Cours : Traitement du signal **TP n°2 : Spectral Analysis**	ISEN ALL IS DIGITAL! BREST yncréa	Houssem Gazzah CIPA4 Nantes

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FFT

The **fft** MATLAB command enables you to obtain the spectrum of a signal
The simplest manner to call ftt is to write: **X=fft(x)**
Input x and output X are vectors with the same length, say N
x represents N **samples of a signal** x(t), at **0,Ts,…,(N-1)Ts** seconds
X represents N **samples of the spectrum** X(f), at **0,fi,…,(N-1)fi** Hz

How is **fi** related to **Ts** ?
Intuitively, Ts is smallest time interval being observed (smallest time resolution)
As a consequence, fs=1/Ts is the largest frequency you could possibly measure
Conclusion: **fs=N.fi** (Notice, N is large enough so that N-1≈N)

Notice that because we manipulate real-valued signals, the spectrum will be symmetrical (redundant). We study the first half of it. Also, we are often interested in the magnitude only of the complex-valued spectrum

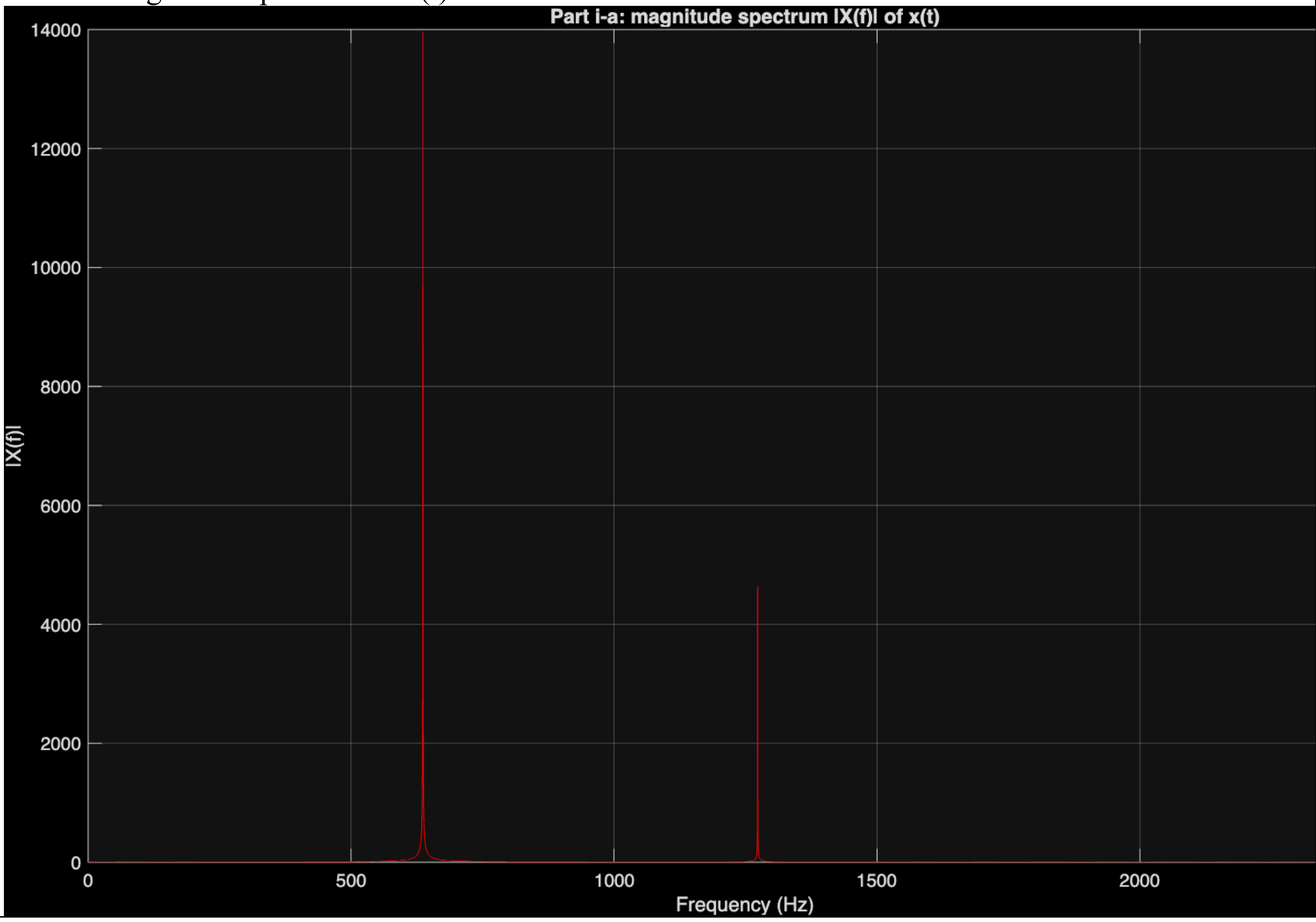
Experiment 1

To Generate a mixture of sinusoidal signals and to verify that the spectrum is as predicted by theory

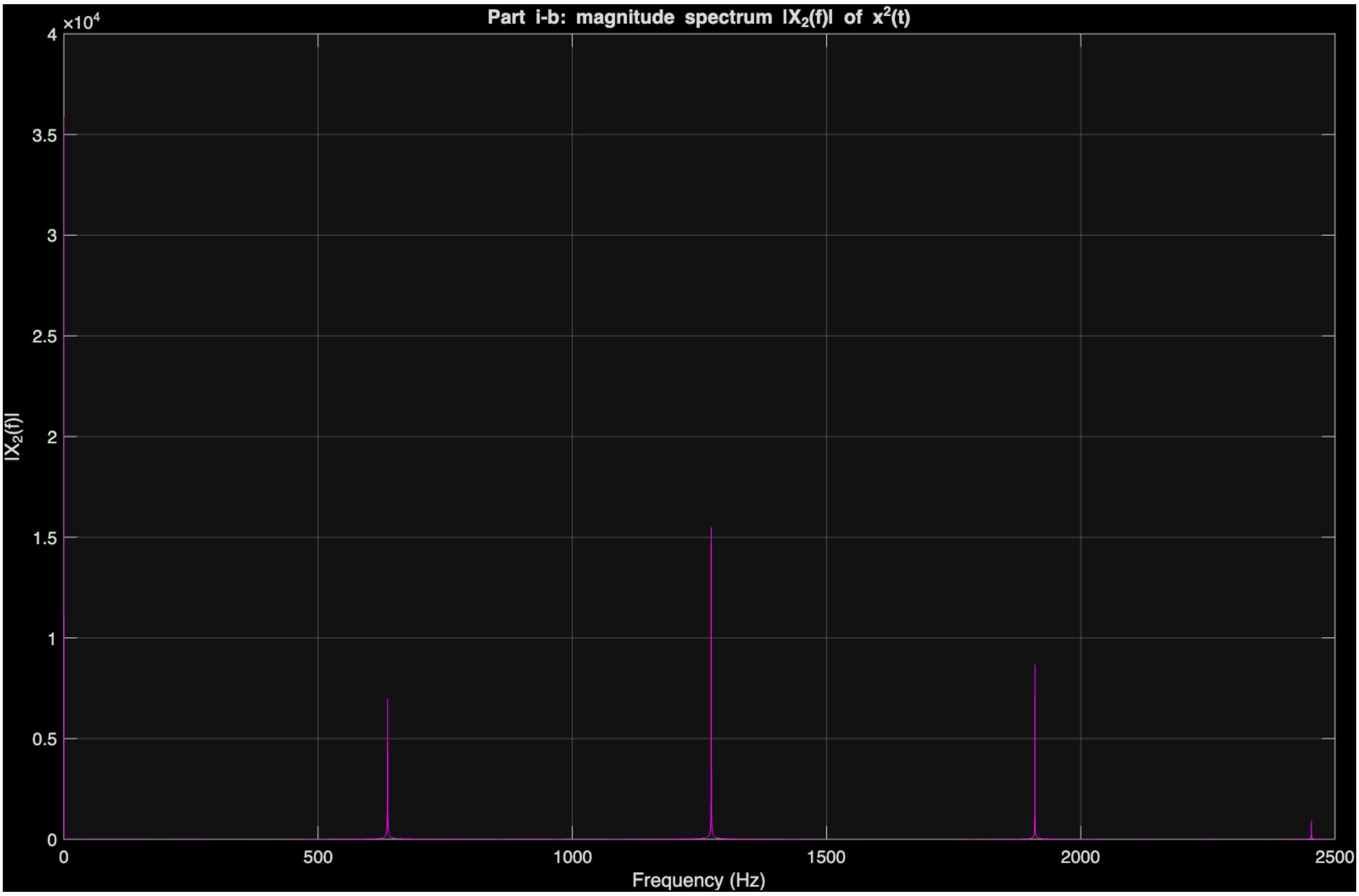
i/ Set the sampling period to 0.2ms and the time interval to [0,4s]

Generate the signal x(t)= sin(2000t+56) sin(56-6000t)+2 cos(4000t)

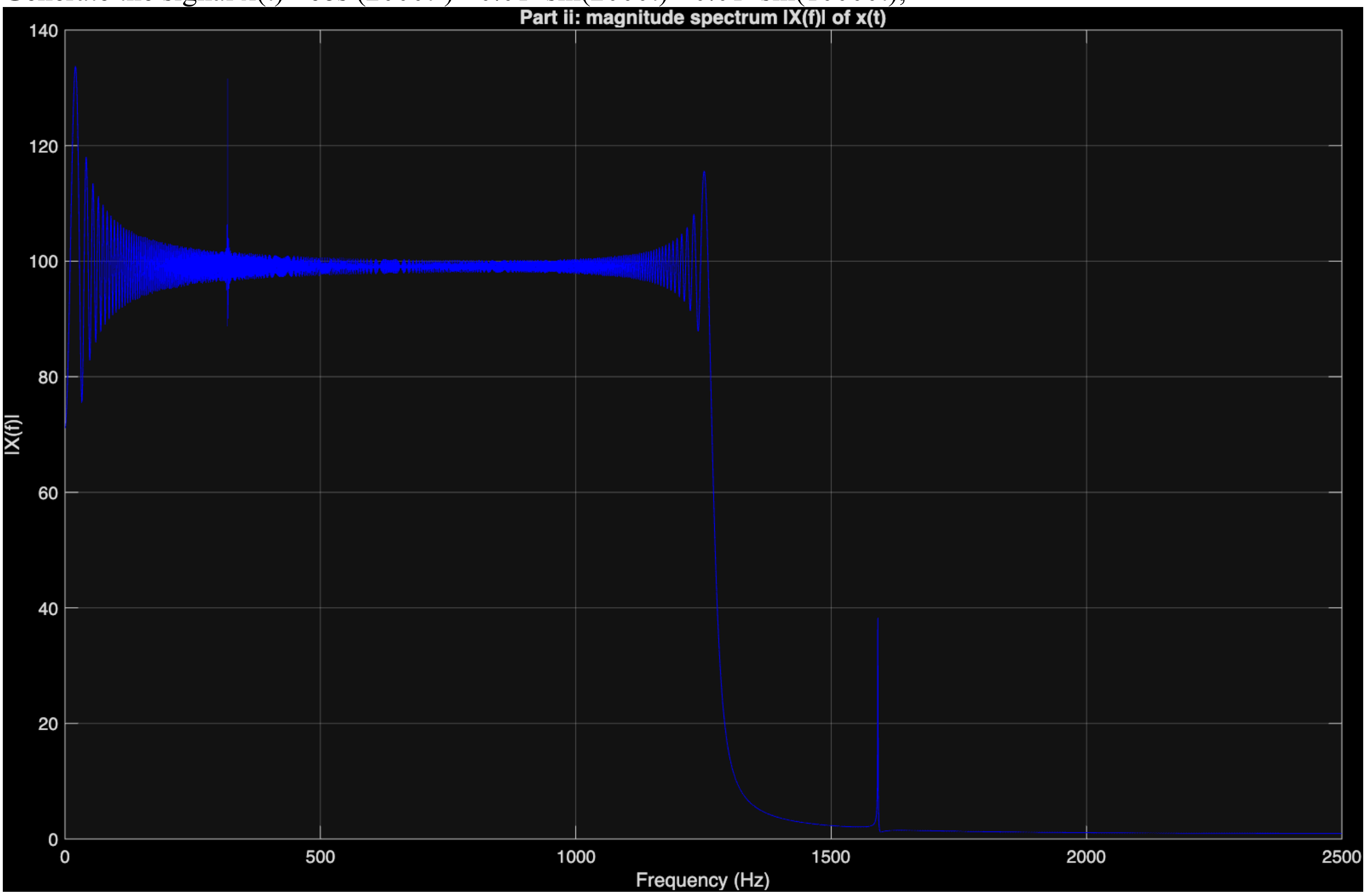
a) Plot the magnitude spectrum of x(t).



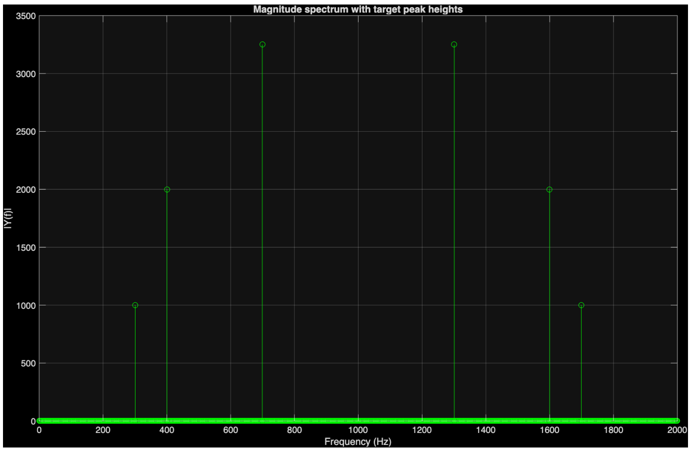
b) Plot the magnitude spectrum of $x^2(t)$**.**



ii/ Set the sampling frequency to 5KHz and the time interval to [0,2s] **(No help will be provided)**
Generate the signal x(t)= cos $(2000t^2)$ +0.01*sin(2000t) +0.01*sin(10000t);



Experiment 2
Consider the following power spectrum of some signal x(t)



Write a MATLAB code that generates a signal y(t) with the same power spectrum

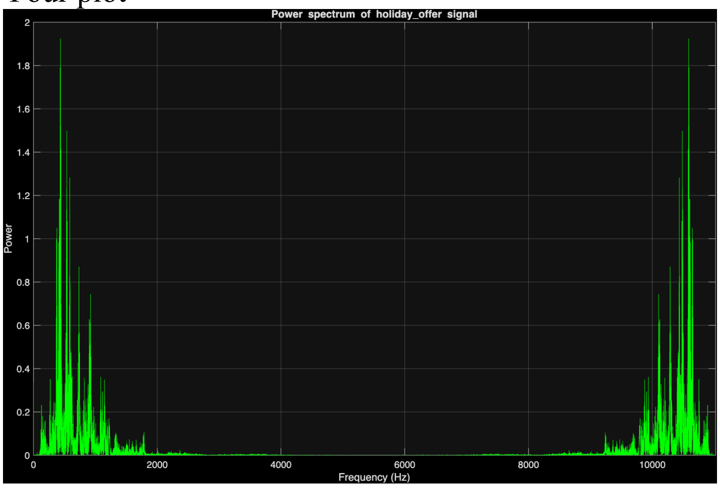
Replace the present figure by yours

Experiment 3

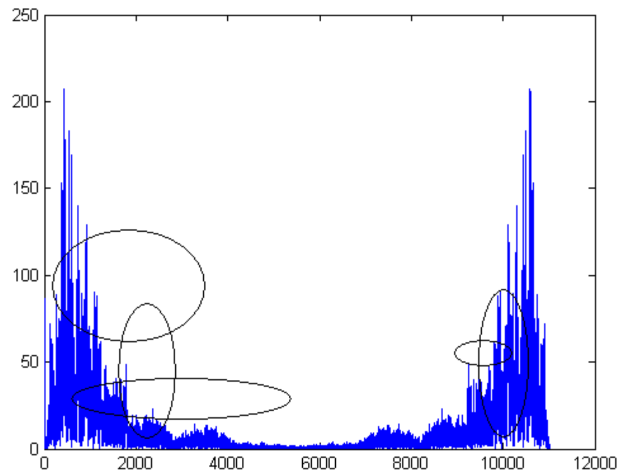
Load (TP 1) the signal from *'holiday_offer.mat'*
It has been sampled at the rate of 11025 samples/second

Plot the associated power spectra. **Insert here**

Your plot



The solution



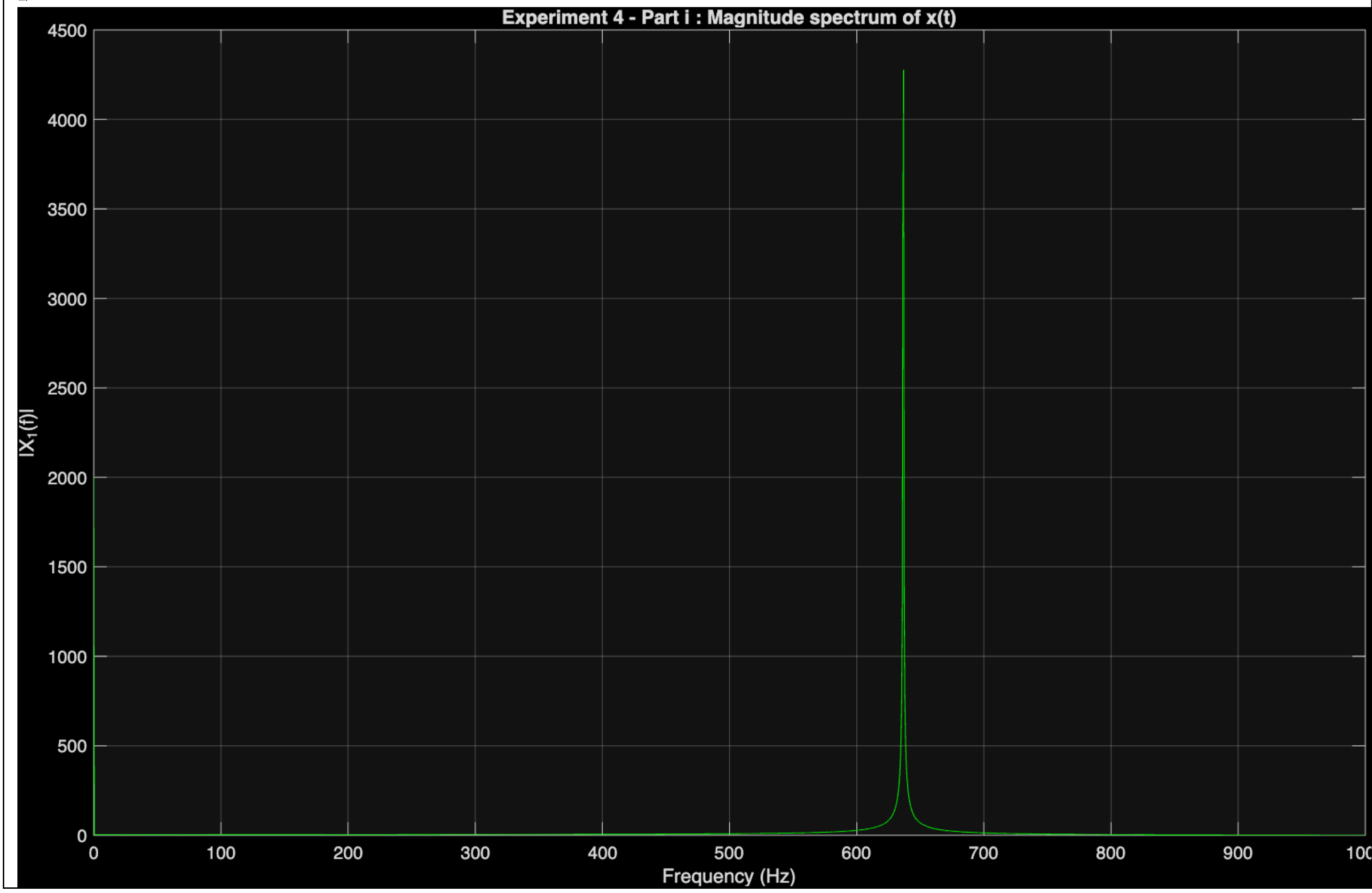
Experiment 4

i/ Set the sampling period to 0.5ms
Set the time interval to [0,2s]
Generate the signal $x(t) = \sin(4000t) + 2\cos(4000t - 32) + \cos^2(2000t)$
Plot the magnitude spectrum with the horizontal axis properly labeled in Hz.

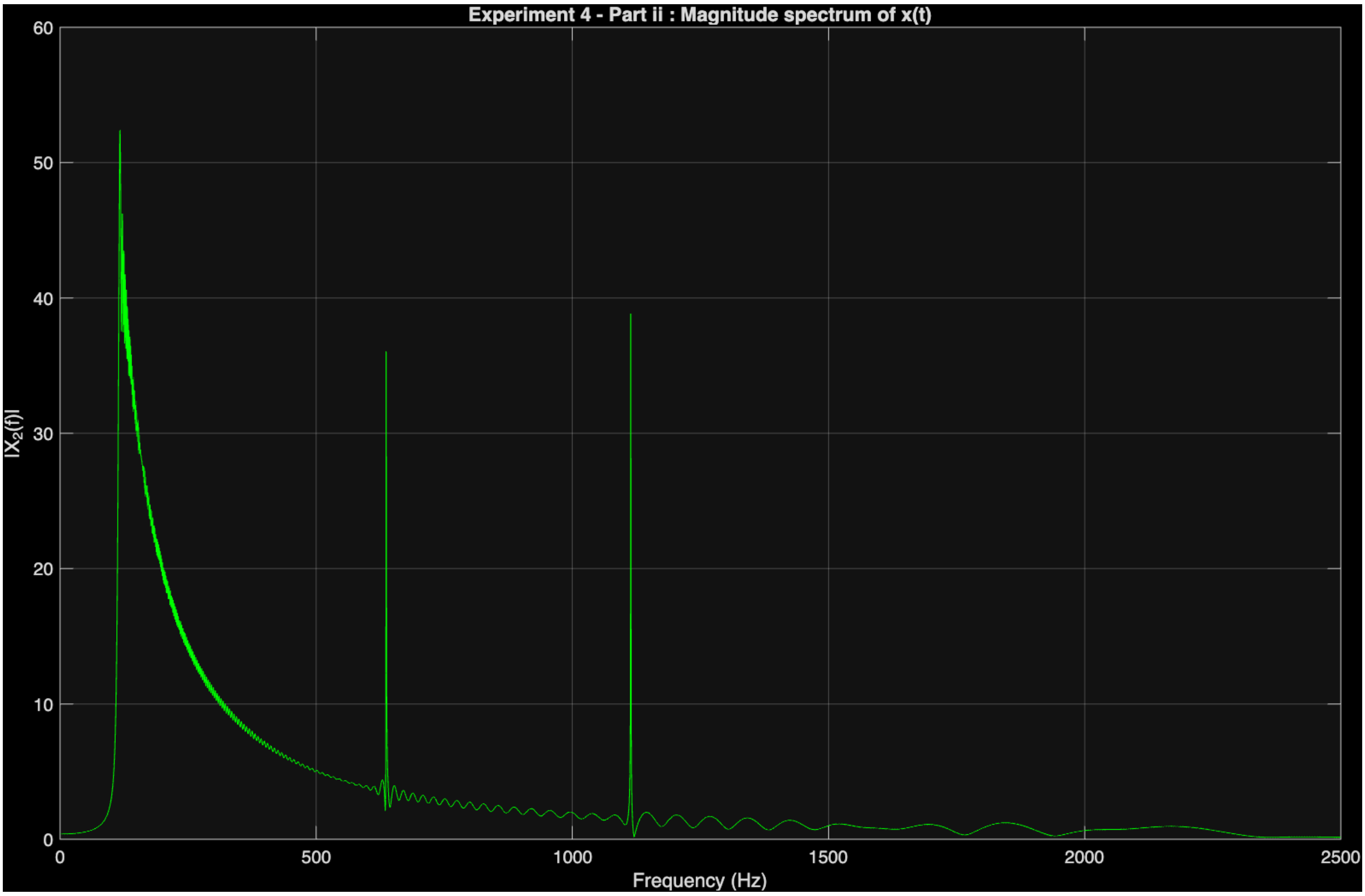
ii/ Set the sampling frequency to 5KHz
Set the time interval to [0,2s]
Generate the signal $x(t) = 0.1\sin(2000t^{1/2}) + 0.01\sin(4000t) + 0.01\cos(7000t)$
Plot the magnitude spectrum with the horizontal axis properly labeled in Hz.

Insert plots here

i/



ii/



Experiment 5

Set the time interval to [0,0.4s]. Consider the signal

$x(t)= \cos(2\pi+20000t)\ \sin(2\pi\ 30000t)+2\ \cos(22000t)$

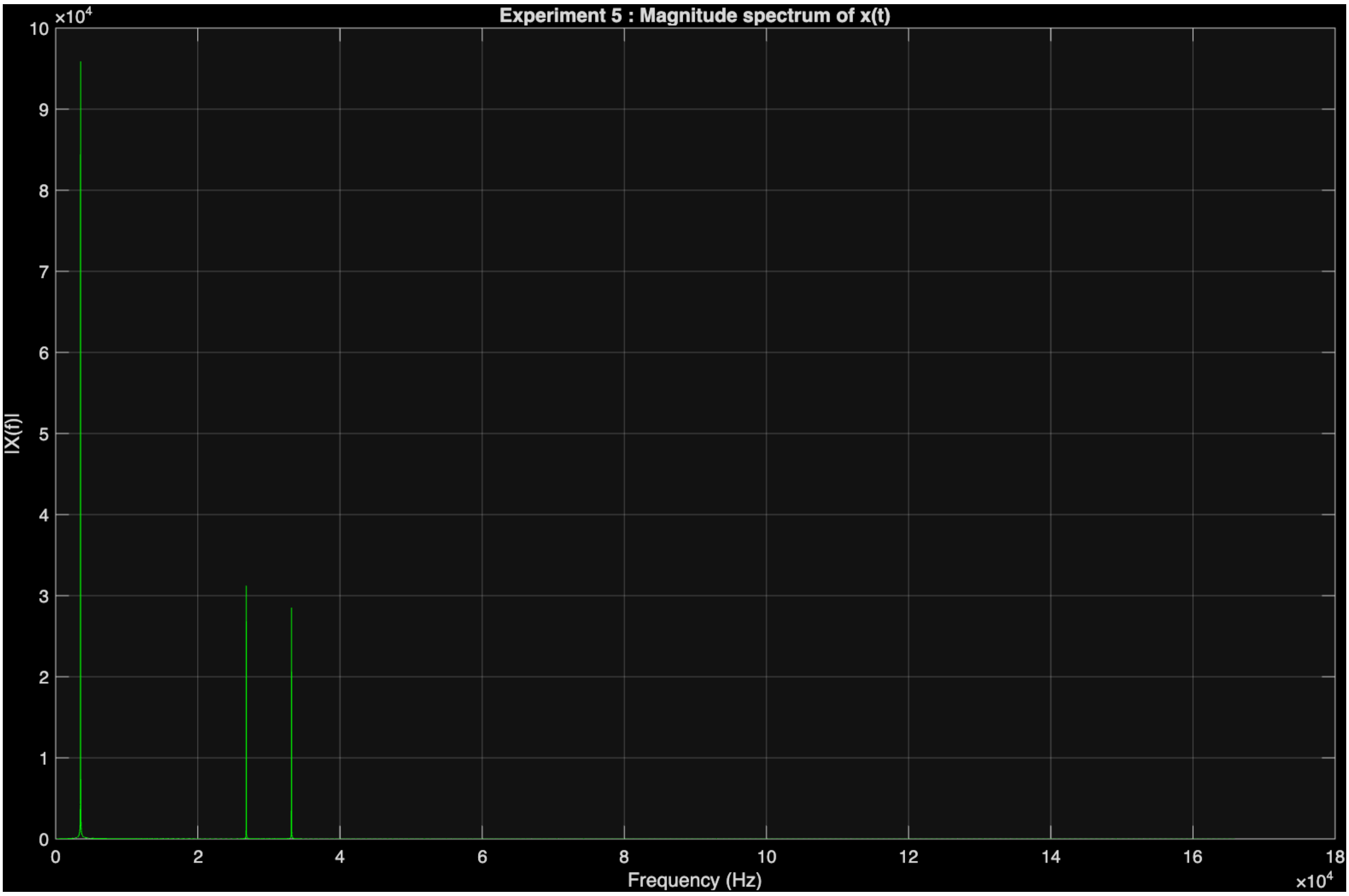
i) Using the Fourier spectral theory, list the frequencies that form the signal

F1 = 20000/ 2π + 30000 Hz

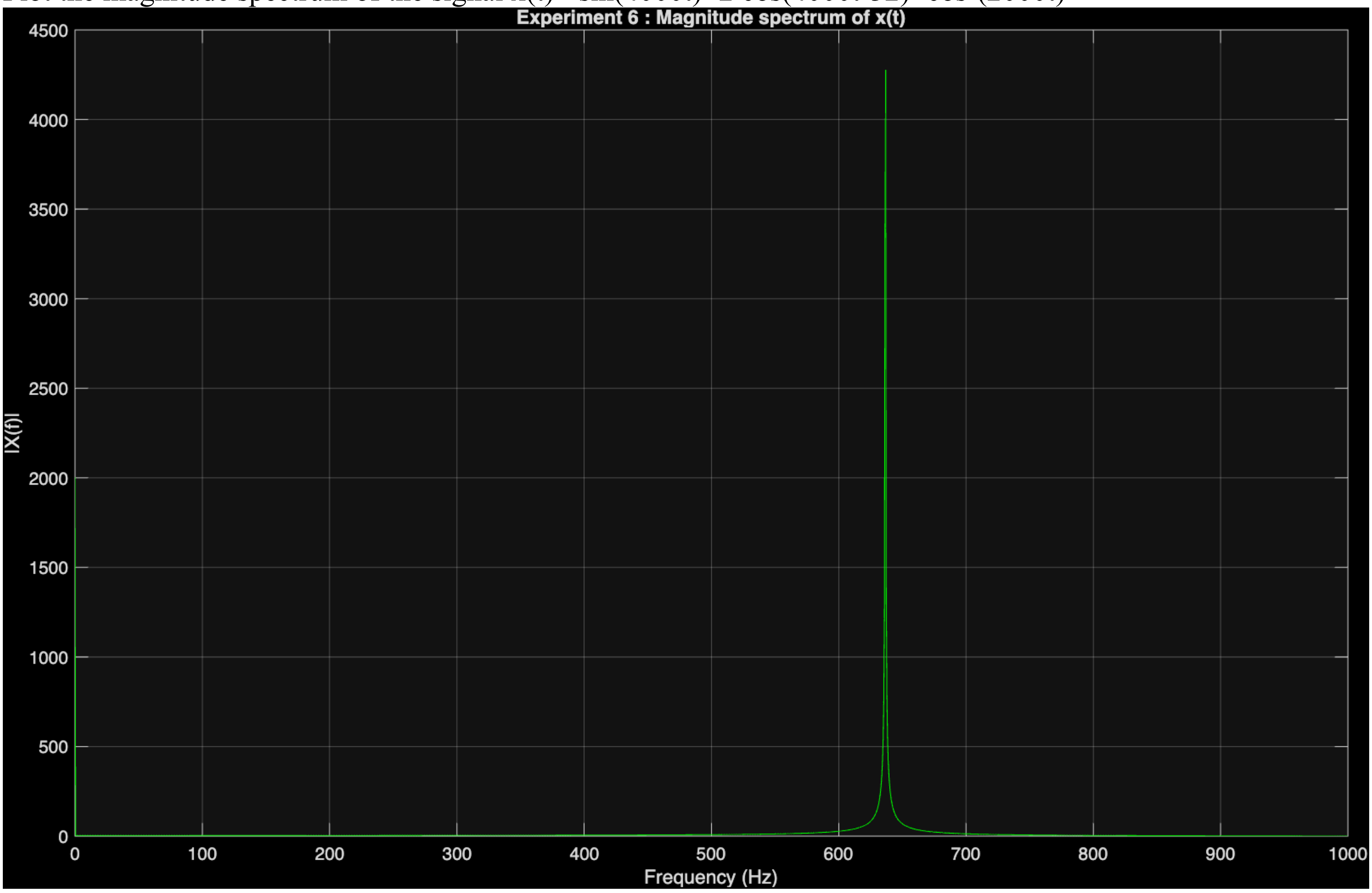
F2 = 30000 – 20000/2π Hz

F3 = 22000/2π Hz

ii) Choose an appropriate sampling period Ts and plot the magnitude spectrum of x(t).



Experiment 6 (10 points. No help)
Set the sampling period to 0.5ms
Set the time interval to [0,2s]
Plot the magnitude spectrum of the signal $x(t)= \sin(4000t)+2 \cos(4000t-32)+\cos^2(2000t)$



Experiment 7
Spectral Analysis of the raised cosine waveform

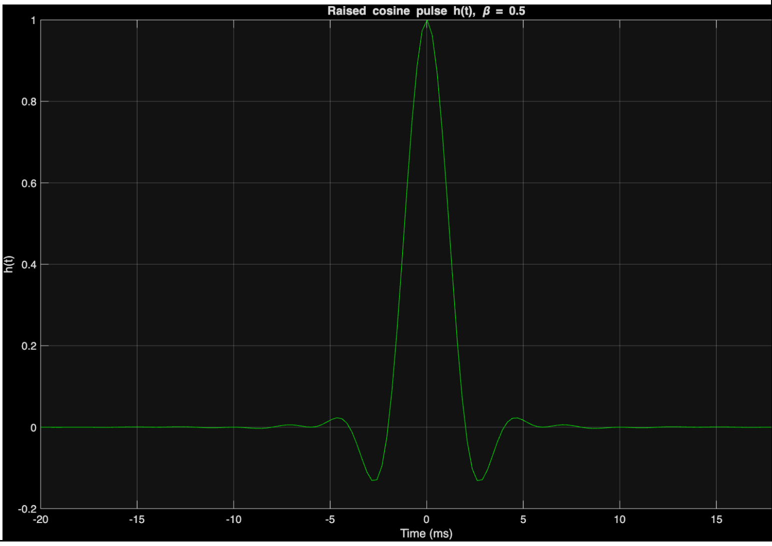
The objective is to generate and analyze the so-called raised cosine pulses used in communication systems
The raised cosine pulse is defined as follows

$$h(t) = \mathrm{sinc}\left(\frac{t}{T}\right)\frac{\cos\left(\frac{\pi\beta t}{T}\right)}{1-\frac{4\beta^2 t^2}{T^2}}$$

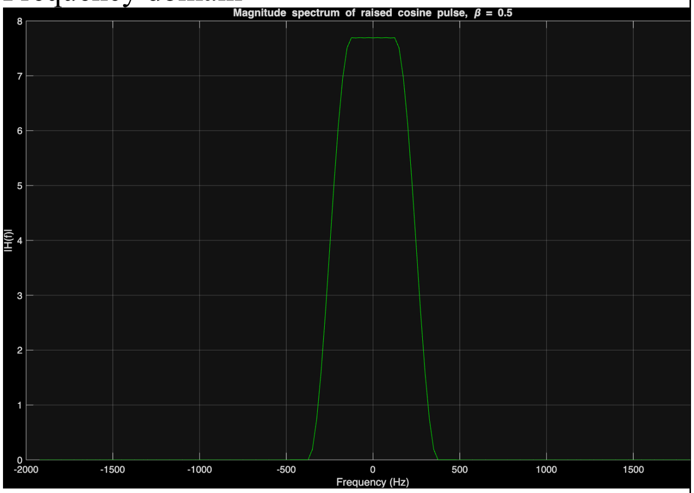
For this experiment, set T=2 ms and β=0.5
Consider generating the pulse for t in [-10T,10T]
Denote **Ts** as the sampling period, set to *0.13 T*

a/ Generate the pulse **h** and plot it. Label the x-axis in ms. Insert your plot here
b/ Compute spectrum **H** of **h**. Plot the magnitude spectrum with the y-axis labeled in Hz. Insert plot here

Time domain



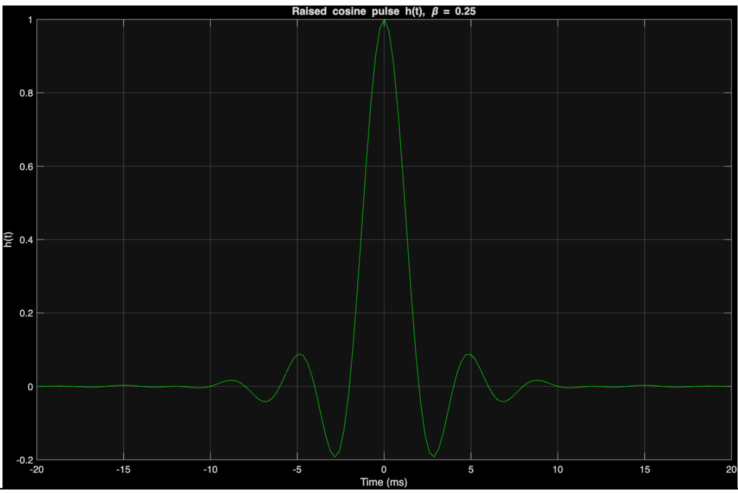
Frequency domain



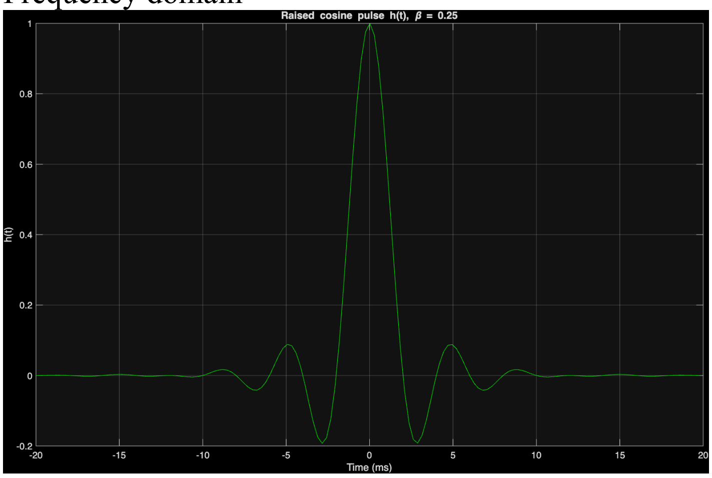
c/ Measure the signal bandwidth. Bandwidth=375.00 Hz

d/ Repeat steps b-d with β =0.25

Time domain



Frequency domain



Bandwidth=**312.5 Hz**