MEHRAN UNIVERSITY OF ENGINEERING & TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION & COMMUNICATION TECHNOLOGIES

ADVANCED DIGITAL SIGNAL PROCESSING

Lab 3: Signal Operations using MATLAB

Objective

The objective of this lab is to plot various signals in time domain as well as perform time shifting and time scaling properties on the given signals.

1 Time Scaling Property

Time scaling of signals of signals involves the modification of a periodicity of the signal, keeping its amplitude constant. Its mathematically expressed as,

$Y(t) = \beta X(t)$

Where, $X(t)$ is the original signal, and β is the scaling factor. If $\beta > 1$ implies, the signal is compressed. And if $\beta < 1$ implies, the signal is expanded.

Following example will help you understand the time scaling property with the help of MATLAB's has a built-in function `tripuls` to generate a triangular pulse.

1.1 Example

Perform time scaling on a triangular pulse $x(t)$ of width 2 and unity height.

```
clc, clear all, close all
t = -5:0.0001:5; % time vector of 5 seconds
x = tripuls(t,2); % triangular pulse of width 2
subplot(3,1,1)
plot(t,x,'r'), grid
title('Triangular pulse with width of 2')
t1 = 2*t; % new time vector scaled by 2
x1 = tripuls(t1,2); % scaled triangular pulse
subplot(3,1,2)
plot(t,x1,'b'), grid
title('Triangular pulse with width of 1')
t3= 1/2*t; % new time vector scaled by 0.5
x3 = tripuls(t3,2); % scaled triangular pulse
subplot(3,1,3)
plot(t,x3,'g'), grid
title('Triangular pulse with width of 4')
```

2 Shifting Property

Time shifting of signals is generally used to fast-forward or delay a signal, as is necessary in most practical circumstances. Time shifting is mathematically expressed as, $Y(t) = X(t - t_0)$. Where, $X(t)$ is the original signal, and t_0 represents the shift in time. For a signal $X(t)$, if the position shift $t_0 > 0$, then the signal is said to be right shifted or delayed. In the same manner, if $t_0 < 0$, implies the signal is left shifted or delayed.

We will be shifting the triangular pulse three units towards left as well as right, i.e. we will be plotting $x(t - 3)$ and $x(t + 3)$. Following example will help you understand shifting property.

2.1 Example

Generate time shifted triangular pulses.

```
clc, clear all, close all
t = -5:0.0001:5; % time vector of 5 seconds
x = tripuls(t,2); % triangular pulse of width 2
subplot(3,1,1)
plot(t,x,'r')
title('Unshifted triangular pulse'), grid
t4= t-3; % shift the pulse 3 units towards
    right
x4 = tripuls(t4,2);
subplot(3,1,2)
plot(t,x4,'b')
title('Triangular pulse shifted 3 units to
    right'), grid
t5 = t + 3; % shift the pulse three units
    towards left
x5 = tripuls(t5,2);
subplot(3,1,3)
plot(t,x5,'g')
title('Triangular pulse shifted 3 units to left
    '), grid
```

3 Exercise

1. Generate and plot a triangular pulse $y(t)$ of width 3 and centre at 0. The height of the pulse is equal to your class roll number. Also plot,
   (a) $y(3t)$
   (b) $y(3t + 2)$
   (c) $y(-2t - 1)$
   (d) $y(2(t + 2))$
   (e) $y(2t - 4)$
   (f) $y(3t) + y(3t + 2)$
2. Generate and plot a rectangular pulse $m(t)$ (use the built-in function `rectpuls`) centered at zero and width 2. The height of the pulse is equal to half of your roll number. Also draw the following,
   (a) $m(t + 3)$
   (b) $m(2t + 3)$
3. Draw the following signal,

$$x(t) = \begin{cases} 5 - t & 4 \le t \le 5 \\ 1 & -4 \le t \le 4 \\ t + 5 & -5 \le t \le -4 \\ 0 & elsewhere \end{cases}$$

4. An exponentially decaying sinusoidal signal is defined by $x(t) = 20\sin(2\pi 1000t - \pi/3)e^{-at}$. Where the exponential parameter a takes on the following set of values: $a = [500, 750, 1000]$. Investigate the impact of varying a on the signal $x(t)$ for $-2 \le t \le 2$ milliseconds.

5. A raised cosine sequence is defined by,

$$w(n) = \begin{cases} \cos(2\pi Fn) & -1/2F \leq n \leq 1/2F \\ 0 & elsewhere \end{cases}$$

   Use MATLAB to plot $w(n)$ versus n for $F = 0.1$.

6. Plot the discrete time signal,

$$x(n) = \begin{cases} R & 0 \leq n \leq -1 \\ 0 & elsewhere \end{cases}$$

   where R is your roll number. Also plot,

   (a) $y(n) = x(n^2)$
   (b) $x(n-2)$
   (c) $y(n-2)$

7. A discrete time signal $x(n)$ is defined as,

$$x(n) = \begin{cases} 1 + \frac{n}{3} & -3 \leq n \leq -1 \\ 1 & 0 \leq n \leq 3 \\ 0 & elsewhere \end{cases}$$

   Also sketch,

   (a) $x(n)$
   (b) $x(n-4)$
   (c) $x(n+4)$