Lab 7： Band-Pass Transmission

Author	Name：应逸雯 陈薇羽　　Student ID: 12210159 12210460

Introduction

Principles

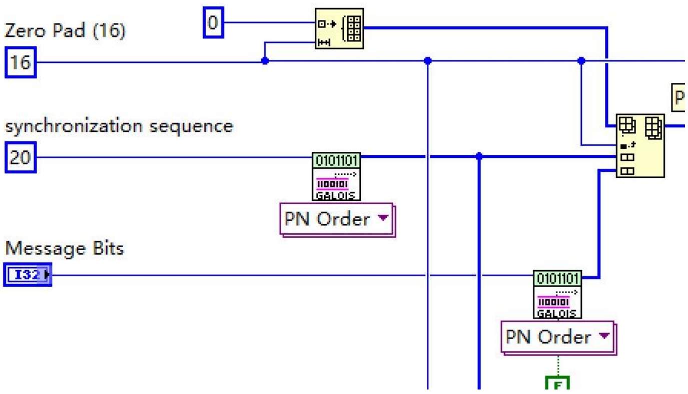
I / Q signal representation

use -1/1 to represent, real part and imaginary part can separately represent a bit

BPSK	
bits	symbols
0	-1
1	1

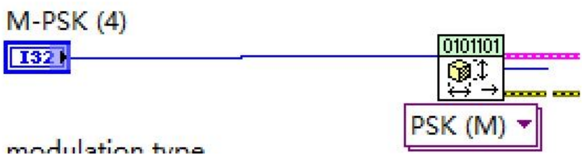
QPSK	
bits	symbols
00	1+1j
01	-1+1j
11	-1-1j
10	1-1j

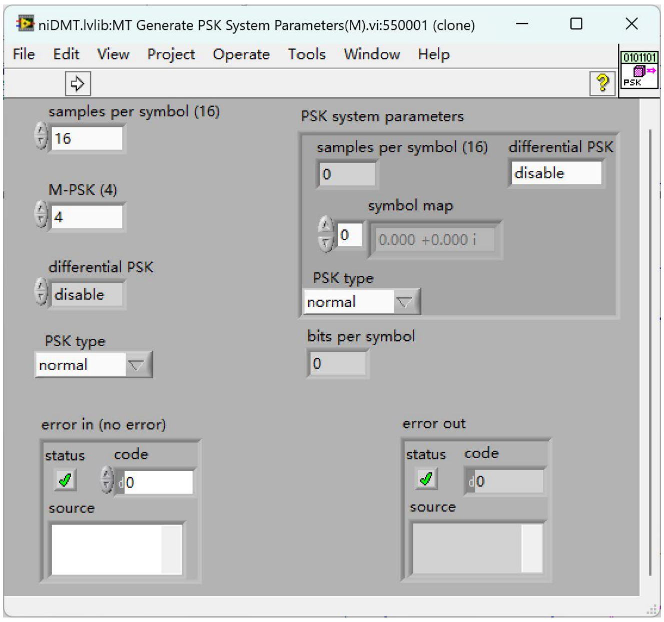
Packet Encapsulation



use MT Generates Bits.vi to generate bits, then use array function to integrate them into a packet

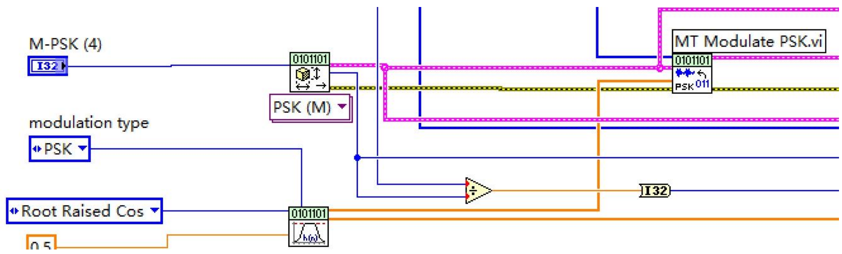
Symbol mapping table





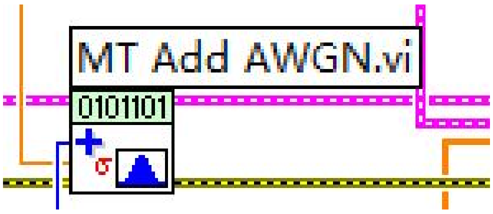
we need to generate PSK codes as the I/Q signal generation, use MT Generate PSK System Parameters.vi to generate PSK codes

PSK modulator



PSK Modulator can modulate digital signal. We can modulate digital signal by sinc, raised cosine, root raised cosine.

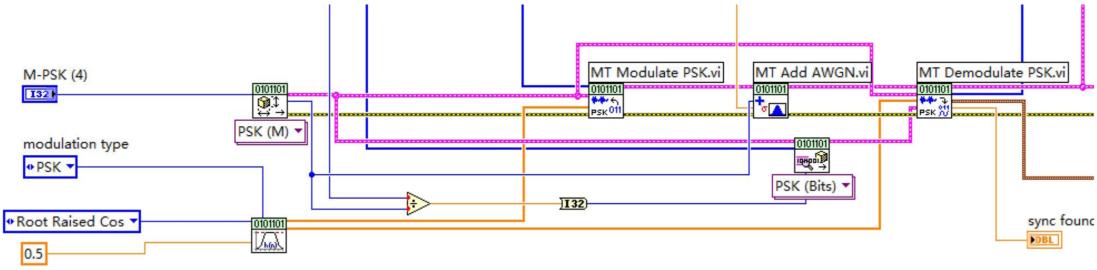
Noise Channel



use MT Add AWGN.vi to simulate noise channel

We use Gaussian noise to represent the signal. SNR can be adjusted by controller.

PSK demodulator

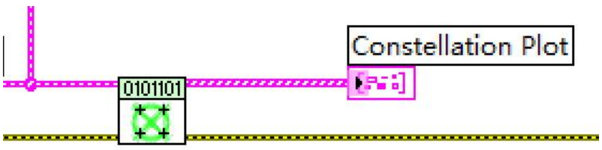


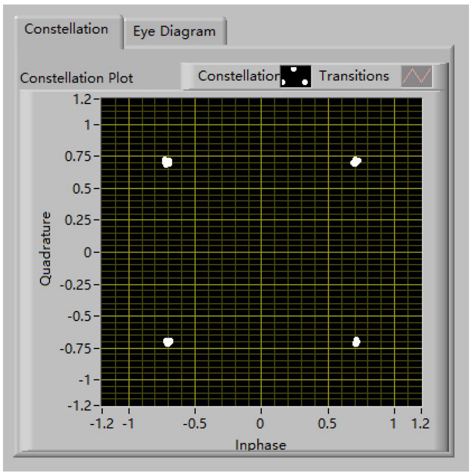
MT Demodulate PSK.vi can demodulate digital signal according to the modulation way.

Synchronisation

MT Generate Synchronization Parameters.vi can guarantee the modulate and demodulate ways to be in the same phase.

Constellation Diagrams

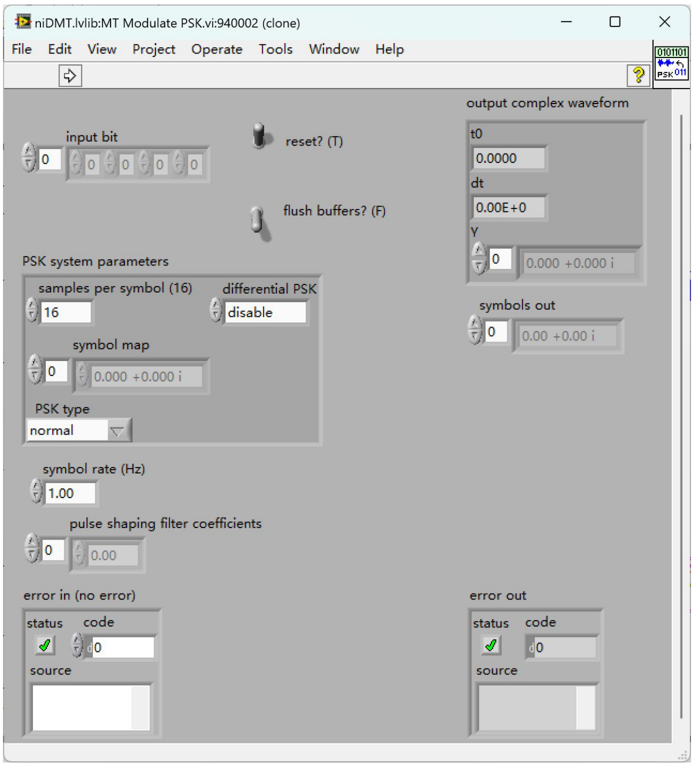




constellation diagram can clearly plot the signal’s inphase and quadrature signal.

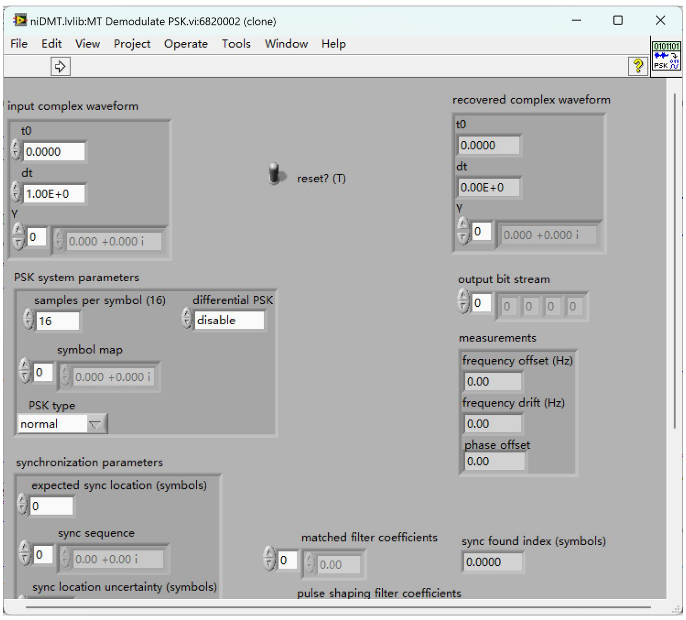
LabVIEW module

MT Modulate PSK.vi module



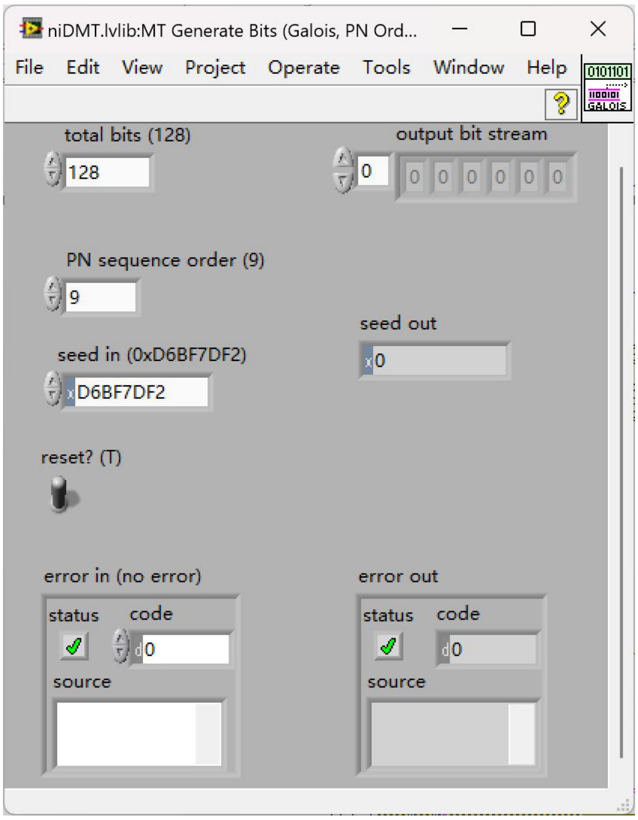
MT Modulate PSK.vi receives a sequence of data bits, performs PSK modulation, and returns the modulated complex baseband waveform in the output complex waveform parameter.

MT DeModulate PSK.vi module



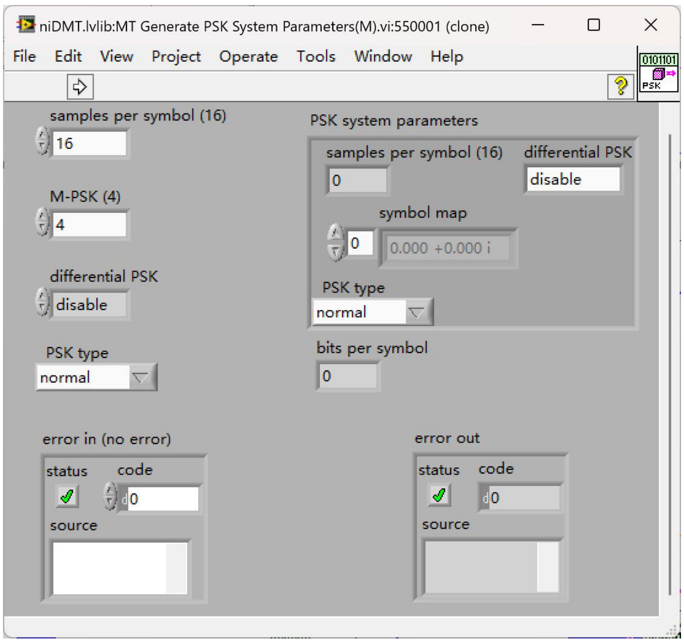
MT Demodulate PSK demodulates a PSK-modulated complex baseband waveform and returns the time-aligned oversampled complex waveform, the demodulated bit stream, and measurement results obtained during demodulation. It can also removes carrier and phase offset by locking to the carrier signal.

MT Generate Bits (poly).VI



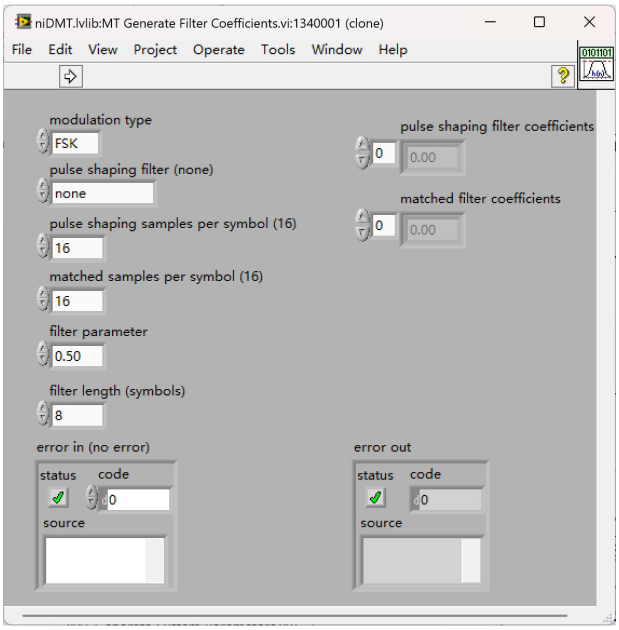
MT Generate Bits.vi can generate sequence of data bits to be modulated. It can generate Fibonacci, Galois pseudonoise bit sequences, or user-defined sequences.

MT Generate System Parameters.VI



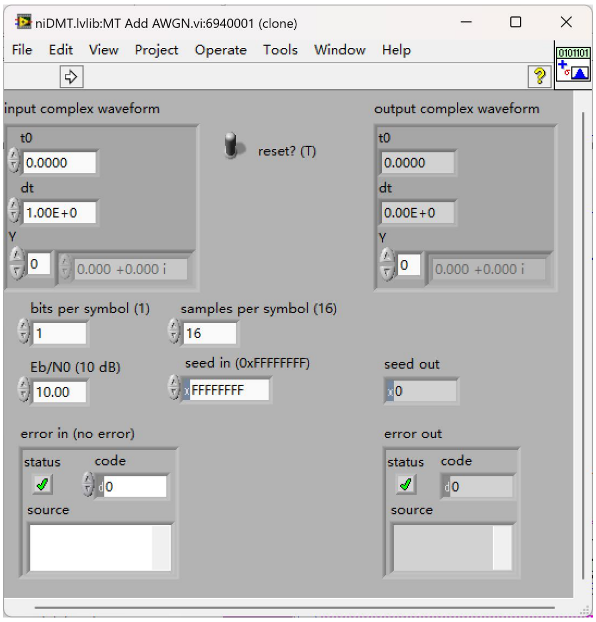
It can calculate parameters for use with modulation and demodulation VIs. It read the bit in PSK(M), then generate parameters for modulation vi and synchronization vi to use.

MT Generate Filter Coefficients.VI



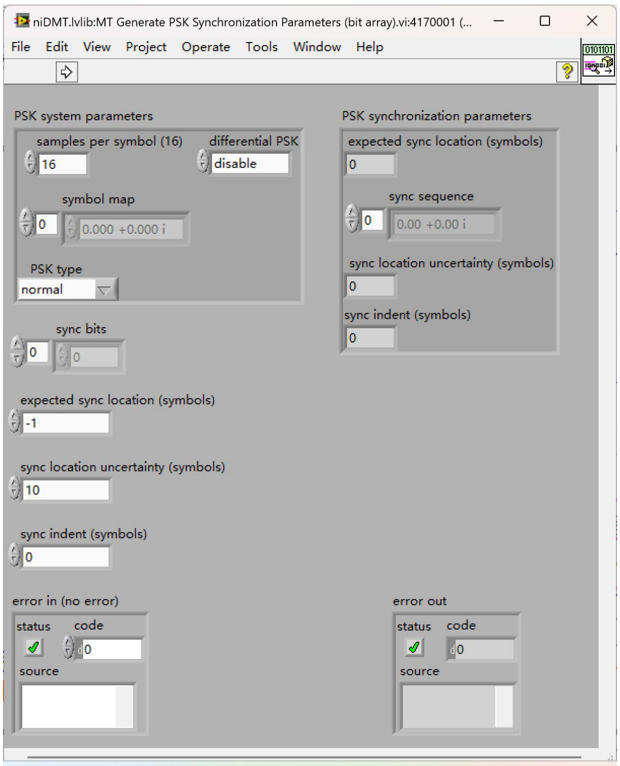
According to pulse shape and modulation type, this vi can generate filters and their coefficients for modulation and demodulation to use.

MT Add AWGN.VI



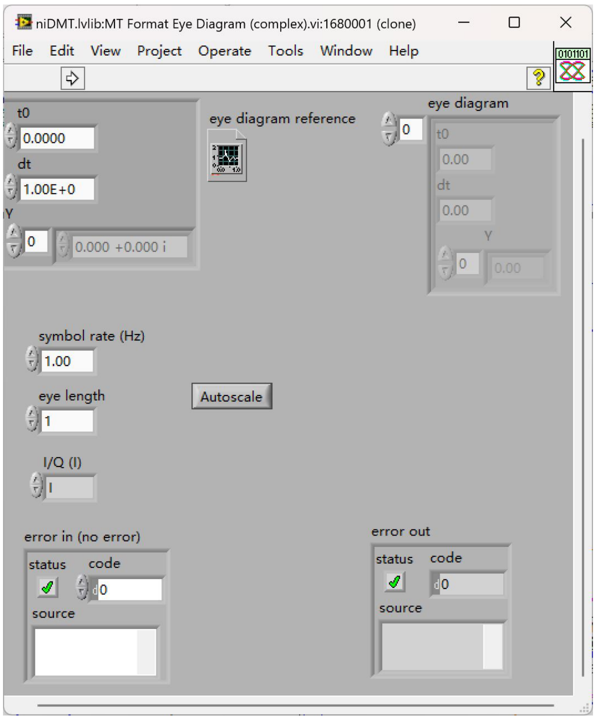
It can add Gaussian Noise according to Eb/N0. Such noise can simulate the channel.

MT Generate Synchronization Parameters.VI



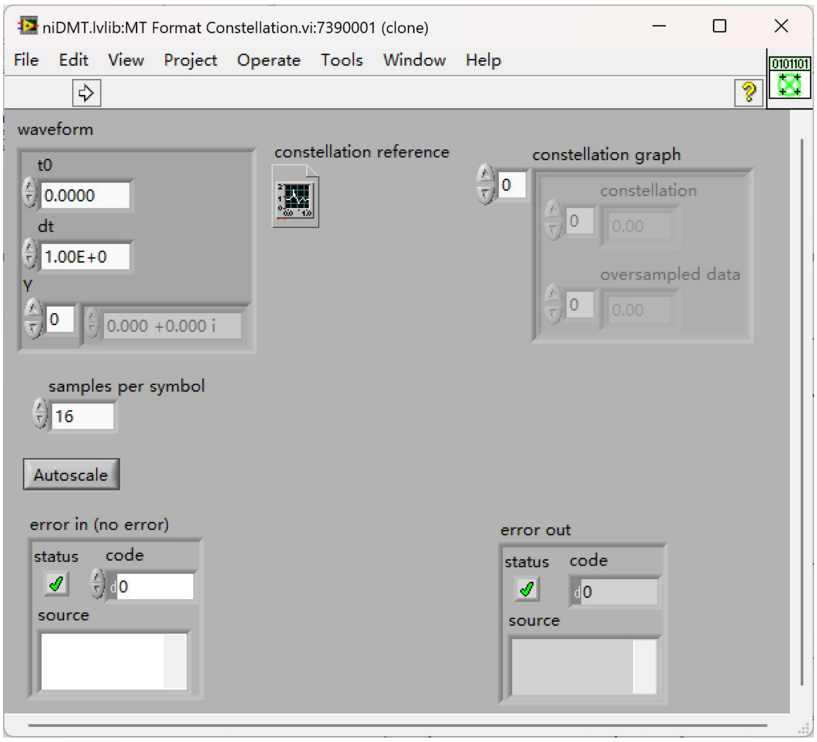
There needs to be a parameter to guarantee that there is no phase ambiguity between modulation vi and demodulation vi. Such vi can generate that parameter.

MT Format Eye Diagram.VI



After demodulation, the data are in complex form. They can’t be directly comprehended. So MT Format Eye Diagram.vi can generate an eye pattern with specific symbol rate and eye length parameters.

MT Format Constellation.VI



After demodulation, the data are in complex form. They can't be directly comprehended. So MT Format Constellation.vi can generate a constellation plot of the waveform contents.

Basic Principles

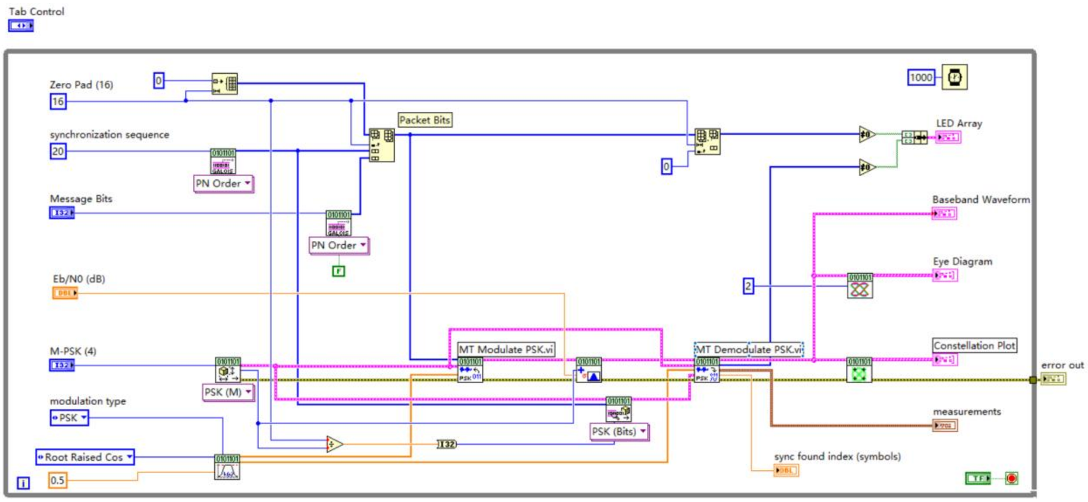
PSK (Phase shift keying) is a modulation technique that uses the carrier phase to represent the input signal information. There are two types of phase shift keying: absolute phase shift and relative phase shift. Phase modulation based on the phase of the unmodulated carrier is called absolute phase shift. Taking binary phase modulation as an example, when the code element is 1, the modulated carrier is in phase with the unmodulated carrier. When the code element is 0, the modulated carrier is inversely phase with the unmodulated carrier. The carrier phase difference after modulation is 180° between 1 and 0.

For one-dimensional modulation schemes (such as PAM, ASK, BPSK), there may be a 180° carrier phase ambiguity. Without the correct synchronization parameters, the demodulator cannot distinguish the positive and negative polarity of the signal, leading to bit errors. The Synchronization VI generates synchronization parameters by receiving an array of synchronization bits or synchronization numbers, which are used to define the phase and frequency characteristics of the signal during demodulation. This avoids phase ambiguity, ensures the correct recovery of the original message data, and improves the reliability of the communication system.

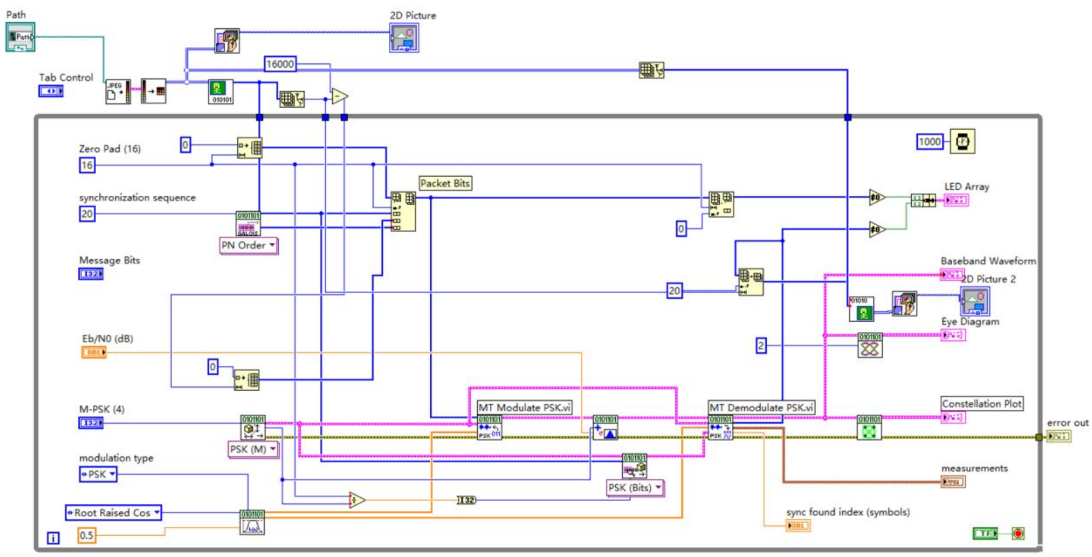
Lab results & Analysis：

Block Diagram

M-PSK bits transmission

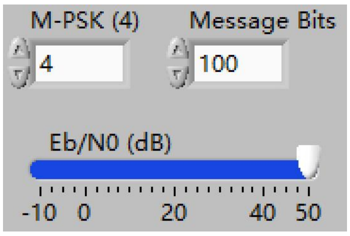


M-PSK image transmission



Experiment Result

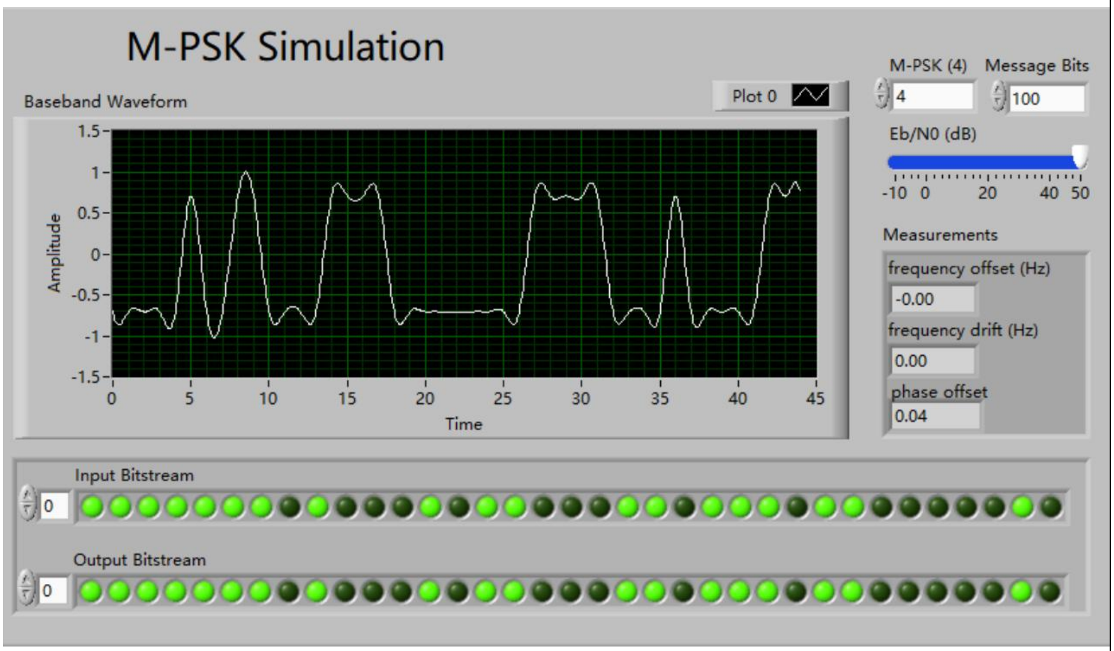
Default parameter



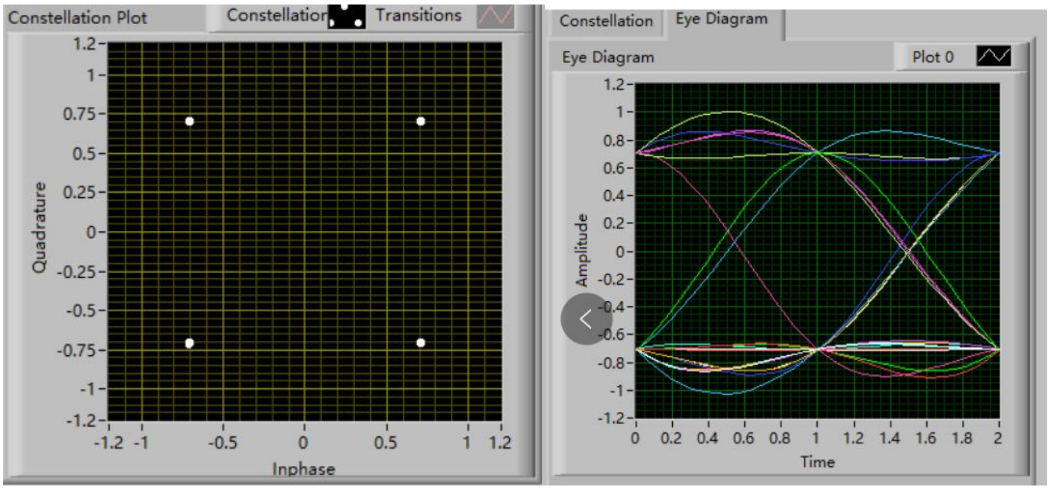
Result Diagram

M-PSK bits transmission

amplitude spectrum and bitstream



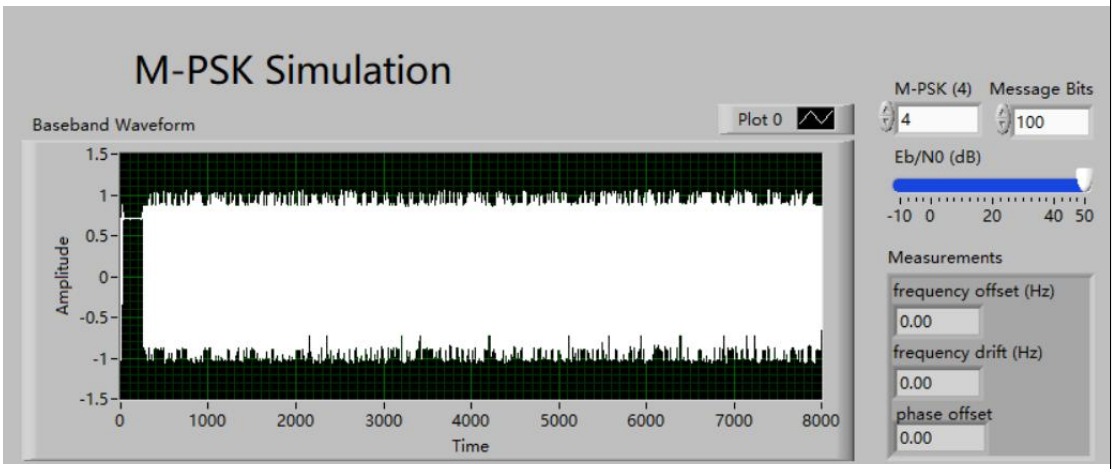
constellation diagram and eye pattern



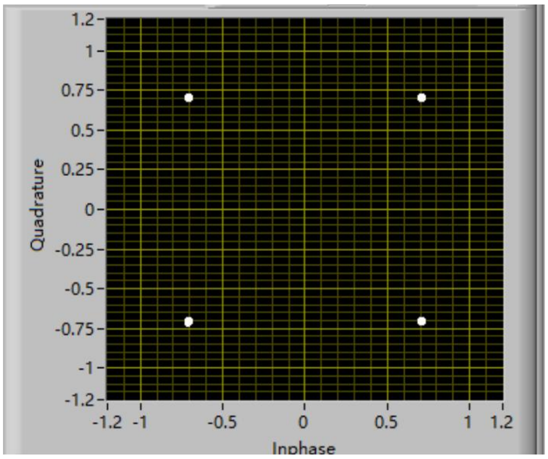
Unit of time: s

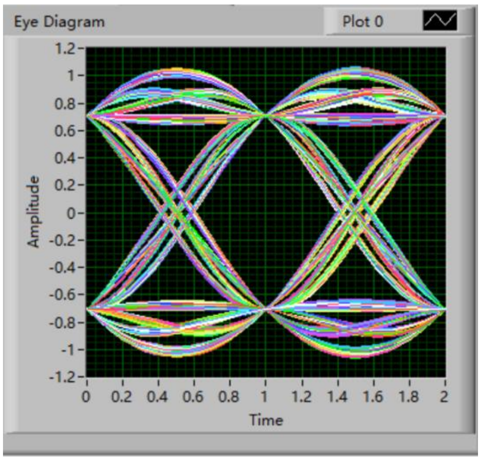
M-PSK image transmission

amplitude spectrum



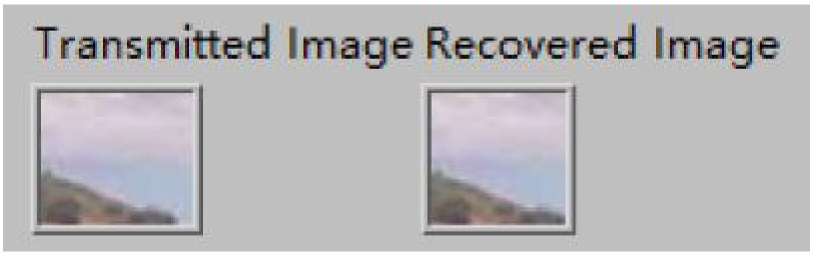
constellation diagram and eye pattern





Input and Output Diagram

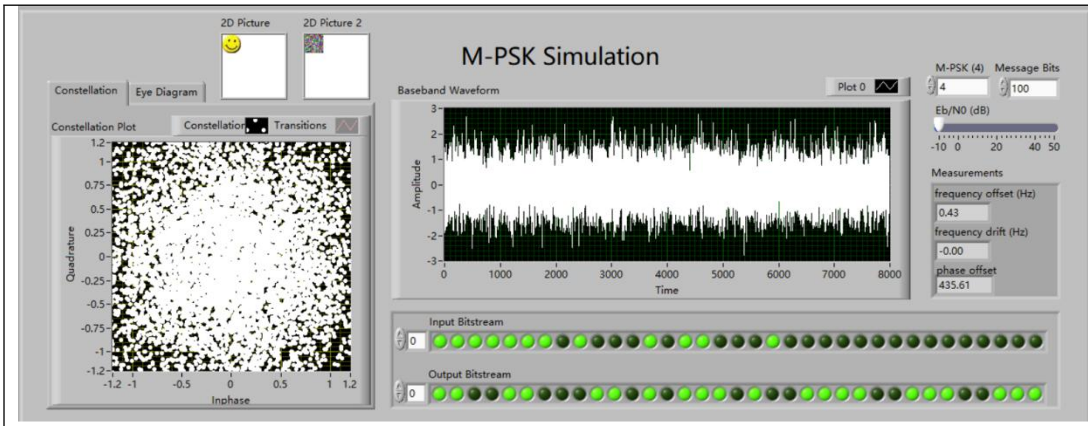
using another image

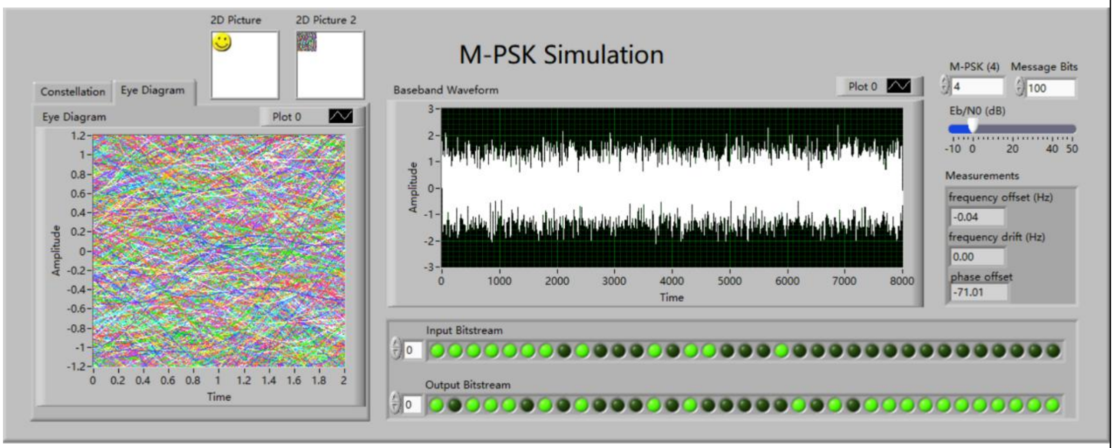


Influence factors

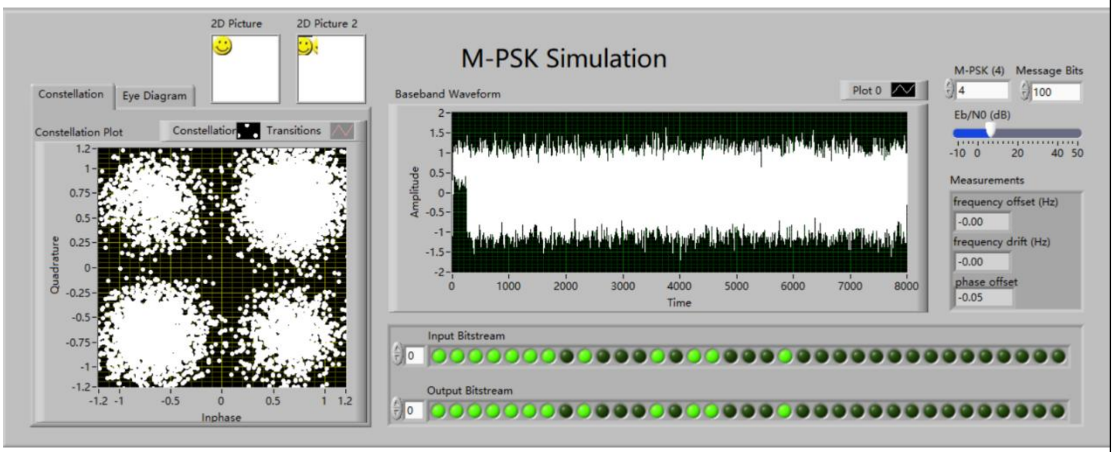
SNR

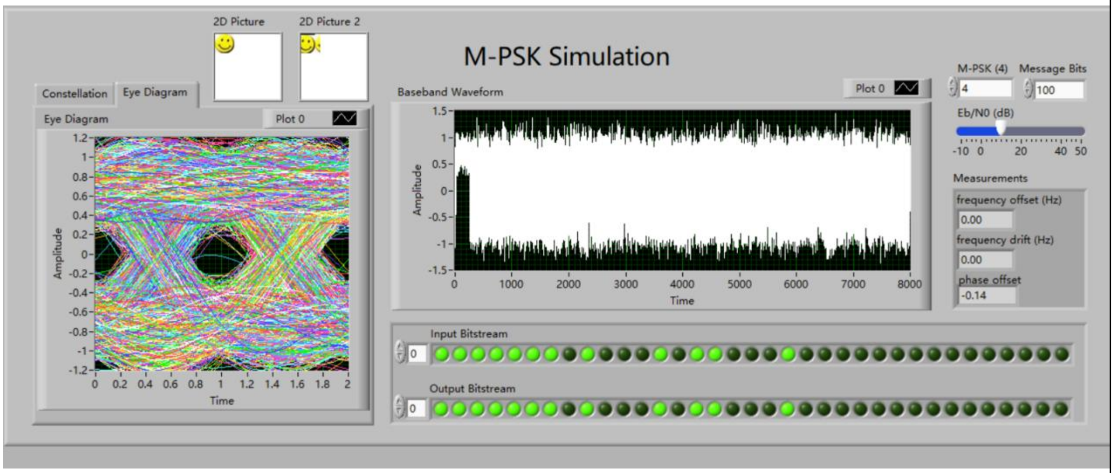
0 dB



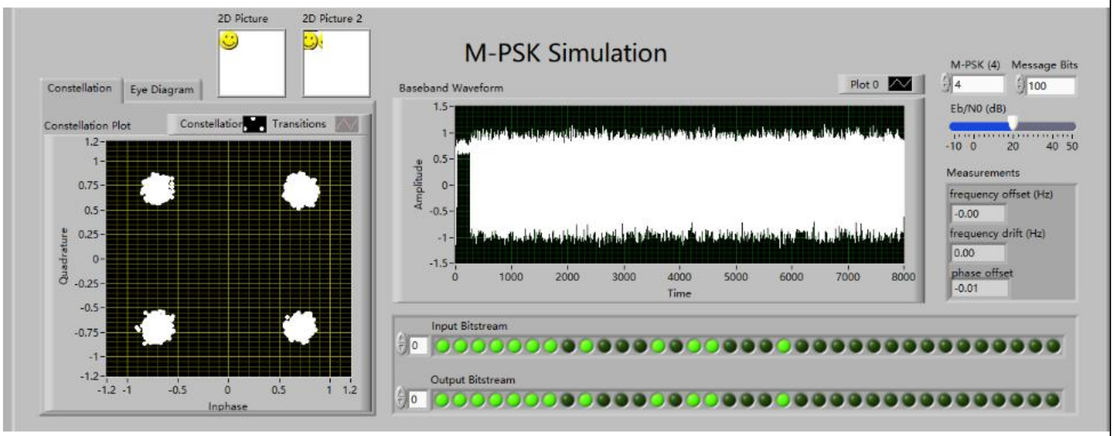


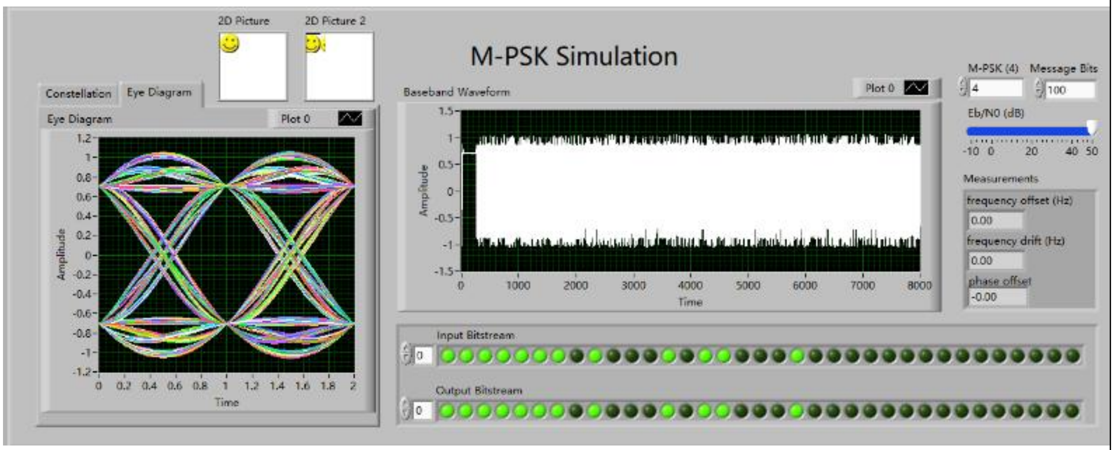
6.5 dB (threshold value)





20 dB

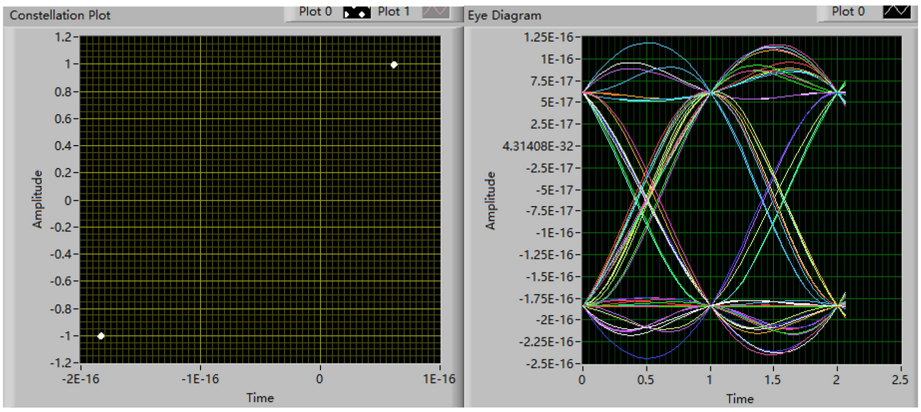




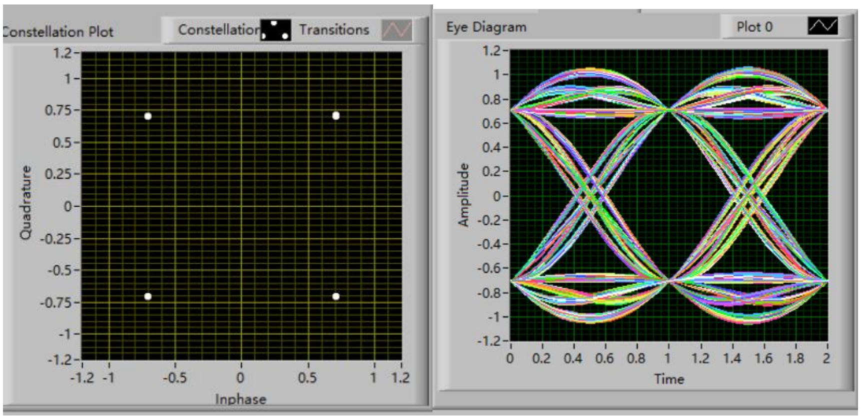
We set the SNR to 0, 6.5 and 20 dB in each test. From the above figure, we can see that as the S/N ratio increases, the four constellations in the constellation diagram become more concentrated in the four quadrants of the diagram, and the eyes open in the eye diagram. Also, the image goes from completely garbled to occasionally garbled to stable and clear, indicating that the transmission performance of the system improves as the SNR increases.

M-PSK

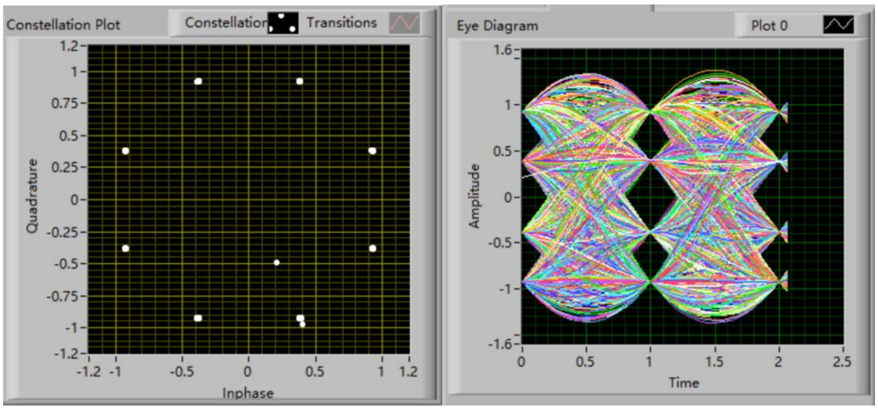
2-PSK



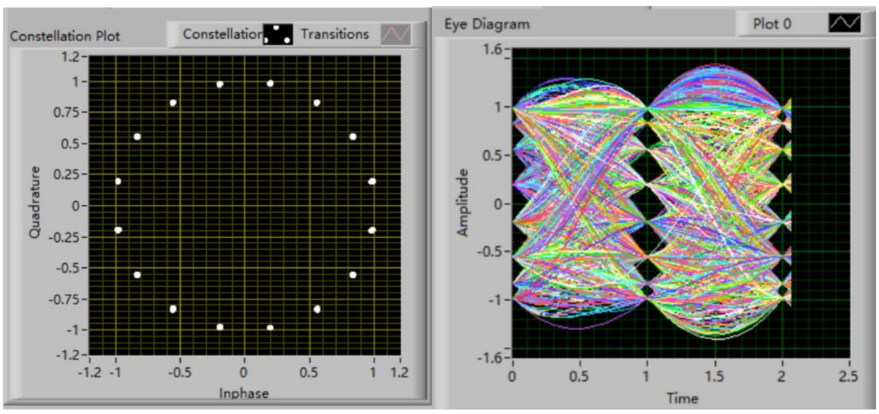
4-PSK



8-PSK



16-PSK



We set the SNR to 50 and test 2-PSK, 4-PSK, 8-PSK and 16-PSK digital carrier transmissions.

From the figure above, we can see that as the number of keys we use increases, there are more and more constellations in the constellation diagram. As the number of keys used to transmit the signals increases, the transmission efficiency of the system also increases, but the probability of ISI also increases.

Advantages of digital carrier modulation systems:

Efficient Band Utilisation: relative to other modulation techniques such as Amplitude Modulation (AM) or Frequency Modulation (FM), PSK can transmit more data in the same bandwidth. This is because each symbol in PSK can carry multiple bits of information (e.g., two bits in QPSK, three bits in 8-PSK, etc.).

Robustness: The PSK modulation system has better resistance to noise and interference in the channel, especially under high signal-to-noise ratio (SNR) conditions, which makes it useful in application scenarios where the quality of communication needs to be guaranteed.

Symmetry and simplicity of the constellation diagram: the points in the constellation diagram are uniformly distributed on the circumference of the circle, which allows the synchronisation and demodulation algorithms at the receiver side to be simpler and more effective.

Disadvantages of digital carrier modulation systems:

Low power efficiency: as the modulation order increases, e.g. from BPSK to QPSK to 8-PSK, the power efficiency of the system decreases because the Euclidean distance between neighbouring symbols decreases, making the system more sensitive to noise.

High hardware requirements: Higher-order PSK systems (e.g., 16-PSK or higher) require more accurate and sophisticated modulation and demodulation equipment, which increases the cost and complexity of the system.

Difficult synchronisation: very precise carrier recovery is required at the receiver side, especially in high-order PSK systems, which is a technical challenge in practice.

Social application value:

Communication systems: digital carrier modulation techniques are widely used in wireless communication systems, such as satellite communications, mobile communications, etc., and they are an integral part of modern communication systems.

Data transmission: In data transmission over the Internet and data centres, PSK technology can provide high-speed and high-quality data services, supporting a large number of online services and applications.

Military and security field: due to the strong anti-jamming ability of PSK technology, it is also often used in military communications and other communication systems that require high security.

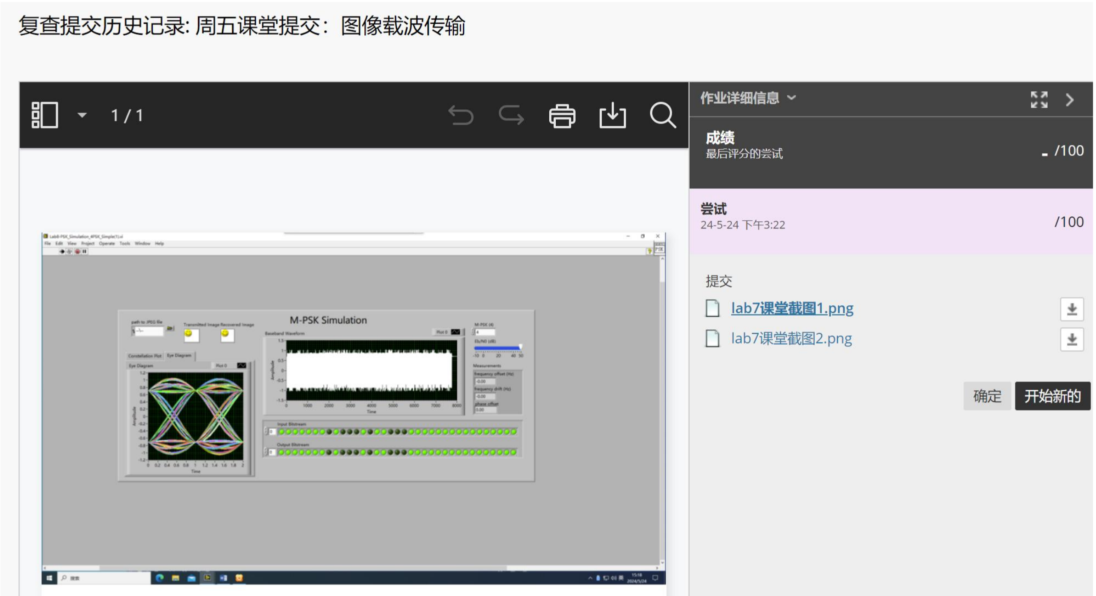
Experience

During this digital carrier transmission experiment, we gained a deeper understanding of the theory and application of M-PSK, particularly the modulation and demodulation processes of BPSK and QPSK. Utilizing simulators and constellation diagrams, I was able to visually observe the effects of signal transmission under different SNR conditions and comprehend how to optimize communication quality by adjusting parameters. Additionally, the pulse shaping and matched filtering stages in the experiment enhanced my appreciation for the complexity of digital communication system design, laying a solid foundation for my future research and work.

Contributions:

YING Yiwen: Complete basic programs in classes. Write the Introduction in the report.

CHEN Weiyu: Complete basic programs in classes. Write the Lab Results and Analysis in the report.



Score	100