

# 无线通信实验在线开放课程

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广东省教学质量工程建设项目





# Lab 8 : Phase Shift Keying

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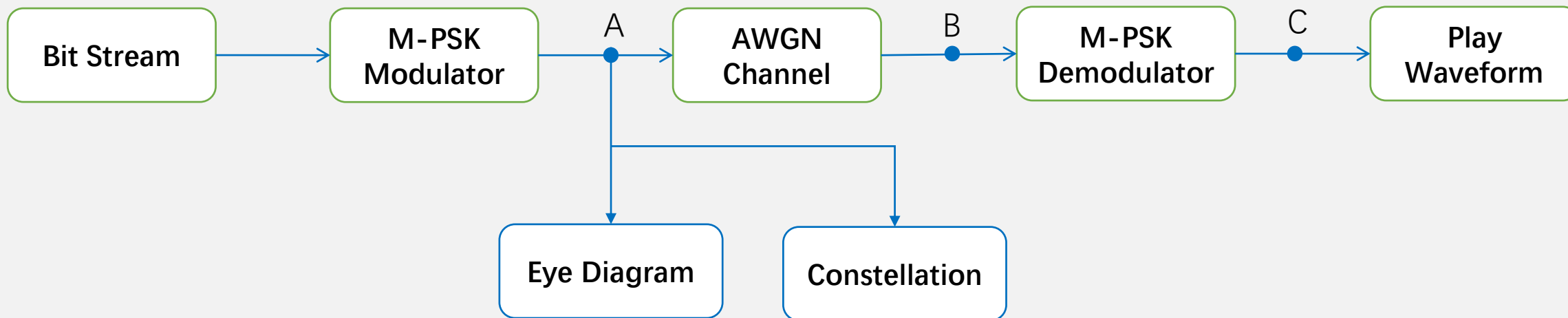
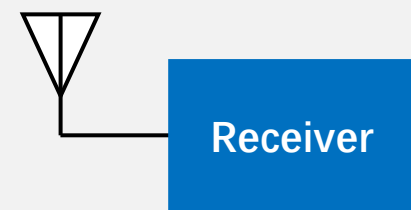
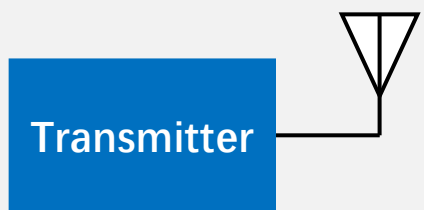
## Lab 8: Phase Shift Keying

1 Band-Pass Transmission System

2 BPSK/QPSK Simulation

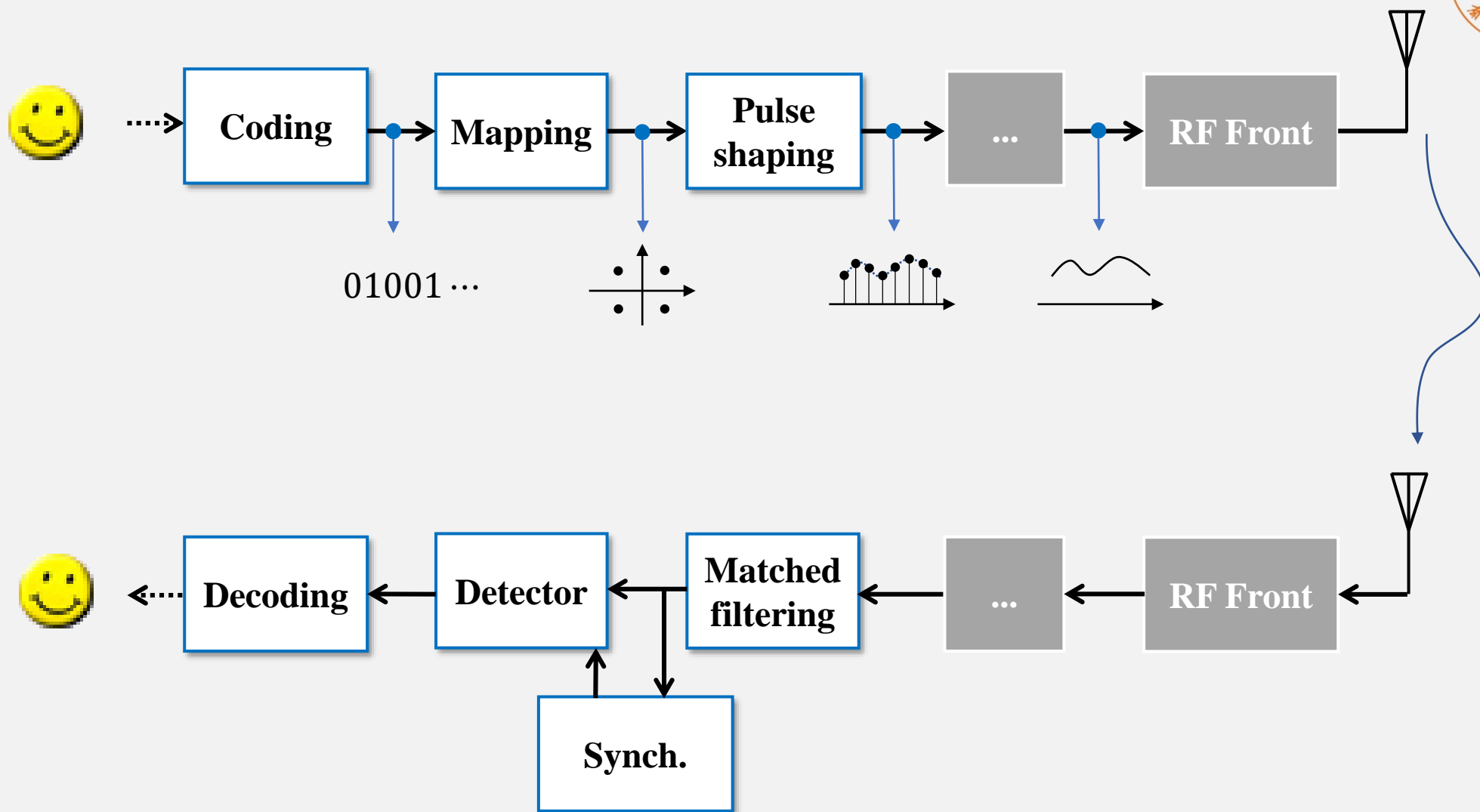
3 BPSK/QPSK Image Transmission

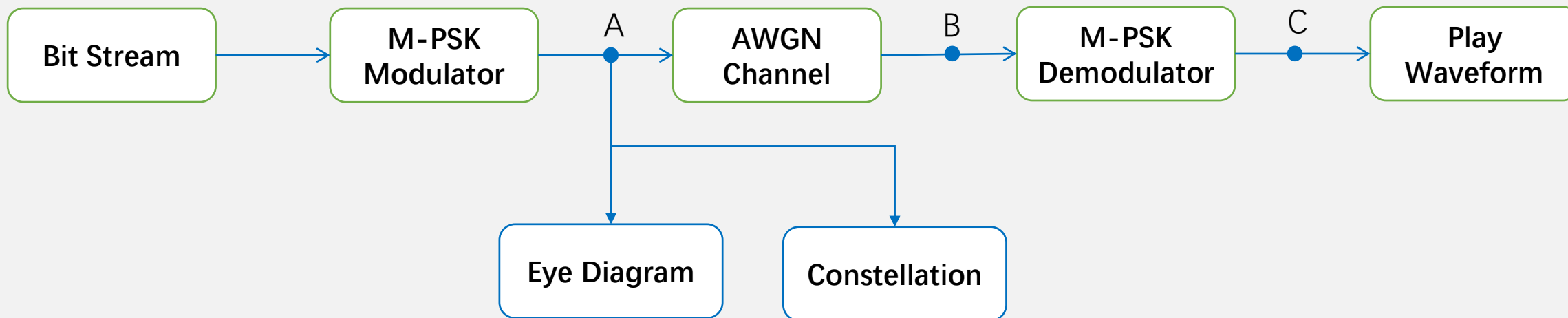
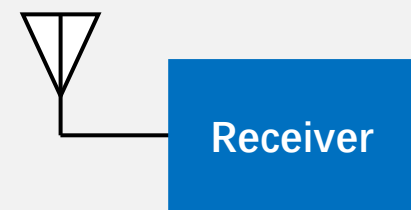
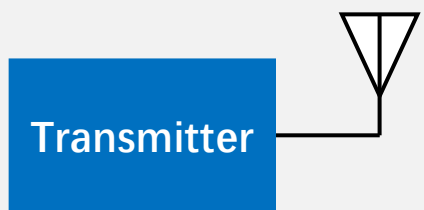
4 8-PSK/16-PSK Image Transmission





# Demo: M-PSK Image Transmission

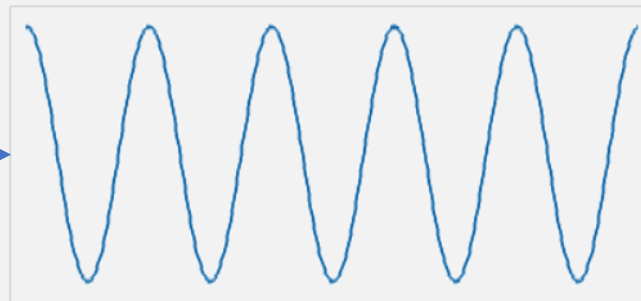






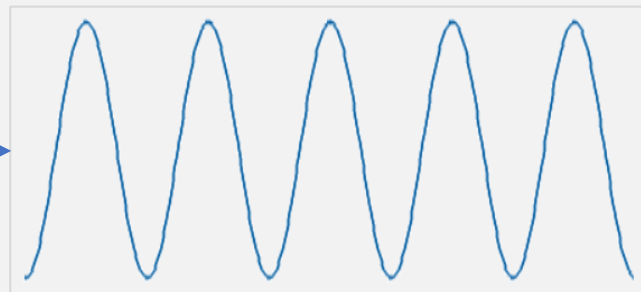
# BPSK

0



$$s_{RF0}(t) = \cos(2\pi f_c t)$$

1



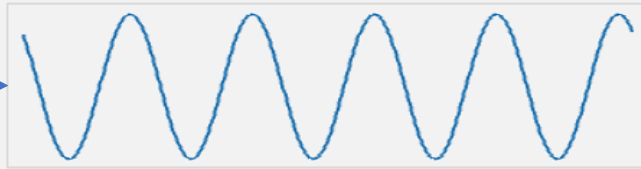
$$s_{RF1}(t) = \cos(2\pi f_c t + \pi)$$



# QPSK

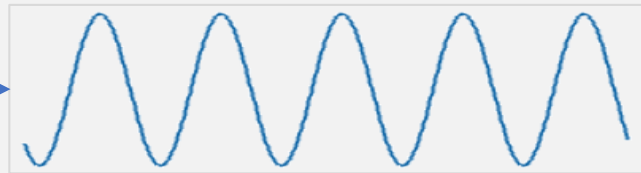


00



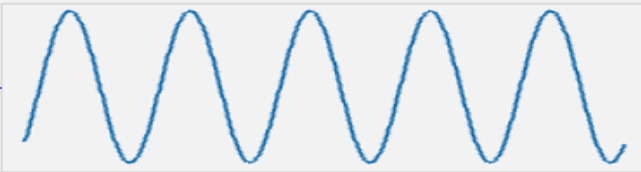
$$s_{RF0}(t) = \sqrt{2}\cos(2\pi f_c t + \frac{\pi}{4})$$

01



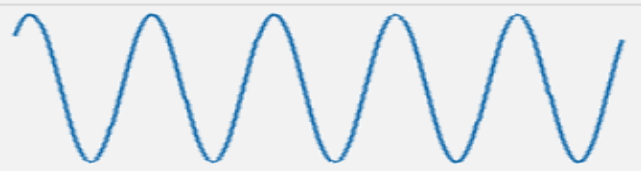
$$s_{RF1}(t) = \sqrt{2}\cos(2\pi f_c t + \frac{3\pi}{4})$$

11

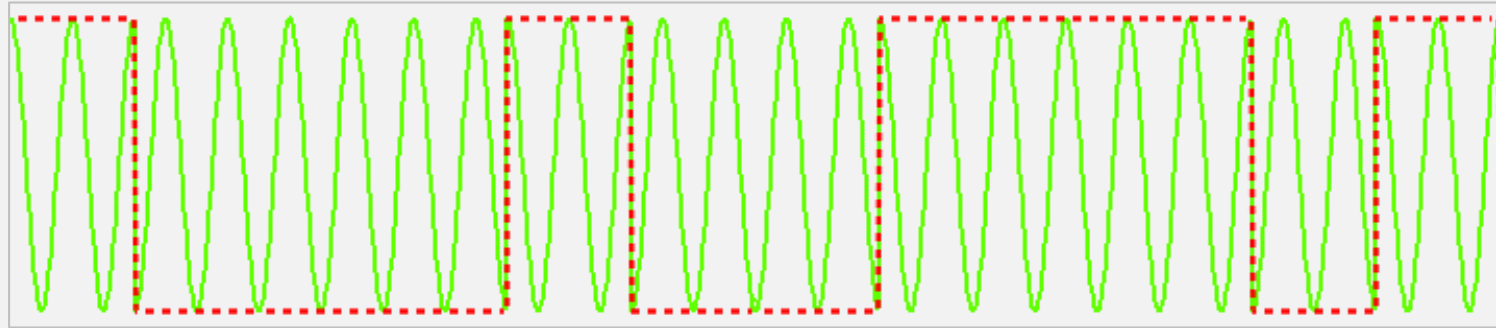


$$s_{RF2}(t) = \sqrt{2}\cos(2\pi f_c t + \frac{5\pi}{4})$$

10

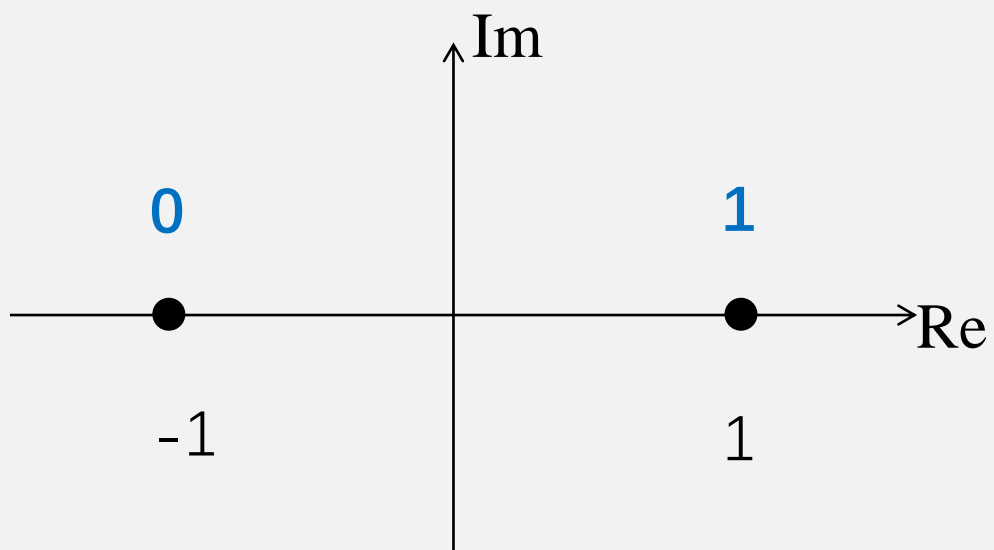


$$s_{RF3}(t) = \sqrt{2}\cos(2\pi f_c t + \frac{7\pi}{4})$$



$$s_{RF0}(t) = 1 \cdot \cos(2\pi f_c t)$$

$$s_{RF1}(t) = -1 \cdot \cos(2\pi f_c t)$$

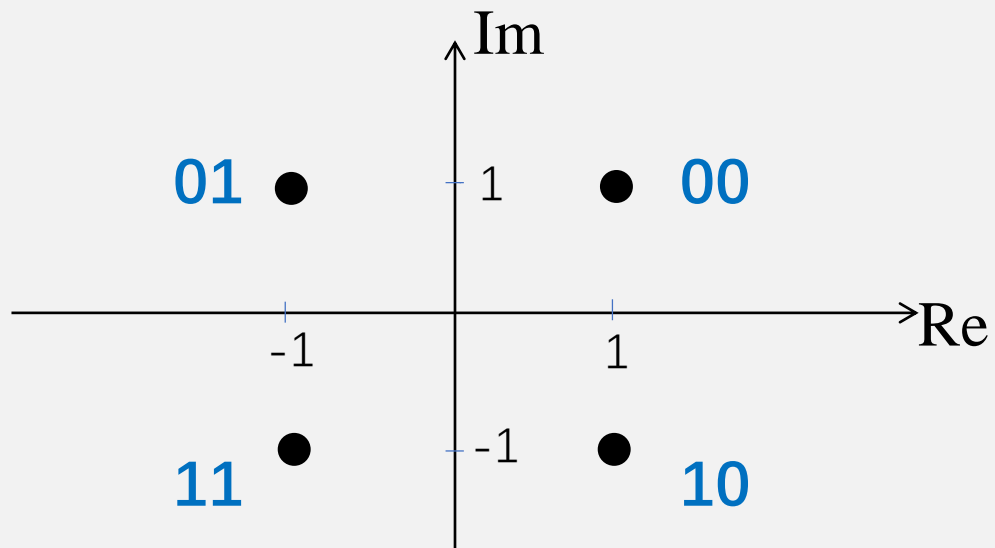


Constellation

BPSK	
bits	Symbols
0	$-1+0i$
1	$+1+0i$

$$s_{RF0}(t) = \sqrt{2} \cos\left(2\pi f_c t + \frac{\pi}{4}\right) = I \cdot \cos(2\pi f_c t) - Q \cdot \sin(2\pi f_c t)$$

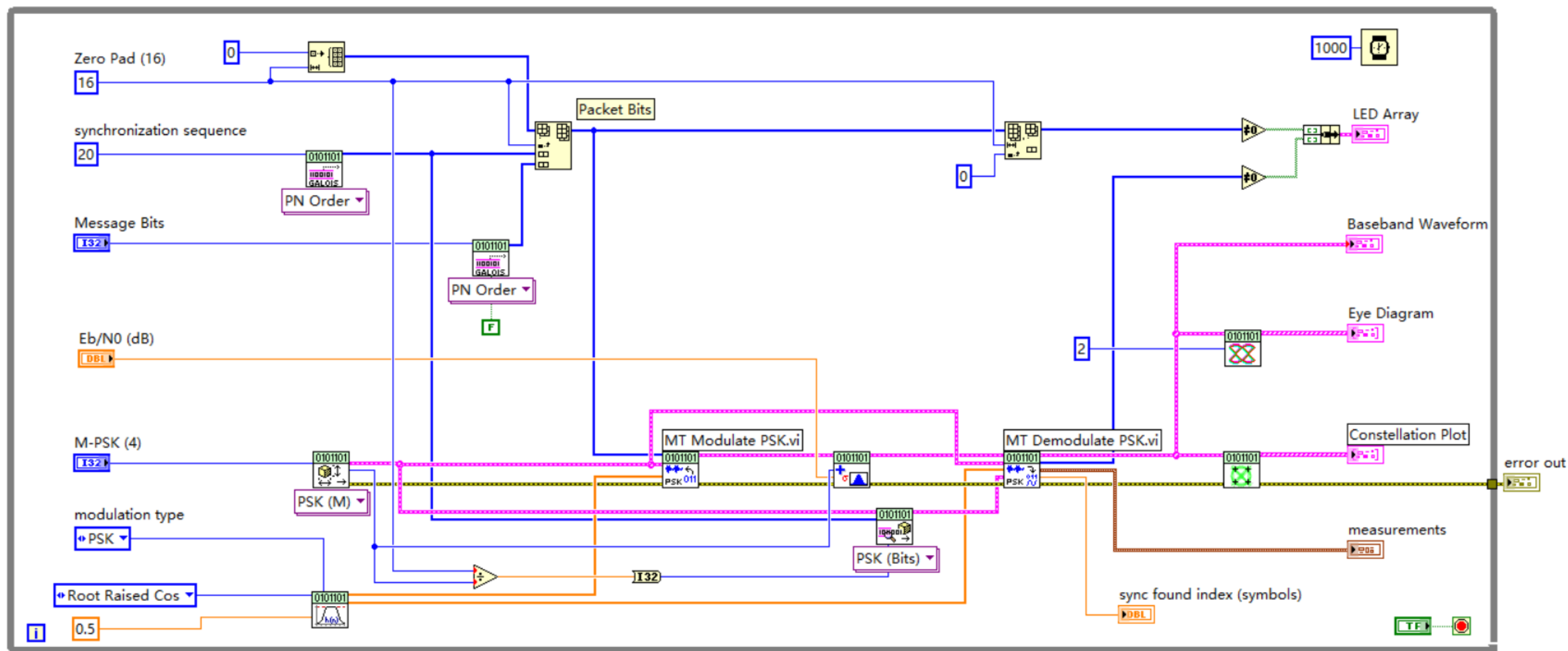
$I + Qj$

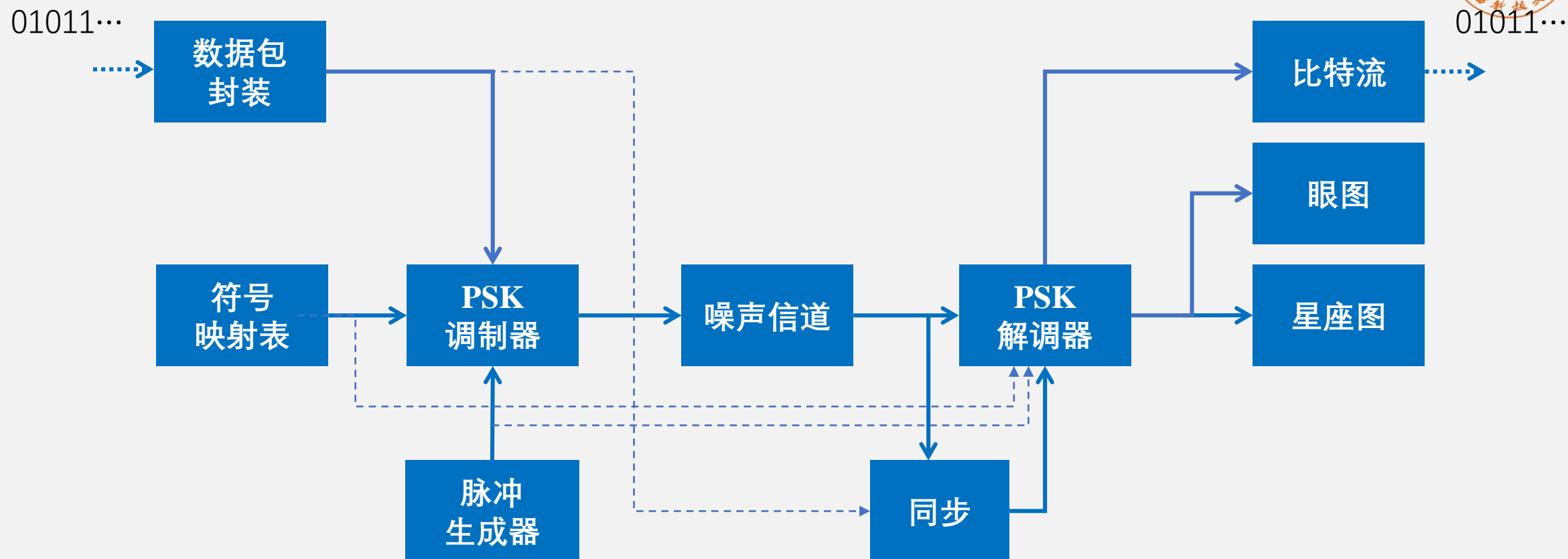


QPSK	
bits	Symbols
00	$1+1j$
01	$-1+1j$
11	$-1-1j$
10	$1-1j$



# Demo: BPSK/QPSK Simulation







# M-PSK Simulation

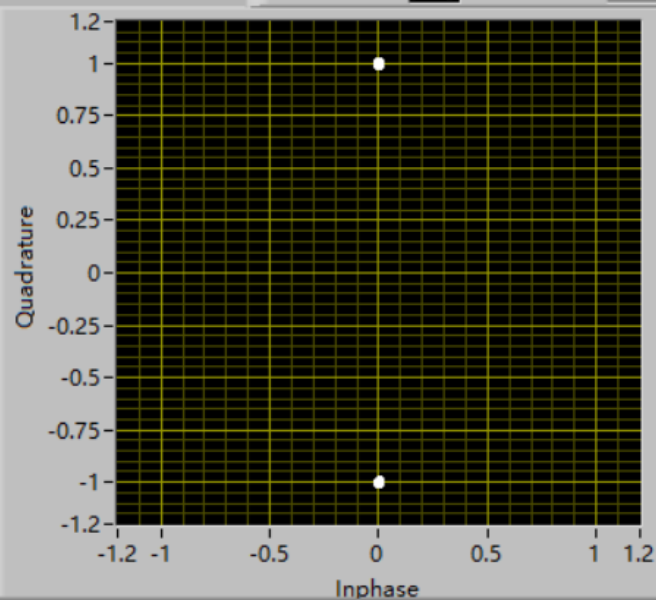
Constellation

Eye Diagram

Constellation Plot

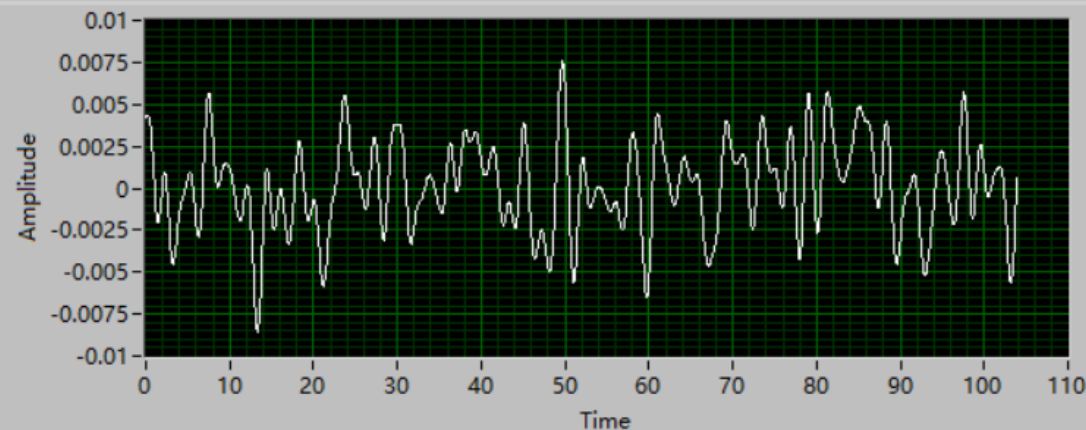
Constellation

Transitions



Baseband Waveform

Plot 0



M-PSK (4) Message Bits

2

100

Eb/N0 (dB)



Measurements

frequency offset (Hz)

-0.00

frequency drift (Hz)

0.00

phase offset

0.03

Input Bitstream

0



Output Bitstream

0







# M-PSK Simulation

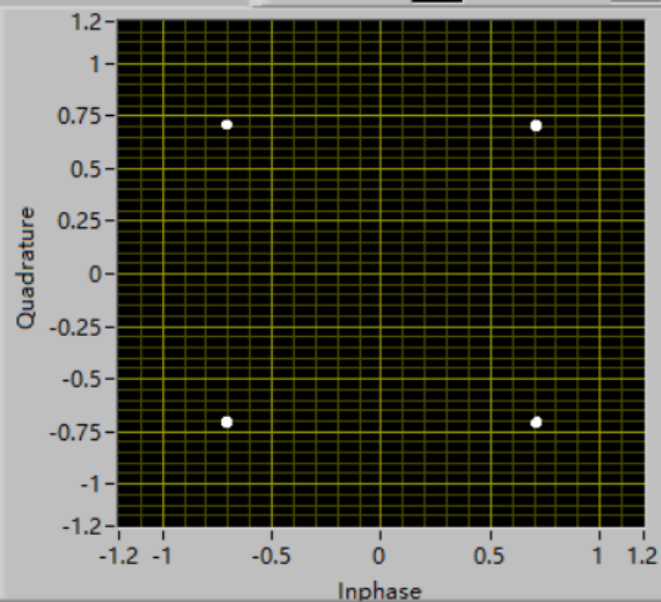
Constellation

Eye Diagram

Constellation Plot

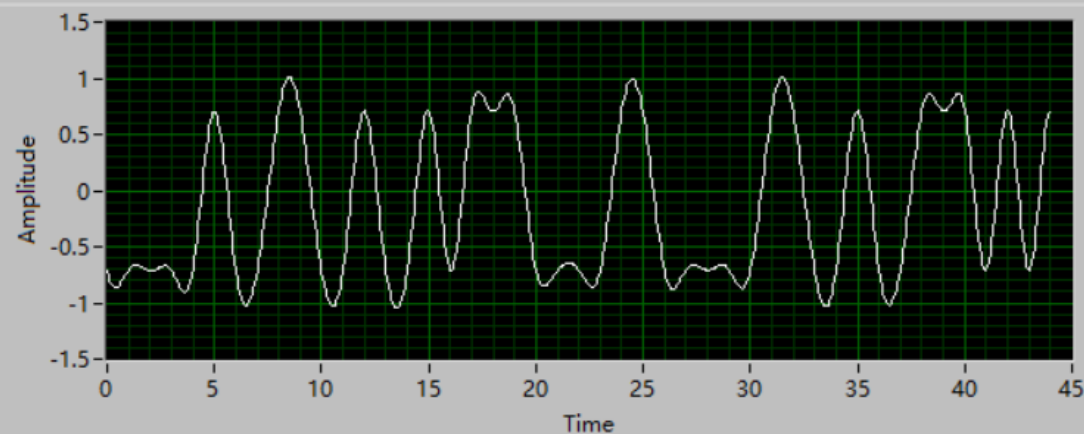
Constellation

Transitions



Baseband Waveform

Plot 0



M-PSK (4)

Message Bits

4

100

$E_b/N_0$  (dB)



Measurements

frequency offset (Hz)

-0.00

frequency drift (Hz)

-0.00

phase offset

0.01

Input Bitstream

0



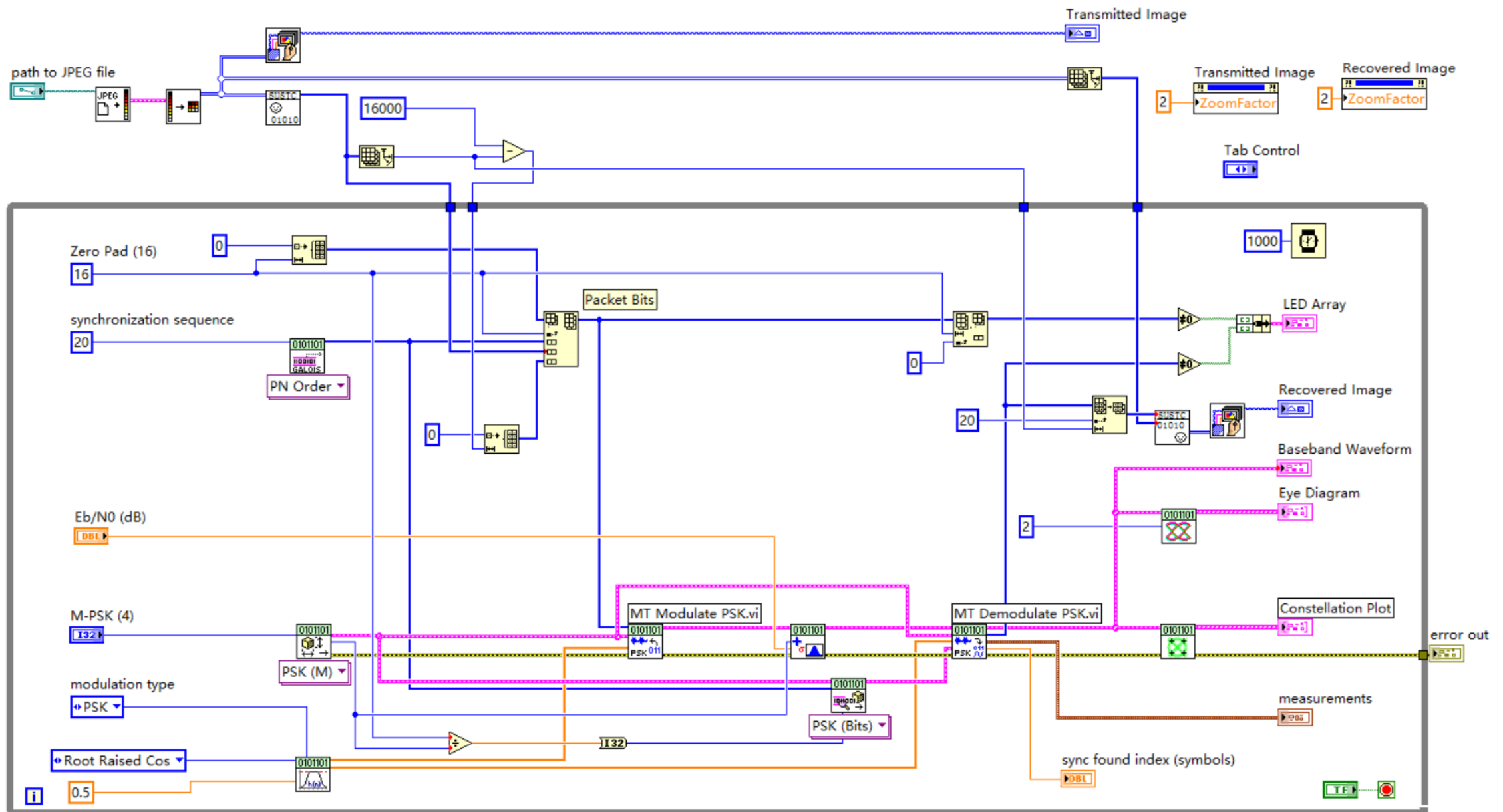
Output Bitstream

0





# Demo: 2/4-PSK Image Transmission





# M-PSK Simulation

path to JPEG file

D:\...字调相系统 (1 Weeks) \smiley\_tiny(recomended).jpg

Image Recover

Constellation

Eye Diagram

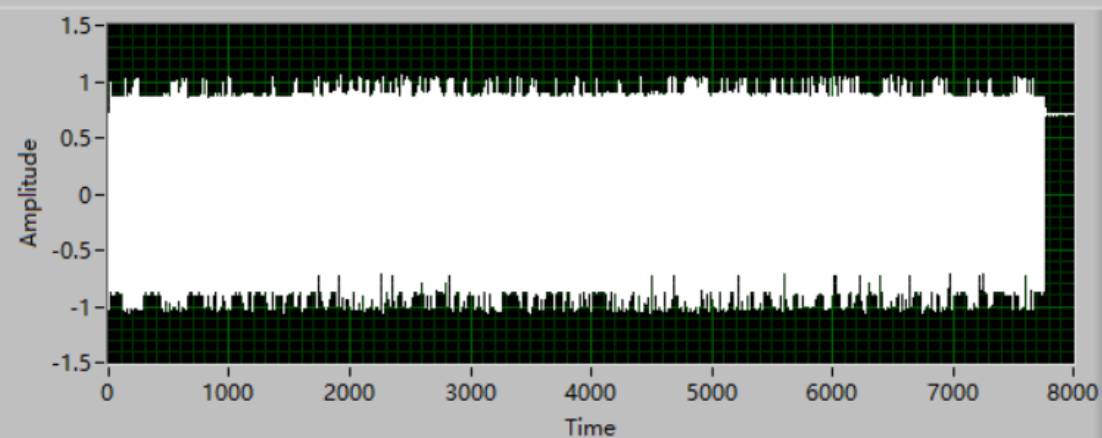
Transmitted Image



Recovered Image



Baseband Waveform



Plot 0



M-PSK (4)

4

sync found index

8.0000

Eb/N0 (dB)



Measurements

frequency offset (Hz)

0.00

frequency drift (Hz)

-0.00

phase offset

-0.00

Input Bitstream

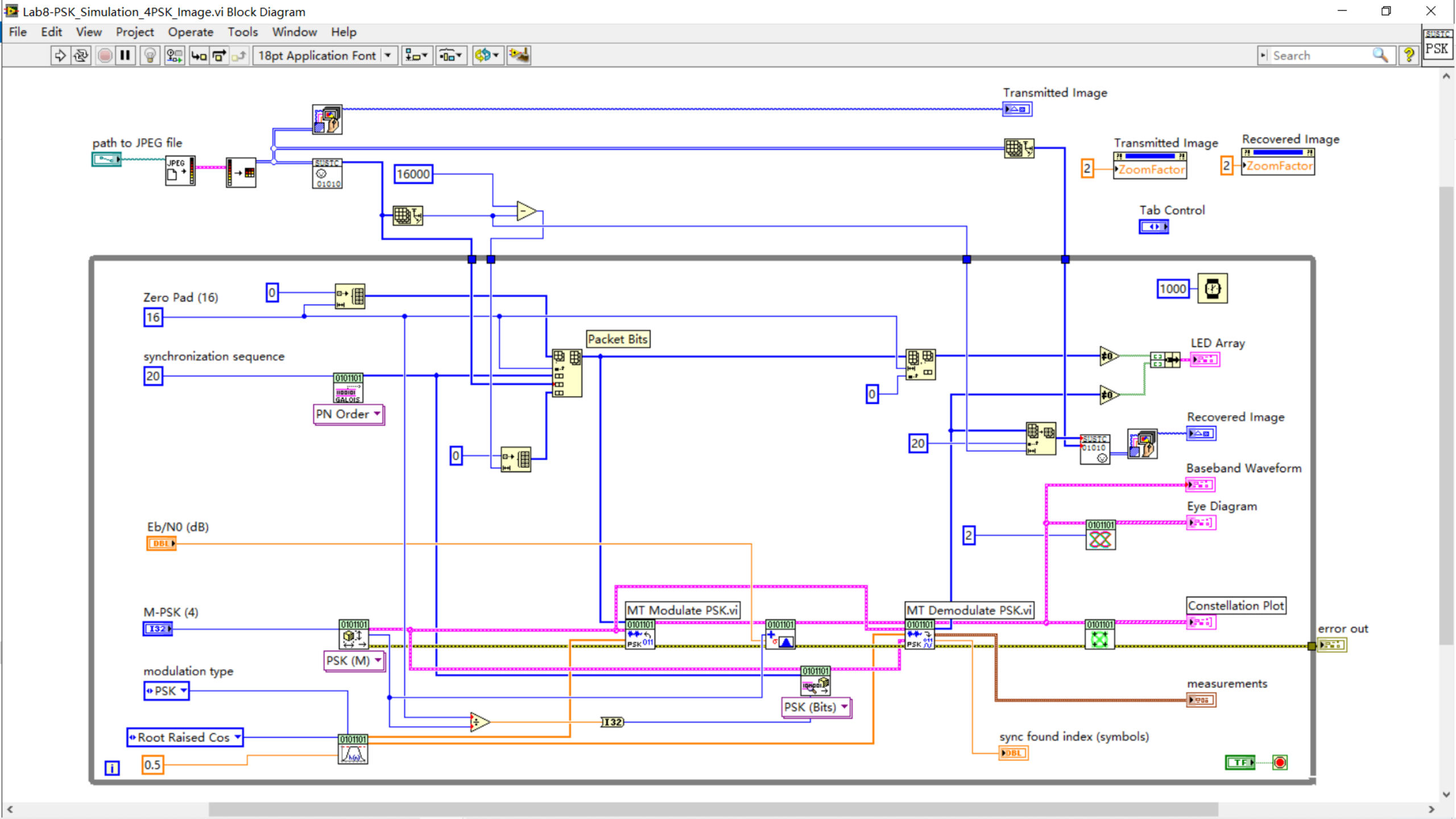
0



Output Bitstream

0



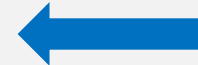
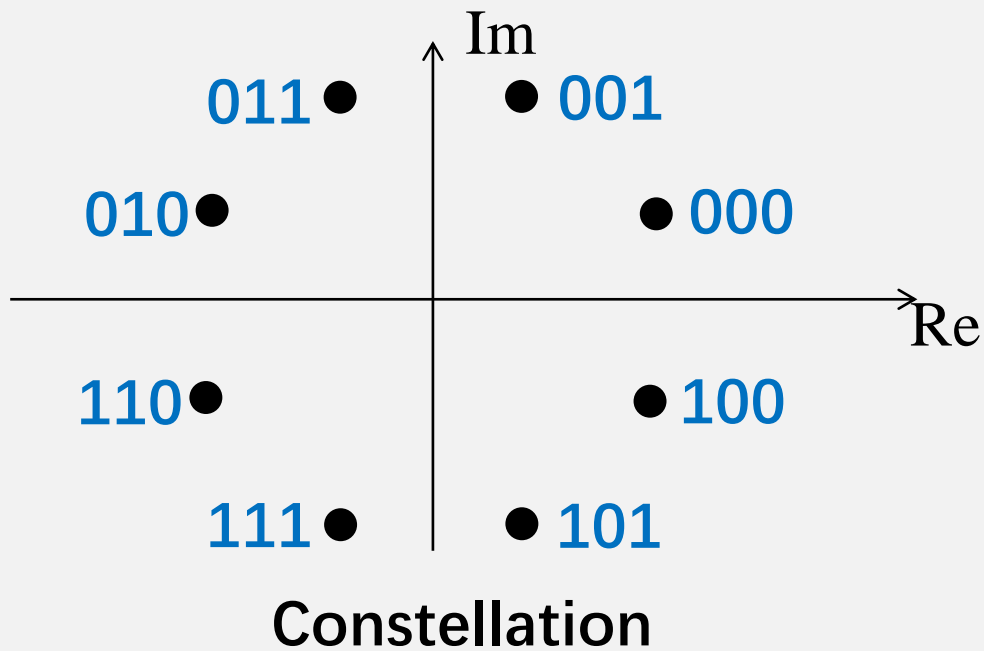




## Demo: 8/16-PSK Simulation

$$s_{RF0}(t) = \frac{\sqrt{2+\sqrt{2}}}{2} \cos\left(2\pi f_c t + \frac{\pi}{8}\right) = I \cdot \cos(2\pi f_c t) - Q \cdot \sin(2\pi f_c t)$$

$I + Qj$



8-PSK	
bits	Symbols
000	$\frac{\sqrt{2+\sqrt{2}}}{2} + \frac{\sqrt{2-\sqrt{2}}}{2} j$
001	$\frac{\sqrt{2-\sqrt{2}}}{2} + \frac{\sqrt{2+\sqrt{2}}}{2} j$
...	...
111	$-\frac{\sqrt{2-\sqrt{2}}}{2} - \frac{\sqrt{2+\sqrt{2}}}{2} j$



# M-PSK Simulation

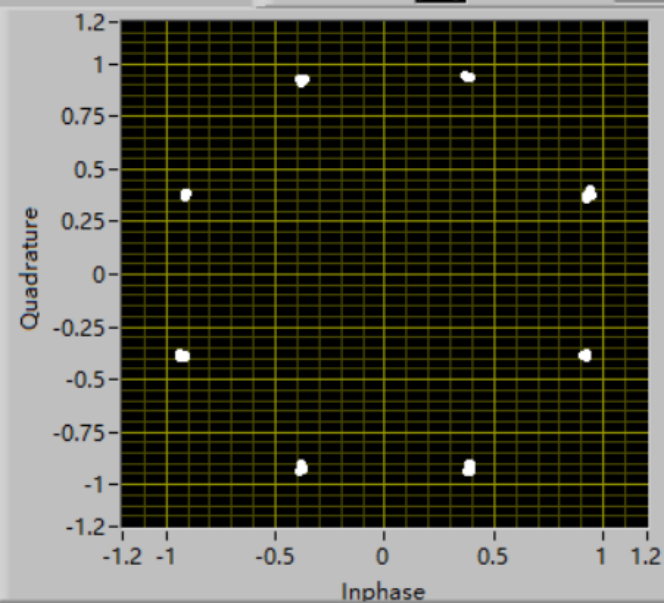
Constellation

Eye Diagram

Constellation Plot

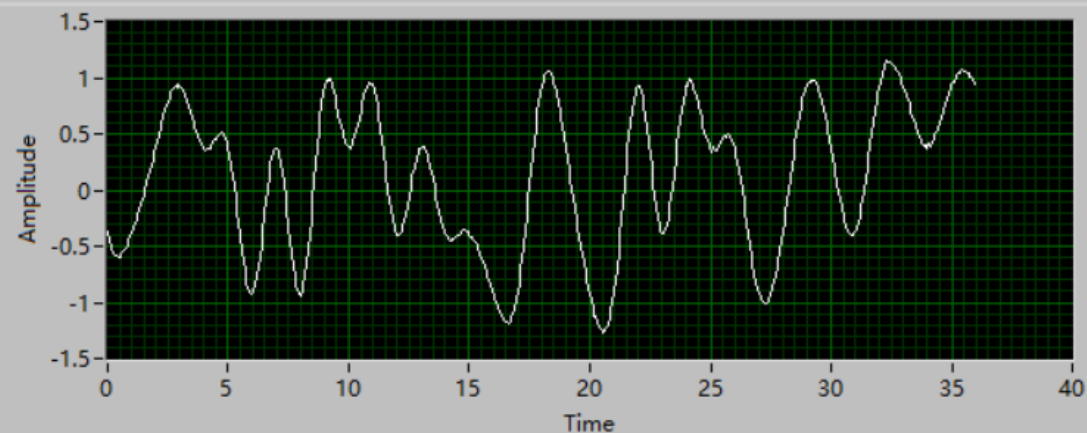
Constellation

Transitions



Baseband Waveform

Plot 0



M-PSK (4) Message Bits

8

100

Eb/N0 (dB)



Measurements

frequency offset (Hz)

-0.00

frequency drift (Hz)

-0.00

phase offset

0.40

Input Bitstream

0

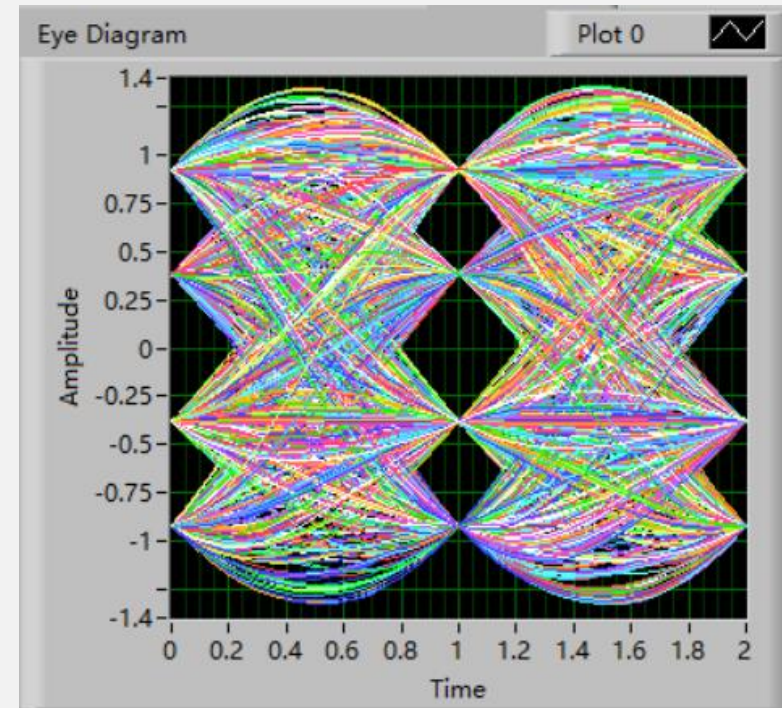
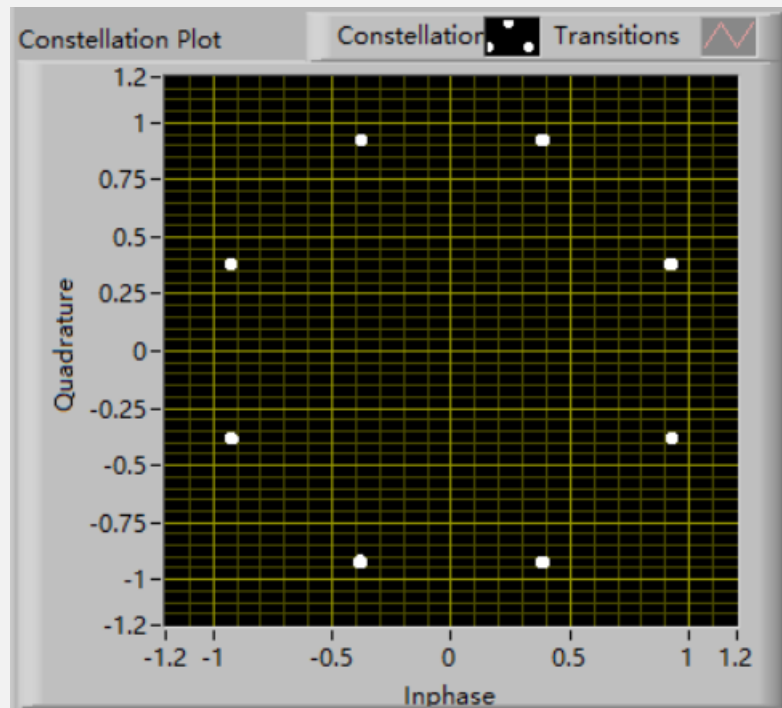


Output Bitstream

0









# M-PSK Simulation

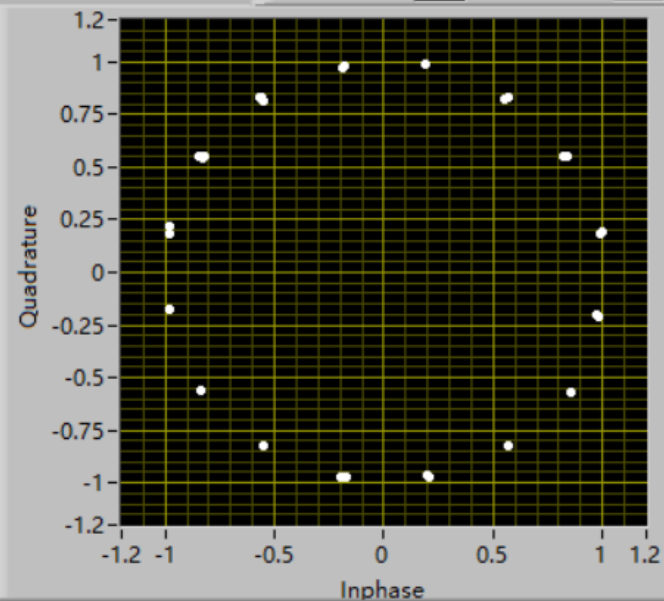
Constellation

Eye Diagram

Constellation Plot

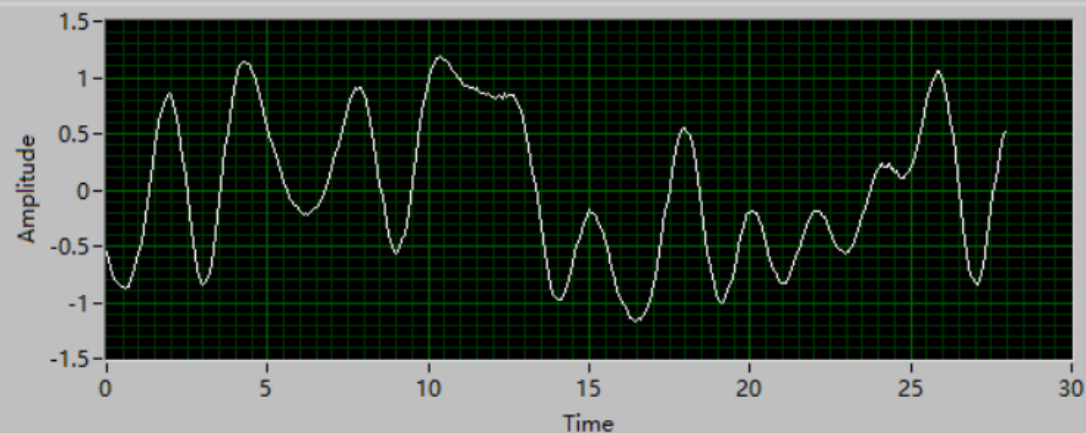
Constellation

Transitions



Baseband Waveform

Plot 0



M-PSK (4) Message Bits

16

100

Eb/N0 (dB)



Measurements

frequency offset (Hz)

-0.00

frequency drift (Hz)

0.00

phase offset

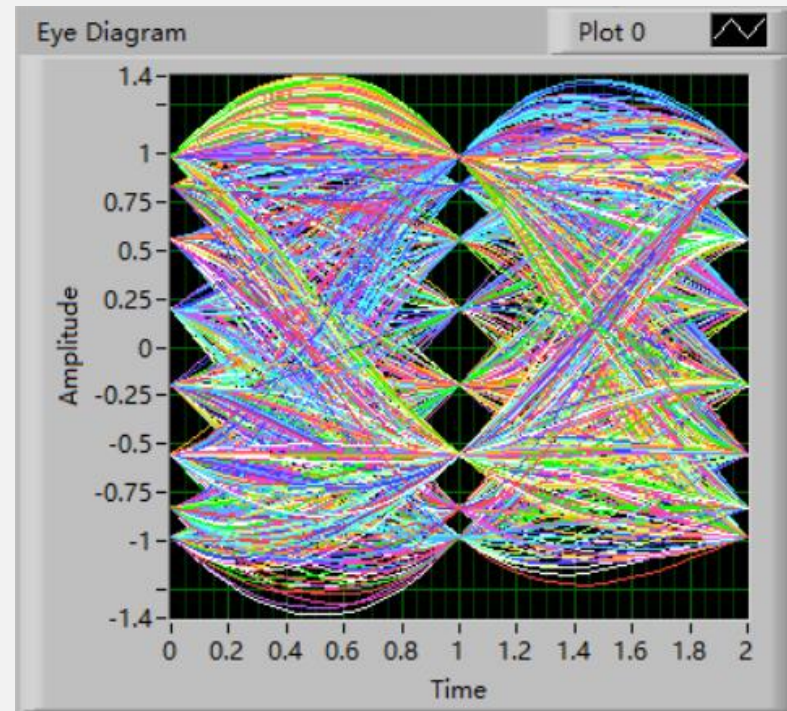
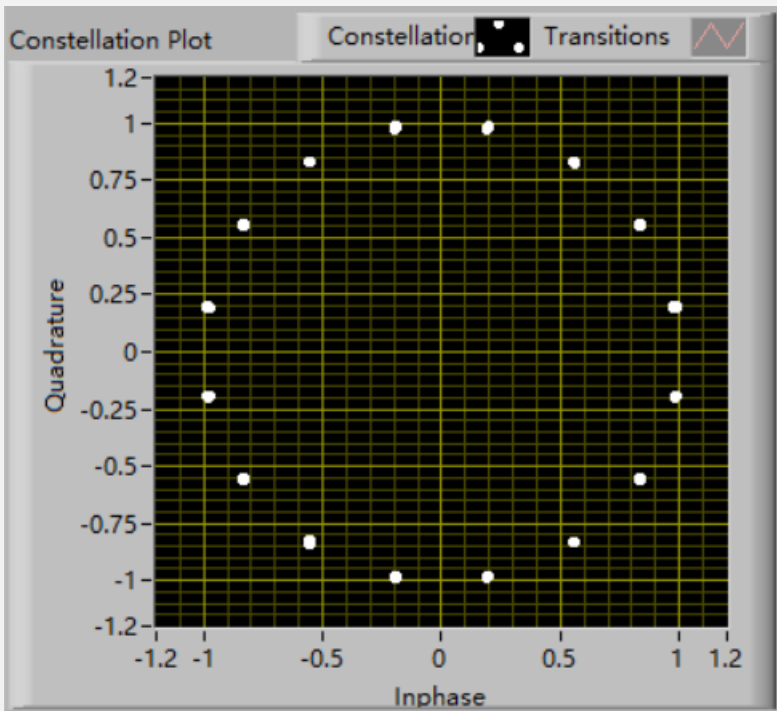
0.22

Input Bitstream



Output Bitstream







# M-PSK Simulation

path to JPEG file

% D:\...字调相系统 (1 Weeks) \smiley\_tiny(recomended).jpg

Image Recover

Constellation

Eye Diagram

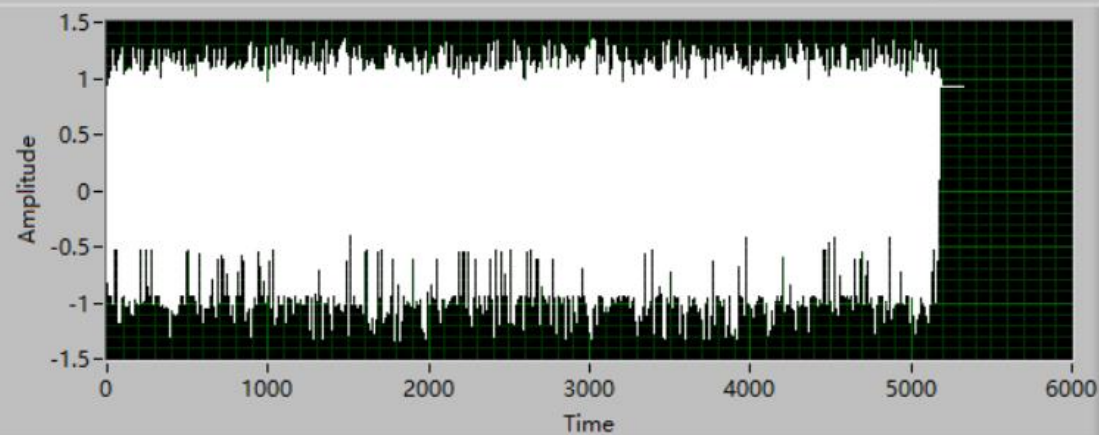
Transmitted Image



Recovered Image



Baseband Waveform



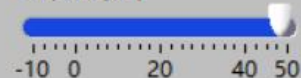
M-PSK (4)

sync found index

8

6.0000

Eb/N0 (dB)



Measurements

frequency offset (Hz)

0.00

frequency drift (Hz)

0.00

phase offset

0.00

Input Bitstream

0



Output Bitstream

0





# M-PSK Simulation

path to JPEG file

D:\...字调相系统 (1 Weeks) \smiley\_tiny(recomended).jpg

Image Recover

Constellation

Eye Diagram

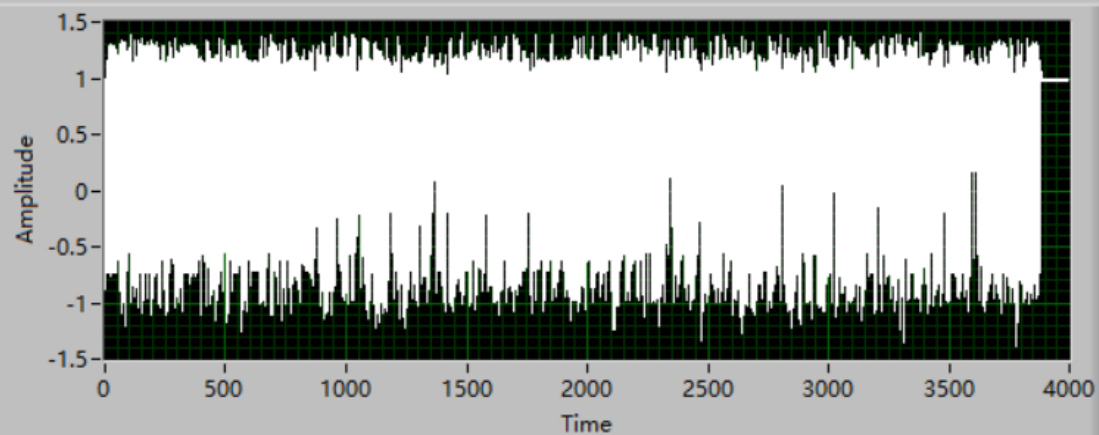
Transmitted Image



Recovered Image



Baseband Waveform



Plot 0



M-PSK (4)

sync found index

16

4.0000

Eb/N0 (dB)



Measurements

frequency offset (Hz)

0.00

frequency drift (Hz)

-0.00

phase offset

-0.00

Input Bitstream



Output Bitstream





$$\varepsilon_s = E [|I_k|^2] = \sum_{k=1}^M \frac{|I_k|^2}{M} = 1$$



$$E_b/N_0 = \frac{\varepsilon_b}{N_0} = \frac{\varepsilon_s}{\log_2(M) \cdot N_0}$$

$$N_A = \sqrt{\frac{N_0}{2}} = \frac{\sqrt{\varepsilon_s}}{\sqrt{2 \cdot \log_2(M) \cdot 10^{\frac{E_b/N_0(dB)}{10}}}}$$





# M-PSK Simulation

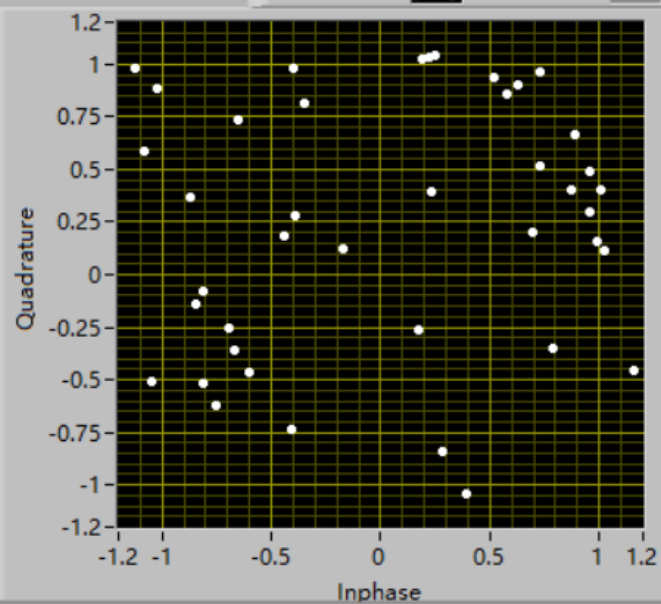
Constellation

Eye Diagram

Constellation Plot

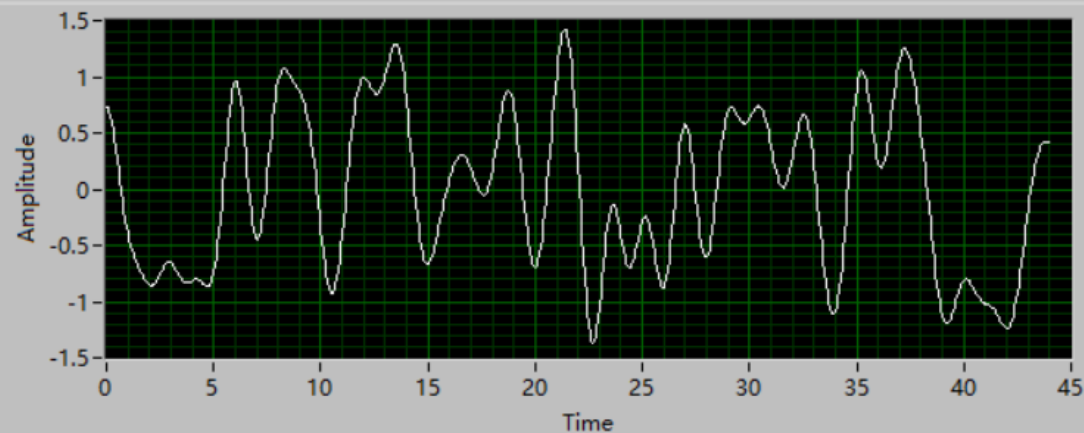
Constellation

Transitions



Baseband Waveform

Plot 0

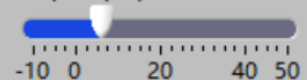


M-PSK (4) Message Bits

4

100

$E_b/N_0$  (dB)



Measurements

frequency offset (Hz)

-0.18

frequency drift (Hz)

0.00

phase offset

-5.75

Input Bitstream

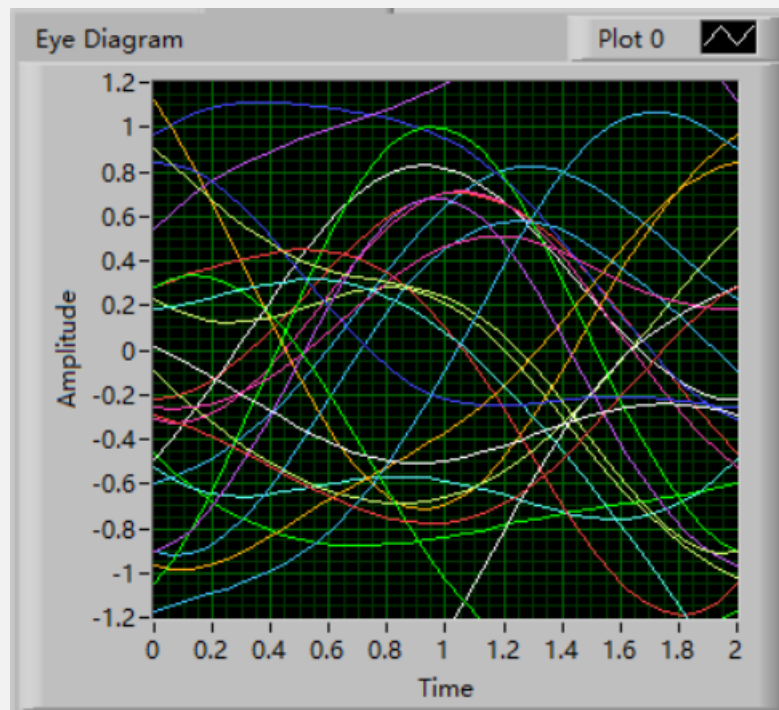
0



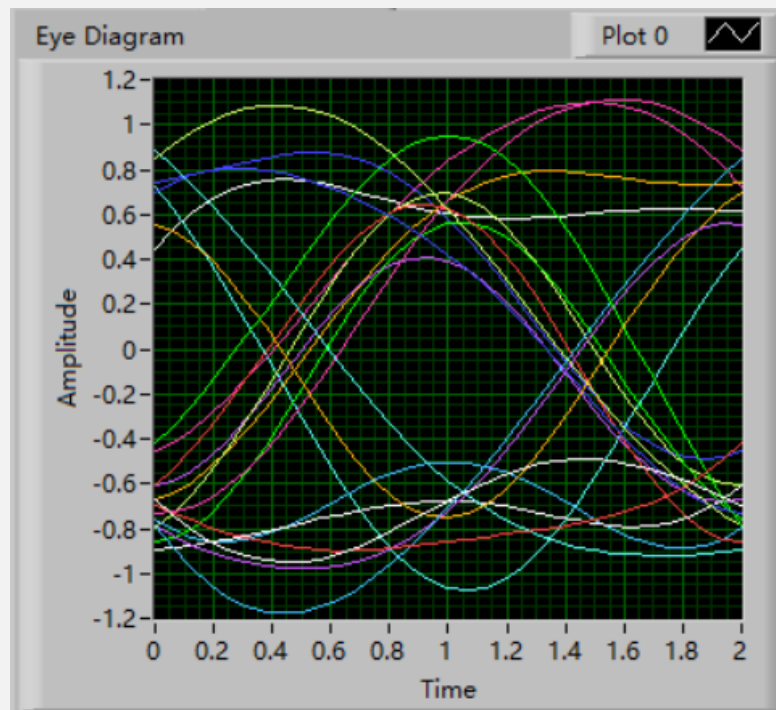
Output Bitstream

0

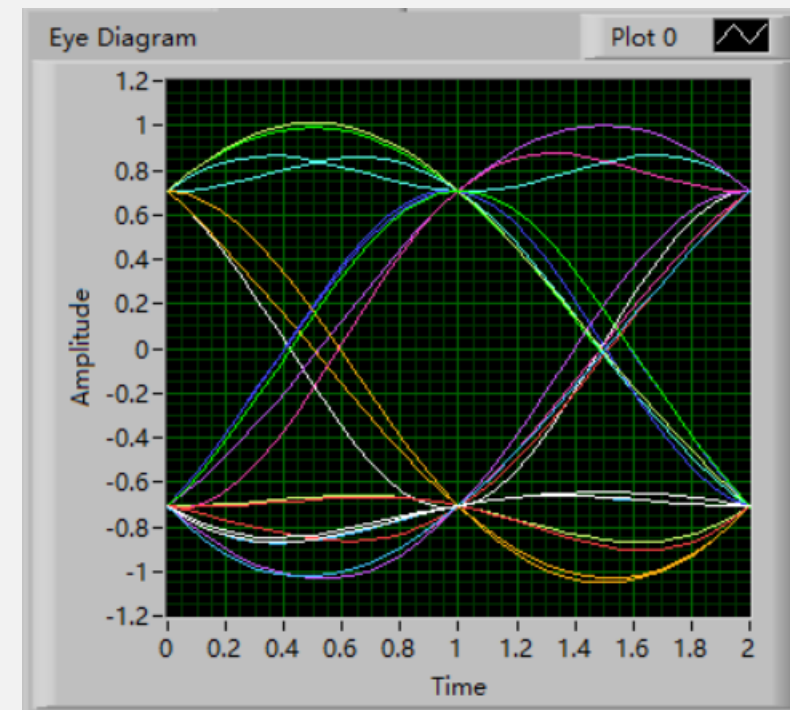




$E_b/N_0 = 0\text{dB}$

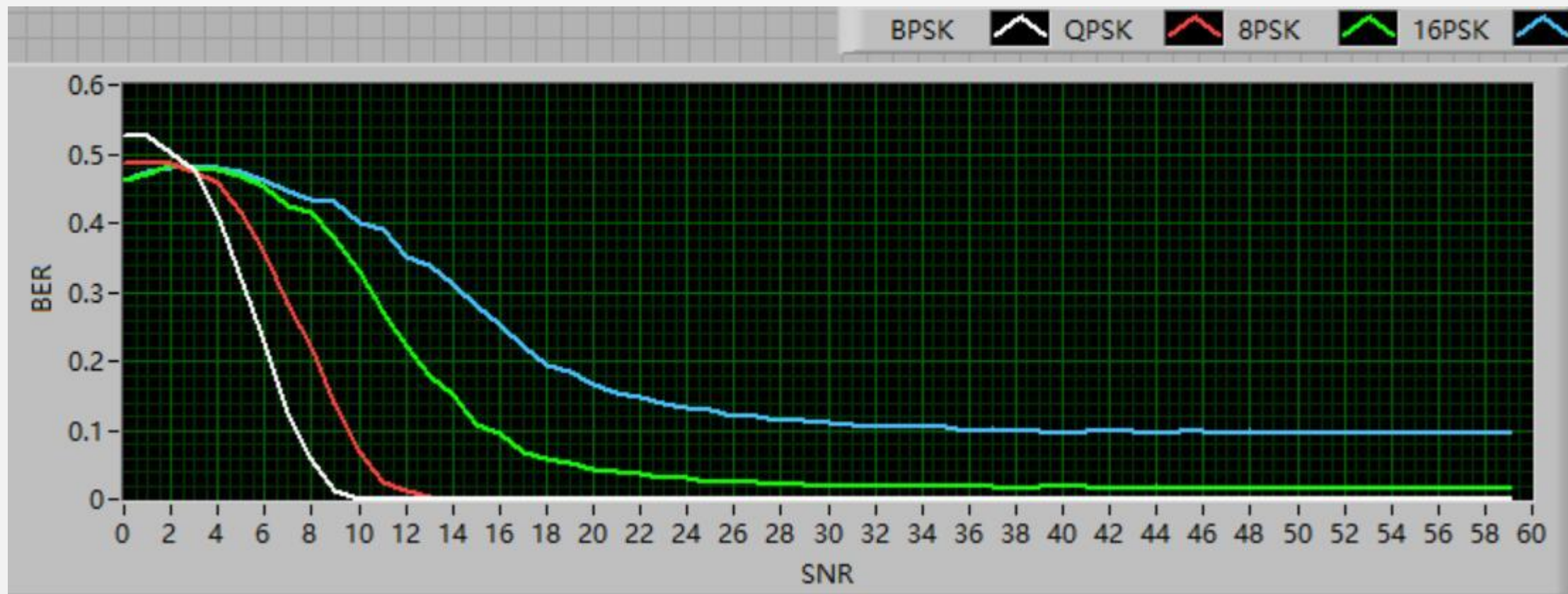


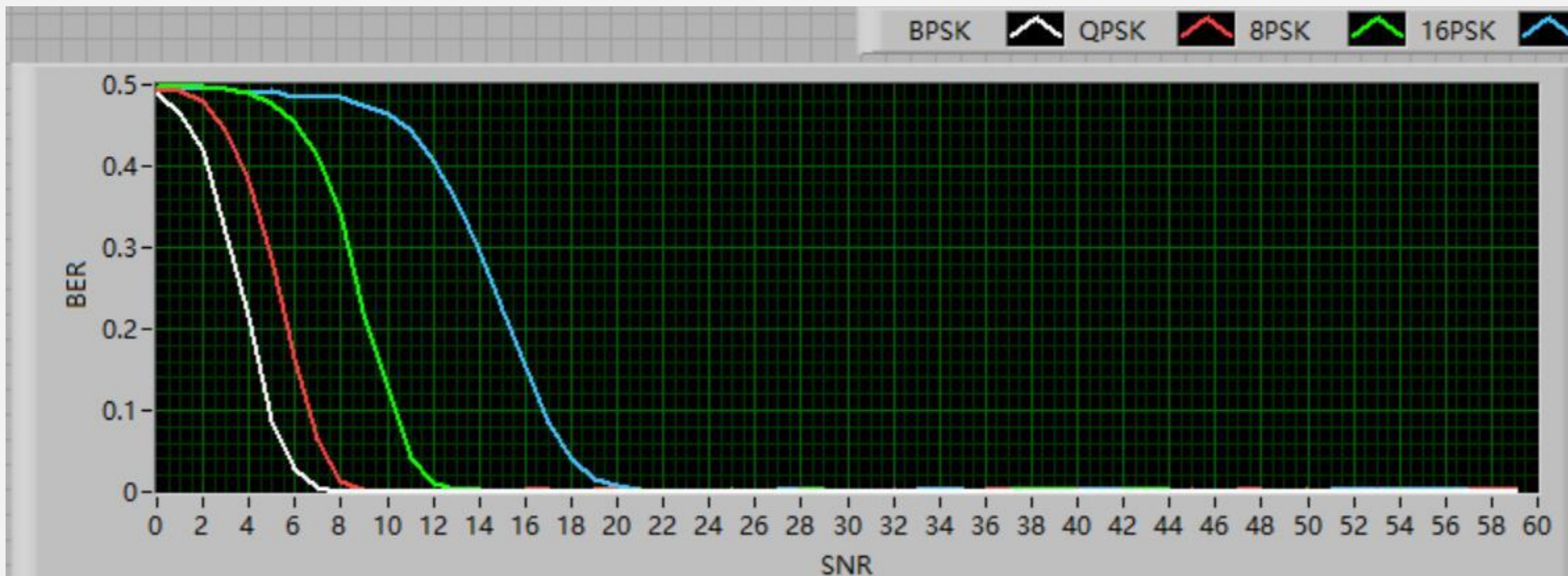
$E_b/N_0 = 10\text{dB}$



$E_b/N_0 = 50\text{dB}$









- Question ?

