# Project 2 – Part A

## CIE 337 - University of Science and Technology- Zewail City

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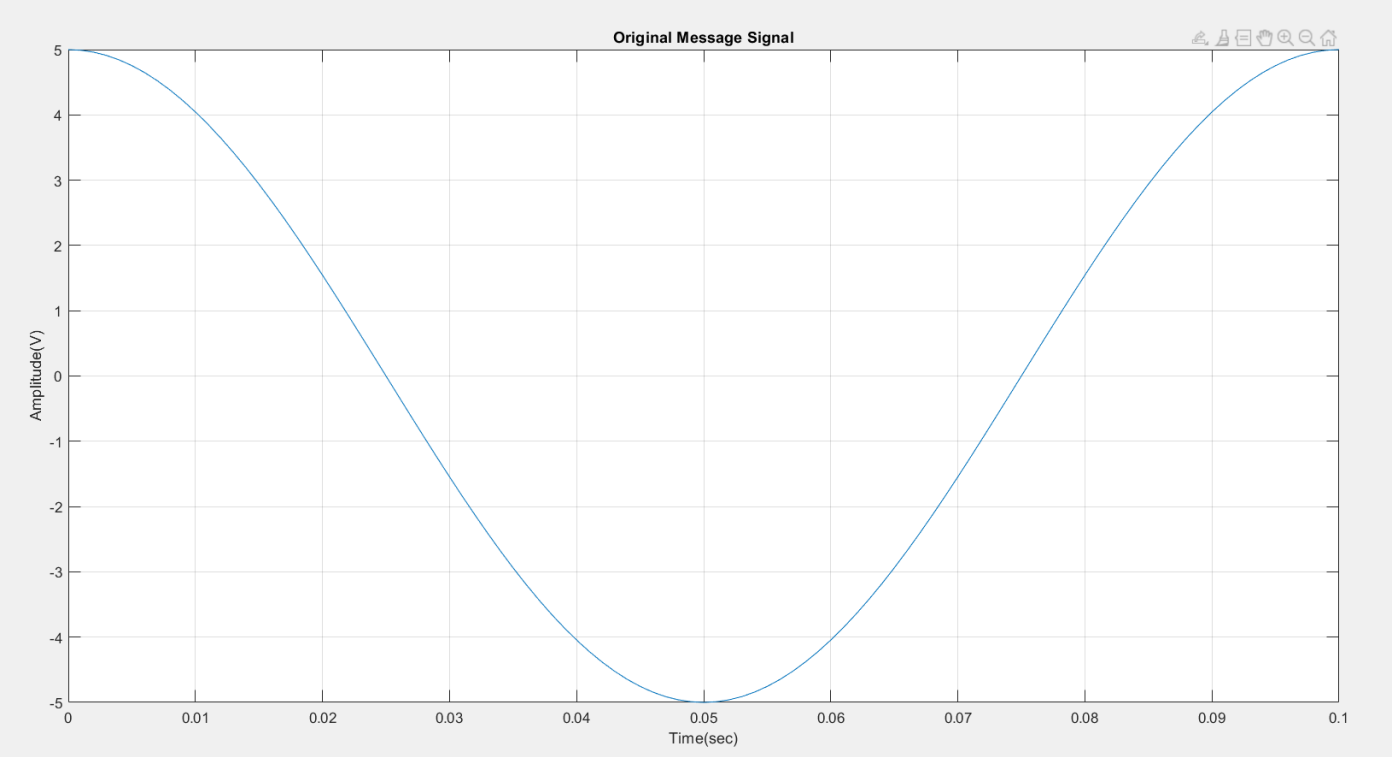
# 1) Part A: PCM Quantization

In this part we built a GUI that is used to quantize an analog discrete signal by taking an input signal in the form of amplitude and time vectors and displays the output quantized signal according to the parameters specified by the user; number of levels L, the peak quantization level (mp) and whether the quantization is mid-rise or mid-tread, also it gives the user to option to choose between uniform and non-uniform quantization (the user specifies the μ-Law parameter in case of non-uniform quantization) and it calculates the mean square quantization error in either case.

The GUI was tested using the input signal $m[k] = 5\cos(2\_f_m k)$ where fm = 10 Hz

## The input signal m(k) plot:

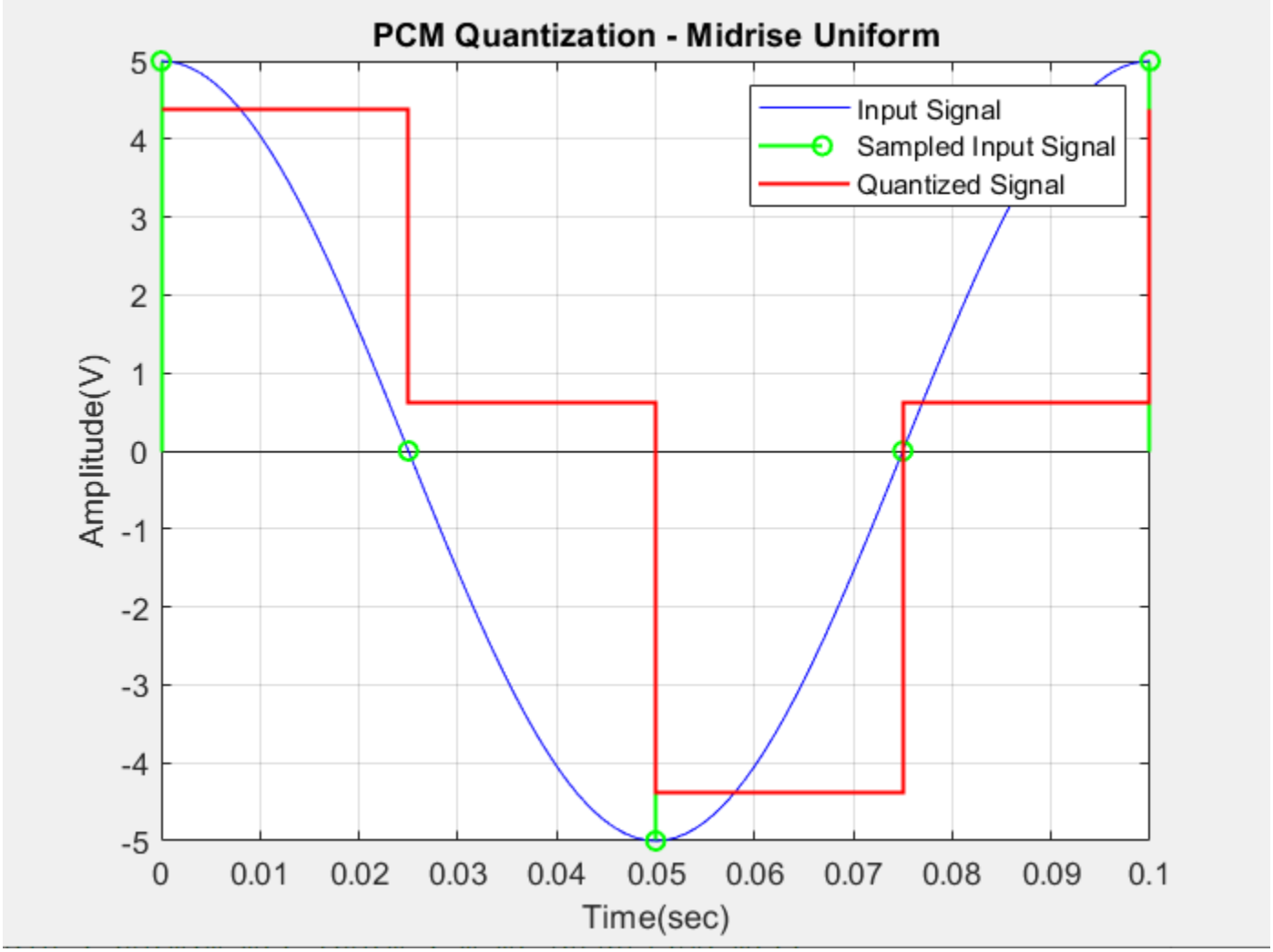



After that we used four test cases to perform quantization on the input signal using different parameters to observe the differences.

## (Case 1) Parameters: fs = 40 Hz, L = 8, mp = 5 and the quantization is uniform.

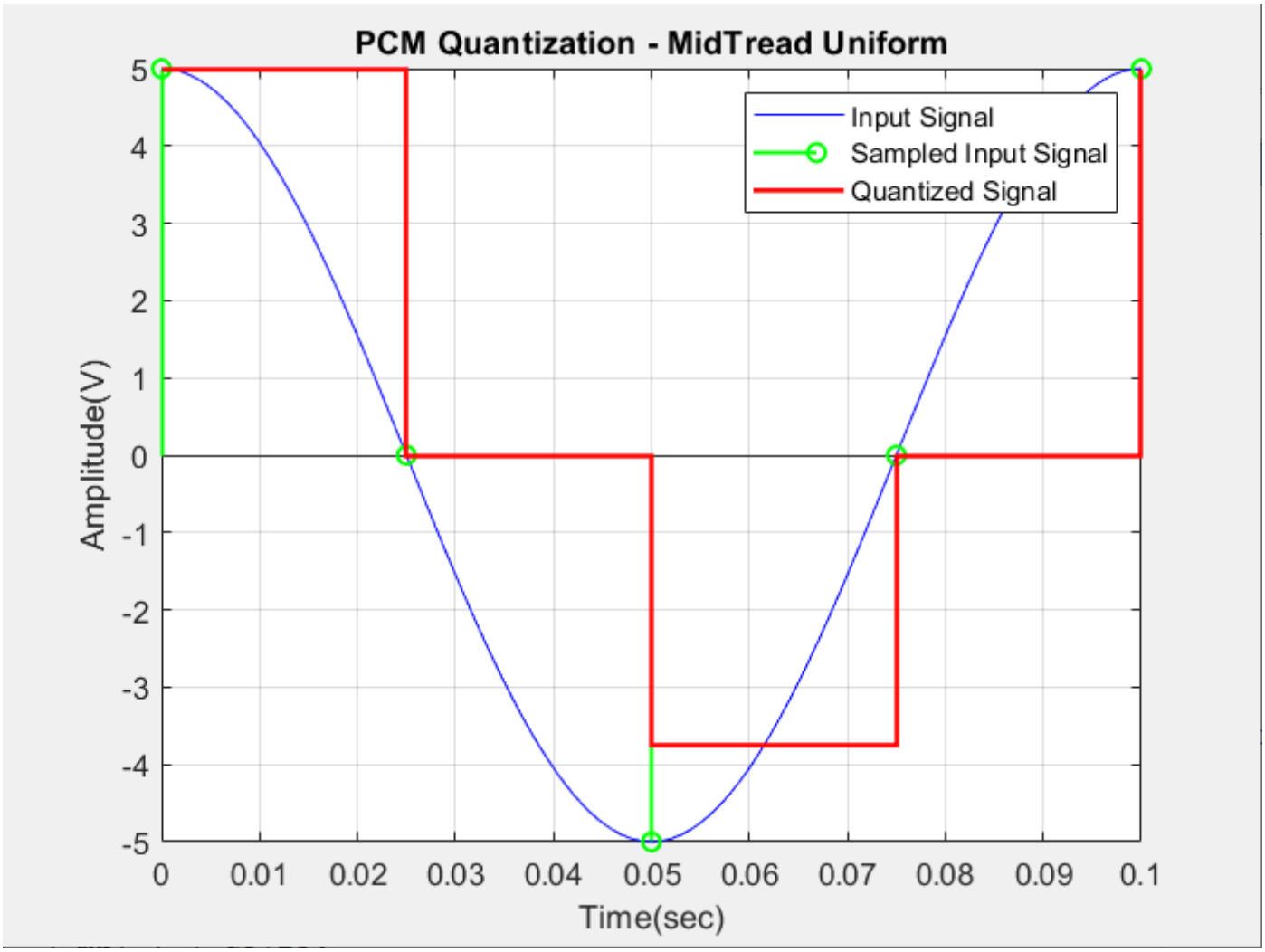
The following two plots (mid-rise and mid-tread) show the input signal as a continuous signal and as a stem plot after the signal is sampled before quantization and the quantized signal as a continuous staircase (with flat top)

## I- Mid-Rise:




The mean square quantization error is 0.3906

## II- Mid-Tread:




The mean square quantization error is 0.3125

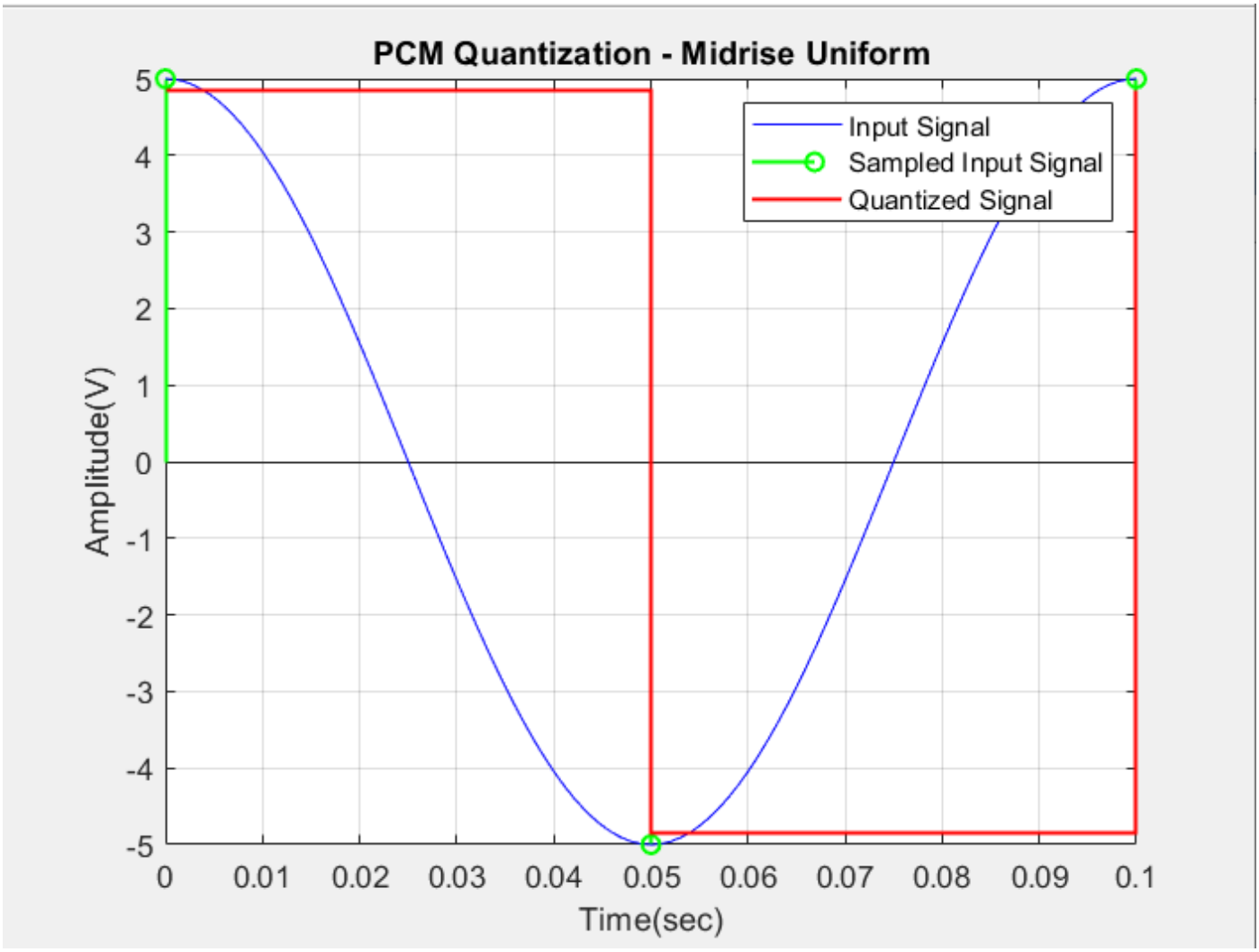
- **Comment:**

-The blue curve shows the original input signal, the green discrete plot is the input signal after sampling it using the sampling frequency specified and the red staircase curve is the quantized signal after approximating the samples to the nearest quantization level. It can be seen that in the mid-rise case the number of levels in the negative side is the same as that in the positive side while in the mid-tread case the number of levels in the positive side is larger by one level due to the presence of zero level.

## (Case 2) Parameters: fs = 20 Hz, L = 32, mp = 5 and the quantization is uniform.

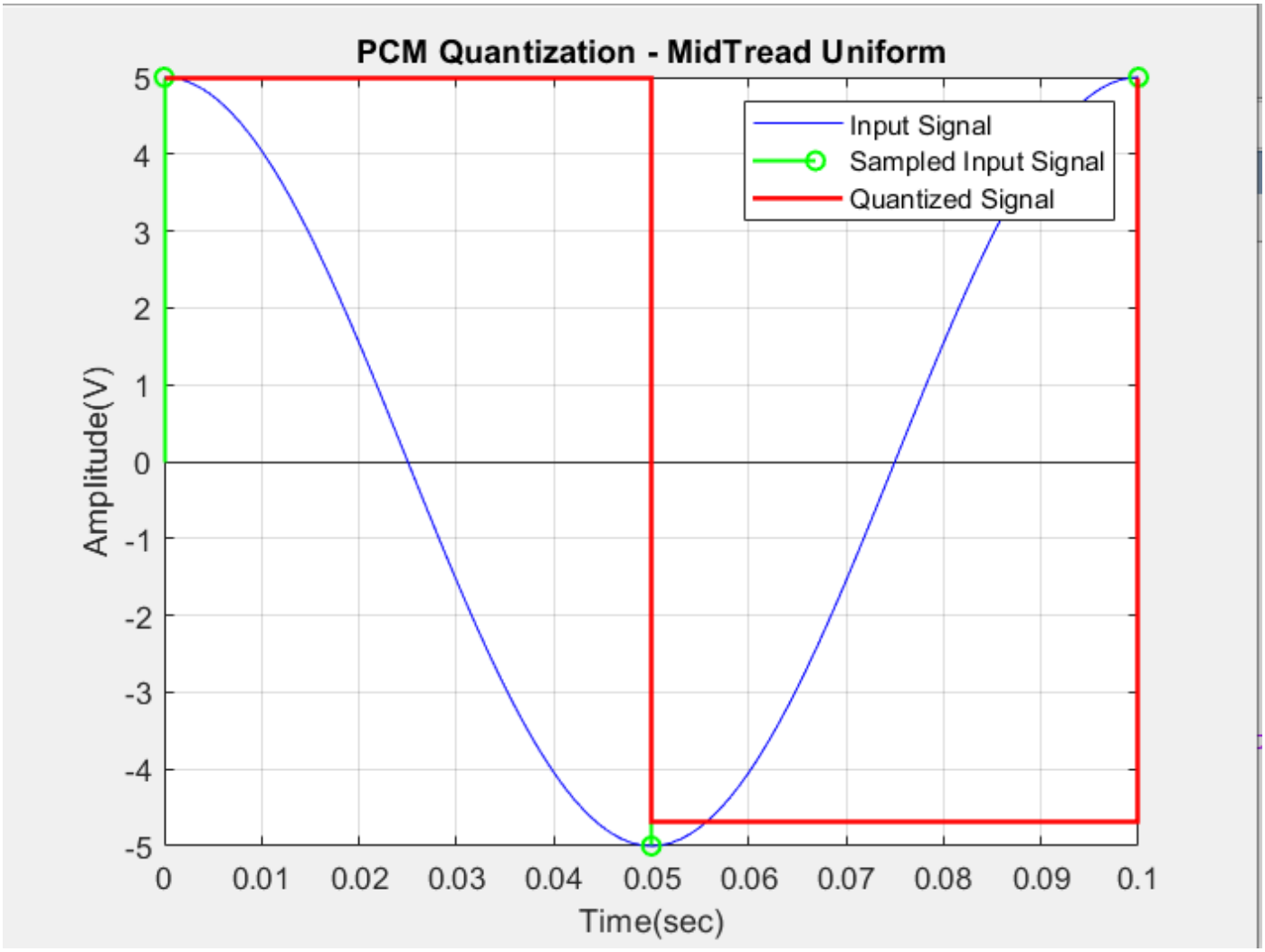
The following two plots (mid-rise and mid-tread) show the input signal as a continuous signal and as a stem plot after the signal is sampled before quantization and the quantized signal as a continuous staircase (with flat top)

## I- Mid-Rise:




The mean square quantization error is 0.0244

## II- Mid-Tread:




The mean square quantization error is 0.0326

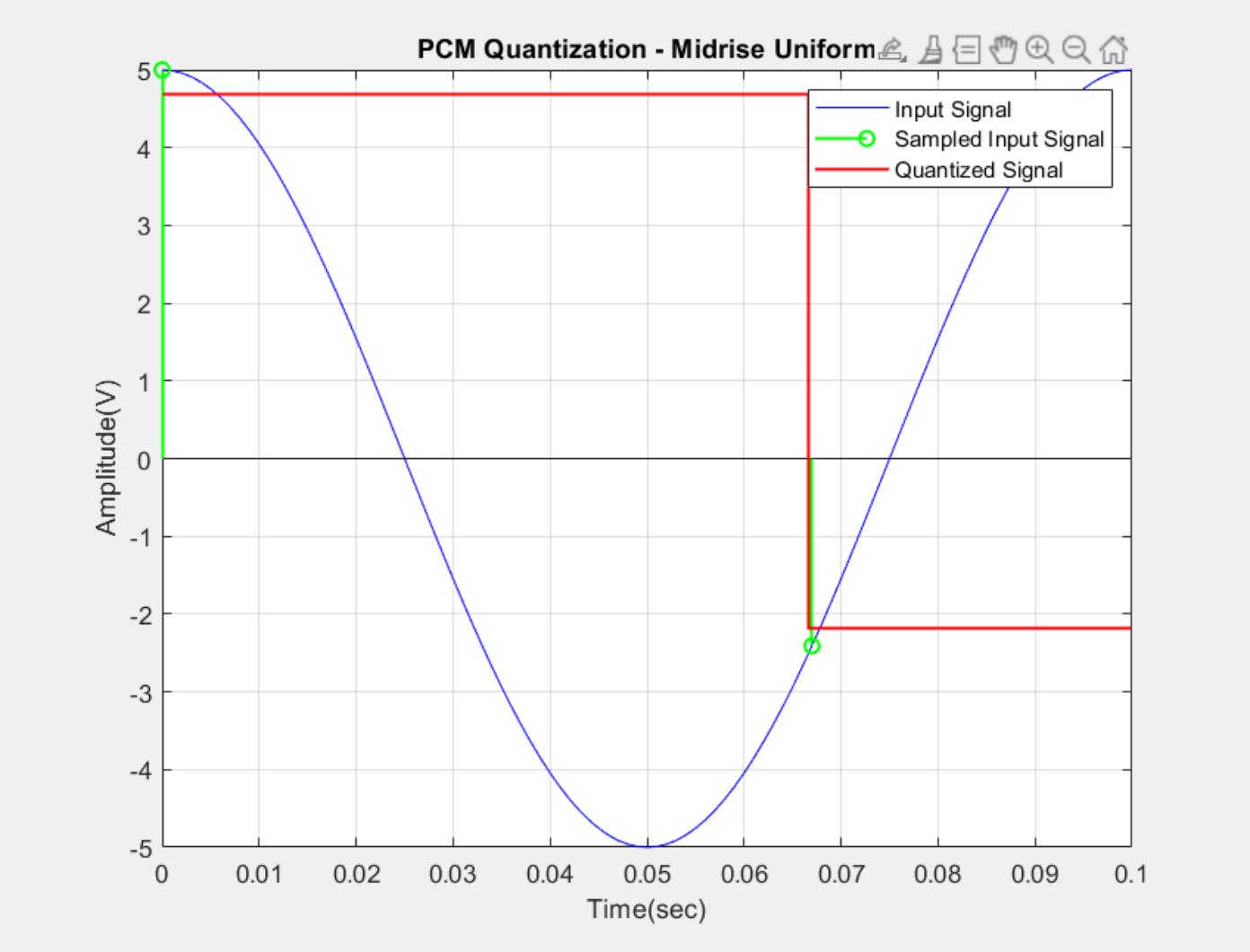
- **Comment:**

-The blue curve shows the original input signal, the green discrete plot is the input signal after sampling it using the sampling frequency specified and the red staircase curve is the quantized signal after approximating the samples to the nearest quantization level. The figures exhibit the same difference between the mid-rise and mid-tread as in the pervious case. (mid-tread has maximum level at mp while mid-rise has maximum level at mp-delta)

## (Case 3) Parameters: fs = 15 Hz, L = 16, mp = 5 and the quantization is uniform.

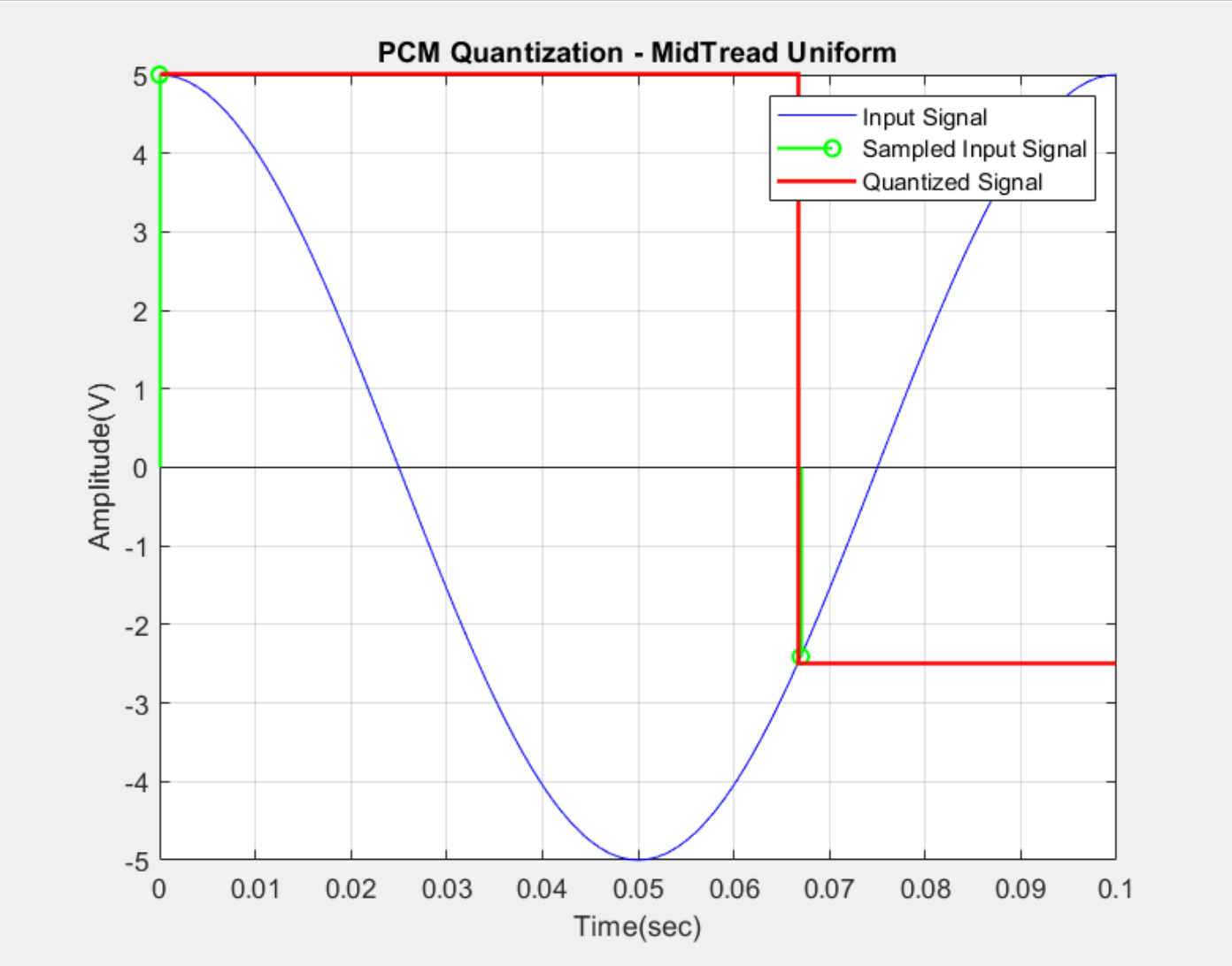
The following two plots (mid-rise and mid-tread) show the input signal as a continuous signal and as a stem plot after the signal is sampled before quantization and the quantized signal as a continuous staircase (with flat top)

## I- Mid-Rise:




The mean square quantization error is 0.0733

## II- Mid-Tread:



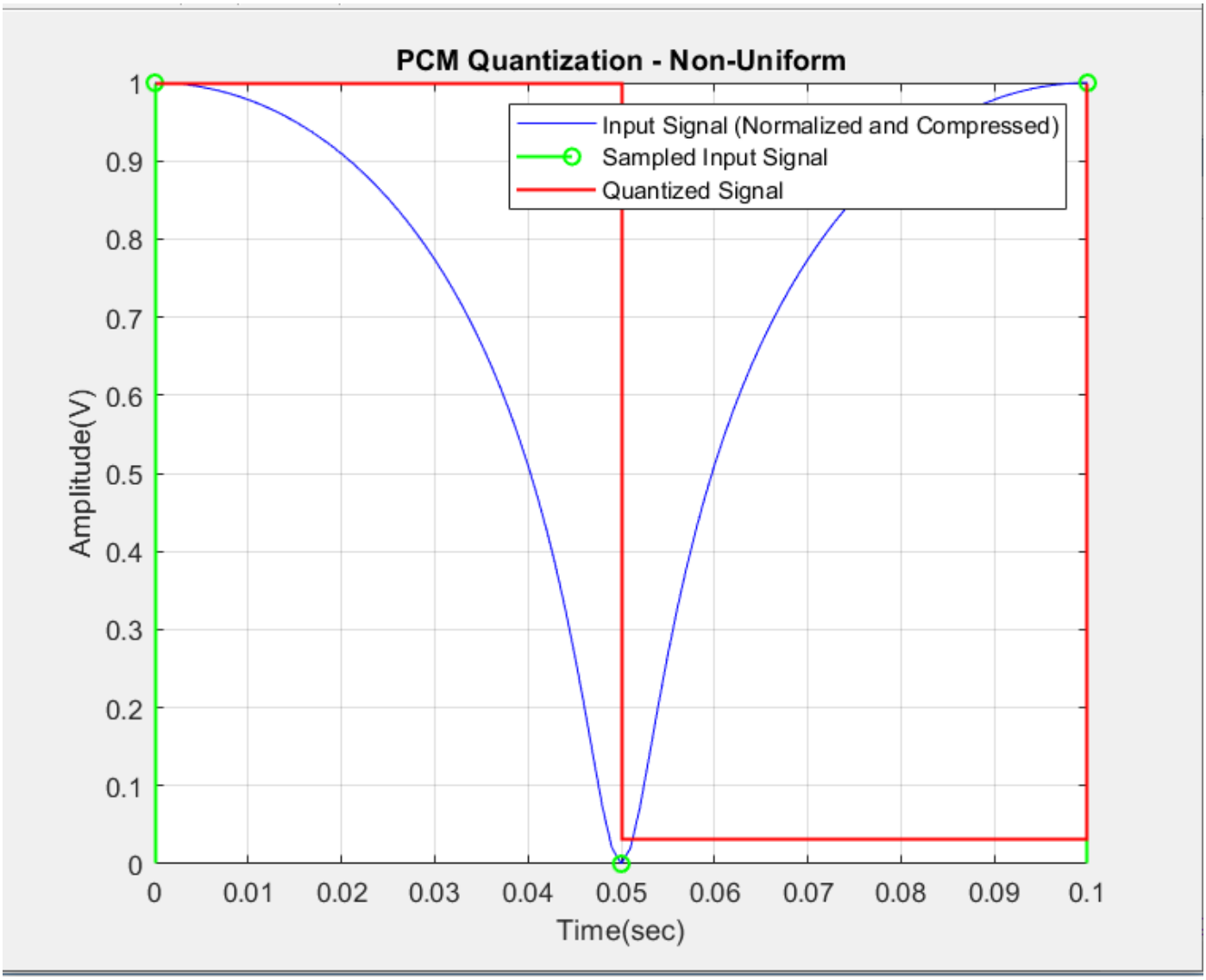

The mean square quantization error is 0.0042

- **Comment:**

-The blue curve shows the original input signal, the green discrete plot is the input signal after sampling it using the sampling frequency specified and the red staircase curve is the quantized signal after approximating the samples to the nearest quantization level. It can be observed here that due to the small value of the sampling frequency only two samples were taken from the complete cycle (one sample at zero and the other at ts=1/fs).

## (Case 4) Parameters: fs = 20 Hz, L = 32, mp = 5 and the quantization is non-uniform.

The following plot shows the input signal as continuous signal and as a stem plot after the signal is sampled before quantization and the quantized signal as a continuous staircase (with flat top)




The mean square quantization error is 3.2552e-04

- **Comment:**

-The blue curve shows the input signal after it was compressed and normalized using the μ-Law parameter where the small amplitudes have higher gain, the green discrete plot is the input signal after sampling it using the sampling frequency specified and the red staircase curve is the quantized signal after approximating the samples to the nearest quantization level. The quantization levels range from delta to 1 (peak) as the signal is normalized. We choose not to have a zero level as it will not make a difference after the reconstruction of the original message from the quantized message. It can be observed that the quantization error is significantly smaller than that of the uniform case (case 2) which is the desired results of the non-uniform quantization.