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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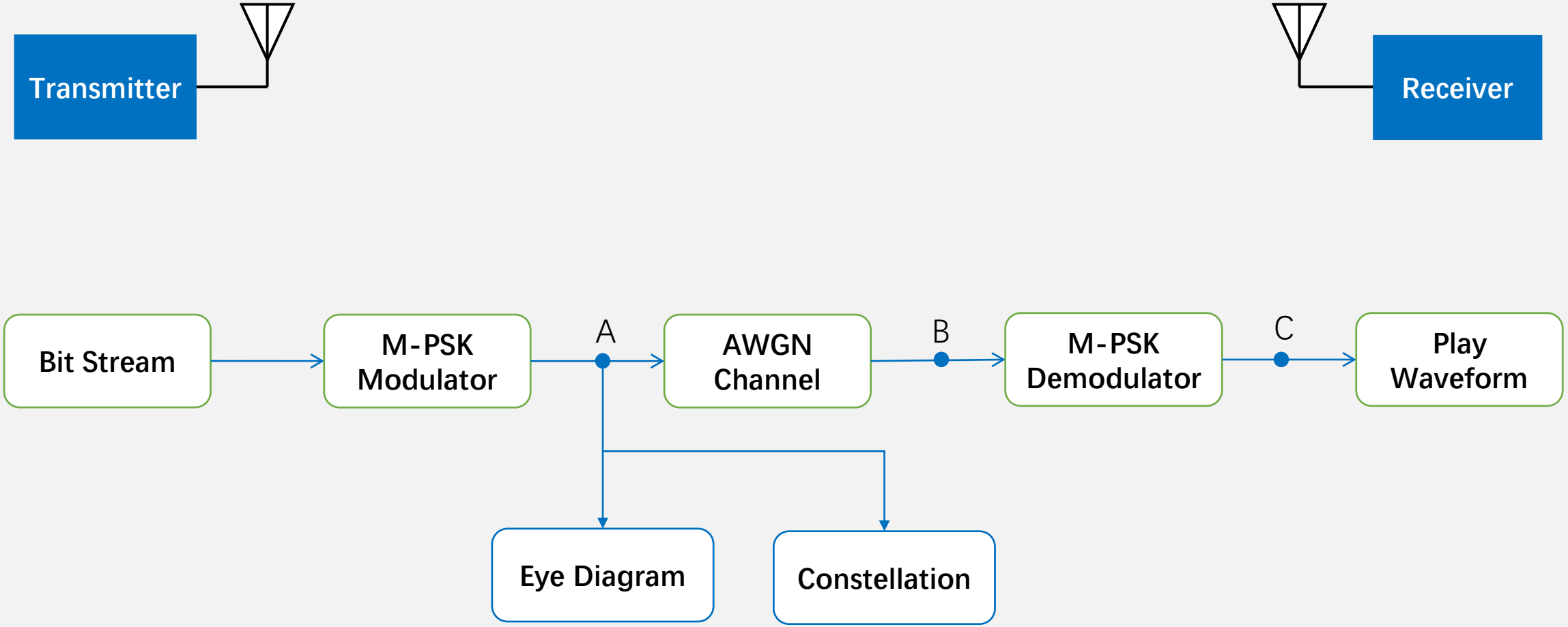
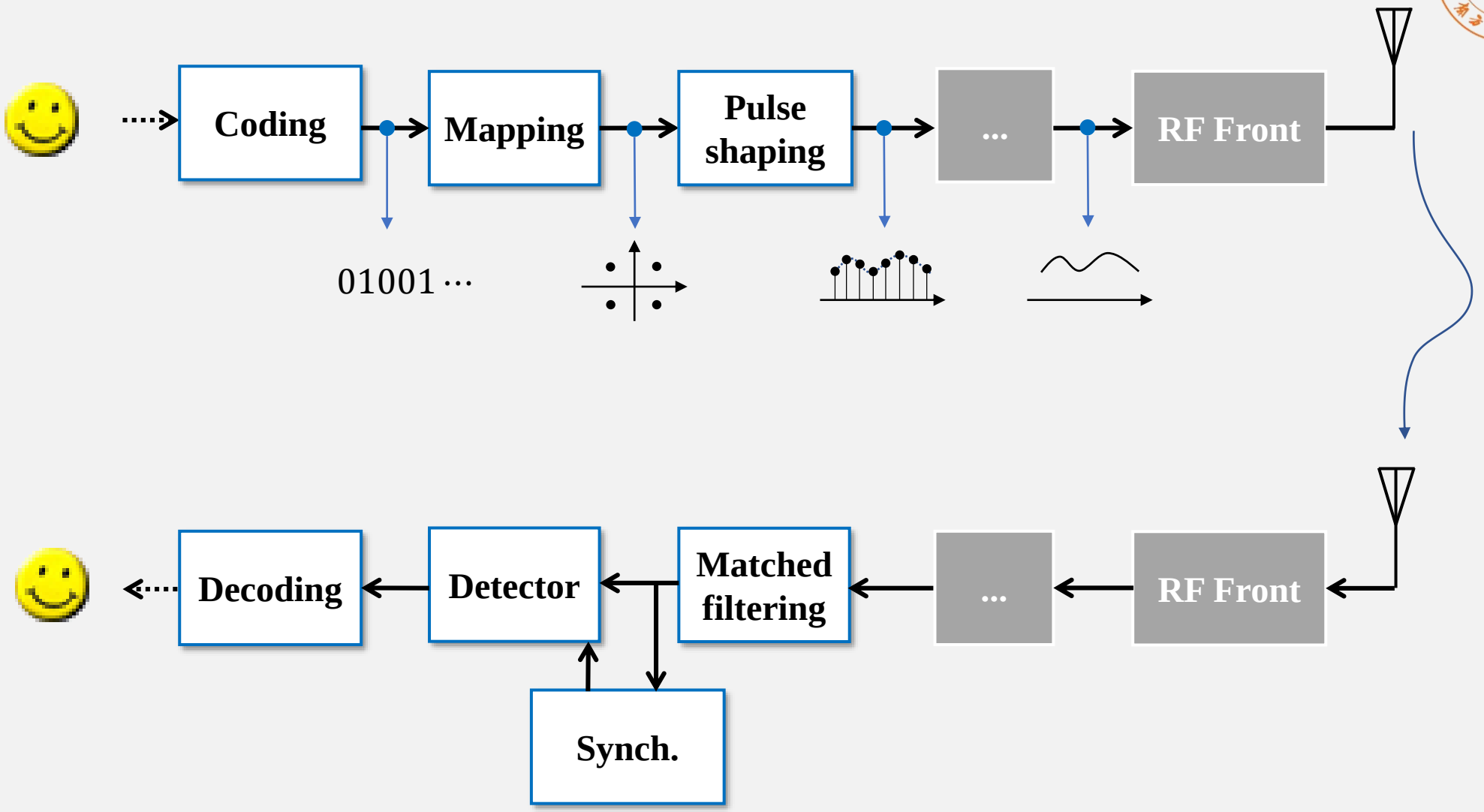
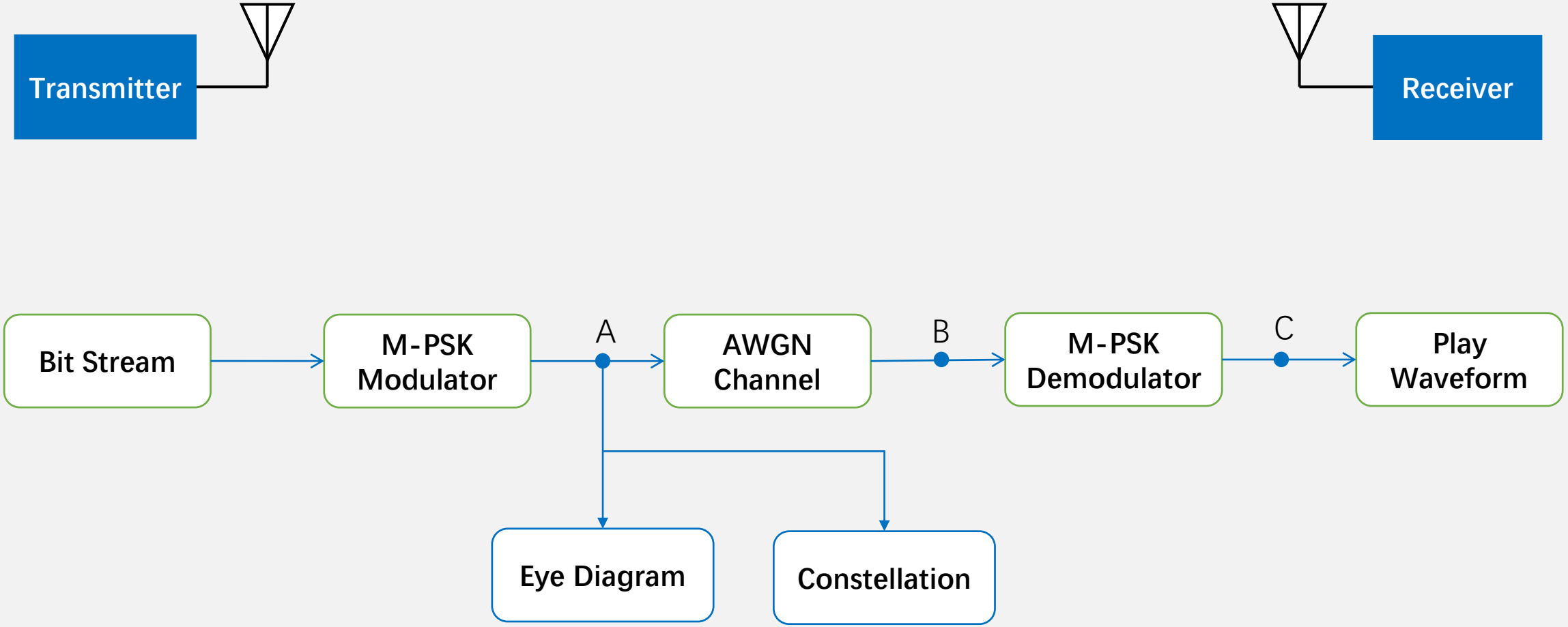
Lab 8: Phase Shift Keying

1. Band-Pass Transmission System
2. BPSK/QPSK Simulation
3. BPSK/QPSK Image Transmission
4. 8-PSK/16-PSK Image Transmission


Transmitter
Receiver
Bit Stream
M-PSK Modulator
A
AWGN Channel
B
M-PSK Demodulator
C
Play Waveform
Eye Diagram
Constellation

Demo: M-PSK Image Transmission


Coding
Mapping
Pulse shaping
...
RF Front
01001…
Decoding
Detector
Matched filtering
...
RF Front
Synch.


Transmitter
Receiver
Bit Stream
M-PSK Modulator
A
AWGN Channel
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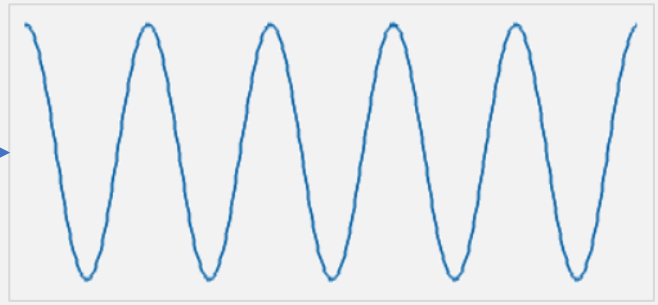
M-PSK Demodulator
C
Play Waveform
Eye Diagram
Constellation

BPSK

增加带宽提高系统传输性能 ← 1、传输效率
2、带宽问题：滚降因子→Max
拖尾衰减→Min

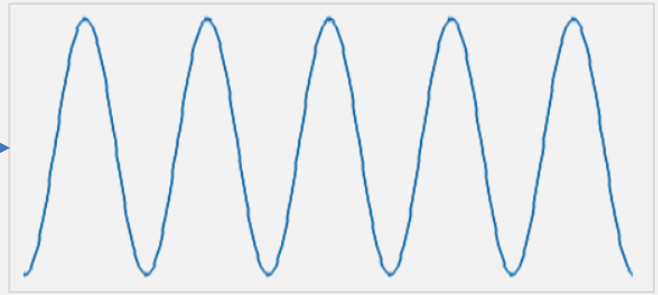
0 →



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

↓ 高频信号

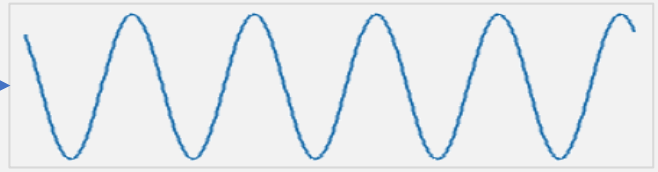
1 →



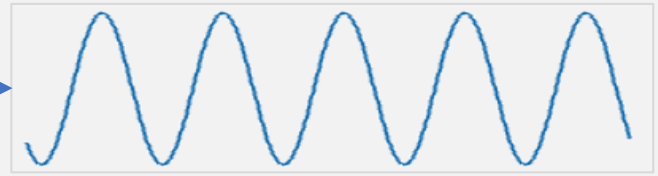
$$s_{RF1}(t) = cos(2\pi f_c t + \pi)$$

QPSK

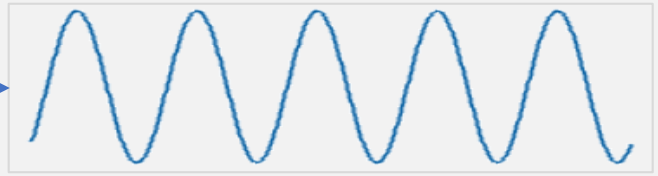
判断相位来判断bit

00 → 

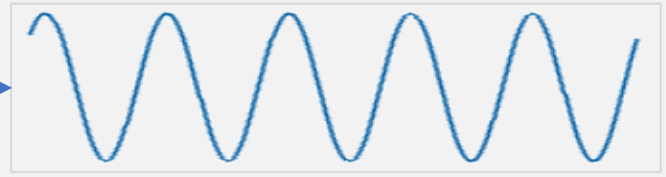
$$s_{RF0}(t) = \sqrt{2}cos(2\pi f_c t + \frac{\pi}{4})$$

01 → 

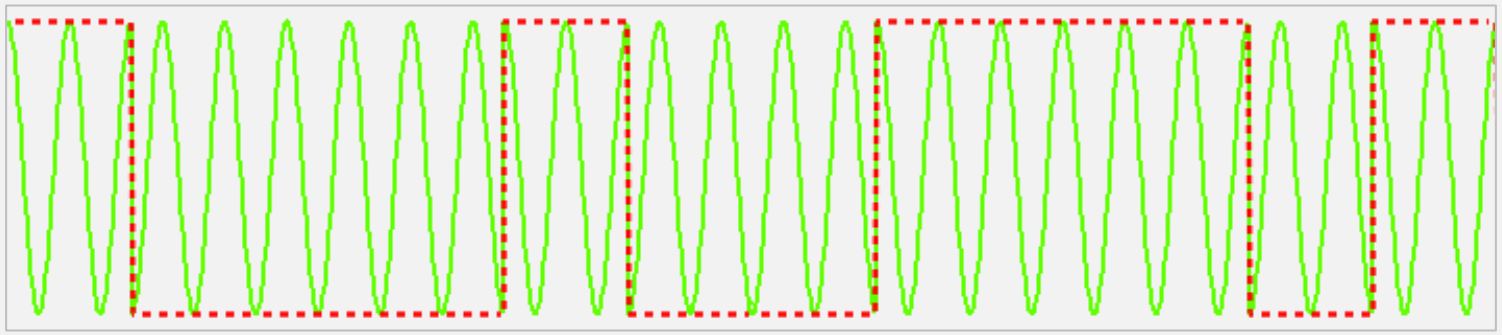
$$s_{RF1}(t) = \sqrt{2}cos(2\pi f_c t + \frac{3\pi}{4})$$

11 → 

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

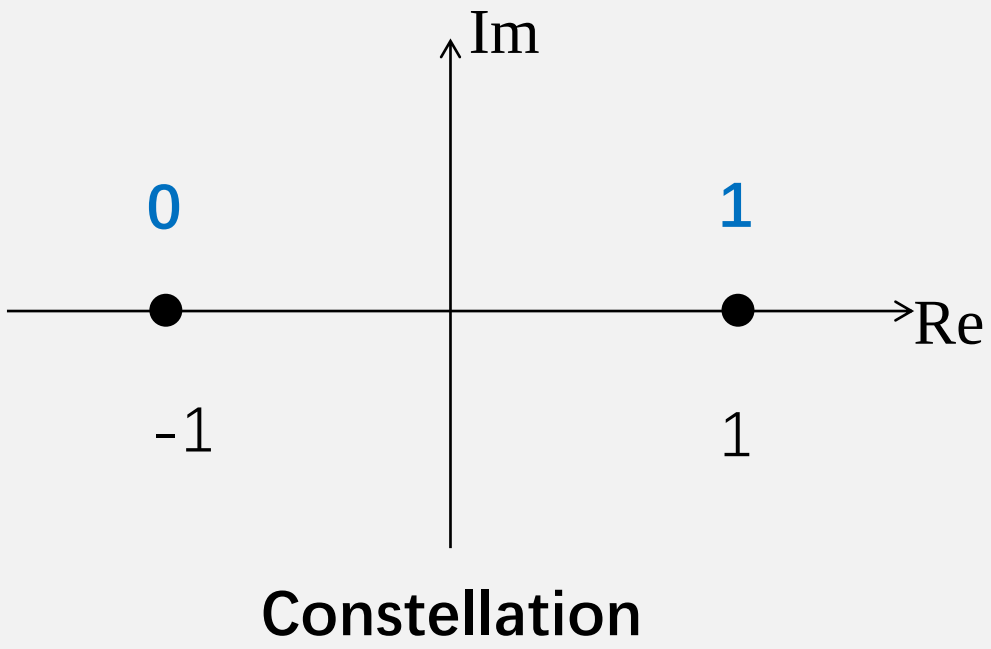
10 → 

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



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

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

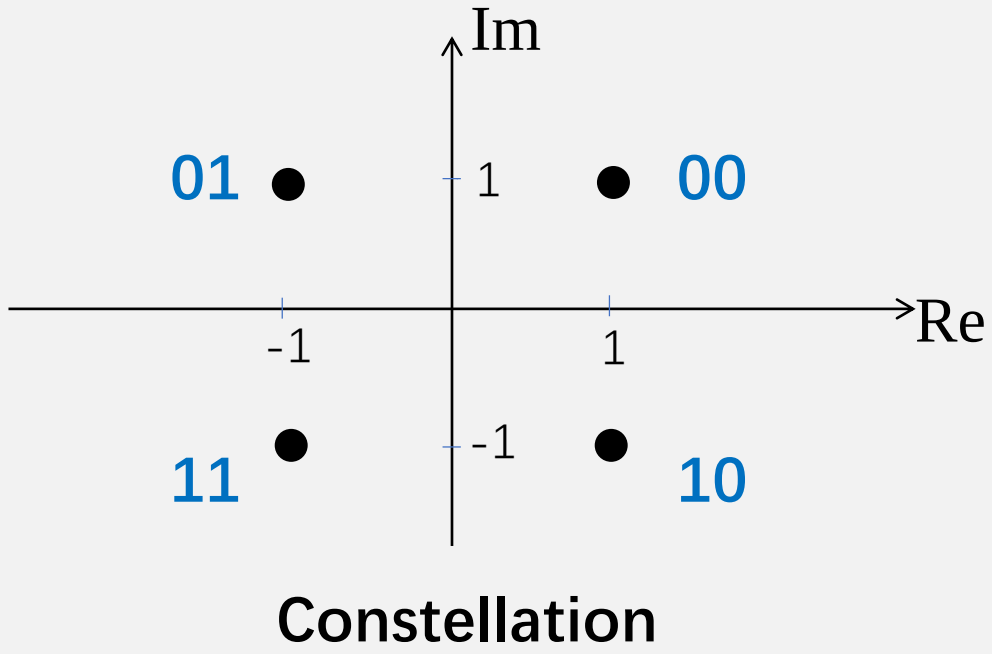


Constellation

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

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

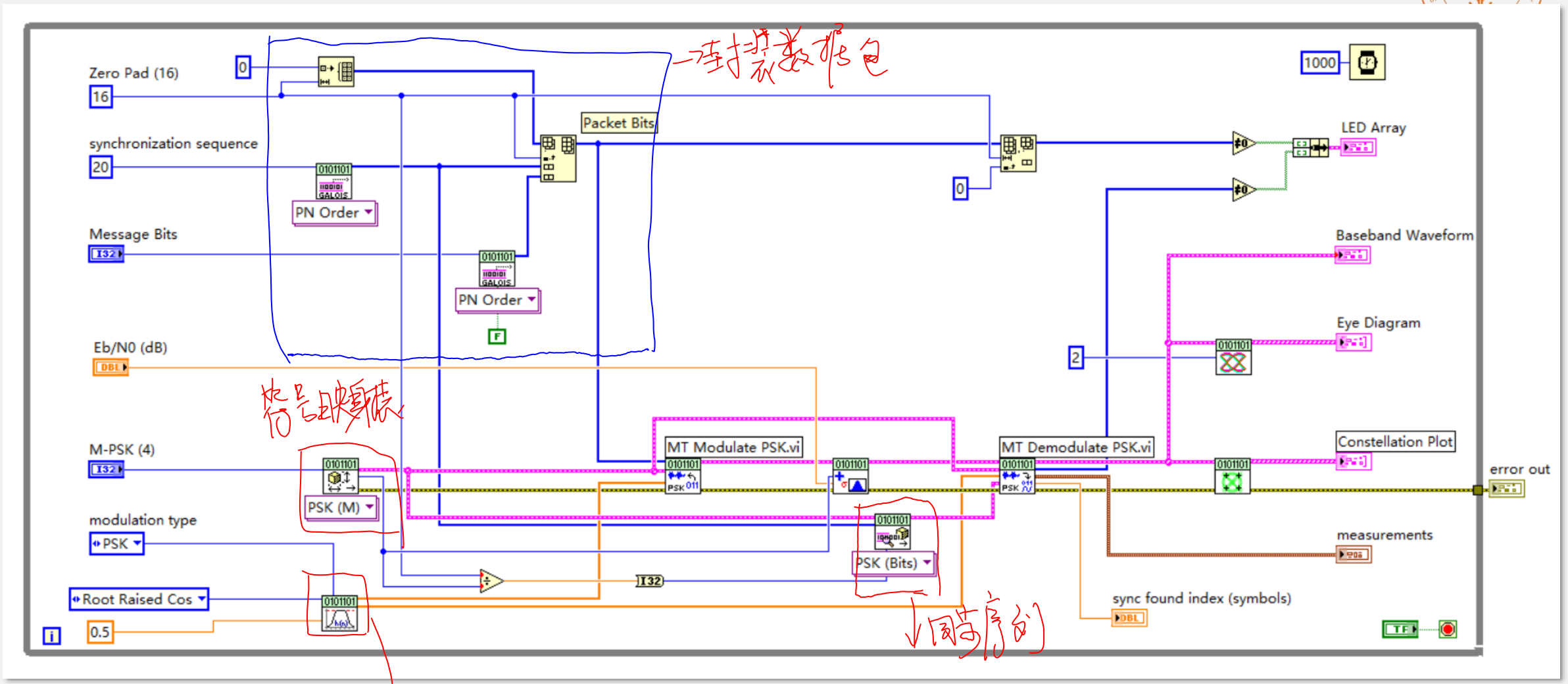
$\mathrm{I} + \mathrm{Qj}$

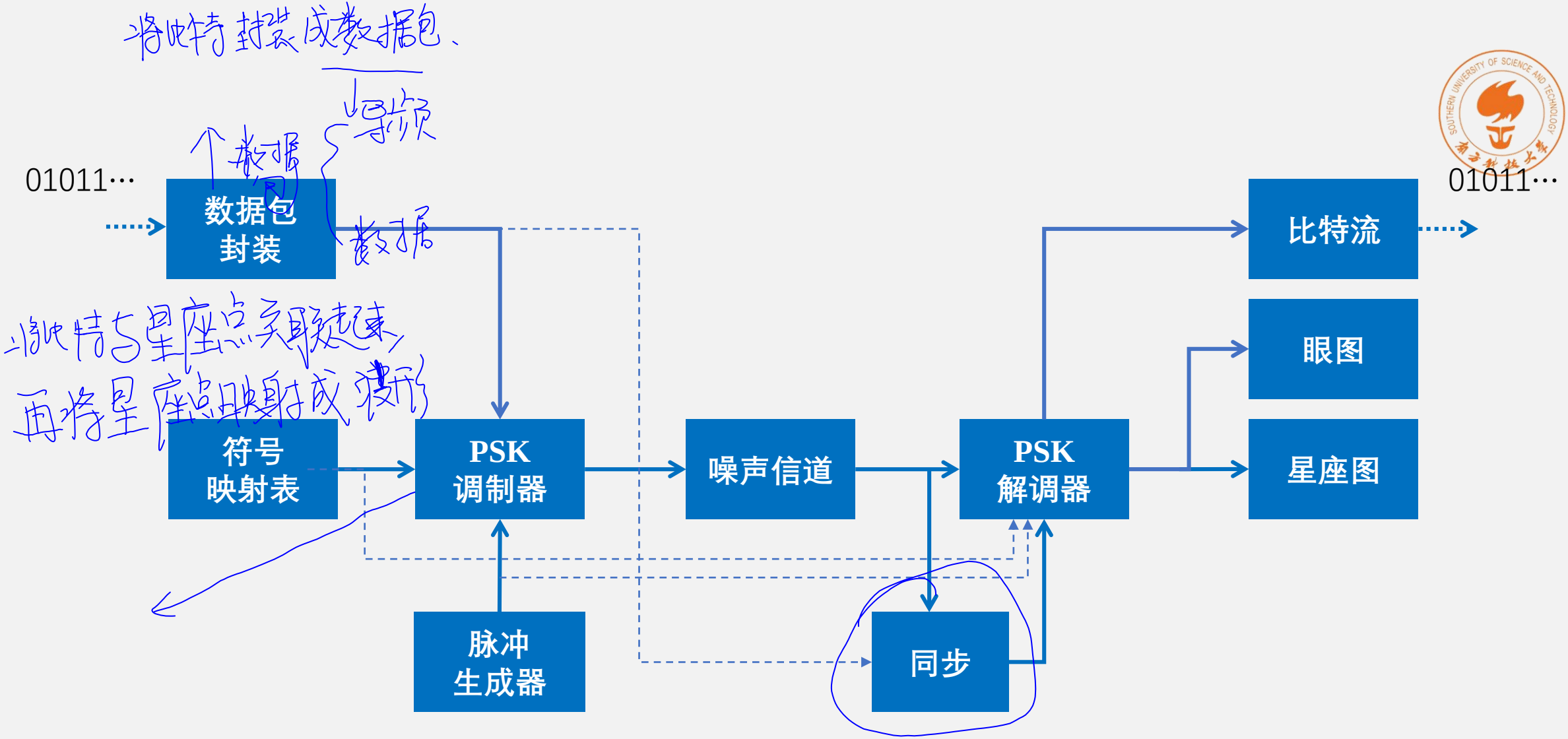


Constellation

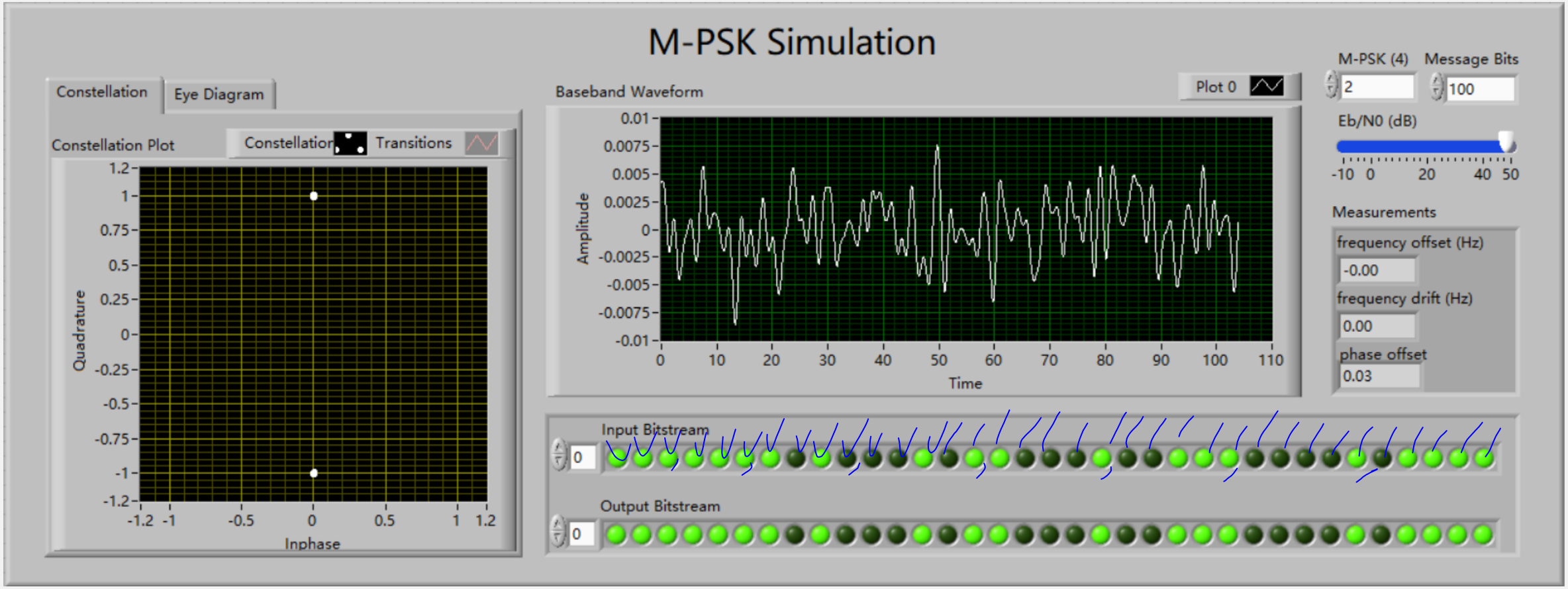
QPSK	
bits	**Symbols**
00	1+1j
01	-1+1j
11	-1-1j
10	-1+1j

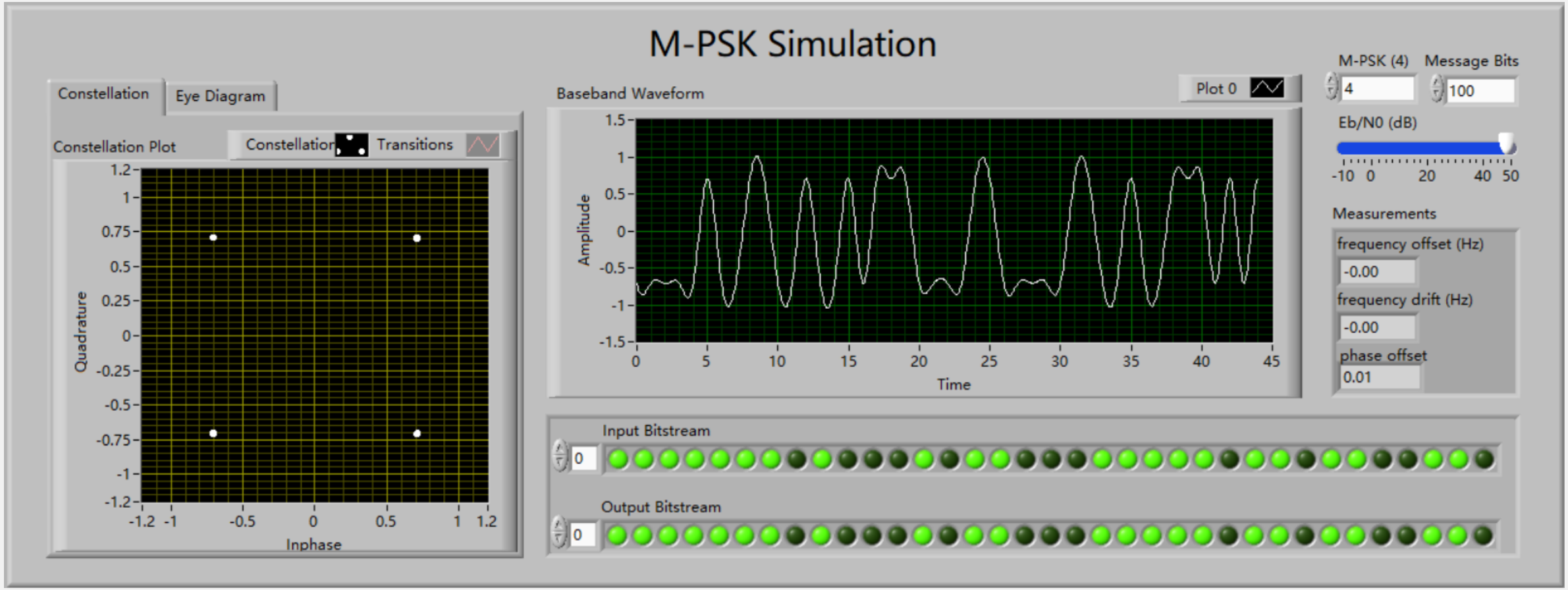
Demo: BPSK/QPSK Simulation


Zero Pad (16)
16
0
synchronization sequence
20
PN Order
Message Bits
I32
PN Order
F
Eb/N0 (dB)
DBL
M-PSK (4)
I32
PSK (M)
modulation type
PSK
Root Raised Cos
0.5
Packet Bits
MT Modulate PSK.vi
PSK (Bits)
I32
MT Demodulate PSK.vi
1000
LED Array
0
Baseband Waveform
2
Eye Diagram
Constellation Plot
error out
measurements
sync found index (symbols)
DBL
TF

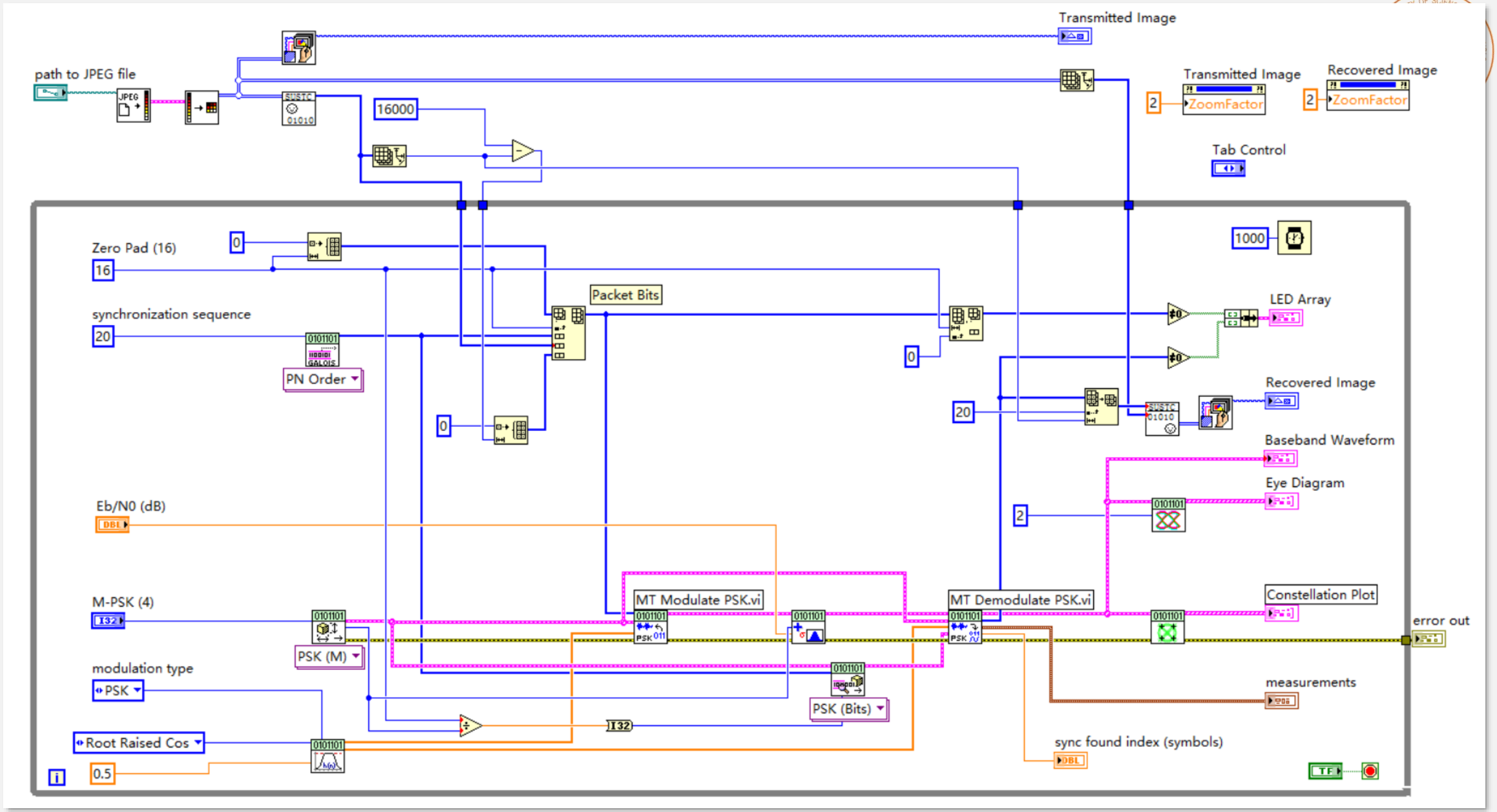

将比特封装成数据包
个数据
导频
数据
01011…
数据包
封装
比特流
01011…
将比特与星座点关联起来
再将星座点映射成波形
符号
映射表
PSK
调制器
噪声信道
PSK
解调器
眼图
星座图
脉冲
生成器
同步

M-PSK Simulation




M-PSK Simulation
Constellation
Eye Diagram
Constellation Plot
Constellation
Transitions
Quadrature
Inphase
Baseband Waveform
Plot 0
Amplitude
Time
M-PSK (4)
Message Bits
4
100
Eb/N0 (dB)
Measurements
frequency offset (Hz)
-0.00
frequency drift (Hz)
-0.00
phase offset
0.01
Input Bitstream
Output Bitstream

Demo: 2/4-PSK Image Transmission


Transmitted Image
path to JPEG file
JPEG
16000
Transmitted Image
Recovered Image
2
ZoomFactor
2
ZoomFactor
Tab Control
1000
Zero Pad (16)
0
16
synchronization sequence
20
PN Order
Packet Bits
0
0
LED Array
Recovered Image
20
Baseband Waveform
Eye Diagram
2
Eb/N0 (dB)
DBL
M-PSK (4)
I32
PSK (M)
MT Modulate PSK.vi
MT Demodulate PSK.vi
Constellation Plot
error out
modulation type
PSK
PSK (Bits)
measurements
I32
Root Raised Cos
0.5
sync found index (symbols)
DBL
TF

M-PSK Simulation

path to JPEG file

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

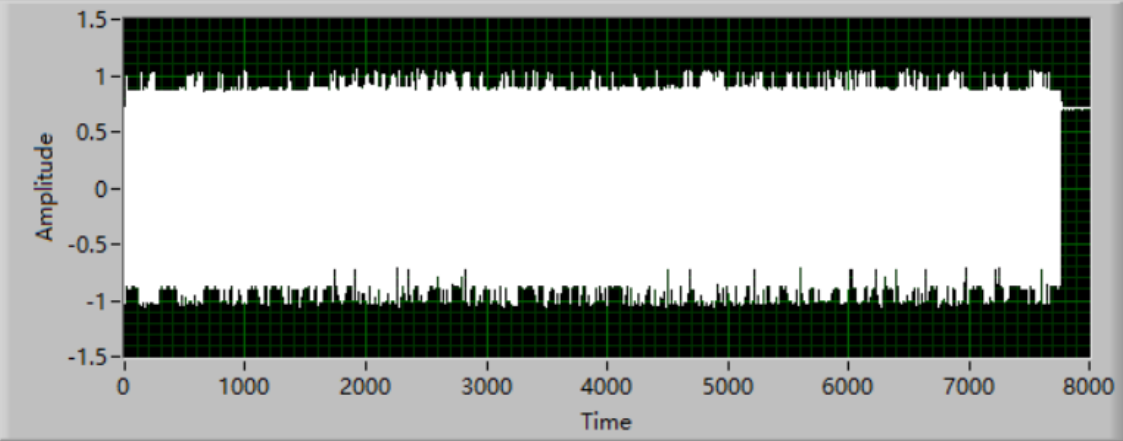
Image Recover | Constellation | Eye Diagram

Transmitted Image

Recovered Image

Baseband Waveform

Plot 0



M-PSK (4)

4

sync found index

8.0000

Eb/N0 (dB)

-10 0 20 40 50

Measurements

frequency offset (Hz)

0.00

frequency drift (Hz)

-0.00

phase offset

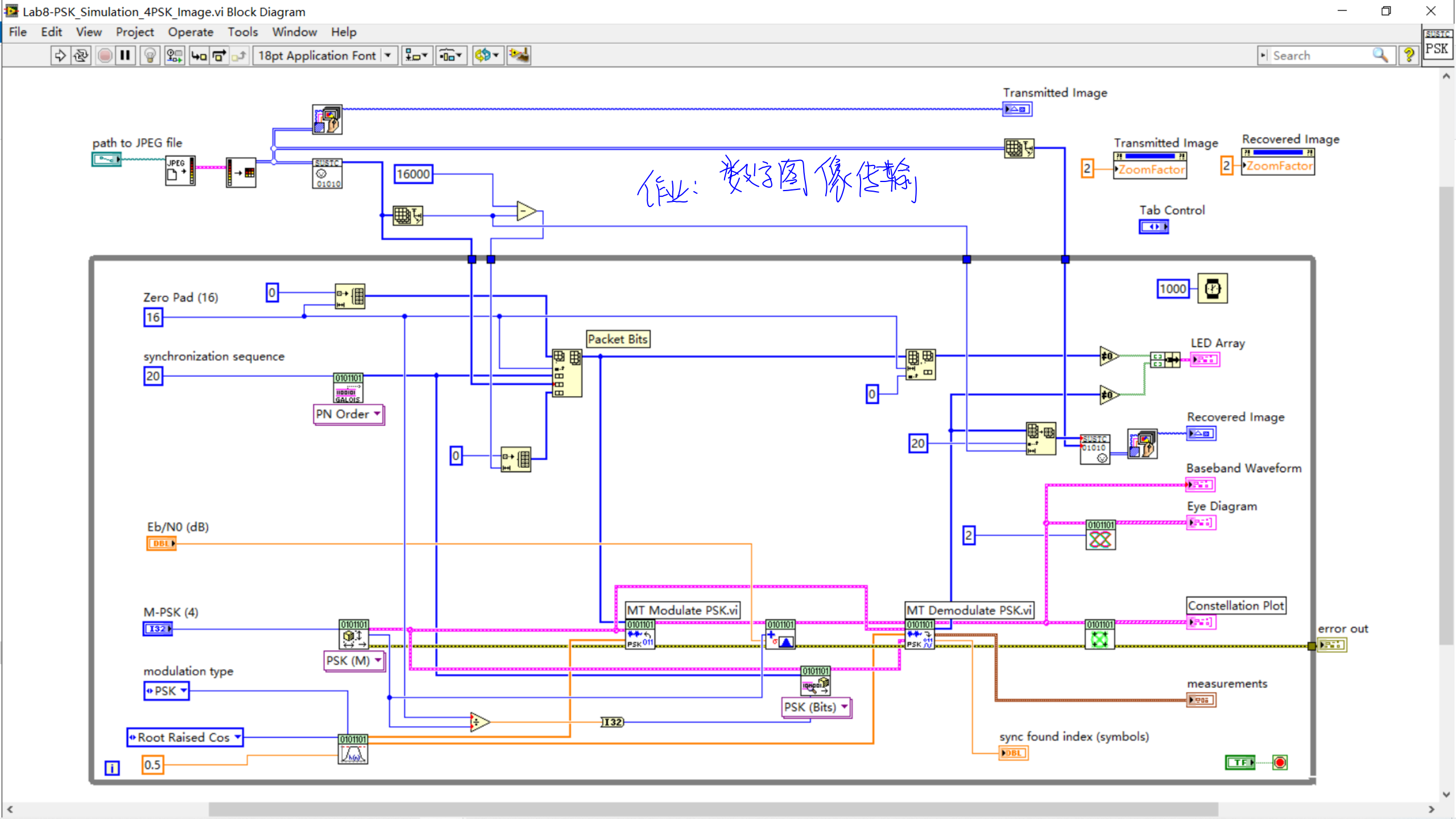
-0.00

Input Bitstream

0

Output Bitstream

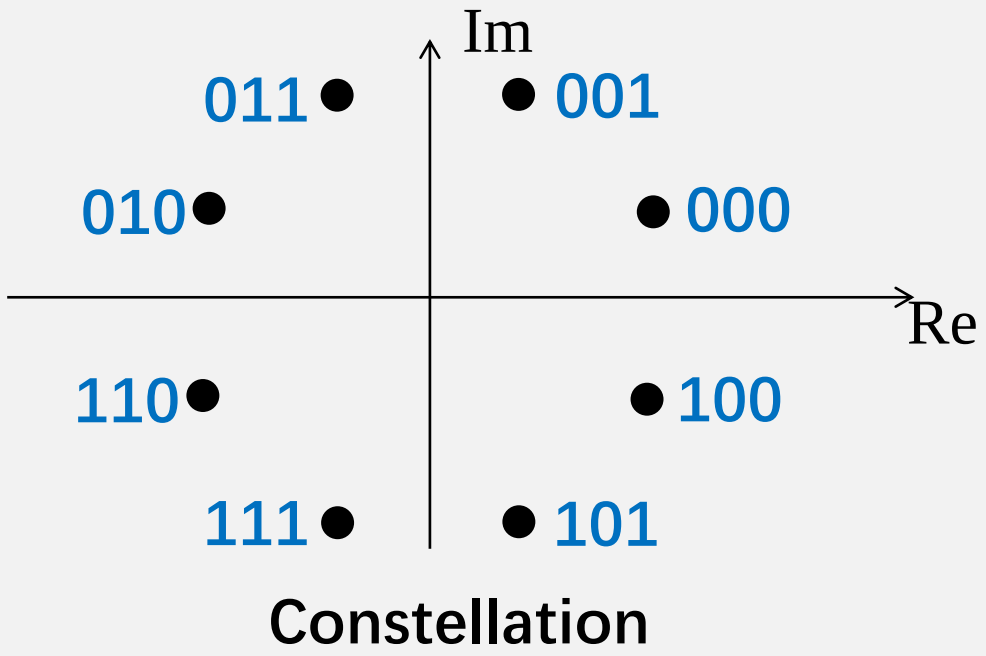
0


Lab8-PSK_Simulation_4PSK_Image.vi Block Diagram
File Edit View Project Operate Tools Window Help
18pt Application Font
Search
PSK
作业：数字图像传输
Transmitted Image
path to JPEG file
JPEG
16000
Transmitted Image
ZoomFactor
Recovered Image
ZoomFactor
Tab Control
Zero Pad (16)
16
synchronization sequence
20
PN Order
Packet Bits
1000
LED Array
Recovered Image
Baseband Waveform
Eye Diagram
Eb/N0 (dB)
DBL
M-PSK (4)
I32
PSK (M)
MT Modulate PSK.vi
MT Demodulate PSK.vi
Constellation Plot
error out
modulation type
PSK
PSK (Bits)
measurements
Root Raised Cos
0.5
sync found index (symbols)
TF

Demo: 8/16-PSK Simulation

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

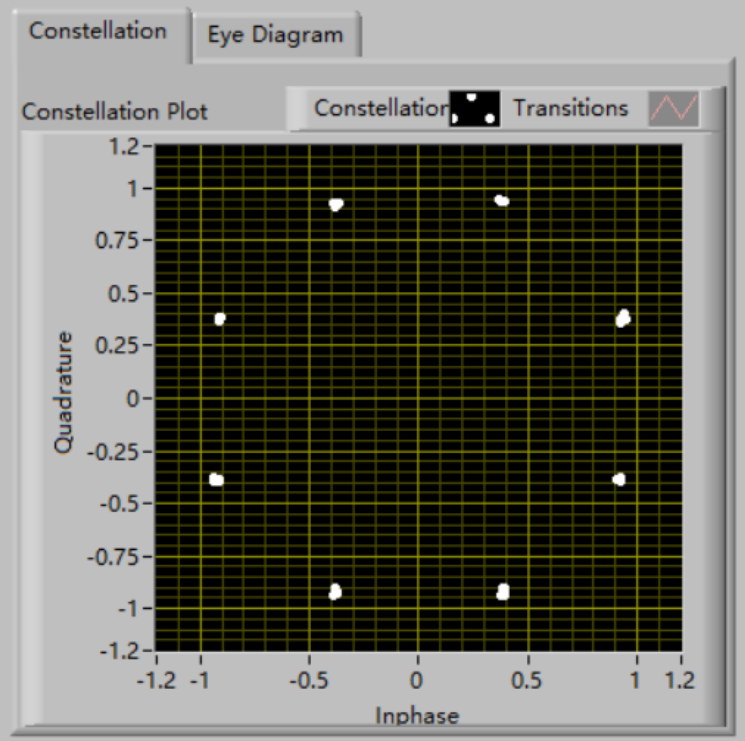
I + Qj

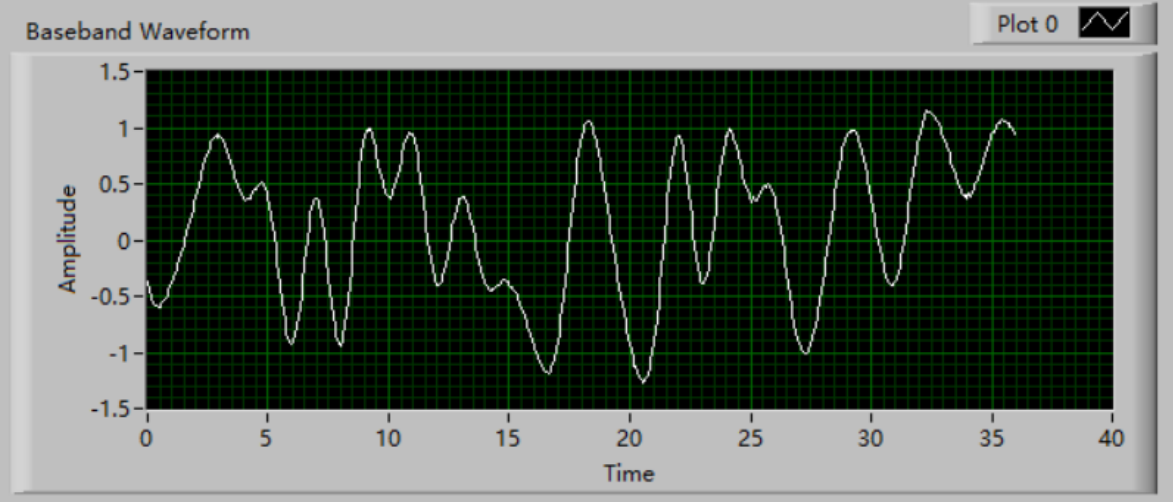


Constellation

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

M-PSK Simulation





M-PSK (4) 8

Message Bits 100

Eb/N0 (dB)

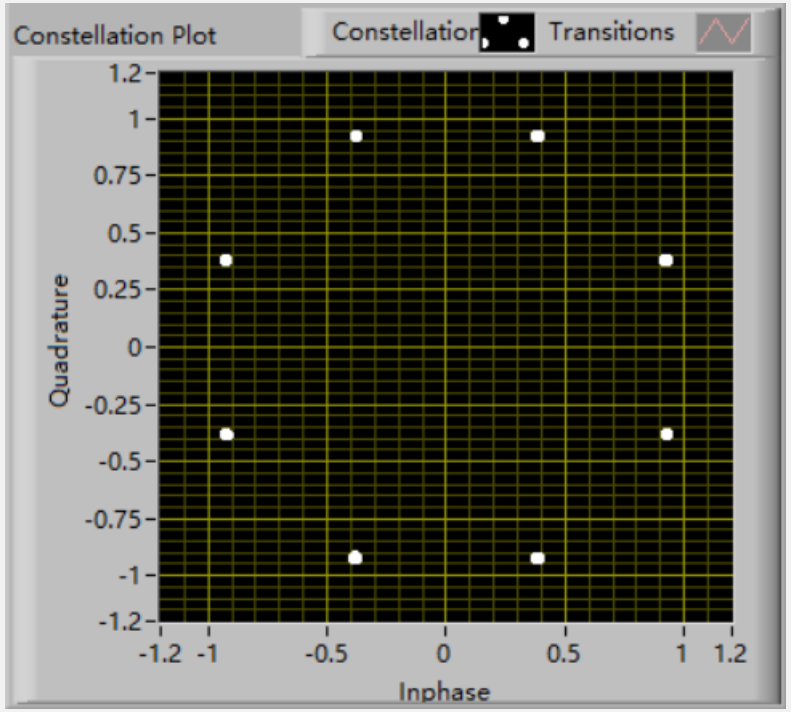
-10 0 20 40 50

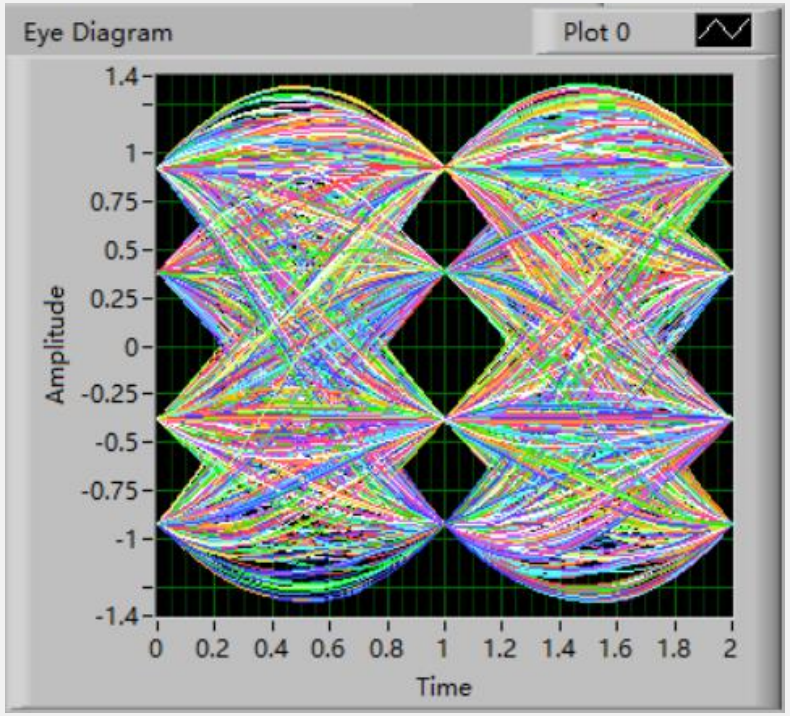
Measurements

frequency offset (Hz) -0.00

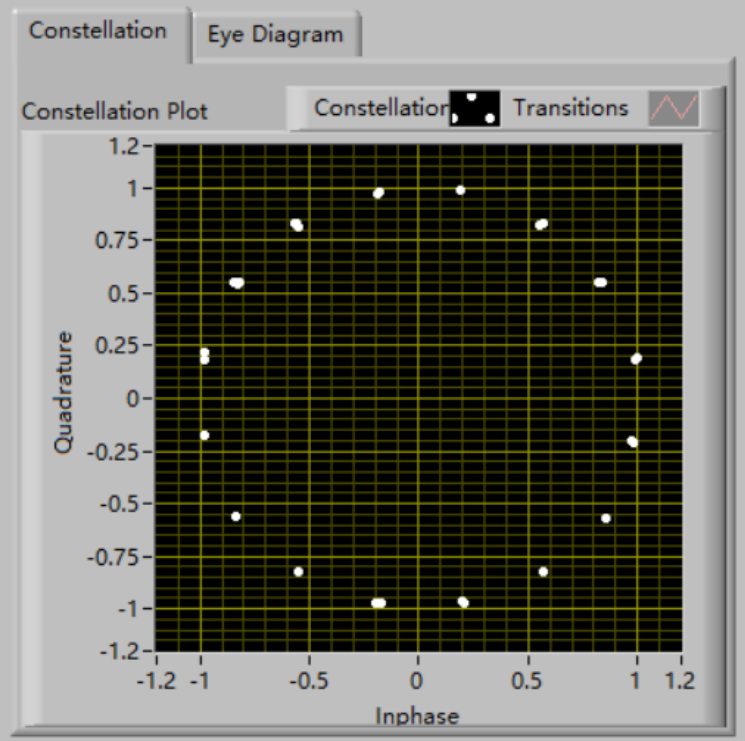
frequency drift (Hz) -0.00

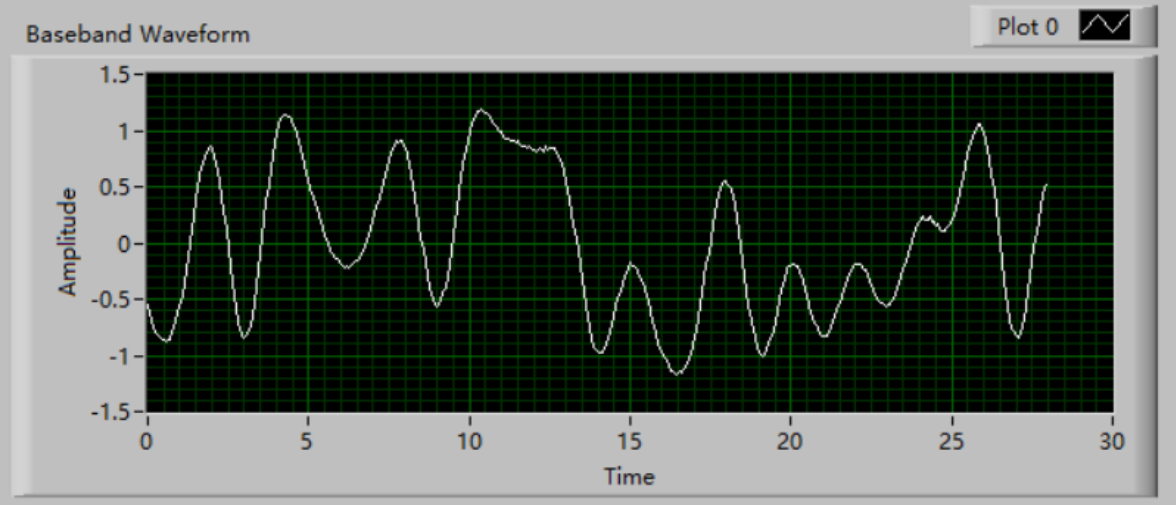
phase offset 0.40

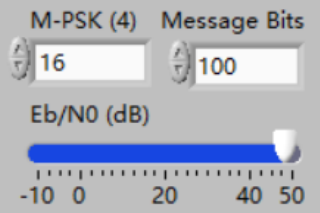

Constellation Plot
Constellation
Transitions
Quadrature
Inphase
1.2
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.2
-1.2 -1 -0.5 0 0.5 1 1.2


Eye Diagram
Plot 0
Amplitude
Time
1.4
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.4
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

M-PSK Simulation







Measurements

frequency offset (Hz)

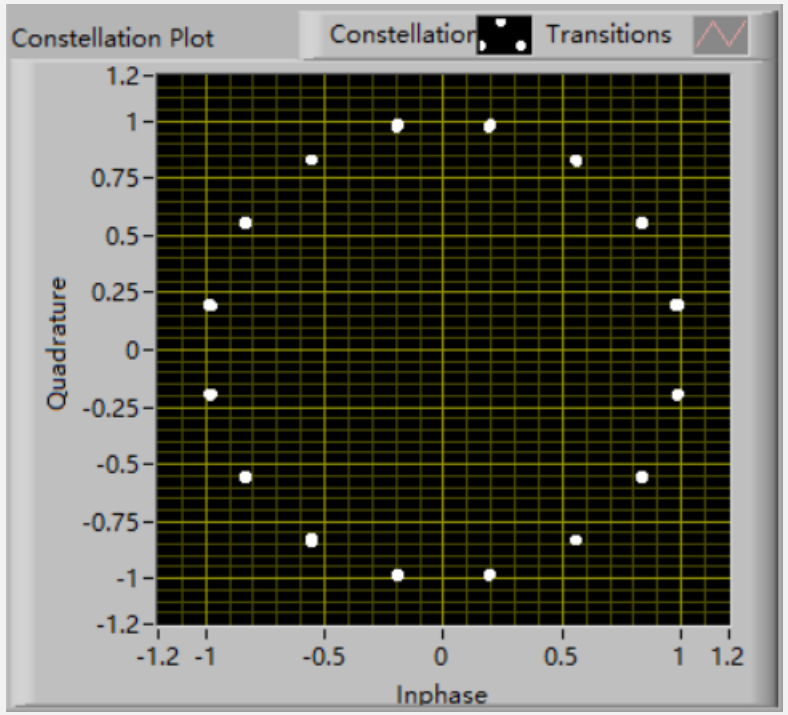
-0.00

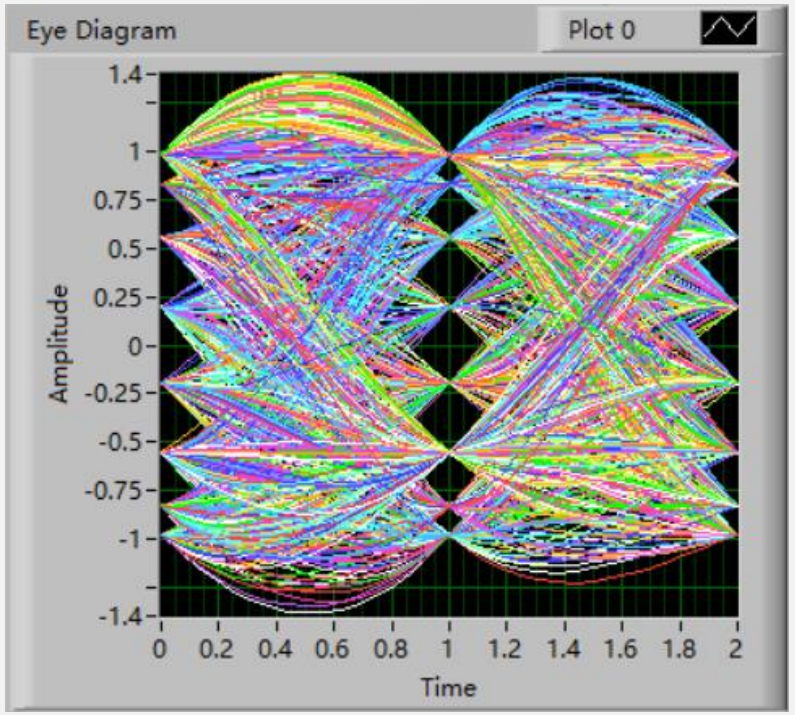
frequency drift (Hz)

0.00

phase offset

0.22


Constellation Plot
Constellation
Transitions
Quadrature
Inphase
1.2
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.2
-1.2 -1 -0.5 0 0.5 1 1.2


Eye Diagram
Plot 0
Amplitude
Time
1.4
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.4
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

M-PSK Simulation

path to JPEG file

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

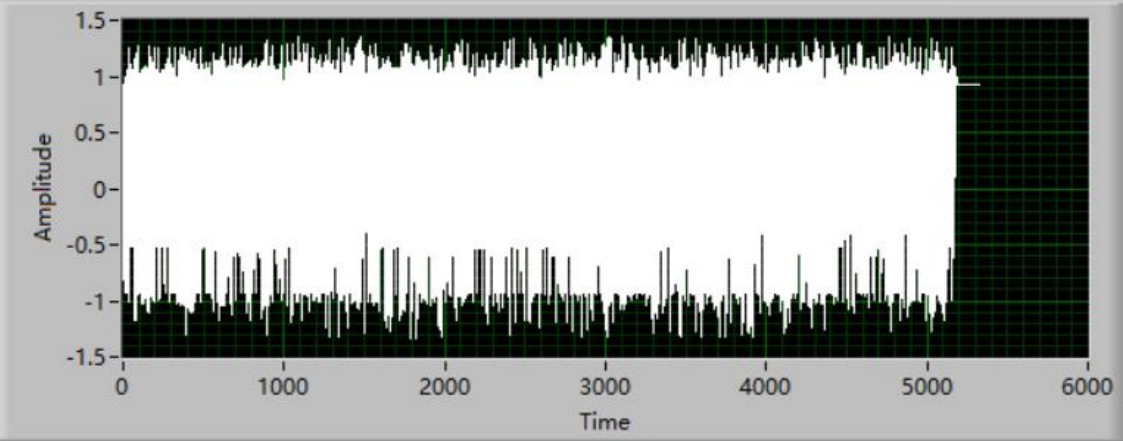
Image Recover | Constellation | Eye Diagram

Transmitted Image

Recovered Image

Baseband Waveform

Plot 0



M-PSK (4)

8

sync found index

6.0000

Eb/N0 (dB)

-10 0 20 40 50

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

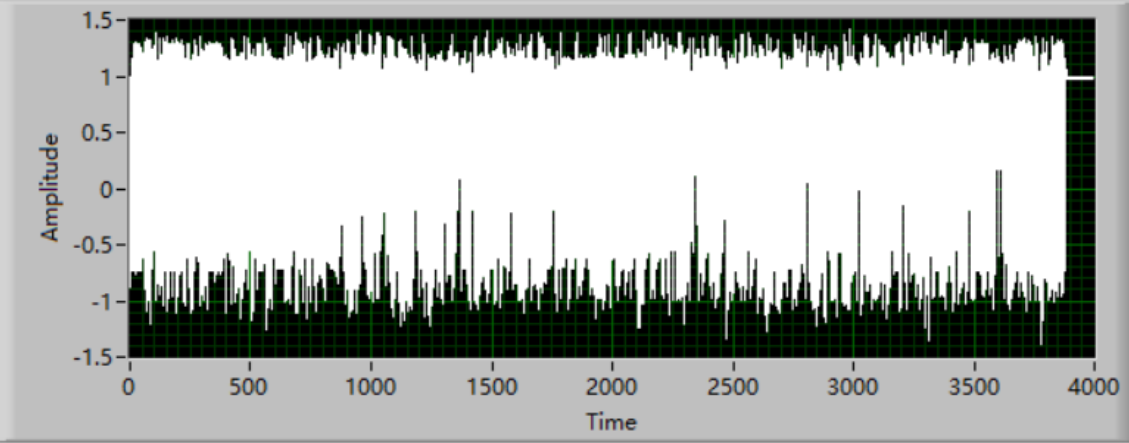
Image Recover | Constellation | Eye Diagram

Transmitted Image

Recovered Image

Baseband Waveform

Plot 0



M-PSK (4)

16

sync found index

4.0000

Eb/N0 (dB)

-10 0 20 40 50

Measurements

frequency offset (Hz)

0.00

frequency drift (Hz)

-0.00

phase offset

-0.00

Input Bitstream

0

Output Bitstream

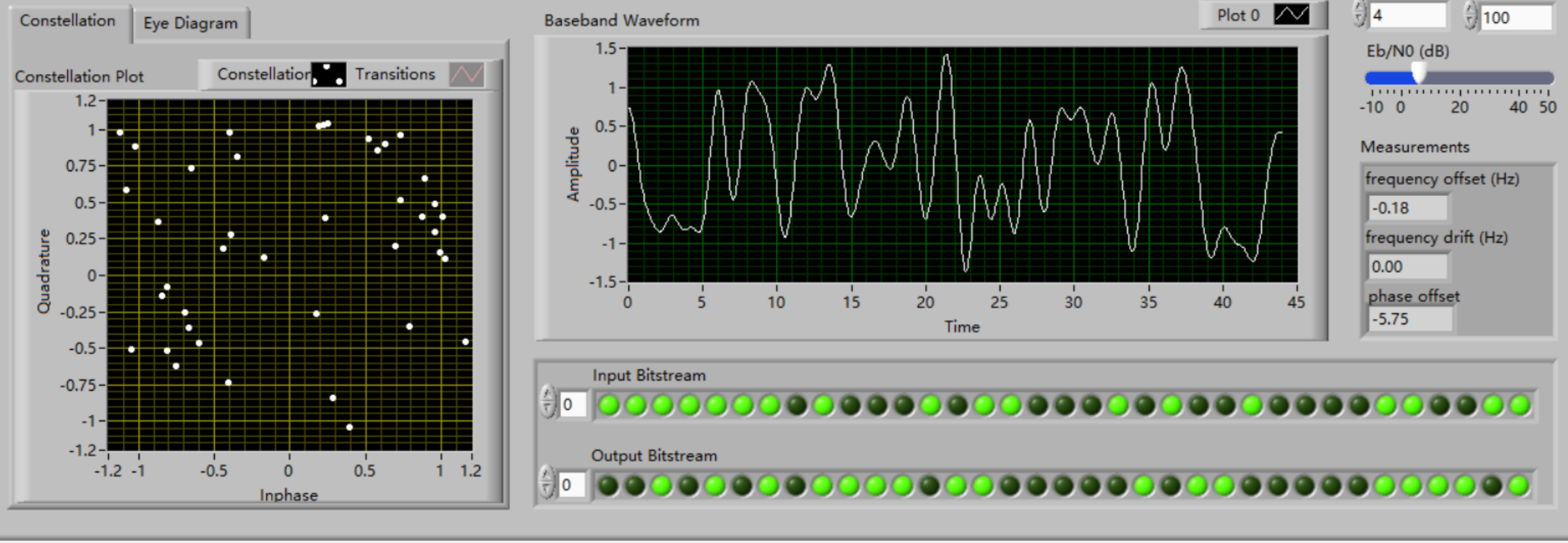
0

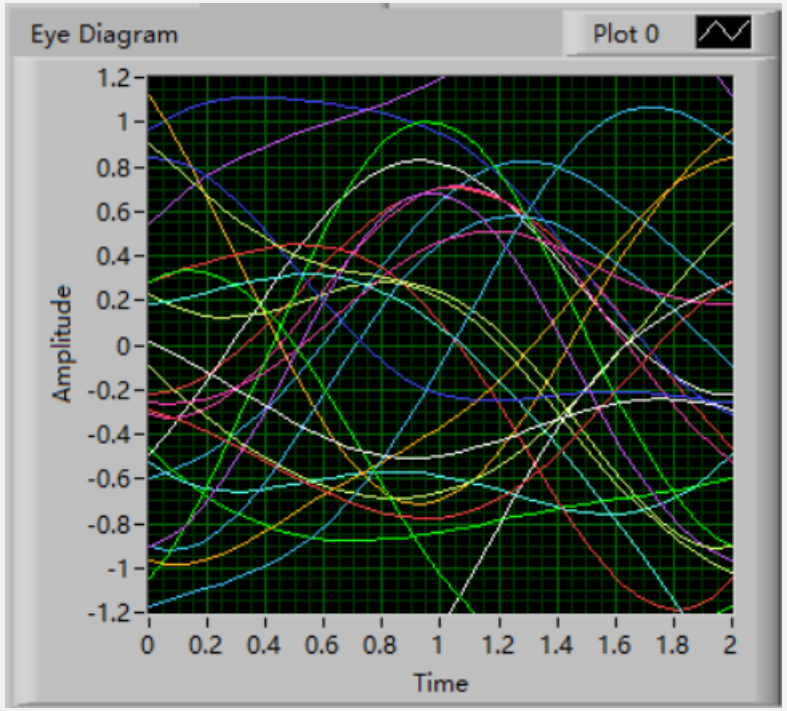
$$\varepsilon_s = E\left[|I_k|^2\right] = \sum_{k=1}^{M} \frac{|I_k|^2}{M} = 1$$

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

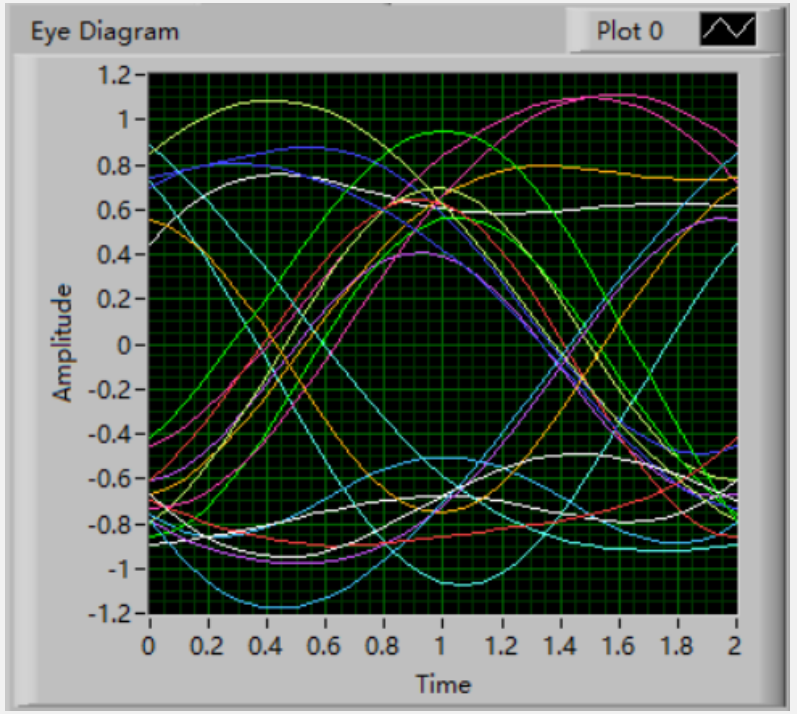
$$N_A = \sqrt{\frac{N_0}{2}} = \frac{\sqrt{\varepsilon_s}}{\sqrt{2 \cdot log_2(M) \cdot 10^{\frac{E_b/N_0(dB)}{10}}}}$$

M-PSK Simulation

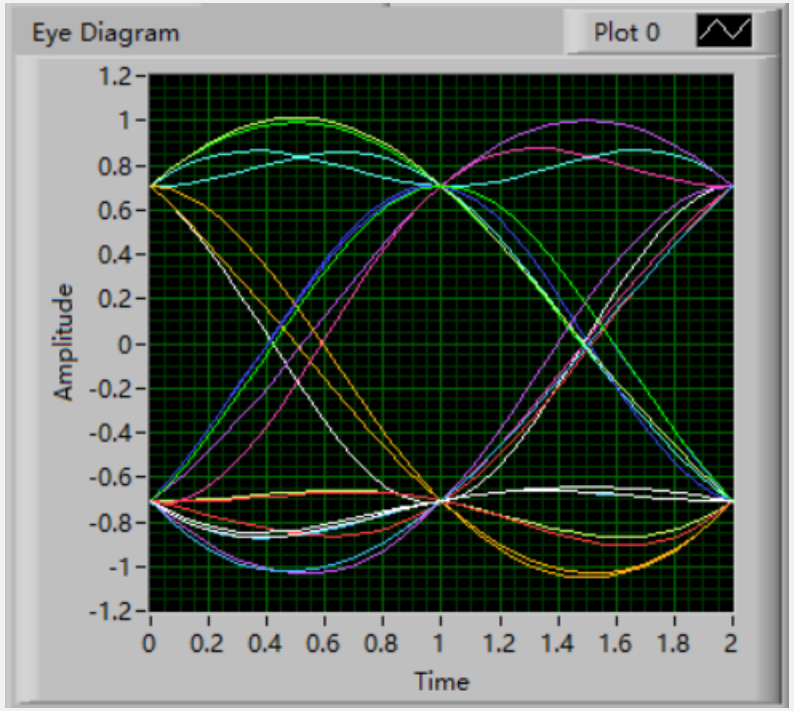




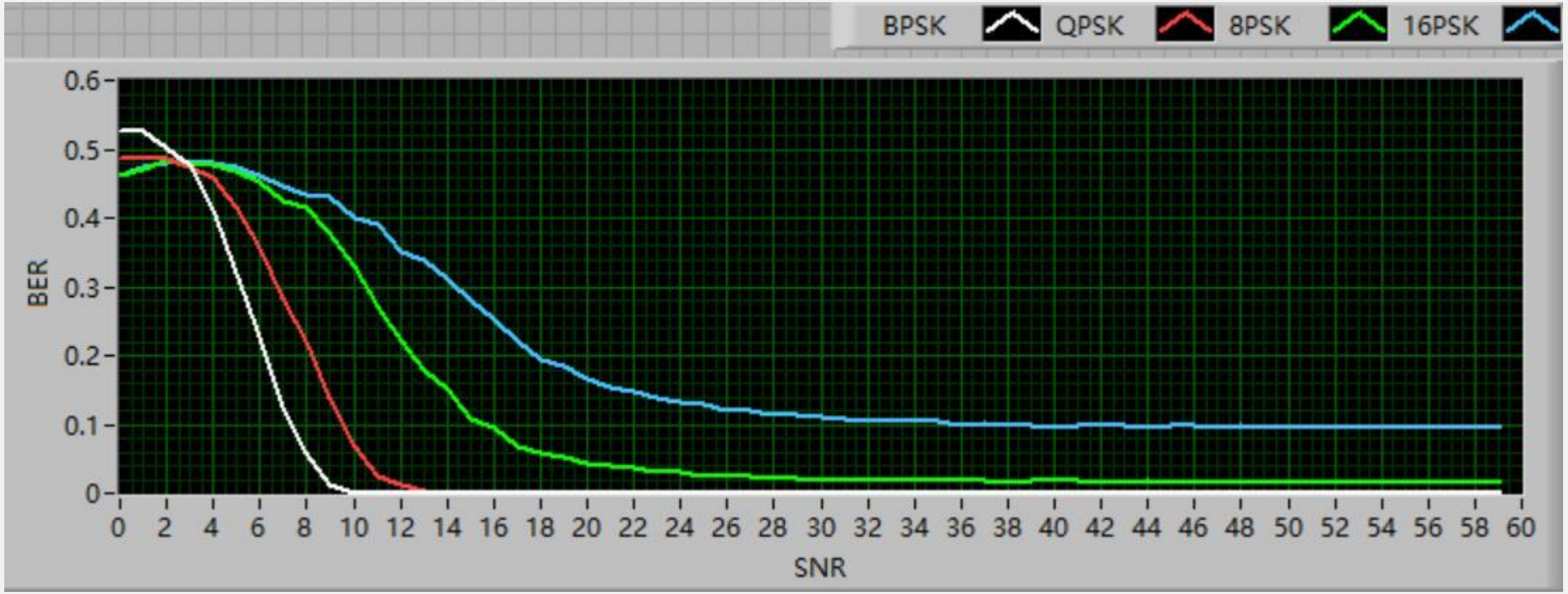
EbN0=0dB

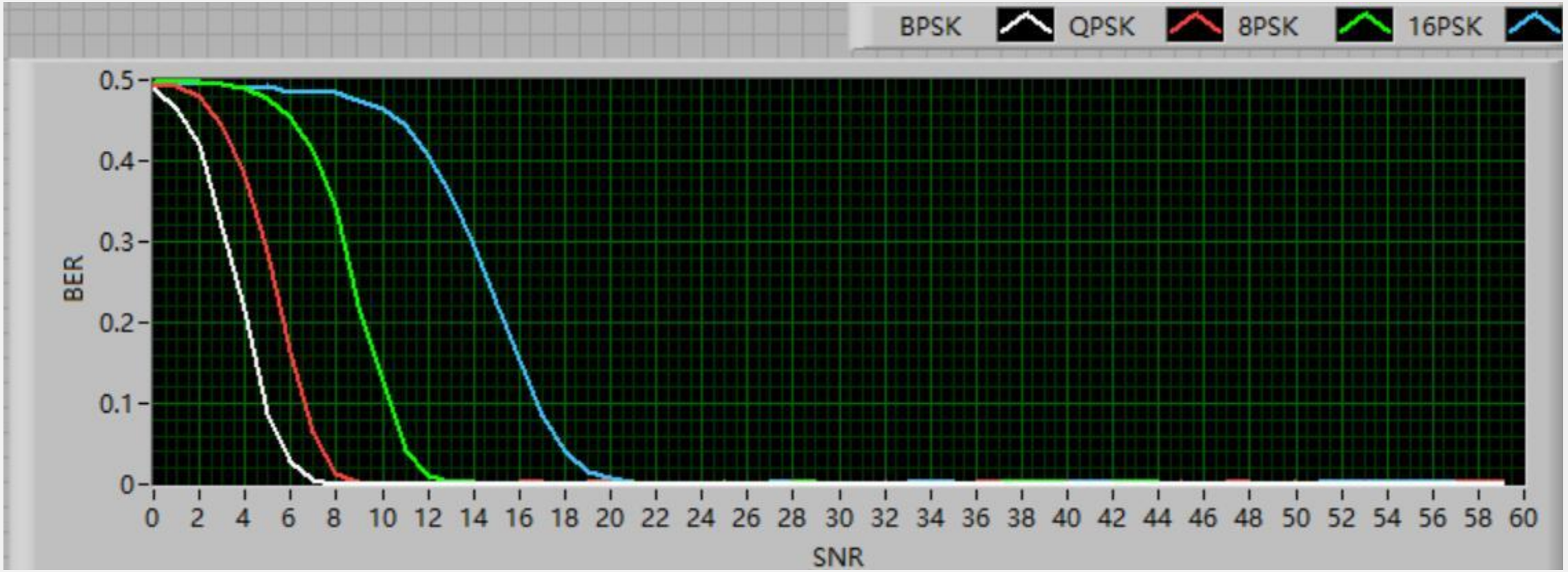


EbN0=10dB



EbN0=50dB


BPSK
QPSK
8PSK
16PSK
BER
0.6
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
SNR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0.1
0
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SNR

- Question ?