ESE-2014 Lab 2

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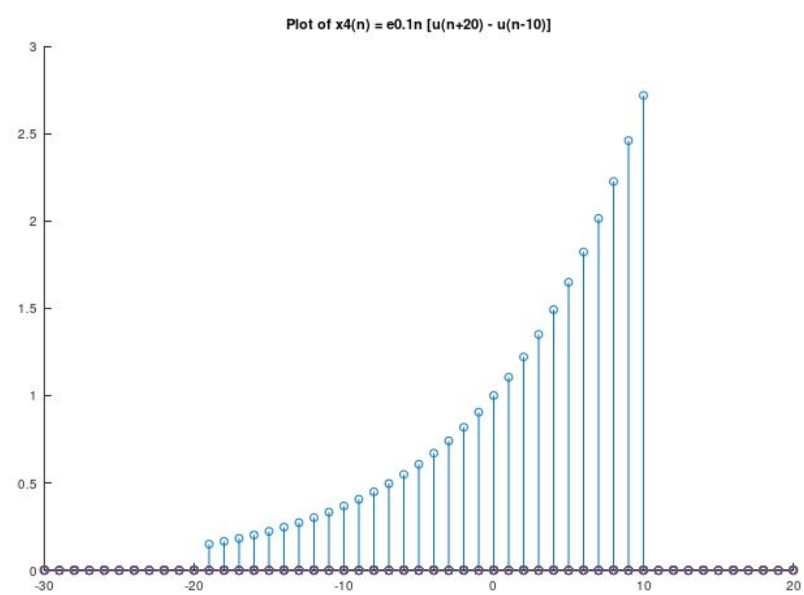
Introduction

In this lab report, we will be looking at some implementation of simple mathematical operations used in DSP in our MATLAB app. Some applications of DSP include image/audio/video processing, SONAR, RADAR and so on.

One of the mathematical function we use in DSP is the unit step function which is defined as:
u(n) = 1 ; if n>0
u(n) = 0 ; otherwise

So, for eg: u(n+20) basically gives a train of samples from -20 to infinity (because u(n) = 1, whenever n is greater than -20).
likewise, u(n-10) gives a sequence of 1s from 10 to infinity.

In the %2nd question, we are subtracting two unit step functions to get a band-limited sequence of 1s and this is multiplied with an exponential function. The result is a set of exponential band-limited samples.



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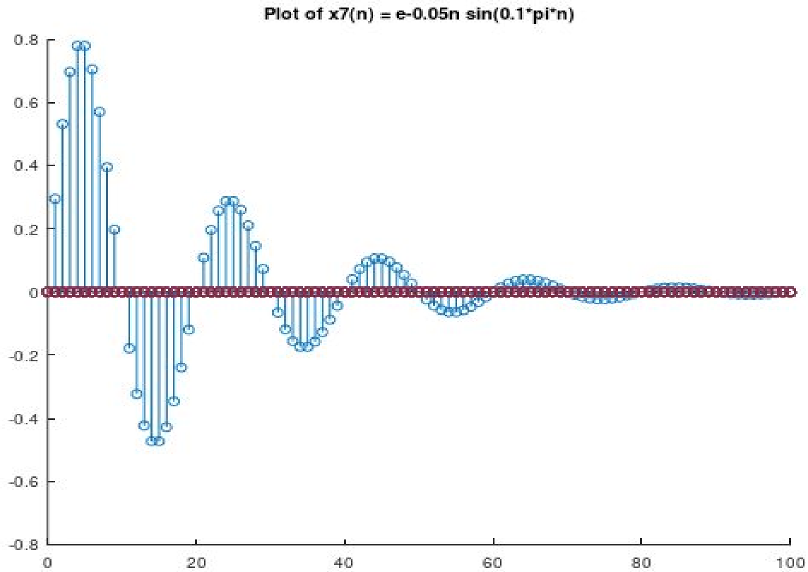
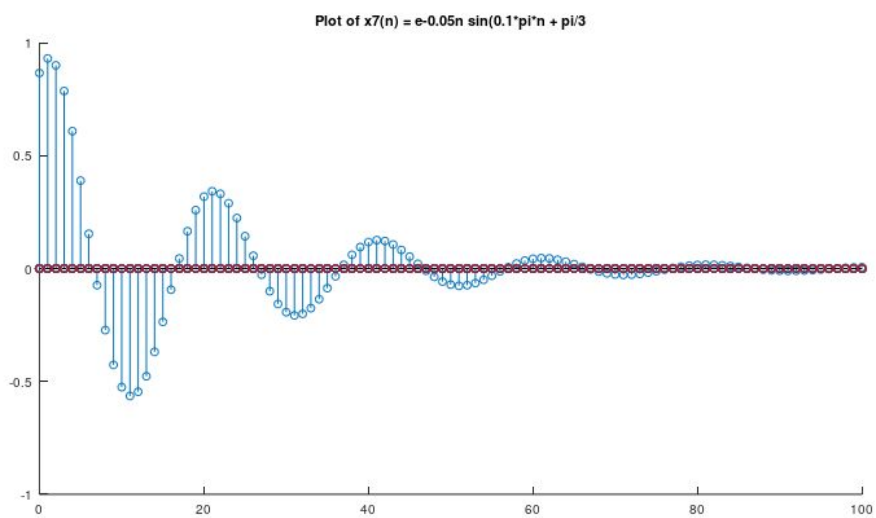
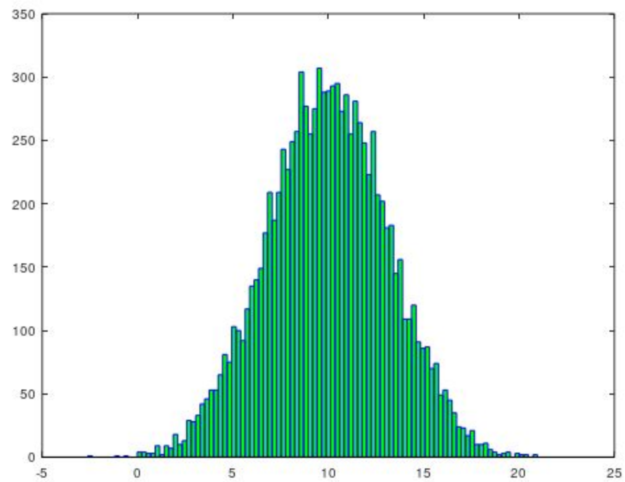
One of the fundamental sinusoidal functions used in DSP is the sine wave. Let's see how a sine function multiplied with a negative exponential function looks like:



Since there is a phase shift of pi/3 added in the given question %3, the result would look like this:



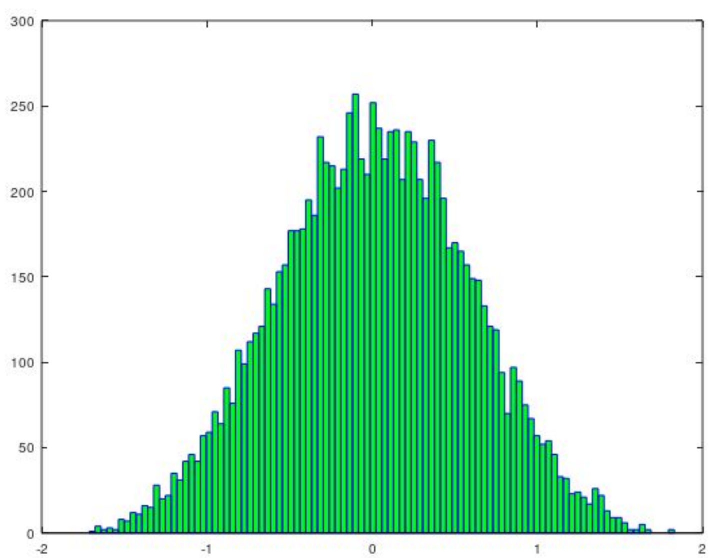
As we know from previous lab report, the normally distributed random sequence is a sequence whose values are concentrated at the mean.
Here is how a Gaussian(normally distributed) random sequence with mean and variance 10 looks like:



When we add a number of the uniformly distributed sequences together, we get a result similar to the above one.

To prove this let's consider a function $x4(n) = \Sigma^4_{k=1} y_k(n);$ where $y_k(n)$ is a uniformly distributed sequence ranging from -0.5 to 0.5.

Now, when we add y1(n), y2(n), y3(n) and y4(n) sequences which are uniformly distributed random values, we get the following result. This, as we see, looks like a normally distributed sequence.
(For details please refer the appendix)



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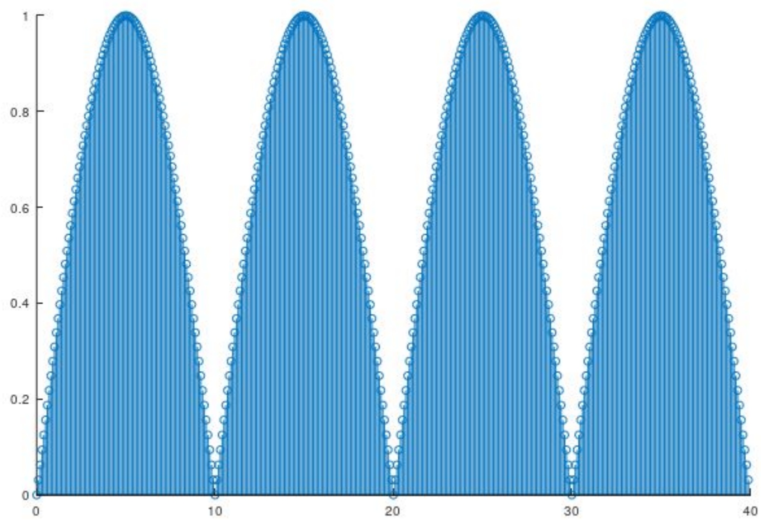
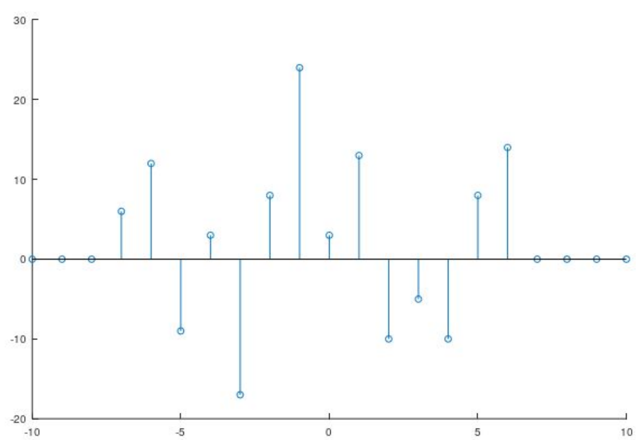
A periodic function is a function where the pattern repeats after the set interval. For eg: `x3(n) = sin(0.1*pi*n)[u(n)-u(n-10)]` The graph of periodic function of x3(n) looks like:



We can also plot for an equation like $x_1(n) = 2x(n-3) + 3x(n+4) - x(n)$ where x(n) is defined as $x(n) = \{2, 4, -3, \underset{\uparrow}{1}, -5, 4, 7\}.$ i.e x(0) is 1, x(1) is -5 and so on. The below plot is for the range n= (-10 to 10)



Conclusion:

MATLAB makes the calculation of the typical DSP problems much easier and obviously faster. It gives a greater understanding of things as well as we can visually see the results(using functions like stem, bar, hist) of our equations.

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Appendix

```
%Generate the following sequences using the basic MATLAB signal functions and the basic MATLAB signal operations discussed in this chapter. Plot signal samples using the stem function.
```

```
%1. x1(n) = 3δ(n+2) + 2δ(n) - δ(n-3) + 5δ(n-7); -5<=n<=15
```

```
function del = delta(n) %defining a function for unit samples
      if(n==0)
            del =1;
      else
            del = 0;
      endif
endfunction

y=zeros(21); %initializing a vector to save the results
x=-5:15; %x-coordinates where the function need to be plotted
 for n = -5:15 %loop to get result for each value in the defined range
      y(n+6) = 3*delta(n+2) + 2*delta(n) - delta(n-3) +5*delta(n-7); %since in matlab, index starts from 1, y(n+6) is written to push the values to start from 1
end
stem(x,y); title("x1(n) = 3δ(n+2) + 2δ(n) - δ(n-3) + 5δ(n-7)");%using stem function to plot the result
```

```
%2. x4(n) = e0.1n [u(n+20) - u(n-10)]
```

```
function step = unitstep(n) %defining a function for unitstep function
      if(n>0)
            step =1;
      else
            step = 0;
      endif
endfunction

x4=zeros(51); %initializing a vector to save the results
x= -30:20; %coordinate range to properly see the results
for n = -30:20 %loop to get result for each value in the defined range
      x4(n+31) = exp(0.1*n)*(unitstep(n+20) - unitstep(n-10));
end
stem(x,x4); title("Plot of x4(n) = e0.1n [u(n+20) - u(n-10)]");
```

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```
%3. x7(n) = e-0.05n sin(0.1*pi*n + pi/3); 0<= n <= 100
x7 = zeros(101);
x = 0:100;
for n = 0:100
x7(n+1) = exp(-0.05*n)*sin(0.1*pi*n + pi/3);
% x7(n+1) because we want it to start with 1 and not 0.
end
stem(x,x7); title("Plot of x7(n) = e-0.05n sin(0.1*pi*n + pi/3)");

%Generate the following random sequences and obtain their histogram using
the hist function with 100 bins. Use the bar function to plot each
histogram
%1. x1(n) is a random sequence whose samples are independent and uniformly
distributed over [0,2] interval. Generate 100,000 samples.

 numberOfBins = 100;
 numberOfRandoms = 100000
 x1 = 2*rand(1,numberOfRandoms);
 hist (x1, numberOfBins, "facecolor", "g", "edgecolor", "b");

%2. x2(n) is a Gaussian random sequence whose samples are independent with
mean 10 and variance 10. Generate 100,000 samples.

 numberOfBins=100;
 mean = 10;
 variance =10;
 numberOfRandoms = 10000;
 randGaussian = mean+(randn(1,numberOfRandoms)* sqrt(variance));
 calulatedVariance=var(randGaussian);
 hist (randGaussian, numberOfBins, "facecolor", "g", "edgecolor", "b");

%3. x4(n) = Σ^4_k=1 y_k(n) where each random sequence y_k(n) is independent of
others with samples uniformly distributed over [-0.5,0.5]. Comment on the
shape of this histogram.

 numberOfSequences = 4;
 Yk= zeros(numberOfSequences,numberOfRandoms);
 for i=1:numberOfSequences
   Yk(i,:)=Yk(i,:) + rand(1, numberOfRandoms) - 0.5;
```

```
endfor
Yk
Z = sum(Yk,1)
hist (Z, numberOfBins, "facecolor", "g", "edgecolor", "b");

%when we add a number of uniformly distributed sequences, the resulting
sequence would be a normally distributed sequence.
```

```
%Generate the following periodic sequences and plot their samples (using
the stem function) over the indicated number of periods.

%1. x1(n) = {...-2.-1.0,1,2..}. Plot 5 periods
x1 = [-2:2]
numberOfCycles = 5;
x = -12:12
x1Periodic = repmat(x1,1,numberOfCycles)
stem(x,x1Periodic);

%2.x3(n) = sin(0.1*pi*n)[u(n)-u(n-10)]. Plot 4 periods
numberOfCycles = 4;
n=[0:.1:9.9]
x3 = sin(0.1*pi*n);
x3Periodic = repmat(x3,1,numberOfCycles);
xaxis = [0:.1:39.9]
stem(xaxis, x3Periodic);
```

%Let $x(n) = \{2, 4, -3, \underset{\uparrow}{1}, -5, 4, 7\}.$ Generate and plot the samples (use the stem function) of the following sequences.

%1. $x_1(n) = 2x(n-3) + 3x(n+4) - x(n)$

```
function ret = xfunc(n)
%This function is used to shift the range from (1 to 7) to (-3 to 3)
x = [2,4,-3,1,-5,4,7];
  if(n>=-3 && n<=3)
    ret = x(n + 4);
  else
    ret = 0;
  endif
endfunction
n = [-10:1:10];
```

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```
j=1
for i = -10:1:10
 x1(j) = 2*xfunc(i-3) + 3*xfunc(i+4) - xfunc(i)
 j = j+1;
endfor
stem(n,x1);
```

%2. $x_4(n) = 2e^{0.5n}x(n) + \cos(0.1\pi n)\,x(n+2), \; -10 \le n \le 10$

```
for i = -10:1:10
 x4(i+11) = 2 * exp(0.5*i)*xfunc(i) + cos(0.1*pi*i)*xfunc(i+2)
endfor
stem(n,x4);
```