DSA ASSIGNMENT-2

SIGNALS :

1) (a) $x[n] = \sin^2(3n+\pi)$

$$= \frac{1+\cos(2\pi+6n)}{2}$$

$$= \frac{1+\cos 6n}{2}$$

The period of $\cos(kn)$ is $2\pi/k$

Hence $\cos(6n)$ period $= 2\pi/6$

$= \pi/3$

period of $x(n) = k$

satisfies

$x[n] = x[n+k]$

since $x[n] = x[n+\pi/3]$

period is $\pi/3$

$\therefore$ ~~$x[n]$~~ period of $x[n]$ is $\pi/3$ and $x[n]$ is periodic

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Since $x(n)$ only takes integers

and calc periodic is irrational i.e $\pi/3$

$x(n)$ is not periodic

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(b) $x[n] = e^{(j\pi n)/8}$

Let its period be k

$x[n+k] = e^{(j\pi(n+k))/8}$

$= e^{j\pi n/8} \times e^{jk\pi/8}$

$= x(n) = e^{j\pi n/8}$

$\therefore e^{jk\pi/8} = 1$

for k to be smallest

$k\pi/8 = 2\pi$

$k = 16$

The period $= 16$

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(c) $x[n] = \cos\left(\frac{\pi n}{15}\right) \cos\left(\frac{\pi n}{30}\right)$

$$= \frac{\cos\left(\frac{2\pi n}{15}\right) + \cos\left(\frac{2\pi n}{15}\right)}{2}$$

The period of $\cos\left(\frac{2\pi n}{15}\right) = \frac{2\pi}{2\pi/15} = 15$

The period of $\cos\left(\frac{\pi n}{15}\right) = \frac{2\pi}{\pi/15} = 30$

period of $x[n] = LCM\left(\text{period}\left(\cos\left(\frac{2\pi n}{15}\right)\right), \text{period}\left(\cos\left(\frac{\pi n}{15}\right)\right)\right)$

$= LCM(15, 30)$

$= 30$

$\therefore$ the $x(n)$ is periodic with period 30

(d) $x(n) = \sin(4\pi n + 3)$

Let k be the period of $x(n)$

$x(n) = x[n+k]$

$\sin(4\pi n + 3) = \sin(4\pi n + 4\pi k + 3)$

W.K.T period of $\sin x$ is 2π

$\therefore 2\pi = 4\pi k$

$k = 1/2$

$\therefore$ ~~$x(n)$ is periodic with period $= 1/2$~~

But since $x(n)$ only takes integers

The period $= \frac{1}{2} \times 2 = 1$

$\therefore x(n)$ is periodic with period $= 1$

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(8) $x(n) = \cos\left(\pi n^2/3\right)$

Let period $= k$

$$x(n+k) = \cos\left(\frac{\pi (n+k)^2}{3}\right)$$

$$= \cos\left(\frac{\pi n^2 + \pi k^2 + 2\pi n k}{3}\right)$$

$$x(n) = \cos\left(\frac{\pi n^2}{3}\right)$$

$$\therefore \cos\left(\frac{\pi n^2 + \pi k^2 + 2\pi n k}{3}\right) = \cos\left(\frac{\pi n^2}{3}\right)$$

$$\therefore \frac{\pi k^2 + 2\pi n k}{3} = 2\pi l$$

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$\pi k^2 + 2\pi n k = 6\pi l$

i.e. both πk^2 and $2\pi n k$ should be a ~~pi~~ multiple of 6π

$2\pi n k$ is a multiple of 6π if $k = 3n$

πk^2 is a multiple of 6π if $k = 6n$

$\therefore$ period $= LCM(3n, 6n)$

$= 6n$

least value $=$ period $= 6$

$\therefore$ $x(n)$ is periodic with period 6

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f) $x(n) = \sum_{k=-\infty}^{\infty} (-1)^k \delta(n-k)$

let this function be periodic with period l

$$x(n+l) = \sum_{-\infty}^{\infty} (-1)^k \delta(n+l-k)$$

let $k-l=t$

$$= \cancel{\sum_{k=-\infty}^{\infty}}$$

$$= \sum_{t+l=-\infty}^{\infty} (-1)^{t+l} \delta(n-t)$$

$$= (-1)^l \sum_{t=-\infty}^{\infty} (-1)^t \delta(n-t)$$

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$$= (-1)^{l} \sum_{k=-\infty}^{\infty} (-1)^{k} \cdot \delta(n-k)$$

$$= (-1)^{l} \, x[n]$$

$$x[n+l] = (-1)^{l} \, x[n]$$

If l is period

$$x[n] = (-1)^{l} \, x[n]$$

$$(-1)^{l} = 1$$

$$l = 2n$$

smallest period $= 2$

$\therefore$ The period of $x[n] = 2$

2(A) (a) $x[n] = \sqrt{2}\cos\left((an+1)/4 \, \pi\right)$

$$x[-n] = \sqrt{2}\cos\left((-an+1)/4 \, \pi\right)$$

even part $= \frac{\sqrt{2}}{2} \, 2\cos \pi/4 \, \cos an\pi/4$

$$= \cos\left(\frac{an\pi}{4}\right)$$

odd part $= \frac{-\sqrt{2}}{2} \, 2\sin(\pi/4) \, \sin\left(an\pi/4\right)$

$$= -\sin\left(an\pi/4\right)$$

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(b)

$$x(n) = e^{jan\pi} + e^{jn\pi/b}$$

$$x(-n) = e^{-jan\pi} + e^{-jn\pi/b}$$

even part $= \dfrac{x(n)+x(-n)}{2} = \dfrac{e^{jan\pi} + e^{-jan\pi}}{2} + \dfrac{e^{jn\pi/b} + e^{-jn\pi/b}}{2}$

odd part $= \dfrac{x(n)-x(-n)}{2} = \dfrac{e^{jan\pi} - e^{-jan\pi}}{2} + \dfrac{e^{jn\pi/b} - e^{-jn\pi/b}}{2}$

3A) (a)

$$x(n) = \begin{cases} 0 & n<0 \\ n & n\geq 0 \end{cases}$$

$$\text{Energy} = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=1}^{\infty} n^2$$

$$= \lim_{n\to\infty} \frac{n(n+1)(2n+1)}{6}$$

Energy is infinite

$$\text{Power} = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \frac{N(N+1)(2N+1)}{6}$$

$$= \lim_{N\to\infty} \frac{N(N+1)}{6}$$

Power is infinite

$\therefore$ Energy, Power is infinite

It is not neither energy nor power

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(b) $x(n) = \cos\left(\frac{n\pi}{2}\right)$

Energy $= \sum_{n=-\infty}^{\infty} \left|\cos\left(\frac{n\pi}{2}\right)^2\right|$

$= \sum_{n=-\infty}^{\infty} \left|\cos\left(\frac{n\pi}{2}\right)^2 + \cos\left(\frac{(n+1)\pi}{2}\right)^2\right|$

$= \sum_{n=-\infty}^{\infty} 1 + 0 =$ not finite.

Power $= \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} \left|\cos\left(\frac{n\pi}{2}\right)\right|^2$

$= \lim_{N\to\infty} \frac{1}{2N+1} \times N$

$= \frac{1}{2} =$ finite.

Hence it is a power signal

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$(1/2)$

Energy $= \sum_{n=-\infty}^{\infty} |x(n)|^2$

$= \sum_{-\infty}^{\infty} |\cos(n\pi/2)|^2$

$= 0$

Energy - finite power - 0

It is an energy signal.

(c) $x[n] = \begin{cases} 3^n & n<0 \\ (1/2)^n & n\geq 0 \end{cases}$

Energy $= \sum_{n=-\infty}^{-1} |x(n)|^2 + \sum_{n=0}^{\infty} |x(n)|^2$

$= \sum_{n=1}^{\infty} 1/(3)^n + \sum_{n=0}^{\infty} 1/4^n$

$= \sum_{n=1}^{\infty} 1/9^n + \sum_{n=0}^{\infty} 1/4^n$

$= \frac{1/9}{1-1/9} + \frac{1}{1-1/4}$

Energy - finite power - 0

It is an energy signal

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(d) $x[n] = a^n u[n]$

$$\text{Energy} = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=-\infty}^{\infty} |a^n u(n)|^2$$

$$= \sum_{n=0}^{\infty} |a^{2n}|$$

if $a \in [-1,1]$

$$\text{Energy} = \sum_{n=0}^{\infty} (|(a^2)|^n)$$

$$= \frac{1}{1-a^2}$$

Energy - finite, Power - 0 (as Power = $\frac{\text{Rate of Energy}}{t}$)

$\therefore$ if $a \notin [-1,1]$

$\therefore$ Energy is not finite.

$$\text{Power} = \cancel{\sum_{N=-\infty}^{\infty}} \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \lim_{N\to\infty} \left(\frac{1}{2N+1}\right) \sum_{n=0}^{N} a^{2n}$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \frac{a^{2(N+1)}-1}{a^2-1}$$

$$= \cancel{\frac{a^{2(0)}-1}{(a^2-1)}} \lim_{n\to\infty} \frac{a^{2(N+1)}-1}{2N+1} \times \frac{1}{a^2-1}$$

Applying L Hopital

$$\text{Power} = \lim_{n\to\infty} \frac{a^{2(N+1)} \, 2\log a}{2} \times \frac{1}{a^2-1}$$

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Not finite.

$\therefore$ It is neither energy nor power signal

(e) $x(n) = e^n \delta(n-4)$

$$\text{Energy} = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=-\infty}^{\infty} |e^n \delta(n-4)|^2$$

$$= e^4$$

i.e finite

Since energy is finite, power is ~~lim.~~ infinite.

$\therefore$ It is an energy signal

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SYSTEMS :-

1A) (a) $y(t) = t^2 x(t-1)$

let the signal y have a delay d i.e $y(t-d)$

$\therefore \quad y(t-d) = (t-d)^2 x(t-d-1)$

let the signal x have a delay d.

Then $y(t) = t^2 x(t-d-1)$

$t^2 x(t-d-1) \neq (t-d)^2 x(t-d-1)$

i.e a delay in x does not correspond to a delay in y.

$\therefore$ It is not time invariant

(b) $y[n] = x[n-1] + x[n+1]$

let the signal y have a delay d i.e $y[n-d]$

$\therefore \quad y[n-d] = x[n-d-1] + x[n-d+1]$

Now let the signal x have a delay d

$\text{output}(x[n-d]) = x[n-d-1] + x[n-d+1]$

$= y[n-d]$

$\therefore$ y is time invariant

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(c) $y(n) = \frac{1}{x(n)}$

If signal y is given a delay d

$y(n-d) = \frac{1}{x(n-d)}$

If signal x is given a delay d, then output$(x(n-d))$ in the system

$= \frac{1}{x(n-d)}$

i.e $= y(n-d)$

~~y(n-~~ i.e delay in x corresponds to delay in y

$\therefore$ It is time invariant

(d) $y(n) = x(n)(g(n) + g(n-1))$

(i) If $g(n) = 1 \quad \forall n$,

$y(n) = x(n)[1+1] = 2x(n)$

'd' delay in y i.e. $y(n-d) = 2x(n-d)$

'd' delay in x leads output$(x(n-d)) = 2x(n-d)$

$= y(n-d)$

$\therefore$ This system is time invariant

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If $g(n) = n$

$y(n) = x(n)\,(g(n) + g(n-1))$

$= x(n)\,[n + n-1]$

$= (2n-1)\,x(n)$

(i) delay in y is $y(n-d) = (2(n-d)-1)\,x(n-d)$

(ii) delay in x i.e. output $(x(n-d)) = (2n-1)\,x(n-d)$

$\neq y(n-d)$

$\therefore$ It is not time invariant

$g(n) = 1 + (-1)^n$

$y(n) = x(n)\,(1+(-1)^n + 1 + (-1)^{n-1})$

$= x(n)\,[2 + (-1)^n\,[1+(-1)]]$

$= 2x(n)$

$\therefore$ The same as the case in (i)

$\therefore$ The system is time invariant

2A) (a) $y(t) = x(\sin t)$

Consider $x(t) = a x_1(t) + b x_2(t)$

Passing $x(t)$ through the system gives

output $(x(t)) = x(\sin t)$

$= a x_1(\sin t) + b x_2(\sin t)$

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$$ay_1(t) + by_2(t) = ax_1(\sin t) + bx_2(\sin t)$$

$$= \text{output}(ax_1 + bx_2)$$

$\therefore$ This system is linear.

(b) $$y(t) = \begin{cases} 0 & t < 0 \\ x(t) + x(t-2) & t \geq 0 \end{cases}$$

Consider $aX(t) = ax_1(t) + bx_2(t)$

output of $X(t)$ in the system $= \begin{cases} 0 & t < 0 \\ ax_1(t) + bx_2(t) + ax_1(t-2) + bx_2(t-2) & t \geq 0 \end{cases}$

$$ay_1(t) + by_2(t) = \begin{cases} 0 & t < 0 \\ ax_1(t) + ax_1(t-2) + bx_2(t) + bx_2(t-2) & t \geq 0 \end{cases}$$

$$= \text{output}(X(t))$$

$\therefore$ This system is linear

(c) $$y(t) = \frac{d(x(t))}{dt}$$

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Consider $x(t) = a x_1(t) + b x_2(t)$

output of $x(t)$ in this system $= \dfrac{d(x(t))}{dt}$

$$= a \frac{d}{dt}(x_1(t)) + b \frac{d}{dt}(x_2(t))$$

$$= a y_1(t) + b y_2(t).$$

$\therefore$ $a y_1(t) + b y_2(t) =$ output $(a x_1(t) + b x_2(t))$

$\therefore$ The system is linear.

(d) $y(n) = \sum_{m=0}^{M} a x(n-m) + \sum_{m=1}^{N} b x(n-m)$

consider $x(n) = k a x_1(n) + l b x_2(n)$

output of this system for $x(n)$

$$= \sum_{m=0}^{M} a x(n-m) + \sum_{m=1}^{N} b x(n-m)$$

$$= \sum_{m=0}^{M} a \left(k x_1(n-m) + l x_2(n-m)\right)$$

$$+ \sum_{m=1}^{N} b \left(k x_1(n-m) + l x_2(n-m)\right)$$

$$= \cancel{k \sum_{m=0}^{M} a (x_1(n-m)) + b x_1}$$

$$= k \left(\sum_{m=0}^{M} a x_1(n-m) + \sum_{m=1}^{M} b x_1(n-m) \right)$$

$$+ l \left(\sum_{m=0}^{M} a x_2(n-m) + \sum_{m=1}^{M} b x_2(n-m) \right)$$

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$= k\, y_1[n] + l\, y_2(n)$

$\therefore$ output $(k x_1(n) + l x_2(n))$

$= k y_1(n) + l y_2(n)$

The system is linear.

(e) $y(n) = a x(n) + b \dfrac{1}{x[n-1]}$

Consider $x(n) = k x_1(n) + l x_2(n)$

output $(x(n)) = a x(n) + b \dfrac{1}{x[n-1]}$

$= a(k x_1[n] + l x_2[n])$

$+ b \dfrac{1}{(k x_1[n] + l x_2[n])}$

$k y_1(n) + l y_2(n) = a(k x_1(n) + l x_2(n))$

$+ b\left(\dfrac{k}{x_1(n)} + \dfrac{l}{x_2(n)}\right)$

Clearly $k y_1(n) + l y_2(n) \neq$ output $(x(n))$

Hence it is not linear.

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3A) (a) $y(t) = x(t-1) + x(2-t)$

at $t=0$

$y(0) = x(-1) + x(2)$

$y(0)$ depends on the future.

$\therefore$ The system is not causal

(b) $y(t) = (\cos 3t)\, x(t)$

$y(t)$ only depends on $x(t)$

i.e the present.

$\therefore$ The system is causal

(c) $y(t) = \int_{-\infty}^{2t} x(\tau)\, d\tau$

$= \int_{-\infty}^{t} x(\tau)\, d\tau + \int_{t}^{2t} x(\tau)\, d\tau$

when $t > 0$

$2t > t$

$y(t)$ depends on the future values of $x(t)$

$\left(\int_{t}^{2t} x(\tau)\, d\tau \right)$

Hence it is not causal

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(d) $y(n) = \sum_{k=0}^{\infty} x(n+k)$

$y(n) = x(n) + x(n+1) + x(n+2) + \cdots$

Clearly depends on the future values $x(n+1)$, $x(n+2)$ ...

$\therefore$ The system is not casual

(e) $y(n) = \sum_{k=0}^{\infty} x(n-k)$

$y(n) = x(n) + x(n-1) + \cdots$

$y(n)$ depends on the past and present values.

Hence it is casual

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SAMPLING FREQUENCY:

1A) ALIASING:

Aliasing is an effect that causes different signals to become indistinguishable from each other during sampling. It is characterized by the altering of output compared to the original signal because resampling or interpolation resulted in a lower resolution in images, a slower frame rate in terms of video or a lower wave resolution in audio.

It occurs when the sampling rate is insufficient to accurately capture the frequency content of the original signal

To avoid aliasing, It is important to follow the sampling theorem, which states that the sampling rate should be at least twice the highest frequency component of the signal.

Given $x(t) = \frac{1}{2\pi} \cos(4000\pi t) \cos(1000\pi t)$

$$x(t) = \frac{1}{4\pi} \left[\cos(5000\pi t) + \cos(3000\pi t) \right]$$

Let Maximum frequency be f_m

$2\pi f_1 = 5000\pi$ | $2\pi f_2 = 3000\pi$

$f_1 = 2500$ | $f_2 = 1500$

$\therefore f_m = 2500$

Therefore the Nyquist rate : 2×2500

$= 5000$

The Nyquist interval : $\frac{1}{5000}$

$= 2 \times 10^{-4}$ sec

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2A)

$$x(t) = 10\cos(1000t + \pi/3) + 20\cos(2000t + \pi/6)$$

$2\pi f = 1000$ / $2\pi f = 2000$

$f = \frac{500}{\pi}$ / $f = \frac{1000}{\pi}$

maximum frequency $f_m = \frac{1000}{\pi}$

$f_s \geq 2 \times f_m = \frac{2000}{\pi}$

maximum allowable time interval $= \frac{1}{f_s}$

$= \frac{\pi}{2000}$

$\simeq 1.57 \times 10^{-3}$ sec

To reproduce 1 hour of this transform we have to make $f_s \times 3600$ samples

$\frac{2000}{\pi} \times 3600$

$= 2.291 \times 10^{6}$

3A) $X_1(\Omega) = 0, \quad 120 \leq |\Omega|$

$X_2(\Omega) = 0, \quad |\Omega| \leq 80 \; ; \; |\Omega| \geq 100$

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$\therefore$ The maximum frequency for which $X_1(\Omega) \neq 0$ is 120

and similarly for $X_2(\Omega) \neq 0$ is 100

as $|\Omega| \leq 60$,

$|\Omega| \geq 100$

$X_2(\Omega) = 0$

(a) Given $x(t) = x_1(t) + x_2(t)$

The max frequency at which $x(t)$ is not equal to 0 is when $x_1(t)$, $x_2(t)$ is not equal to zero

$x_1(t) \neq 0$ at max frequency of 120

$x_2(t) \neq 0$ at max frequency of 100

i.e $2\pi F = 120$, $2\pi F = 100$

max frequency $= \max(120, 100)$

$= 120 \Rightarrow f_s = 2f_m$

$= 240$

(b) $x(t) = x_1(t)\, x_2(t)$

From convolution property

$$X(\omega) = \int_{-\infty}^{\infty} X_1(\omega')\, X_2(\omega - \omega')\, d\omega'$$

We have to find the maximum frequency

given $X_1(\omega') = 0$ $\forall$ $|\omega'| \geq 120$

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$$\therefore X(\omega) = \int_{-120}^{120} X_1(\omega') X_2(\omega-\omega')\, d\omega'$$

$X_2(\omega-\omega')$ should also be $\neq 0$

$X_2(\omega-\omega') = 0$ when $|\omega-\omega'| \leq 60$

$|\omega-\omega'| \geq 100$

ie $X_2(\omega-\omega') \neq 0$

when $60 \leq |\omega-\omega'| \leq 100$

$60 \leq |\omega-\omega'|$

$-60 \leq \omega-\omega' \leq 60$

$60 \leq \omega-\omega'$ (or) $\omega-\omega' < -60$

$60+\omega' \leq \omega$ (or) $\omega < \omega'-60$

$|\omega-\omega'| \leq 100$

$-100 \leq \omega-\omega' \leq 100$

$\omega'-100 \leq \omega \leq 100+\omega'$

The maximum frequency for ($\omega' \in (-120, 120)$)

for $\omega = 100+\omega'$

while $X(\omega) \neq 0$

$= 100+120 = 220$

$\therefore$ The maximum sampling frequency $= 220 \times 2$

$= 440$

(e) $x(t) = \cos(3.6\pi t + 9.23)$

$2\pi f_m = 3.6\pi$

$f_m = 1.8$

$f_s \geq 2f_m = 3.6$

$\therefore$ minimum sampling rate $= 3.6$

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SECTION - 4 QUANTIZATION:-

1A) $x(t) = \begin{cases} -2\sin\left(\frac{\pi x}{4}\right) & 0 \le x < 4 \\ x-4 & 4 \le x < 5 \\ 1 & 5 \le x < 7 \\ 8-x & 7 \le x \le 10 \end{cases}$

sampled at 1000Hz, given input range -2V to 2V

2- Bit Quantizer

(a) sampling period $(T_s) = \frac{1}{f_s} = \frac{1}{1000}$ sec

sample points are $T_s, 2T_s, 3T_s, \ldots$

$= \frac{1}{1000}, \frac{2}{1000}, \frac{3}{1000}, \ldots \frac{1000}{1000}$

$\therefore$ sample points = 1ms, 2ms, 3ms, ---, 1sec

(b) step size $= \frac{2-(-2)}{2^2} = 1$

$\therefore$ 00 $\equiv$ $-2 \rightarrow -1$ Quantization intervals

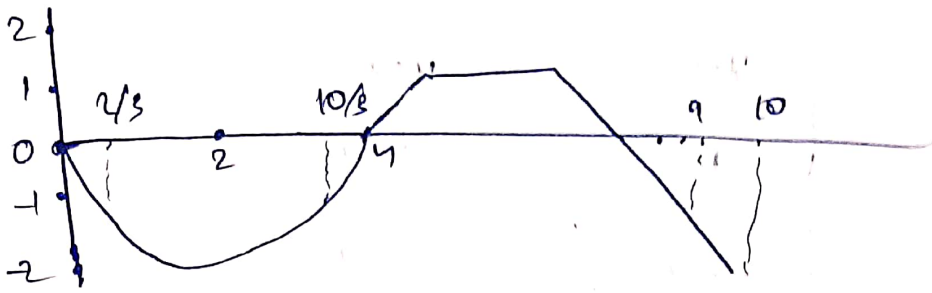
01 $\equiv$ $-1 \rightarrow 0$ i.e

10 $\equiv$ $0 \rightarrow 1$

11 $\equiv$ $1 \rightarrow 2$

(c)

The graph of $x(t)$ is



For interval $(0, 2/3)$ $x(t) \in [-1, 0)$

Similarly $(0, 2/3) \rightarrow 01 \rightarrow [2/3 \times 1000] = 666$ samples

$(2/3, 10/3) \rightarrow 00 \rightarrow (8/3 \times 1000) = 2667$ samples

$x(t) \in [-2, -1]$

$[10/3, 4] \rightarrow 01 \rightarrow [2/3 \times 1000] = 666$ samples

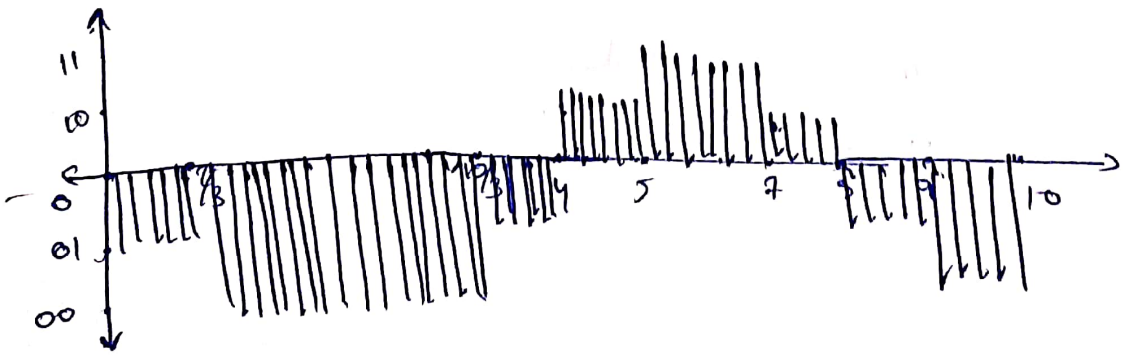
$[4, 5] \rightarrow 10 \rightarrow [1 \times 1000] = 1000$ samples

$(5, 7) \rightarrow 11 \rightarrow (2 \times 1000) = 2000$ samples

$[7, 8] \rightarrow 10 \rightarrow [1 \times 1000] = 1000$ samples

$[8, 9] \rightarrow 01 \rightarrow [1 \times 1000] = 1000$ samples

$[9, 10] \rightarrow 00 \rightarrow [1 \times 1000] = 1000$ samples



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(d) The resulting bit stream

(12)

| (01)(01)(01) — (01) | (00)(00)(00) — (00) | (01)(01)(01) — (01) |

— 666 — — 2667 — — 666 —

| (10)(10)(10)(10) — (10) | (11)(11) — (11) | (10)(10) — (10) |

1000 samples 2000 samples 1000 samples

| (01)(01)(01) — (01) | (00)(00) — (00) |

1000 samples 1000 samples

(e) Total no of samples = 1000 × 10

= 10000 samples

Each sample has 2 bits

∴ Total bits = 20000 bits

20000 bits

$$\text{bitrate} = \frac{\text{Total bits}}{\text{Total time}} = \frac{20000}{10}$$

= 2000 bits/sec

(f) Quantization 20000 = $\dfrac{\text{max Voltage} - \text{min Voltage}}{2^{N+1}}$

$$= \frac{2-(-2)}{23}$$

$$= 4/8 = 0.5$$

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3-bit Quantization :

(a) Sample points : $T_s, 2T_s, 3T_s$ ——

= 1m.sec , 2msec , 3msec

. —— 1sec

(b) Quantization step size = $\frac{\text{max Voltage} - \text{min voltage}}{2^N}$

$= \frac{2-(-2)}{2^3}$

$= 0.5$

000 ≡ -2 to -1.5

001 ≡ -1.5 to -1

010 ≡ -1 to -0.5

011 ≡ -0.5 to 0

100 ≡ 0 to 0.5

101 ≡ 0.5 to 1

110 ≡ 1 to 1.5

111 ≡ 1.5 to 2

(d) 0 to 0.328 — $x(t) \in [-0.5, 0)$ - 322 samples

0.328 to 0.667 - $x(t) \in [-1, -0.5]$ - 345 samples

0.667 to 1.68 - $x(t) \in [-1.5, -1]$ - 413 samples

1.68 to 2.92 — $x(t) \in [-2, -1.5]$ - 1840 samples

2.92 to 3.333 - $x(t) \in [-1.5, -1)$ - 413 samples

3.33 to 3.678 - $x(t) \in [-1, -0.5)$ - 345 samples

3.678 to 4 - $x(t) \in [-0.5, 0]$ - 322 samples

4 to 4.5 - $x(t) \in [0, 0.5]$ - 500 samples

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$[4.5, 5] \rightarrow x(t) \in [0.5, 1] \rightarrow$ 500 samples

$[5, 7] \rightarrow x(t) \in [1, 1.5] \rightarrow$ 2000 samples

$[7, 7.5] \rightarrow x(t) \in [0.5, 1] \rightarrow$ 500 samples

$[7.5, 8] \rightarrow x(t) \in [0, 0.5] \rightarrow$ 500 samples

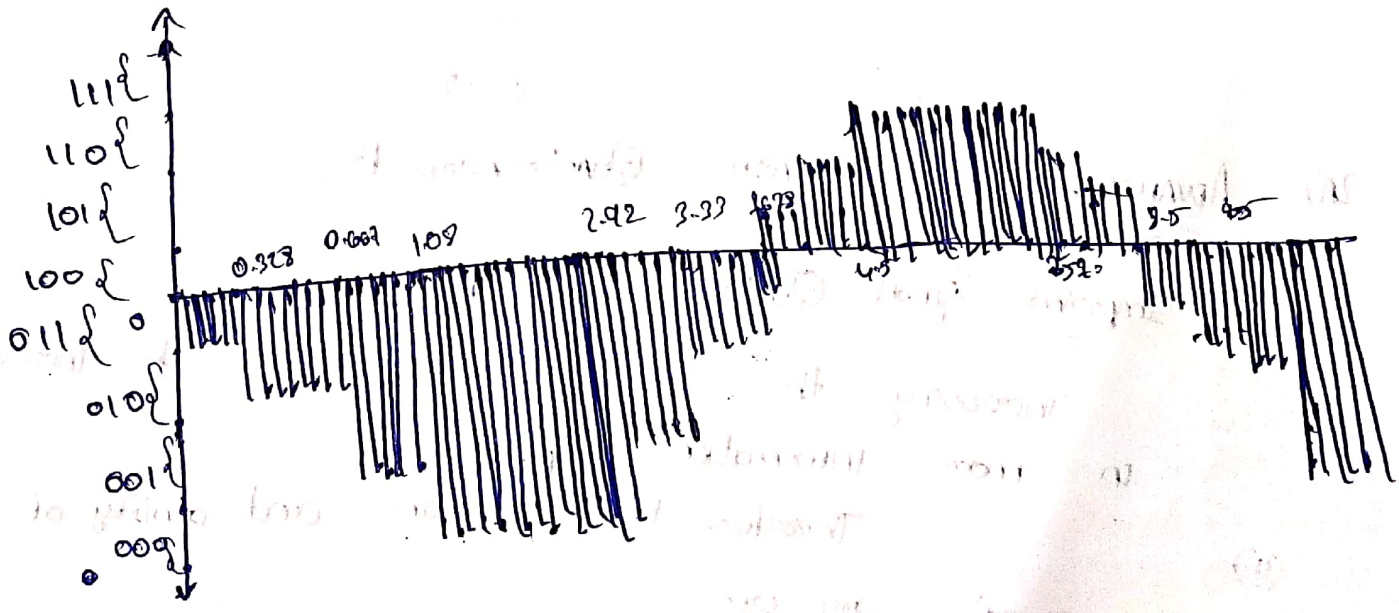
$[8, 8.5] \rightarrow x(t) \in [-0.5, 0] \rightarrow$ 500 samples

$[8.5, 9] \rightarrow x(t) \in [-1, -0.5] \rightarrow$ 500 samples

$[9, 9.5] \rightarrow x(t) \in [-1.5, -1] \rightarrow$ 500 samples

$[9.5, 10] \rightarrow x(t) \in [-2, -1.5] \rightarrow$ 500 samples

(c)



(d) $(011)(011) \cdots 011)$ 322 times $(010 \cdots)$ 345 times $(001 \cdots)$ 413 times $(000 \cdots)$ 1040 times

(001) 413 times $(010$ 345 times $(011$ 322 times $(100$ 500 times

$(101$ 500 times $(110$ 2000 times $(101$ 500 times $(100$ 500 times

$(011$ 500 times $(010$ 500 times $(001$ 500 times $(000$ 500 times

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(e)

Total samples = 1000 × 10 = 10000

no of bits / sample = 3

$$\text{bit rate} = \frac{30000}{10}$$

$$= 3000$$

(f) quantization error =

$$\frac{\text{max voltage} - \text{min voltage}}{2^{N+1}}$$

$$= \frac{2-(-2)}{2^{3+1}}$$

$$= 0.25$$

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ADVANTAGES :-

2A) (i) Improves the quality of the signal

(ii) Reduces quantization error as more no of bits are used.

(iii) ~~The~~ The ~~repr~~ precision of the ~~the~~ representation the signal would be high if more bits are used.

(iv) Increases the dynamic range of the digital signal.

DISADVANTAGES :-

(i) The complexity of computation and usage of memory would increase.

(ii) The power consumption would increase as more power is required to process

~~(iii)~~

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