| Solve for Q. NO. 1 |

Sumon DSP 01

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1-07

1(a) (i) Multichannel signal:

Sensor is a divice which convents any physical quantity to an equivalent eletrical signal.

The signal generated from multiple sources or Sensors is called multichannel signal.

example: Eletro cardiography signal (ECG)

(ii) multidimension Signal:

If the signal is a quantity with more than one indipendent variable then it is called multidimensional signal.

Ex: Telivision signal.

(iii) Baseband form of simpling theorom:

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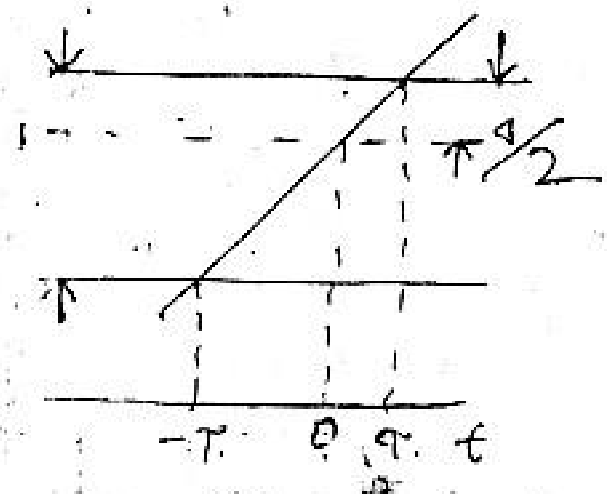
(b) For a quantized sinusoid show that the SQNR increase approximately 6dB for every bit added to the word length.

Ans: The quantization error e in the fig (a) is

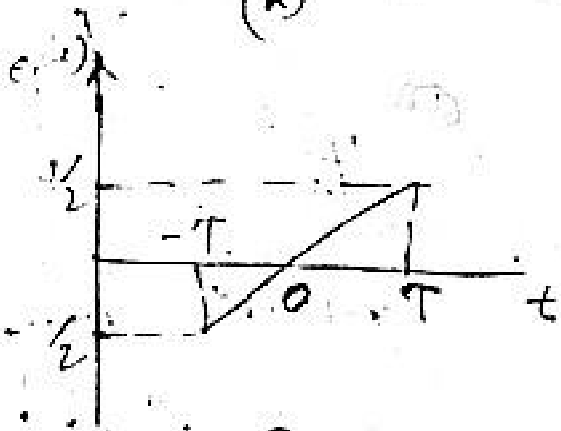


(a)

$$e_q(t) = x_a(t) - x_q(t)$$

$$e_q(t) = \frac{\Delta}{2\tau} t \quad \text{---} (1)$$

in fig (b) τ denotes the time that $x_a(t)$ stays within the quantization levels.



(b)

The mean-square error power P_q is

$$P_q = \frac{1}{2\tau}\int_{-\tau}^{\tau} e_q^2(t)\, dt$$

$$= \frac{1}{\tau}\int_0^{\tau}\left(\frac{\Delta}{2\tau} t\right)^2 dt$$

$$= \frac{\Delta^2}{4\tau^3}\frac{t^3}{3}\Big|_0^{\tau} = \frac{\Delta^2}{4\tau^3}\cdot\frac{1}{3}\left[\tau^3 - 0\right]$$

$$P_q = \frac{\Delta^2}{12} \quad \text{---} (2)$$

If the quantizer has b bit of accuracy and the quantizer covers the entire range $2A$ the quantization

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So, $P_q = \dfrac{\left(2A/2^b\right)^2}{12} = \dfrac{\frac{4A^2}{2^{2b}}}{12}$

$= \dfrac{A^2/3}{2^{2b}}$

The avarage power of the signal $x_a(t)$ is

$$P_{(x)} = \frac{1}{T_P}\int_0^{T_P}\left(A\cos\Omega_0 t\right)^2 dt$$

$$= \frac{A^2}{T_P}\int_0^{T_P}\cos^2\Omega_0 t\, dt$$

$\cos^2 A = \frac{1}{2}\left(1+\cos 2A\right)$

$$= \frac{A^2}{2T_P}\int_0^{T_P}\left(1+\cos 2\Omega_0 t\right)dt$$

$$= \frac{A^2}{2T_P}\left[t+\frac{1}{2\Omega_0}\sin 2\Omega_0 t\right]_0^{T_P}$$

$$= \frac{A^2}{2T_P}\left\{\left[T_P-0\right]+\frac{1}{2\Omega_0}\left[\sin 2\Omega_0 T_P-\sin 0\right]\right\}$$

$$P_{(x)} = \frac{A^2}{2T_P}\times T_P = \frac{A^2}{2}$$

The o/p of the A/D convertor is usally mesured by the signal-to-quantization noise ratio (SQNR), which provides the ratio of the signal power to the noise power.

$$SQNR = \frac{P_x}{P_q} = \frac{A^2}{2}\times\frac{3\cdot 2^{2b}}{A^2}$$

$$= \frac{3}{2}\cdot 2^{2b}$$

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Expressed in decibels (dB), the SQNR is

$$SQNR(dB) = 10\log_{10}(SQNR)$$
$$= 10\log_{10}\left(\frac{3}{2}\cdot 2^{2b}\right)$$
$$= 10\log_{10}\frac{3}{2} + 10\log_{10}2^{2b}$$
$$= 1.76 + 2b\log_{10}2$$

$$\boxed{SQNR(dB) = 1.76 + 6.02b}$$

F-07
same
1. 06

Determine the bit rate and the resoluting in the sampling of a seismic signal with dynamic range of 1 volt if the sampling rate is $F_s = 20$ samples/sec and we use an 8 bit A/D converter? what is the maximum frequency that can be present in the resulting digital seismic signal.

Soln:

$$\text{bit rate}\left(\frac{\text{bit}}{\text{second}}\right) = \frac{\text{bit}}{\text{Sample}} \times \frac{\text{Sample}}{\text{sec}}$$
$$= 8 \times 20 = 160 \text{ bps (Ans)}$$

$$\text{Resolution } \Delta = \frac{1\text{ volt}}{2^b - 1} = \frac{1}{\cancel{1024-1}} =$$
$$= \frac{1}{2^8 - 1} = 0.0039 = 0.004 \text{ (Ans)}$$

$$\text{Maximum} = \frac{F_s}{2} = \frac{20}{2} = 10\,Hz \text{ (Ans)}$$

Note: [যদি F_s এর পরিবর্তে 50ms থাকে তাহলে $F_s = \frac{1}{T} = \frac{1}{50\times10^{-3}} = 20$ samples/sec]

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S-07

1(a) A continuous time sinusoid is always periodic regardless of the value of its frequency Ω. But a discret time sinusoide $\cos\omega n$ is periodic only if ω is 2π time some rational number - justify this statment.

.06 S-06

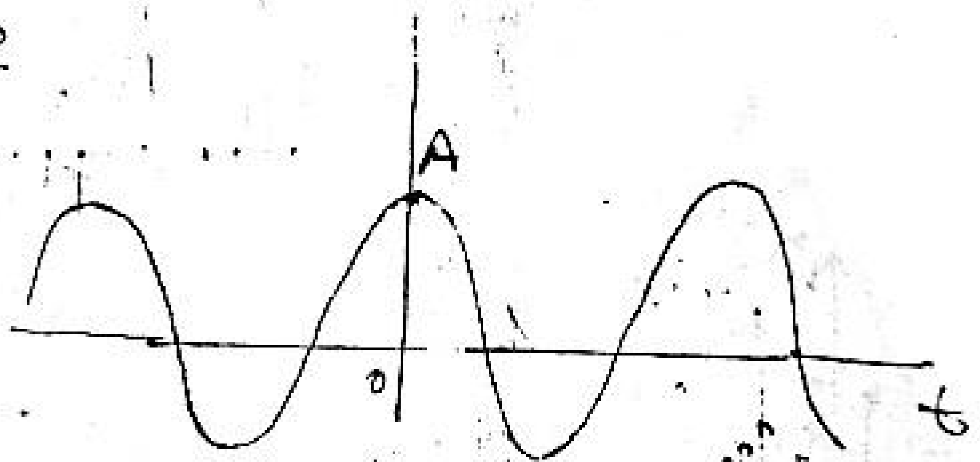
1(a) show that the highest rate of oscillation in a discret time sinusoid is attained when $\omega = \pi$ (or $\omega = -\pi$)

(i) Ans: characteristic of CTS.

$X(t) = A \sin(\Omega t + \theta) \quad -\alpha < t < \alpha$

phase

But $\Omega = 2\pi f$



(i) $X(t)$ is periodic for every fixed value of frequency f.

$x(t + T_p) = X(t)$ the T_p = Time period

and minimum value of T_p in the fundamental period.

(ii) Continuous time sinosoidial signal with distinct (different) frequencies are themselves distinct.

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v.v.i

(ii) Ans: Highest rate of oscillation occurs at $\omega = \pi$ (or $f = \frac{1}{2}$ or $-\frac{1}{2}$) or $\omega = -\pi$

Ans: The sinusoidal signal sequence

$$x(n) = \cos \omega_0 n$$

when the frequency varies from 0 to π, we take the value $\omega_0 = 0, \pi/8, \pi/4, \pi/2, \pi$ and $f = 0, \frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{1}{2}$ and period $N = \infty, 16, 8, 4, 2$ as depicted in Fig-1

So, period decreases and frequency is increases.

we can see the rate of oscillation increases as the frequency increase.

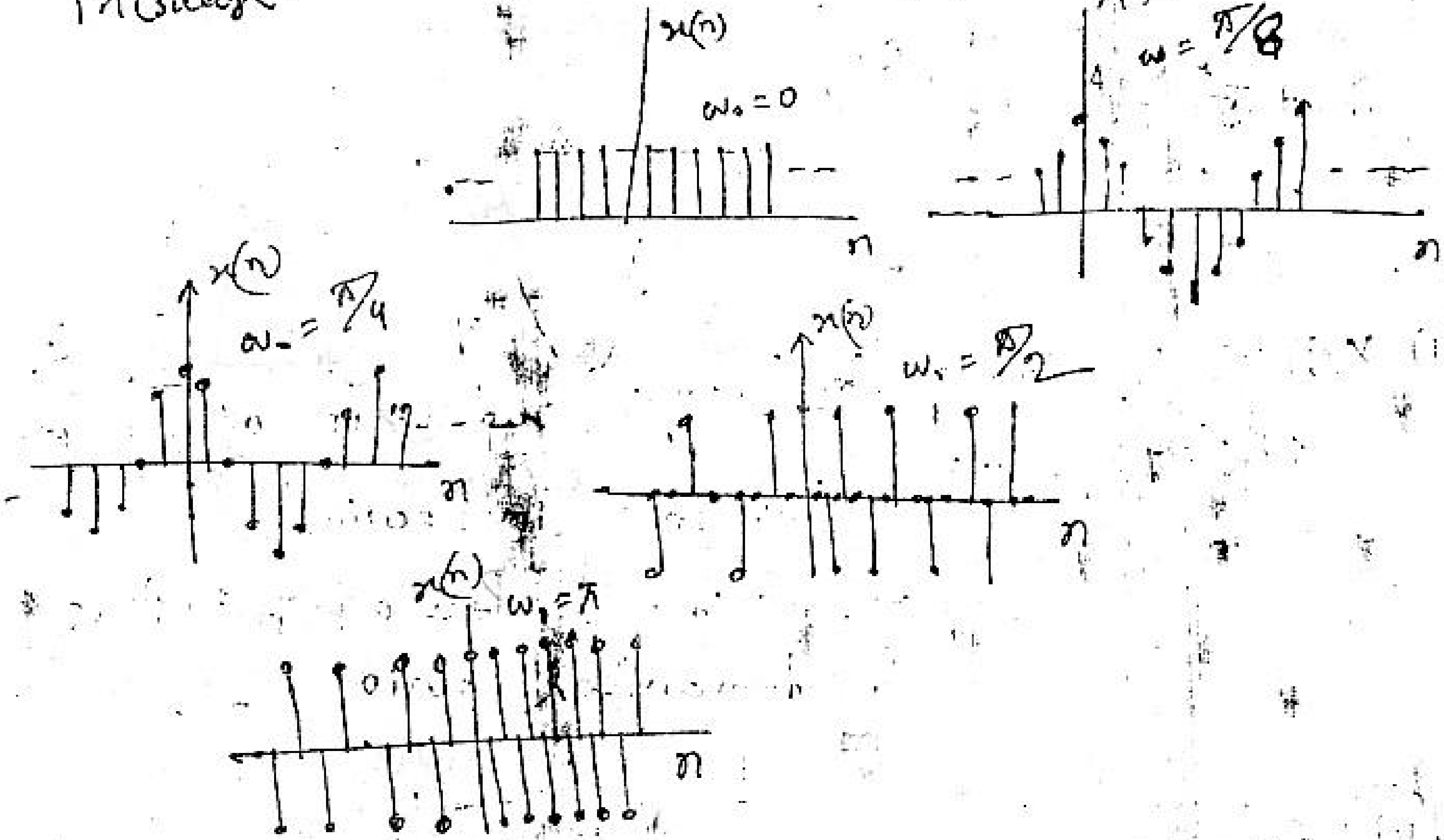

Fig: $x(n) = \cos \omega_0 n$ for various values of the frequency ω_0

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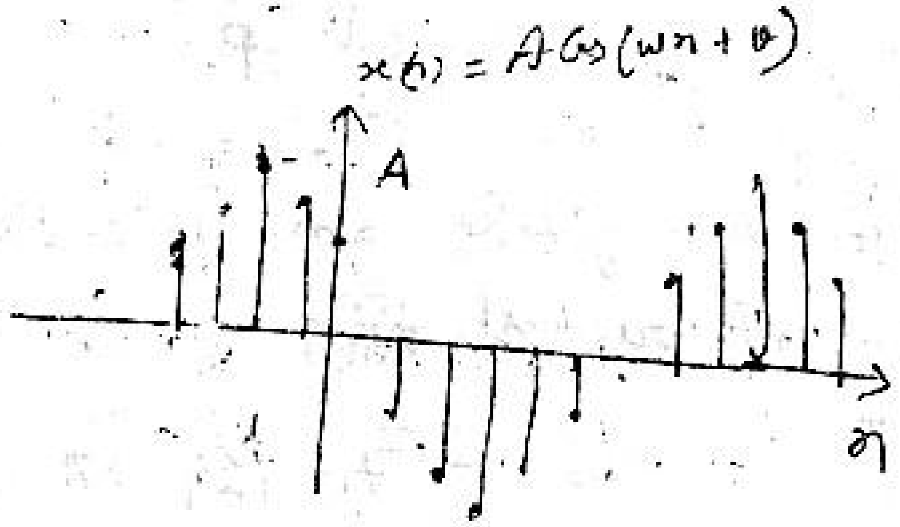
D.T.S. is periodic only if its frequency is a rational no.

Discrete time sinusoidal signal may be write

$$x(n) = A\cos(\omega n + \theta) \qquad -\alpha < n < \alpha$$

But $\omega = 2\pi f$

$$x(n) = A\cos(2\pi f n + \theta) \qquad -\alpha < n < \alpha$$



By D.T.S. $x(n)$ is periodic with period N ($N > 0$) if and only if

$$x(n+N) = x(n) \quad \text{for all } n$$

$$x(n) = A\cos(2\pi f n + \theta) \qquad N - \text{fundu.}$$

$$x(n+N) = A\cos[2\pi f(n+N) + \theta]$$

$$= A\cos(2\pi f n + 2\pi f N + \theta)$$

if $2\pi f N = 2\pi k$ k is the integer number.

$$f = \frac{k}{N}$$

Example: $f_1 = \frac{31}{60}$ fandamental period $N_1 = 60$

$f_2 = \frac{30}{60} = \frac{1}{2}$ "   " $N_2 = 2$

So, (k এর value যখন vary করলে fandamudal frequny সেখানে vary করে)

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5-07

(b) 5-05 stat the advantage of digital over analog signal

Ans: (1) Reconfiguration

2. Accuracy

3. Storage

4. Implimendion of sophisticated Algorithm

5. cheap.

5-07

(c) A digital communication link carrie binary coded words representing samples of an input signal

$$x_a(t) = 7\cos(1400\pi t) + 3\sin(2600\pi t + \pi/2)$$

The link is operated at 20,000 bits/sec and each input Sample is quantized into 1024 different voltage levels. The quantizer covers a range of 10V. Find.

(i) Nyquist rate, (ii) Folding frequency (F_s)

(iii) Discrete time signal $x(n)$

(iv) analog signal $y_a(t)$

(v) Resulation Δ

(vi) average power,

(vii) mean-square error power P_q

(vii) SQNR

(viii) SQNR(in

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Soln:

Given,

$L = 1024$

$x_a(t) = 7\cos(1400\pi t) + 3\sin(2600\pi t + \pi/2)$

$= 7\cos(1400\pi t) + 3\{\sin 2600\pi t \cos\pi/2 + \cos 2600\pi t \sin\pi/2\}$

$x_a(t) = 7\cos(1400\pi t) + 3\cos(2600\pi t)$ —— (1)

(a) $F_1 = \frac{1400}{2} = 700\,Hz$ $F_2 = \frac{2600}{2} = 1300\,Hz$

Thus $F_{max} = 1300\,Hz$

$\boxed{F_s > 2F_{max} = 2600\,Hz}$

The Nyquist Rat is $F_N = 2F_{mx} = 2600\,Hz$

(b) we know,

$L = 2^b$

$1024 = 2^b$

$\log_{10} 1024 = \log_{10}(2^b)$

$b = \frac{\log_{10} 1024}{\log_{10} 2} = 10$ bit/Sample

We know, ~~bit~~ F_s = Sample/sec

$\therefore \frac{bit/sec}{bit/Sample} = \frac{20,000}{10} = 2000$

$\therefore F_s = 2000\,Hz$

c. Folding frequency $= F_s/2 = 2000/2$

$= 1000$ Hz.

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(c) $F_s = 2\,kHz$

We know,
Discrete time signal,

$$x(n) = x_a(nT) = x_a\left(\frac{n}{F_s}\right)$$

$$x(n) = 7\cos 2\pi\left(\frac{7}{2}\right)n + 3\cos 2\pi\left(\frac{13}{2}\right)n$$

$$= 7\cos 2\pi\left(3+\frac{1}{2}\right)n + 3\cos 2\pi\left(6+\frac{1}{2}\right)n$$

$$= 7\cos \pi n + 3\cos \pi n$$

$$x(n) = 10\cos \pi n$$

$f = 1\,Hz$

(d) ~~$y_a(t) = 10\cos 1000\pi t$~~

Analog time signal,

$$y_a(t) = 10\cos \pi F t$$

$$y_a(t) = 10\cos 2000\pi t$$

$F = f F_s$

$= 2000\,Hz$

(e) Resolution $\Delta = \frac{2A}{2^b - 1}$

Another procedure

$\frac{10v}{2^b-1} = 0.00977$

$$= \frac{x_{max} - x_{min}}{2^b - 1}$$

$$= \frac{1300 - 700}{2^{10} - 1} = \frac{600}{1023}$$

$$= 0.586$$

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(f) Avarage power

$$P_{av} = \frac{A^2}{2} = \frac{(10)^2}{2} = 50\ w.$$

Mean square error power,

(g) $$P_q = \frac{A^2/3}{2^{2b}} = \frac{(10)^2/3}{2^{20}} = \frac{(10)^2}{2^{20} * 3} = ~~0.0000000317~~$$

$$= 3.17 * 10^{-5}$$

(H) SQNR/~~S~~NR $= \frac{P_x}{P_q} = \frac{3}{2} \cdot 2^{2b}$

$= ~~15.77 \times 10^6~~ = 1.572 \times 10^6$ (Ans).

(I) SQNR(dB) $= ~~1.76 + 6~~\ 10 \log_{10}(\text{SQNR})$

$= ~~71.97~~$ ~~(Ans)~~ $= 61.97$ (Ans)

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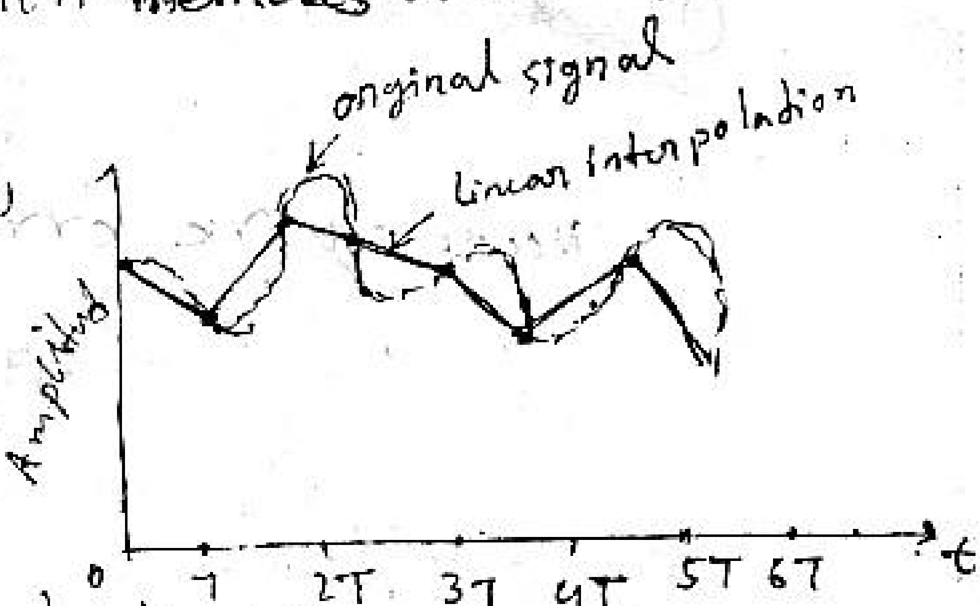
5-06
1 (c) Briefly describe the interpolation methods used in D/A converter.

Ans:

Interpolation as shown in Fig (k) to connect successive samples with straight-line segment.



Better interpolation can be achieved by using more sophisticated higher order interpolation techniques.

In general, suboptimum interpolation techniques result in passing frequencies above the folding frequency. Such frequency components are ~~undesi~~ undesirable and are usually removed by passing the output of the interpolator through a proper analog filter, which is called a postfilter or smoothing filter.