EBU4375: SIGNALS AND SYSTEMS

LAB1: MATLAB FOR REPRESENTING AND MANIPULATING SIGNALS

Queen Mary
University of London

ACKNOWLEDGMENT

These slides are partially from Labs prepared by

Dr Jesus Raquena Carrion.

YOUR TASKS

- BEFORE THE LAB:
  - Read the slides carefully.
  - Create a ID_FS.txt file where ID is your QMUL ID number, F is the first letter of your forename and S is the first letter of your surname.
  - Type all the code in a red frame in the ID_FS.txt file and submit to the QMplus link.
- DURING THE LAB:
  - Copy/paste the code from ID_FS.txt into Matlab command window as required- indicated by
  - Take note of the results and your answers to questions indicated by
- **Make sure you do the work yourself as there will be questions in the class tests and exam related to Matlab.**

WHY MATLAB?

There exist several numerical computing environments that can be used for Signals and Systems, such as Matlab or Python. In this module, we will use Matlab:

- Matlab is a numerical computing environment that allows vector and matrix manipulations, representation of data and implementation of algorithms.
- Matlab is a natural platform for signal processing and includes a convenient toolbox for modeling in a graphical interface.

DEFINING SIGNALS IN MATLAB

- Signal are a form of time-series data where the x-axes represents the time and the y-axes represents the value of the signal at each time instance.
- Values on both axes are presented in a vector form.

```
>> v = [1 2 3 4]

v =

     1     2     3     4

>> w = [0.1 0.2 0.3 0.4]

w =

    0.1000    0.2000    0.3000    0.4000
```

DISCRETE-TIME SIGNALS

- Once defined, a DT signal can be plotted by using the command stem.
- The following is a Matlab script that defines and represent the DT signal $x[n] = 3 \times n$ in the time interval $-4 \leq b \leq 4$:

```
n = [-4 -3 -2 -1 0 1 2 3 4]; % Variable n denotes time
x = 3*n; % Variable x is the signal value

stem(n,x) % plots x agains n
xlabel('n') % adds text below the X-axis
ylabel('x[n]') % adds text beside the Y-axis
```

CONTINUOUS-TIME SIGNALS

- Once defined, a CT signal can be plotted by using the command plot.
- BUT, it is impossible to have a vector that contains ALL values of time.
- INSTEAD, we only use the values at a finite number of time instants, which we call samples.
- For example, we define $x(t) = 3 \times \mathrm{t}$ by taking small steps in time, say $\Delta t = 0.25$ as follows:

```
t = [-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1]; % Variable t ...
    denotes time
x = 3*t; % Variable x is the signal value

plot(t,x) % plots x agains n
xlabel('t') % adds text below the X-axis
ylabel('x(t)') % adds text beside the Y-axis
```

EXAMPLES OF DT SIGNALS

- Before the LAB, type in your .txt file:
  - %Code from LAB1Slide8 – QMULID= 191234567
  - Then the boxed code below.
  - Type your code after `%ADD THE CODE FOR PLOTTING x1, x2, x3r, x3i` referring to Slide 6
  - Define the value of *ne* as minimum 20 else equal to the last two digits of your QMUL ID number. If your ID is 191234567, *ne =67;* if ID=191234501, *ne=20.*

```
ns=0;
ne=20;
n = ns:1:ne; % Time
x1 = exp(-0.2*n); % exponential signal
x2 = cos(2*pi*n/10); % sinusoidal signal
x3 = exp(j*2*pi*n/10); % complex exponential signal
x3r = real(x3); % real part of x3
x3i = imag(x3); % imaginary part of x3
x3a = abs(x3); % magnitude of x3
x3p = angle(x3); % phase of x3
figure
%ADD THE CODE FOR PLOTTING x1, x2, x3r, x3i
%remember to type figure before each
```

Question:
How do you compare the plots of x2[n] and x3r[n]?

- Time shifted
- Amplified
- Not correlated
- Similar

EXAMPLES OF CT SIGNALS

- Before the LAB, type in your .txt file:
  - %Code from LAB1Slide9 – QMULID= 191234567
  - Then the boxed code below.
  - Type your code after `%ADD THE CODE FOR PLOTTING x1, x2, x3r, x3i` referring to Slide 7
  - Define the value of *te* as minimum 20 else equal to the last two digits of your QMUL ID number. If your ID is 191234567, *te =67*; if ID=191234501, *te=20.*

```
ts=0;
te=20;
dt=0.001;
t = ts:dt:te; % Time
x1 = exp(-0.2*t); % exponential signal
x2 = cos(2*pi*t/10); % sinusoidal signal
x3 = exp(j*2*pi*t/10); % complex exponential signal
x3r = real(x3); % real part of x3
x3i = imag(x3); % imaginary part of x3
x3a = abs(x3); % magnitude of x3
x3p = angle(x3); % angle of x3
figure
%ADD THE CODE FOR PLOTTING x1, x2, x3r, x3i
%remember to type figure before each
```

Question:
How do you compare the plots of x3i(t)and x3r(t)?

- Time shifted
- Amplified
- Not correlated
- Similar

BASIC OPERATIONS WITH SIGNALS IN MATLAB

Operating with signals in Matlab means operating with the vectors that represent them. Mathematically, signals extend from $-\infty$ to ∞. However, in Matlab we can only represent a finite number of samples.

- The following are some examples of operations with DT signals in Matlab:

```
n = -10:1:10; % definition of n
x = ones(size(n)); % x is a vector with the same size as n ...
    and all ones
y = 2*x; % y is a scaled version of x
z = x + y; % z is the sum of x and y
v = y.*z ; % v is the product of x and y, DO NOT FORGET THE DOT!
w = zeros(size(n)); % w is a vector with the same size as n ...
    and all zeros
w(11:end) = 1; % The samples 11 to 21 of w are set to 1
```

BASIC OPERATIONS WITH SIGNALS IN MATLAB

- Calculating the area, average value, energy and mean power of CT signals involves integration. In Matlab, we only represent a finite number of samples and the integral will be approximated by a sum. Given a CT signal *x* in Matlab and a time step between *dt*, area, average value, energy and mean power can be calculated as shown below.
- Before the LAB, type in your .txt file:
  - %Code from LAB1Slide11 – QMULID= 191234567
  - Then the boxed code below.
- For signals *x1*, *x2*, and *x3r* defined in Slide 8, enter the values *Arx*, *Acx*, *Ex*, *Px* in the lab sheet on QMplus after the lab session.

```
Arx = sum(x)*dt; % Area of x
Avx = (sum(x)*dt)/(length(x)*dt); % Average value of x
Ex = sum(x.^2)*dt; % Energy of x
Px = (sum(x.^2)*dt)/(length(x)*dt); % Average value of x
```

Question:
Fill in the values

ne	Axr	Axv	Ex	Px
x1				
x2				
x3r				

BASIC OPERATIONS WITH SIGNALS IN MATLAB

- Calculating the area, average value, energy and mean power of DT signals involves adding samples or the square of the samples.
- In Matlab, we use sum to a add up the samples in a vector, length to obtain the number of samples in a vector and x.^2 to square each sample in x.
- Before the LAB, type in your .txt file:
  - %Code from LAB1Slide12 – QMULID= 191234567
  - Then the boxed code below.
- For signals *x1*, *x2*, and *x3r* defined in Slide 9, enter the values *Arx*, *Acx*, *Ex*, *Px* in the lab sheet on QMplus after the lab session.

```
Arx= sum(x); % Area of x
Avx = sum(x)/length(x); % Average
value of x
Ex = sum(x.^2); % Energy of x, DO NOT
FORGET THE DOT!
Px = sum(x.^2)/length(x); %Mean Power
of x, DO NOT FORGET THE DOT!
```

Question: Fill in the values

te	Axr	Axv	Ex	Px
x1				
x2				
x3r				

TIPS FOR THE LAB

- Prepare well and upload your .txt file before coming to the LAB.
- Open you .txt file and copy/paste into the *Command Window* the following:
  - Slide 8 code: Take some time to understand the plots.
  - Slide 11 code: Take note of all results as you need those for Lab-sheet submission
  - Slide 9 code: Take some time to understand the plots.
  - Slide 12 code: Take note of all results as you need those for Lab-sheet submission
- If you have any questions during the preparation, please post them on the Qmplus forum.
- If you have questions during the LAB please ask the supervisors.