**Lab 2: Packet Transmission**

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| **Introduction**  In this experiment, we focus on learning MATLAB object-oriented programming methods and keywords, and try to create new classes and corresponding attributes. After that, we interpreted the object-oriented programming method of QPSK transmitter and receiver through official documents, and further deepened our understanding of MATLAB object-oriented programming through the interpretation of QPSK communication system program. Finally, by comparing the difference between 16QAM and QPSK, we changed QPSK to 16QAM and added one bit to the output, so as to verify the feasibility of the 16QAM communication system in MATLAB.  **Lab results & Analysis**：  **Theoretical analysis:**   1. **MATLAB object-oriented programming**   Just like JAVA and C++, MATLAB can be programmed based on objects. The advantage of this is that it makes our programs modular and easy to modify and maintain. In the official documentation, we can find some introduction to MATLAB object-oriented programming, such as the keyword definition and the use of class, attribute, constructor and class attribute method. In this experiment, we found that the official documents of QPSK transmitter and receiver MATLAB program is based on this object-oriented programming. The architecture of the entire program is as follows:  20220303163113  Figure 1 The program architecture of QPSK transmitter and receiver  From the above program architecture, we can clearly see that the design of the QPSK transmitter and receiver is based on MATLAB object-oriented programming. Firstly, commqpsktxrx\_init initializes the parameters needed in the transmitter and receiver. After that, QPSK transmitter, channel, receiver and other class files are created, and instances of the objects based on these classes are created in runQPSKSystemUnderTest. Finally, we put these instances into a for loop to simulate the working process of a QPSK communication system.   1. **QPSK&16QAM**   Phase shift keying (PSK) is a digital modulation method that transmits information by changing the phase of a given modulated signal. In orthogonal PSK (QPSK), we will use four different phases to represent two bits of data that need to be transmitted.  QAM is a combination of amplitude and phase modulation technology, which uses the amplitude and phase of the carrier to transmit bits of information, so it can achieve a higher frequency band utilization under the condition of the same minimum distance. The highest QAM has reached 1024-QAM (1024 samples). In 16-QAM modulation, each symbol represents four bits of data, and 16 constellation points are distributed in a square array, in which each constellation point represents a vector state.  20220303171117  Figure 2 The constellation figure of 16-QAM  **Lab results & Analysis**：  **Task1: Explain the functions**  **Automatic Gain Control (AGC)：**AGC is an automatic control method in which the gain of an amplifier circuit is automatically adjusted according to the signal strength. The circuit that does this is called an AGC ring. AGC loop is a closed loop electronic circuit, which is a negative feedback system.  **Coarse frequency compensation:** When the data after signal detection enters the baseband processing of the receiver, coarse carrier frequency offset estimation and carrier frequency offset compensation are carried out to correct and compensate the input signal, which are collectively referred to as coarse frequency correction.  **Fine frequency compensation:** According to the attenuation curves of different frequency components, different amplifications are given to different frequency components to achieve the synchronization between input and output frequencies and reduce the problem of sharp attenuation of a certain frequency component.  **Timing recovery :** Timing recovery is a process in which periodic timing signals are derived from received digital signals according to the periodicity of digital time slots. The purpose is to generate the local clock matching the symbol rate and obtain the best sampling point.  **Frame** **synchronization：**In the digital time division multiplex communication system, in order to correctly separate the time slot signals, the sender must provide the starting mark of each frame, and the process of accurately detecting and acquiring this mark at the receiver is called frame synchronization.  **Data decoder:** A device that processes the received signal at the receiver and obtains the transmitted data through the constellation diagram.  **Task 2: Implement 16-QAM Transmitter and Receiver according to the example**  **Result:**  20220303203335  Figure 2 The Overall Result  20220303204328  Figure 3 The Constellation Results  **20220303204519**  Figure 4 The Spectrum Results  **20220303204704**  Figure 5 The Error rate of the command line window  **Task3: Compare the BER between QPSK and 16-QAM under different EbN0 condition.**  **Result:**   1. **QPSK**   **EbN0 = 0: 20220303214935**  **EbN0 = 20:**  **859QEA_A$`O@5FH_PCKCORB**  **EbN0=40:**  **DZX``SG~BNN8A7JOM`$LKNG**  Figure 6-8 The Error rate of the command line window under different EbN0 in QPSK   1. **16-QAM**   **EbN0 = 0:**  **20220303210204**  **EbN0 = 20:**  **20220303210350**  **EbN0=40:**  **20220303210454**  Figure 9-11 The Error rate of the command line window under different EbN0 in QPSK  From the analysis of the results above, we can easily see that for the same EbN0,  At the same time, **with the increase of EbN0, the bit error rate for the same modulation mode decreases.**  **Analysis：**  By comparing the analysis of QPSK and 16QAM bit error rate under the same EbN0, we can get: Under the same EbN0, the bit error rate of QPSK is obviously lower than 16QAM. This is because the constellation map of QPSK is relatively scattered, so it is not easy to make mistakes in judgment when receiving, while the constellation map of 16QAM is relatively dense, so it may make mistakes in judgment when receiving. However, although the bit error rate of 16QAM is higher than that of QPSK, the data transmission rate and efficiency of 16QAM is significantly higher than that of QPSK. Therefore, the method of improving transmission efficiency by sacrificing the bit error rate can also be regarded as a transmission strategy. Under the condition of certain bit error rate, we can use higher order QAM for data transmission. | |
| **Experience**  Through this experiment, I have a deeper understanding of MATLAB object-oriented programming. Through the simulation of QPSK and 16QAM communication system, I have some practical experience in object-oriented programming of MATLAB, and also have a clear cognition of the advantages and disadvantages of the modulation mode of PSK and QAM. However, this experiment also exposed a lot of problems, most of which were caused by my unproficiency in MATLAB programming, which is what I need to improve in the future. | |
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