Week -3 (Signals & Systems) –Part 1

➢ Defining/Creating the Continuous-time Signal :

- **Inline** functions { >> prompt is used in following every MATLAB Statements}

Any signals are most conveniently represented using MATLAB built-in command (object) ***inline***.

Ex: Consider a continuous time everlasting signal: **$x(t) = e^{-t}\cos(2\pi t)$** which can be expressed as,

>>x = inline('exp(-t).*cos(2*pi*t)','t')

Once defined, x(t) can be evaluated simply by passing the input arguments as,

Ex: >> t = 0; % t is a scalar value

>> x(t) % x(t) is a scalar value which is computed by passing t = 0 in “x” inline object.

======== > ans = 1

Similarly, an array “x(t)” can be created by defining “t” over the interval $-2 \le t \le 2$ as (signal duration)

>> t= [-2:.01:2]; % is an array whose values vary from-2 to 2 which also the is presentation duration

>> x(t) % is an array whose values are computed by passing “t” in “x” inline object.

======== > ans = …… 100 values of x(t) …….

>> plot(t,x(t)); % sketch of the above function.

>>u=inline('t>=0','t') % creates a unit step function.

>>p=inline('((t>=0)&(t<1))','t') % creates a unit pulse of duration 1s. Logical “1” is defined between 0 to 1.

NOTE: **To achieve an accurate representation of discontinuity in the signals like “step”, while defining the continuous-time signals, it is recommended to adopt at least 100 samples per unit x-axis value. Increment chosen in array must be < 0.01.**

<u>Constructing energy signal (finite duration signal) from everlasting signal</u>

>>x = inline('exp(-t).*cos(2*pi*t) .* ((t>=-2)&(t<1)) ','t')

% creates a function x(t) valid for interval -2 to 1s (signal non-zero range).

Note: signal non-zero duration is -2 to 1s, but presentation duration is $-2 \le t \le 2$ as chosen above

>>p = inline('t.* ((t>=0)&(t<1)) + exp(-t).* ((t>=1)&(t<2)) ','t')

creates a single function made out of two different functions valid for two different intervals.

>>plot(t,p(-t)) % sketch of the above defined functions after reversing

>>plot(t,p(t-5)) % sketch of the above function time shifted right (delay) by 5 sec.

>>plot(t,p(2*t)) % sketch of the above function compressed in time by a factor 2

<u>To calculate the energy of a signal - method -1</u>

>>f=inline('exp(-t).*cos(2*pi*t).*((t>=-2)&(t<1))','t')

>>t=[-4.1:.001:4.1]; % defines the range of t with increment 0.001

>>dt=0.001;   % defines increment for integration 0.001 (should be same as above)

>>energy1=sum((f(t).*f(t))*dt)   % computes the energy of the signal

To find the ODD and EVEN components:

EVEN :   >> xe = 0.5*(f(t)+f(-t))   % computing even part of signal

ODD :   >> xo = 0.5*(f(t)-f(-t))   % computing odd part of signal

Note: **Care should be taken in selecting the presentation duration i.e. t=[-4.1:.001:4.1]; such a way that full duration of odd / even components are presented.**

To calculate the energy, Even & Odd part of a signal – method -2: without using "inline" objects:

t = -4.1:0.01:4.1;   % creating array of time (presentation duration)

x = exp(-t).*cos(2*pi*t).*((t>=-2)&(t<1));   % signal definition with non-zero between -2 to 1

energy2 = sum(x.^2*0.01)   % computing energy (discussed in following section)

xr = exp(t).*cos(2*pi*(-t)).*((t>=-1)&(t<2)); % creating time reversal of signal without "inline" object

plot(t,x,'r',t,xr,'g')   % sketching the signal and reversed signal

EVEN :   >> xe = 0.5*(x+xr)   % computing even part of signal

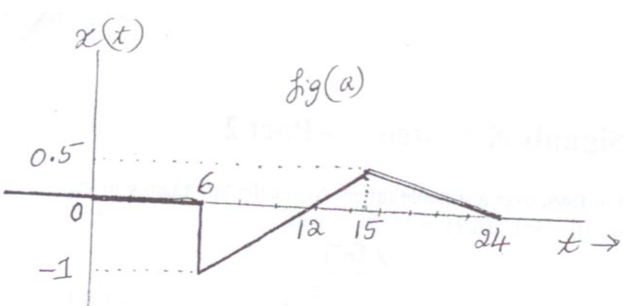
ODD :   >> xo = 0.5*(x-xr)   % computing odd part of signal

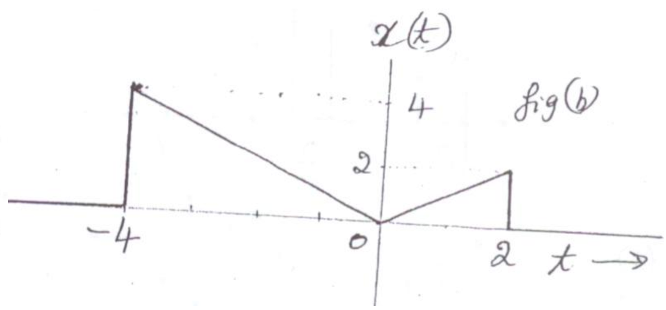
>>plot(t,xe)   sketch of the above computed even function

>>plot(t,xo)   sketch of the above computed odd function

Exercises

1) Sketch the following signals shown in Fig. a) and b), over a suitable range.
   Find x(–t), x(t+60), x(3t), x(t/20), x(2t+8), –3x(–0.2t–80)+1.5, 2x(2–t)–4.





2) The raised cosine pulse x(t) is defined as $x(t)=\begin{cases}\frac{1}{2}[\cos(wt)+1], & -\pi/w \le t \le \pi/w \\ 0, & otherwise\end{cases}$

Plot the curve and determine the total energy of x(t) for radian frequency w = 100π, 500π and 1000π.
Find 15x(-0.5t-8)–5,

3) The trapezoidal pulse x(t) is defined by $x(t)=\begin{Bmatrix} 5-t & 4\le t\le 5 \\ 1 & -4\le t\le 4 \\ t+5 & -5\le t\le -4 \\ 0 & otherwise \end{Bmatrix}$.

Plot the curve and determine the total energy of x(t).

Modify the signal to create the periodic function of period 10 and sketch for 3 cycles.

4) Find and plot over a suitable range, the following signals, the even and odd components of each of the signals:

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

b) x(t) $1 + t + 3t^2 + 5t^2 + 9t^4$

c) x(t) = 1+ t cos(t) + t^2 sin(t) + t^3 sin(t) cos(t)

d) x(t) = (1+ t^3) $\cos^3(10t)$

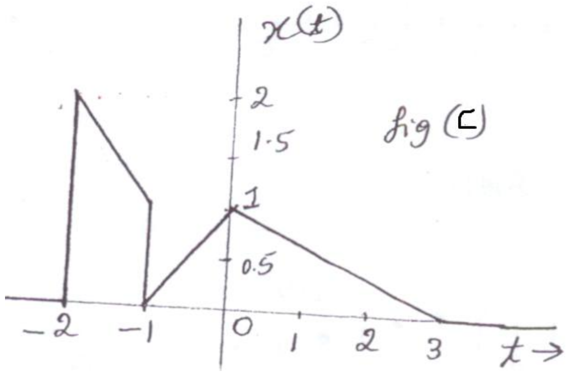
5) Consider the signal x(t) shown in Fig. c),

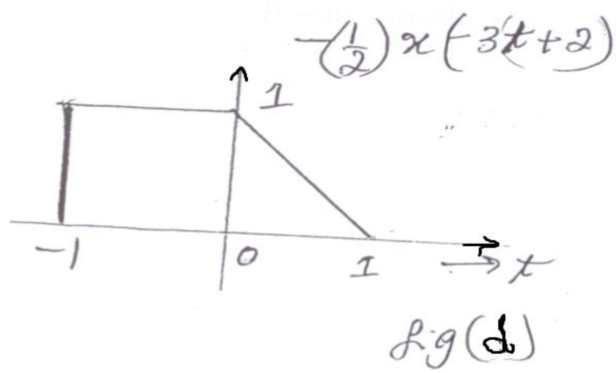
a) Determine and carefully sketch v(t) = 3x(– (1/2)(t+1))

b) Determine the signal size of v(t).

c) Determine and sketch the even portion of v(t)

d) Let a=2 and b= –3, sketch v(at+b), v(at)+b, av(t+b), and av(t)+b





6) Consider the signal y(t)= –(1/2)x(-3t+2) shown in Fig. d),

a) Determine x(t) as a function of y and t. Sketch the original signal x(t).

b) From the sketch, identify the key coordinate points. Then manually derive the equation to the line to reconstruct y(t).

c) Determine and sketch the even and odd portion of the original signal x(t).

7) Draw all possible cases of exponentials signals $e^{\lambda t}u(t)$ using subplots in a single figure window, where, λ = ε+jω, with ε and ω being real and positive. Also, provide commentary on the resulting signal patterns.