Lab Assignment – 07 – Spring 2020

Signal & Systems

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Summary:

- This assignment mainly dealt with determining the Nyquist rate of a signal and sampling a given signal with different sampling rates fs.
- The main thing we learnt from this exercise is that we can represent a continuous signal in discrete form by sampling it

1) Given the following signal, we had to determine and plot the Fourier transform and then determine the Nyquist sampling rate.

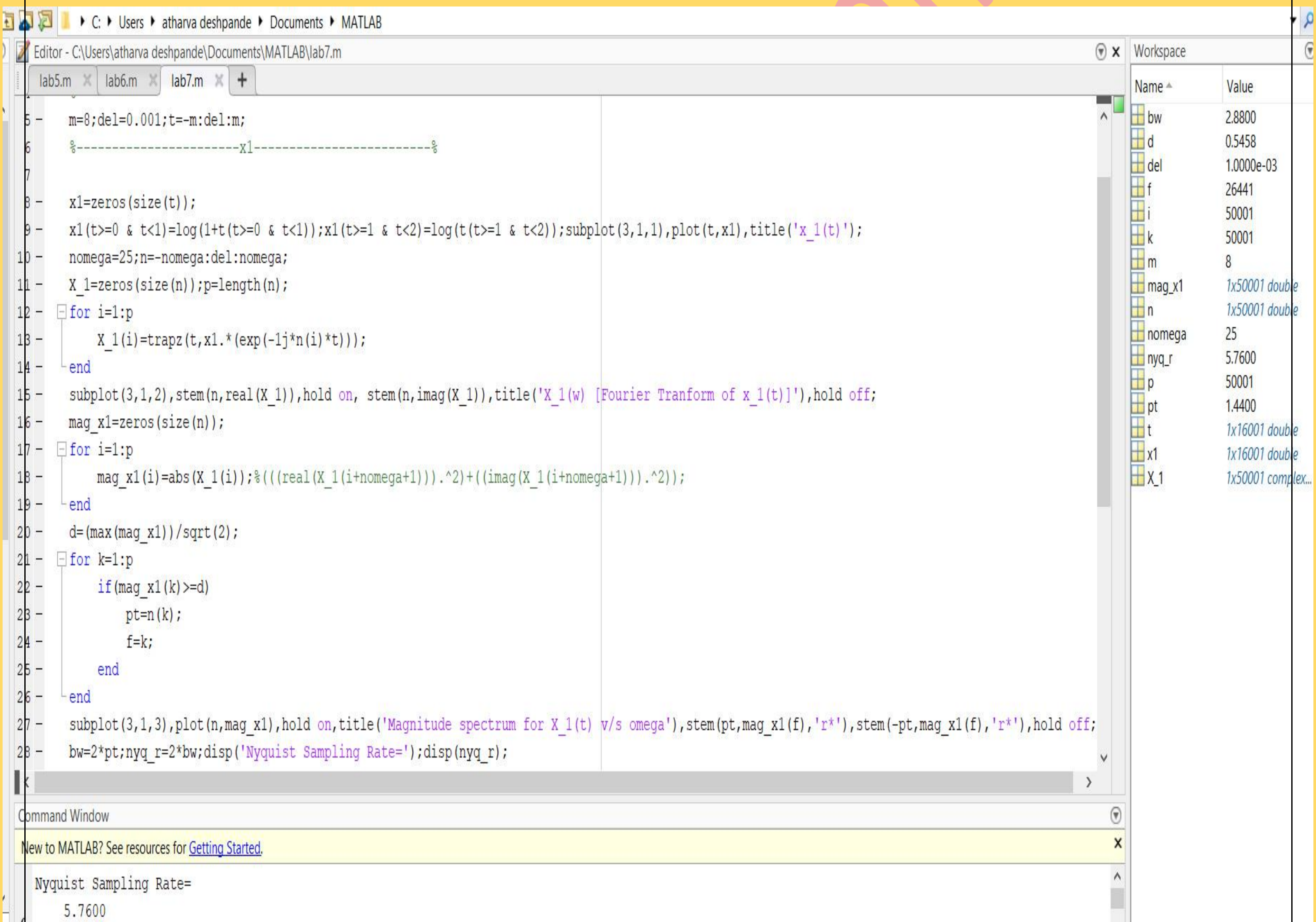
$$x(t) = \begin{cases} \ln(1+t) & 0 < t < 1 \\ \ln(t) & 1 \le t < 2 \\ 0 & \text{elsewhere} \end{cases}$$

-> First, we'll create the code for finding the Fourier transform of the signal x(t).

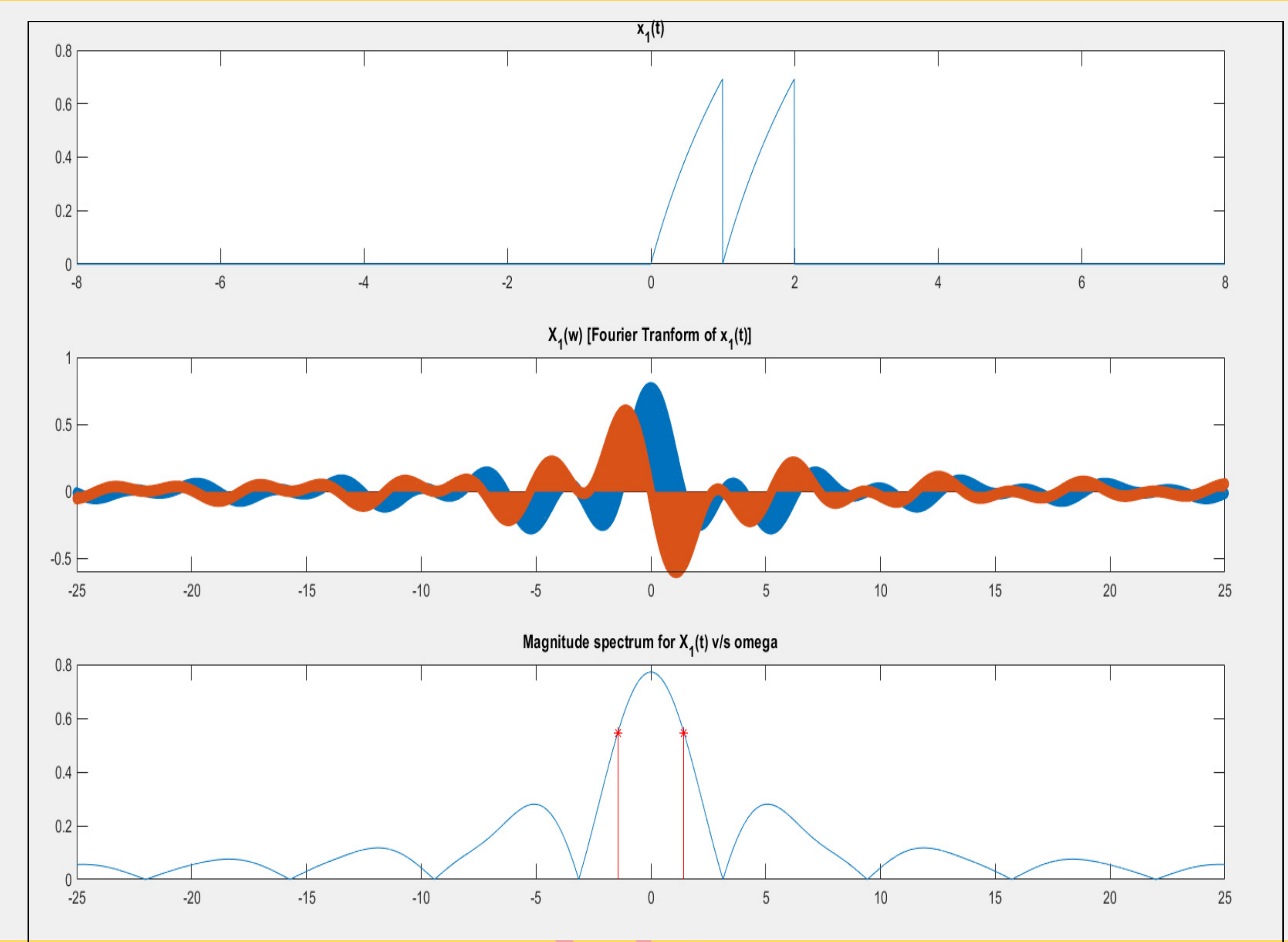
->We'll find out the x-point where the y-value is just (1/√2) x (peak value). Then as the graph comes out to be symmetric, we'll double the x-point to get the bandwidth. Nyquist rate = 2 x Bandwidth.

->Finally, we'll display the Nyquist rate on the command window.

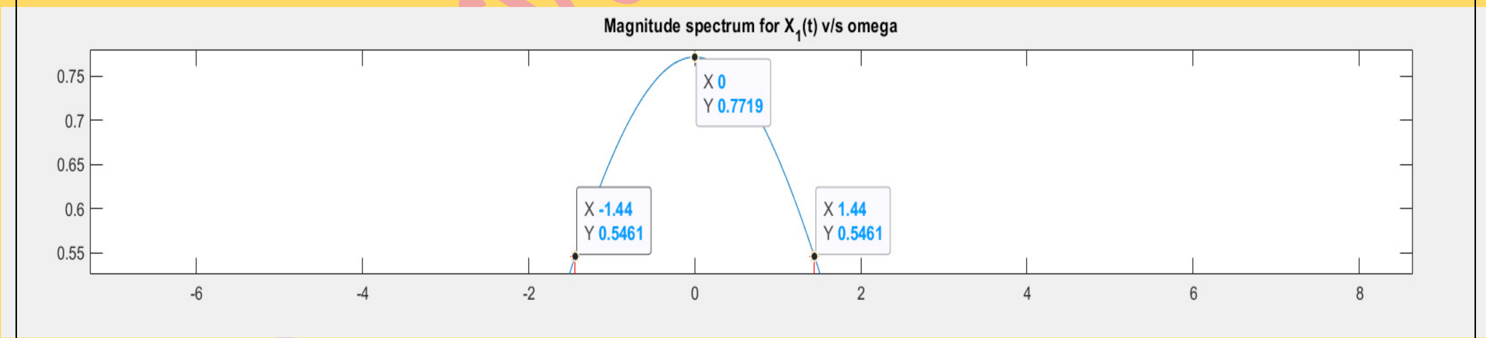
Here's the code:



Here's the output:



On a closer look at the 3rd graph,



What we can conclude from the combined output obtained from command window, graph and workspace is that for the given signal,

Bandwidth = 2.8800

Nyquist Sampling Rate = 5.760

2) For the given signal with f0 = 4,

x(t) = exp(−0.1t) x cos(2πf0t +π/7)(u(t) − u(t − 1))

simulate and plot the sampled discrete signals at the following sampling rates

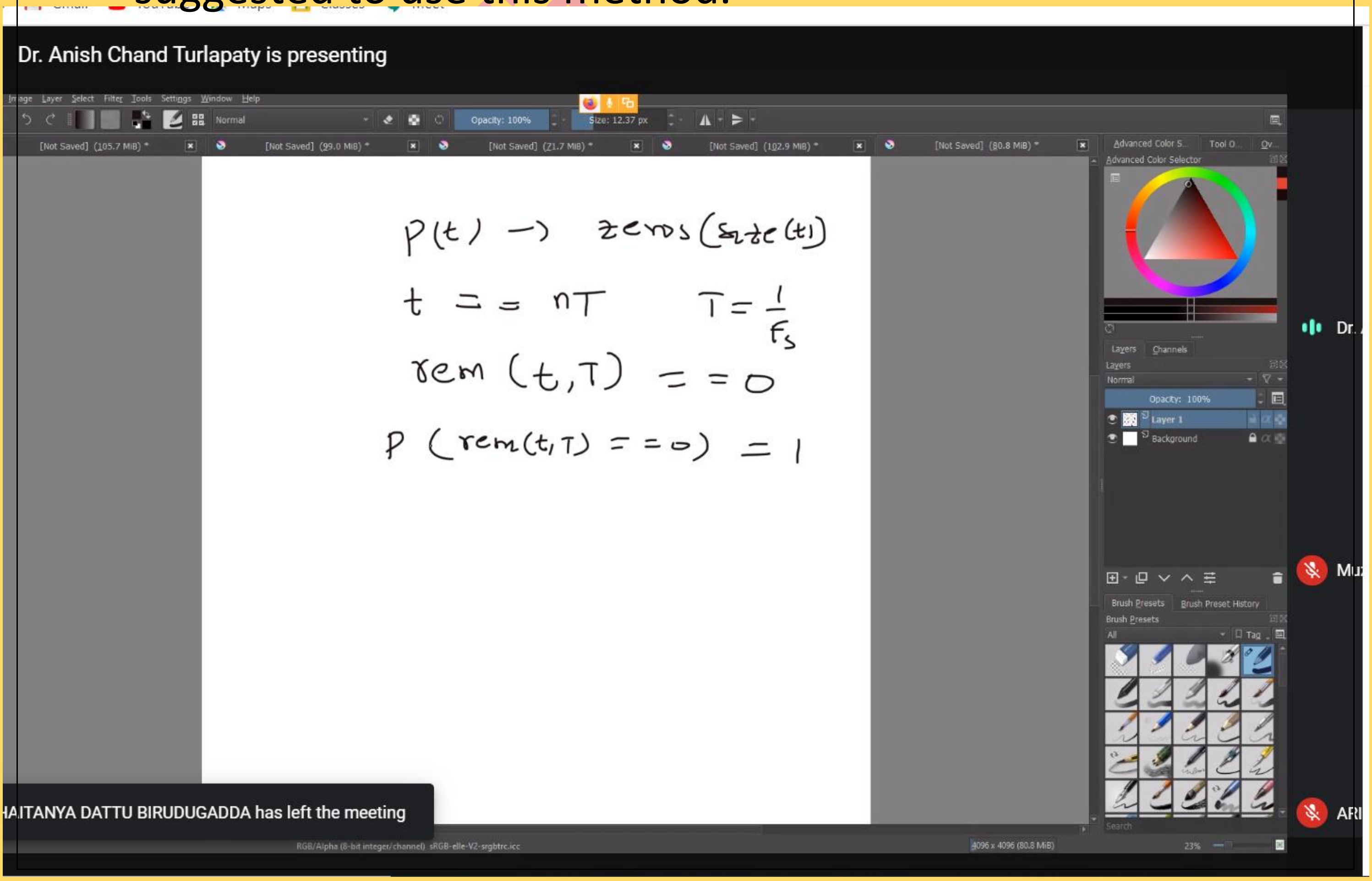
a) fs = 2f0, b) fs = 3f0 and c) fs = 10f0

->First, we'll create a train of impulse with heads having value equal to one.

->Then, we'll multiply those impulse to the given signal and thus get it's sampled discrete signal.

Here's the code:

(i) Before that let me clear the picture. At the end, it is necessary to have a train of impulse p(t). It was suggested to use this method.

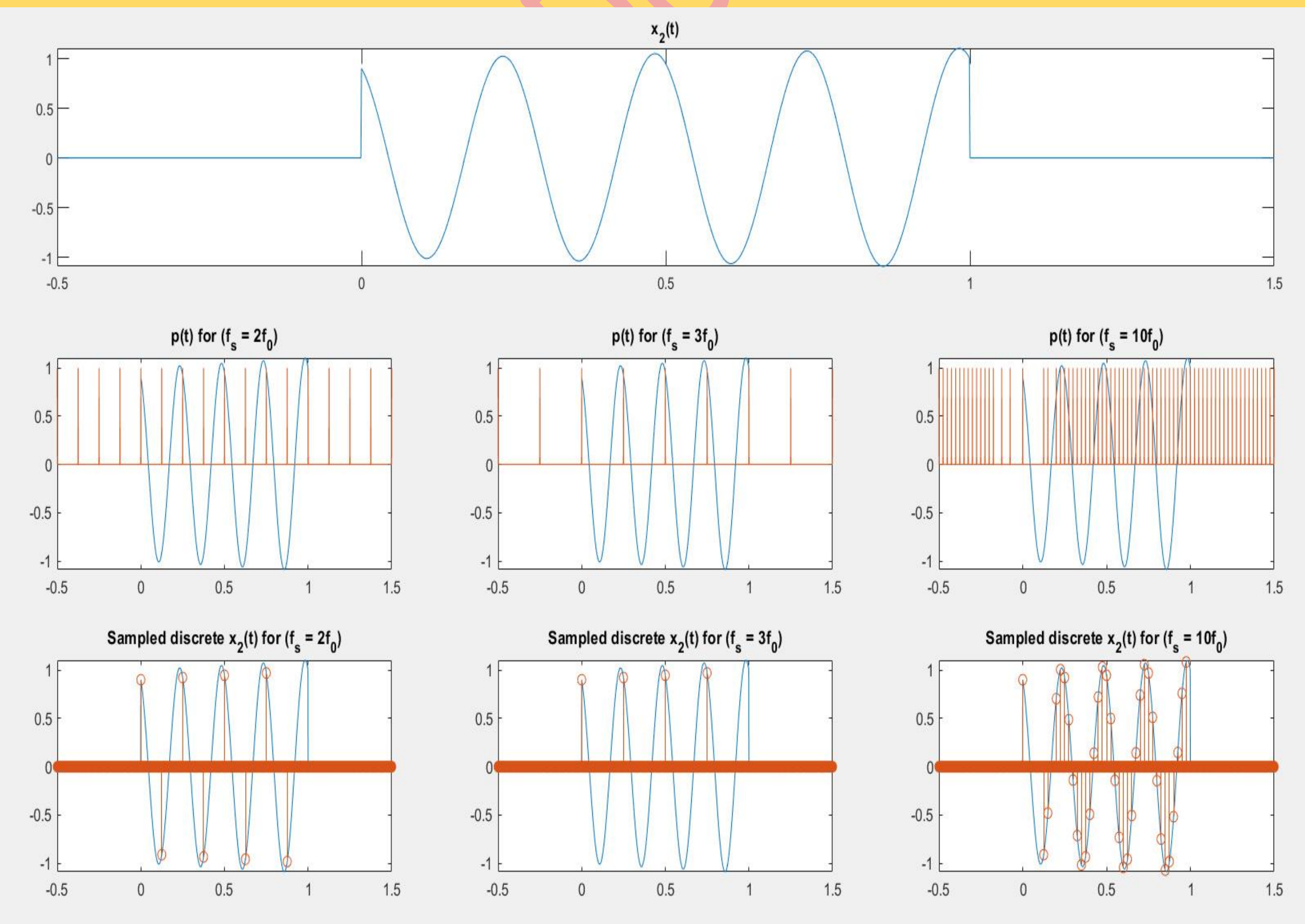


So, we implemented that method.

```
%-----------------------x2-------------------------%

t=-0.5:del:1.5;
f0=4;x2=zeros(size(t));
x2(t>=0 & t<1)=exp(0.1*t(t>=0 & t<1)).*cos((2*pi*f0*t(t>=0 & t<1))+(pi/7));subplot(3,3,[1,2,3]),plot(t,x2),title('x_2(t)');
%a)fs = 2f0
fs=2*f0;cap_t=1/fs;p=zeros(size(t));p(rem(t,cap_t)==0)=1;subplot(3,3,4),plot(t,x2),hold on,plot(t,p),title('p(t) for (f_s = 2f_0)'),hold off;
z=x2.*p;
subplot(3,3,7),plot(t,x2),hold on,stem(t,z),title('Sampled discrete x_2(t) for (f_s = 2f_0)'),hold off;
%b)fs = 3f0
fs=3*f0;cap_t=1/fs;p=zeros(size(t));p(rem(t,cap_t)==0)=1;subplot(3,3,5),plot(t,x2),hold on,plot(t,p),title('p(t) for (f_s = 3f_0)'),hold off;
z=x2.*p;
subplot(3,3,8),plot(t,x2),hold on,stem(t,z),title('Sampled discrete x_2(t) for (f_s = 3f_0)'),hold off;
%c)fs = 10f0
fs=10*f0;cap_t=1/fs;p=zeros(size(t));p(rem(t,cap_t)==0)=1;subplot(3,3,6),plot(t,x2),hold on,plot(t,p),title('p(t) for (f_s = 10f_0)'),hold off;
z=x2.*p;
subplot(3,3,9),plot(t,x2),hold on,stem(t,z),title('Sampled discrete x_2(t) for (f_s = 10f_0)'),hold off;
```

We got this:



Observation:

As you can see, when we increased fs from 2f0 to 3f0 we got fewer samples, which ideally should not have happened as we are decreasing T(Since, T=1/fs). When we checked the values, they were actually what they were not supposed to be. It should be t=nxT. But those values were not showing up that frequently at the appropriate values. Also, there’s a gap in between when fs=10xf0. So, we cross checked the output for fs>10Xf0. Again, it had gaps at the same place every time. Hence, we need to find another method to generate a harmonic impulse train.

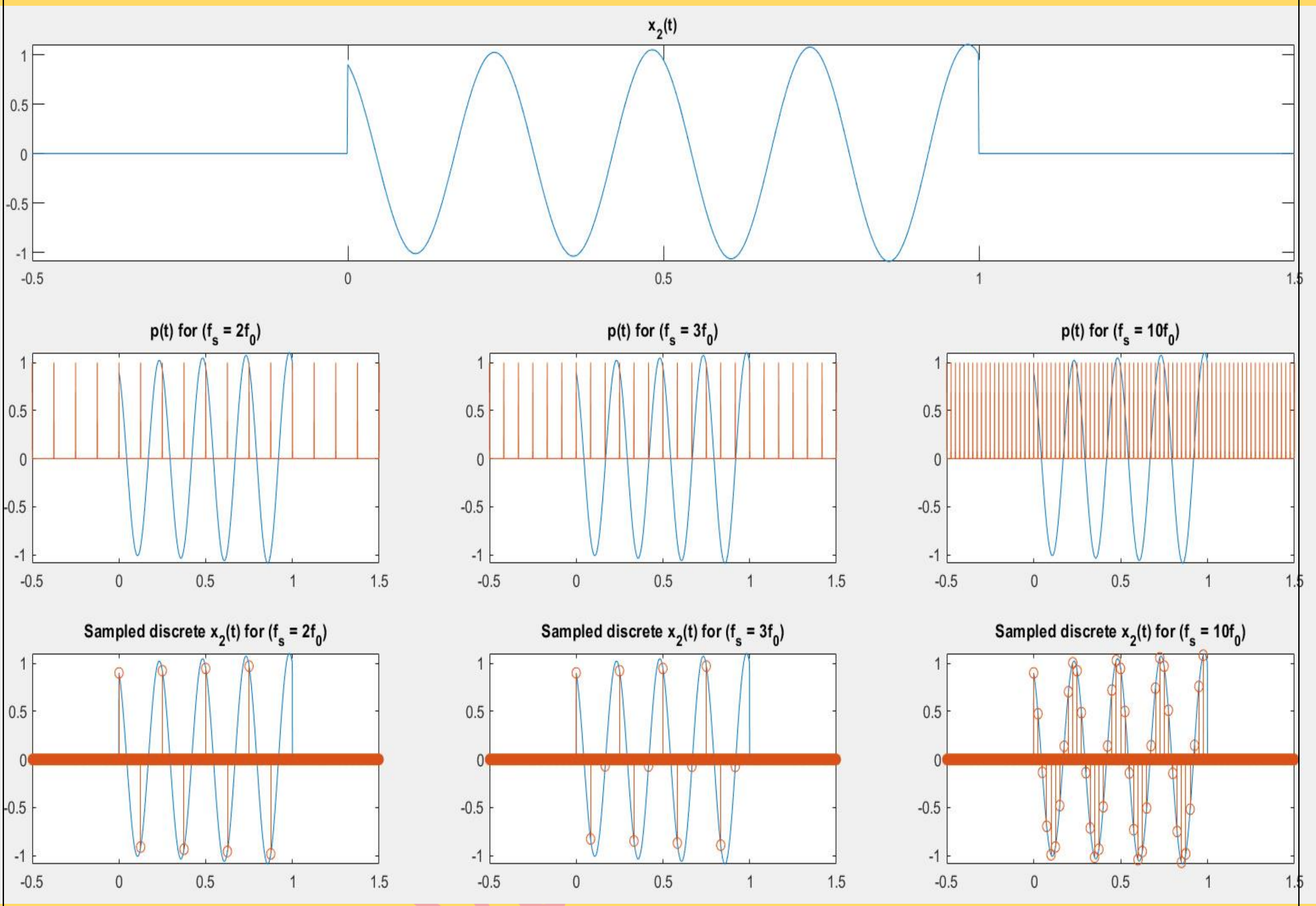
(ii)So, we made few changes and it solved the problem.

Here’s the code:

```
%-----------------------x2------------------------%

t=-0.5:del:1.5;
f0=4;x2=zeros(size(t));
x2(t>=0 & t<1)=exp(0.1*t(t>=0 & t<1)).*cos((2*pi*f0*t(t>=0 & t<1))+(pi/7));subplot(3,3,[1,2,3]),plot(t,x2),title('x_2(t)');
%a)fs = 2f0
fs=2*f0;cap_t=1/fs;p=zeros(size(t));p(1:(cap_t/del):end)=1;subplot(3,3,4),plot(t,x2),hold on,plot(t,p),title('p(t) for (f_s = 2f_0)'),hold off;
z=x2.*p;
subplot(3,3,7),plot(t,x2),hold on,stem(t,z),title('Sampled discrete x_2(t) for (f_s = 2f_0)'),hold off;
%b)fs = 3f0
fs=3*f0;cap_t=1/fs;p=zeros(size(t));p(1:(cap_t/del):end)=1;subplot(3,3,5),plot(t,x2),hold on,plot(t,p),title('p(t) for (f_s = 3f_0)'),hold off;
z=x2.*p;
subplot(3,3,8),plot(t,x2),hold on,stem(t,z),title('Sampled discrete x_2(t) for (f_s = 3f_0)'),hold off;
%c)fs = 10f0
fs=10*f0;cap_t=1/fs;p=zeros(size(t));p(1:(cap_t/del):end)=1;subplot(3,3,6),plot(t,x2),hold on,plot(t,p),title('p(t) for (f_s = 10f_0)'),hold off;
z=x2.*p;
subplot(3,3,9),plot(t,x2),hold on,stem(t,z),title('Sampled discrete x_2(t) for (f_s = 10f_0)'),hold off;
```

Here’s the output:



Observation:

- Now we can conclude that the obtained graph is correct as when we increase the sampling rate the number of samples too increase.
- Also, we find no gap in the impulse train of any of the graphs.