Lab 6：Baseband Transmission

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Introduction:

1. Basic principles of FM modulation/demodulation

Basic principles:

- **Symbol Mapping:**Symbol mapping is a process used in digital baseband transmission where discrete digital information symbols are mapped into a series of continuous-time waveforms that can be transmitted over a communication channel.
  The mapping process is often designed to optimize the use of available channel bandwidth, while minimizing the effects of noise and interference. The resulting signal can be transmitted over the communication channel using a modulation scheme, such as Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), or Phase Shift Keying (PSK).
- **Interpolation:**Interpolation is the process of estimating a value between two known values. In Digital Signal Processing, interpolation is often used to upsample a signal, which means to increase the sample rate or the number of samples per second. This is often done in order to prepare a signal for further processing or transmission. Interpolation can be performed by various methods, as linear, cubic, or spline interpolation. Linear interpolation, for example, estimates the value of a point between two known points as a straight line, while cubic interpolation estimates the value as a more complex curve. The choice of the interpolation method depends on the application and the desired accuracy of the estimated values.
- **Pulse Shaping**: pulse shaping is a process used in digital signal processing to modify or shape a pulse waveform. The goal of pulse forming is to tailor the pulse waveform to meet specific needs of a communication system, such as reducing interference, optimizing energy efficiency, or increasing the signal-to-noise ratio. There are many techniques for pulse forming, and the choice of technique depends on the specific application and the desired characteristics of the pulse waveform. Some popular techniques include Gaussian pulse shaping, raised cosine pulse shaping, and root-raised cosine pulse shaping. These methods modify the pulse waveform by varying the amplitude and phase of the transmitted signal. Pulse shaping is widely used in digital communication systems, such as wireless communication systems, fiber optic communication systems, and satellite communication systems. The choice of pulse shaping technique can significantly affect the performance of the communication system, and careful consideration should be given to the choice of technique.
- **Ascending Cosine Roll-Off Function:** The ascending cosine roll-off function, also known as raised cosine filter, is commonly used as a pulse shaping filter in digital baseband transmission systems. The main role of this filter is to limit the bandwidth of the transmitted signal in order to reduce

intersymbol interference (ISI) between successive symbols. When symbols are transmitted over a communication channel, they are generally represented as a series of pulses. These pulses can potentially overlap with each other, causing ISI and making it difficult for the receiver to correctly determine the transmitted symbols. By using a pulse shaping filter such as the raised cosine filter, the width of each pulse is extended, and its shape is modified so that the pulse energy is spread out over a wider period of time. This reduces the potential overlap between successive symbols, thus reducing the potential for ISI.

- **ISI:** Inter-symbol interference (ISI) is a phenomenon that occurs in digital communication when the transmitted pulses overlap in time or when there is a delay in the received signal. The resulting signal distortion can make it difficult for the receiver to accurately decode the information.
- **Eye Diagram:**An eye diagram is a commonly used tool in the analysis of digital communication systems. It is a graphical representation of a digital signal's waveform characteristics over time, which enables an engineer to visualize the performance of the signal in terms of jitter, noise, and other signal impairments. Specifically, an eye diagram shows the superimposed waveforms of several consecutive transmitted bit sequences over time, with each sequence represented as a horizontal line. Typically, the diagram is overlaid with a grid of horizontal and vertical markers that help to determine the signal characteristics, such as rise time, fall time, and timing jitter. By analyzing the eye diagram, it is possible to determine the extent of signal distortion, the level of noise, and the effectiveness of various signal processing techniques used for correcting or mitigating signal impairments. This makes the eye diagram a valuable tool for optimizing and troubleshooting digital communication systems.

2.LabVIEW Express Module:

- **UpSample module:**

  In LabVIEW, the UpSample module is used to insert zeros between samples of an input signal to increase the signal's sample rate. This is also known as an upsampling operation. When a signal is upsampled, new samples are generated by adding zeros to the original signal's sample stream. The UpSample module uses an interpolation filter to filter out the images that would be generated due to the upsampling process.

  The UpSample module takes an input signal along with an integer value which specifies the upsample factor. The module then inserts zeros between every original sample and applies an interpolation filter to the resulting signal. The output signal will have a higher sample rate and increased resolution.

- **Sinc Pattern Module:**

  In LabVIEW, the Sinc Pattern module is a function that generates a signal with a Sinc shape--that is, a waveform that is a sinusoidal function divided by the independent variable. The Sinc Pattern module is typically used for filtering and resampling operations.

  The Sinc Pattern module takes as input parameters the desired length of the output signal, the sample rate of the input signal, and the cutoff frequency of the filter. Typically, the cutoff frequency is specified as a fraction of the Nyquist frequency - highest that can be represented by the sampled data.

Once these parameters have been specified, the Sinc Pattern module generates a waveform with a Sinc shape, centered around the mid-point of the signal. This waveform acts as the filter kernel to be convolved with the original signal. The length of the filter kernel depends on the cutoff frequency chosen.

- **Arctangent Module:**

  In the LabVIEW Decimate module, the downsampling operation is accomplished by selecting every Nth sample in the input signal, where N is the decimation factor. The module features several options for resampling, such anti-aliasing filter design and filter order.

  The anti-aliasing filter design is the process of designing a filter that removes higher frequency components that might cause aliasing, which occurs when the signal frequency content exceeds the Nyquist frequency. The filter order determines the complexity of the filter and can help improve the signal quality.

- **Sinc Pattern Module:**

  Formula nodes in LabVIEW are a programming construct that allows you to write mathematical expressions in textual form. You can use them to perform calculations on input data, manipulate signals, or transform data into different representations.

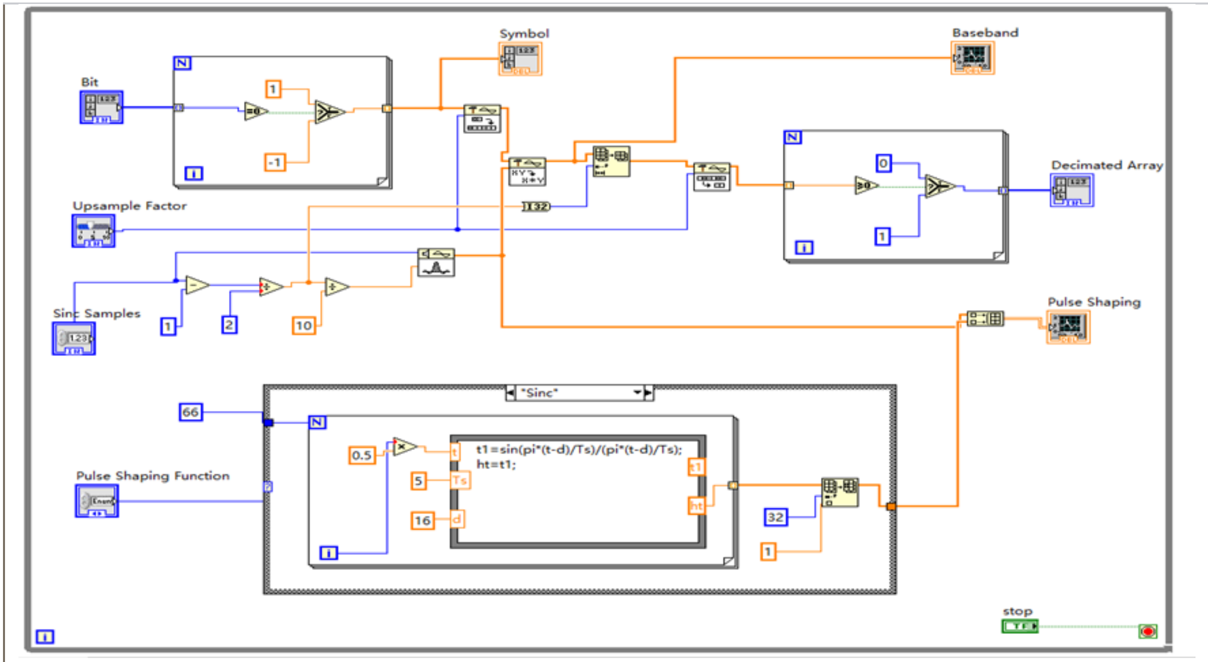
  Using a formula node is straightforward. You drag a formula node from the functions palette and place it on the block diagram. Then you double click the node and insert your mathematical expression or formula. The inputs and outputs of the formula node are represented by terminals, which are connected to other nodes on the block diagram.

  Formula nodes can be used for complex mathematics and higher-level algorithms. LabVIEW provides a rich set of mathematical functions, including trigonometric, exponential, logarithmic, and statistical functions. You can use these functions in combination with your own standard arithmetic operators.

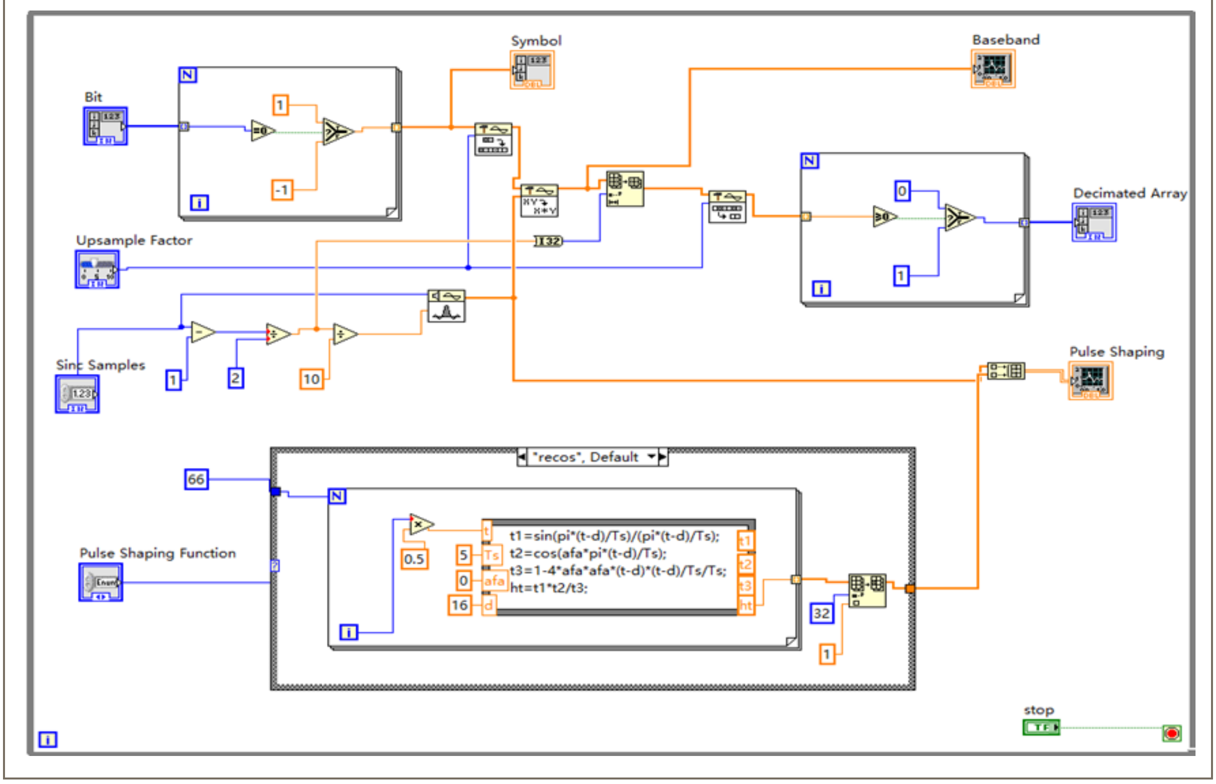
Lab results & Analysis:

1.The Simulation of Digital Baseband Transmission System

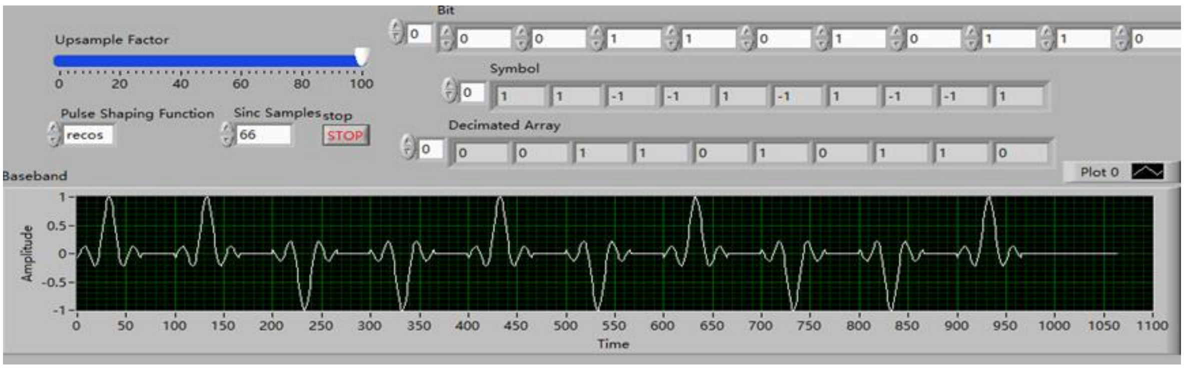
a.sinc modulation



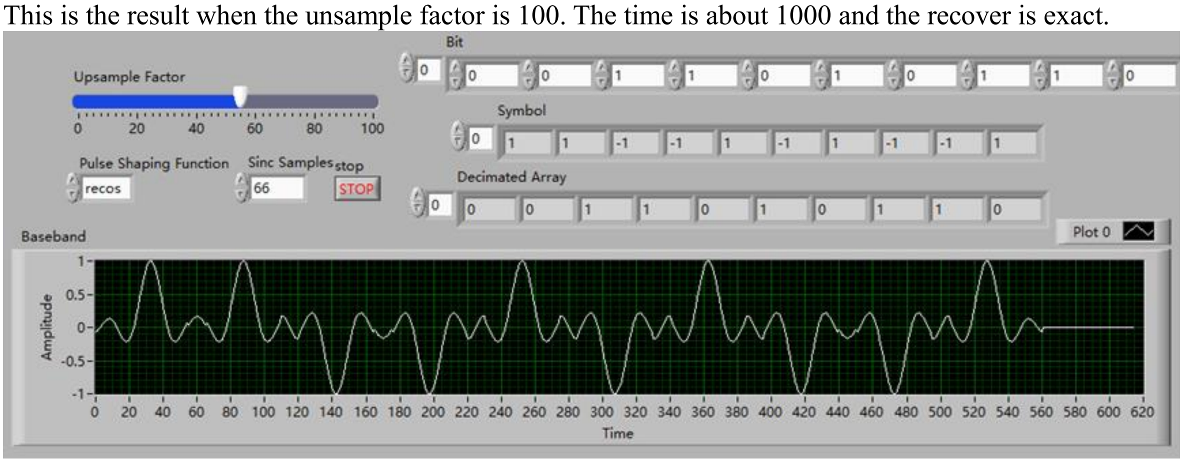
b.recos modulation



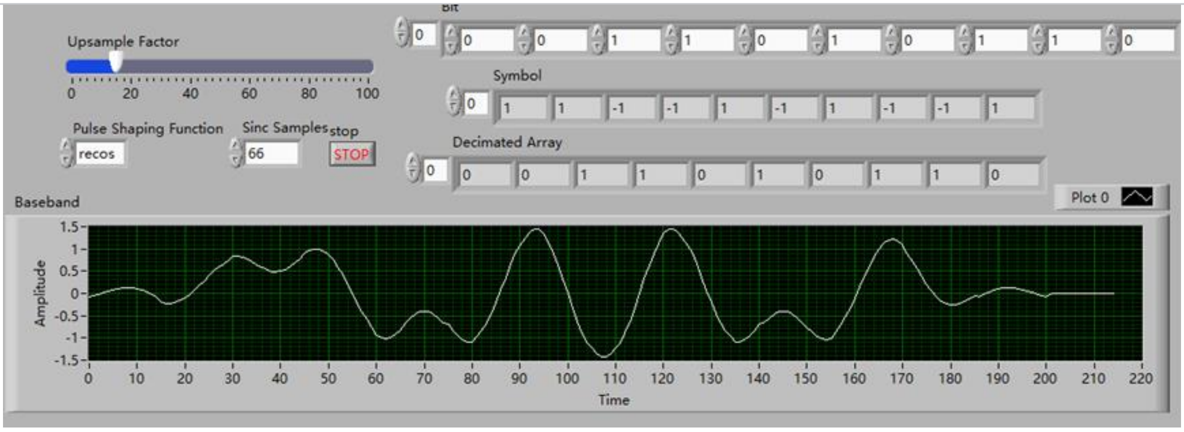
2.The effect of unsample factor on the system



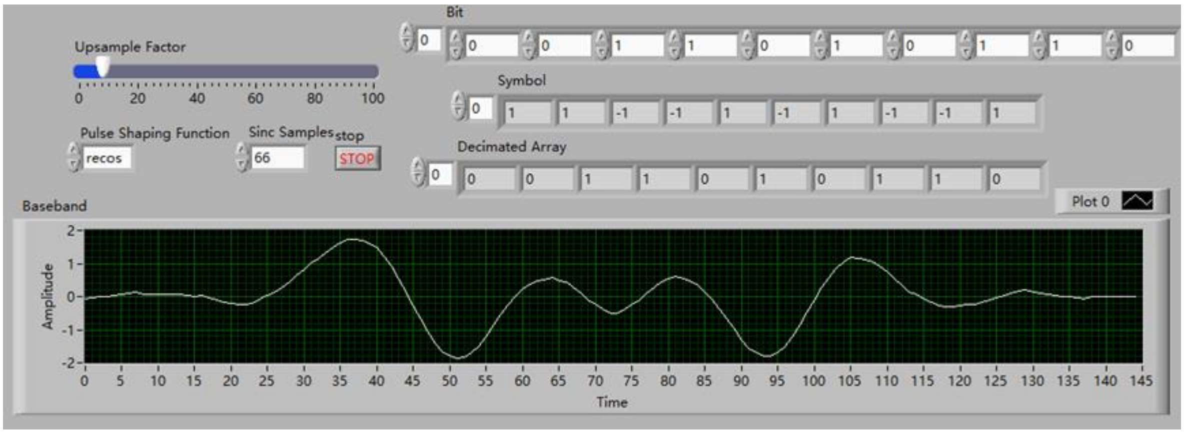
The higher the unsample factor, the longer the signal transformed, the longer the frequency band is. The unsamle factor has a connection about the distance between peeks of recos signals.
This is the result when the unsample factor is 100. The time is about 1000 and the recover is exact.



When the factor turn to 50 the time is about 620 and the recos signal show a part of overlap. But the recover signal is still exact.

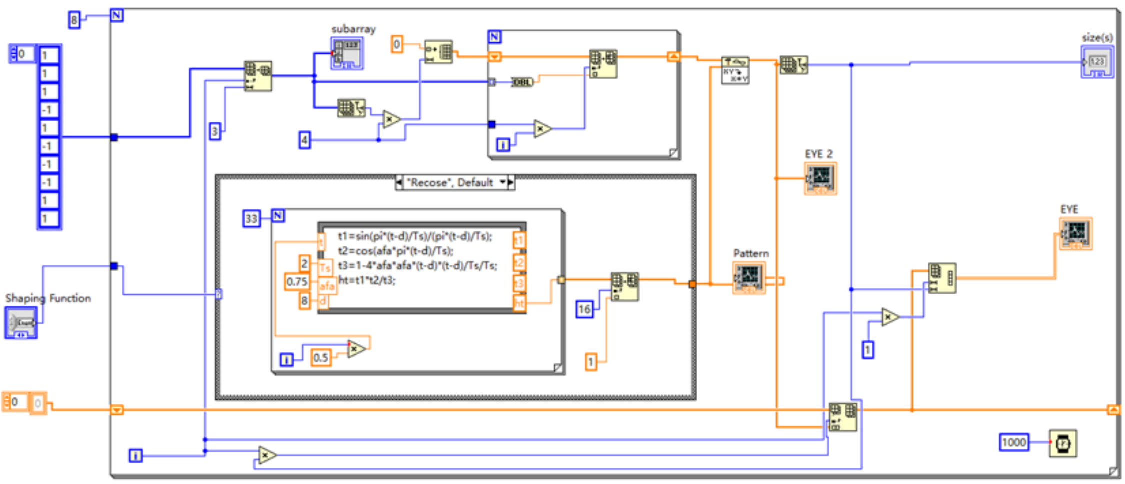


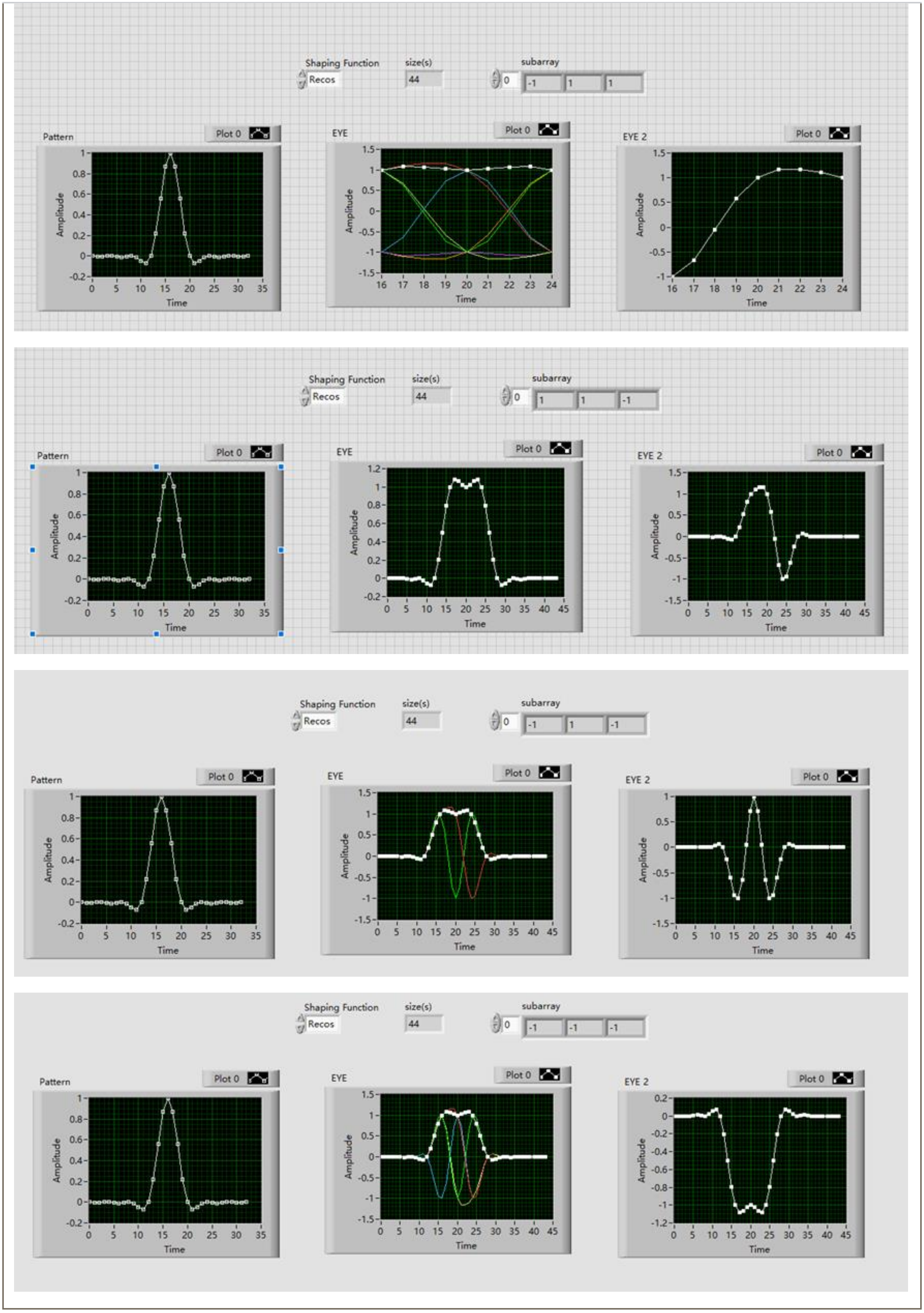
When the factor turn to 15. The deformation is serious. It’s hard to tell the full recos shape. But the output is still correct.



The factor is 6. The ISI appears. There is a large mistake in recovering.
From the results above we can see that the larger the unsample factor is, the more exact the recovery is. But it will cost more bandwith.

3.The Eye picture (based on formula Nodes)




Shaping Function
Recos
size(s)
44
subarray
0
-1
1
1
Pattern
Plot 0
Amplitude
Time
EYE
Plot 0
Amplitude
Time
EYE 2
Plot 0
Amplitude
Time
Shaping Function
Recos
size(s)
44
subarray
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Pattern
Plot 0
Amplitude
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EYE
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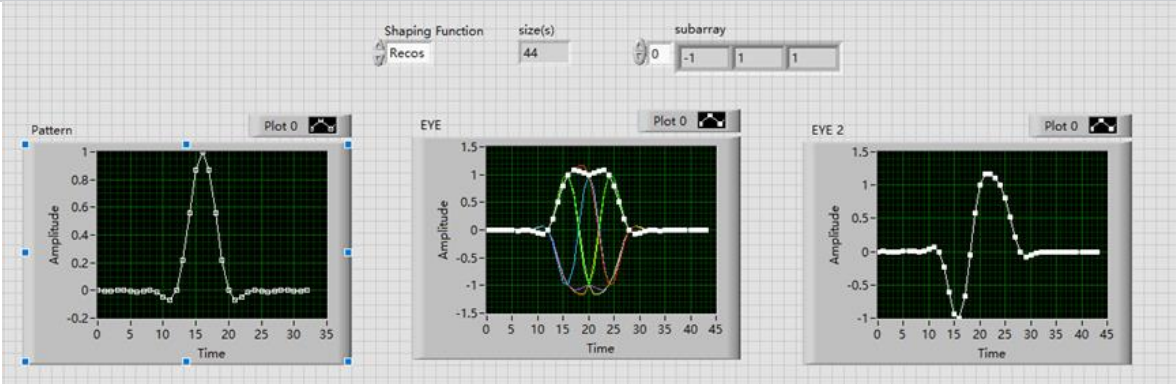
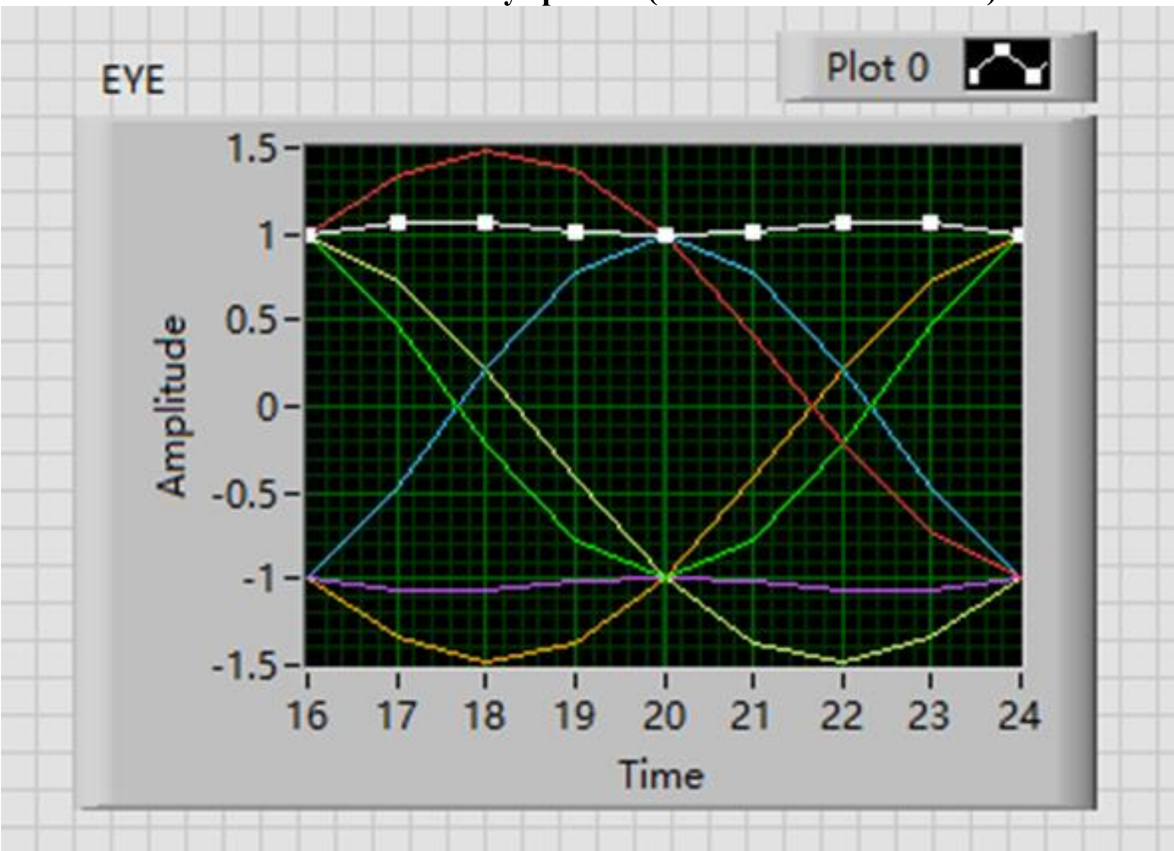


4.The effect of Roll down factor on Eye picture (based on formula Nodes)



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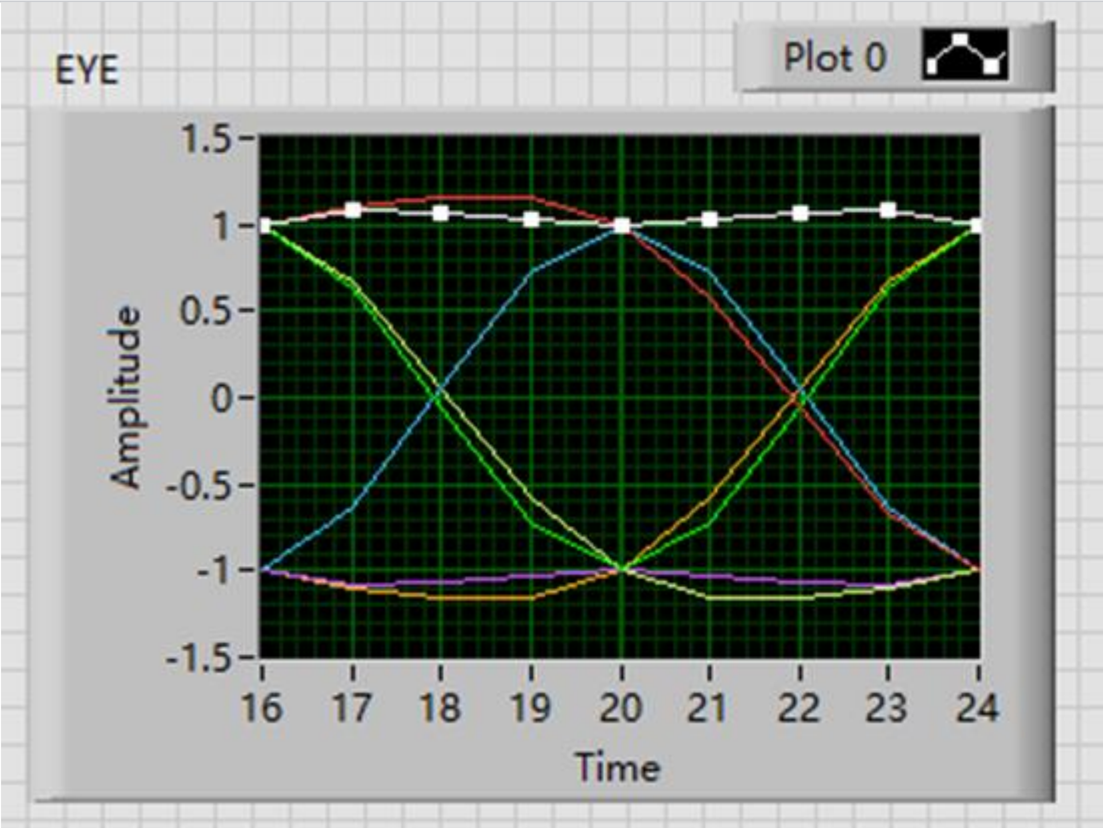

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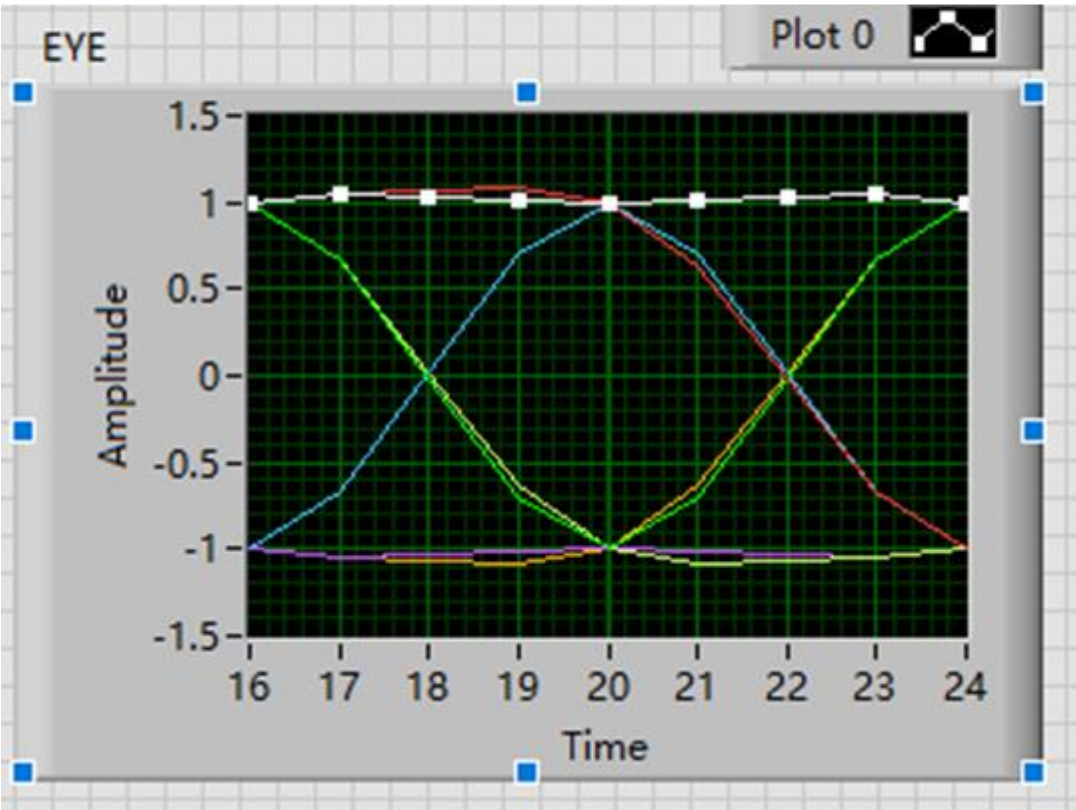

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4.Factors Affecting Digatal Baseband Modulation System

The performance of digital baseband modulation systems is affected by several factors, including the following:

- **Signal-to-Noise Ratio (SNR):** SNR is a measure of the quality of the received signal compared to the noise level. In digital baseband modulation systems, high SNR is desired to ensure reliable signal reception and decoding.
- **Carrier frequency offset:** Carrier frequency offset occurs when the transmitter and receiver oscillators are not at the same frequency. This can lead to distortion in the signal, which can result in errors in the modulation process.
- **Phase noise:** Phase noise is random phase variations in the signal caused by oscillator imperfections. High levels of phase noise can cause errors in the signal, leading to degradation of the modulation system's performance.
- **Interference:** Interference from other devices or sources can affect the quality of the received signal. This can cause errors in the modulation process, leading to lower performance.
- **Channel distortion:** Channel distortion when the signal travels through a communication channel and experiences filtering, attenuation, and other effects. This can lead to errors in the modulation process and lower the system's performance.
- **Modulation scheme:** The choice of modulation scheme affects the performance of the digital baseband modulation system. Some modulation schemes, such as QPSK and QAM, provide increased data throughput and increased spectral efficiency, while others, such as BPSK, offer better receiver sensitivity and reliability.

5.Advantages and Disadvantages of Digatal Baseband Modulation System and Its Value

Advantages:

- **Robustness:** Digital baseband modulation systems are less susceptible to noise and interference, as they use discrete signals that are easier to detect and correct errors.
- **Flexibility:** Digital baseband modulation systems can be easily adjusted and optimized for different applications and scenarios, allowing for efficient use of the available bandwidth.
- **Advanced Error Correction Techniques:** Digital baseband modulation systems are capable of using advanced error correction techniques to mitigate the effects of channel distortion and interference, enabling reliable communication over longer distances.
- **High Spectral Efficiency:** Digital baseband modulation systems can achieve higher spectral efficiency than analog modulation systems, allowing for more data to be transmitted in a given bandwidth.
- **Compatibility with Digital Data:**Digital baseband modulation systems can directly encode and transmit digital data, making them suitable for modern communications systems that use digital formats.

Disadvantages:

- **Higher Complexity:**Digital baseband modulation systems are more complex than analog modulation systems, requiring extensive processing and sophisticated hardware to operate effectively.

- **Latency:** Digital baseband modulation systems can introduce latency or delay in transmitting data due to the complexity of the modulation process.
- **Limited Range:** Digital baseband modulation systems typically have limited range due to the attenuation of high-frequency signals in the transmission medium.
- **Higher Bandwidth Requirements**:Digital baseband modulation systems require higher bandwidth than analog modulation systems to transmit the amount of data.
- **Vulnerability to Hacking:** Digital modulation systems can be vulnerable to hacking and interception, making them less secure than analog communication systems.

Value:

Digital baseband modulation is used in many social applications that we use regularly. For example:

Video chats: Applications such as Skype, Zoom, and FaceTime use digital baseband modulation to transmit video and audio signals in real-time. By converting the analog signals from your microphone and camera into digital signals, the applications can transmit your voice and video over the internet.

Text messages: Most messaging apps on your smartphone, such as WhatsApp, iMessage, and Facebook Messenger, use digital baseband modulation for sending text messages. The text is converted into digital data and sent over the internet, allowing users to communicate with each other in real-time.

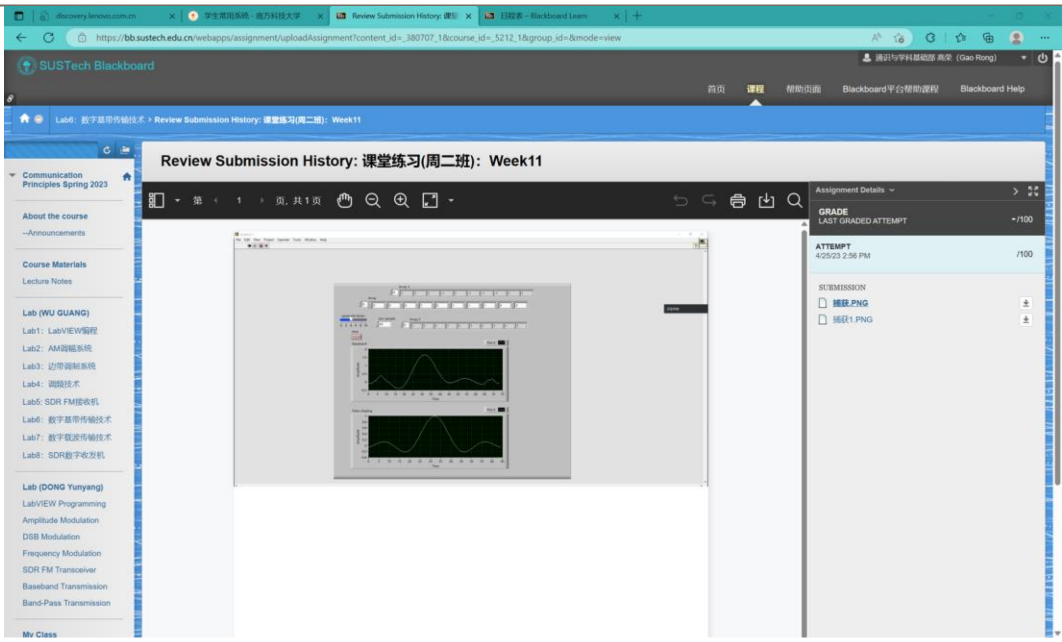
Phone calls: Digital baseband modulation is used in cell phones and other telecommunications systems to transform analog voice signals into digital signals. The digital signals are then transmitted over a digital network, allowing you to make phone calls from virtually anywhere in the world.

Overall, digital baseband modulation is necessary for social applications as it enables improved communication quality, faster transmission speeds, and enhanced security, ensuring that individuals can stay connected with each other reliably and securely.

Experience:

Submit shot:

12110301 高荣：



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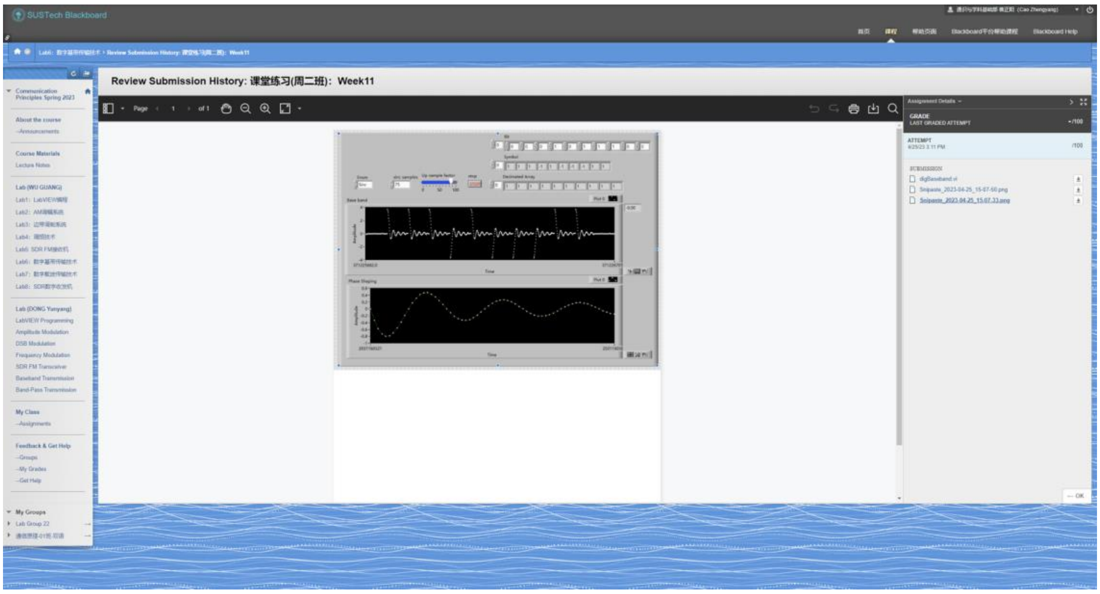

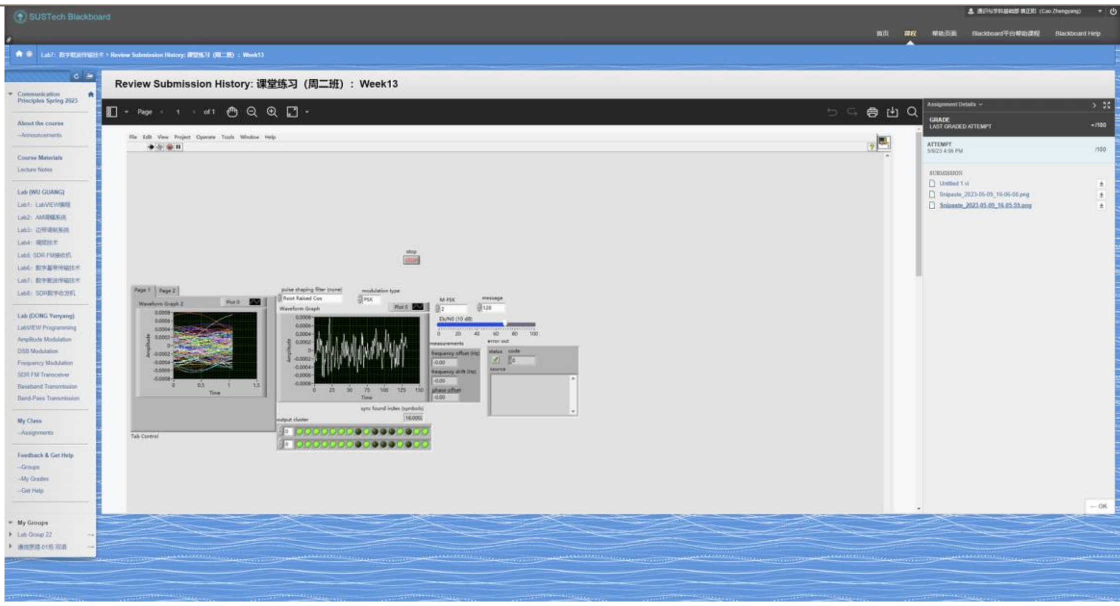

Score:	高荣：96　　曹正阳：95