

Lab 1-Fall 2016-2017 Visualizing Signals (Continuous & Discrete)

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

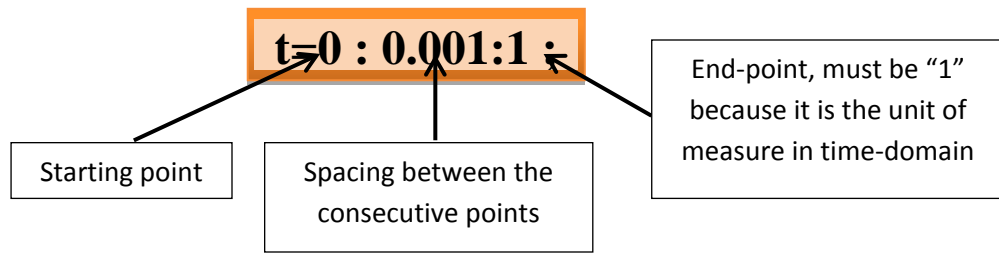
Pre-requests: Basics of MATLAB and fundamentals of signals & systems.

Useful References:

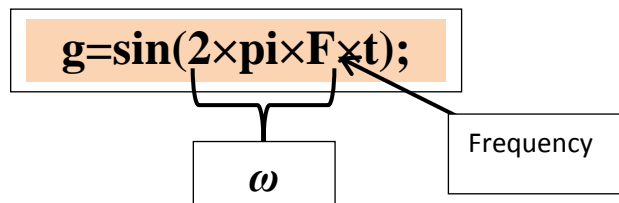
- Lecture Notes of the course,
- Signal processing & Linear Systems, (B. P. Lathi, ©2004, ISBN: 978-0-19-568583-1).
- Communication Systems, (Simon S. Haykin, © 2000, ISBN: 978-0-47-117869-9).

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

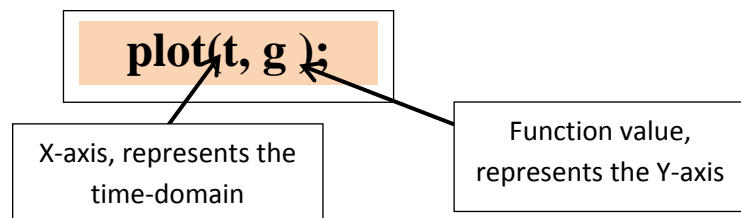
1. To visualize a continuous signal, first, create the time-domain axis, as follows:-



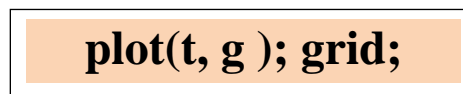
2. The sinusoidal signal, such as 'sin', can be written as:-



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



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



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)', $\cos(2\pi 12t)$, and $y=2\sin(2\pi 2t)+1.75\cos(2\pi 5t)$.
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?

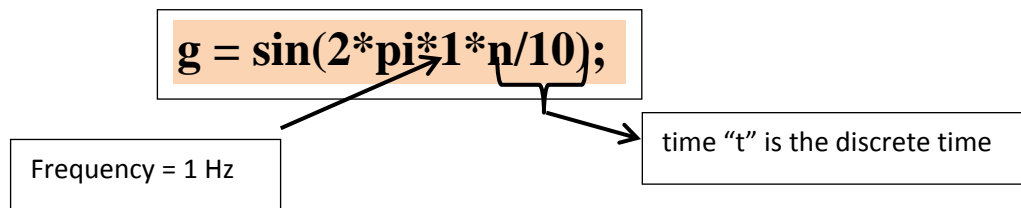
Procedure part II: For Discrete-time signals; (30 minutes)

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,



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(-0.5t)', cos(2π12t), and y=2sin(2π2t)+1.75cos(2π5t).

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

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

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

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

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 give 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,
$$x_2(t) = \text{sinc}(t) \cos(20\pi t)$$
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. Both discrete and continuous time-domain. Proving the properties of the signals, like the time-shifting, scaling, convolution, correlation...

Good luck
Dr. Montadar Abas Taher