

MATLAB Simulation based on OFDM Technology

Song Xiuping

Chongqing College of Electronic Engineering, Chongqing, China

410441527@qq.com

Keywords: OFDM; Simulation; MATLAB

Abstract: Orthogonal frequency division multiplexing (orthogonal frequency division multiplexing) is one of the most promising technologies in wireless communication tools. OFDM systems can be inserted through the cyclic prefix, effective to suppress the inter-symbol interference of multipath transmission bring, can also be based on accurate estimate of the channel characteristics, to reduce the influence of channel time-varying nature of the system. Moreover, the application of OFDM technology in the field of wireless communication has attracted wide attention due to its use of Fourier transform to greatly reduce the receiver complexity. As an efficient transmission technology, OFDM has become the core technology of fourth-generation mobile communication. To study OFDM system, a complete OFDM system is needed. After briefly introducing the basic principle of OFDM, this paper constructs a complete OFDM dynamic simulation system based on MATLAB.

1. Introduction

OFDM is a special multi-carrier transmission scheme, which can be considered as a modulation or multiplexing technology. Because of the multi-carrier transmission bit stream data inflow, each sub-data stream will have a lower bit rate. The low-rate multi-state symbols formed by such a low bit rate and then the corresponding sub-carriers are modulated to form a transmission system of parallel transmission of multiple low-rate symbols. Orthogonal frequency division multiplexing (OFDM) is an improvement of multi-carrier modulation (MCM). Its characteristic is that each subcarrier is orthogonal and the spectrum can overlap with each other, which not only reduces the interference between subcarriers, but also greatly improves the spectrum utilization.

In multipath fading channels, inter-symbol interference (ISI) is the main problem of broadband transmission. Multicarrier modulation technology, including OFDM technology, is the most promising method and technology to solve this problem. Digital implementation using OFDM technology and IFFT mode is more suitable for environments with significant multipath effects, such as high-speed WLAN and digital video broadcasting DVB. As an efficient transmission technology, OFDM has become the core technology of the fourth generation mobile communication. In order to study the system, it is necessary to build a complete OFDM system. After briefly introducing the basic principles of OFDM, a complete dynamic simulation system of OFDM is constructed based on MATLAB.

2. Feasibility analysis

It is convenient to design the OFDM receiving system in the combination of language and graphics by MATLAB, and the initial parameters of the system can be set at the beginning of the MATLAB program.

The OFDM modulation signal and analog channel noise and Gauss white noise can be set according to the requirements, that is to say, AWGN channel is used as channel model to partly complete the serial receiving system and conversion, CP, FFT, and string conversion, signal mediation. These part of the design can be implemented in MATLAB simulation.

Write the MATLAB program to realize the demodulation of OFDM signal through AWGN channel, that is to say, complete the demodulation function of an OFDM receiving system.

3. Basic Principles of OFDM

The basic idea of OFDM is to modulate serial data on multiple orthogonal subcarriers in parallel, which can reduce the symbol rate of each subcarrier, increase the symbol period of the symbol, and improve the anti-fading and interference ability of the system. At the same time, the orthogonality of each subcarrier greatly improves the utilization of spectrum, so it is very suitable. High-speed transmission in mobile applications.

The transmitter generates modulation signals by input modulation mapped high bit stream, then converts the modulation signals into N parallel low-speed sub-data streams. Each N parallel low-speed sub-data stream constitutes an OFDM symbol. When the pilot signal is inserted, the fast Fourier inverse transform (IFFT) is performed to modulate the N data of each OFDM symbol. Finally, the time domain signal is formed as follows:

$$x(n) = IFFT[x(n)] = \sum_{m=0}^{N-1} X(m)e^{j\hat{\lambda}_m n / N},$$

$$n = 0, 1 \dots N - 1$$

Among them, m is the discrete point in frequency domain, n is the discrete point in time domain and N is the number of carriers. In order to effectively suppress inter-symbol interference (ISI), it is usually necessary to add protection interval (GI) before OFDM symbols in each time domain. After the protection interval, the signal can be expressed as formula (2-2). The final signal is transmitted by the transmitting antenna after series conversion and D/A conversion.

$$x_{GI} = \begin{cases} x(N+n), n = -N_{GI}, -N_{GI}+1, \dots, -1 \\ x(n), n = 0, 1, \dots, N-1 \end{cases}$$

The receiving end processes the received signal to complete timing synchronization and carrier synchronization. After A/D conversion, the signal can be expressed as:

$$yG(n) = xG(n) * h(n) + z(n) + w(n)$$

Then, after removing the CP, FFT demodulation is performed, and channel estimation (based on the inserted pilot signal) is performed. Then the channel estimation and FFT demodulation are sent to the detector for coherent detection, and the information symbols on each subcarrier are detected. Finally, the original bit stream is recovered by reflecting the transmission and channel decoding. The number after removing the cyclic prefix (CP) and FFT transformation can be expressed as:

$$Y(m) = FFT[y(n)] = \frac{1}{N} \sum_{n=0}^{N-1} y(n)e^{-j2\pi mn/N}, \quad m=0, 1, \dots, N-1$$

$$Y(m) = X(m)H(m) + Z(m) + W(m), \quad m=0, 1, \dots, N-1$$

H(m) is the Fourier transform of channel h(n), Z(m) is the inter-symbol interference and inter-carrier interference, Z(m) is the Fourier transform, and W(m) is the Fourier transform of additive white Gaussian noise w(n).

4. OFDM system simulation and result analysis

4.1 Simulation program

This program mainly uses Rand() function to generate random data, and calls the function QAM16_mod(), so that the generated data are mapped to the coordinate system one by one, forming a 16QAM constellation map. Then the QAM_16demod() function is called to re-map the demodulated data to the 16QAM constellation.

The main program of QAM16_mod() function is as follows:

```
function complex=QAM16_mod(number)
16QAM Constellation Mapping - Mapping the number of inputs into the corresponding
coordinates (complex)
```

```
A=[-3-3*i,-3-i,-1-3*i,-1-i,-3+3*i,-3+i,-1+3*i,-1+i,3-3*i,3-i,1-3*i,1-i,3+3*i,3+i,1+3*i,1+i];
complex=A(number+1);
```

Complex is the coordinate (complex) of the constellation point mapping for the input data.

The main program of QAM_16demod() function is as follows:

```
function [number, complex]=QAM16_demod(c)
```

```
16QAM Constellation Mapping - Find the nearest point on the scattered point as its constellation
point on the constellation map
```

```
Complete is the coordinate of the nearest point to the constellation point, which is the
demodulated coordinate.
```

```
Number is demodulated OFDM data:
```

```
A=[-3-3*i,-3-i,-1-3*i,-1-i,-3+3*i,-3+i,-1+3*i,-1+i,3-3*i,3-i,1-3*i,1-i,3+3*i,3+i,1+3*i,1+i];
for k=1:16
```

```
B(k)=sqrt((real(c)-real(A(k)))^2+(imag(c)-imag(A(k)))^2);
```

```
end
```

```
number=find(B==min(B))-1;
```

```
complex=A(find(B==min(B)));
```

4.2 Simulation results and analysis

(1) Input SNR = 25dB. The simulation results are shown in Fig. 3. The bit error rate from the output signal is 0.1641.

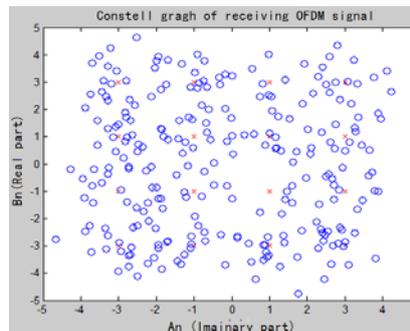


Fig. 1 OFDM constellation (1)

(2) Input SNR = 40dB. The simulation figure is shown in Fig. 4. It is the constellation of the received OFDM signal. It can be seen from the figure that when the signal-to-noise ratio is 40 decibels, the system error rate is 0. After adding Gauss white noise, the position of the constellation points changes little. They are distributed around the constellation points before passing through the noise. They are closer to the constellation points of the original signal. It can be said that there is no change in the constellation map, that is, the received OFDM symbols have no error code.

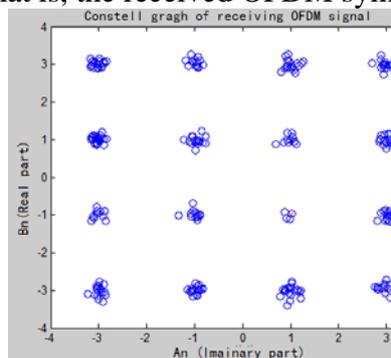


Figure 2 OFDM Constellation (2)

5. Conclusion

For the above two simulations of OFDM system, the constellations of random data are obtained, the real and imaginary images of the OFDM signal before and after adding noise are obtained, and the images of the amplitude and phase parts of the OFDM signal before and after adding noise are obtained, and the waveforms of the OFDM signal with or without cyclic prefix are compared. The results show that the signal changes before and after the white Gaussian noise channel, and the signal is distorted. The reason for this change is the influence of the white Gaussian noise in the channel. However, by comparing the above figure with the data, with the increase of the input signal-to-noise ratio, the bit error rate of the system will be reduced, and the system performance will become better.

References

- [1] Fan Changxin, Cao Lina. Communication Principles (6th Edition) [M]. Beijing: National Defense Industry Press, 2009
- [2] Cheng Xiangjun, Chen Shengtian. Signals and Systems [M]. Xi'an: Xi'an University of Electronic Science and Technology Press, 1990
- [3] Cao Zhigang, Qian Yousheng. Modern Communication Principle [M]. Beijing: Tsinghua University Press, 1992.17-45
- [4] Liu Min, Wei Ling. MATLAB Communication Simulation and Application [M]. Beijing: National Defense Industry Press, 2001
- [5] Yu Wanbo. Image Processing Based on MATLAB (2nd Edition) [M]. Tsinghua University Press, 2011
- [6] Zhang Xiaoying. Channel Estimation of OFDM System[D]. Hunan: University of National Defense Science and Technology, 2005
- [7] Wang Wenbo, Zheng Kan. Broadband wireless communication OFDM technology (second edition) [M]. Inner Mongolia: People's Posts and Telecommunications Press, 2007.8-9
- [9] Yin Changchuan, Luo Tao, Le Guangxin. Multicarrier Broadband Wireless Communication Technology [M]. Beijing: Beijing University of Posts and Telecommunications Press, 2004.20-45
- [10] Zhou Zhenglan. Simulink implementation of OFDM and its link-level platform [J]. China Data Communication, 2003, (10): 90-92
- [11] Fan Changxin, Xu Bingxiang. Communication Principle [M]. Beijing: Tsinghua University Press, 2006.161-172