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ADVANCED DIGITAL SIGNAL PROCESSING

Lab 2: Generation of commonly used signals using MATLAB

Objective

The objective of this lab is to generate and plot commonly used continuous as well as discrete time signals.

1 Triangular Wave

MATLAB has a built-in function `sawtooth` to generate a periodic triangular waveform. Following example will help you draw such a waveform.

1.1 Example

Generate triangular wave having amplitude of 2 and frequency of 2 Hz with a width of 0.5 units

```
clc, clear all, close all
t = 0:.0001:1; % time
A = 2; % amplitude
f = 2; % frequency
W = 0.5; % width
y = A*sawtooth(2*pi*f*t,W);
plot(t,y)
axis([0 1 -3 3])
xlabel('Time in seconds')
ylabel('Amplitude')
title('Triangular Wave')
grid
```

2 Square Wave

MATLAB has a built-in function `square` to generate a periodic square waveform. Following example will help you draw such a waveform.

2.1 Example

Generate a square wave having amplitude 3 and frequency of 2 Hz

```
clc, clear all, close all
t = 0:.0001:1; % time
A = 3; % amplitude
f = 2; % frequency
d = 50; % duty cycle in percentage
y = A*square(2*pi*f*t,d);
plot(t,y)
axis([0 1 -4 4])
xlabel('Time in seconds')
ylabel('Amplitude')
title('Square Wave')
grid
```

3 Discrete Time Signals

To visualize a discrete time signal, we may use the `stem` function. Specifically, stem(n,x) depicts the data contained in vector `x` as a discrete time signal at the time values defined by `n`. The vectors `n` and `x` must, of course, have compatible dimensions. Following example will help you draw such a waveform.

3.1 Example

Generate discrete time square wave of amplitude 3 and frequency of 2 Hz

```
clc, clear all, close all
t = 0:0.1:1; % time (sampling freq. 10 Hz)
A = 3; % amplitude
f = 2; % frequency
y = A*square(2*pi*f*t); % the command y(y<0)=0;
    removes -ve values
stem(t,y)
axis([0 1 -4 4])
xlabel('Time in seconds')
ylabel('Amplitude')
title('Discrete Signal')
grid
```

A discrete time unit step function $u(n)$ may be created using following example.

```
clc, clear all, close all
t = 0:0.1:5;
x = ones(1,length(t));
stem(t,x)
axis([0 1 -4 4])
xlabel('Time in seconds')
ylabel('Amplitude')
title('Step Function')
axis([-1 5 0 2])
grid
```

4 Exponential Signals

There are two types of exponential signals namely decaying exponentials and growing exponentials. Following example will help you draw such a waveform.

4.1 Example

Generate growing and decaying exponential signals with amplitude 2

```
clc, clear all, close all
t = 0:0.1:1; % time
A = 3; % amplitude
g = A*exp(A*t); % growing
d = A*exp(-A*t); % decaying
subplot(2,1,1)
plot(t,g)
title('Growing Exponential Function')
grid
subplot(2,1,2)
plot(t,d)
title('Decaying Exponential Function')
grid
```

5 Even and Odd Signals

The even and odd parts of a signal $x(t)$ are computed by using the following formulae.

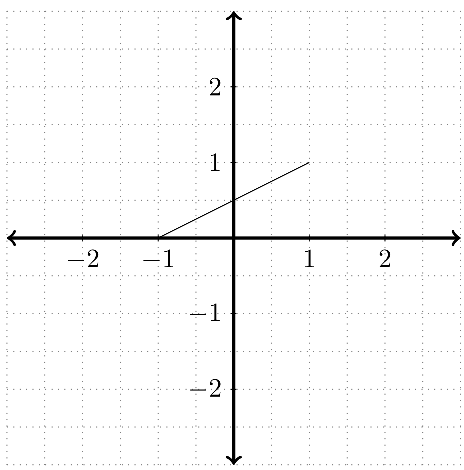
$$Even, \quad x_e(t) = 1/2\,[x(t) + x(-t)]$$
$$Odd, \quad x_o(t) = 1/2\,[x(t) - x(-t)]$$

Where, $x(-t)$ is reflected signal of $x(t)$, i.e. the transformed image obtained is exactly the mirror image of the parent signal.

5.1 Example

Consider a signal which is mathematically represented as follows.

$$x(t) = \begin{cases} 1/2(t+1) & -1 \leq t \leq 1 \\ 0 & elsewhere \end{cases}$$



The Matlab code to plot this signal is following.

```
clc, clear all, close all
t = -1:0.0001:1;
x = 1/2*(t+1);
plot(t,x), grid
hold on
line([-2 2],[0 0],'Color',[.8 .8 .8])
line([0 0],[-2 2],'Color',[.8 .8 .8])
hold off
```

Now, even and odd parts of the signal may be plotted as follows.

```
clc, clear all, close all
t = -1:0.0001:1;
x = 1/2*(t+1);
x1 = fliplr(x); % folded version of the signal
xe = 1/2*(x + x1); % Even part
xo = 1/2*(x - x1); % Odd part
subplot(2,1,1)
plot(t, xe)
xlabel ('Time')
ylabel('Even part of x(t)')
subplot(2,1,2)
plot (t, xo)
xlabel('Time')
ylabel('Odd part of x(t)')
```

6 Exercise

1. Generate a discrete time triangular wave of unity amplitude with width 0 and frequency $\pi/8$ radians per second. Plot for 100 seconds (0 to 100 sec).

2. Draw the following sinusoidal signals for 100 seconds.

   (a) $A\cos(\omega + f)$

   (b) $A\sin(\omega + f)$
   where A = 4; $\omega = \pi/8$ and f = 30 degrees. Note: Convert degrees into radians.

3. Draw the following signals

   (a) $x(t) = 5e^{-6t}$

   (b) $y(t) = 3e^{5t}$

   (c) $z(t) = 60\sin(20\pi t)e^{-6t}$

   (d) $x(n) = 2(0.85)^n$

   (e) $y(n) = 60\sin(20\pi n)e^{-6n}$

4. Draw the signal $x[n] = n$ (ramp function)

5. Plot continuous time and discrete time `sinc` function (i.e. $sin(x)/x$) for x between -5 and 5. Use the built-in function `sinc`.

6. Plot a rectangular function of width 3 units. (use the built-in function `rectpuls`.

7. Draw a discrete time triangular pulse using the built-in function `tripuls`. Plot the function from -3 to 3 seconds.

8. Find and plot $u(n) - u(n-5)$, where $u(n)$ is a discrete time unit step signal.

9. Plot the following signals for $-5 \leq t \leq 5$ seconds. Also plot even and odd parts of each.

   (a) $x(t) = \cos(t) + \sin(t) + \cos(t)\sin(t)$

   (b) $x(t) = (1 + t3)\cos 3(10t)$

   (c) $x(n) = [1\,1\,1\,1\,0\,0\,0]$

   (d) $y(n) = [1\,0\,0\,1\,0\,1\,1\,0\,1\,1]$

   Also compute the energy of $x(n)$ and $y(n)$.
   Hint: Energy of a signal $x(n)$ may be computed as $sum(abs(x.^2))$.