ISSN: 2664-9640

Software Development of Video Transmission System Based on Software Radio and DVB-T

Feng Liu, Juanjuan Gu *

College of Information Engineering, Shanghai Maritime University, Shanghai 201306, China.

* gjj_mail@163.com

Abstract

With the rapid development of wireless communication technology, software radio technology has been vigorously promoted and applied to multimedia, digital image and other fields. Based on the GNU Radio software platform and the USRP hardware equipment, this paper uses the signal processing module in the GNU Radio library to build the DVB-T standard video transmission system. The feasibility of the scheme was verified in the simulation environment, and then a PC and two USRP B210 devices were used in the actual environment to achieve single-delivery and single-receipt video transmission test. Run the stream graph of the receiver first in the GRC interface, and then run the stream graph of the sender in another GRC interface, and play the received video file in TS format through the VLC player. Finally, by adjusting the antenna gain, antenna distance and other parameters, and observing the dispersion of the symbol points in the constellation of the receiving end, the influence on the receiving performance is analyzed.

Keywords

DVB-T,GNU Radio, USRP, Video transmission.

1. Introduction

Digital terrestrial broadcasting (DVB-T) is a transmission standard for MPEG-2 digital television using open ground transmission media. The standard adopts the channel modulation technology of COFDM and provides a combination of multiple parameters, which enables it to adapt to the transmission of video images in various multi-path channels, and at the same time, it is accompanied by powerful error correction codes, in order to maintain the balance between spectrum utilization and transmission reliability. In addition, digital terrestrial television broadcasting also has the advantages of low cost, flexible transmission and reception and wide coverage [1].

In this paper, a video transmission system is built based on digital terrestrial broadcasting standard (DVB-T) and Linux operating system, using software Radio hardware and software platforms, namely GNU Radio and USRP.GNU Radio is an open source, free software toolkit for learning, building, and applying a software Radio platform, and USRP is a software-reconfigurable RF hardware and digital signal-processing module. The function of this video transmission system is to send and receive TS video files based on DVB-T standard on a PC.

2. Software radio

The basic idea of software radio technology is to use programmable hardware as the general platform and to realize various radio functions with repeatable configuration software. With the rapid development of wireless communication technology, considering the advantages of software radio technology such as flexibility and openness, more and more people began to

ISSN: 2664-9640

study software radio technology related work, so there are also a lot of general software radio platform. The software Radio platform selected in this paper is the combination of GNU Radio and USRP, because the software of this platform is completely open source and has significant advantages such as strong system flexibility, low hardware cost and low technical threshold [2].

2.1. GNU Radio software Platform

GNU Radio is mainly a software Radio tool platform based on Linux operating system, which can be used with a variety of Radio devices, as shown in Figure 1.

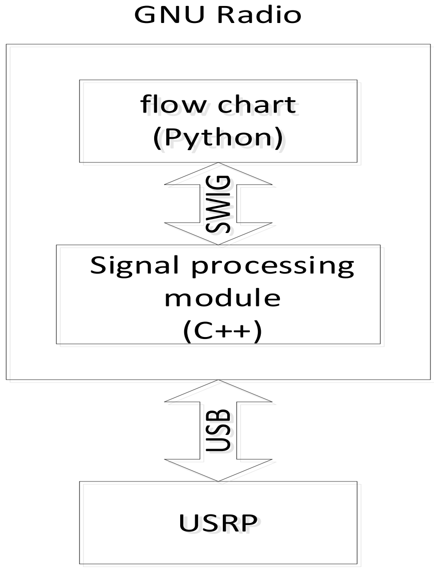


Figure 1: The architecture of GNU Radio

Its main software programming languages are object-oriented development languages C++ and Python. The two programming languages are combined to develop. In GNU Radio, Python execution files are generated through a visual signal flow diagram, while signal processing modules with different functions are implemented through C++ language. These signal processing modules can be called from the GNU Radio library or written according to their own requirements. SWIG, also known as the simplified encapsulation and interface generator, is the "glue" between Python files and C++ signal processing modules. Python execution files use SWIG to invoke C++ signal processing modules to achieve signal processing [3-4].

2.2. USRP hardware platform

USRP (Universal Software Radio Peripheral) enables a common PC to handle digital signals with high speed through USRP equipment. USRP equipment is mainly composed of motherboard and subboard. Motherboard is responsible for the baseband signal with the intermediate frequency signal conversion between, motherboard contains the FPGA, A/D and D/A module, which contains A filter in the FPGA function and the function of the digital frequency up and down, some of the computational cost is larger operation is done on the FPGA, sub board is responsible for the intermediate frequency signal and rf signal conversion between, covering different frequency range, is responsible for sending and receiving antenna rf signal[5-6].

In this paper, a USRP B210 hardware device is adopted, which integrates the mother board, child board and antenna, and connects to the PC end through USB 3.0 data line to complete the conversion of digital baseband signals to RF analog signals, or convert the analog signals received by the receiving antenna into digital baseband signals on the PC end through analog-to-digital conversion [7].

ISSN: 2664-9640

3. DVB-T system

DVB-T (Digital Video Broadcasting -Terrestrial) is the digital terrestrial television broadcasting system standard in a series of tables developed by the European Union for digital television broadcasting. This standard uses MPEG-2 to transmit bitstream multiplexing, adopts RS coding and COFDM modulation, and divides the transmitted data into thousands of sub-carriers with low bit rate. COFDM channel modulation coding technology uses 1705 carriers (2K mode) or 6817 carriers (8K mode), 3 modulation modes (QPSK, 16QAM and 64QAM), and 4 protection intervals (1/32, 1/16, 1/8, 1/4 symbol period). A cyclic prefix is added to prevent reflection interference and to receive signals from multiple transmitters of the same frequency, and hierarchical modulation is adopted to adapt to signal transmission in various environments.

The block diagram of the transmitter and receiver of the DVB-T system is shown in Figure 2 and Figure 3[8].

From the transmitter block diagram of DVB-T, it can be seen that the system includes such functional modules as energy dispersion, outer coding, outer interweaving, inner coding, inner interweaving, constellation mapping, OFDM modulation and insertion of cyclic prefix. The interleaved module can be divided into bit interleaved and symbol interleaved. What the system realizes is that the video bitstream conforming to MPEG-2 format is used as the input information source. After the encoding and modulation of the above functional modules, the baseband signal conforming to DVB-T protocol is finally generated, and then the baseband signal is converted into rf signal through digital-to-analog conversion module and digital up-conversion module, and finally transmitted through the antenna. The following is the function introduction of each module of transmitter.

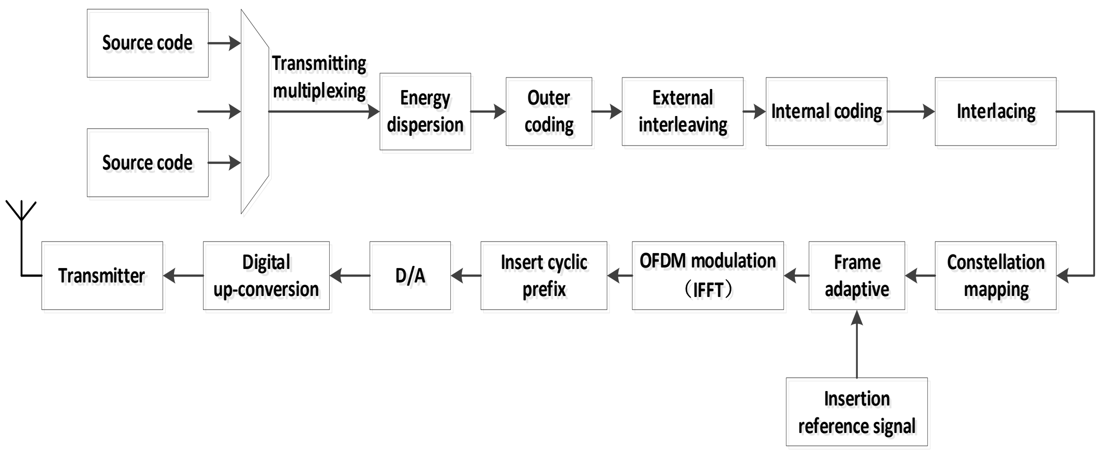


Figure 2: Block diagram of DVB-T system transmitter

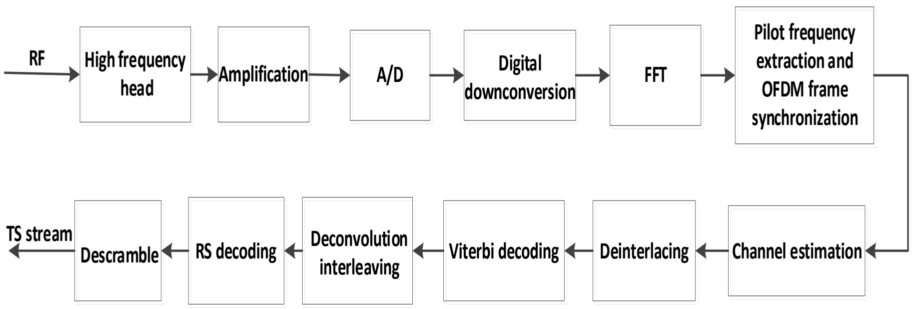


Figure 3: Block diagram of DVB-T system receiver

Energy dispersion: Energy dispersion is also called perturbation. The function of this module is to add the possible continuous "0" and "1" bitstreams in the input TS video stream, so that the probability of "1" and "0" appearing in the data stream is basically equal. In this way, uneven

ISSN: 2664-9640

energy distribution can be prevented, peak to average ratio of the system can be increased, and emission performance can be affected. At the receiving end, the original data stream can be restored by simply unscrambling or scrambling.

Outer coding: Outer coding, also known as outer error correction code, adopts RS coding with strong error correction ability to solve the problem of continuous burst byte errors occurred in transmission. The main function is to generate 16 check bytes for MPEG-2 data with 188 bytes in a transport packet, and then input the sum of data bytes and check bytes into the next module as a transport packet (204 bytes).

External interleaving: Convolution interleaving is adopted in DVB-T system to carry out external interleaving of bytes. This is to solve the problem that continuous bytes appear in the transmission byte stream, but RS encoding may not be able to correct the error. After the external interleaving, the wrong bytes can be evenly distributed in the transmission byte stream, so as to facilitate the correct decoding of the RS decoding module.

Internal coding: Internal coding is also known as internal error correction code. DVB-T system adopts contraction convolutional code to solve the problem of continuous burst bit errors. The system puts forward five error correcting code rates: 1/2, 2/3, 3/4, 5/6 and 7/8. The higher the error correcting code rate is, the higher the bandwidth utilization rate is, while the lower the error correcting capacity is. On the contrary, the lower the error-correcting code rate, the higher the error-correcting capability and the lower the bandwidth utilization. Therefore, in the actual transmission, the appropriate bit rate should be selected according to the channel characteristics of the actual environment and the requirements of the receiving system, so that the system bit error rate and bandwidth utilization can reach a balance state.

Interlacing: The interlacing module of DVB-T system is divided into bit-interlacing and symbol interlacing. Bit interweaving mainly solves the problem that the continuous bit errors in the data bit stream may exceed the error correction capability of the contracted convolutional code. Symbol interlacing is to map the symbol composed of the V-bit data stream output by bit interlacing to the OFDM symbol subcarrier. V is related to the constellation mapping mode. There are three constellation mapping modes, namely QPSK, 16QAM and 64QAM, and the corresponding V is 2, 4 and 6 respectively.

Constellation mapping: Constellation mapping is a kind of multi-system mapping. Under the same symbol rate, the more bits in a single sign constellation map, the higher the effective information bit rate of the system will be. But the more constellation points, the closer the distance between constellation points, which will increase the decoding difficulty of the system, will also increase the error rate of the system.

Reference signal: The reference signal of DVB-T system includes pilot information and transmission parameter information (TPS). Pilot information is to achieve good channel estimation and channel equalization at the receiving end and ensure accurate information recovery. TPS mainly includes system parameter information such as system transmission mode, error-correcting code rate, constellation mapping mode and cyclic prefix length.

OFDM modulation: DVB-T system adopts the method of zeroing OFDM subcarrier number K, where K is the integer power of 2, and OFDM modulation can be realized more quickly through IFFT (Inverse Fast Fourier Transform).

Cyclic prefix: In order to reduce intercarrier interference caused by multipath delay effect, DVB-T system inserts a section of data at the end of OFDM symbol into the front end of OFDM symbol, which is called cyclic prefix. In order to adapt to signal transmission at different transmission distances, DVB-T system provides four kinds of cyclic prefix lengths to choose from, which are respectively 1/4, 1/8, 1/16 and 1/32 IFFT lengths.

DVB-T system the inverse process, the working process of the receiver is the transmitter is the rf signal after the antenna into the mixer, through the intermediate frequency amplifier, adc

ISSN: 2664-9640

converted to digital down-conversion, the pilot again after FFT demodulation are extracted and OFDM frame synchronization, channel estimation and equalization, after the constellation demodulation, solution and victor than after decoding and RS decoding module, finally restore flow output for TS [9-10].

4. Design and implementation of video transmission module

Under the Linux operating system, installation of GNU Radio and UHD is dependent. On the GNU Radio software platform, the GRC flow diagram is used to call the modules built in the software platform, and these modules are connected one by one on the GRC flow diagram interface, so as to build the sending end flow diagram and receiving end flow diagram of the video transmission system based on DVB-T standard [11].

4.1. Flow diagram of sending end of DVB-T system

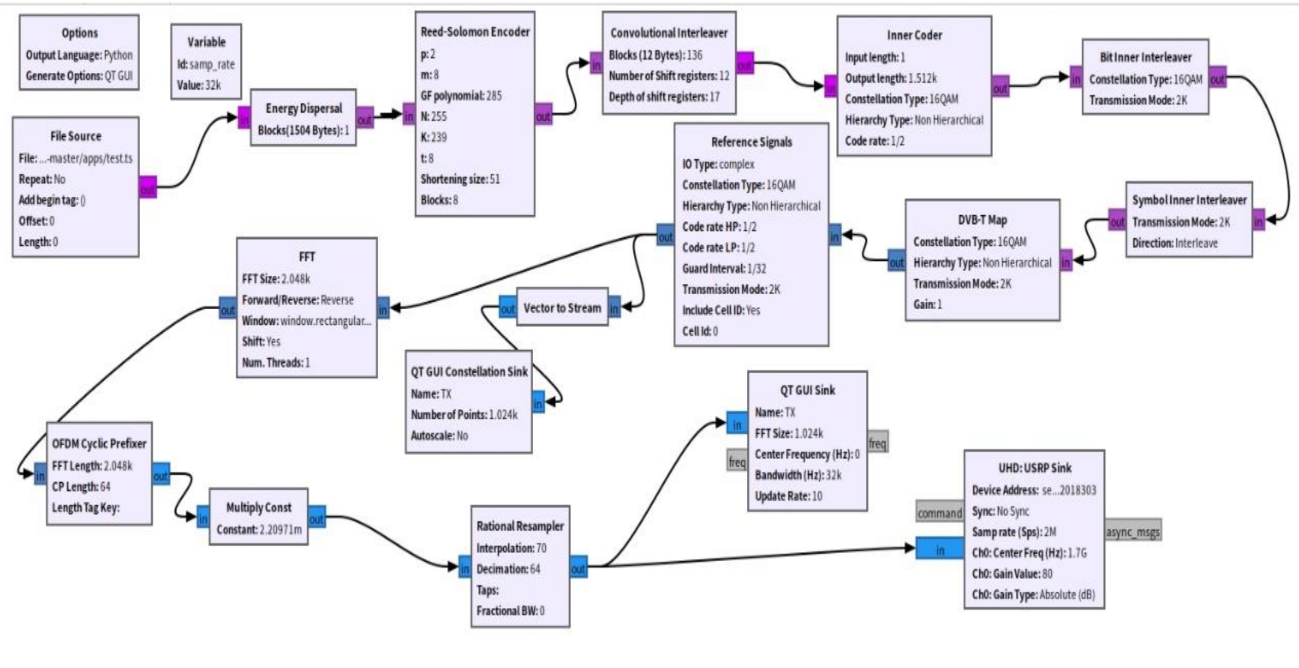


Figure 4: Sending end flow diagram of DVB-T system

In a GRC flow diagram of PC interface structures, as shown in figure 4 the sender the flow graph, select TS format video streaming as sending the source files, through the discrete energy outside, outside the coding, interleaving, mixed bits interweave and symbol, module of bitstream data processing, and in the form of 16QAM modulation constellation mapping, and then through the reference signal module Settings information transmission system parameter, the error correction coding bit rate for 1/2, for 16 QAM constellation mapping mode, transfer mode for 2K, the length of the cyclic prefix length is 1/32 IFFT. After that, inverse Fast Fourier transform, cyclic prefix addition, extraction value interpolation and other processing were carried out. Finally, the processed baseband signals were input into the USRP credit module for processing, and finally the RF signals were emitted at a sampling rate of 2M.

ISSN: 2664-9640

4.2. Flow diagram of receiving end of DVB-T system

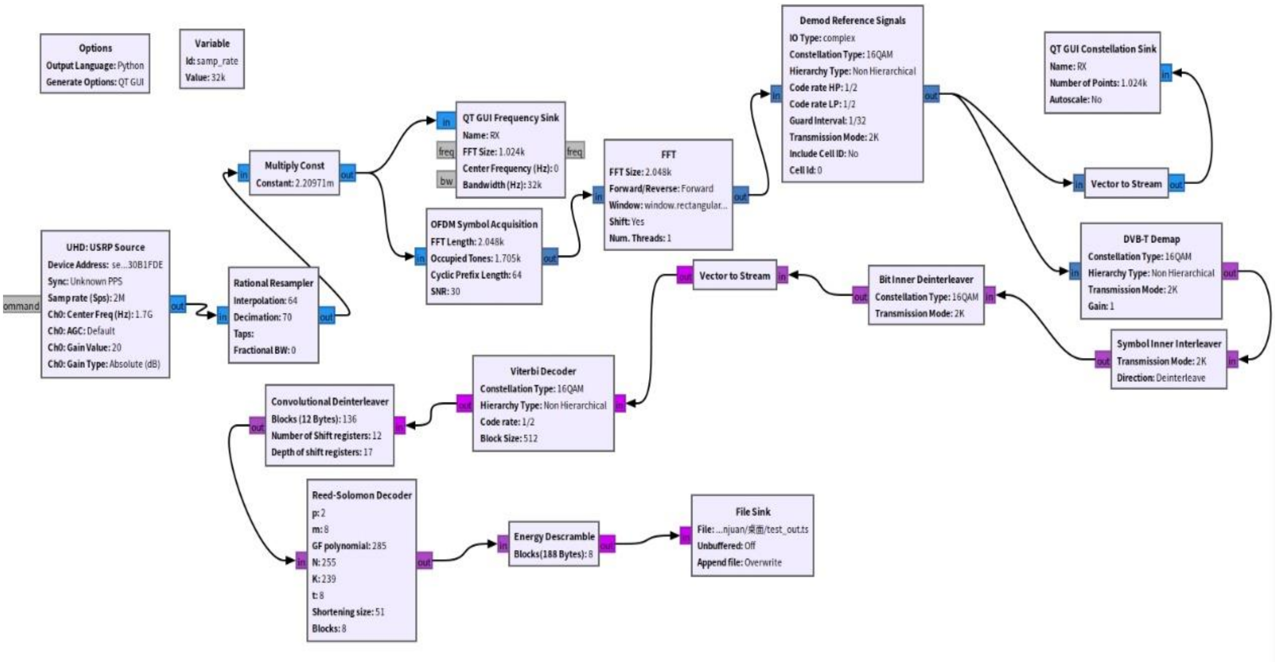


Figure 5: Receiving end flow diagram of DVB-T system

Another GRC flow diagram in the PC interface structures, such as flow chart of the receiving end, as is shown in sending the USRP Sink the rf signal emitted module through indoor actual channel transmission, the USRP at the receiving end receives the Source module, rf and digital intermediate frequency and the corresponding processing, the final output baseband signals, followed by fast Fourier transform (FFT), after the extraction of pilot signal and frame synchronization for channel estimation and equalization, constellation demodulation, outside mixed solution, victor than decoding, the RS decoding reconciliation interference function modules such as signal processing, Finally, input TS video stream and store it in test_out.ts, which can play the received video through VLC player and analyze the performance of the video transmission system by comparing the video before sending[12].

QT GUI Constellation Sink module and QT GUI Sink module are also connected in the DVB-T sending end flow diagram and receiving end. The former module is used to display Constellation diagram, and the receiving performance of the system can be observed through the Constellation diagram of the receiving end. The latter module is used to display FFT spectrum diagrams of the video data through which the correctness of the data can be observed.

5. Experimental results and analysis

In order to verify the feasibility of the established video transmission system, the flow diagrams of the sending end and the receiving end are put into the same GRC flow diagram interface for simulation test [13]. The simulation flow figure 6 of the video transmission system is shown as follows:

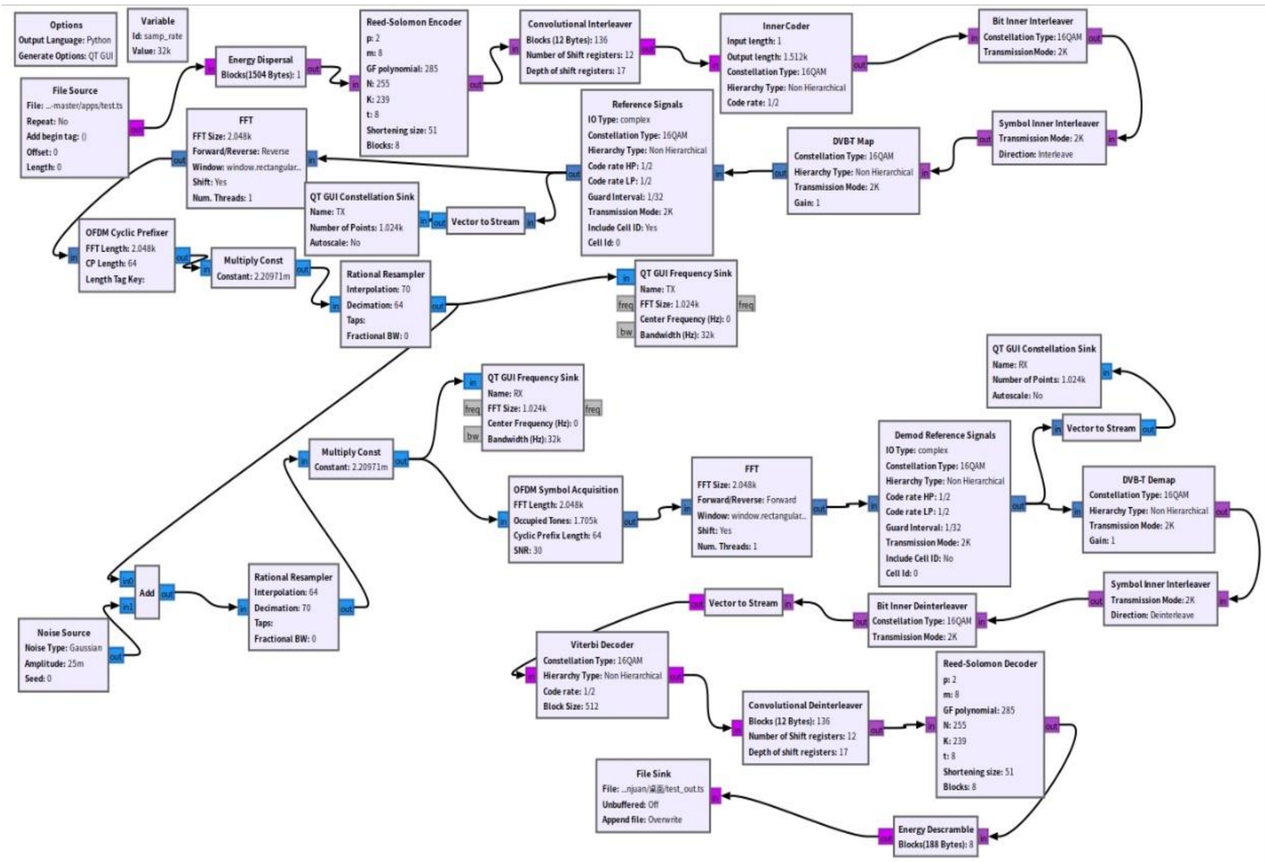
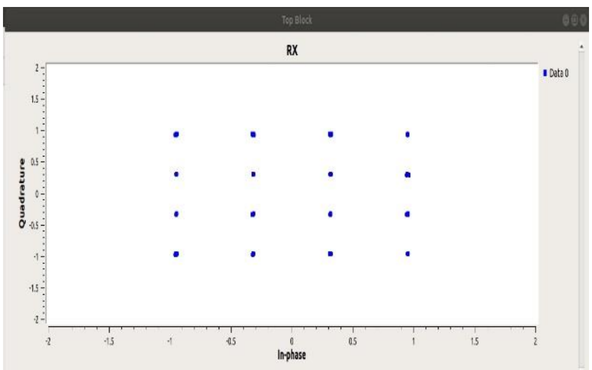


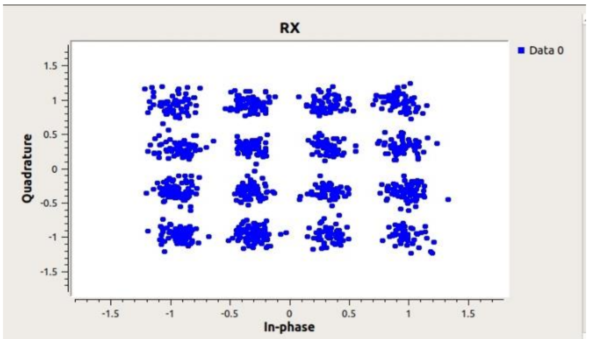
Figure 6: Simulation flow diagram of video transmission system based on DVB-T standard

In the construction of simulation flow diagram, a Noise Source is added, which is used as the receiver's Source together with the output of the end module of the sending end. It is found that the video stream in TS format can be transmitted normally, and the video can also be played normally. This shows that the video transmission system based on DVB-T standard is feasible.

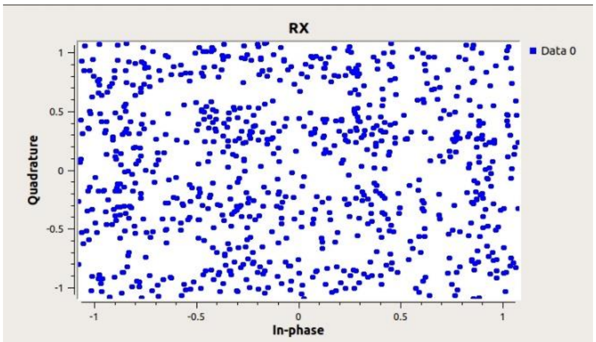
Under the condition that the modulation mode is kept constant at 16QAM, the amplitude value of noise in the noise module is gradually increased, that is, the signal to noise ratio (SNR) is continuously reduced. The constellation diagram can be observed to analyze the influence of noise on the received signal in the video transmission system. In the case of different noise amplitude values, the constellation diagram is shown in the figure below:



(a) Noise amplitude value is 0



(b)Noise amplitude value is 0.012



(c)Noise amplitude value of 0.025

Figure 7: Constellation diagram under different noise amplitude values

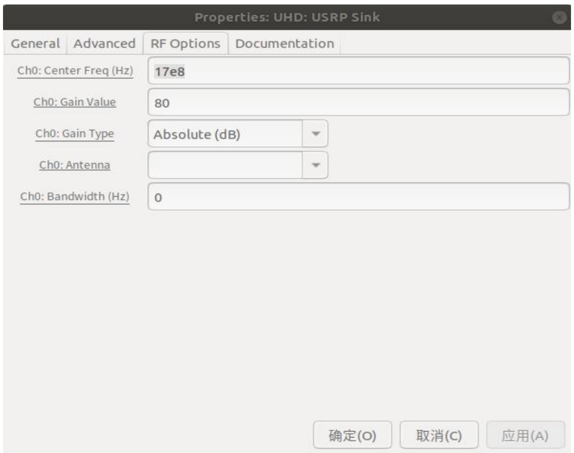
From the above figure analysis, it can be seen that the larger the noise amplitude value is, namely, the smaller the SNR is, the more serious the symbol point in the constellation spreads out from the center point, and the larger the bit error rate is. On the contrary, the symbol points in the constellation are relatively concentrated, and the bit error rate is smaller.

In this paper, two sets of USRP B210 devices and a PC are used to set up the sending end and receiving end of the video transmission system, so as to complete the single delivery and receipt of the video transmission system. As shown in Figure 8 below, the distance between two USRP devices is 0.6m.

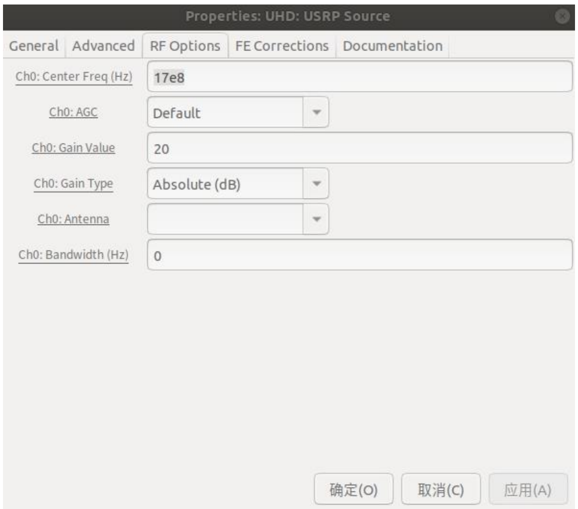
Figure 8: Actual experimental picture

The specific parameter Settings of the transmitter USRP Sink module and the receiver USRP Source module are shown in Figure 9.

ISSN: 2664-9640



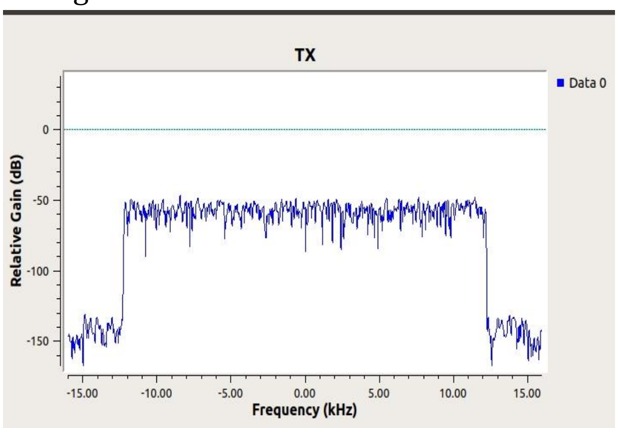
(a)Setting of USRP Sink module parameters at the sending end



(b)Setting of USRP Source module parameters at the receiving end

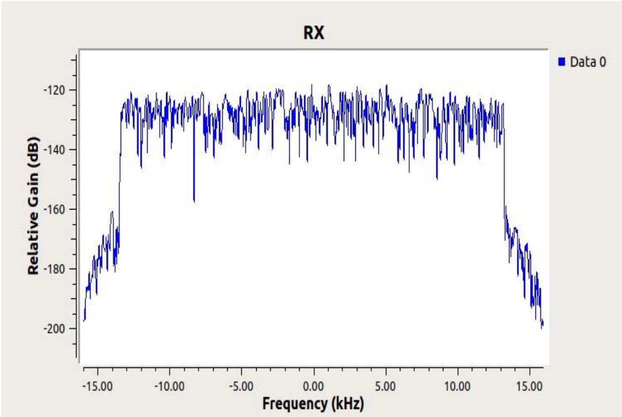
Figure 9: Parameter Settings for sender and receiver

Run the GRC flow diagram at the receiver first and then the GRC flow diagram at the sender to prevent the loss of received data. Run to get FFT spectrum diagrams of the sending and receiving ends, as shown in Figure 10.



(a)FFT spectrum diagram of the sending end

ISSN: 2664-9640



(b)FFT spectrum diagram of the receiving end

Figure 10: FFT Spectrum diagram of sending end and receiving end

The results show that the video transmission system based on DVB-T standard can transmit data successfully, and the FFT spectrum of the receiver can be affected by the noise in the real channel by comparing the two images.

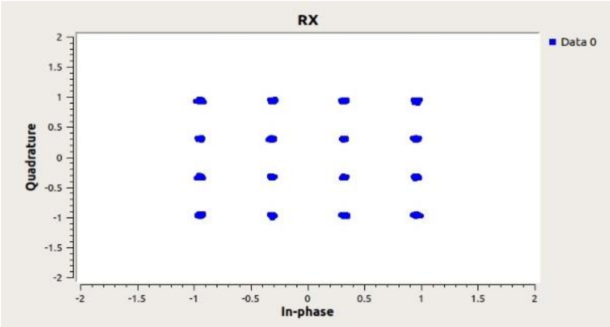
Figure 11(a) is the screenshot of the video being sent by the receiver, and Figure 11(b) is the screenshot of the video being received by the receiver. By comparing the figure and the figure, it can be found that the receiver can correctly receive the sent video, but some frames will be lost in the received video.

(a)Video screenshot of the sending end

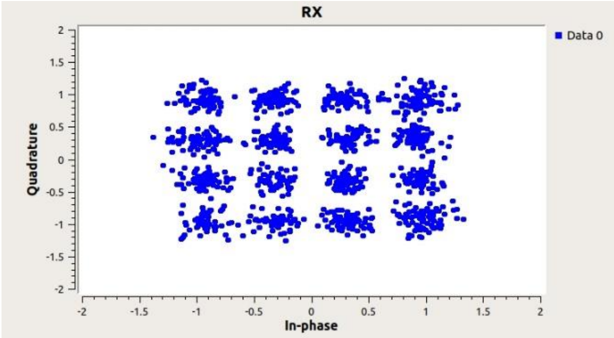
(b)Video screenshots of the receiving end

Figure 11: Video screenshots of the sending end and receiving end

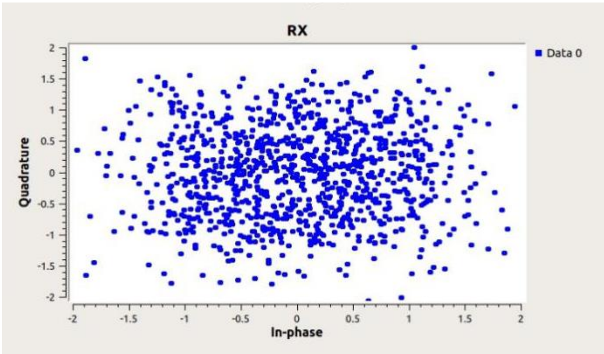
Under the condition that the gain at the receiving end is 20dB and other parameters remain unchanged, the gain of the transmitting antenna is continuously reduced, that is, the SNR is reduced, and the dispersion of the symbol points in the constellation diagram is observed.



(a)The transmission gain is 80dB



(b)The transmission gain is 60dB



(c)The transmission gain is 50dB

Figure 12: Constellation diagram under different emission gains

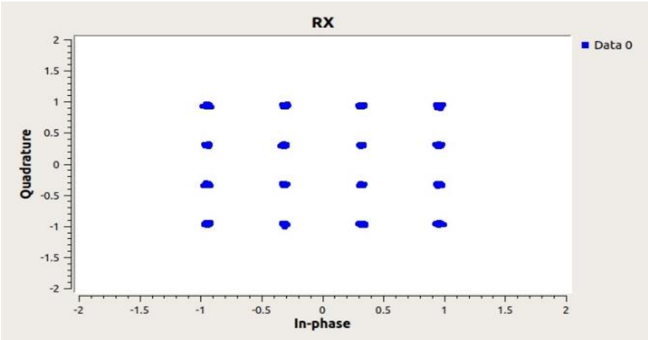
Available from the above graph analysis: in the case of receiving gain certain, launch the gain is smaller, the smaller the signal-to-noise ratio (SNR), in the constellation diagram symbols point relative to the center to spread beyond the more severe, the bit error rate is, the greater the gain and when launch small to a certain value, the constellation diagram has not observed modulation method chosen; On the contrary, the larger the emission gain, the more concentrated the symbol points in the constellation, and the smaller the bit error rate.

The gain of the transmitter is also guaranteed to be 80dB and other parameters remain unchanged. The experiment is carried out by changing the gain of the receiver. The conclusion is as follows: in the case of a certain transmitting gain, the larger the receiving gain, that is, the smaller the SNR, the more serious the outward diffusion of the symbol points in the constellation will be, and the larger the bit error rate will be. When the receiving gain reaches a certain value, the symbol points in the constellation will be in disorder, and the mapping mode of the constellation cannot be observed.

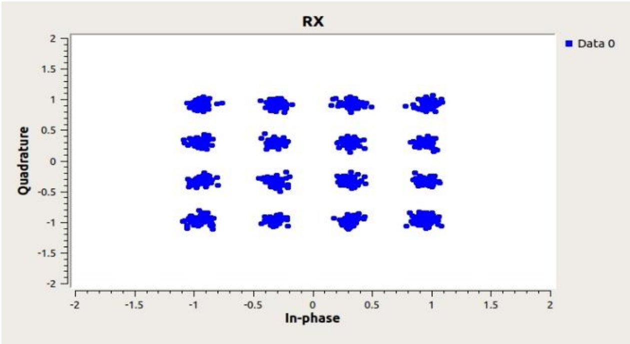
This paper also studies the influence of two environmental factors on the video transmission system, such as the distance between the transmitting and receiving antennas and whether there is an obstacle between the two antennas.

ISSN: 2664-9640

As shown in the figure, Figure 13(a) is the constellation of the receiving end of the antenna with no obstacles, and Figure 13(b) is the constellation of the receiving end with obstacles between the antennas.



(a)There are no obstacles between the antennas



(b)There are obstacles between the antennas

Figure 13: Constellation diagram of whether there are obstacles between antennas

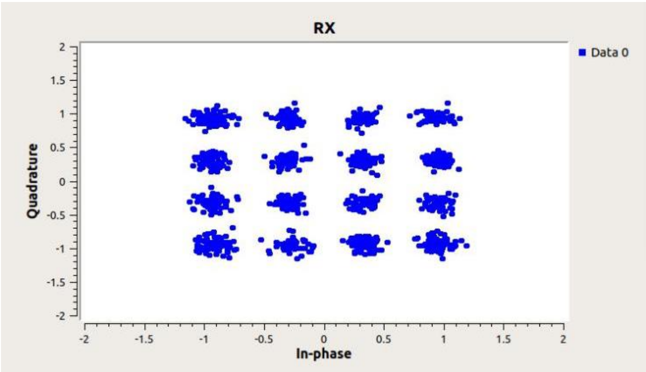


Figure 14: Antenna distance is 1.5m

As can be seen from the above two figures, when there are obstacles between antennas, the symbol points in the constellation diagram at the receiving end will spread outwards. This is because the signal transmission in the direction of obstacles is affected, resulting in gain and loss in the direction of obstacles, resulting in poor performance of the received signals, and thus affecting the performance of video reception.

Figure 13(a) is the constellation diagram of the receiving end when the antenna distance is 0.6m, and Figure 14 is the constellation diagram of the receiving end when the antenna distance is 1.5m. It can be seen from the two figures that the larger the distance between antennas, the more serious the outward diffusion of the symbol points in the constellation diagram of the receiving end is. This is because the farther the distance between antennas, the greater the transmission loss, and the worse the performance of the receiving end.

ISSN: 2664-9640

6. Conclusion

In this paper, a video transmission system based on DVB-T standard is built and implemented based on GNU Radio and USRP hardware and software platforms. This article first introduced the software Radio platform as the GNU Radio and the composition of USRP, DVB-T system are introduced the components of the transmitter and receiver two parts, and then expounds the video transmission system in GRC flow diagram design, under the simulation environment after verify the feasibility of this video transmission scheme, the last of the actual circumstances, and by adjusting the parameters such as antenna gain and antenna distance to observe its influence on video transmission system, at the same time, observing the VLC player to receive video effect.

The experimental results show that the video transmission system built on the software radio platform can successfully transmit TS video files. Through the experiments in the simulation environment and the actual environment, we can observe that the influence of noise, antenna gain and other factors on the video transmission effect can be observed. In addition, the system can flexibly configure the system parameters. By adding or modifying the signal processing module, the video transmission system can be further optimized.

Acknowledgments

This work was partially supported by the National Natural Science Foundation of China (U1701265) and the Natural Science Foundation of Shanghai (20ZR1423200).

References

[1]Wang Wei.Design and Implementation of DVB-T transmitter based on FPGA [D].Nanjing University of Posts and Telecommunications, 2013.

[2]Gan Hui. Research on OFDM System based on GNU Radio and USRP platform [D].Beijing University of Posts and Telecommunications, 2014.

[3]Li Biao. Research and Implementation of PEAK average power reduction technology of OFDM system based on USRP [D].Hunan University of Technology, 2019.

[4]Gu Kai. Dynamic spectrum perception and data transmission based on GNU Radio [D].Hainan University, 2015.

[5]Guo Zhigang, Fu Yi. Research on radio Transceiver System based on USRP [J]. Electronic Quality, 2016(11):5-10.

[6]Zhao Tingting. MIMO System Design and Implementation based on USRP [D]. Nanjing University of Posts and Telecommunications, 2016.

[7]Wang Erlei. Design and Implementation of FDD-LTE downstream MIMO based on GNU Radio [D]. Xidian University, 2015.

[8]Xu Jiafu. OFDM synchronization technology and its application in DVB-T [D].Taiyuan University of Technology, 2008.

[9]Lu Putian. Realization of DVB-T transmission system and its application in medical image transmission [D].Hefei University of Technology, 2017.

[10]Wu Jun. Simulation implementation of OFDM Modem in DVB-T system [D].Southwest Jiaotong University, 2008.

[11]Yan Haixia, Zheng Yuzheng.Video Transmission Implementation based on USRP and GNU Radio [J]. Information Technology and Informatization, 2016(12):26-29.

[12]Wang Jinqiang. Design and Implementation of LTE downstream MIMO space reuse Technology based on GNU Radio [D]. Xidian University, 2017.

[13]Tang Dongyuan. Implementation of DCSK modulation and demodulation System based on GNURADIO and USRP platform [D].Xiamen University, 2017.