

Simulation of Wireless Communication System Protocol Based on the Simulink of MATLAB Software

Zonghan Yang, Sheng Liu

Beijing Bayi School, China.

Abstract

With the rapid development of information technology, the application of mobile communication technology in the civil and military fields is ubiquitous, involving all aspects of life, including the upcoming unmanned technology and Internet of Things technology. Wireless communication technology that does not operate at a stable and high rate. How to improve the information transmission rate and maintain a high stability of noise resistance is one of the hot issues of current communication system research and research. The fifth generation mobile communication technology (5G) has emerged with the current mobile communication field, and has a higher transmission rate and a lower error rate than the past mobile wireless communication. In this paper, the Simulink module in the simulation software MATLAB is used to simulate the popular 5G communication system, and the anti-noise performance of Time Division Multiple Access (TDMA) used in MIMO multi-input and multi-output communication is simulated. Analysis of the simulation results to improve its noise immunity. This research has certain practical reference and guiding significance for further research on future wireless communication.

Keywords

5G communication system; DMA communication protocol; Wireless communication channel.

1. Introduction

2000 years ago, the use of phoenix smoke to transmit information to today's wireless communication using electromagnetic waves, the pace of human exploration of communication technology has never stopped. In order to meet people's increasing spiritual needs, after decades of continuous research, exploration and innovation in modern times, the development of mobile communication has evolved from the simple first-generation to the current multi-functional fifth generation communication. From the initial size of the brick based on frequency division multiple-access multiplexing, to the succeeding era of data traffic, and then to live video, it has all reflected the great innovation and change of science and technology. Through backward compatibility and upward innovation, each generation of system reform is based on the previous foundation, so we cannot study a certain generation in isolation. By studying the various wireless communication network standards in this paper, we can integrate, summarize, and innovate from the most basic. The currently developed 5G standard is also multiplexed on the basis of the previous four generations, and has also been innovating to solve some of the shortcomings of the previous four generations. For example, four generations of communication that has just been passed, when data calls are made, data traffic communication is Disruption, through the integration of technology, we have now successfully addressed this issue.

The proposal of multiple access technology is of critical significance for expanding communication capacity. The traditional three-multiple-address technology represents three generations of communication technologies. For example, the multiple access technology used in the first generation communication is FDMA (Frequency Division Multiple Access). Multiple access technology that uses different frequency bands to divide into separate channels. FDMA technology allocates one or more frequency bands / channels to users individually, which are utilized to simulate the transmission process, such as fixed telephone, radio, and satellite communications. Due to the scarcity of channel

resources and low spectrum utilization, FDMA has been integrated into new communication technologies for collaborative use.

Time Division Multiple Access (Time Division Multiple Access) technology, referred to as TDMA, was first applied in North America's communication system, and it is also the second-generation communication system adopted by China Mobile Communications Company in China. Its characteristic is that the uplink and downlink can work at the same frequency at the same time. The principle is the case that each frame of the signal is sampled in time slots for each signal. Discrete signals can be restored based on the sampling theorem. Multiple signal sources can be inserted in a time slot, because after a continuous signal is sampled, there will be an idle segment in the middle, that is, this segment we can insert another discrete signal to repeatedly from a signal frame sequence. Compared to frequency division multiple-access multiplexing, our duplex can be set at the same time. During uplink and downlink transmission, we add a blank time slot to distinguish and protect. Of course, it also needs to add numerous overhead time slots, such as synchronization and starting position determination. Of course, this also has disadvantages, such as poor confidentiality, lengthy information, etc. In the future, frequency hopping will need to be used, and the frequency is constantly changed to solve the problem.

This article mainly uses MATLAB software to simulate wireless communication systems. MATLAB is a very powerful mathematical related software, formerly known as Matrix Lab. It is commonly used in algorithm development, data visualization, and mathematical modeling and simulation. Because its powerful functions are concentrated in a simple visual window. MATLAB has many programmed functions for us to call, and it supports C language and Java language programming to meet the functions that are not part of the library. Simulink, as one of the most important simulation module components in MATLAB, has the advantages of close to reality, high efficiency, and fine simulation. Provide dynamic modeling, simulation and analysis in communication. There are already well-written module tools, such as oscilloscopes and spectrum analyzers, which can give us convenient support for studying signal changes in communication. This article mainly analyzes through Simulink simulation communication system and MATLAB programming simulation communication system.

The module library consists of multiple modules. The entire Simulink module library contains several module groups. For example: commonly used module group: Commonly Used Blocks; continuous module group: Continuous; discontinuous module group: Discontinuities; discrete module group: Discrete; logical and binary operation module group: Logic and Bit Operations; table lookup operation group: Lookup Tables, etc. The user can customize the module group. The module is the foundation of the simulation model. At the same time, there are some simulation modules for experimental devices, such as oscilloscopes. We can directly read the real-time state of the signals and extract them.

5G communication technology needs to be improved on the basis of the above-mentioned key multiple-access technology. By stimulating and improving the above three protocols, we can better improve the performance of 5G communication system. Simulink visualization software was utilized to simulate the performance of the 5G communication protocol and analyze its noise optimization.

2. FDMA communication system

2.1 Design goals

2.1.1 Significance of design scheme

Frequency division multiple-access technology is to divide the frequency band of communication into a number of equally spaced frequency channels, indicating that communication rooms of different users are divided by different frequency channels, which is called frequency division multiple access. Early wireless communication systems also included the current radio broadcast (shortwave) and most dedicated communication networks were implemented using frequency division multiple access. The main procedural requirements of frequency division multiple-access

communication equipment are: the frequency is accurate and stable, and the frequency band occupied by the signal is within the channel range. But now frequency division multiple-access is often used in 5G communications in combination with time division multiple-access and code division multiple access.

In this competition, the Simulink module in MATLAB software, which is very effectual, was used. First, the FDMA communication system was designed. Although the function is not perfect, the rudimentary communication function has been realized.

2.1.2 Introduction to Design Functions

- (1) The input modulation signal can be demodulator without distortion when it is output.
- (2) The information can be transmitted with the lowest bit error rate in the Gaussian white noise channel.
- (3) The waveform can be seen directly by the spectrum analyzer and oscilloscope.

2.1.3 FDMA overall design ideas

The main design idea is to carry out ASK analog modulation of three unique analog signals through the carrier wave, then pass through the Gaussian white noise channel, and finally use coherent demodulation to restore the signal through a low-pass filter.

2.2 Module implementation plans and software simulation

2.2.1 Scheme selection argument

The reason why the Simulink module is used is because it supports the combination of the module and programming and the signals and modules can be intuitively observed through the oscilloscope and spectrum analyzer.

2.2.2 FDMA System Main Module

The overall simulation diagram of the FDMA system in Simulink is shown in Figure 2.1:

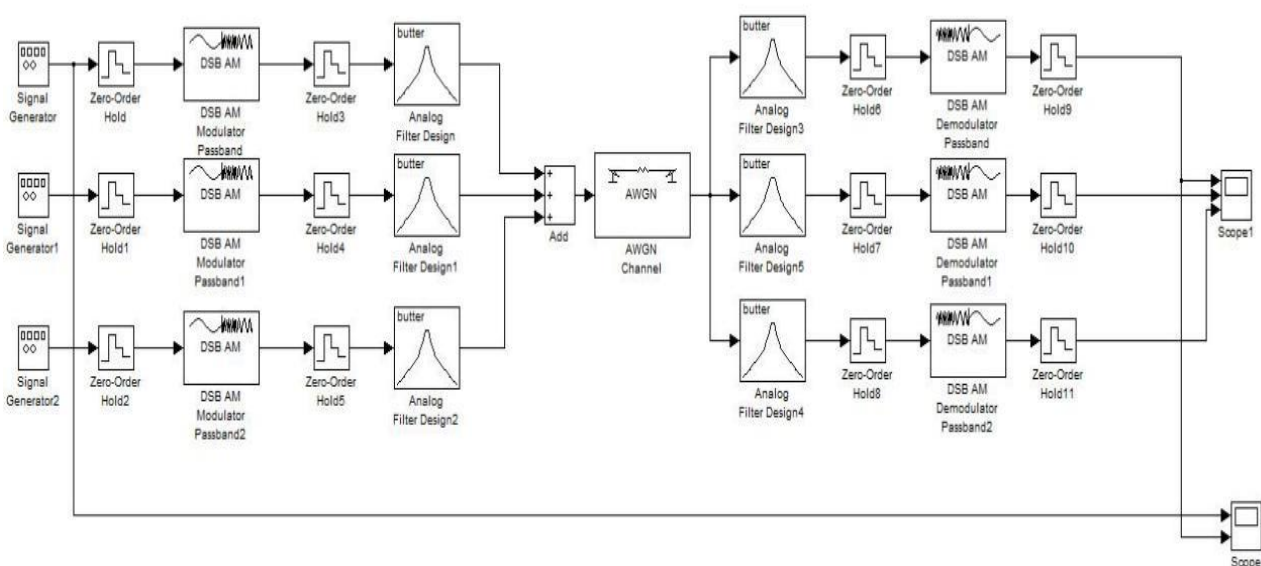


Figure 2. 1 FDMA overall system diagram

2.2.3 FDMA System Module Design

- (1) Generation of input signals

The frequency division multiple-access (FDMA) signal input module is shown in Figure 2.2:

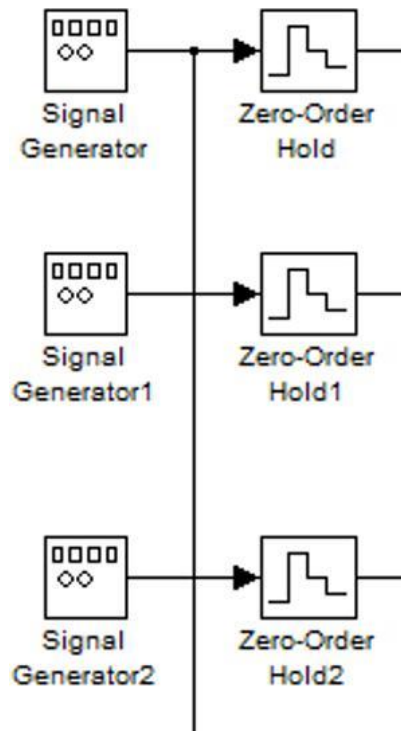


Figure 2. 2 FDMA signal generation modules

Utilizing three signal generators in Simulink, they generate sinusoidal signals with an amplitude of 1 and a frequency of 4 Hz, square wave signals with a frequency of 0.5 Hz, and sawtooth wave signals with a frequency of 1 Hz. The continuous signal becomes a discrete signal, which facilitates the modulation of the DSB single sideband later.

(2) Modulation and demodulation module

The frequency division multiple-access (FDMA) modulation and demodulation module is shown in Figure 2.3:

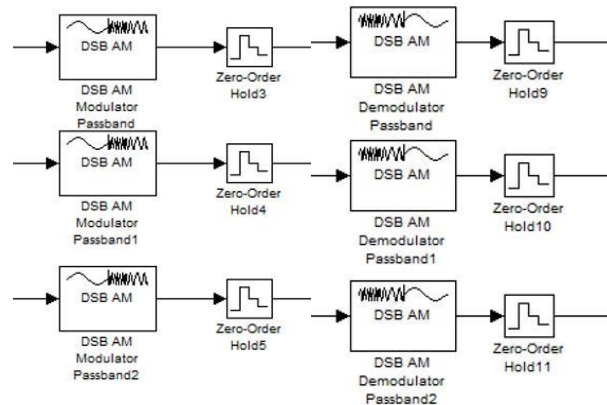


Figure 2. 3 FDMA modulations and demodulation module

The function of the module DSB is to modulate the baseband signal to a higher frequency band, while also making them not interfere with each other when transmitting in distinct frequency bands, increasing the frequency band utilization rate. The sine wave, square wave, and triangle wave is adjusted to the frequency bands of 40, 60, 80Hz by using a sine carrier signal. The use of zero-order holders is specifically required for DSB modules. Demodulation the DSB module is the inverse of modulation.

(3) Design of analog band-pass filter

The frequency division multiple-access (FDMA) band-pass filter module is shown in Figure 2.4:

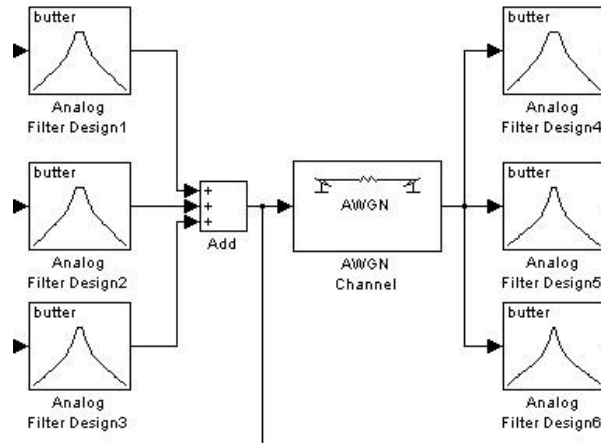


Figure 2. 4 Frequency Division Multiple Access (FDMA) Band Pass Filter Module

The input signal is modulated to a frequency of 40Hz , 60Hz , 80Hz. Therefore, the function of the first three analog filters is to filter out the signals in this frequency band separately to reduce the interference of additional signals. The remaining three analog filters filter the signals mixed through the Gaussian white noise channel separately, so that each signal can be guaranteed not to interfere with each other. Table 2.1 is the design of the filter parameters.

Table 2. 1 Design of 1 filter parameter

	Design method	Filter type	Filter order	Frequency 1	Frequency 2
Analog filter 1	Butterworth	Bandpass	4	220rad/s	280rad/s
Analog filter 2	Butterworth	Bandpass	4	310rad/s	440rad/s
Analog filter 3	Butterworth	Bandpass	4	440rad/s	570rad/s

(4) Gaussian white noise channel

The transmission channel of the FDMA system is generated by the AWGN module in Simulink. The parameter design is shown in Table 2.2:

Table 2.2 Design of 2 Gaussian channel parameters

	Initial seed	Mode	Variance
AWGN Channel	67	Variance from mask	0.01

2.3 Simulink simulation and debugging of FDMA communication system

2.3.1 Simulation and Results of Frequency Division Multiple Access System

(1) Input combined signal

As showed in Figure 2.5, the three channels of signals that have been modulated pass through the adder in the time domain state and the signals in the frequency domain state. The three channels are in the 40, 60, 80Hz frequency band, as showed in Figure 2.5 and 2.6.

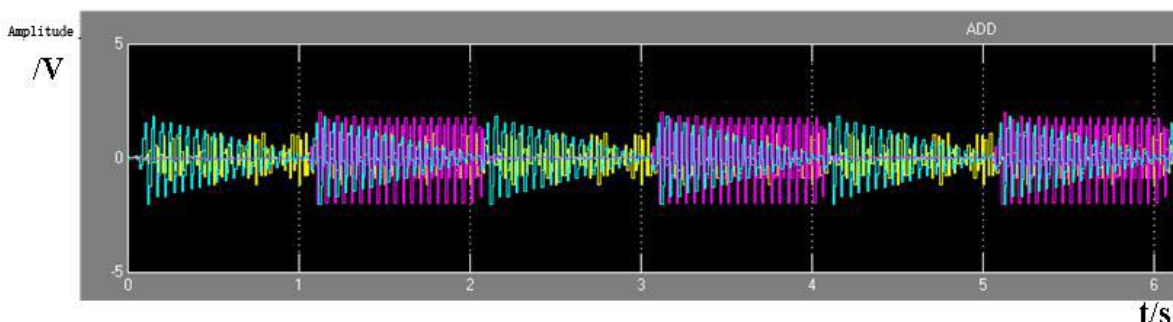


Figure 2. 5 Time-domain state of 5 three-user frequency division multiplexing

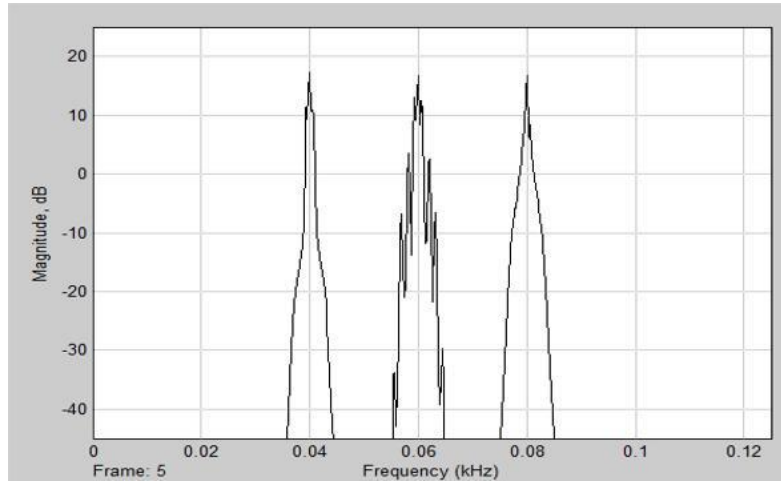


Figure 2. 6 three-user frequency divisions multiplexed frequency domain state

(2) Time-domain of each signal demodulated

Observe the modulation of the three signals of square wave, triangle wave, and sine signal with the oscilloscope and the signal demodulation by the channel, and find that the input signal is basically the same as the demodulation signal. Since the signal holding module is utilized, the originally demodulated signal should be an ideal point. A signal similar to that illustrated in figure 2.7 will appear when the amplitude signal is supplemented by the signals of adjacent time slots. Nevertheless, the distortion of this signal does not affect our acceptance of the signal.

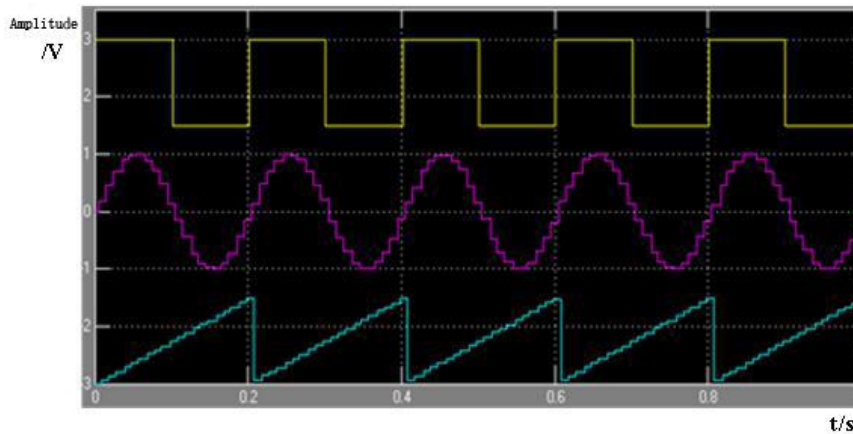


Figure 2. 7 Demodulated Signals from Three Users

2.3.2 FDMA communication system program simulation

(1) Programming flowchart

Programming with MATLAB, mainly generates three signals, collects the audio signals of three recordings, multiplies them with a sine function signal to modulate to high frequencies, adds them through a filter, and filters and demodulates the low-pass output after passing through a Gaussian channel. The idea is generally consistent with the simulation of the Simulink module described above, as shown in Figure 2.8:

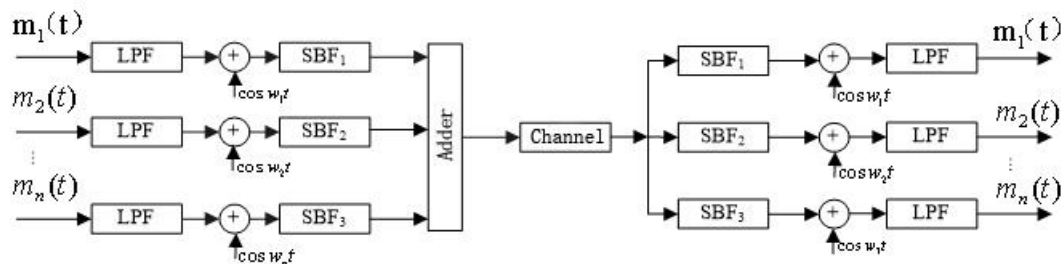


Figure 2. 8 Simulation module diagrams

(2) Programming ideas

a) Voice signal acquisition

We use the function `war-lord` in Matlab software. This function can read and collect language signals. By talking to function, it will indirectly call the built-in recording device. Call the format `war-lord` (n, fs, ch). In order to better ensure the voice signal we use, we set the frequency to 44.1KHz. This bandwidth guarantees the voice quality and meets the minimum adoption theorem. Finally, we use the function `favorite` to save the collected voice signal.

b) Speech signal modulation

The modulation is actually mixing. The carrier frequency is selected founded on the frequency of the baseband. The frequency of normal human speech is approximately 30-3400Hz. Bandwidth after modulation is twice the baseband. That is $B = 2f_H$, in order to prevent the frequency bands from interfering with each other, the carrier frequency interval It must be greater than 6.8KHz, so the carrier frequency interval is 7000Hz, that is, the modulation carriers of the three signals are 4000、11000、18000Hz. In MATLAB programming, three sinusoidal signals are utilized to multiply. At the same time, in order to assure that the signal amplitude is not too small, the amplitude must be increased.

c) Design of the filter

First, according to the design of the digital filter, we use a Chebyshev filter to calculate the elementary parameter index order n, the boundary frequency W_p , the stopband boundary frequency W_s , and the cutoff frequency W_n . Assign function $[n, W_n] = \text{cheb2ord}(W_p, W_s, R_p, R_s)$, then $[b, a] = \text{cheby2}(n, R_s, W_n)$, and finally $y = \text{filter}(b, a, s)$. From this, low-pass and band-pass filters can be derived.

d) Channel design

In order to meet the needs of the actual channel and simulate the calculation of the bit error rate at the same time, we use the simplest Gaussian signal model and call the system's model to randomly generate a Gaussian white noise because there is a mature calculation formula.

(3) Time-domain **and** frequency domain simulation of speech signals

The program sets the sampling audio signal time to three seconds and divides it into three channels for acquisition. The frequency domain falls between 300 and 3400HZ, which are consistent with the sound of normal people. As showing in Figure 2.9 and Figure 2.10:

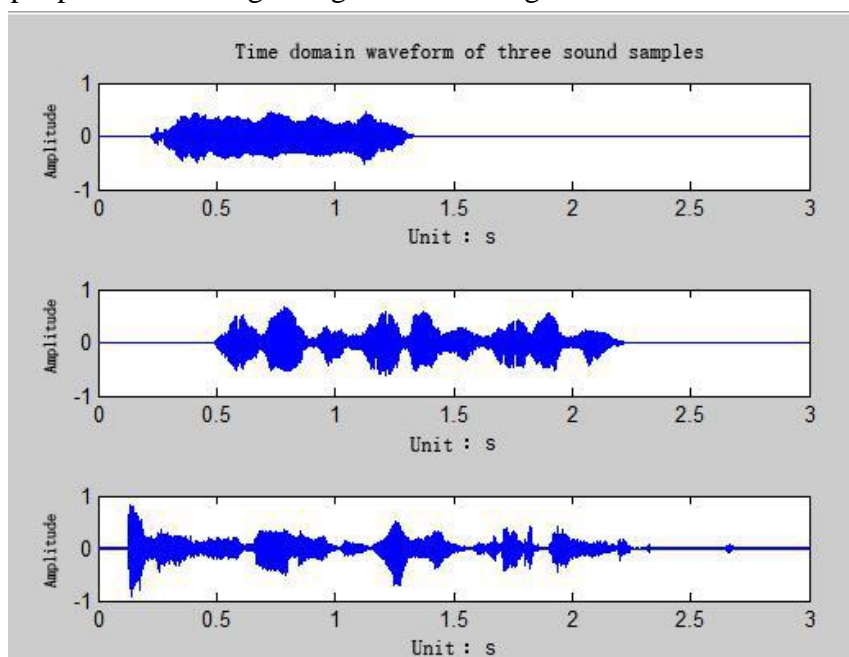


Figure 2. 9 Time domain waveforms of the 9 user three original signals

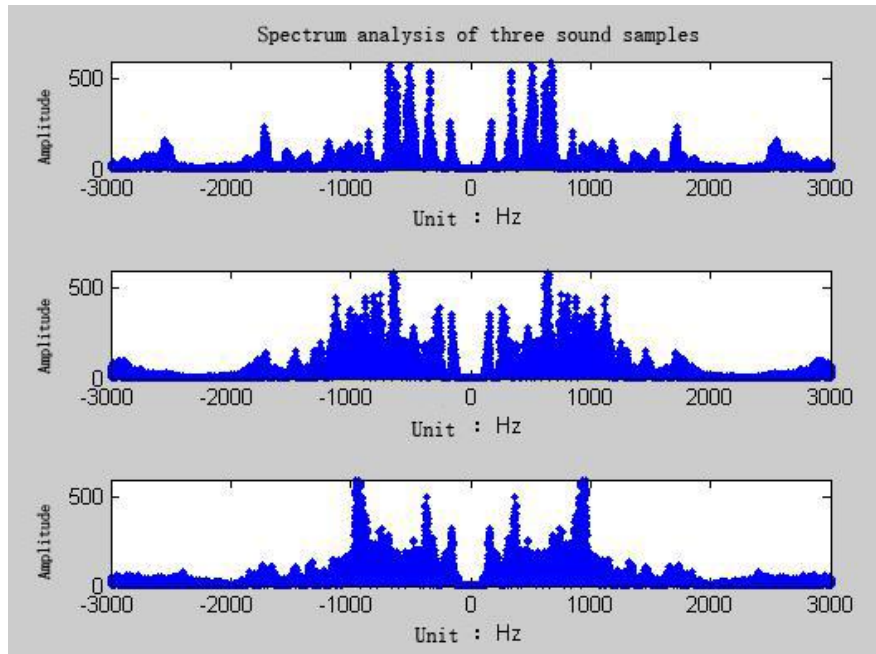


Fig. 2. 10 Frequency domain waveform of three original signals of 10 users

2.4 Summary

This chapter mainly designs the FDMA system theory, simulates the communication system of Simulink, and then performs programming. The difficulty of the FDMA module lies in the design of the filter parameters. At the same time, MATLAB FDMA program simulation was performed, and a deeper understanding of MATLAB was used. We modified the Matlab algorithm simulation program through repeating debugging. At the beginning, the program was all running errors. After thorough searching, the program was finally able to run. We have designed the band-pass and low-pass filters of the corresponding carrier frequency band by calling the voice signals of discrete external frequencies. The difficulty of the program is the way to use the bandwidth calculation in the time domain. Too minute will cause signal distortion, and too large will cause long running time. To solve the problem of internal interference between signal frequencies, we must increase the bandwidth of the frequency of use, so how to choose a suitable bandwidth of use has become a key factor in this experiment. After our repeated experiments, we finally selected the appropriate bandwidth and restored the signals of different frequencies.

3. TDMA communication system

3.1 Design goals

3.1.1 Significance of design scheme

Time division multiple-access technology uses time slots to reorder signals, which improves utilization. Time-division multiple-access technology is currently the mainstream technology of wireless communication. The advantage of this technology is the fact that it can have a larger capacity than using frequency division multiple-access technology alone. The transmission information room is transmitted through the concept of time slots, and finally packed into frames for communication. The TDMA communication system mainly uses a three-way signal generator to generate a representative information source. The foremost requirement of time division multiple-access technology is the synchronization of transmission and reception. At the same time, simulation results are utilized to prove the correctness of the system model design.

3.1.2 Introduction to Design Functions

- (1) The input modulation signal can be demodulator without distortion when output.
- (2) The information can be circulated under the condition that the bit error rate of the Gaussian white noise channel is as low as possible.

(3) Use the spectrum analyzer and oscilloscope to directly see the waveform.

3.1.3 TDMA overall design block diagram

The overall block diagram model structure of TDMA in Simulink time domain design is shown in Figure 3.1:

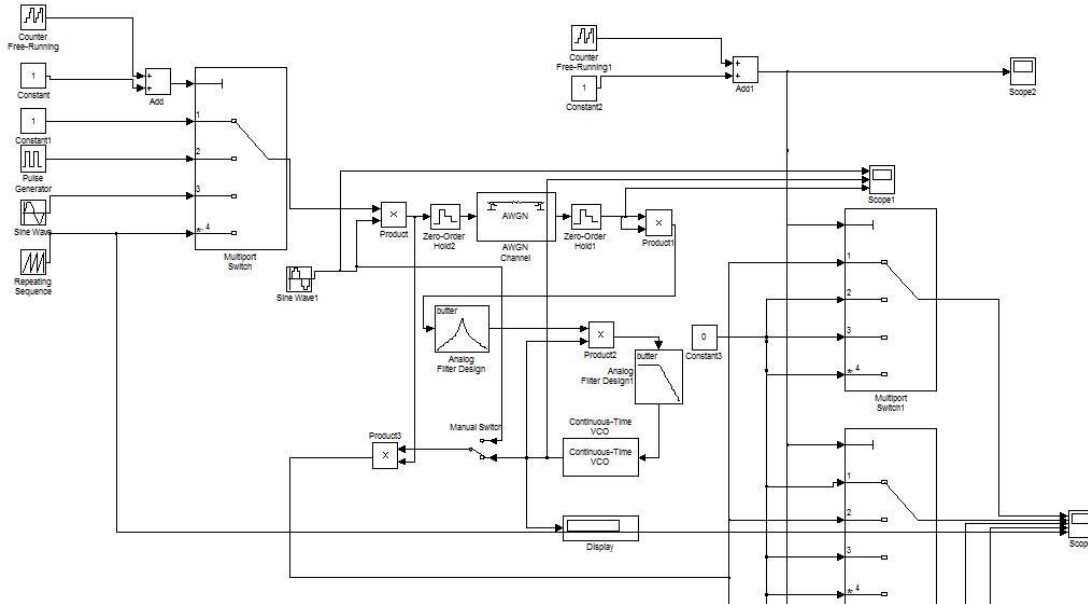


Figure 3. 1 TDMA design simulation block diagram

3.2 Module implementation plans and software simulation

3.2.1 Design of each module of the TDMA system

(1) Source generator and time division multiplexer

As showed in Figure 3.2, the source module is used to generate a sine, square wave, and triangle wave. Because the decision threshold of the time division multiplexer is 0-3, a constant is added to the sine, square wave, and triangle wave to make its amplitude meet the time division multiplex. It performs time division multiplexing so that signals received at the receiving end do not overlap in different time slots. Demultiplexing is the opposite of time division multiplexing.

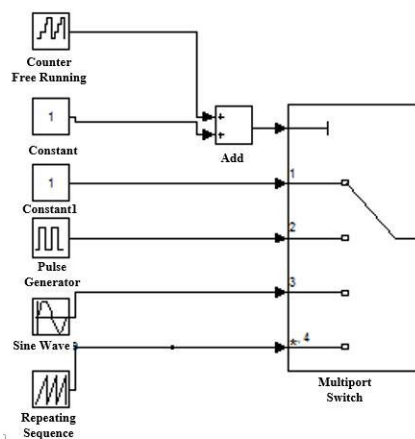


Figure 3. 2 TDMA source generators and multiplexer

(2) Carrier synchronization module

The design of the TDMA communication system uses coherent demodulation, which requires carrier synchronization. The carrier signal needs to be separated from the received signal at the receiving end as a narrow coherent carrier. Although the separated carrier frequency is the same as the modulated carrier frequency, the phase is not necessarily. Similarly, in order to achieve the purpose

of the same frequency and phase, a phase locked loop circuit is required to achieve the same frequency and phase of the coherent carrier and the modulated carrier. Figure 3.3 is the principle block diagram of the rectangular loop, which is the principle block diagram of extracting the coherent carrier.

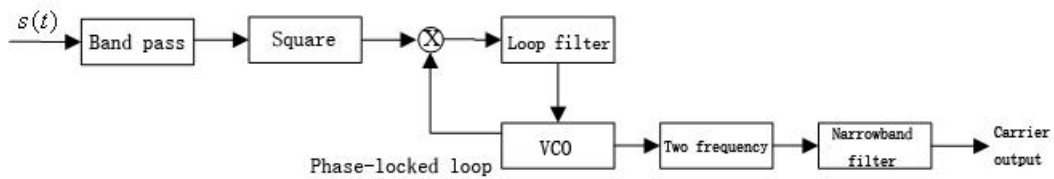


Figure 3. 3 TDMA synchronization modules

3.2.2 Simulink simulation and debugging of TDMA communication system

(1) Time Division Multiple Access Input Combined Modulation

As showed in Figure 3.4, this combined signal is information for a simulated TDMA system. The three sources of the square wave, triangle wave, and sine wave are modulated and superimposed on the time axis, and they are respectively in different time slots.

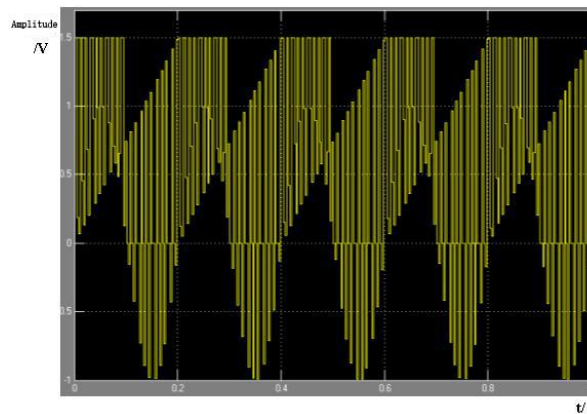


Figure 3. 4 TDMA Synthesis Time Slots

(2) Time-division multiple-access time slot separation signal

As showed in Figure 3.5, the first set of waveforms is triangular waves separated from the receiving end, and the second set of waveforms is triangular waves at the transmitting end. Regardless of the fact that the waveforms at the receiving end and the transmitting end are different, they will not be noticed during daily use. It can be known from the sampling theorem that this difference is only due to the distortion of the spectral amplitude, and it can be ignored as long as the time slot is slight enough.

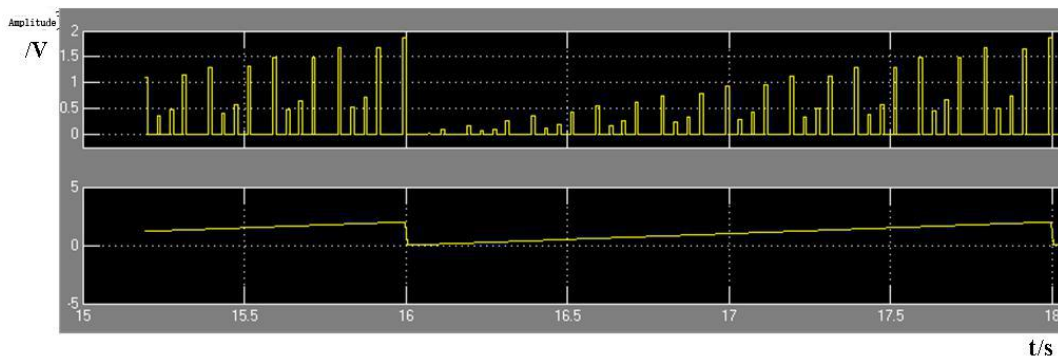


Figure 3. 5 TDMA signal separations and quantization

3.3 Summary

In the process of simulating a TDMA system, the frequency of the simulation signal is made smaller, but this is not without its generality, and the simulation results fully demonstrate the correctness of the system design. When we simulated, the selected communication channel was added with Gaussian

white noise. This is the simplest noise with theoretical model calculations, and its average value is 0. By controlling the amplitude of the signal, that is, the signal-to-noise ratio, the number of bit errors of the received signal is judged, thereby determining the anti-noise performance of the time division system. In the later period, we can choose more noise and fading channels with real life. For example, the Rely channel. From the side, it is also proved that the anti-noise performance of the time division system is not strong. We can next section code division multiple access technology, focus on its excellent anti-noise, and do anti-interference in the coding. Through the above analysis, we can learn lessons and experiences in future wireless communications.

4. CDMA communication system

4.1 Design goals

4.1.1 Significance of design scheme

CDMA (Code Division Multiple Access) is prepared on the basis of spread spectrum communication. It has exceptional anti-interference performance and can provide high-security communication confidential processing. In today's lack of radio frequency spectrum resources, sufficient channel resources can be made to meet increasing user demand. Spread spectrum is a way of calibrating users by using orthogonal random codes to realize signal transmission at the same frequency. Code division multiple-access is mainly used in China Unicom and telecommunications operators to improve its transmission rate so that it has a transmission rate comparable to 4G, and coding technology is currently a hot research topic.

Its advantage is that it has a soft capacity and no fixed number of users. Unlike TDMA, if the number of fixed users exceeds the number of calls, the call will be deleted, and CDMA will only degrade the quality of the call. Moreover, CDMA's anti-interference and anti-eavesdropping capabilities are stronger than the other two multiple access technologies, and information is hard to leak. It is the mainstream technology today. Most domestic operators utilize CDMA, so the research on CDMA is of great significance to us.

4.1.2 Introduction to Design Functions

- (1) The input modulation signal can be demodulator without distortion when output.
- (2) The information can be circulated under the condition that the bit error rate of the Gaussian white noise channel is as low as possible.
- (3) Use the spectrum analyzer and oscilloscope to directly see the waveform.

4.1.3 CDMA System General Module

The CDMA communication module also uses three signal sources, but this time it is a digital signal, so a digital filter is used for filtering. The same channel is a Gaussian white noise channel. The pseudo-random code PN code is spread by the M sequence, and the sine carrier is modulated, as shown in Figure 4.1:

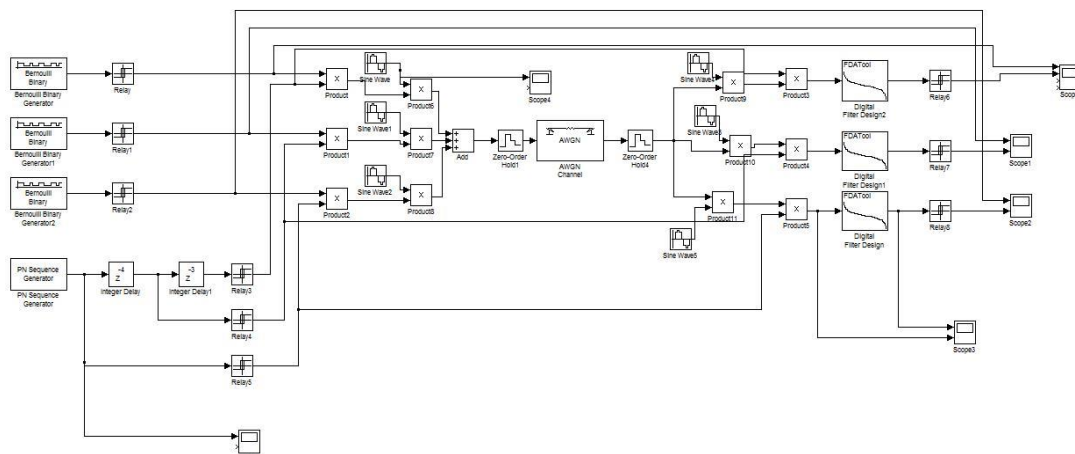


Figure 4. 1 Schematic diagram of the overall CDMA module

4.2 Module implementation plans and software simulation

4.2.1 CDMA system module design

(1) Source generator

Through the Simulink binary random sequence generation module, the Relay module changes the unipolar code to bipolar, as showed in Figure 4.2:

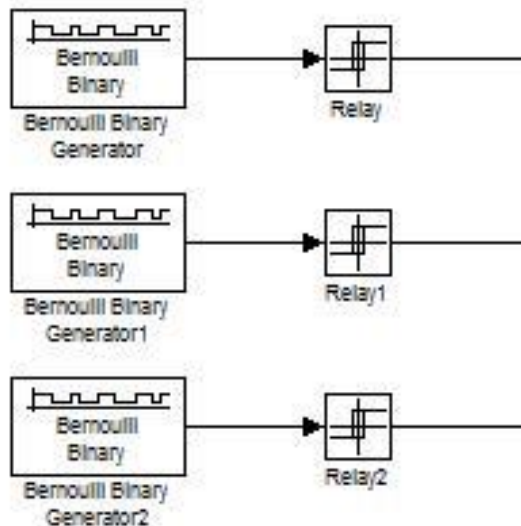


Figure 4. 2 Binary Random Sequence Generation Module

(2) PN code sequence generator

The function of this module is mainly relative to the carrier of FDMA, modulation to diverse frequency bands, and the time division multiplexer of TDMA to different time slots. The m-sequence is generated by the PN sequence module generator, and then the delay is multiplied with the corresponding source to spread the frequency. As showing in Figure 4.3:

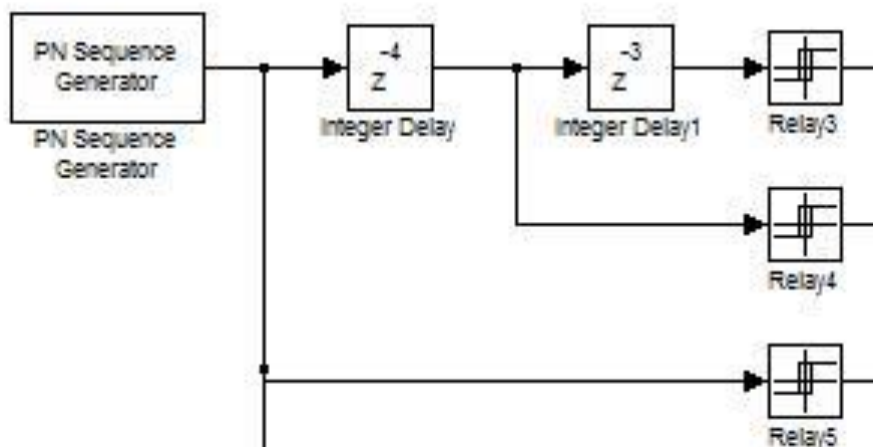


Figure 4. 3 PN code sequence generators

(3) Spread spectrum modulation

Spread spectrum is the most important thing core technology of CDMA. The signal increases by the spread code. In the design, the PN code sampling time is 0.01s, that is, the transmission code rate is 100bit / s, and the source code rate is 2bit / s. According to the spreading principle, the spreading factor is 50. From the spectrum of the source and the spectrum after spreading, it can be recognized that the spectrum bandwidth of each frame of the source is greatly expanded, which basically accords with the theory and the spreading gain is 50. As showing in Figure 4.4:

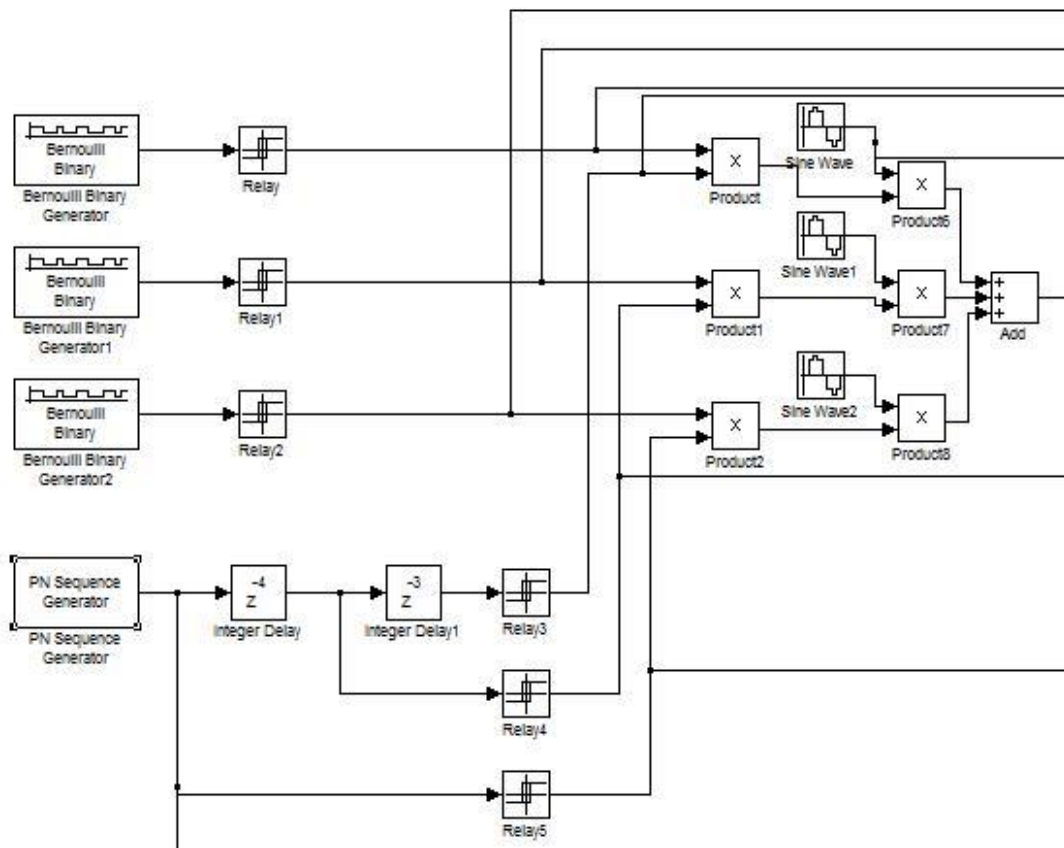


Figure 4. 4 Spread Spectrum Module

4.2.2 Simulink simulation and debugging of CDMA communication system

(1) CDMA spread-spectrum modulated signal

As shown in Figure 4.5, for a signal that has been spread spectrum modulated and passed through a Gaussian white noise channel, the original information is first multiplied by a high-speed PN code to expand the spectrum, and then BPSK-modulated with a sinusoidal carrier to shift the frequency from baseband Move to high frequency, then add the signal to the other two multiple access interference, and then pass through the Gaussian white noise channel.

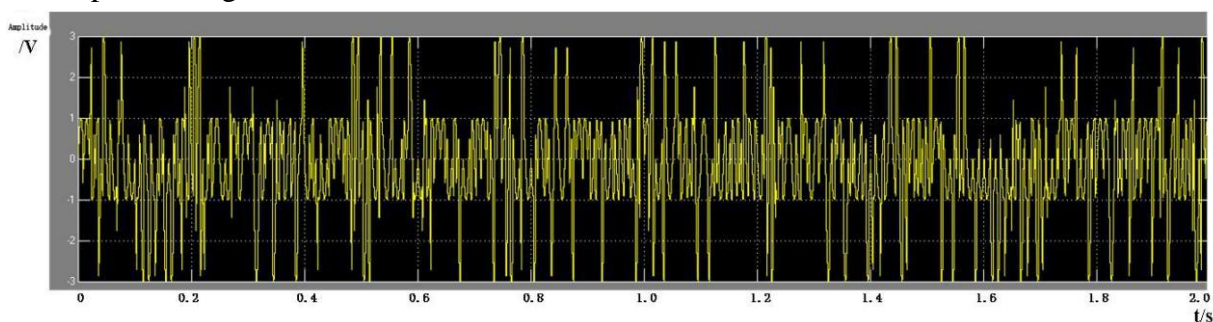


Figure 4. 5 Mixed Gaussian White Noise

(2) CDMA demodulator and dispread signal

The signal arriving at the receiving end after Gaussian white noise is synchronized with the sine carrier by BPSK demodulation, and then decreasing with the synchronous PN code to obtain the waveform profile. A low-pass filter is added for contour detection and sampling. After the decision processing is resumed, the data at the receiving end are obtained. As showed in Figure 4.6, the first set of waveforms is the square wave signal at the transmitting end, and the second set of square wave signals is received at the receiving end. Despite the fact that the two sets of signals are delayed, there is no error. Code is to prove that the CDMA communication system design simulation meets the theoretical requirements.

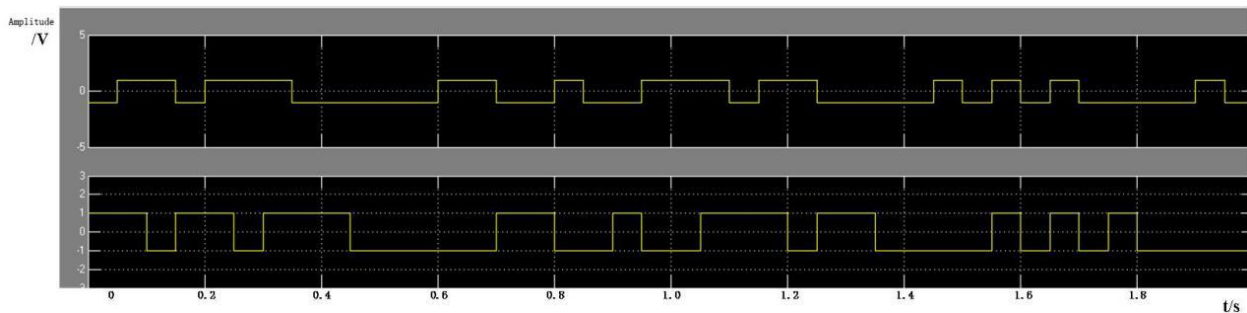


Figure 4. 6 Demodulated Signal Diagram

4.3 Summary

Owing to the time relationship, in this simulation model, we only consider the user's model, because the simulation of the multi-user situation needs to consider the actual situation, which is more complicated. At the same time, the communication channels we use are ideal Gaussian channels without considering various fading and multiple The effect of the path is simply a consideration of the ideal simulation conditions.

5. Conclusion

This paper mainly uses Matlab software to analyze, model, and simulate the wireless communication module in theory. The three wireless communication methods are explained theoretically for different wireless communication protocols. First of all, for the earliest FDMA, frequency division multiple-access multiplexing, the protocol is the first time generation of mobile phone communication, which is the original Big Brother system. Through simulation, we can clearly show that its anti-noise is weak, easygoing to be eavesdropped, and the efficiency is not High; the second generation system is TDMA, real-time division multiple access. This system has changed greatly from the initial generation, and various applications have emerged endlessly. For example, in the original generation, we can only make voice service calls separately, but In the second-generation we can interact with data streams. The third generation standard is CDMA, which is code division multiple-access multiplexing. Compared with the preceding two generations, the transmission rate is faster. It extends various video applications and no longer limits to simple text interaction. Next is the fourth generation of communication, which combines the applications of the previous three generations, and solves the fundamental voice call without data interruption. At the same time, due to the superposition of various multiplexing, various live short video applications have been spawned, including future 5G wireless Communication is also compatible and improved in the previous protocol, and it has also spawned concepts such as artificial intelligence, autonomous driving and the interconnection of all things. Each generation of standard change will bring about the replacement of industries. By modeling and simulating the previous standards, we have a deeper understanding of the direction we need to master, and constantly draw new knowledge and learn new things in order to move forward with the trend of the time. In the past, we were all quiet in simple book theory, without the feeling of building a tall building. Through this study, I also deeply understood the powerful functions of Matlab, friendly interactive interface, and simple programming language, especially Simlink integrated various Powerful communication modules, including the oscilloscope of measurement instruments we often use, by reading the signal distribution on the oscilloscope, we can quickly calculate and analyze. All in all, through the simulation of several systems, the fusion of programming and modules is innovatively added, and a transformation understanding of the entire wireless system is obtained.

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