For first 3 questions:
T=0.001
T_s=0.0012

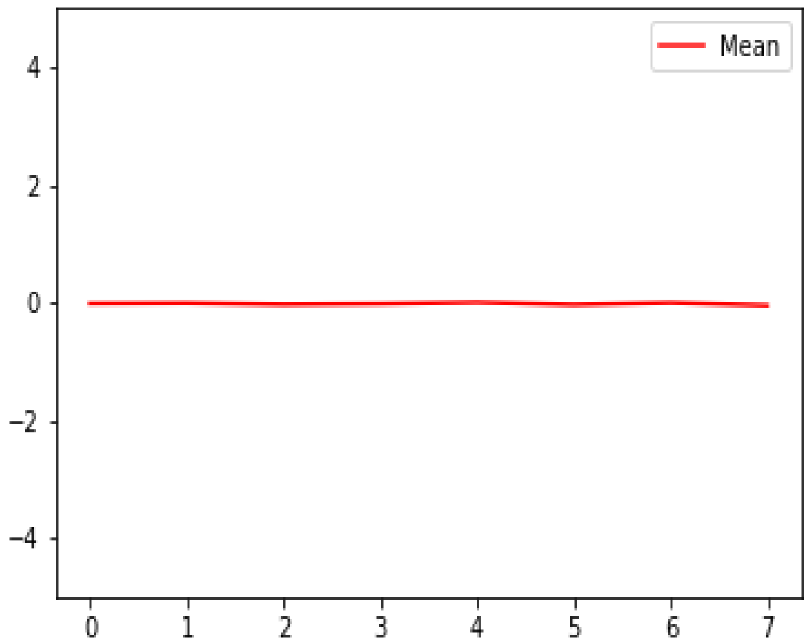
a) Generating Stochastic Process $X(n) = X(nT_s)$

- To generate $X(n)$ we use numpy.random.uniform(0,2) function and typecast it to integer to get the desired independent bit stream.
- In order to sample it we used sampling time as T_s and denote the number of samples thus produced as N(=T/T_s).
- We repeated the entry of each bit in $X(n)$ for N times to produced the sampled version $X(nT_s)$.

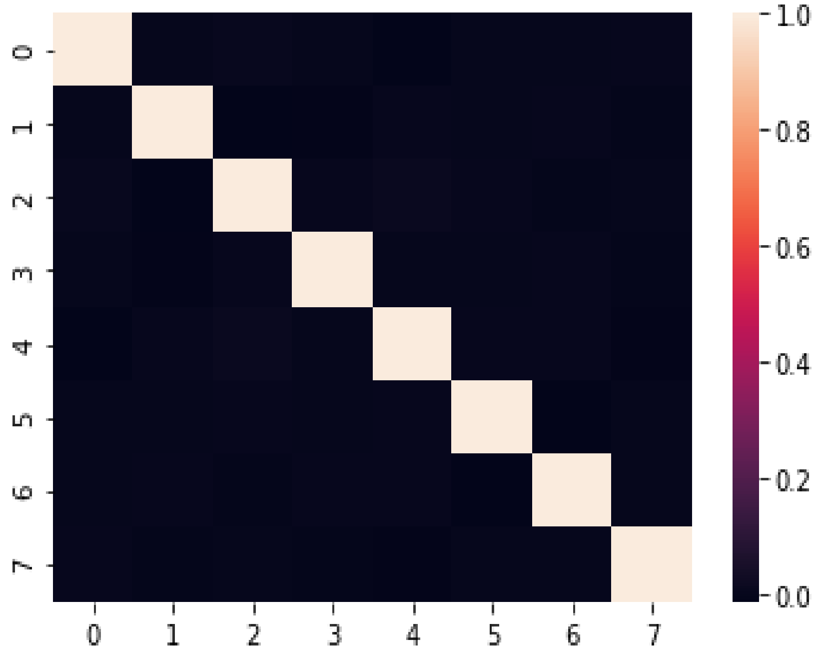
b) For this part we produced 20000 samples of the stochastic process and followed the following procedure:

- To compute the mean we took average of each instance of time for all the 20000 samples.

Plot for mean of sampled signal:



- To compute the Auto-Correlation we took transpose of the sampled matrix and found the correlation coefficients and plotted using heatmap to clearly see the results.



Conclusion:

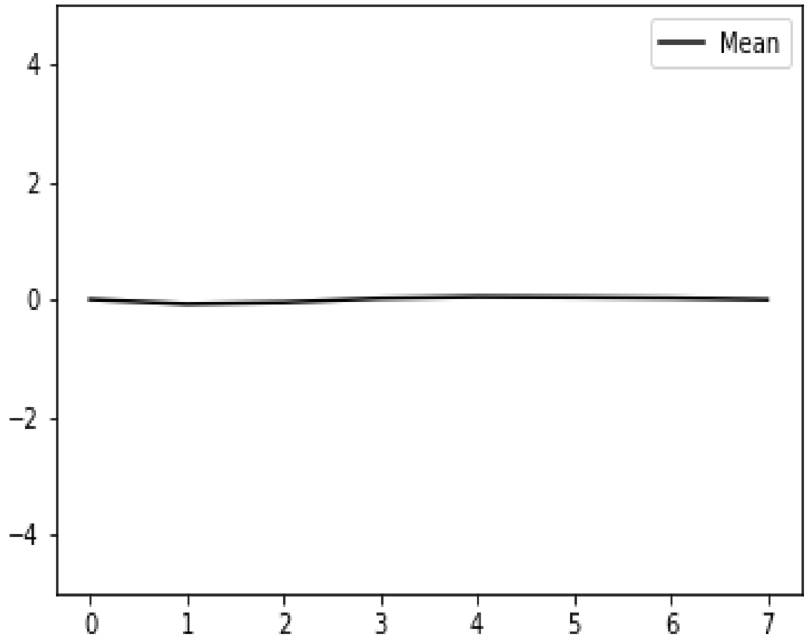
- We can see from the above figure that mean is almost constant and the Auto-correlation shows that the diagonal entries have same values clearly reflecting that the Auto-correlation depends only on the time difference and not the actual values.
- Thus, the NRZ-L $X(n)$=$X(nT_s)$ is Wide Sense Stationary.
- When we take the case of T>T_s the obtained process is not Wide Sense Stationary because of the repeated samples obtained from the sampling of the function.

c) To produce the delayed version of NRZ-L we followed following steps:

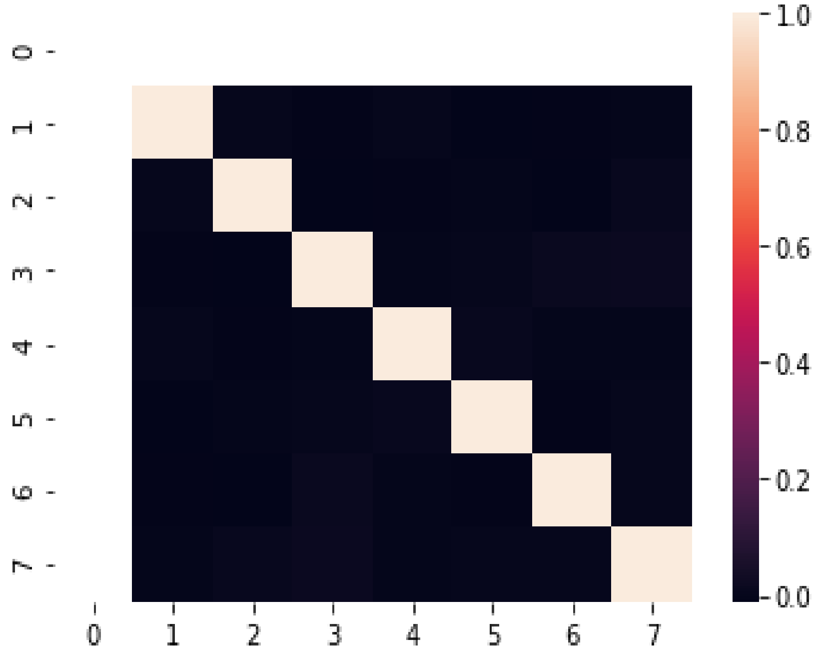
- Produce random delay d,for each sample function using numpy.random.uniform(0,T).
- Represent the delay by appending d zeros at the beginning of the sample.To maintain the constant size of the array we shall truncate the last d elements from the original sample as well.

- Shift the already obtained *X(n)*=*X*(nT_s) in previous question by d i.e. take first sample at d followed by next samples after every T_s time interval to get $X_1(nT_s)$.
- Then we repeat the process to find the mean and Auto-Correlation of $X_1(nT_s)$.

Mean of $X_1(nT_s)$:



Auto-Correlation of $X_1(nT_s)$:

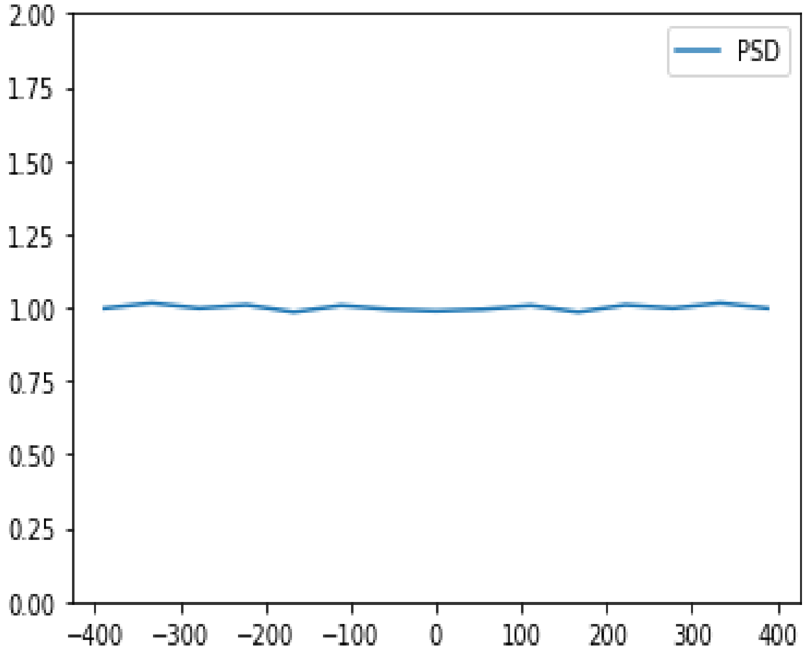


Conclusion:

- In our case where $T<T_s$,we see that mean is almost constant and the Auto-correlation also shows that the diagonal entries have almost same values.
- Here, due to T<T_s the samples generated are independent of each other and so we see that the sampled and delayed version, X_1(nT_s) is a Wide Sense Stationary Process.
- If $T>T_s$, then both $X(nT_s)$ and X_1(nT_s) (sampled version) are not Wide Sense Stationary.This is because we will obtain multiple samples of the same value. Hence those values will not be independent of each other and will have a high correlation.Also as soon as the value changes we will obtain a sudden dip in the value of the correlation coefficient for the same time difference which does not satisfy the criteria for Wide Sense Stationary Process.

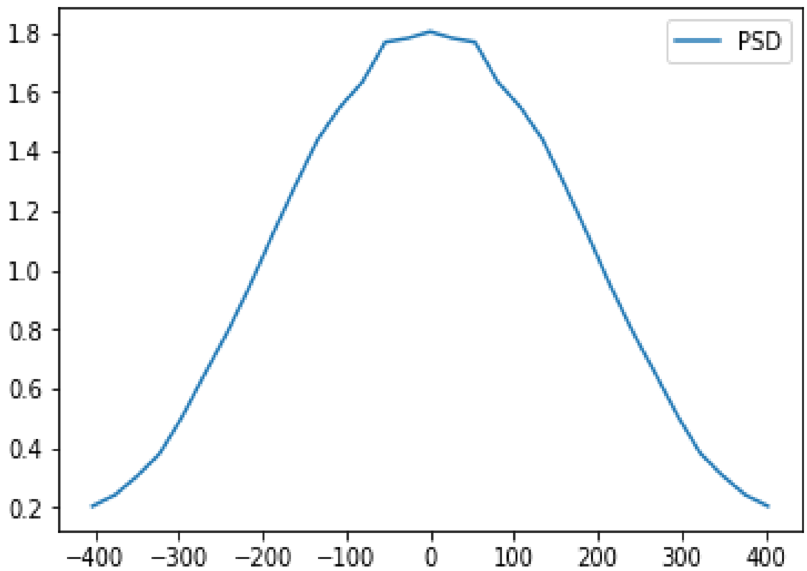
d) In this part we need to find the PSD for different pulse-width T.
For this part we take two different values of T for T_s=0.0012:

(a) T= 0.001 $\quad T<T_s$



- We obtain almost a constant PSD for the given range.
- This is because the PSD expression comes out to be a sum of Dirac Delta functions centred at all the frequencies present in the range.This can be attributed to the independence of the variables(their values) present in the sample function.

(b) T=0.002 $T > T_s$



- We obtain a Non-Constant Distribution for the PSD.
- This is primarily because, when we obtain multiple samples of the same value because of which the independence of the variables (their values) present in the modified sample function is hampered. This can also be seen from the Auto-correlation matrix.

Since PSD is primarily the Fourier Transform of the Auto-correlation matrix, hence we can easily extend our observations from there.