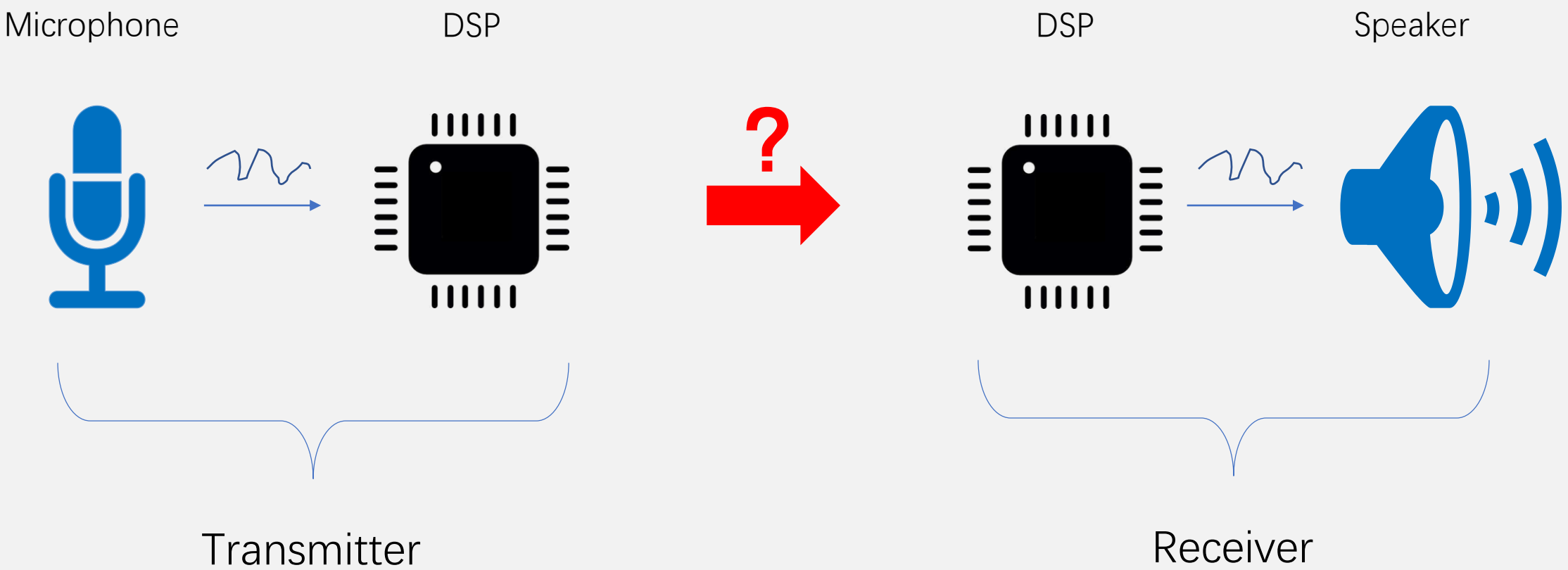
无线通信实验在线开放课程

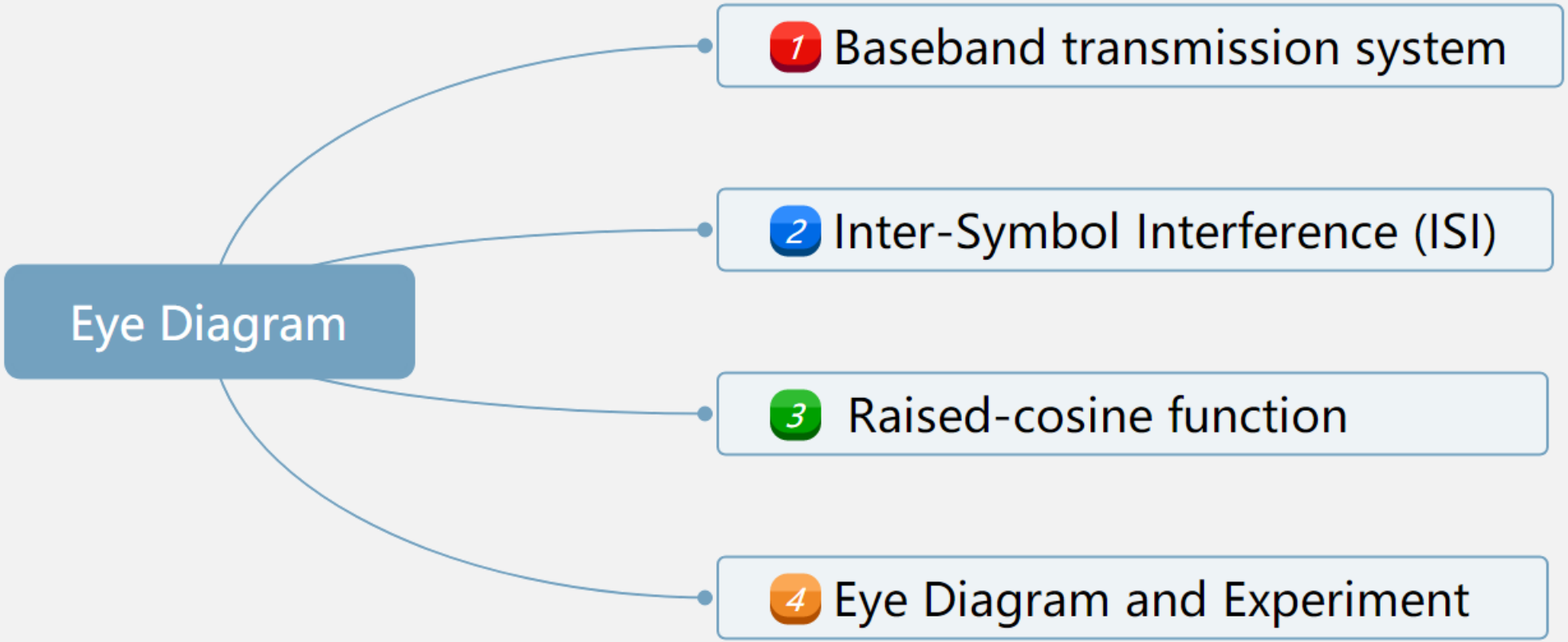
主讲人：吴光 博士

广东省教学质量工程建设项目

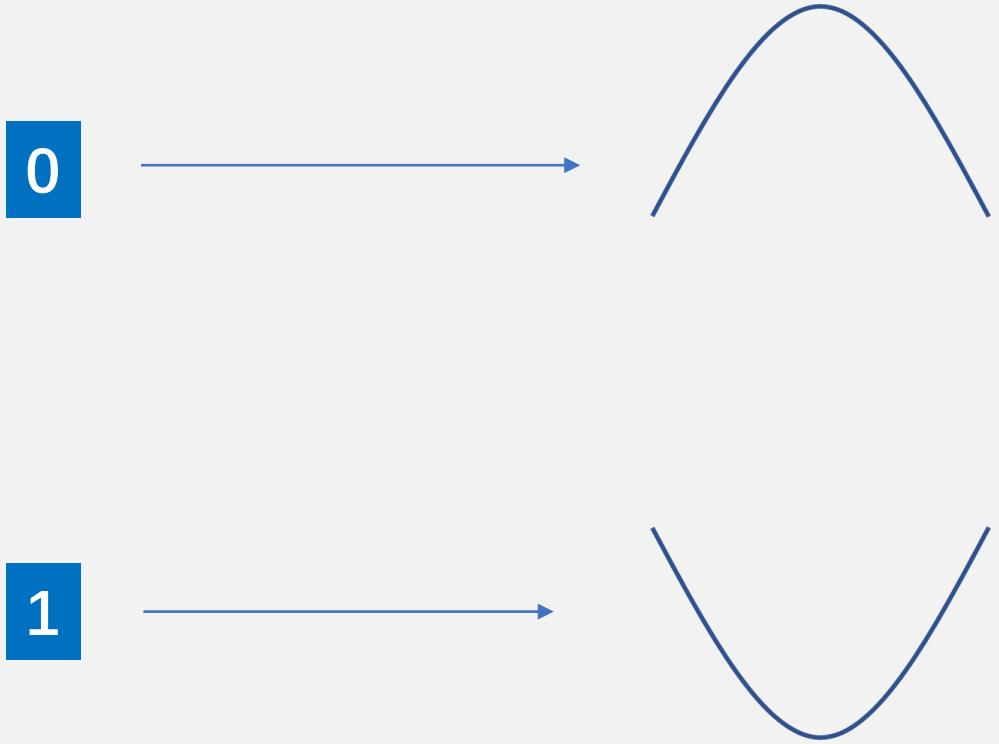

Microphone
DSP
?
DSP
Speaker
Transmitter
Receiver

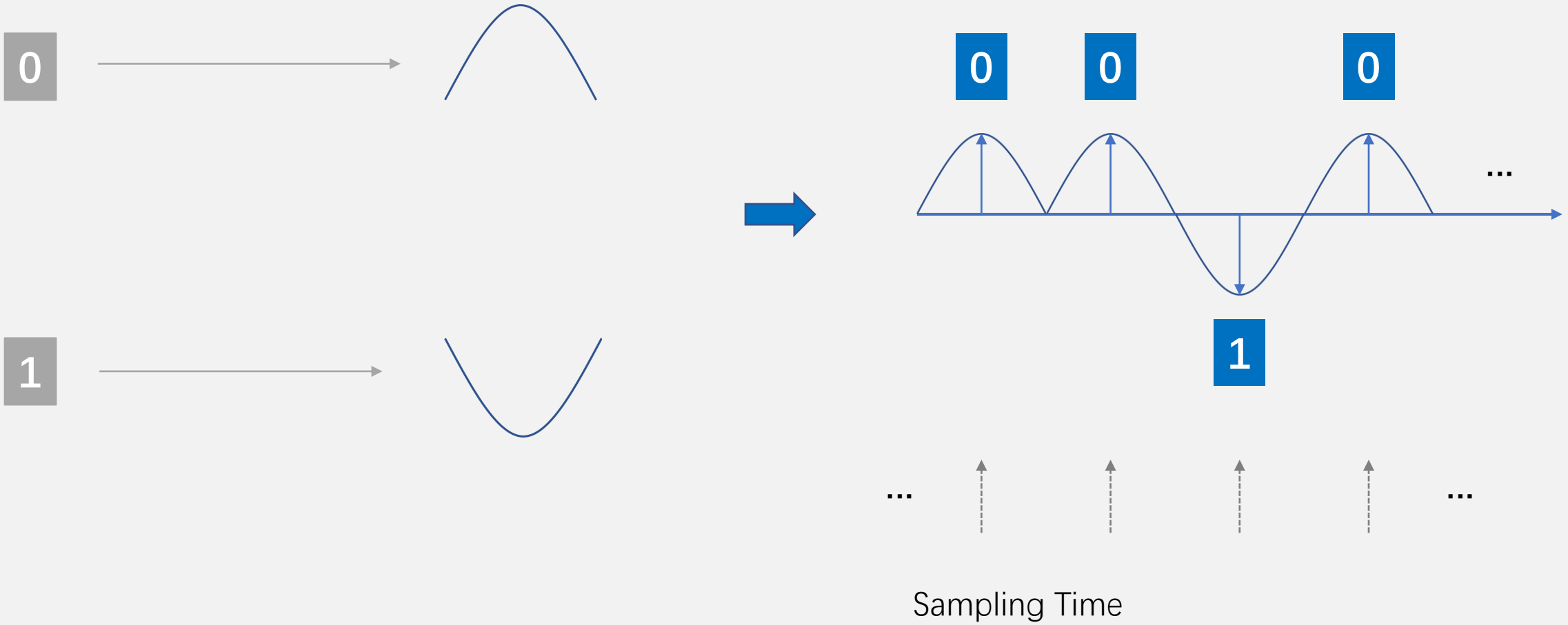
Lab 7 : Baseband Transmission

主讲人：吴光 博士
Email: wug@sustech.edu.cn


Eye Diagram
1 Baseband transmission system
2 Inter-Symbol Interference (ISI)
3 Raised-cosine function
4 Eye Diagram and Experiment

Demo: Baseband Signal Transmission


0
1


0
1
0
0
0
1
...
...
...
Sampling Time

Exercise: Baseband Signal Transmission

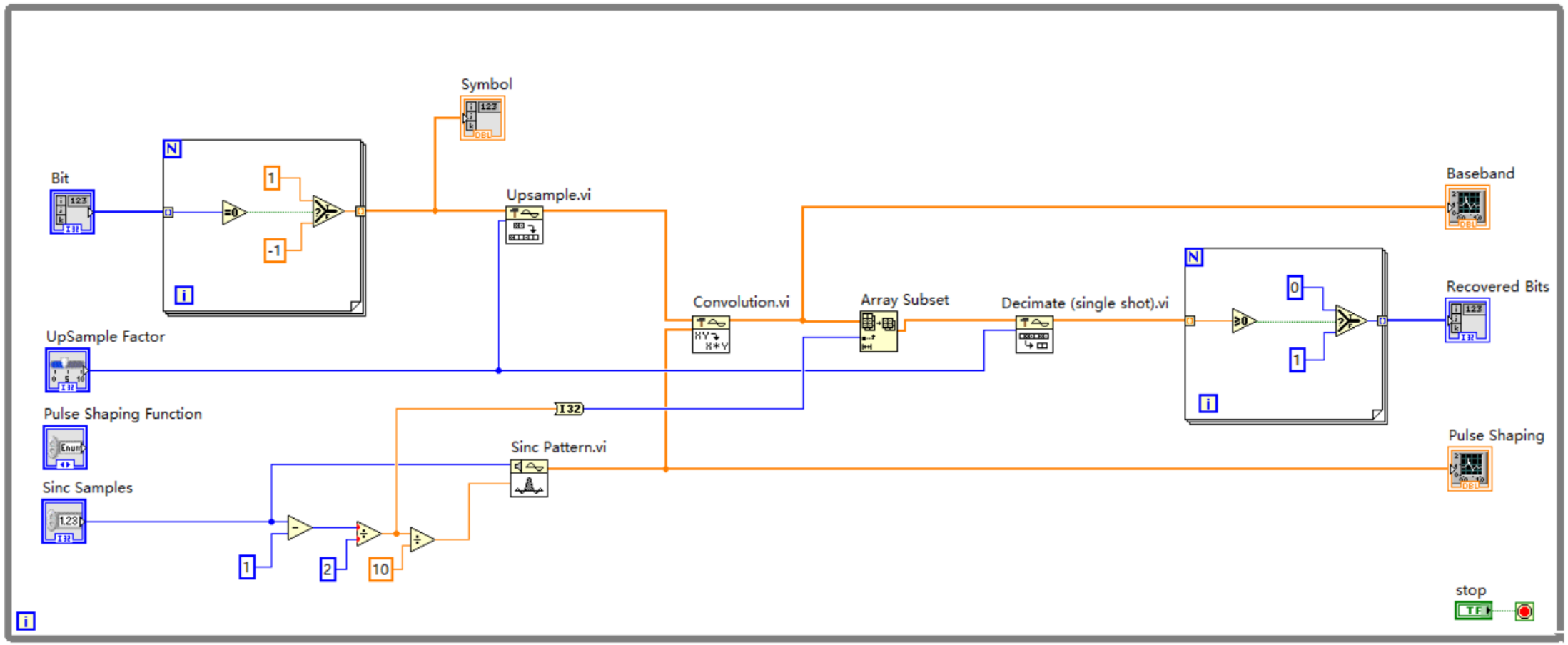
本节的主要任务是练习程序，大概10分钟

Baseband Transmission-Simple.vi Block Diagram

File Edit View Project Operate Tools Window Help

18pt Application Font

Search



Baseband Transmission

Pulse Shaping Function: Sinc

Sinc Samples: 65

UpSample Factor: 1 20 40 60 80 100

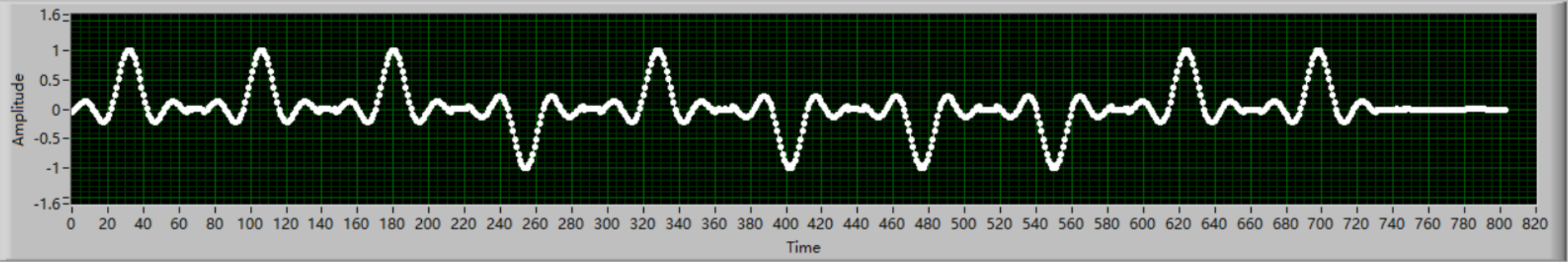
stop: STOP

Bit: 0 | 0 0 0 1 0 1 1 1 0 0

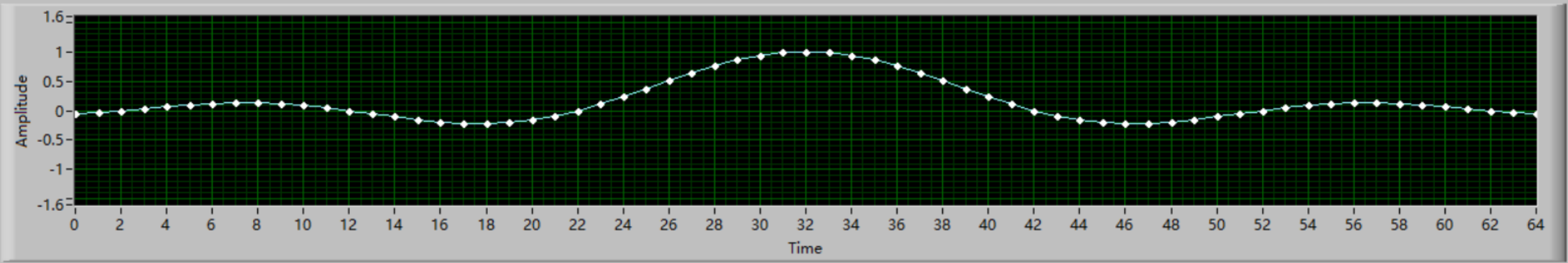
Symbol: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

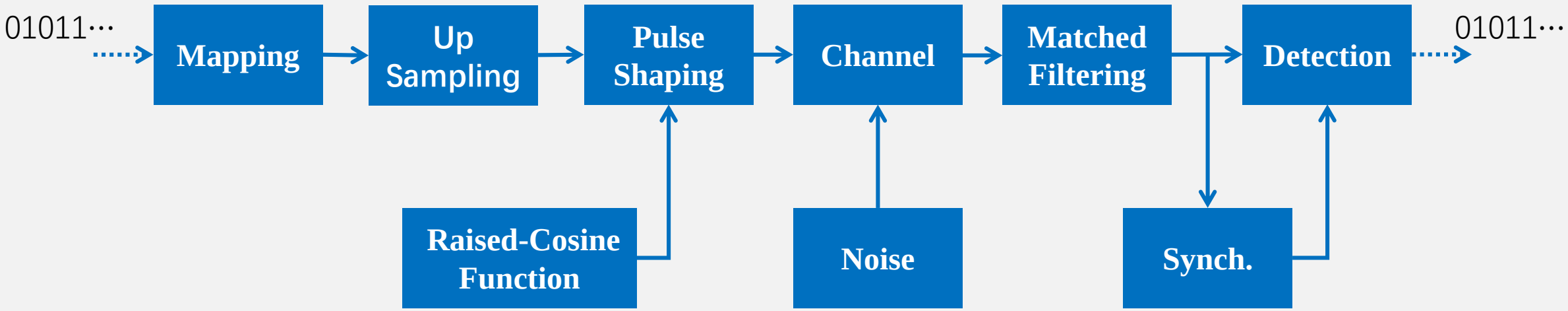
Decimated Array: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

Baseband



Pulse Shaping



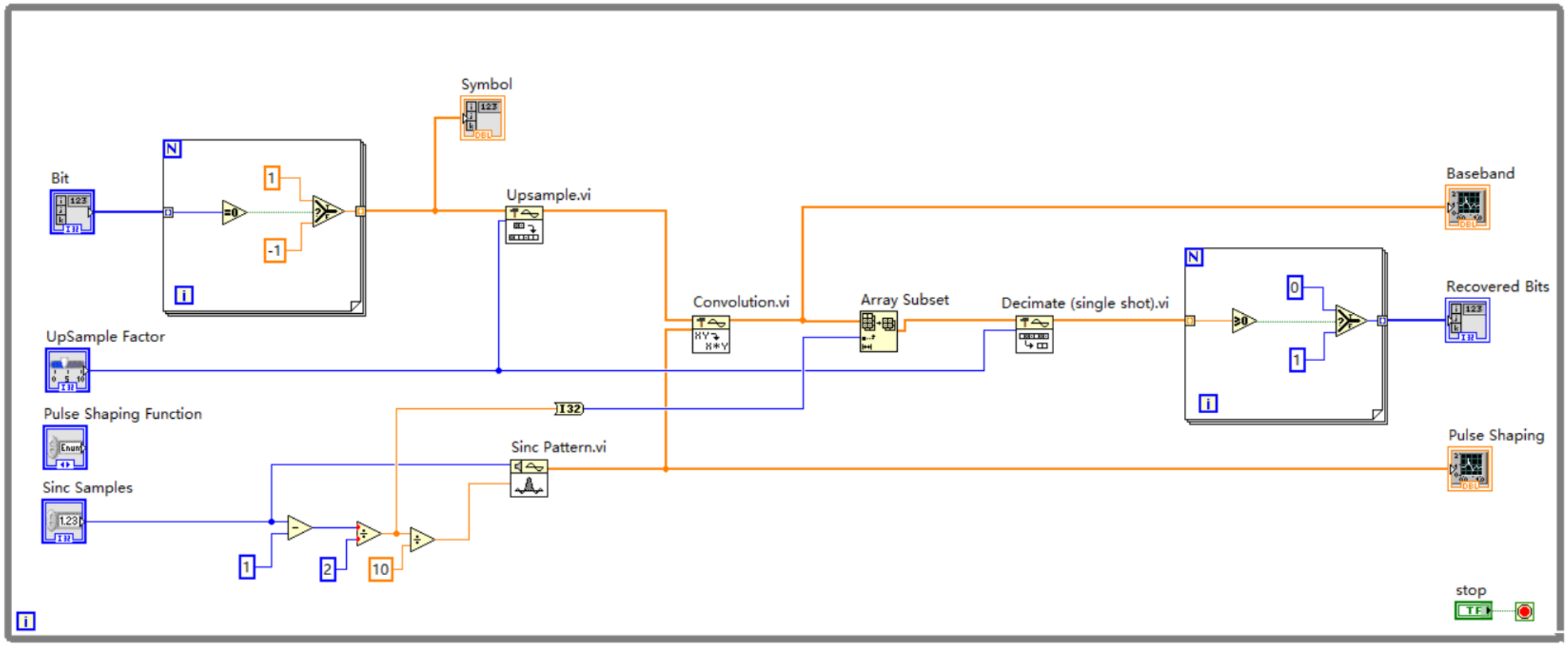

01011…
Mapping
Up Sampling
Pulse Shaping
Channel
Matched Filtering
Detection
01011…
Raised-Cosine Function
Noise
Synch.

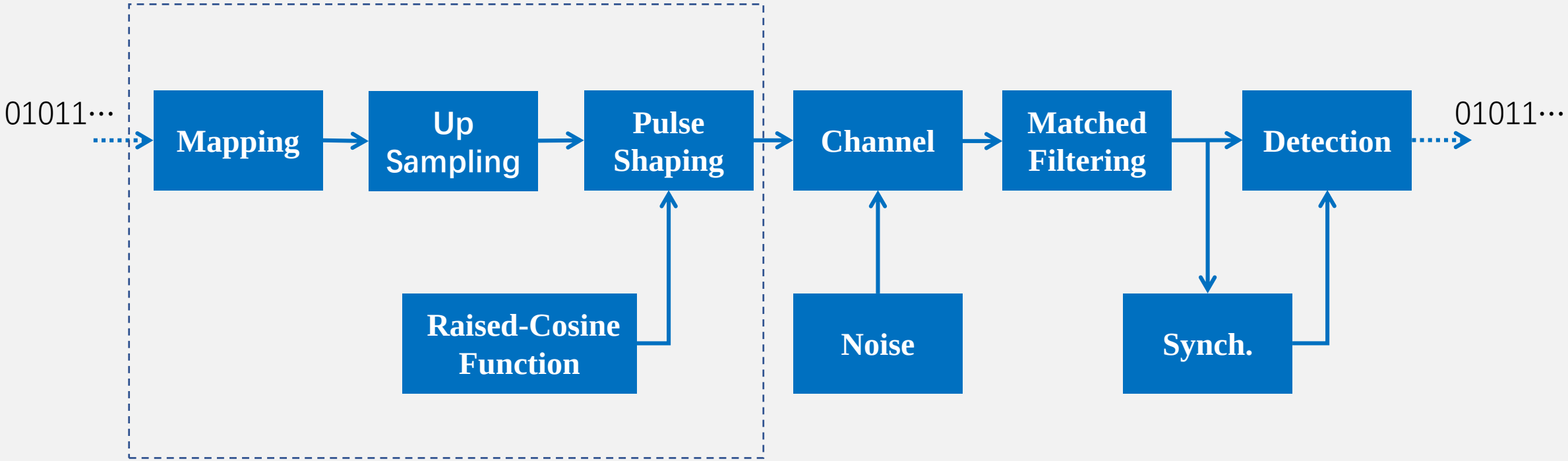
Baseband Transmission-Simple.vi Block Diagram

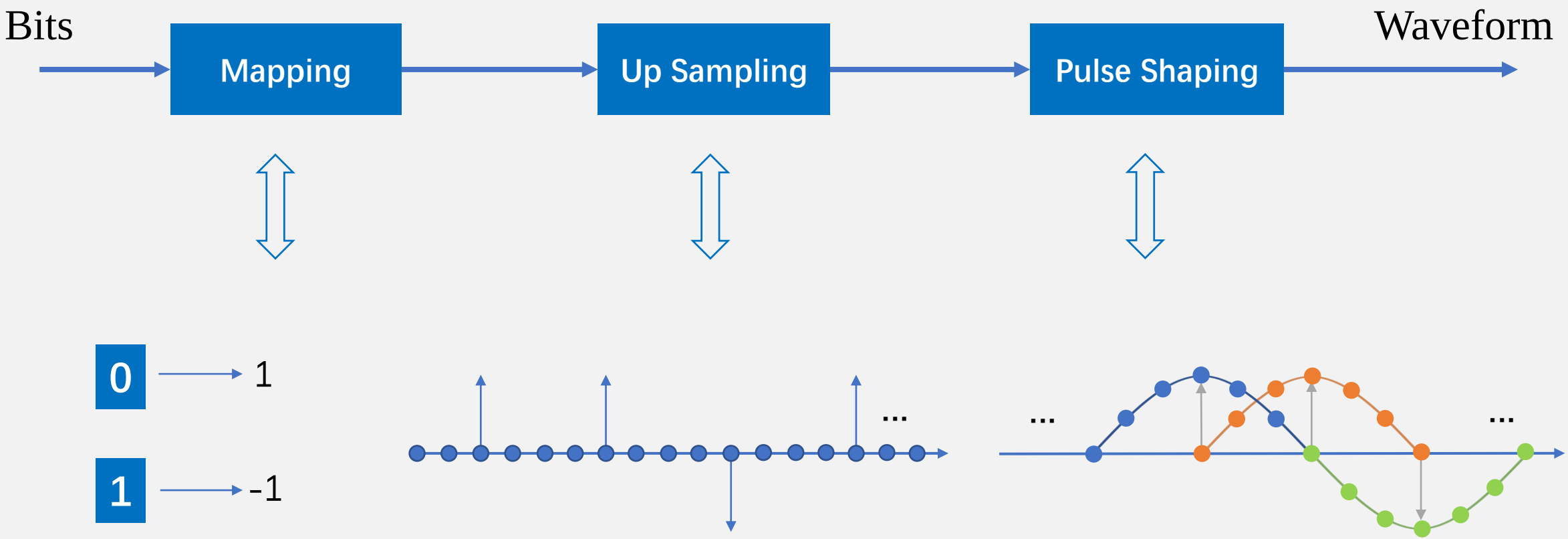
File Edit View Project Operate Tools Window Help

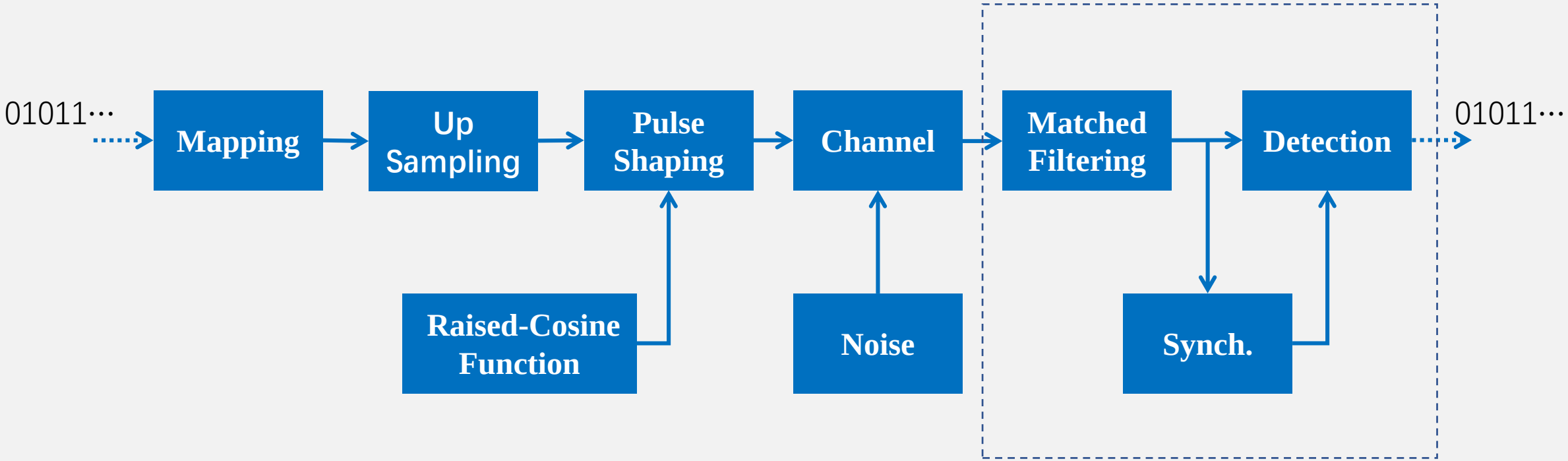
18pt Application Font

Search

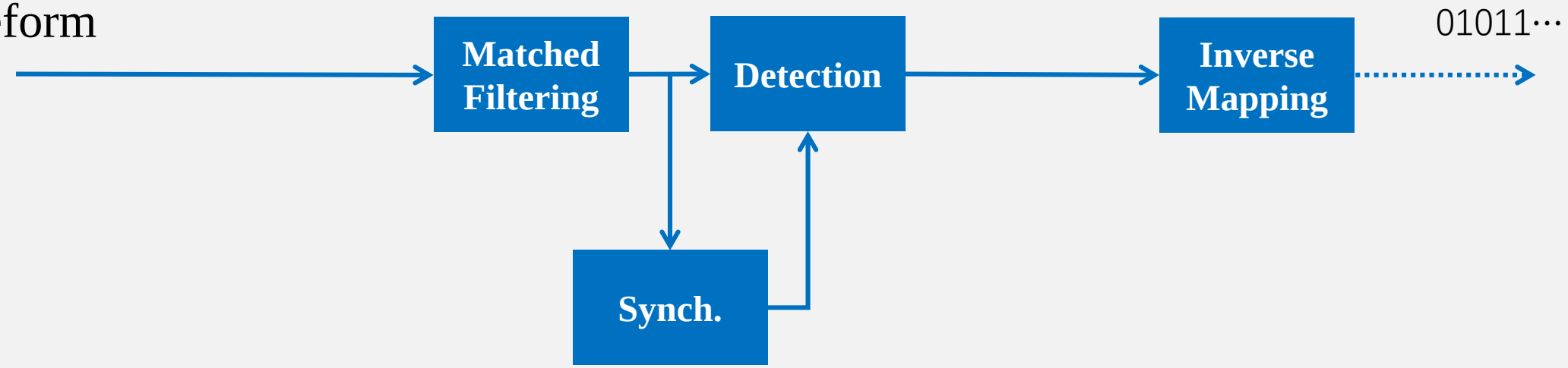


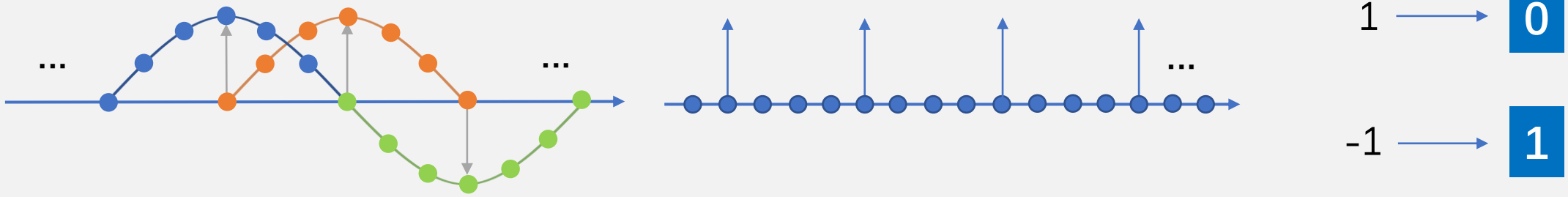

01011…
Mapping
Up Sampling
Pulse Shaping
Raised-Cosine Function
Channel
Noise
Matched Filtering
Synch.
Detection
01011…


Bits
Mapping
Up Sampling
Pulse Shaping
Waveform
0
1
1
-1
...
...
...


01011…
Mapping
Up Sampling
Pulse Shaping
Channel
Matched Filtering
Detection
01011…
Raised-Cosine Function
Noise
Synch.

Waveform


Matched Filtering
Detection
Inverse Mapping
01011…
Synch.


…
…
…
1
0
-1
1

Baseband Transmission-Simple.vi

File Edit View Project Operate Tools Window Help

Baseband Transmission

Pulse Shaping Function: Sinc

Sinc Samples: 65

UpSample Factor: 1 20 40 60 80 100

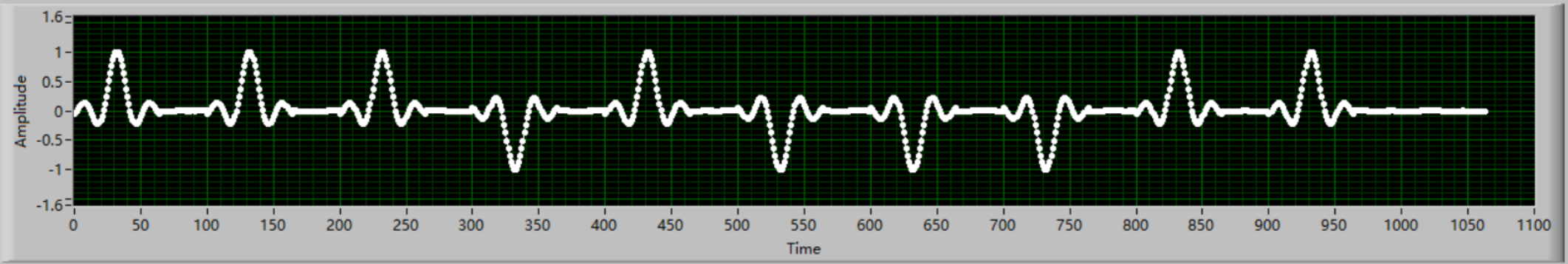
stop: STOP

Bit: 0 | 0 0 0 1 0 1 1 1 0 0

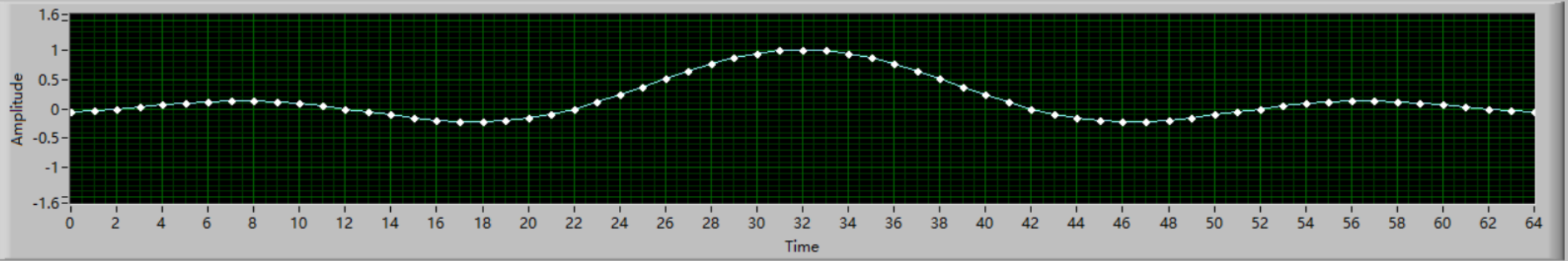
Symbol: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

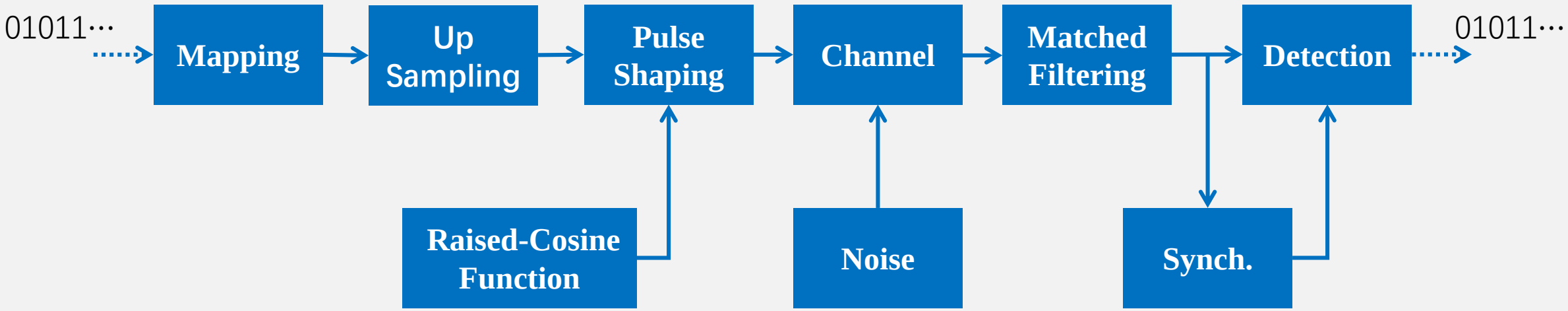
Recovered Bits: 0 | 0 0 0 1 0 1 1 1 0 0

Baseband



Pulse Shaping

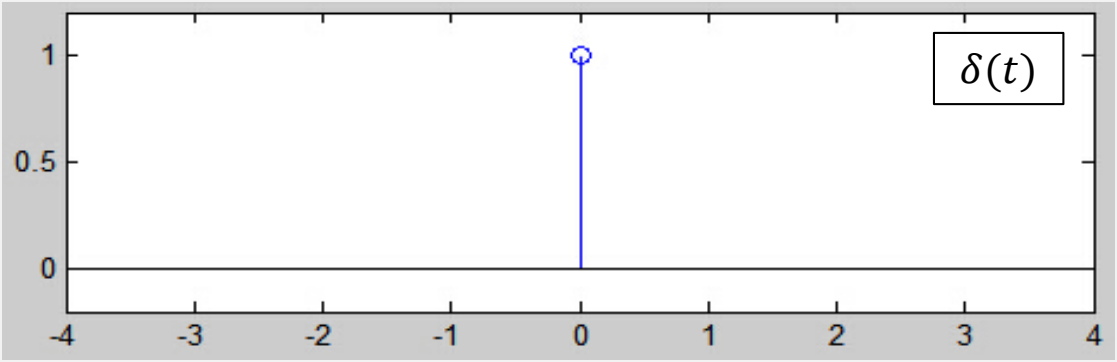


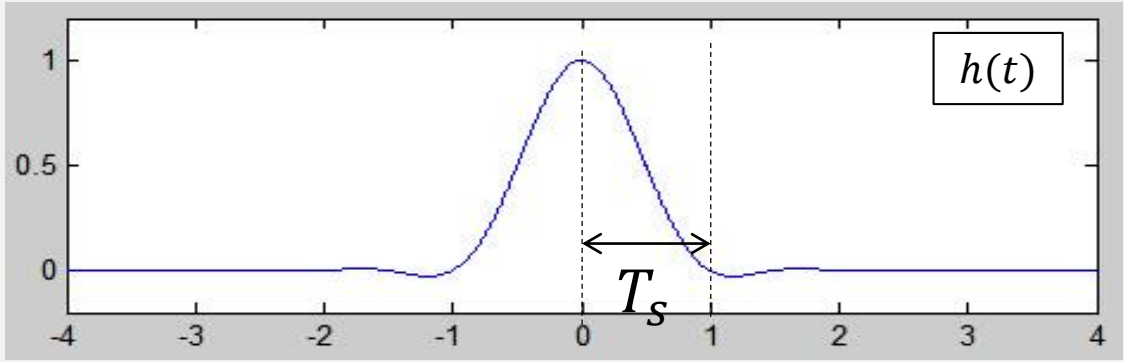

01011…
Mapping
Up Sampling
Pulse Shaping
Channel
Matched Filtering
Detection
01011…
Raised-Cosine Function
Noise
Synch.

Linear Time Invariant System

Pre-Lab: Linear time invariant system

$$H\{I_k\delta(t-kT_s)\} = I_k h(t-kT_s)$$



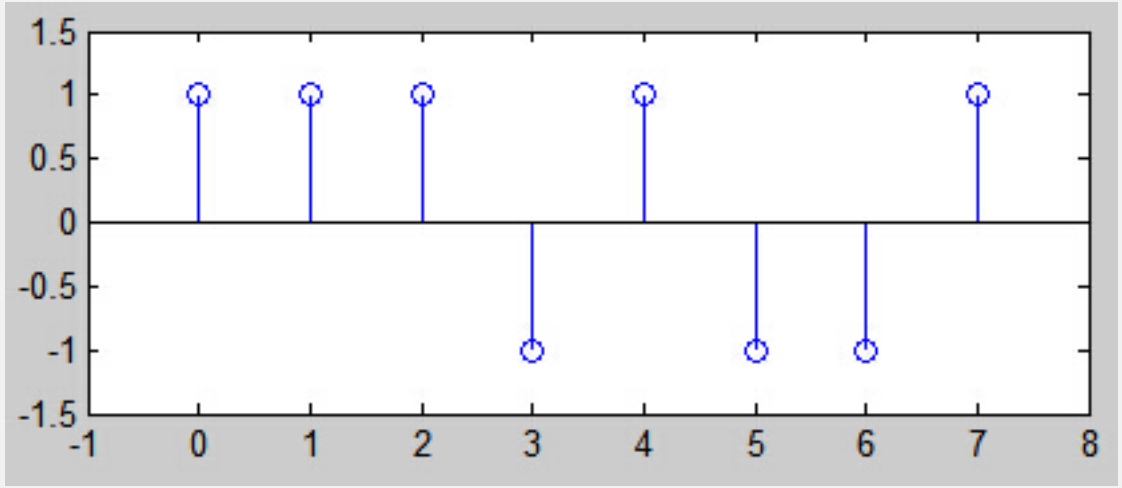


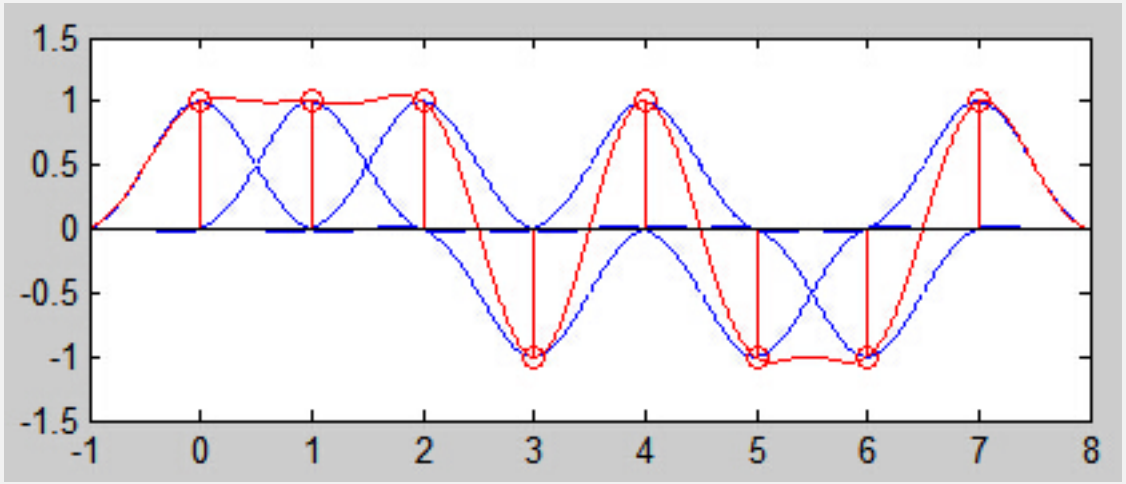
Pre-Lab: Linear time invariant system

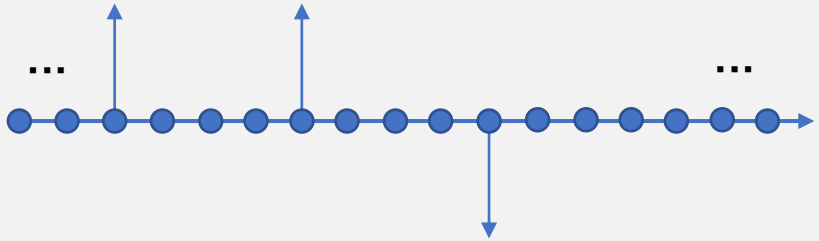
$$H\left\{\sum_k I_k \delta(t - kT_s)\right\} = \sum_k I_k h(t - kT_s)$$

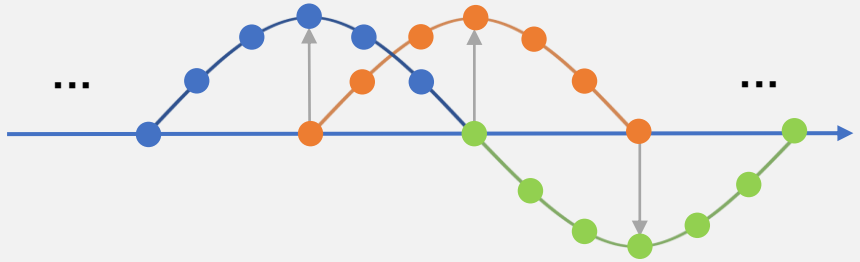
Pre-Lab: Linear time invariant system

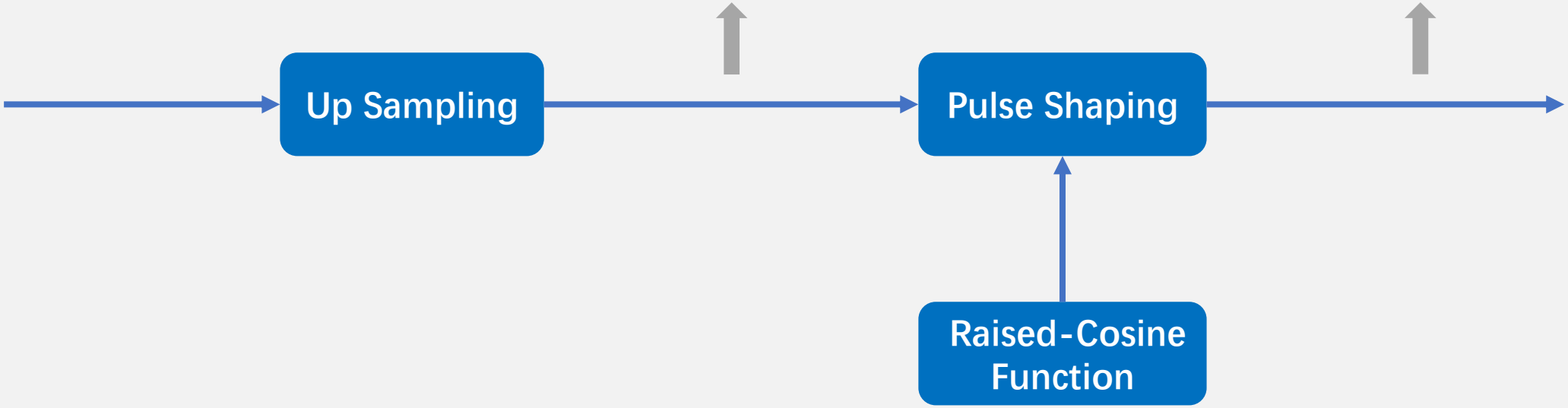
$$\sum_k I_k \delta(t - kT_s) \longrightarrow \boxed{\mathbf{H}\{\cdot\}} \longrightarrow \sum_k I_k h(t - kT_s)$$

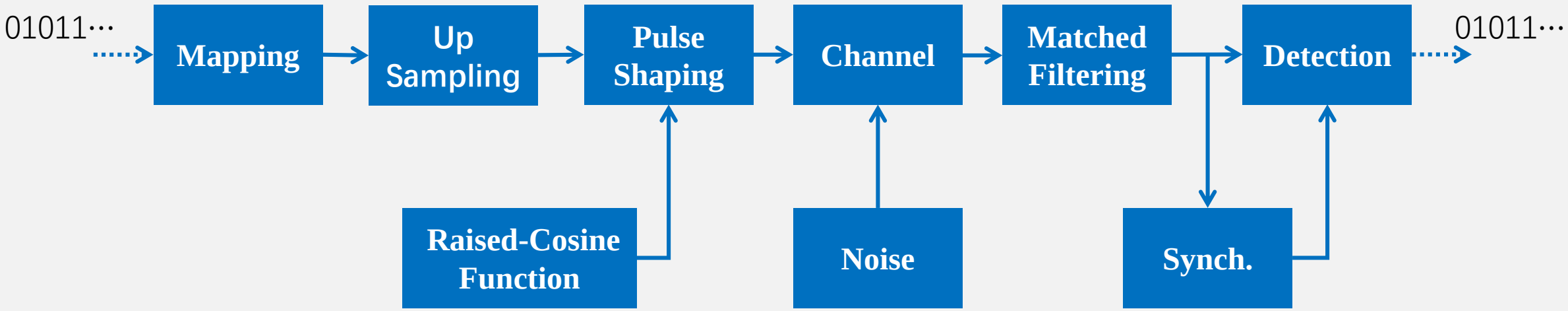









Up Sampling
Pulse Shaping
Raised-Cosine Function

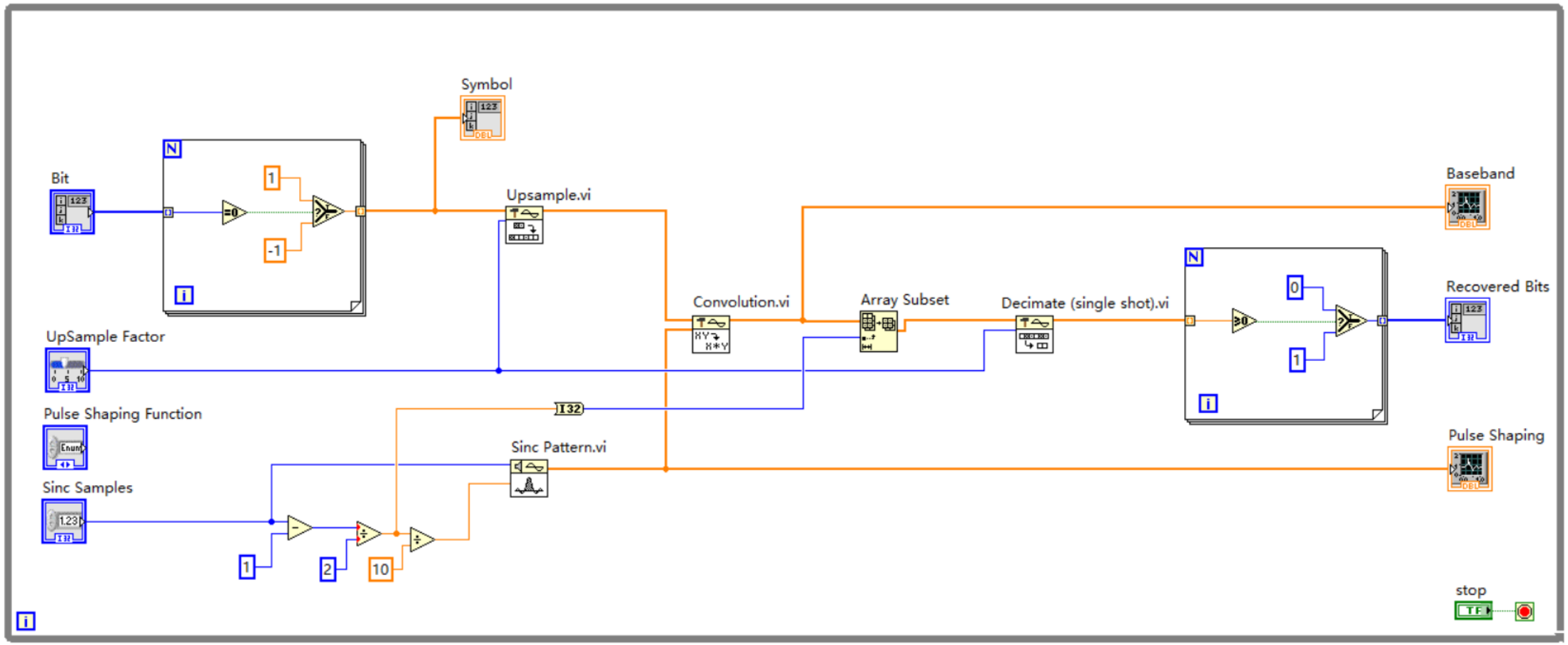

01011…
Mapping
Up Sampling
Pulse Shaping
Channel
Matched Filtering
Detection
01011…
Raised-Cosine Function
Noise
Synch.

Baseband Transmission-Simple.vi Block Diagram

File Edit View Project Operate Tools Window Help

18pt Application Font

Search



Baseband Transmission-Simple.vi

File Edit View Project Operate Tools Window Help

Baseband Transmission

Pulse Shaping Function: Sinc

Sinc Samples: 65

UpSample Factor: 1 20 40 60 80 100

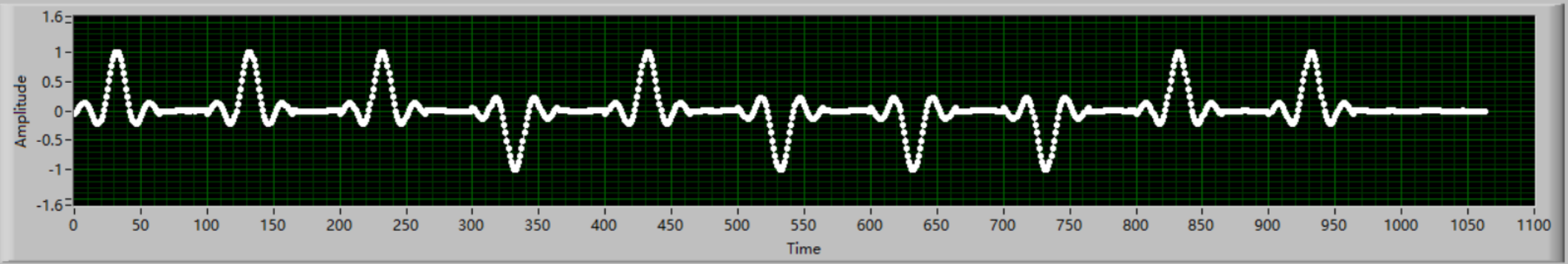
stop: STOP

Bit: 0 | 0 0 0 1 0 1 1 1 0 0

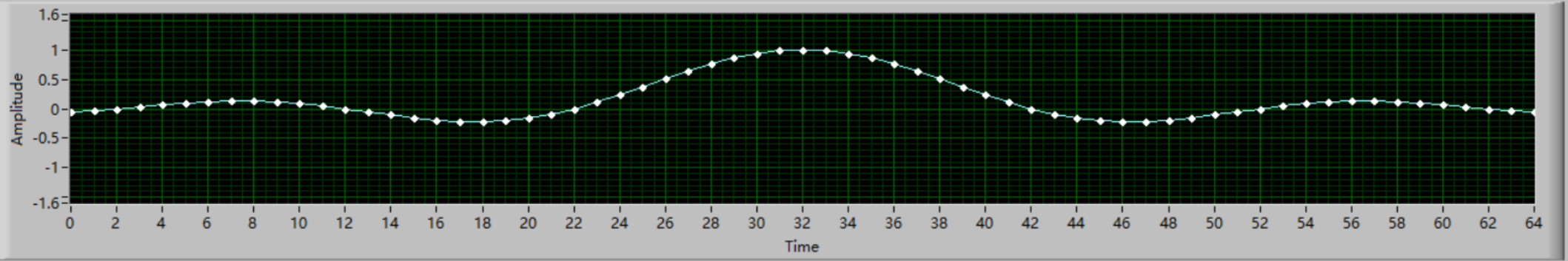
Symbol: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

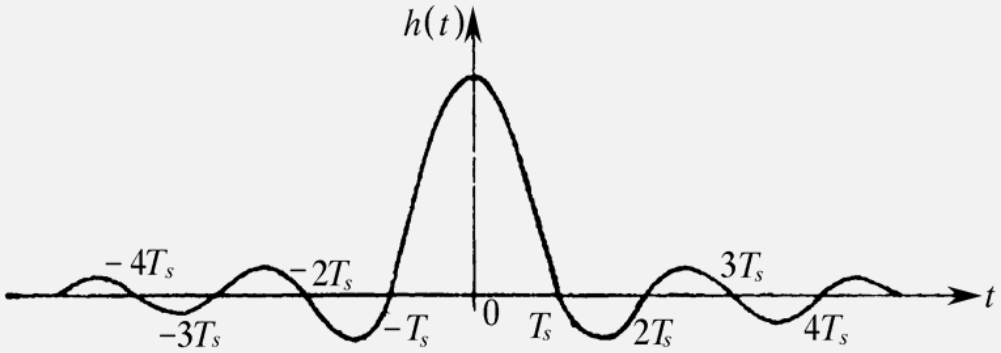
Recovered Bits: 0 | 0 0 0 1 0 1 1 1 0 0

Baseband



Pulse Shaping





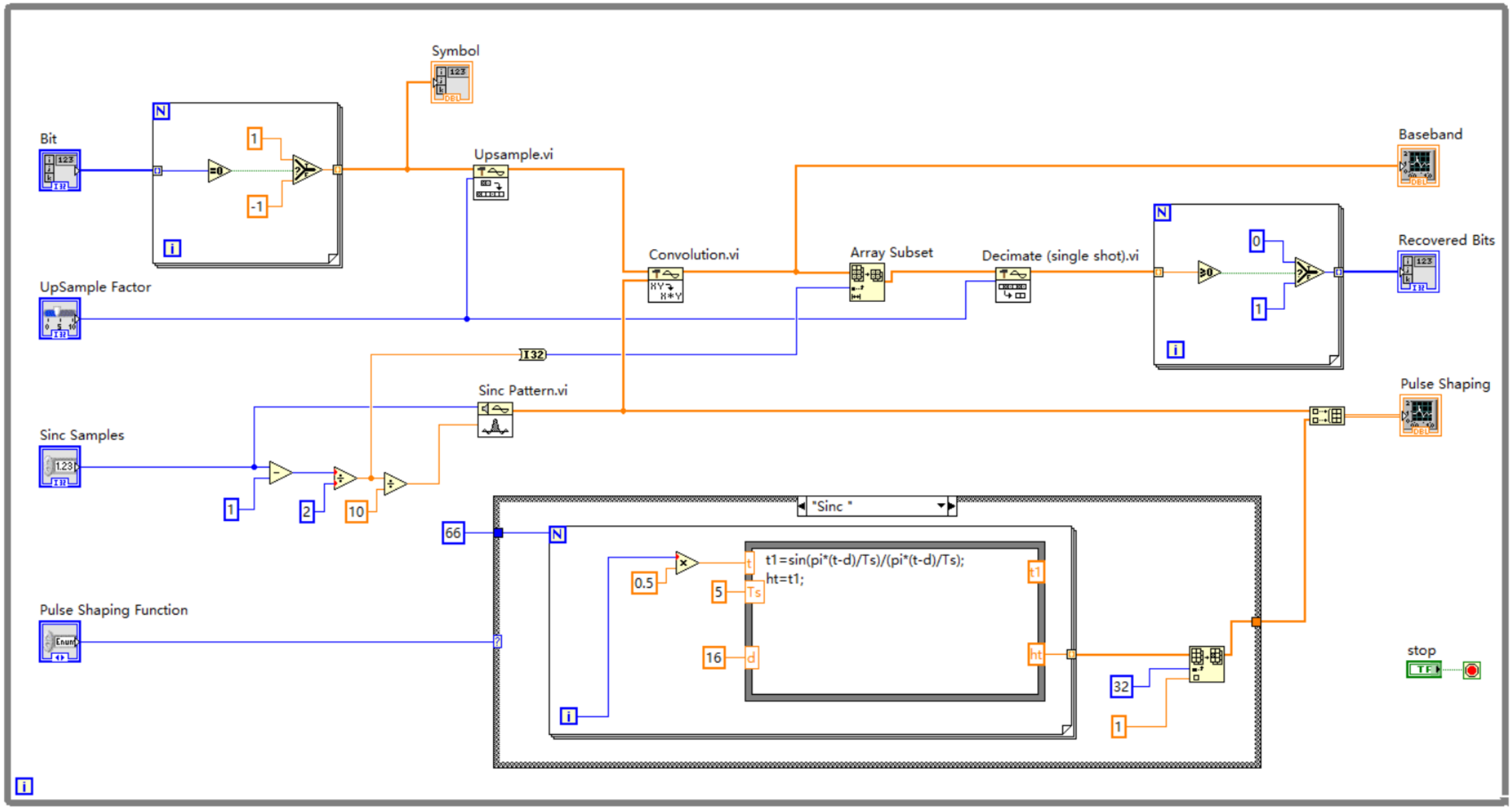
$$h(t) = \frac{\sin\frac{\pi}{T_s}t}{\frac{\pi}{T_s}t}$$

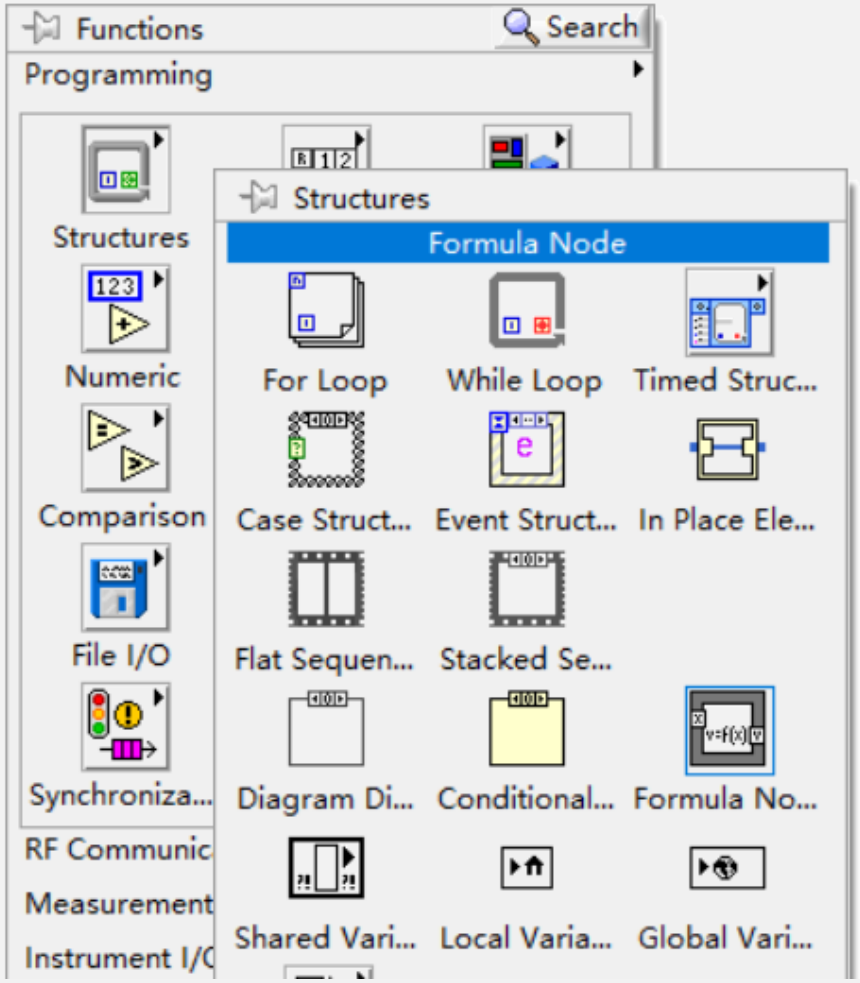
Baseband Transmission-Simple - Demo.vi Block Diagram

File Edit View Project Operate Tools Window Help

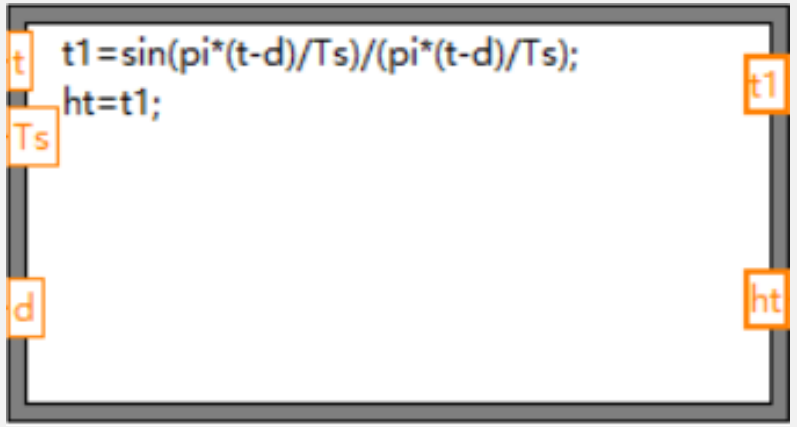
18pt Application Font

Search





$$h(t) = \frac{\sin\frac{\pi}{T_s}t}{\frac{\pi}{T_s}t}$$

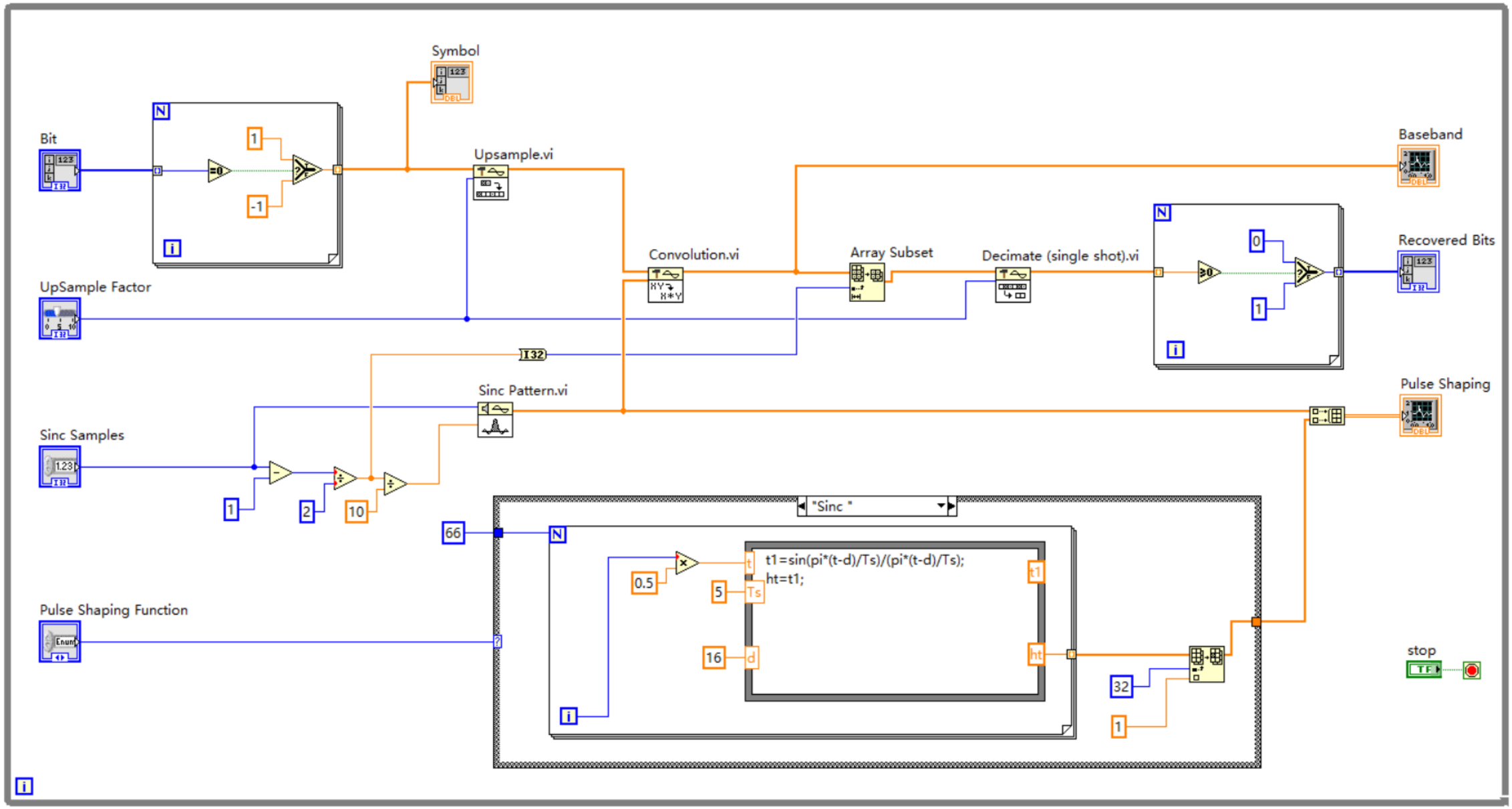


Baseband Transmission-Simple - Demo.vi Block Diagram

File Edit View Project Operate Tools Window Help

18pt Application Font

Search



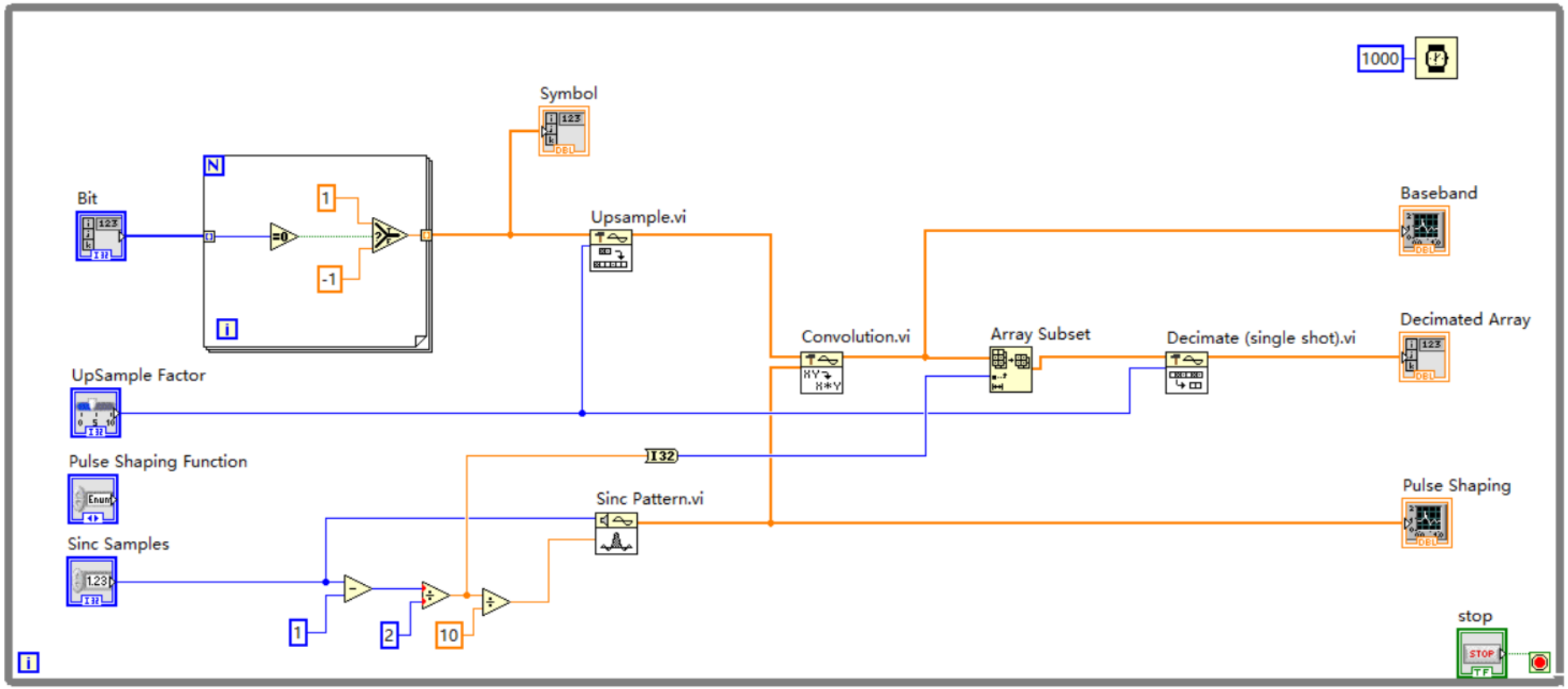
Demo: Baseband Signal Transmission

Baseband Transmission-Simple.vi Block Diagram

File Edit View Project Operate Tools Window Help

18pt Application Font

Search



Baseband Transmission-Simple.vi

File Edit View Project Operate Tools Window Help

Baseband Transmission

Pulse Shaping Function: Sinc

Sinc Samples: 65

UpSample Factor: 1 20 40 60 80 100

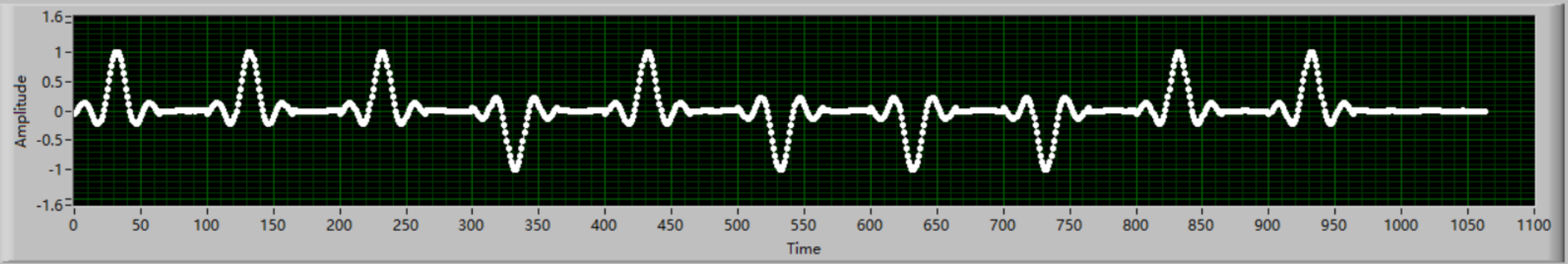
stop: STOP

Bit: 0 | 0 0 0 1 0 1 1 1 0 0

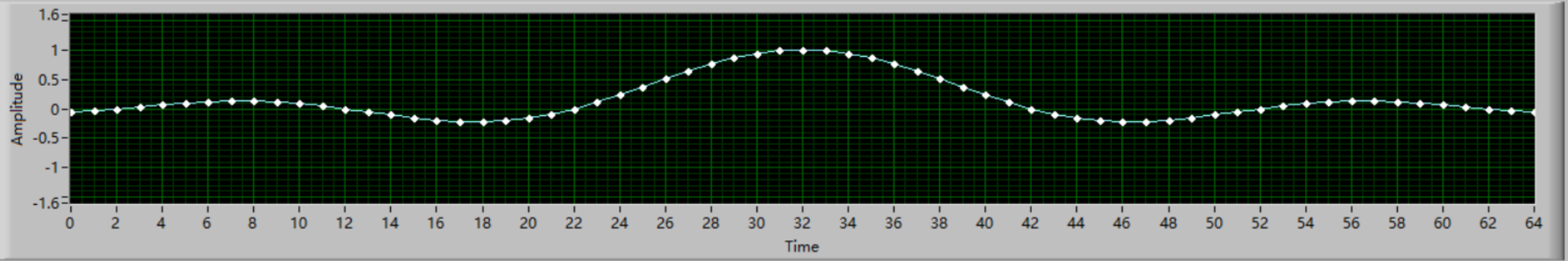
Symbol: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

Recovered Bits: 0 | 0 0 0 1 0 1 1 1 0 0

Baseband



Pulse Shaping



Baseband Transmission-Simple.vi

File Edit View Project Operate Tools Window Help

Baseband Transmission

Pulse Shaping Function: Sinc

Sinc Samples: 65

UpSample Factor: 1 20 40 60 80 100

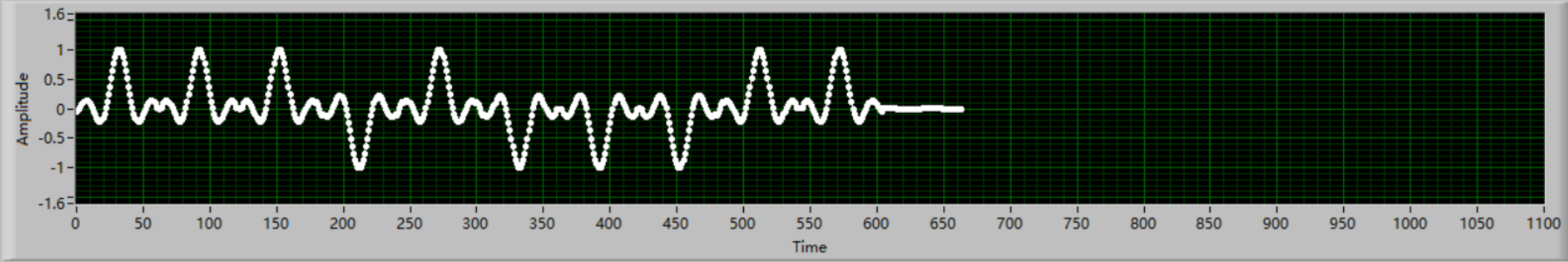
stop: STOP

Bit: 0 | 0 0 0 1 0 1 1 1 0 0

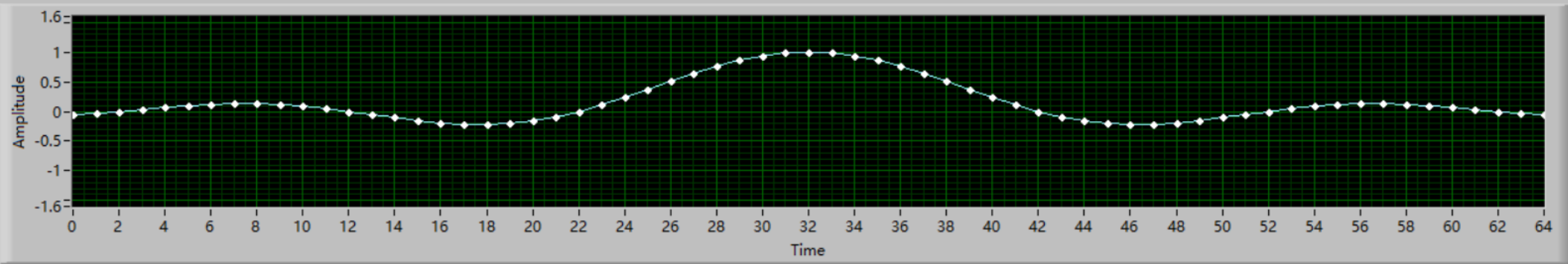
Symbol: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

Recovered Bits: 0 | 0 0 0 1 0 1 1 1 0 0

Baseband



Pulse Shaping



Baseband Transmission

Bit

0	0	0	0	1	0	1	1	1	0	0

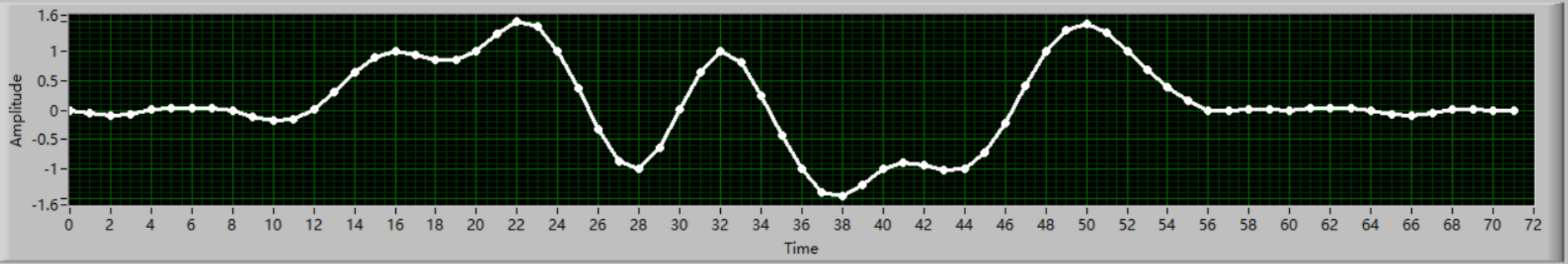
Symbol

0	1	1	1	-1	1	-1	-1	-1	1	1

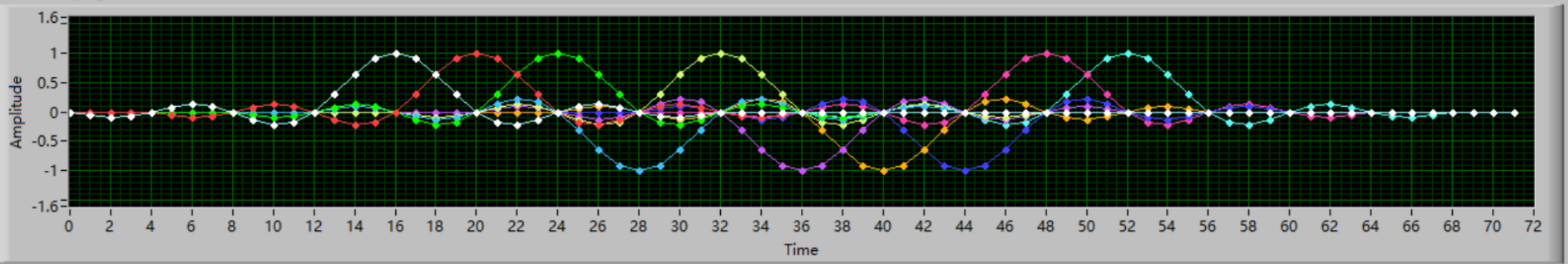
Pulse Shaping Function: Sinc

Upsampled Symbol: 0 | 1

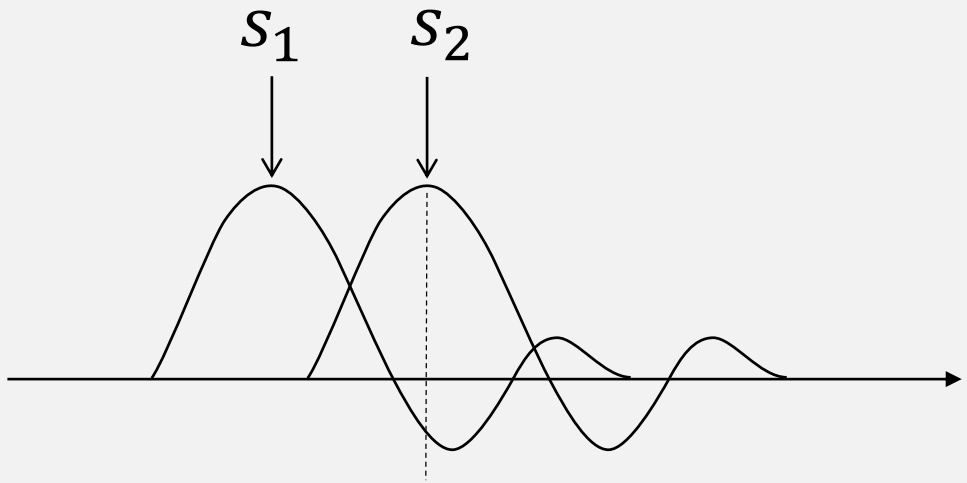
Baseband



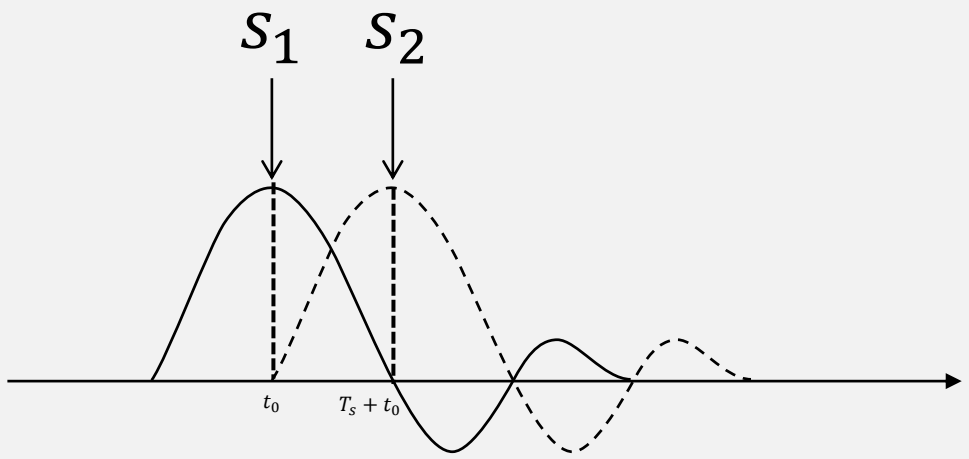
Pulse Shaping



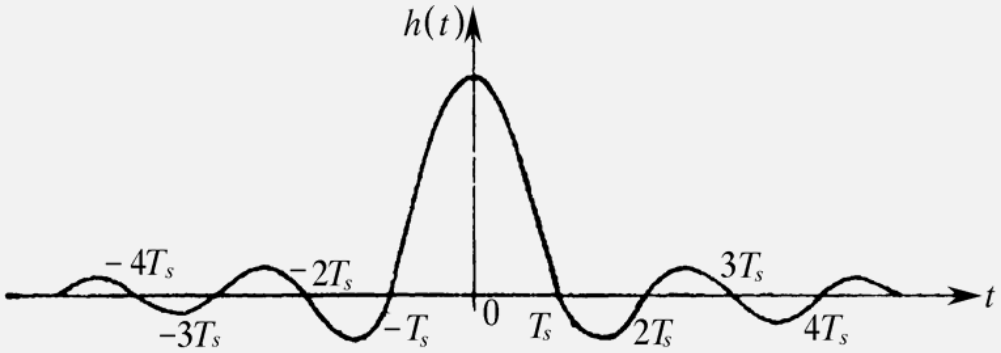
Inter-Symbol Interference (ISI)



Inter-Symbol Interference (ISI)



Send the S_2 waveform at $T_s + t_0$.



$$h(t)=\frac{\sin\frac{\pi}{T_S}t}{\frac{\pi}{T_S}t}$$

Baseband Transmission

Bit

0	0	0	0	1	0	1	1	1	0	0

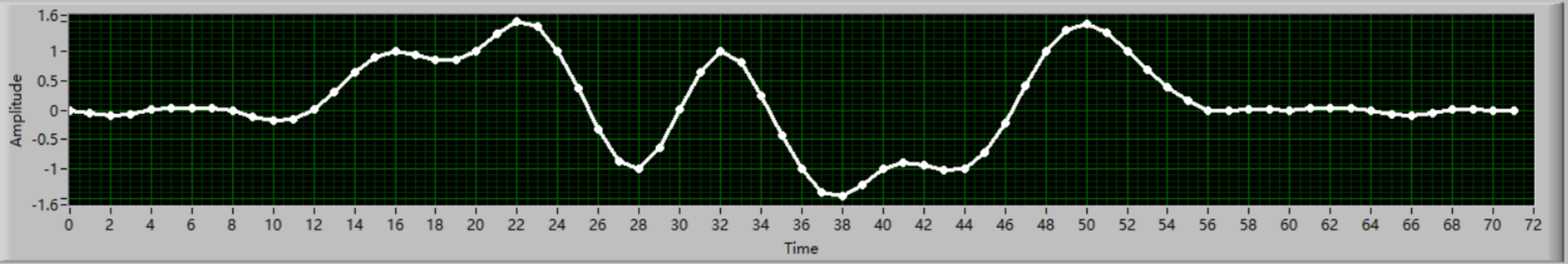
Symbol

0	1	1	1	-1	1	-1	-1	-1	1	1

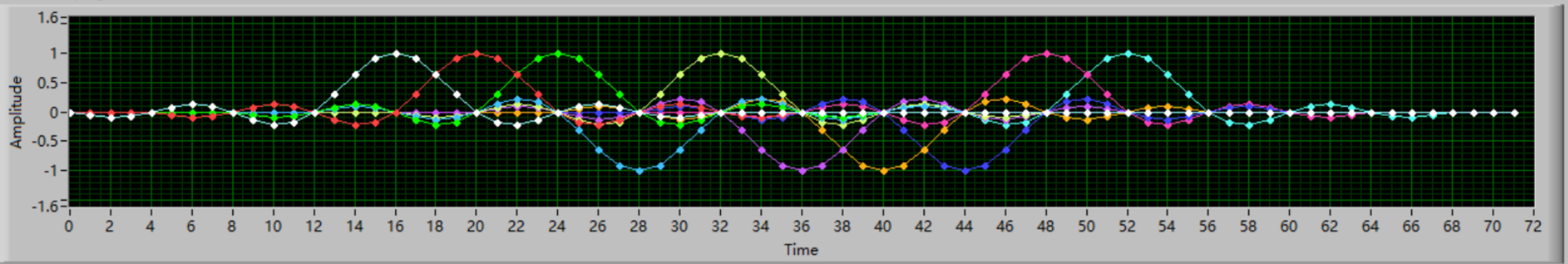
Pulse Shaping Function: Sinc

Upsampled Symbol: 0 | 1

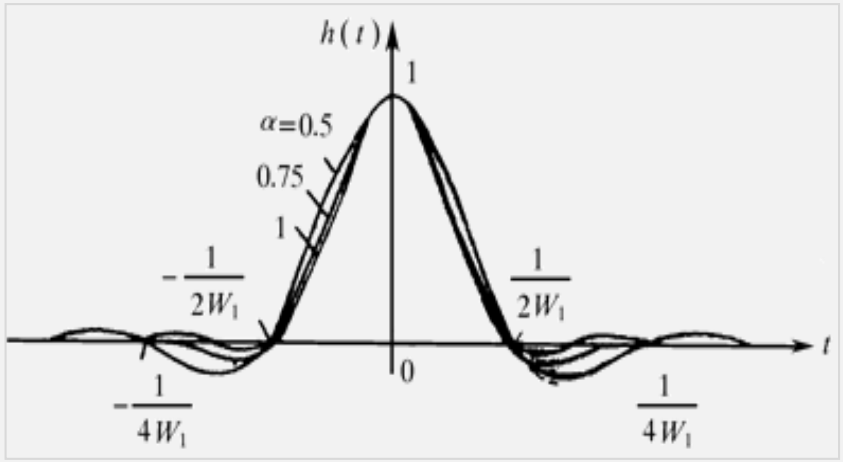
Baseband

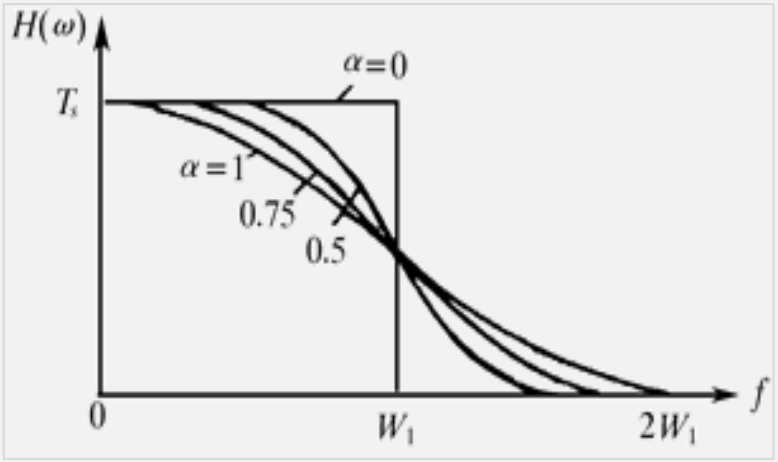


Pulse Shaping



Raised-cosine function





$$h(t)=\frac{\sin\frac{\pi}{T_S}t}{\frac{\pi}{T_S}t} \rightarrow h(t)=\frac{\sin \pi t/T_S}{\pi t/T_S}\cdot\frac{\cos \alpha\pi t/T_S}{1-4\alpha^2t^2/T_S^2}$$

$$H(\omega)=\begin{cases} T_S, & 0\le|\omega|<\frac{(1-\alpha)\pi}{T_S} \\ \frac{T_S}{2}[1+\sin\frac{T_S}{2\alpha}(\frac{\pi}{T_S}-\omega)], & \frac{(1-\alpha)\pi}{T_S}\le|\omega|<\frac{(1+\alpha)\pi}{T_S} \\ 0, & |\omega|\ge\frac{(1+\alpha)\pi}{T_S} \end{cases}$$

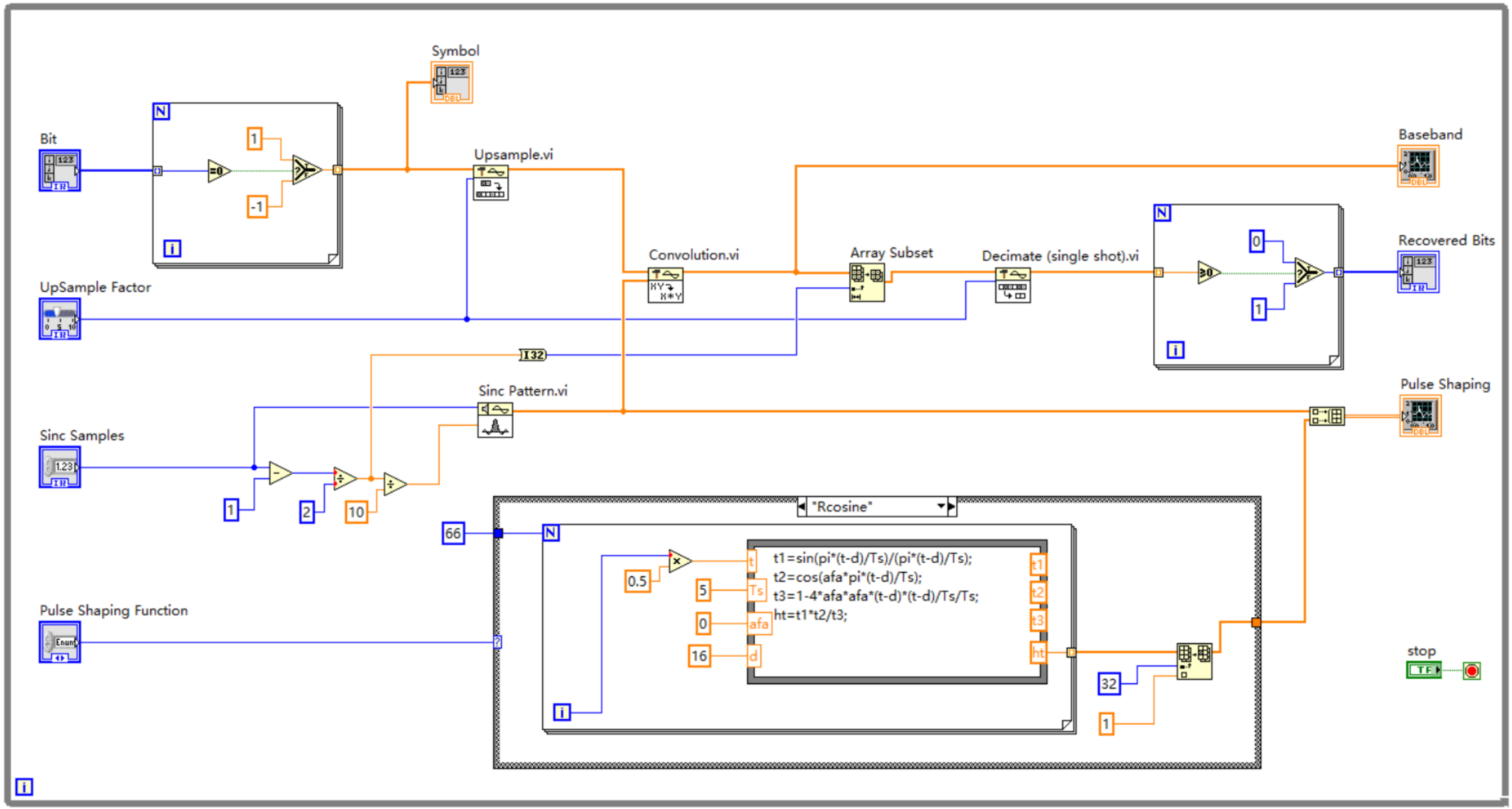
Demo: Baseband Transmission

Baseband Transmission-Simple - Demo.vi Block Diagram

File Edit View Project Operate Tools Window Help

18pt Application Font

Search



Baseband Transmission-Simple - Demo.vi

File Edit View Project Operate Tools Window Help

Baseband Transmission

Pulse Shaping Function: Rcosine

Sinc Samples: 65

UpSample Factor: 1 20 40 60 80 100

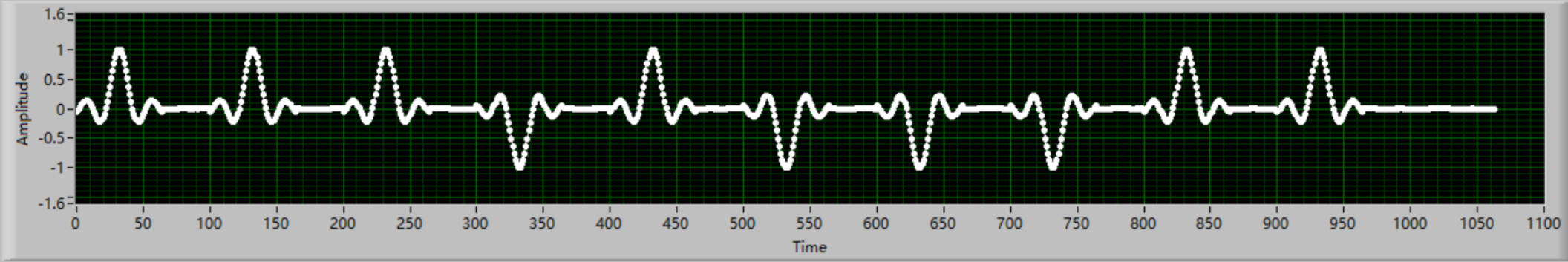
stop: STOP

Bit: 0 | 0 0 0 1 0 1 1 1 0 0

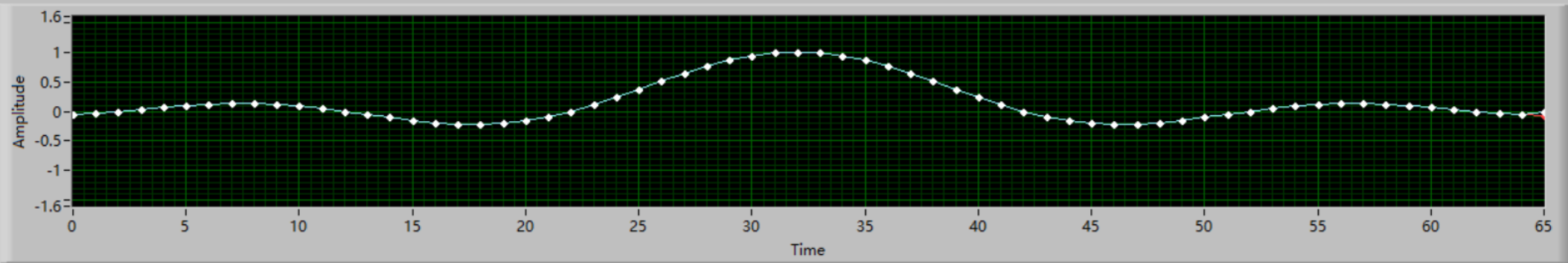
Symbol: 0 | 1 1 1 -1 1 -1 -1 -1 1 1

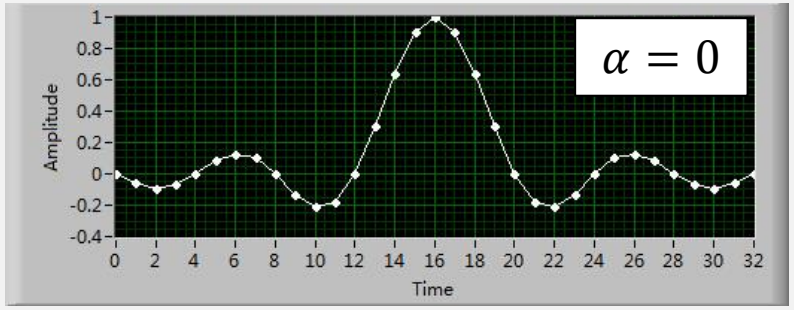
Recovered Bits: 0 | 0 0 0 1 0 1 1 1 0 0

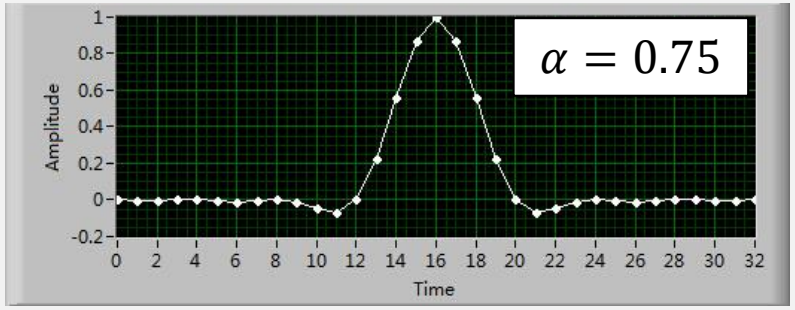
Baseband



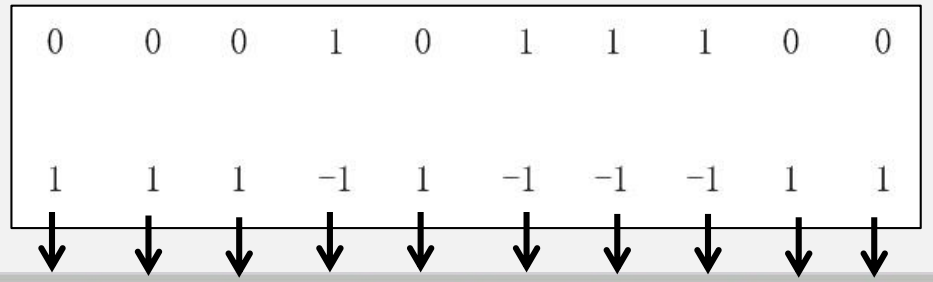
Pulse Shaping

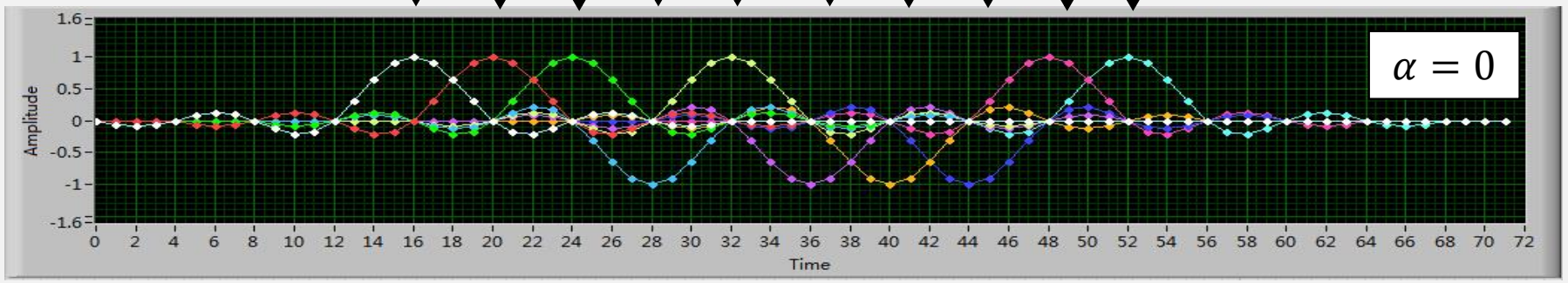


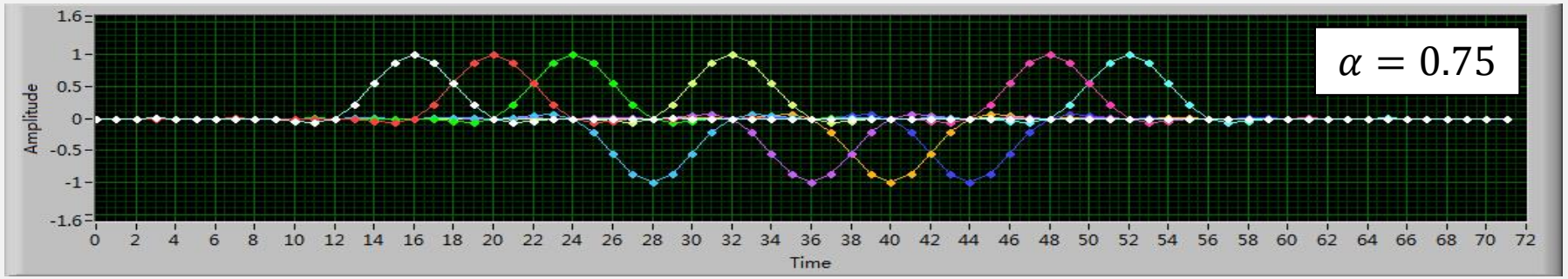

$\alpha = 0$
Amplitude
Time

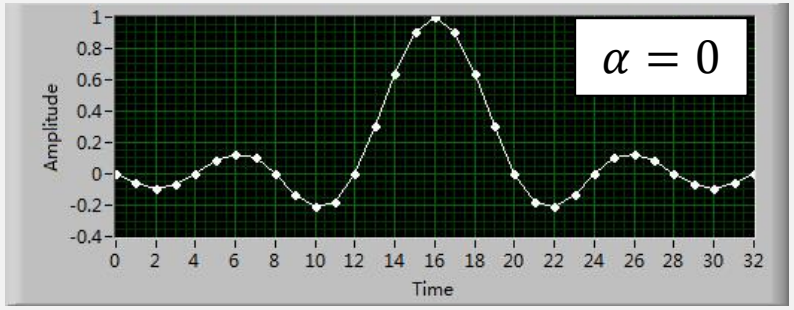

$\alpha = 0.75$
Amplitude
Time

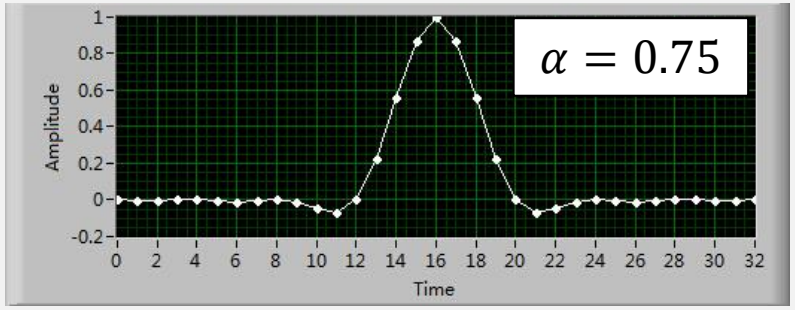
Bits Stream


0 0 0 1 0 1 1 1 0 0
1 1 1 −1 1 −1 −1 −1 1 1

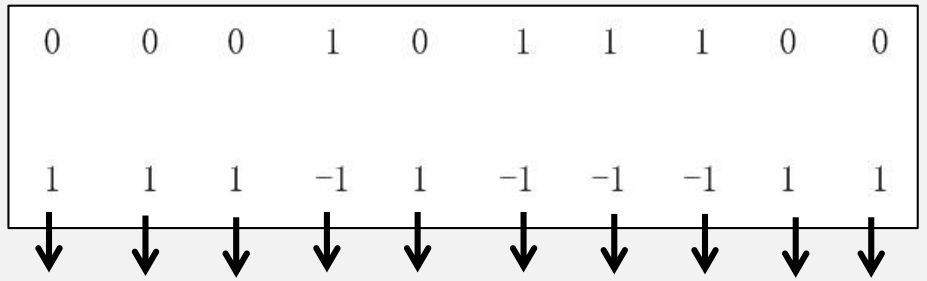

$\alpha = 0$
Amplitude
Time

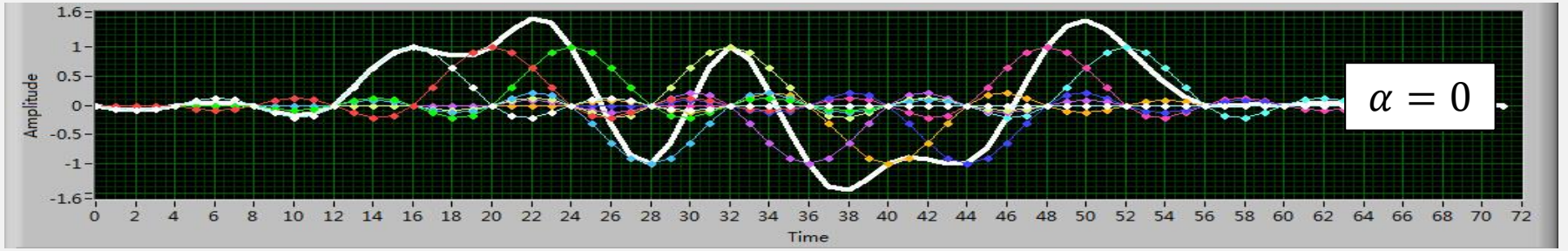

$\alpha = 0.75$
Amplitude
Time

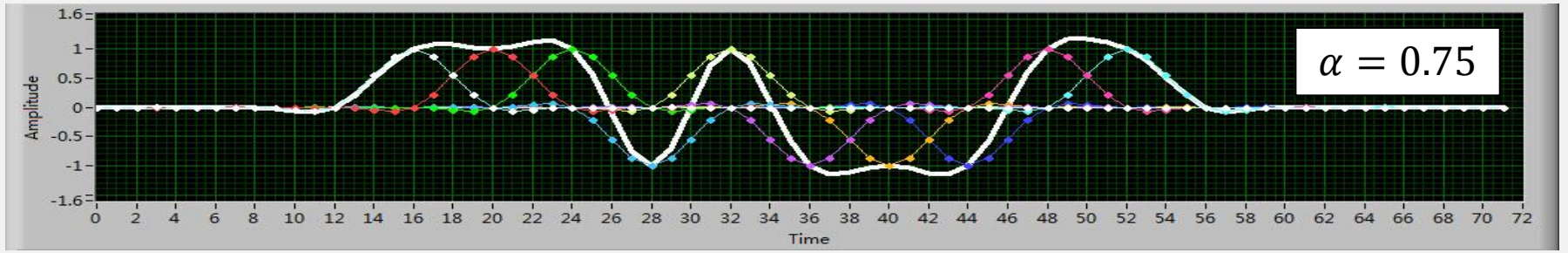

$\alpha = 0$
Amplitude
Time


$\alpha = 0.75$
Amplitude
Time

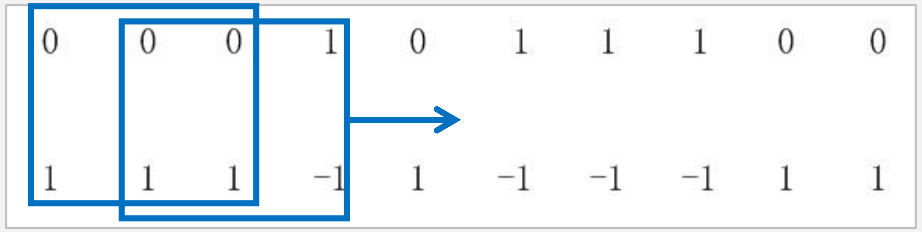
Bits Stream

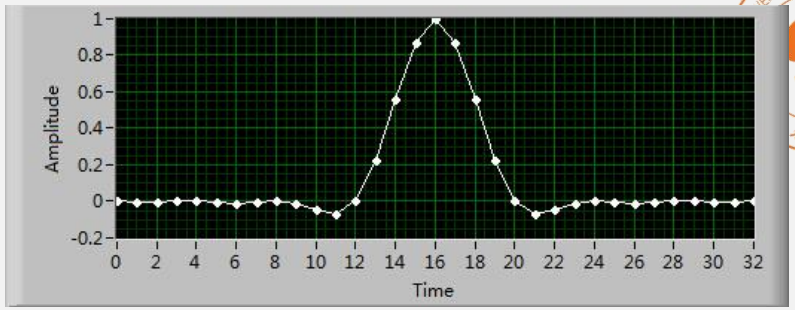

0 0 0 1 0 1 1 1 0 0
1 1 1 −1 1 −1 −1 −1 1 1

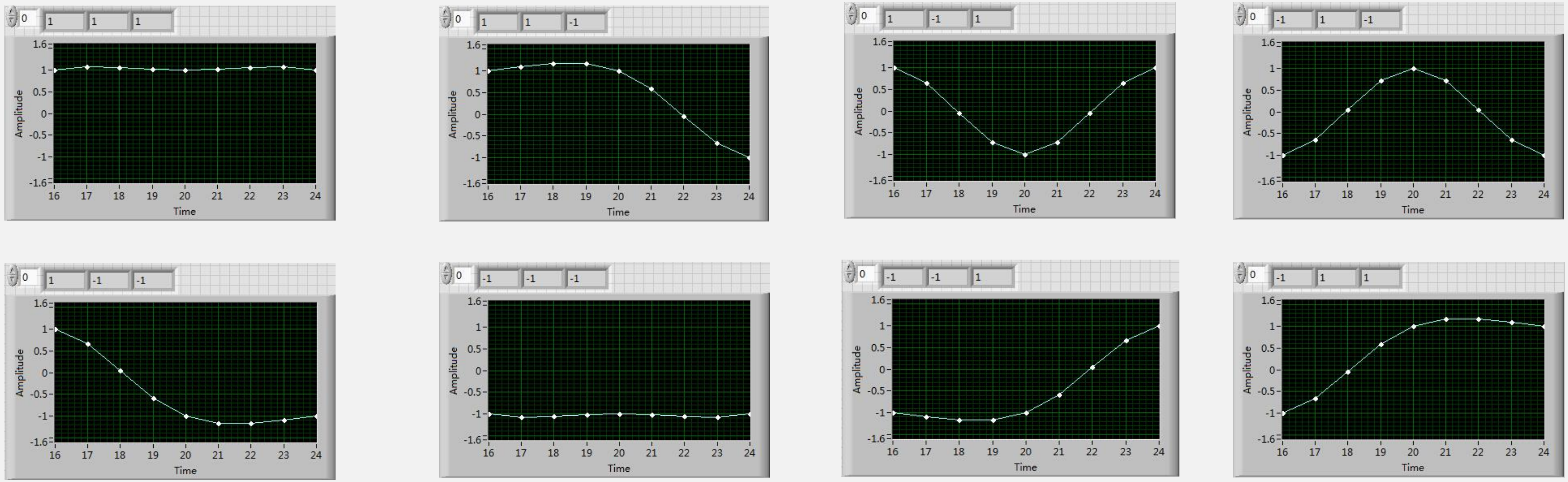

$\alpha = 0$
Amplitude
Time

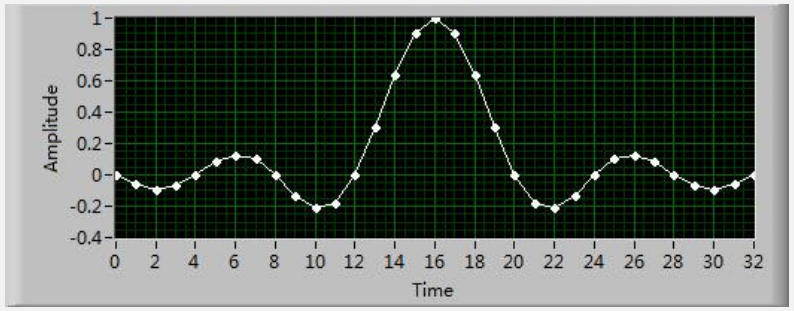

$\alpha = 0.75$
Amplitude
Time

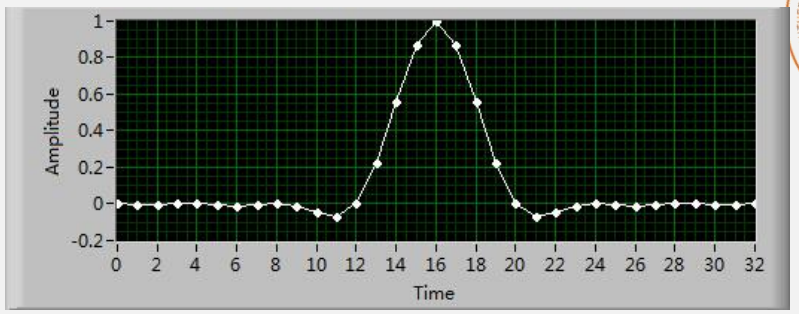
Demo: Eye Diagram


0 0 0 1 0 1 1 1 0 0
1 1 1 −1 1 −1 −1 −1 1 1


Amplitude
Time

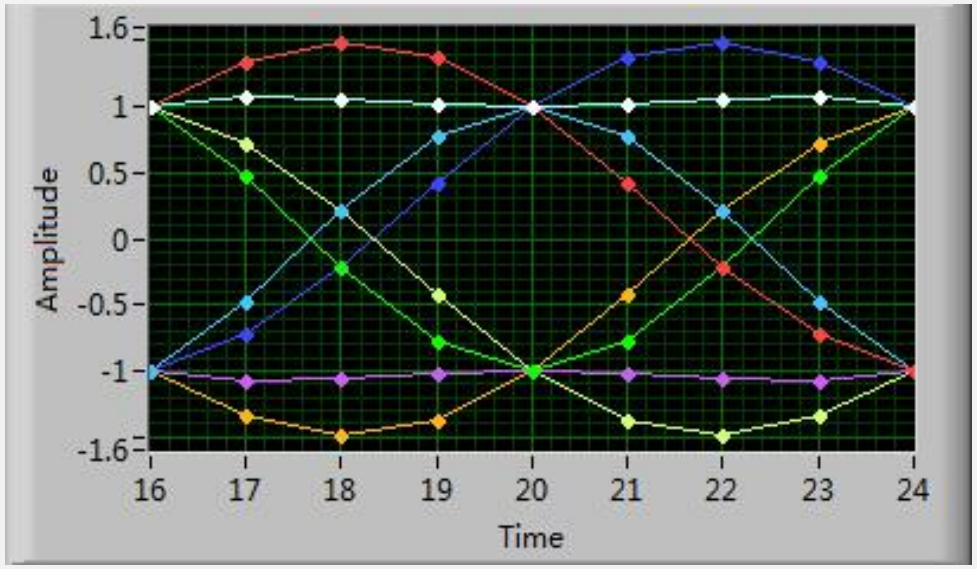

0 1 1 1
0 1 1 -1
0 1 -1 1
0 -1 1 -1
0 1 -1 -1
0 -1 -1 -1
0 -1 -1 1
0 -1 1 1
Amplitude
Time

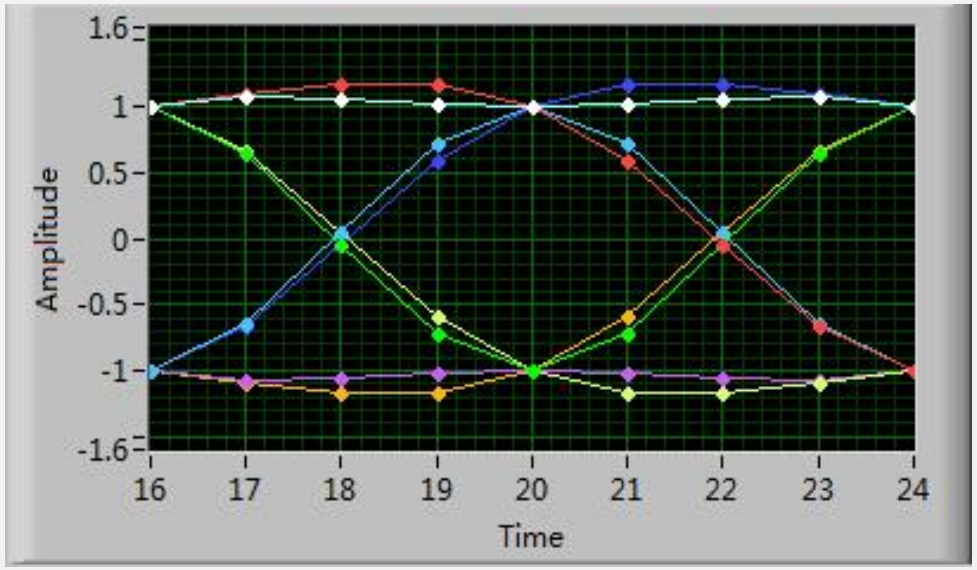




$\alpha = 0$

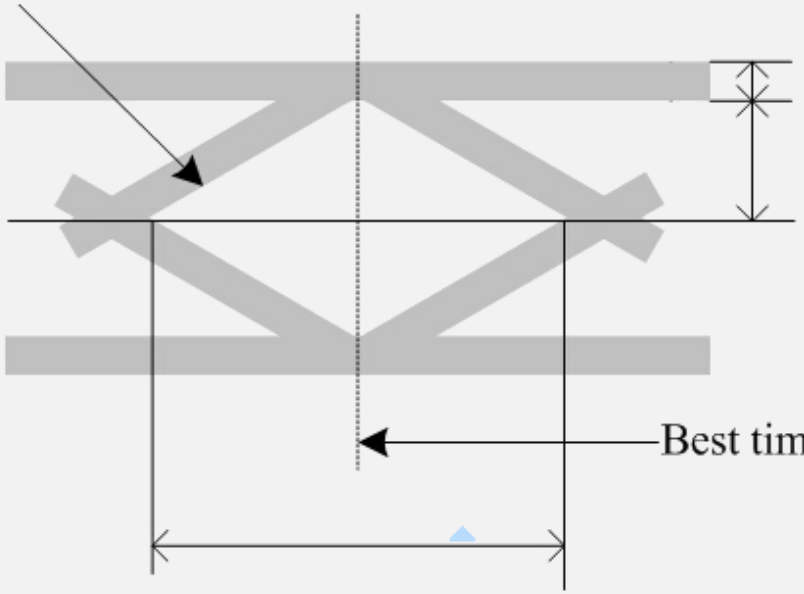
$\alpha = 0.75$





Eye Diagram

Slope indicates sensitivity to timing error.



Amount of distortion at sampling instant.
Amount of noise that can be tolerated by the signal, the larger is better.

Best time to sample

Opening of the eye, time over which we can successfully sample the waveform

- Question ?