RESEARCH & PROJECT SUBMISSIONS

Program:

Course Code: ECE351

Course Name: Communication Systems

Examination Committee

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Ain Shams University

Faculty of Engineering

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics & Communication Engineering Dept.

Group No. 18

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Part 5: Phase Modulation PM

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Submission Contents

Introduction:

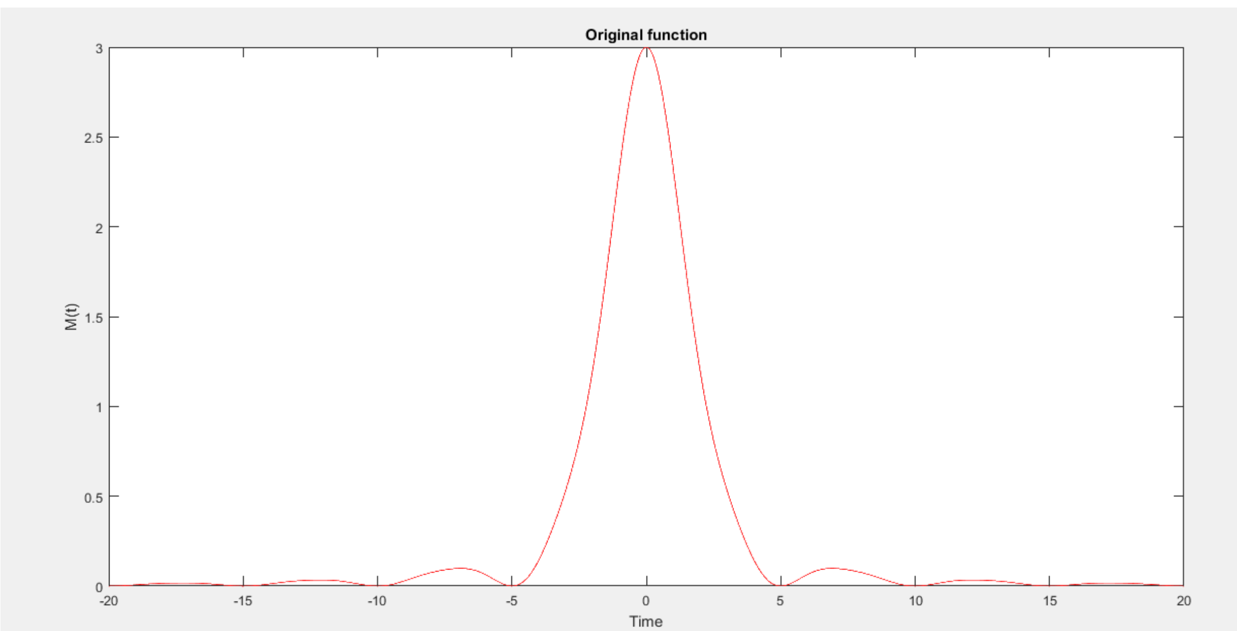
Angle modulation is a process of take the message signal and modulate it inside the angle of carrier, and this type of modulation used to avoid the noise which have been formed at conventional amplitude modulation. And we have two types of angle modulation if we take input message to angle directly so we called it phase modulation, and the second type if we take the input message to the derivative of carrier's angle we called this type frequency modulation. In general at this part we discuss phase modulation PM whose modulated signal can be written as the following:

$$S_{pm}(t) = A_c * \cos(2\pi f_c t + k_p * m(t)).$$

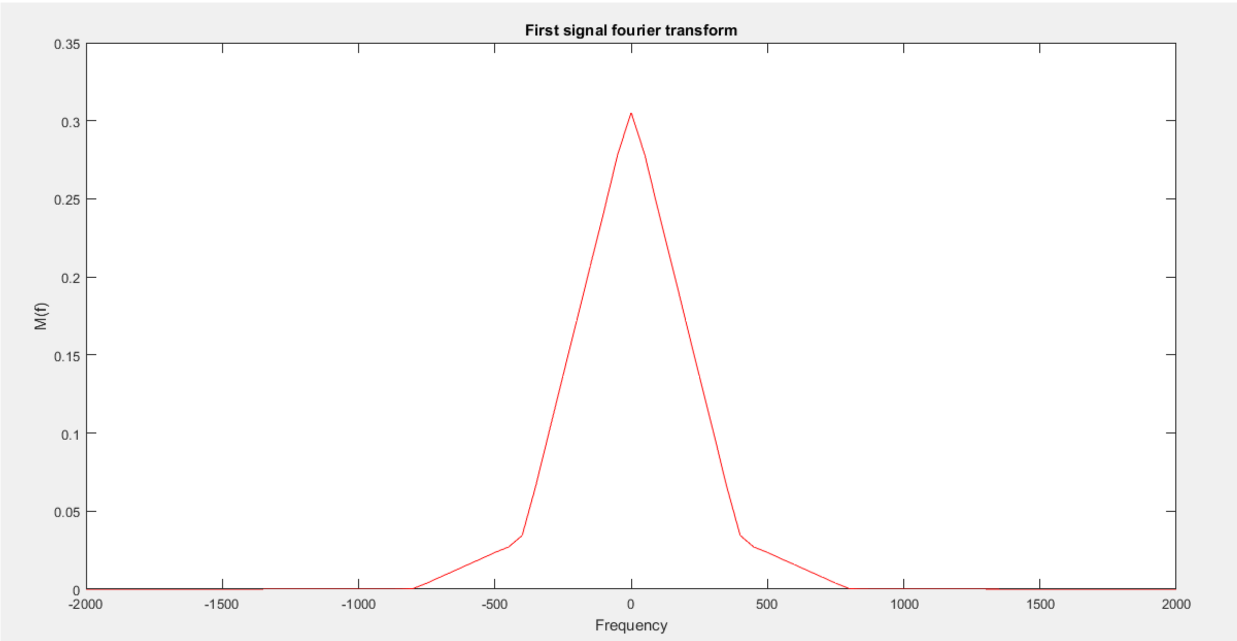
Part 1:

1. Message Signal

$$m(t) = 2sinc^2(200\pi t) + sinc^2(400\pi t)$$



2. Fourier Transform of m(t)



As time range increases the amplitude of the Fourier transformed signal decreases.

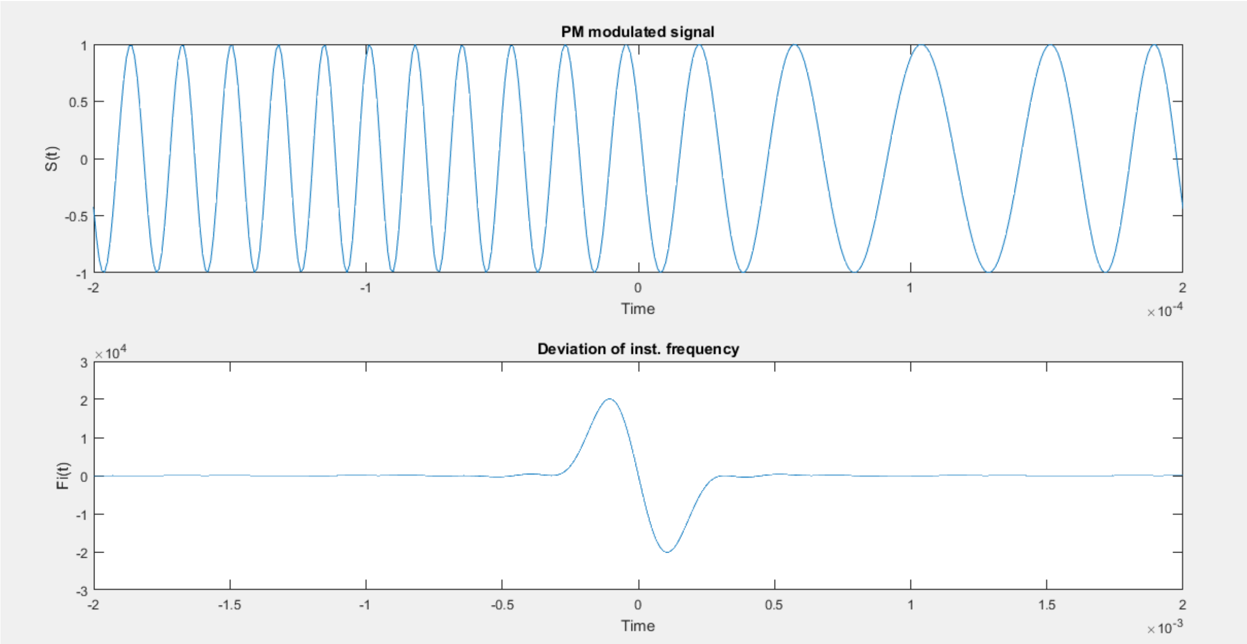
As time step increases the bandwidth of the Fourier transformed signal increases.

Part 5:

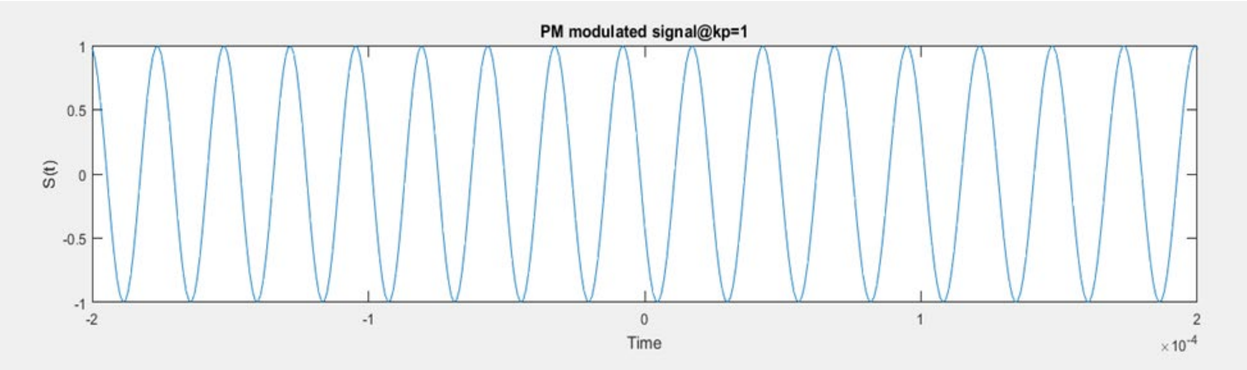
1. Let message signal will be 2nd signal: $m(t) = 2sinc(1000\pi t)$.
   And we have carrier will be: $c(t) = \cos(40000 * 2\pi t)$.
   So, we have $K_p = 10\, {}^{rad}/_{volt}, fc = 40kHz, fm = 500Hz$.
   From previous PM modulated signal will be:
   $S(t) = \cos\,(40000 * 2\pi t + 10 * 2sinc(1000\pi t))$.
   And deviation of instantaneous frequency will be:

$$\Delta f = \frac{10}{2\pi} * \frac{dm(t)}{dt} Hz.$$

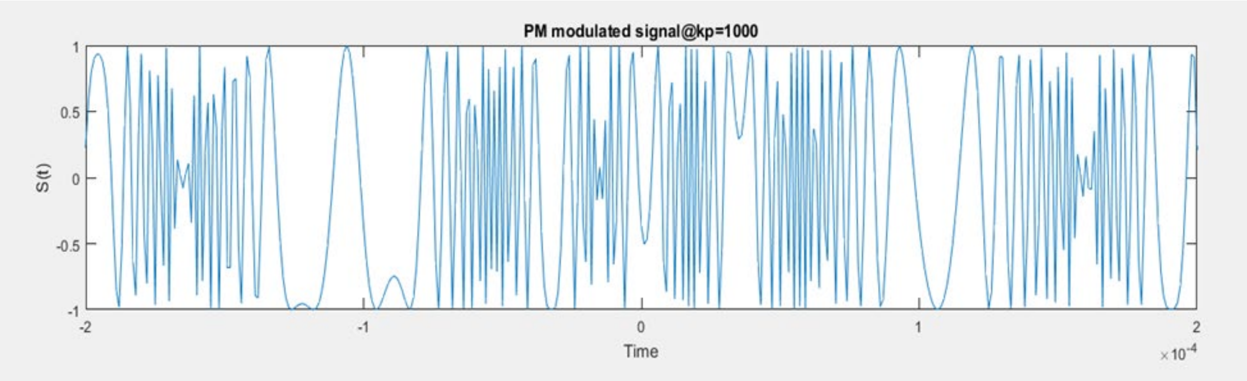
Waveforms of signals from MATLAB will be:



2. The modulated signal@$Kp = 1 \, {}^{rad}/_{volt}$:



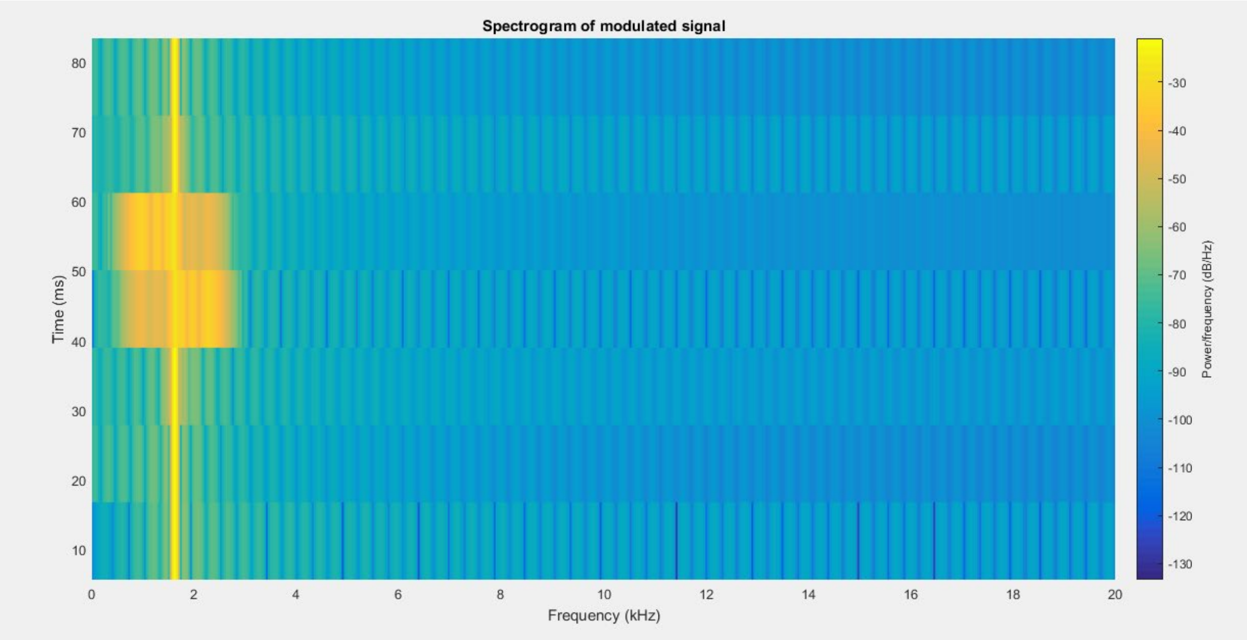
The modulated signal@$Kp = 1000 \, {}^{rad}/_{volt}$:



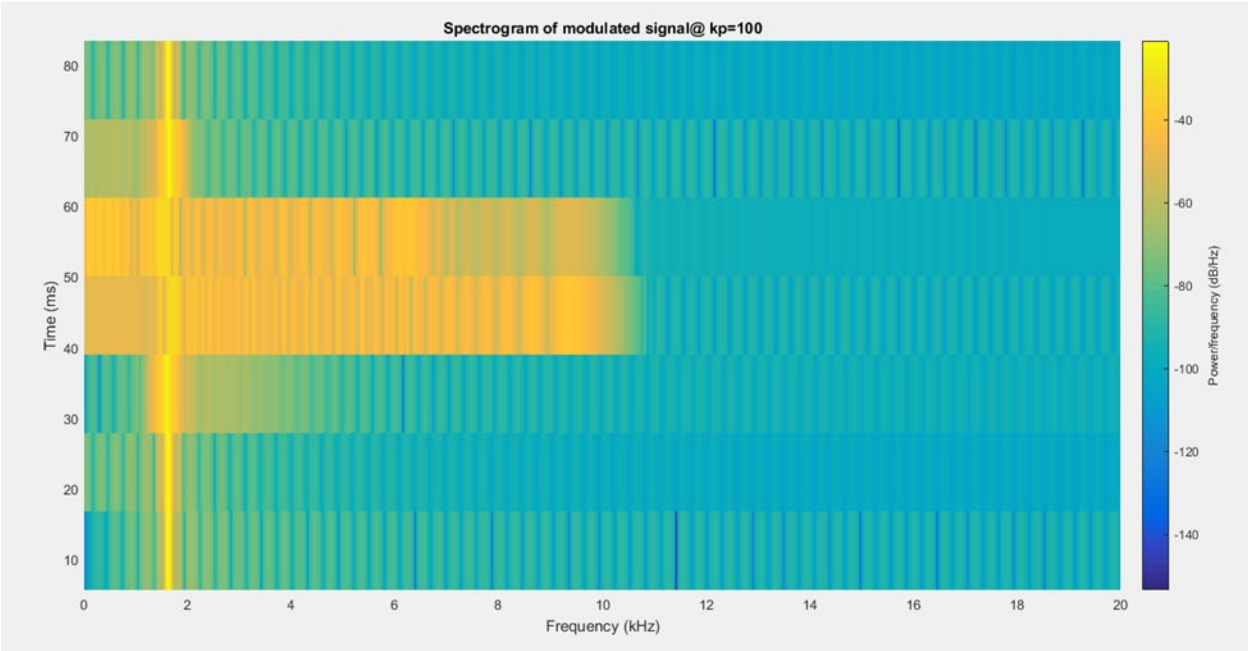
Comment: as we see that by increasing phase sensitivity KP the deviation of frequency from carrier frequency increase and the transmitted bandwidth increases also due to the following relations:

$$\Delta f = \frac{kp}{2\pi} * \frac{dm(t)}{dt}, B_T = 2(\Delta f + fm).$$

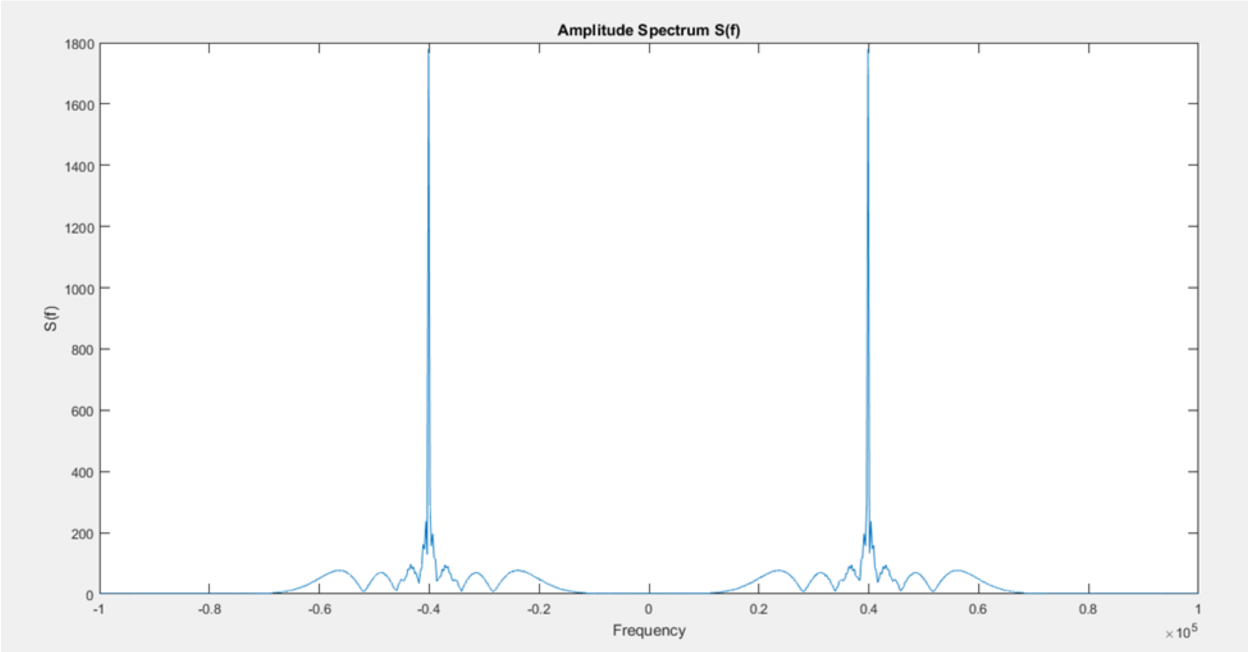
3. Spectrogram of modulated signal:



4. Spectrogram of modulated signal@$Kp = 100\, {}^{rad}/_{volt}$:

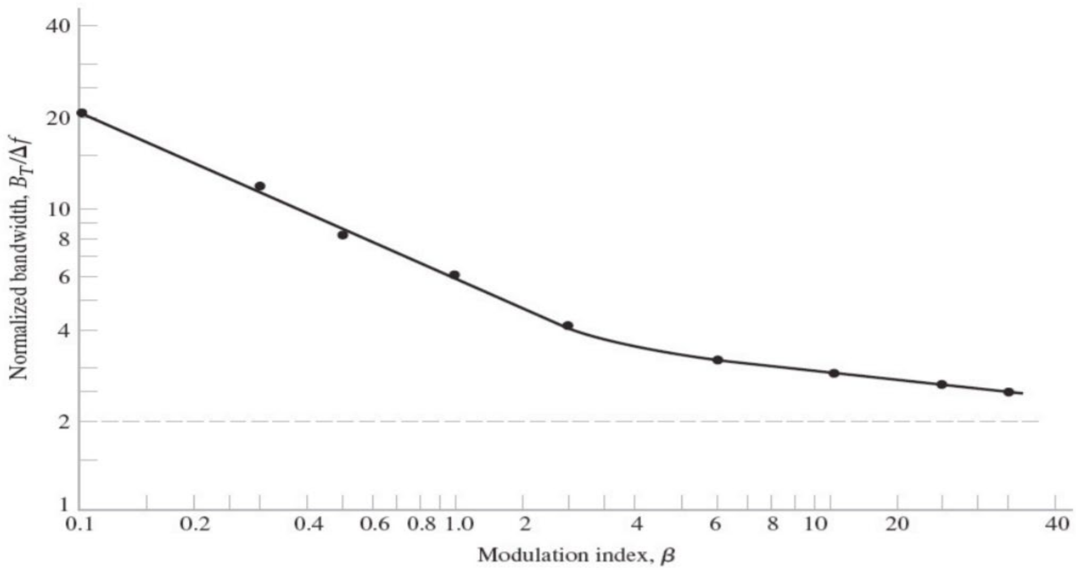


5. Bandwidth from MATLAB: we transfer the modulated signal to frequency domain to get the bandwidth and from spectrum we get BW=41kHz.



Bandwidth using Carson's rule: we use MATLAB to get value $\nabla f = kp * \frac{dm(t)}{dt} = 20kHz$, and we have fm=500Hz, so using Carson's rule: $B_T = 2(\Delta f + fm) = 41kHz.$

Bandwidth using universal curve: we have $\beta = \frac{\Delta f}{fm} = 40.$

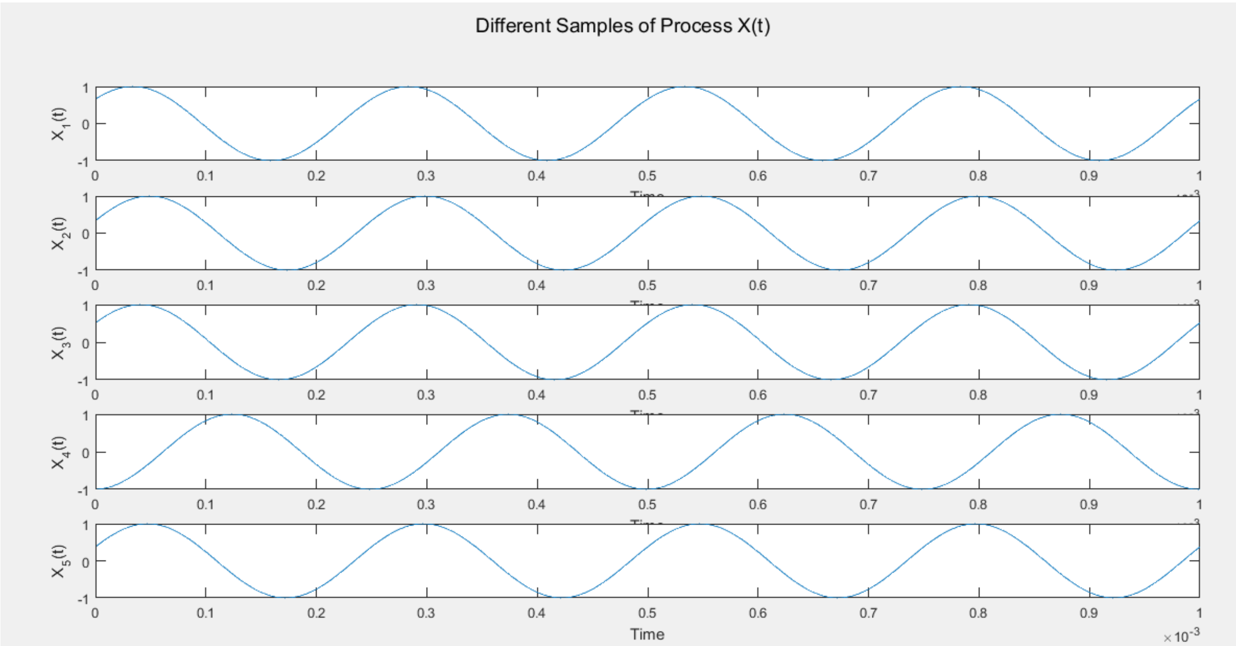


And we have $\frac{B_T}{\Delta f} = 2$, so from previous curve BW= $40kHz$.

Part 6:

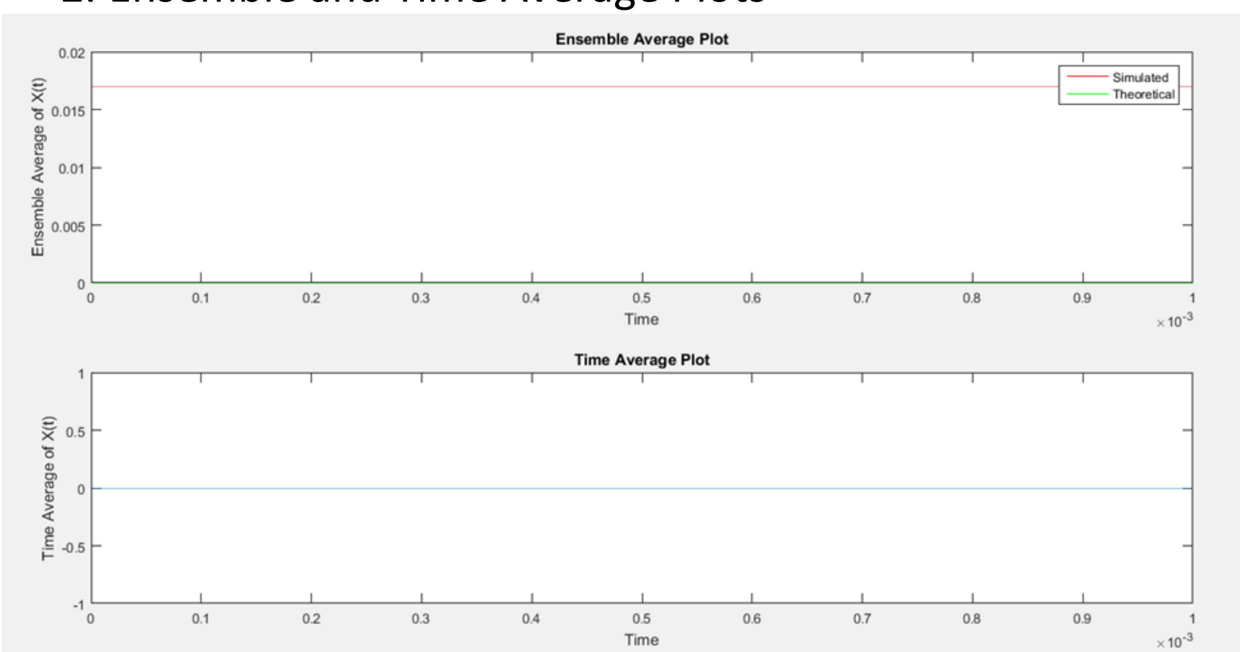
$$X(t) = \cos(2\pi f t + \theta)$$

1. Five Samples of this Random Process



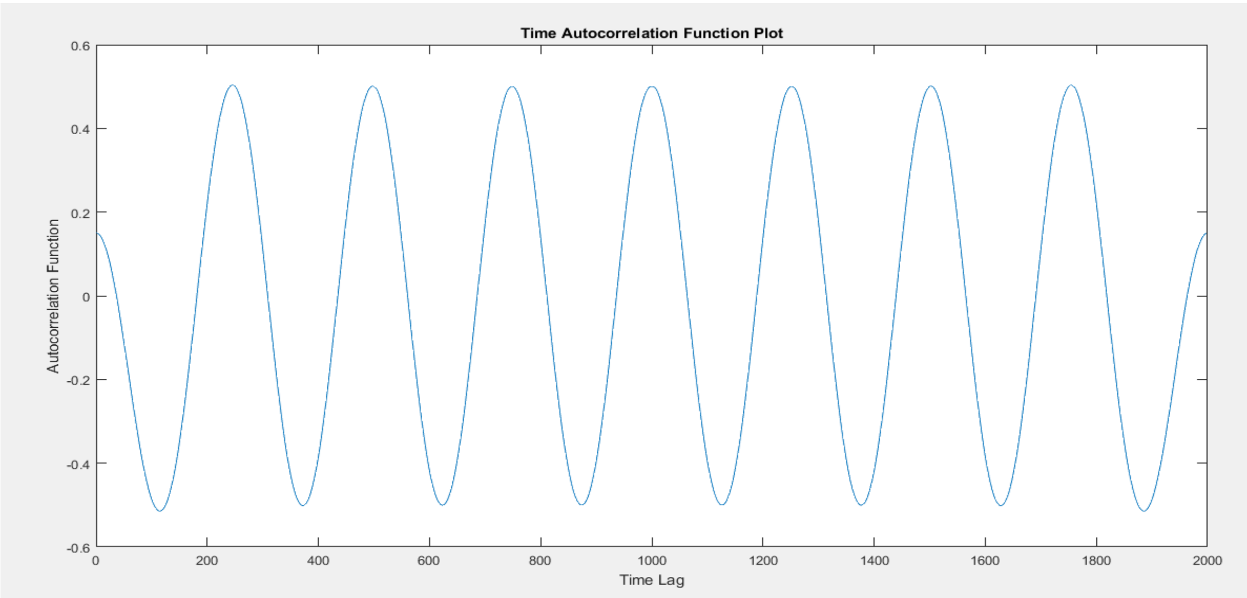
As noticed that each plot differs from the others by a phase shift that occurred due to the random generation of Theta.

2. Ensemble and Time Average Plots



The values of simulated ensemble average are different in each simulation due to random process in Theta while time average and theoretical ensemble average is always constant.

3. Time Autocorrelation



$$X(t) = \cos(2\pi f t + \theta)$$

$$R_{xx} = E\{X(t+\tau) * X(t)\}$$

$$R_{xx} = \mathrm{E}\{\cos(2\pi f(t+\tau) + \theta) * \cos(2\pi f t + \theta)\}$$

$$R_{xx} = E\{0.5\cos(2\pi f\tau) + 0.5\cos(2\pi f(t+\tau) + 2\theta)\}$$

After integrating on Theta, the second component will be 0 while first component does not depend on the Theta (random variable).

$$R_{xx} = \frac{1}{2} * \cos(2\pi f\tau)$$

The function is cosine it does not depend on time but depends on time lag and this solution satisfies the analytical solution.

Drive Link

https://drive.google.com/drive/folders/1YPrjK7E9OQczohTvoMfto8xDgjNvgtAz?fbclid=IwAR0lMew6w4j1tJ34alyhhO2QiDv0AwIfElNhvfaXkCS6zEzat6WUnmJ5tcU