Open Elective Signals Processing & Applications

Tutorial No: 1

Q 1. Sketch the following signals. State whether energy or power signal. Hence find the value of energy or power to prove your statement.

(i) $x(t) = e^{-\alpha|t|}$ for $\alpha > 0$ (ii) $x(n) = \left(\frac{1}{2}\right)^n u(n)$ (iii) $x(n) = 2\cos\frac{\pi}{2}n$

Periodic Power signal.

Q 2. Sketch and label the signal after performing the following operations on the signal shown in fig 1

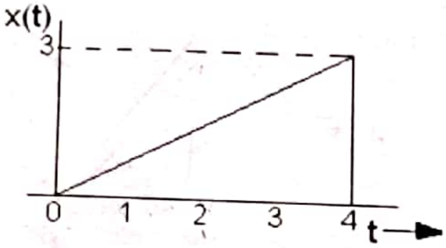


Fig 1

(i) x(t - 2)
(ii) x(2t)
(iii) x(t/2)
(iv) x(-t)
(v) x((t/2)+1)
(vi) x(-t + 2)

Q 3. Sketch and label the signal after performing the following operations on the signal shown in fig 2

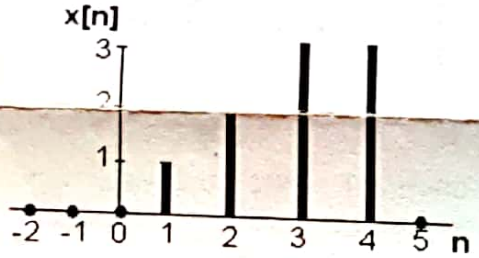


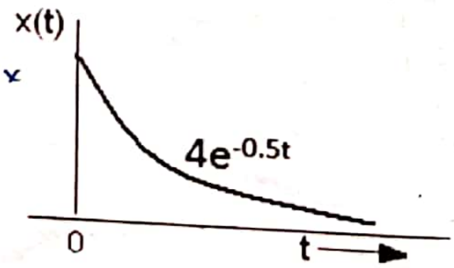
Fig 2

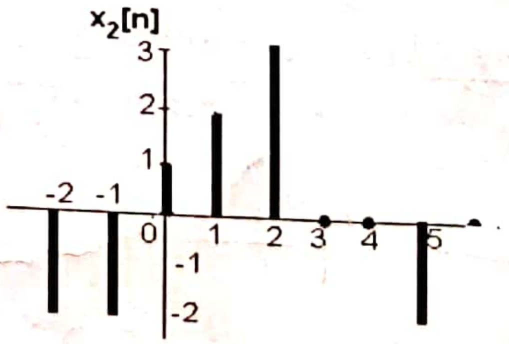
(i) x(n - 2)
(ii) x(2n)
(iii) ~~x(-n)~~
(iv) x(-n + 2)
(v) x((n/2)+1)

Q.4: Sketch and label the even and odd components of the signals

$x_e(t) = \frac{1}{2}[x(t) + x(-t)]$, $x_o(t) = \frac{1}{2}[x(t) - x(-t)]$

$x_e(n) = \frac{1}{2}[x(n) + x(-n)]$ $x_o(n) = \frac{1}{2}[x(n) - x(-n)]$





Q 5. For a system the impulse response h(t) = tu(t). Find the output y(t) if the system is excited by $x(t) = e^{-3t}u(t)$

Q 6. Obtain the following

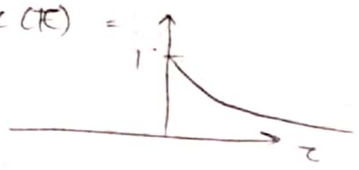
(i) $x(t) * \partial(t))$

$x(t)$

(ii) $x(n) * u(n - n_0)$

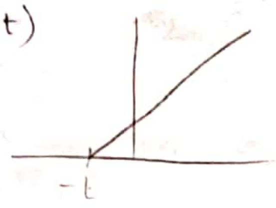
$x(n - n_0)$

$x(\tau) =$

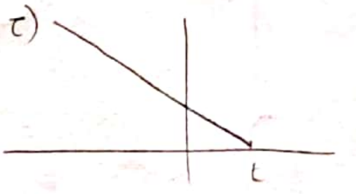


$h(\tau)$

$h(\tau + t)$



$h(t - \tau)$



$y(t) = \int_0^t e^{-3\tau}(t - \tau)\, d\tau$

$= \left[t \int e^{-3t} - \int e^{-3t} \right]$

$= t\left(\frac{e^{-3\tau}}{-3}\right)_0^t - \int_0^t \tau e^{-3\tau} d\tau$

$= t\left(\frac{1 - e^{-3t}}{3}\right) - \left[\tau \int e^{-3\tau} - \int \frac{e^{-3\tau}}{-3}\right]$

$t\left(\frac{1 - e^{-3t}}{3}\right) - \left[-\frac{\tau e^{-3\tau}}{-3} - \frac{e^{-3\tau}}{9}\right]_0^t$

$t\frac{(1 - e^{-3t})}{3} + \left[\frac{\tau e^{-3\tau}}{3} + \frac{e^{-3\tau}}{9}\right]_0^t$

$= \frac{t}{3}(1 - e^{-3t}) + \frac{t(e^{-3t} - 1)}{3} + \frac{e^{-3t} - 1}{9}$

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Tutorial No: 2

Q1. Obtain the CTFT of the following signal. Plot the magnitude and phase spectrum

$$x(t) = \begin{cases} 1, & 0 \le t \le 4 \\ 0, & otherwise \end{cases}$$

Q2. Consider the signal

$$x(n) = 2 + 2\cos\frac{\pi n}{4} + \frac{1}{2}\cos\frac{3\pi n}{4}$$ N = 8

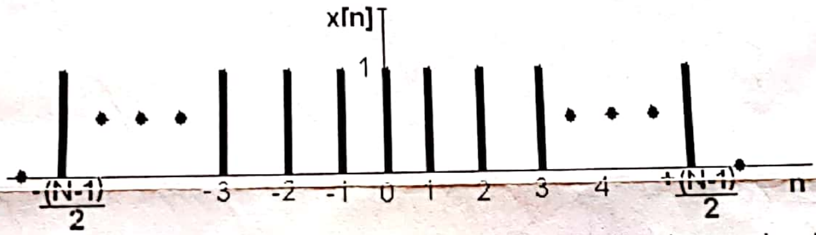
Determine the Fourier series components, magnitude and phase

Q3. Determine the DTFS

$$x[n] = \cos^2\left[\frac{\pi}{6}n\right]$$

Q.4 Q1. (i) Find the Fourier Transform of the rectangular pulse $x(n) = u(n) - u(n-(N))$.

(ii) If the pulse is modified as shown in fig. Obtain the Fourier Transform



(iii) Obtain the Fourier Transform of the pulse shown in fig above using the Fourier Transform of Q4(i) and properties. State the property used. Verify the result with Q4 (ii)

By shifting property.

Q5. Obtain the DTFT of the following signals. Plot the Magnitude and Phase Spectrum

(a) $x(n) = \begin{cases} 1 & 0 \le n \le 4 \\ 0 & otherwise \end{cases}$

(b) $x(n) = a^{|n|}\,u(n) \qquad 0 < a < 1$

Q6. The impulse response of a continuous time system is expressed as $h(t) = \frac{1}{RC}e^{-t/RC}u(t)$. (i) Find the frequency response. (ii) Plot the magnitude and phase response. (iii) Comment on the type of magnitude response $= \sqrt{R^2 + I^2}$. (if 1st low pass / high pass / band pass).

H(ω)

DTFT/CTFT of h(n) or h(t). is freq response.

3

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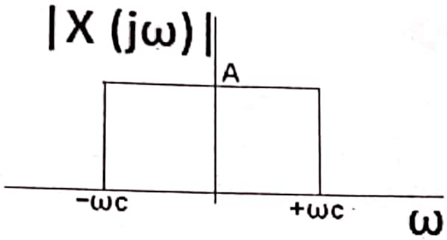
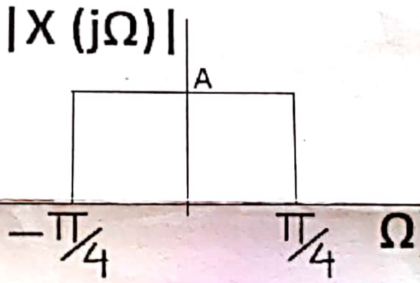
Tutorial No: 3

Q1. Obtain the IDTFT of the following signal. Plot x[n]



Q2. Obtain the ICTFT of the following Plot x(t)



Q3. Obtain the Laplace Transform of (i) $te^{-at}u(t)$ (ii) $e^{-t}(t-2)u(t-2)$ (iii) $u(t-5)$ (iv) $e^{5t}u(-t+2)$ (v) $e^{-2t}(u(t) - u(t-5))$

Q4. Obtain the inverse Laplace Transform

$$\frac{2s+4}{s^2+4s+3} \qquad Re(s) > -1$$

$$\frac{s^3+2s^2+6}{s^2+3s} \qquad Re(s) > 0$$

+ $$\frac{5s+13}{s^2+3s+13} \qquad Re(s) > 0$$

Q5. An LTI system is described by H(s) = $\frac{2s+4}{s^2+4s+3}$ $Re(s) > -1$. . Find the system response for $x(t) = 2e^{-2t}(u(t))$

y(t)

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Q6. Find the Z transform and ROC for each of the following sequences:

(a) $x[n] = \cos(w_0 n)u[n]$

(b) $x[n] = \sin(w_0 n)u[n]$

(c) $x[n] = 1 \quad 0 \le n \le N-1$
$\quad\;\; = 0 \quad$ elsewhere

(d) $x[n] = \delta[n - n_0]$

(e) $x[n] = u[n - n_0]$

(f) $x[n] = a^n u[n-1]$

(g) $x[n] = na^n u[n]$

(h) $x[n] = na^{n-1} u[n]$

Q7. Obtain the inverse Z transform of following using (i) Power series expansion (ii) Partial Fraction Method

(1) $X(z) = \frac{2+z^{-1}}{1-\frac{1}{2}z^{-1}}$ with ROC $|z| > \frac{1}{2}$

(2) $X(z) = \frac{2+z^{-1}}{1-\frac{1}{2}z^{-1}}$ with ROC $|z| < \frac{1}{2}$

Q8. A DT LTI system is described by $y[n] - \frac{3}{4}y[n-1] + \frac{1}{8}y[n-2] = x[n]$

(a) Determine the system function $H(z)$

(b) Obtain impulse response $h[n]$

(c) Obtain step response of the system

impulse fn = $\delta(t)$ / $\delta(n)$
step fn = $u(t)$ / $u(n)$

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$\omega_p \rightarrow$ rad
$\Omega \rightarrow$ rad/s

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Tutorial No: 4

Q1. If $x(n) = \delta(n) + \delta(n-1) + 2\delta(n-3)$,
(a) Find $X(e^{j\omega})$ DTFT.
(b) Find $X(k)$ 4-point DFT
(c) Show that DFT is the sampled version of $X(e^{j\omega})$

even terms will be same, odd terms will be -ve of each other

Q2.. Using DITFFT find DFT of $x_1(n) = \{1, 2, -1, 2, 4, 2, -1, 2\}$. Further using DFT properties
(a) if $X_2(k) = X_1(k-2)$ obtain $x_2(n)$ frequency shifting
(b) if $x_3(n) = x_1(-n)$, Obtain $X_3(k)$ time shifting
(c) Let $g(n) = x_1(n) + x_2(n)$ and $x_2(n) = \{4, 2, -1, 2, 1, 2, -1, 2\}$ find $G(k)$ using the above result and DFT properties

$x_2(n)$ is delayed of $x_1(n)$ by $N/2$

Q3. (a) A sequence $x(n)$ is given by $x(n) = (1, -0.5, 0, -0.5)$. Find the DFT
(b) Let $x_1(n)$ be derived from $x(n)$ such that $x_1(n) = (1, 0, -0.5, 0, 0, 0, -0.5, 0)$, without performing DFT/FFT, using properties find $X_1(k)$ delayed by $\frac{N}{2}$ DIT FFT
(c) Let $g_1(n) = (1, -0.5, 0, -0.5, 0, 0, 0, 0)$ and $g_2(n) = (0, 0, 0, 0, 1, -0.5, 0, -0.5)$ and $g(n) = g_1(n) + g_2(n)$, using properties and results of (a) find $G(k)$ and prove that $G(k) = \{2X_1(0), 0, 2X_1(2), 0, 2X_1(4), 0, 2X_1(6), 0\}$ where $X_1(k)$ is the DFT of $x(n)$ DIF FFT.
(d) Perform DIT-FFT or DIF-FFT obtain $g(n)$ from $G(k)$ and Verify

Q4. (a) Let $x_1(n) = (3, 2, 1, 4)$ and $x_2(n) = (4, 3, 2, 1)$. Find the DFT using basic definition to either of them.
(b) Using the properties and not otherwise find the DFT of the following sequences
(i) $(3 + j4, 2 + j3, 1 + j2, 4 + j1)$ using linearity property.
(ii) $(4, 1, 2, 3)$ $= x_2(-n)$
(iii) $(2, 1, 4, 3)$ $= x_1(n+1)$;

$x_2(n) = x_1(n-1)$ Delayed by 1

Tutorial No: 5

Q1. Design using bilinear transformation. The filter should have a monotonic pass and stop bands — Low Pass filter

$0.8 \le |H(e^{j\omega})| \le 1$ for $0 \le \omega \le 0.2\pi$

$|H(e^{j\omega})| \le 0.2$ for $0.6\pi \le \omega \le \pi$ Ω_s

Q2. Find the attenuation at the frequency of 8000 Hz of a 4^{th} order Butterworth filter whose 1 dB pass band edge is located at 2500 Hz. Ω_p A_p use eqn for N.

Q3. Show the poles of a second order normalized low pass butterworth filter. Obtain the transfer function. Hence obtain the transfer function of a high pass filter with cutoff frequency 2 Ω_c rads/sec. replace s by $\frac{\Omega_c}{s}$

Q4. Design a linear phase FIR filter using windowing techniques

$|H(e^{j\omega})| \le 0.01$ $0 \le |\omega| \le 0.3\pi$

$0.99 \le |H(e^{j\omega})| \le 1.01$ $0.35\pi \le |\omega| \le \pi$

Q5. Design a low pass digital filter that will have 3 dB cutoff at 30π dB rad/sec and an attenuation of 40 dB cutoff at 45π dB rad/sec. The filter should have linear phase charateristics and has a sampling frequency of 100 samples/sec.

* rad/sec means analog dom

1. i) Specifications are given in digital → convert to analog.

$\omega_p = 0.2\pi$ | $A_p = -20 \log 0.8$ | $\Omega_p = \frac{2}{T} \tan \omega_p/2$

$\omega_s = 0.6\pi$ | $A_s = -20 \log 0.2$ | $\Omega_s = \frac{2}{T} \tan \omega_s/2$

ii) Find N → Poles → $H(s)$

iii) For actual $H(s)$, $s \Rightarrow s/\Omega_c$ — not given → Use $\left(\frac{\Omega_p}{\Omega_c}\right)^{2N} = 10^{A_p/10} - 1$ to find Ω_c.

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VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

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MID-SEMESTER TEST	*September 2018*	DATE OF EXAM.	*24/09/18*
SEMESTER & PROGRAM	Sem VII. **B.Tech**		
TIME ALLOWED	*90 mins.*	MARKS	*40*
COURSE (Course Code)	**Signal Processing and Applications (Open Elective)**		

Instructions:-

1) **All questions are compulsory.**
2) **All sub-questions of a given question should be grouped & written together.**

Q1. A Sketch the following signals. State whether energy or power signal. Hence find the value of energy or power to prove your statement. (06)

(i) $x(t) = e^{-\alpha|t|}$ for α >0 (ii) $x(n) = \left(\frac{1}{2}\right)^n u(n)$ (iii) $x(n) = 2\cos\frac{\pi}{2}n$

B. Sketch and label the signal after performing the following operations on the signal shown in fig 1 (04)

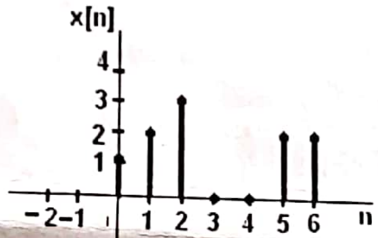

Fig 1

(i) x(n - 2)
(ii) x(2n)
(iii) x(-n)
(iv) x(n/3)

Q2. A Perform convolution of the following two signals (05)

$x_1(t) = e^{-3t}u(t)$ and $x_2(t) = tu(t)$

Find y(n) if the input to a system with h(n) = {1, 2, 3, 1} is x(n) = { 1, 0, 1, 1} . (05)

Q3 A Sketch and label the even and odd components of the following signals (06)

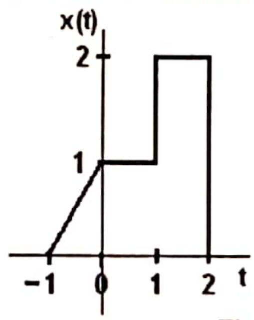

Fig 2

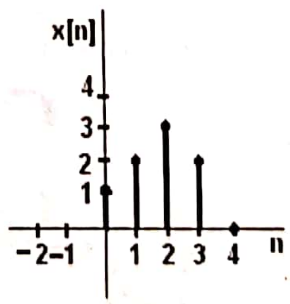

Fig 3

	1	2	3	1
1	1	2	3	1
0	0	0	0	0
1	1	2	3	1
1	1	2	3	1

1, 2, 4, 4, 5, 4, 1

$e^{-j\pi/4} = \cos(-\pi/4) + j\sin(-\pi/4)$

$\frac{1}{\sqrt{2}} \quad -\frac{1}{\sqrt{2}}$

B For the continuous time signal $x(t) = \begin{cases} 1-|t| & -1 \le t \le 1 \\ 0 & otherwise \end{cases}$ (04)

Determine the resultant discrete time signal in the form of sequence, obtained by uniform sampling of x(t) with a sampling interval of (a) 0.25 sec (b) 0.5 sec

Q4 A Obtain the frequency response of the discrete time system, if its impulse response is $h[n] = \left(\frac{1}{2}\right)^n u[n]$. (06)

B Further obtain the output y(n), if the input $x[n] = 2\cos\frac{\pi}{4}n$ (04)

$H(e^{j\omega}) = |H(e^{j\omega})| e^{j\arg(H(e^{j\omega}))}$

$H(e^{-j\omega}) = |H(e^{j\omega})| e^{-j\arg(H(e^{j\omega}))}$

① $x[n] \rightarrow \boxed{LTI}_{h[n]} \rightarrow y[n]$

② If $x[n] = e^{j\omega n}$

$y[n] = \sum_{k=-\infty}^{\infty} h(k) e^{j\omega(n-k)}$

$= e^{j\omega n} \underbrace{\sum_{k=-\infty}^{\infty} h(k) e^{-j\omega k}}_{\text{DTFT of } h(k)}$

$= e^{j\omega n} H(e^{j\omega})$

$\therefore \boxed{e^{j\omega n} \xrightarrow{LTI} y(n) = H(e^{j\omega}) e^{j\omega n}}$

③ Similarly,

$\boxed{e^{-j\omega n} \xrightarrow{LTI} H(e^{-j\omega}) e^{-j\omega n}}$

④ ~~cos~~ $e^{j\omega n} + e^{-j\omega n} = 2\cos(\omega n)$.

$\therefore \cos(\omega n) \longrightarrow \frac{H(e^{j\omega})e^{j\omega n} + H(e^{-j\omega})e^{-j\omega n}}{2}$

$= \frac{1}{2}\left\{ |H(e^{j\omega})| \left\{ e^{j\arg(H(e^{j\omega}))} \cdot e^{j\omega n} + e^{-j\arg H(e^{j\omega})} \cdot e^{-j\omega n} \right\}\right\}$

$= \frac{1}{2} |H(e^{j\omega})| \left[e^{j(\omega n + \arg H(e^{j\omega}))} + e^{-j(\arg H(e^{j\omega}) + \omega n)} \right]$

$\boxed{= |H(e^{j\omega})| \cos(\omega n + \arg[H(e^{j\omega})])}$

$h[n] = \left(\frac{1}{2}\right)^n u[n]$

$\therefore H(e^{j\omega}) = \frac{1}{1 - \frac{1}{2}e^{-j\omega}}$

$\therefore H(e^{j\pi/4}) = \frac{1}{1 - \frac{1}{2}e^{-j\pi/4}}$

$|H| = 1.36$

$\angle(H) = -0.5$

$\therefore y(n) = 2 \times 1.36 \cos\left(\frac{\pi n}{4} - 0.5\right)$

$= 2.72 \cos\left(\frac{\pi n - 2}{4}\right)$ //