no mutual interference between multiple sub channel spectra. Thus, the presence of such a sub channel spectrum is maximized, and other channel spectra are zero, which avoids the occurrence of inter-carrier interference (ICI).

3.OFDM system simulation

3.1 OFDM transmission module

An OFDM symbol from time to time can be expressed as:

(3-1)

Where the composite modulation symbol is the carrier number, T is the symbol duration, and the carrier frequency, the standard DVB (digital video broadcast) is as follows:

(3-2)

Among them:

For the number of carriers;

The number of OFDM symbols;

For the number of frames transmitted;

The number of transmitted carriers;

For the symbol duration;

For the time delay carrier interval;

For the protection interval;

For the RF signal center frequency;

For the carrier relative to the center frequency;

The kth carrier of the first data symbol in the compound symbol;

The kth carrier of the second data symbol in the compound symbol;

Is the kth carrier of the 64th data symbol in the compound symbol;

In this case, a digital broadcasting transmission standard with a transmission rate of 2K is used. This mode is defined as a mobile reception standard in digital broadcasting television (DTV). The transmitted OFDM symbol consists of a number of frame structures, each of which contains 68 OFDM symbols for each duration. The four frames form a large frame structure, and each symbol is composed of 1705 subcarriers in 2K mode, and its transmission duration is. The duration of the valid symbol in the symbol duration is, the guard interval time is. 2K mode of the specific parameters sees Table 3.1:

Table 3.1 2K mode OFDM parameters

Parameter 2K model

Number of carriers K 1705

Minimum carrier number 0

Maximum number of carriers 1704

Duration 224

Carrier spacing 4464Hz

Minimum carrier with maximum carrier (K-1)/interval of 7.61MHz

Allowable protection interval 1/4 1/8 1/16 1/32

Effective symbol duration 2048 × T

224

Protection to see a duration of 512 × T

56 256 × T

28 128 × T

14 64 × T

56

Basic cycle T 7/64

OFDM symbol duration = + 2560 × T

280 2304 × T

252 2176 × T

238 2112 × T

231

From t = 0 to t = analysis of Equation 3-2, Equation 3-3:

(3-3)

It is clear that there is a similarity between the above equation and the inverse Fourier transform (IDF)

(3-4)

There are many different FFT algorithms that can implement discrete Fourier transform (DFT) and discrete Fourier transforms (IDFT). This makes it easy to form N samples in practical applications so that the duration of each symbol useful part is The In the time guard interval will be copied to the front of the same point, and then through the integrated uplink conversion so that the center of the letter s (t) fc.

3.2 Generation of OFDM symbols

OFDM spectrum is mainly concentrated in the vicinity of fc, a more convenient way to achieve the use of 2-FFT and 2-IFFT and T/2 as its basic cycle. As can be seen from Table 2.1, the OFDM symbol duration is, which an IFFT transform of 2048 points is; therefore, an IFFT of 4096 points is performed. Figure 3.2 shows a block diagram of the OFDM symbol generation, where some of the variables have been marked for use in Matlab code for easy analysis. T is defined as the basic period of the signal since it is necessary to consider its time period (1/Rs) at least twice the carrier frequency when simulating a bandpass signal. More generally, with an integer multiple of Rs = 40/T. Such a relationship makes the carrier frequency close to 902MHz, which is described in Figure 3.2. First, a binary sequence of 3412 is randomly generated. Then, using QAM mapping, each two binary bits are mapped to one of {± 1 ± j}. After 4096 IFFT transform, first into the analog value, and then through a Butterworth low-pass filter, and finally in the transmitter frequency conversion to the radio frequency band to s (t) sent out.

Add 4906-1708 = 2391 zeros to the source symbol A to double the sample and reach the desired center frequency. As can be seen from Figures 3.3 and 3.4, the effect of this is such that the carrier takes T/2 as its time period. It is also noted that the carrier is a baseband signal with discrete time, and a continuous time signal g (t) is generated by the transmission filter as a complex signal carrier. The impulse response and pulse shape are shown in Figure 3.5.

Figure 3.3 Time domain response of signal carrier at B

The output of this transmit filter in the time domain, and frequency domain is shown in Figure 3.7 and Figure 3.8. The frequency response of Figure 3.8 is periodic because the discrete time signal is periodic in the frequency domain and its spectral bandwidth depends on Rs. The period of U (t) is T/2, and the reconstruction filter will have (T/2 = 18.286) -7.61 = 10.675MHz the transition bandwidth can be used. If the N-point IFFT is used, the excess bandwidth is only (1/T = 9.143) -7.61 = 1.533MHz, so in order to avoid confusion requires a very sharp roll-off to less reconstruct the complexity of the filter.

Figure 3.6 D/A filter response

Figure 3.7 Signal U time domain response at point C

Figure 3.6 shows the frequency response of the ideal D \\ A filter. It is a 13-step cut-off frequency of 1/T of the Butterworth filter. The filter's time domain and frequency domain response are shown in Figure 3.9 and Figure 3.10, respectively. It is worth noting that in the filtering process, the delay occurs near 210-7, except that it will be filtered as expected. At this time, the subcarriers 853 to 1705 are located at the right of the center frequency (0 Hz), and the No. 1 subcarrier to the 852 is in the range of 4fc at the center frequency (0Hz). The next step is to perform multiple biorthogonal single sideband amplitude modulation uoft (t). In this modulation, there is an in-phase signal mI (τ) and a quadrature signal mQ (τ) which satisfies equations (3-5):

(3-5)

Formula 2-3 can be expanded as Equation 2-6:

(3-6)

Where the in-phase signal and the quadrature signal are respectively implemented as the real and imaginary parts of the 4-QAM. The corresponding IFFT process is:

(3-7)

The time domain and frequency domain response of the signal s (t) are shown in Figure 3.11 and Figure 3.12.

Figure 3.9 Time domain response of the signal at point D

Figure 3.10 Signal at the point D at the frequency response

The following are the same as the

Figure 3.11 Signal s (t) Time domain response at point E Figure 3.12 Signal s (t) Frequency response at point E

In conclusion

Through the simulation of mobile communication system, the working principle of OFDM system and the interference in the transmission process are simulated and analyzed. The basic working principle of OFDM system is clarified, which lays the foundation for improving the efficiency of mobile communication and further reducing the signal interference.

OFDM system is suitable for multi-service, highly flexible communication system, the spectrum utilization is high, and the system stability is good. At present, OFDM has been widely used in Europe and Australia, digital broadband audio systems and digital broadband video systems, OFDM-based communication technology, enabling the transmission process to achieve low latency, high-speed data transmission. 54Mbit/s bandwidth is basically able to meet the majority of users on the wireless network requirements. With the continuous improvement of OFDM technology, its application will be extended to various fields.

For the fourth generation of mobile communication standards, OFDM still has many problems to be solved, select OFDM as the fourth generation of mobile communication core technology, the main reasons include high spectral efficiency, anti-noise ability, suitable for high-speed data transmission factor.

REFERENCES

[1] Ding Shuyu, Chen Jian; Fundamentals of OFDM and FFT Implementation [J]; Shanxi Electronics; 2004-05

[2] Zhang Ke, Zhou Xiaozheng, Xu Xizong. Analysis of multi-symbol signal detection method based on TCM-OFDM [J]; Journal of Beijing Institute of Petrochemical Technology; 2005-01

[3] Liu Peng. High-speed wireless communication in the orthogonal multi-carrier modulation technology [J]; Western radio and television; 2002 11

[4] School of Computer Science and Technology, Chongqing Normal University, Xi'an 710049, China; High-speed wireless transmission technology [J]; Journal of Chongqing Normal University (Natural Science Edition); 2002-03

[5] Li Fenglin; Using FFT to realize OFDM modulation and demodulation [J]; Journal of Huaihai Institute of Technology; 2001-03

[6] Zhang Gexiang, Li Na. MATLAB simulation technology and application [M]. Beijing: Tsinghua University Press. 2003

[7] Da Xinyu. Communication principle experiment and curriculum design [M]. Beijing: Beijing University of Posts and Telecommunications Press, 2004

[8] Qu Yue, Hou Chunping. A new method to reduce the peak-to-average power ratio of OFDM systems [J]; Electronic Products World; 2006: 19

[9] Liu Min, Wei Ling. MATLAB communication simulation and application [M]. Beijing: National Defense Industry Press, 2005

[10] Shi Yang. MATLAB language essence and dynamic simulation tools - SIMULINK [M]. Xi'an: Northwestern Polytechnical University Press, 1997.

[11] Journal of Electronics & Information Technology; 2002-04

[12] Hu Liangliang, Zhou Yuefeng et al. PAPR suppression method based on non-uniform quantization in OFDM system [J]. Communication Technology 2003-3: 28-30

[13] G Wade, et al. Peak-to-average power reduction for OFDM schemes by selective scrambling [J] .lectronics letters, 1996, 32 (21).

[14] Chen Bing. OFDM technology in mobile data communication applications [J]; China New Communication; 2008 13

[15] Shao Yubin .Matlab/Simulink communication system modeling and simulation examples [M], Beijing: Tsinghua University Press, 2008.

[16] Wang Lining, Le Guangxin, Zhan Fei. MATLAB and communication simulation [M]. Beijing: People's Posts and Telecommunications Press, 2000

[17] Fan Changxin, Cao Lina. Communication principle [M]. Beijing: National Defense Industry Press, 2008

[18] Deng Hua. MATLAB communication simulation and application examples [M]. Beijing: People's Posts and Telecommunications Press, 2003

[19] YIN Chang-chuan, et al. Multi-carrier broadband wireless communication technology [M]. Beijing University of Posts and Telecommunications Press .2004

[20] A Method for Reducing Average Power Ratio of Orthogonal Frequency Division Multiplexing [J]. Telecommunications Technology, 2002-5: 92-95 (in Chinese with English abstract)