Lab 1-Fall 2016-2017

Visualizing Signals (Continuous & Discrete)

Objective: to visualize continuous and discrete time-domain signals using MATLAB.

Pre-requests: Basics of MATLAB and fundamentals of signals & systems.
Useful References:

- Lecture Notes of the course,
- Signal processing & Linear Systems, (B. P. Lathi, ©2004, ISBN: 978-0-19-568583-1).
- Communication Systems, (Simon S. Haykin, © 2000, ISBN: 978-0-47-117869-9).

Procedure part I: For continuous-time signals; (30 minutes)

1. To visualize a continuous signal, first, create the time-domain axis, as follows:-

```
t=0 : 0.001:1 ;
```

Starting point

Spacing between the consecutive points

End-point, must be "1" because it is the unit of measure in time-domain

2. The sinusoidal signal, such as '**sin**', can be written as:-

```
g=sin(2×pi×F×t);
```

ω

Frequency

3. Now the signal can be drawn, using the plot command, as follows:-

```
plot(t, g );
```

X-axis, represents the time-domain

Function value, represents the Y-axis

4. Use the grid command to show the grid lines on the drawing window as follows:-

```
plot(t, g ); grid;
```

5. Now, change the frequency and plot the signal for different values of **F**, draw the results in your lab-note books to be signed by the instructor.
6. It is easy to change the drawing properties like the **line-width**, **line-color**, and the **line-style** as follows:-

```
plot(x, y, lineParameters), grid;
```

For more help about this command, refer to the lecture notes of your teacher. On the other hand, you can type-in 'help plot' to see full and detailed help.

In our experiment, we will use the following combination:-

a) Changing the line-style and its color;

```
plot(t,g, '--g'), grid;
```

Where
"**--**" means dashed-line,
"**g**" means green color.

b) Changing the line-width;

```
plot(t,g, '--g','LineWidth',3), grid;
```

7. Try plotting another signals, for instance, plot 'exp(-0.5t)', cos(2π12t), and y=2sin(2π2t)+1.75cos(2π5t).

8. Try to alter the time-domain spacing from 0.001 to 0.05 and plot one of the above signals and answer the following:-

   i. What happen to the smoothness of the signal?
   ii. Can you recognize the spacing segments? Why?
   iii. Can we consider the plot continuous anymore?

Procedure part II: For Discrete-time signals; (30 minutes)

Time-domain signal now is discrete, in other words, the signal is defined in a specific time instance points only, rather than at any instance. Thus, the signal is discrete time. In the first part of this experiment, the time-domain index vector was at least 2-times the largest frequency in the signal, which is required to be plotted. After converting the signal from the continuous time to discrete time, the time-domain vector is decimal such as 1, 2… N. So, the time-vector can be expressed as n=1:100. Follow the following procedure to implement the experiment successfully.

1. Define the discrete time-domain vector,

```
n= 0:10;
```

2. The sinusoidal signal, like the '**sin**', can be expressed as,

```
g = sin(2*pi*1*n/10);
```

Frequency = 1 Hz

time "t" is the discrete time

3. Plot the signal using the **stem**-command,
4. Change the frequency to 2 Hz, then 4 Hz and plot all the results.
   What you have seen after changing the frequency?
5. Now, change the time index vector to include more points, as follows,

```
n= 0:30;
```

6. Repeat steps 3 and 4 and answer the following,
   i. What happen to the smoothness of the signal?
   ii. Can you recognize the spacing segments? Why?
   iii. Is the signal continuous or discrete?

7. Try plotting another signals, for instance, plot '$\exp(-0.5\underline{\mathbf{t}})$', $\cos(2\pi 12\underline{\mathbf{t}})$, and $y=2\sin(2\pi 2\underline{\mathbf{t}})+1.75\cos(2\pi 5\underline{\mathbf{t}})$.

Procedure part III: Finding signal energy and power of signals; (10 minutes)

Introduction: Investigate the function "**sum**" in MATLAB. To be ready to determine the signal power or energy.

The signal energy of a signal $x(t)$ is

$$E_x = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

While the power of a signal $x(t)$ is

$$P_x = \lim_{T\to\infty} \frac{1}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} |x(t)|^2 dt$$

However, for periodic signal, the power will be

$$P_x = \frac{1}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} |x(t)|^2 dt$$

For the discrete signals, the integration will be replaced by the summation only. Thus, the energy of a discrete signal is

$$E_x = \sum_{n=-\infty}^{n=\infty} |x[n]|^2$$

While the power of a discrete signal is

$$P_x = \lim_{N\to\infty} \frac{1}{N} \sum_{n=0}^{n=N-1} |x[n]|^2$$

And power of a periodic discrete signal is

$$P_x = \frac{1}{N} \sum_{n=0}^{n=N-1} |x[n]|^2$$

1. To compute the energy of a signal, as a first step, create the time-vector,
   t = 0:0.001: 0.999;
   note that the time period is ***T* = 1**. The spacing is ***dt* = 0.001.**
2. Suppose the signal is $x(t) = \sin(2 \times \pi 3t)$,
   xt = sin(2×pi×3×t);
3. Plot the above signal,
4. Now compute the energy,
   abs_xt_2=abs(xt.^2);
5. Now do the summation operation,
   energy_xt=sum(abs_xt_2)
6. Determine the power of the above signal by dividing the energy by the size of the time-vector,
   power_xt=energy_xt/length(t)
   where the command **length(t)** will gives you the total length of the input "**t**"

Homework:

1. Plot the following signal,
   $$x_1(t) = e^{-t}\sin(20\pi t) + e^{-t/2}\sin(19\pi t)$$
2. Plot the following signal,
   $$x_2(t) = \mathrm{sinc}(t)\cos(20\pi t)$$
3. Calculate the energy for each signal above in step 1 and 2.

Next week

Representing the unit step function, unit ramp function, unit impulse function, and the sinc function. Bothe discrete and continuous time-domain. Proofing the properties of the signals, like the time-shifting, scaling, convolution, correlation…

Good luck
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