Round 2

Experiment ID: <mark>(NUMBER?)</mark> **PCM Simulator**

1. Story Outline:

Pulse code modulation (PCM) is a type of analog to digital (A/D) conversion technique in which the input analog signal is sampled at regular intervals and the information in each sample is represented in digital form. The goal of this experiment is to understand the basic principle of pulse code modulation (PCM) and demodulation and how well the analog signal at the transmitter is converted into n-bit binary (digital) using sampler, quantizer and encoder. Sampling is the process of converting continuous time signal into discrete time signal. The continuous amplitude signal is converted into discrete amplitude signal by means of quantizer and the signal discrete in both time and amplitude into digital using encoder. The baseband signal at the receiver is retrieved from the encoded binary data by using decoder and reconstruction filter. The required transmission bandwidth, signaling rate, and signal to quantization noise ratio (SQNR) are examined to evaluate the performance of the PCM system.

2. Story:

1.1: Set the visual stage description:

The simulator workspace comprises of the blocks sine wave generator, sampler, quantizer, encoder, decoder, reconstruction filter and evaluate block. The position of the blocks are static and wires are to be connected by the user as per the block diagram to perform pulse code modulation and demodulation.

1.2: Set user objectives & Goals:
- State the principle of pulse code modulation and demodulation.
- Recall sampling, quantization, encoding and decoding process for analog to digital conversion.
- Calculate the required transmission bandwidth and signaling rate of PCM signal.

- Analyze the performance of PCM system by varying the frequency and amplitude of the input baseband signal.
- Evaluate signal to quantization ratio (SQNR) of PCM signal to analyze the efficacy of PCM.

1.3: Set the pathway activities:

- Students should click on the theory icon to browse through the theory and procedure for simulating Pulse Code Modulation and Demodulation.
- The user should next connect the blocks as per the block diagram in theory. This is done by clicking the connection points (red circles on every block) in the correct order.
- Double click the sine wave generator block to set the amplitude and frequency of the input signal
- Double click the sampler block to set the frequency of the sampler(sampling frequency)
- Double click the quantizer block to view the quantized form of the wave.
- Double click the encoder block to observe the PCM wave for various bit lengths.
- Double click the decoder block to observe the decoded wave.
- Double click the Reconstruction Filter block to observe the reconstructed wave.
- Double click the Evaluate block to view overall PCM plot and transmission bandwidth, signaling rate and SQNR of the system are observed
- Vary the amplitude, frequency and sampling frequency to avoid distortion and compare the same with the simulated result.
- Calculate the output signal parameters like transmission bandwidth, signaling rate and SQNR for the proposed circuit and compare the same with the simulation generated values.

1.4: Set Challenges and Questions/Complexity/Variation:

1. Identify the suitable digital pulse modulation which represent the signal in the form of sequence of coded pulses.

   a) AM
   b) FM
   c) PM
   d) PCM
   Answer d

2. Calculate the signal to quantization noise ratio of 7- bit PCM system for the message bandwidth of 500 Hz.
   a) 53.8 dB
   b) 43.8dB
   c) 63.8dB
   d) 33.8dB
      Answer: b

3. What is the drawback of PCM?
   a) Increased delay
   b) Increased bandwidth
   c) Analog output
   d) Digital output

      Answer: b

4. Find the transmission bandwidth and signaling rate of 9- bit PCM for the message bandwidth of 800Hz.
   a) 7.2KHz, 14.4Kbps
   b) 8KHz,16Kbps
   c) 6.kHz, 3Kbps
   d) 9.2 KHz, 9.2Kbps

      Answer: a

5. Identify the block in PCM which converts continuous amplitude samples into discrete amplitude samples.

a) Sampler
b) Encoder
c) Quantizer
d) Repeater
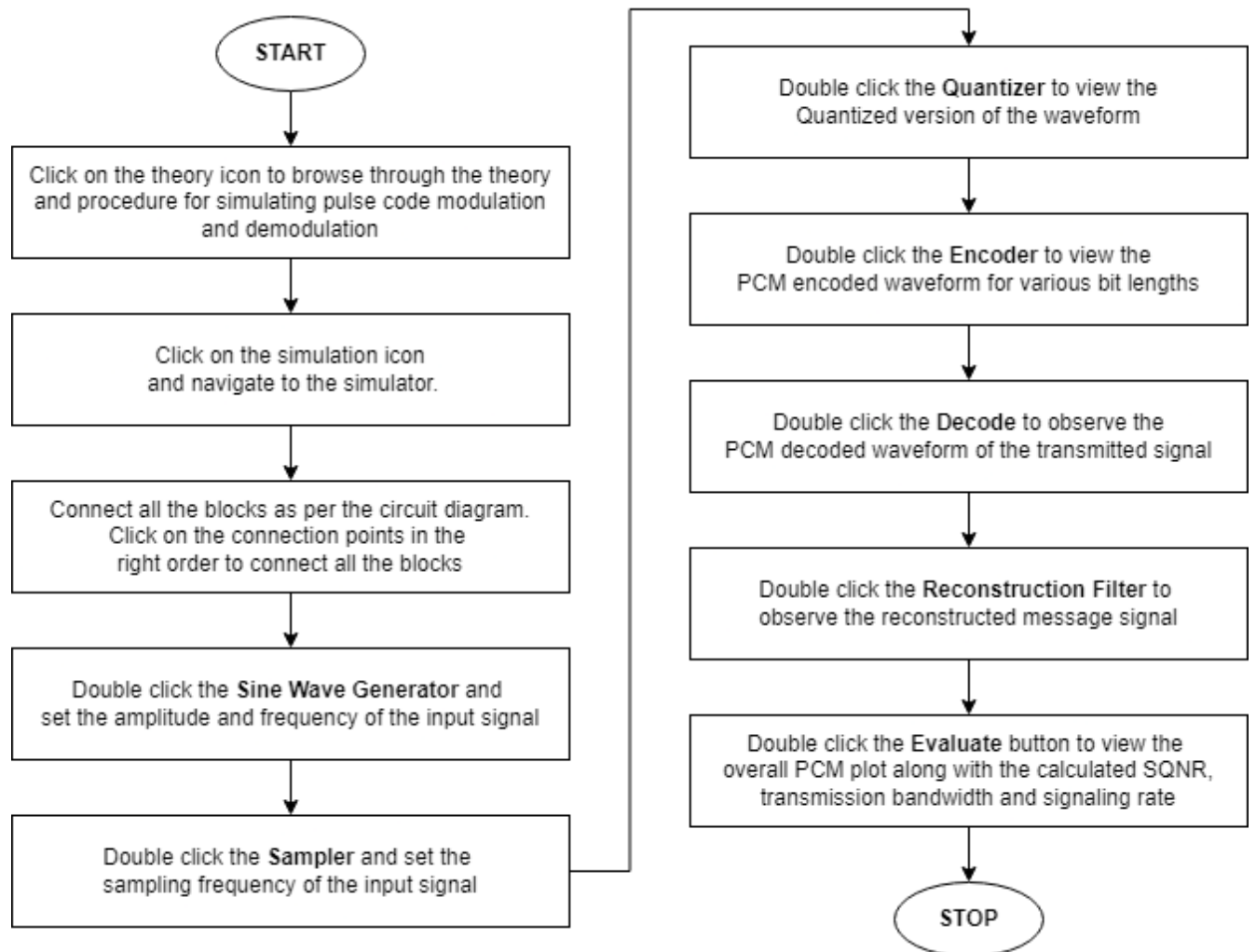   Answer : c

1.5: Allow pitfalls: NA

1.6: Conclusion:

By doing the above experiment the user would get familiarized with the concept of pulse code modulation and demodulation. The approximate time required to understand the procedure to perform the experiment would take about 5 min. To connect all the different blocks and to set the input parameter for modulation & demodulation will take another 7 min. Analyzing the output with theory calculations will take 5 min. Answering the assessment questions will take about 5 min. The total time needed to perform the experiment is around 22 mins.
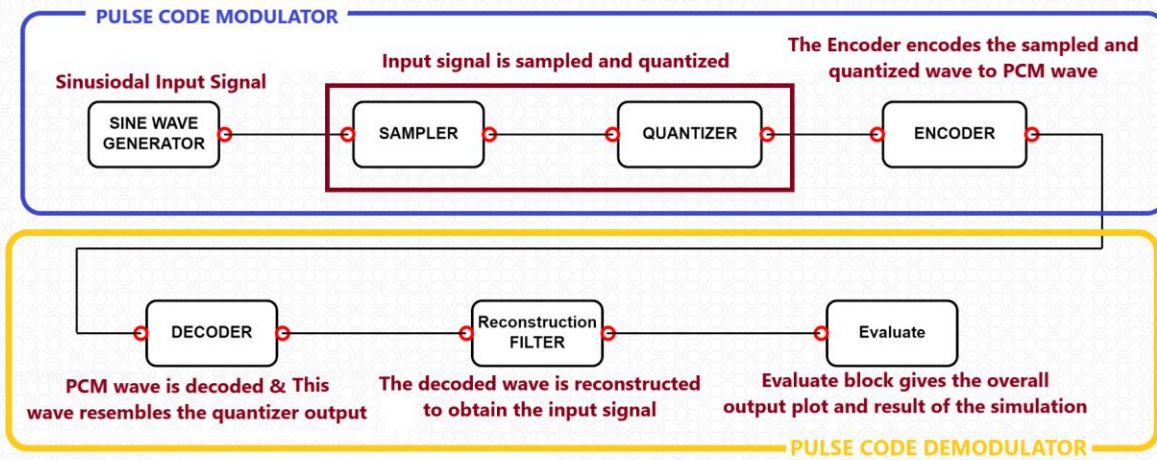
1.7: Equations/Formulas:

Transmission Bandwidth (Hz)	$B_T = nW$	Where 'n' is the number of bits/sample and 'W' is the message bandwidth.
Signaling rate (bits/sec)	$r = 2nW$	
Signal to quantization noise ratio (dB)	$SQNR = 1.8 + 6n$	

3. FlowChart:

START

Click on the theory icon to browse through the theory
and procedure for simulating pulse code modulation
and demodulation

Click on the simulation icon
and navigate to the simulator.

Connect all the blocks as per the circuit diagram.
Click on the connection points in the
right order to connect all the blocks

Double click the **Sine Wave Generator** and
set the amplitude and frequency of the input signal

Double click the **Sampler** and set the
sampling frequency of the input signal

Double click the **Quantizer** to view the
Quantized version of the waveform

Double click the **Encoder** to view the
PCM encoded waveform for various bit lengths

Double click the **Decode** to observe the
PCM decoded waveform of the transmitted signal

Double click the **Reconstruction Filter** to
observe the reconstructed message signal

Double click the **Evaluate** button to view the
overall PCM plot along with the calculated SQNR,
transmission bandwidth and signaling rate

STOP

4. MindMap:

Pulse Code Modulation & Demodulation

PULSE CODE MODULATOR

Sinusiodal Input Signal

Input signal is sampled and quantized

The Encoder encodes the sampled and quantized wave to PCM wave

SINE WAVE GENERATOR → SAMPLER → QUANTIZER → ENCODER

DECODER → Reconstruction FILTER → Evaluate

PCM wave is decoded & This wave resembles the quantizer output

The decoded wave is reconstructed to obtain the input signal

Evaluate block gives the overall output plot and result of the simulation

PULSE CODE DEMODULATOR

WORKSPACE MINDMAP 1

PCM Evaluation

FINAL OUTPUT GRAPH

Amplitude

SIMULATION RESULT

Result

Input Signal Amplitude (V) : 12 V

Input Signal Frequency (Hz) : 7 Hz

Sampling Frequency (Hz) : 47 Hz

Bit length : 8

Transmission Bandwidth (Hz) :

Signaling Rate :

SQNR:

WORKSPACE MINDMAP 2

5. Storyboard:

To study and understand the process of Pulse Code Modulation/ Demodulation scheme using the **Virtual Labs Assessment Tool (V.L.A.T)**.

Components Required :

Sinewave Generator, Sampler, Quantizer, Encoder, Decoder, Reconstruction Filter, Evaluate Block - Quantity : 1.

Step-by-Step Procedure to perform the Experiment :

STEP 1 : The user should click on the theory under which the concept behind the working of the experiment would be displayed followed by the procedure on the screen. The user should perform the experiments based on the

guidelines listed under the procedure.

STEP 2 : The blocks required are statically positioned. Click on any one connection point to initiate the wire connection and click on another connection point to complete the connection. Clicking on any part of the simulation canvas after initiating a wire will the wire to be anchored to that point. Connect all the blocks in the right order.
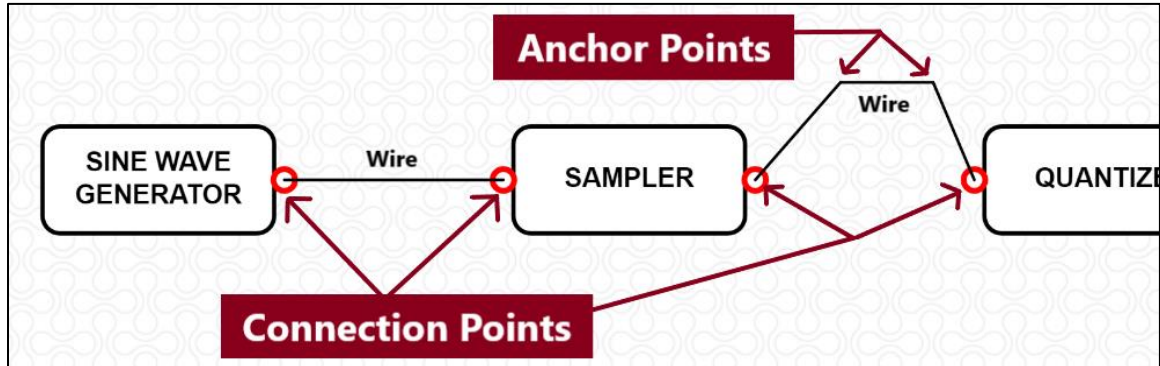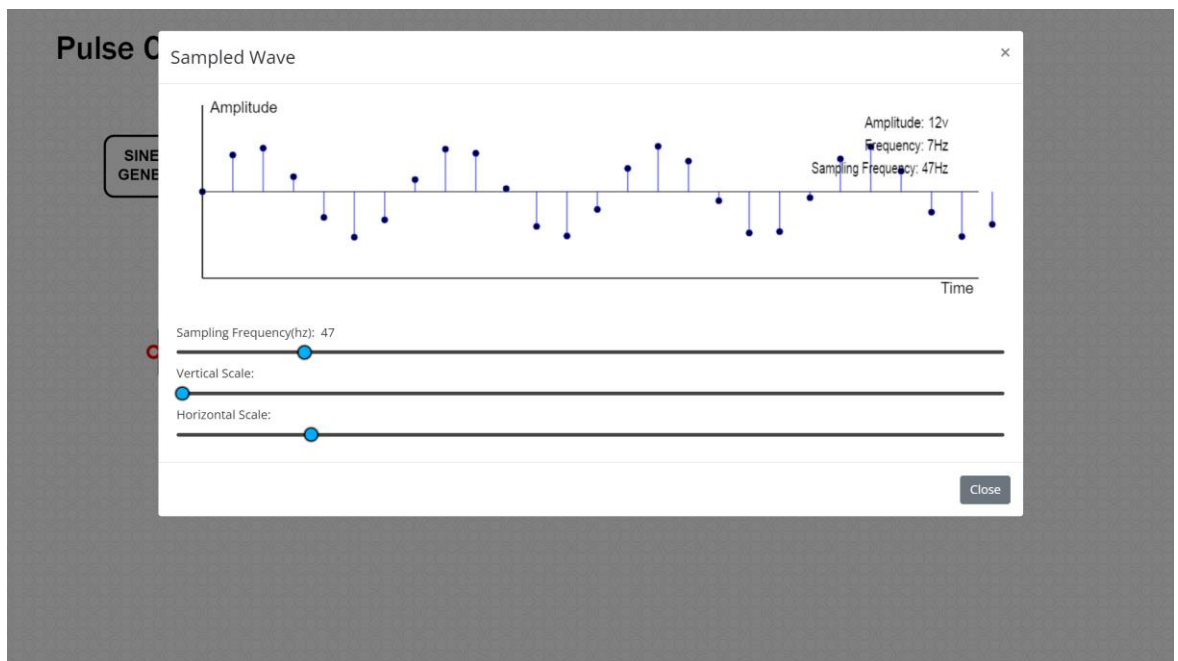

Once all the connections are made as per the block diagram, the simulator screen will look like
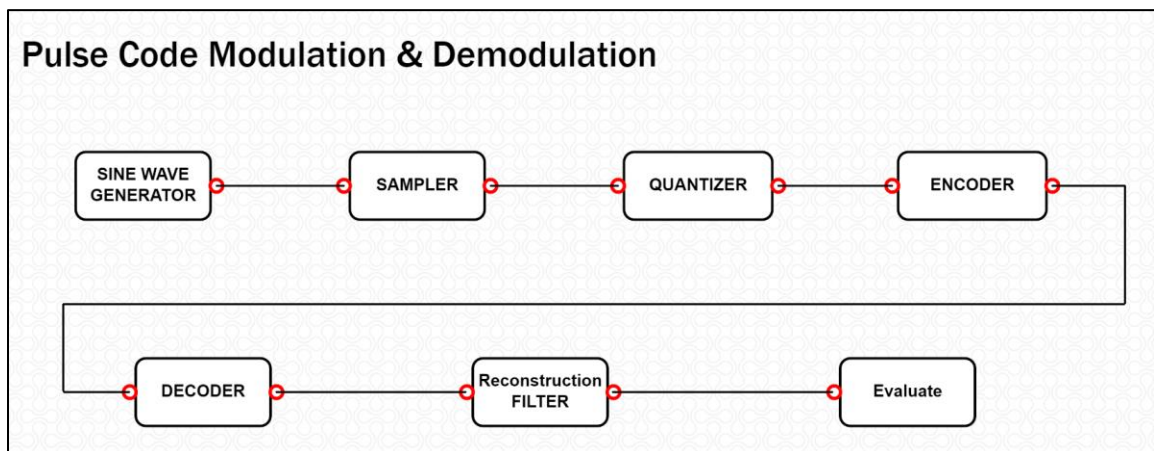
STEP 3 : Double click the **SINE WAVE GENERATOR** block and set the amplitude and frequency of the input sinusoidal wave.
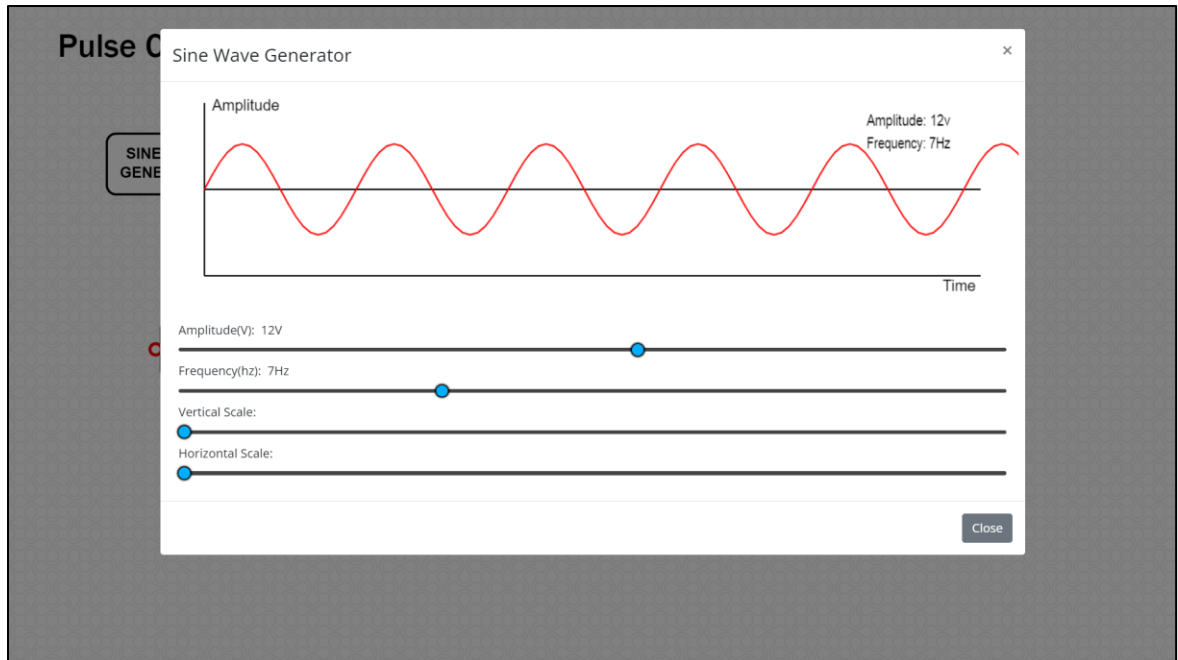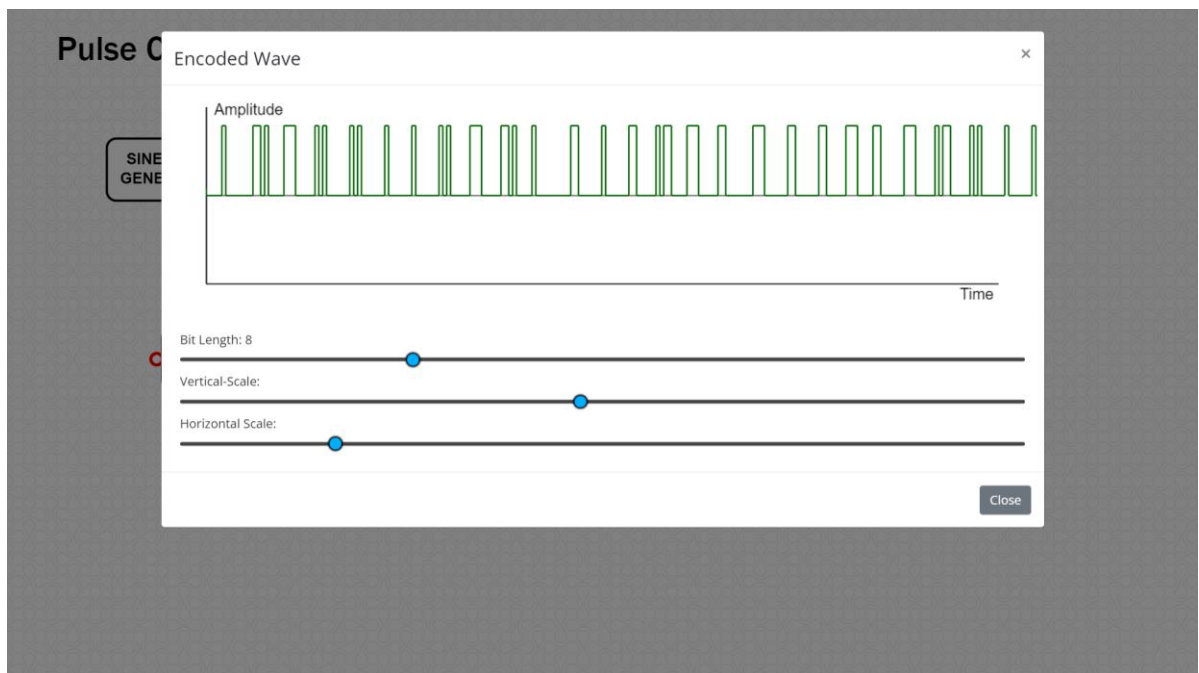
STEP 4 : Double click the **SAMPLER** block and set the frequency of the sampler (Sampling Frequency).
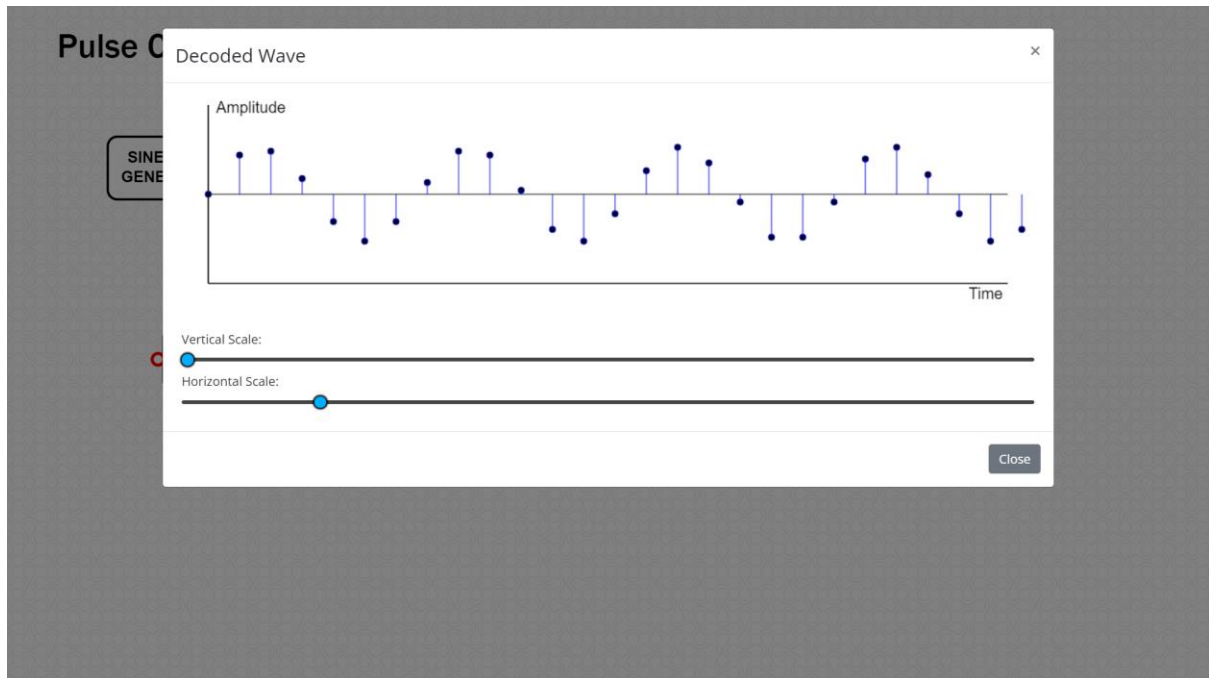

STEP 5 : Double click the **Quantizer** block to view the sampled & quantized form of the input signal.
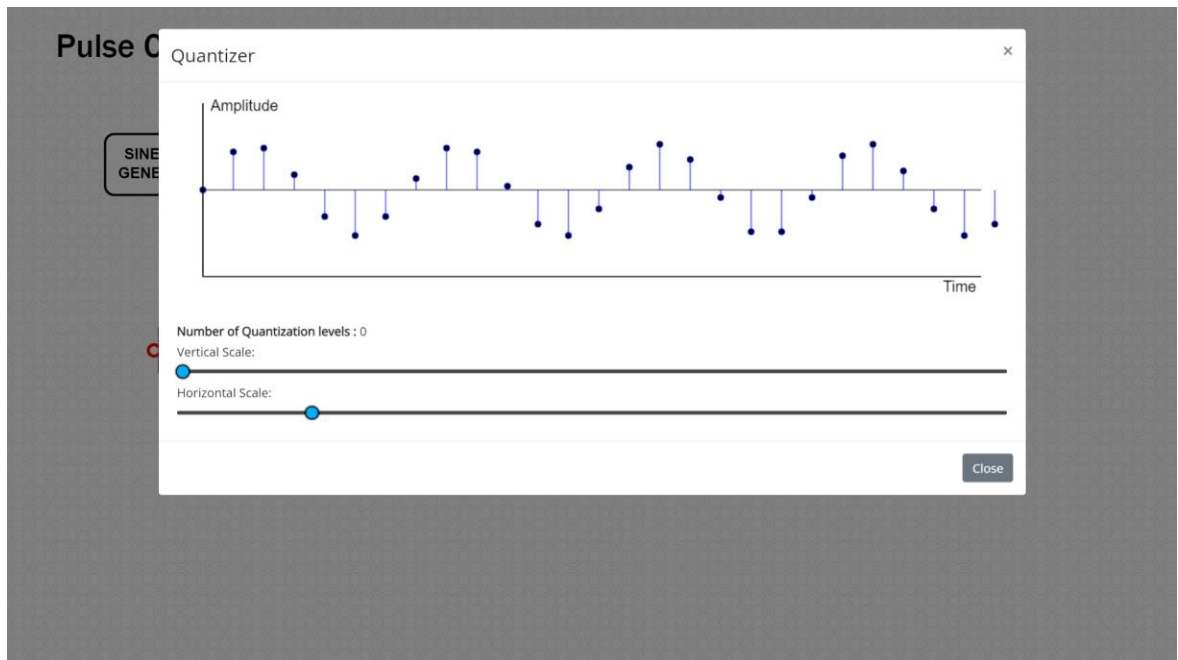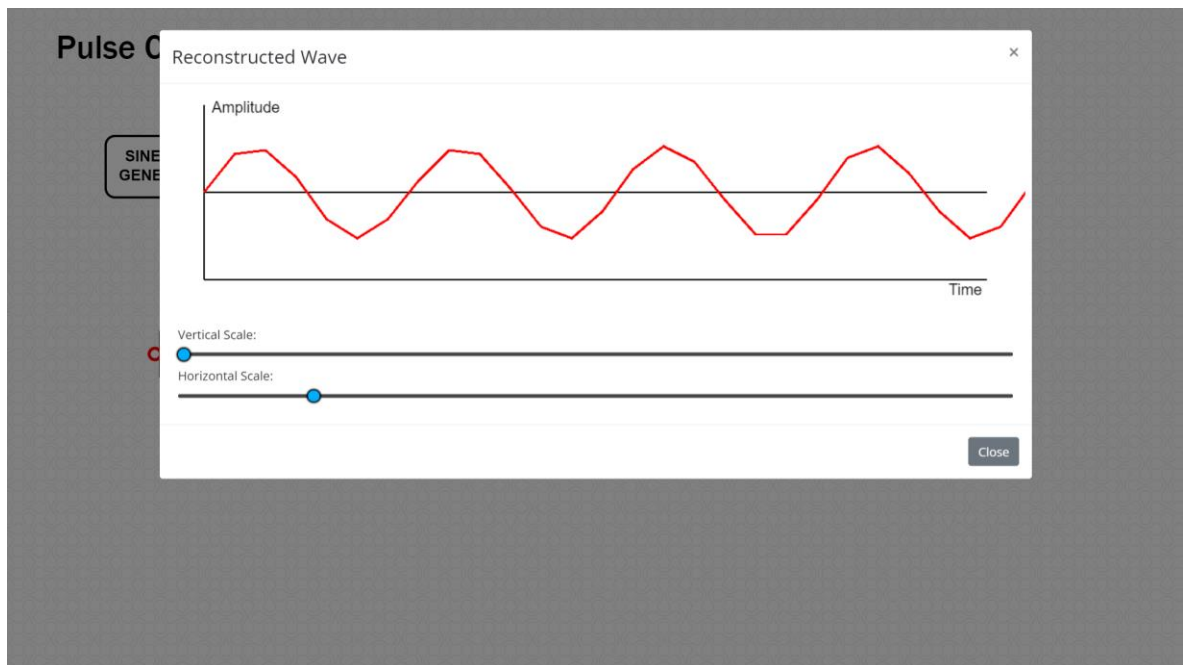
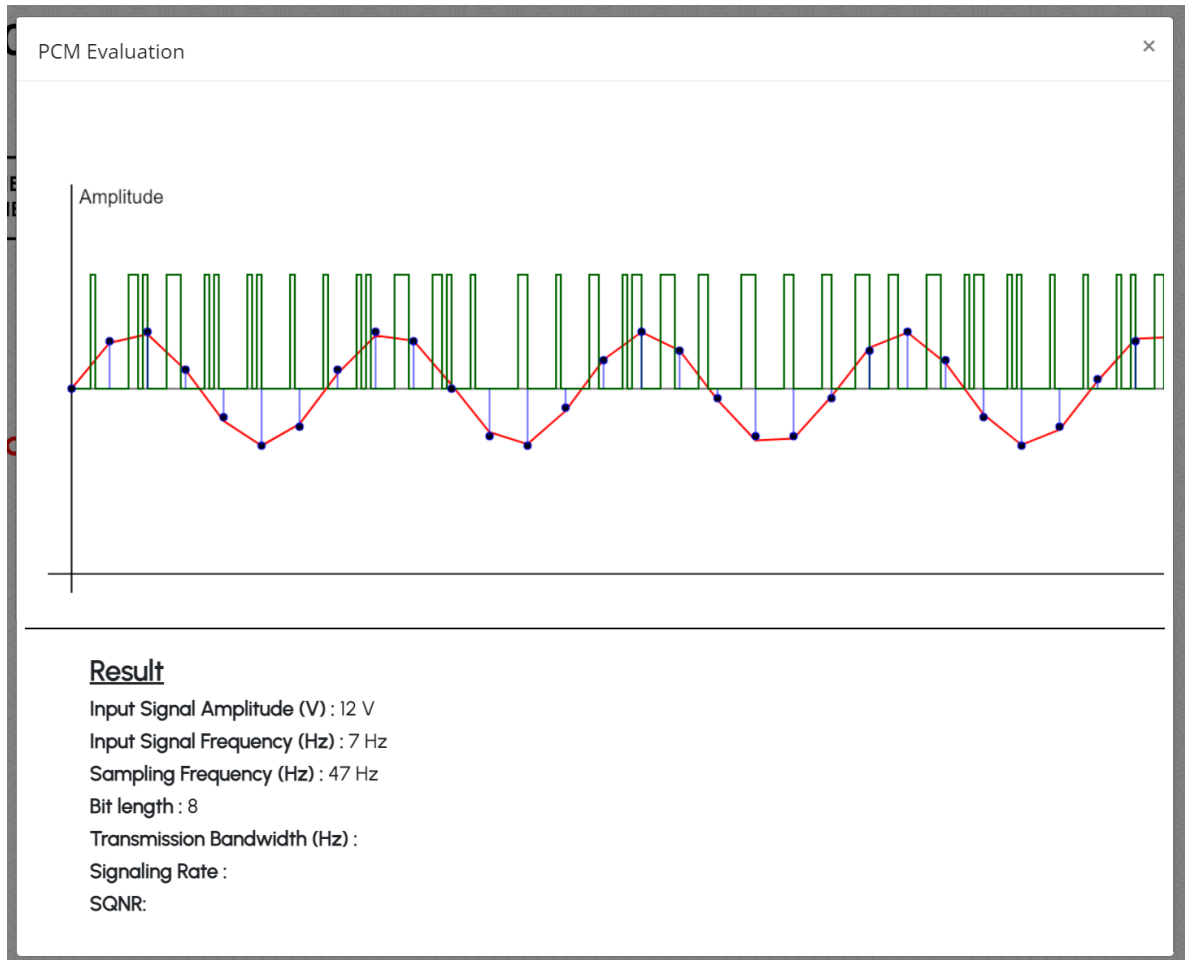**STEP 6 :** Double click the **ENCODER** block to observe and analyze the PCM wave for various bit lengths.

STEP 7 : Double click the **DECODER** block to observe the decoded PCM wave. This waveform resembles that of the QUANTIZER output.

STEP 8 : Double click the **RECONSTRUCTION FILTER** block to reconstruct the message signal from the decoded signal.

STEP 9 : Double click the **Evaluate** block to observe all the Pulse Code Modulation and Demodulation plots and verify the simulation calculated values of PCM parameters SQNR, Transmission Bandwidth and signaling rate.

PCM Evaluation

Amplitude

Result

Input Signal Amplitude (V) : 12 V
Input Signal Frequency (Hz) : 7 Hz
Sampling Frequency (Hz) : 47 Hz
Bit length : 8
Transmission Bandwidth (Hz) :
Signaling Rate :
SQNR:

STEP 10 : Vary the block parameters and observe the values corresponding to the maximum efficiency of the system.