Spring 2017

(Test 1 Sol)

-1

1. What is first order entropy? A binary source has the probabilities $p_1 = 0.2$ and $p_2 = 0.8$. Calculate first order entropy for the source. [10 points]

2. Complete the following matrices:

1	5	9
3	2	4

1:2 up sampling H & V
Based on ZOH
→

1	7
3	6

1:2 up sampling H & V
Based on FOH
→

[20 points]

3. Describe pseudorandom noise quantization (dithering) with a block diagram. What are the advantages of dithering? [10 points]

4. For a uniform quantizer number of levels L = 32. Calculate the number of bits per level and SNR for the quantizer. If the number of output levels is doubled to L = 64 then the SNR will be changed by how many dB (specify increase or decrease) and how the bandwidth will be affected. [10 points]

5. With sketch describe compandor. Is it a uniform or nonuniform quantizer? [10 points]

6. Describe contrast quantization (sketch). What are the advantages? [10 points]

7. Describe what is half tone image generation (sketch)? [10 points]

8. Define and explain clearly with figures:
   a) Uniform Sampling
   b) Non-Uniform sampling
   c) Nyquist Theorem
   d) Aliasing

[20 points]

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1) First order entropy:

It is defined as minimum theoritical bit rate at which a group of 'N' samples can be coded. It is given by

$$\boxed{H(x) = -\sum_{i=1}^{L} P_i \log_2 P_i}$$

P_i = probability of symbol 'i'

L = # of levels.

→ Given

$P_1 = 0.2$, $P_2 = 0.8$

First order entropy $H(x) = -\sum_{i=1}^{2} P_i \log P_i$

$$= -[0.2\log_2 0.2 + 0.8\log_2 0.8]$$

$$= -[-0.464 + (-0.257)]$$

$$= 0.721 \text{ bits/symbol}$$

2)

1	5	9
3	2	4

$\xrightarrow[\text{ZOH}]{1:2 \text{ up sam}}$

1	1	5	5	9	9
1	1	5	5	9	9
3	3	2	2	4	4
3	3	2	2	4	4

1	7
3	6

2x2

$\xrightarrow[\text{Sampling}]{1:2 \text{ up}}$

1	0	7	0
0	0	0	0
3	0	6	0
0	0	0	0

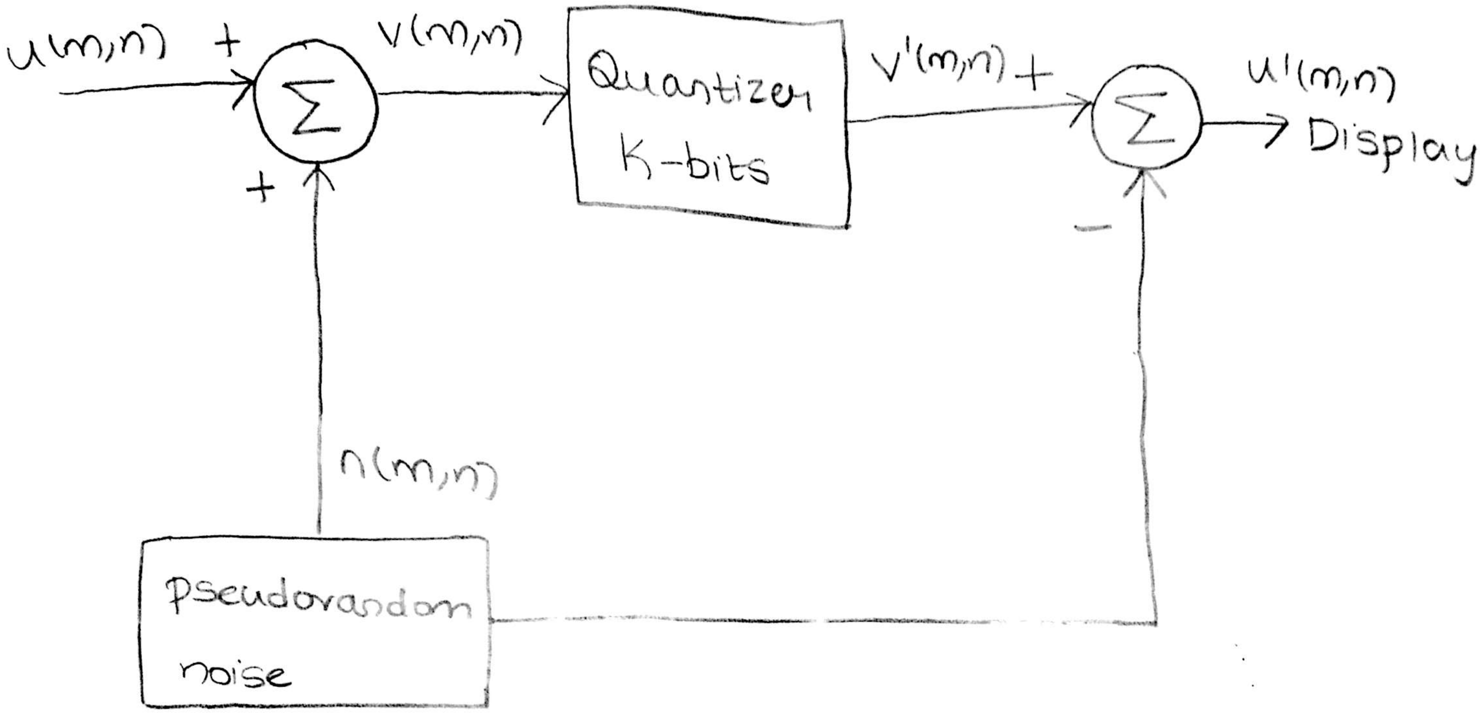
4x4

$\downarrow$ FOH

1	4	7	3.5
2	4.25	6.5	3.25
3	4.5	6	3
1.5	2.25	3	1.5

4x4

3) Pseudorandom noise quantization: (Dithering)



Block diagram

→ To suppress the contouring effects, uniformly distributed pseudorandom noise is added to the input luminance values before quantization.

→ This pseudorandom noise is also called dither.

→ Advantage:

→ Same amount of pseudorandom noise is subtracted from the quantizer output to display the image.

→ The effect is that noise breaks the contours by making pixels go above or below the decision levels.

Few more points:

→ During the display, the noise fills in the regions of contours in such a way that spatial ~~averting~~ averaging is minimized.

→ Amount of noise added should be small enough to maintain the spatial resolution and large enough to allow luminance values to vary randomly.

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4) Given

$L = 32$

To find number of bits?

$L = 2^B = 2^5$

$\therefore$ Number of bits $= 5$

$$SNR = 10\log_{10} L^2$$

$$= 10\log(32^2)$$

$$= \underline{\underline{30.10\,dB}}$$

$\rightarrow$ L is doubled, $L = 64$

$L = 2^B = 2^6$

$\therefore$ Number of bits $= 64$

$$SNR = 10\log_{10} L^2$$

$$= 10\log(64^2)$$

$$= \underline{\underline{36.12\,dB}}$$

$\therefore$ If L is doubled, SNR will <u>increase</u> by roughly 6 <u>dB</u>.

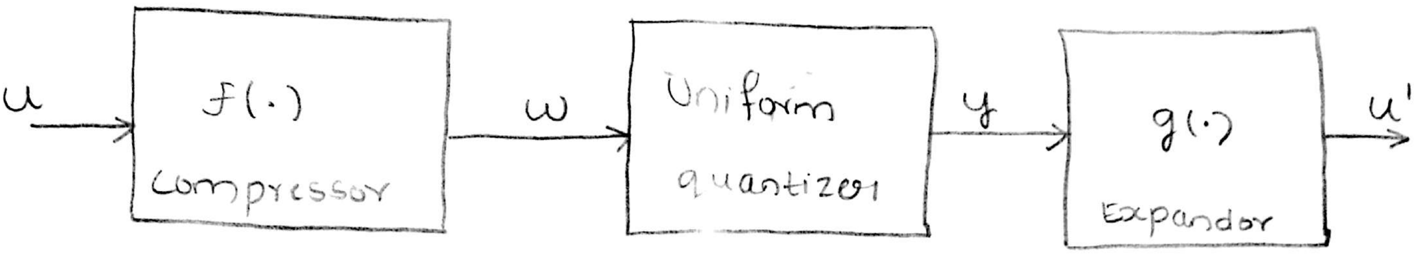
<u>Penalty:</u>

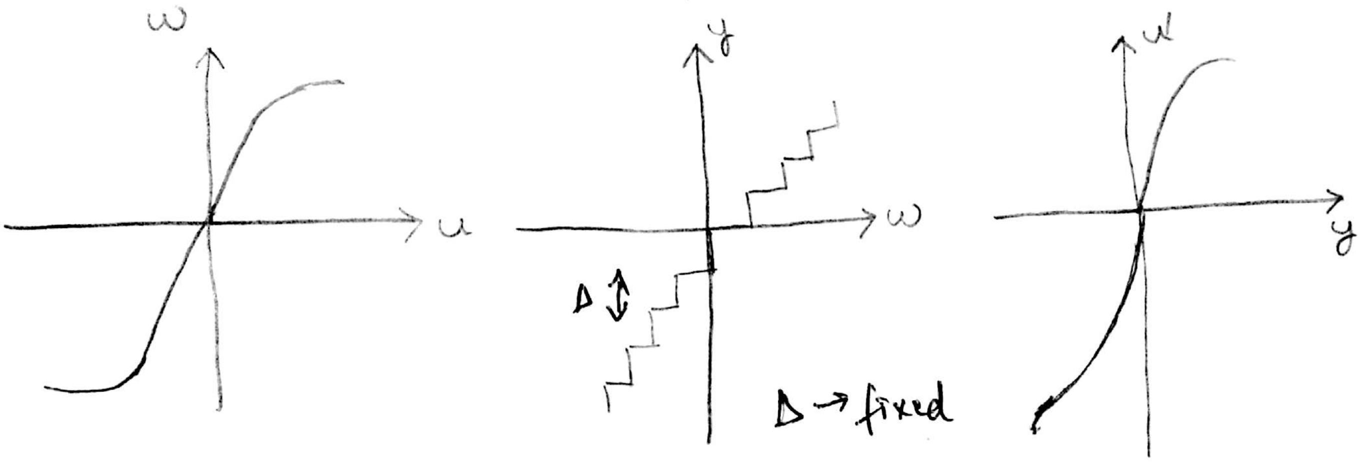
If L <u>increases</u>, then Bandwidth will be $\boxed{\text{doubled}}$.

$\uparrow$ $\uparrow\uparrow$

5) <u>Compandor:</u> (compressor-expandor)

→ Compandor is a uniform quantizer preceded and succeded by a non-linear transformations.





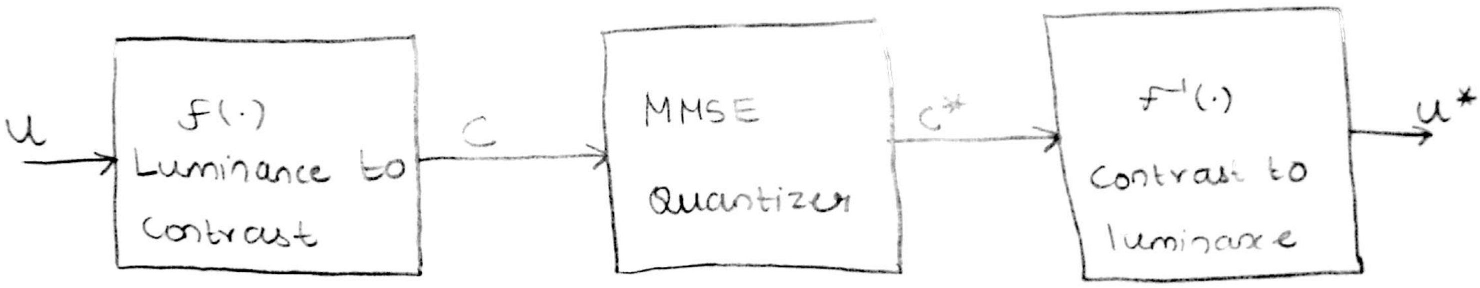
→ First, input luminance value is passed through a non-linear memoryless transformation f(·) to yield output w.

→ 'w' will undergo uniform quantization to yield output y.

→ 'y' is passed through a non-linear transformation to get the output u'

→ The overall transformation from u to u' is $\boxed{\text{nonuniform quantizer}}$.

6) Contrast quantization:



→ In contrast quantization, quantization is performed on contrast values instead of luminance values

→ First, luminance values are converted to contrast using non-linear transformation f(·).

→ contrast values 'c' are passed through a MMSE quantizer

→ Contrast values are given by

$$\boxed{\begin{array}{ll} C = \alpha \ln(1+\beta u) , & 0 \le u \le 1 \\ C = \alpha u^{\beta} & \\ , & \alpha = 1, \ \beta = \frac{1}{3} \end{array}}$$

Suggested values.

→ contrast undergoes quantization using 4 to 5 bpp rather than 6 bpp taken by uniform quantizer.

→ Finally, contrast values are converted to the luminance values using inverse transformation $f^{-1}(\cdot)$.

Advantages:

→ It decreases the contouring effect.

→ Experimental results show 2% increase in the contrast, makes visible to human eye.

7) Half tone image generation:

→ They are binary images used for grayscale rendition

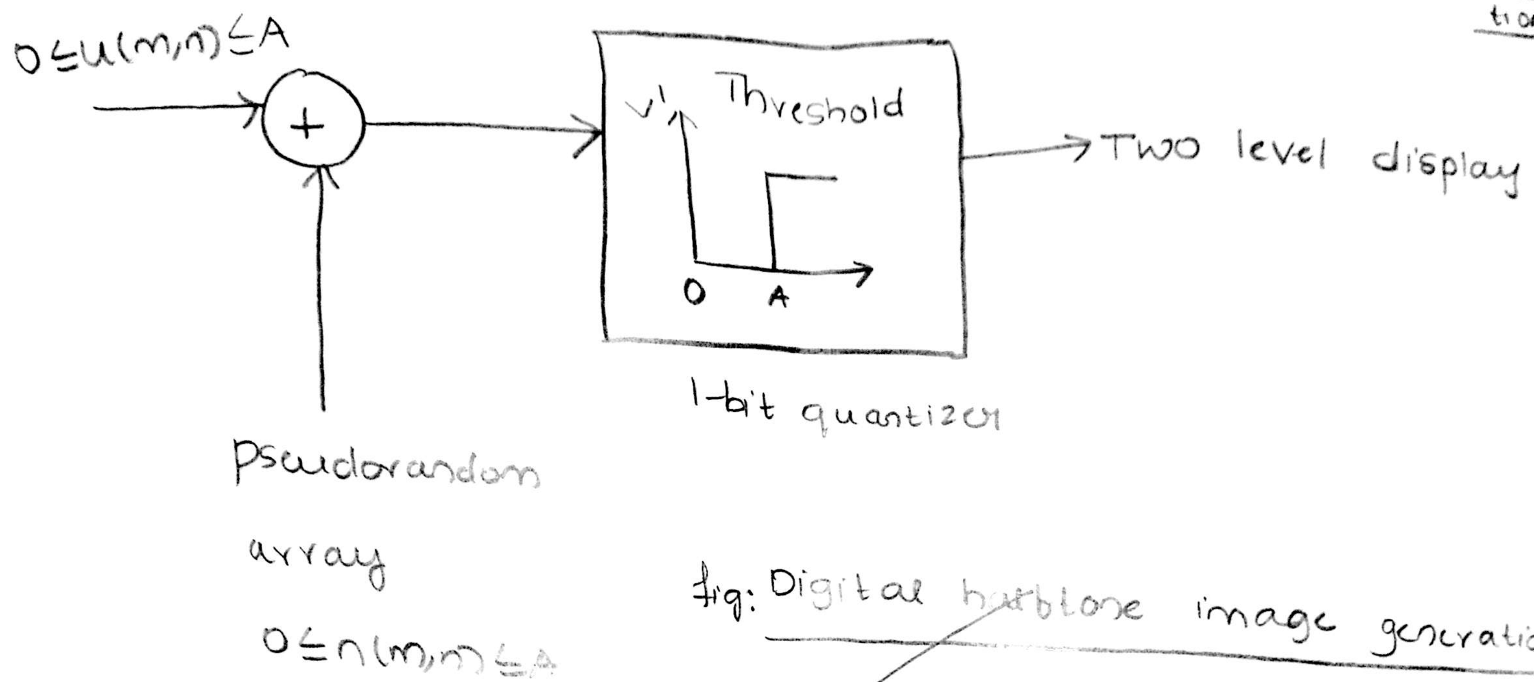


fig: Digital halftone image generation

→ To the input luminance values, random values from pseudorandom array are added.

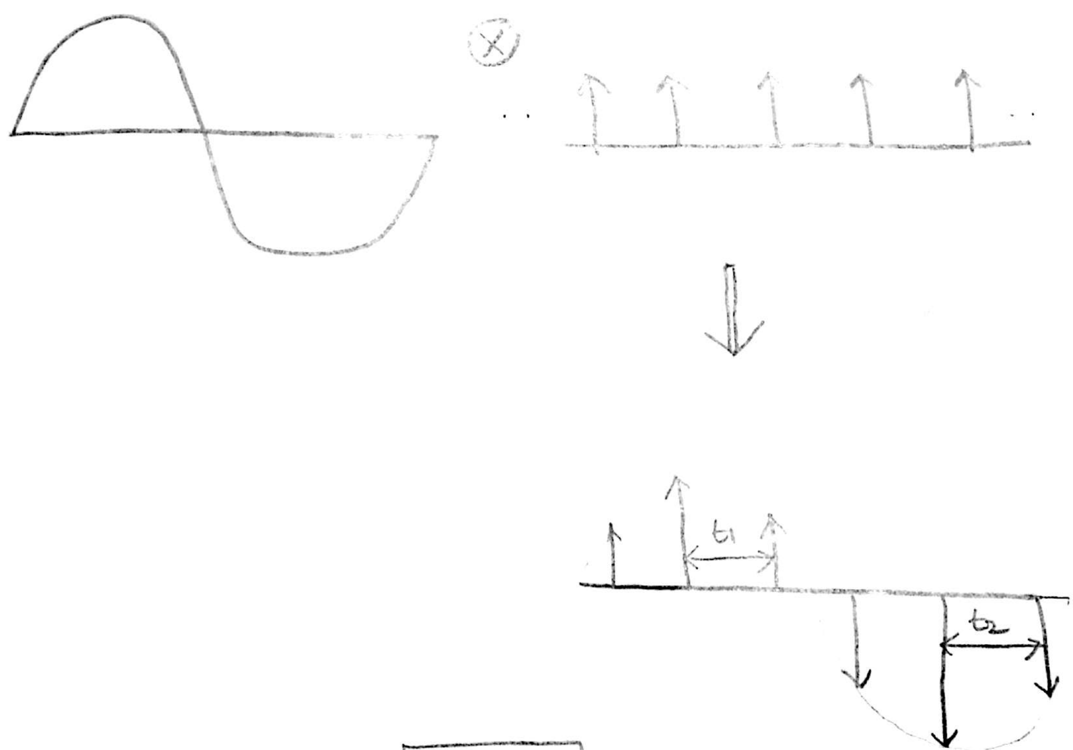
→ The output $v(m,n)$ is sent to a 1-bit quantizer. The output of the quantizer (0/1) represents black or white dot.

→ Halftone image generation in grayscale is due to spatial averaging performed by the eye.

8)

a) <u>Uniform sampling:</u>

→ During sampling, an analog signal is said to be uniformly sampled, if the sampling interval is constant. (between any two samples)

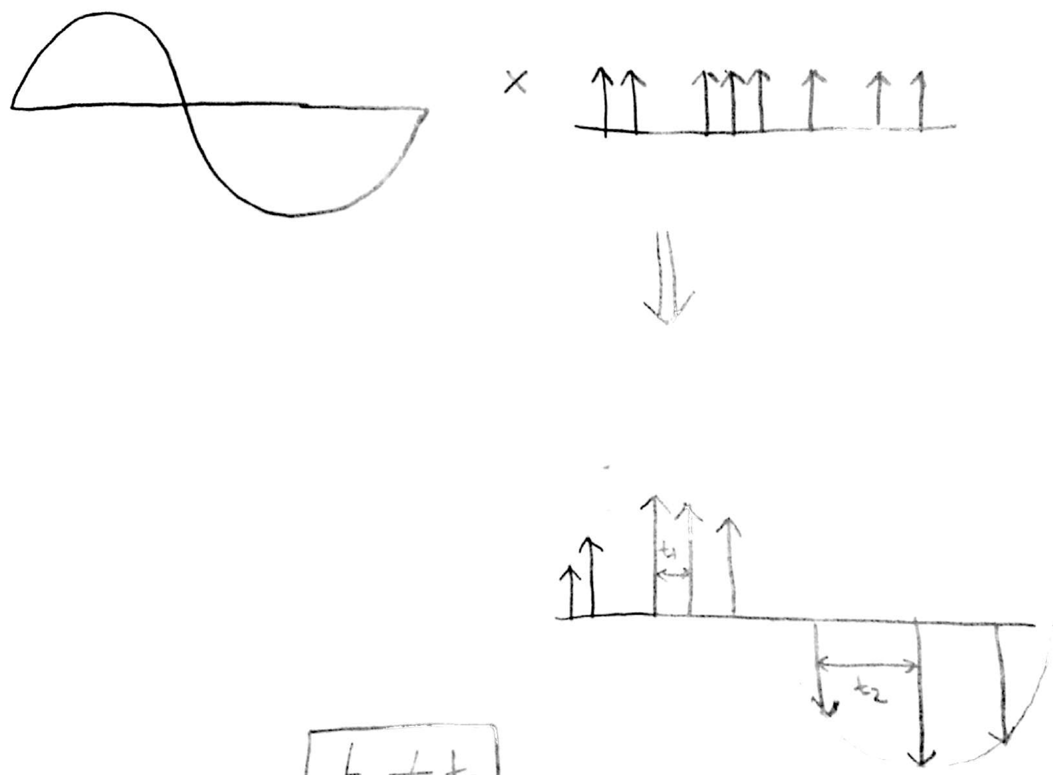


$\boxed{t_1 = t_2}$

b) <u>Non-uniform sampling:</u>

→

→ During sampling, an analog signal is said to be non-uniformly sampled, if the sampling interval is not same between any two samples.



$\boxed{t_1 \neq t_2}$

c) <u>Nyquist theorem:</u>

It states that, an analog signal can be successfully reconstructed from its samples, if it is sampled at a rate equal to or greater than the.

twice the bandwidth of the signal.

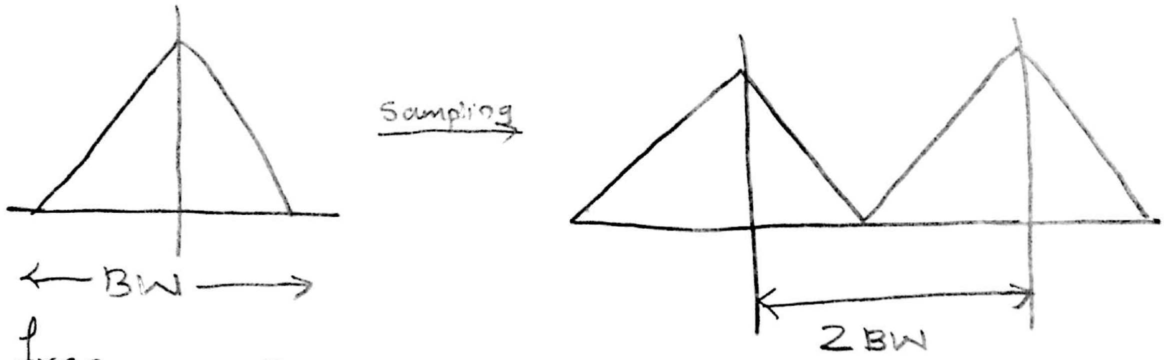
let min freq $= f_{min}$

max freq $= f_{max}$

Bandwidth of the signal $BW = f_{max} - f_{min}$

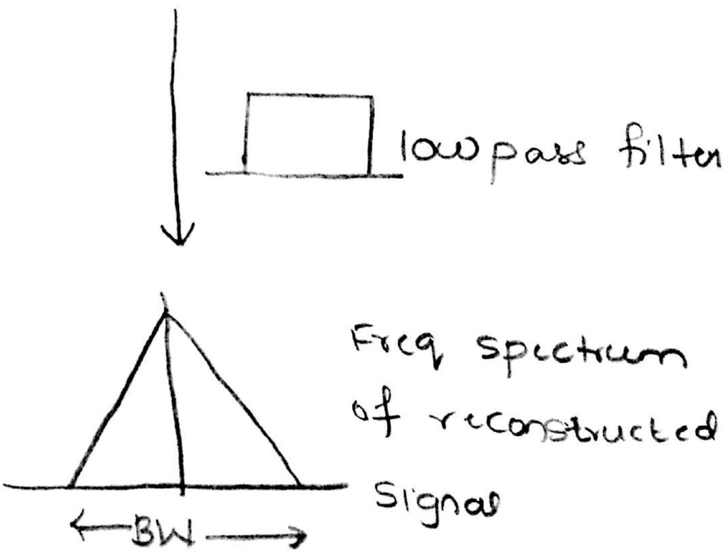
$f_S \geq 2BW$.

let $f_S = 2BW$



frequency spectrum of the signal

frequency spectrum of the sampled signal



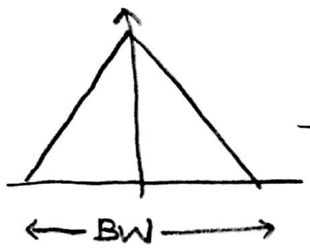
Freq spectrum of reconstructed signal

d). Aliasing:

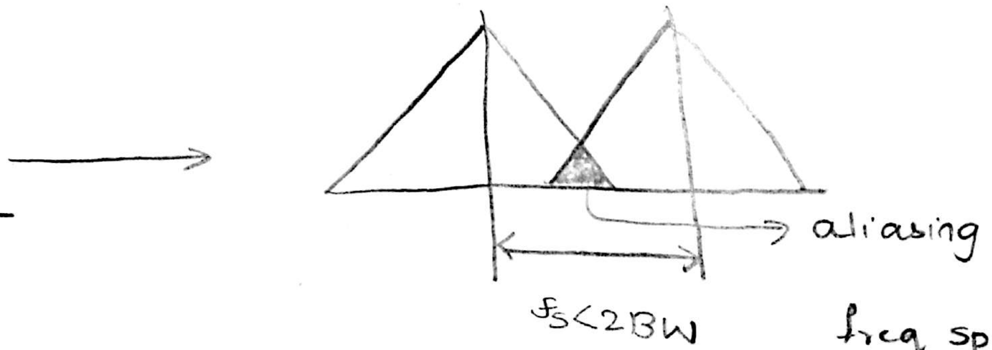
→ If the Nyquist theorem is not followed and $f_s < 2BW$ then the frequency spectrum of Sampled signal looks like overlapping version of the frequency spectrum of the signal.

→ This results in the foldover frequencies.

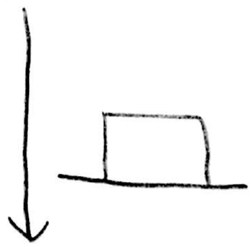
→ This is known as aliasing effect.



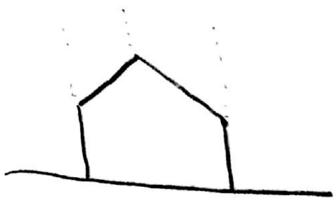
frequency spectrum of the signal



freq spectrum of Sampled signal



low pass filter



freq spectrum of reconstructed signal.

reconstructed signal