CMR
INSTITUTE OF
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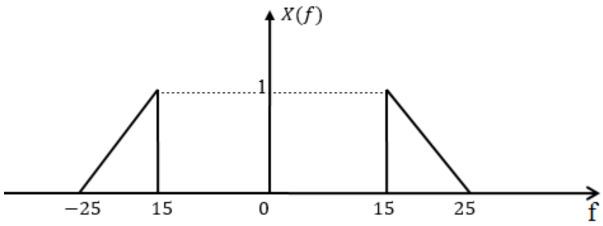
Internal Assesment Test - II

Sub:	DIGITAL COMMUNICATION							Code:	10EC/TE61
Date:	08 / 05 / 2017	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE(D)/TCE(B)
Answer Any FIVE FULL Questions									

		Marks	OBE CO	OBE RBT
1	Explain flat top sampling with necessary waveforms and equations. Discuss aperture effect.	[10]	CO1	L2
2(a)	A bandpass signal $x(t)$ has the spectrum shown in Figure 1. The signal $x(t)$ is sampled at 25 Hz. Draw the spectrum of the resulting signal. Indicate how the original signal can be reconstructed from the sampled signal.  Figure 1.	[05]	CO1	L2
2(b)	Four message signals bandlimited to 3 kHz, 1 kHz, 1 kHz and 1 kHz are to be transmitted over a channel in TDM fashion. Set up a scheme for realizing this requirement. What should be the speed of the commutator? What is the minimum channel bandwidth required?	[05]	CO1	L3
3(a)	A PCM system uses a uniform quantizer followed by an n-bit encoder. Assuming sinusoidal input, show that SQNR $= 1.76 + 6.02n$ dB.	[05]	CO1	L3
3(b)	A compact disc recording system samples each of two stereo signals with a 16 bit analog to digital converter at 44.1 kHz. Determine the output SQNR for a full scale sinusoid. If the CD can record 1 hour music, determine the number of bits recorded on the CD.	[05]	CO1	L3
4	Discuss the need for non-uniform quantizer for speech signals. Explain μ −law and A-law.	[10]	CO1	L1
5	With neat block diagrams and necessary equations, explain DPCM transmitter and receiver system.	[10]	CO1	L2
6	Discuss slope overload distortion and granular noise with respect to delta modulation. Derive an expression for maximum output SQNR of a delta modulator assuming sinusoidal input.	[10]	CO1	L3
7	Assuming equiprobable 0s and 1s, derive an expression for the power spectral density of NRZ unipolar signal.	[10]	CO2	L2
8	Derive Nyquist criterion for distortionless transmission of binary symbols. Arrive at the ideal solution to ISI.	[10]	CO2	L2

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CMR Institute of Technology

Dept. of ECE/TCE

Digital Communication

IAT II.

8/5/2017

Scheme of evaluation

1. $s(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\, h(t - nT_s)$ --- (1)

$S(f) = X_\delta(f)\, H(f)$ --- (3)

$H(f) = T\,\mathrm{sinc}(fT)\, e^{-j\pi f T}$ --- (2)

Aperture effect --- (2)

Equalizer --- (2)

2a Plot of $X_\delta(f)$ --- (5)

2b Commutator setup --- (3)

Speed of commutator --- (1)

Bandwidth calculation --- (1)

3a Signal power --- (1)

Quantization noise power --- (1)

SQNR --- (3)

3b $R_b = nf_s$ --- (2)

Capacity of CD --- (3)

4 Need for non-uniform quantizer --- (2)

A-law --- (4)

μ-law --- (4)

5 Block diagram of transmitter --- (2)

Related Equations --- (2)

Description of blocks --- (4)

Block diagram of receiver --- (2)

6 Slope overload distortion --- (3)

Granular noise --- (3)

SQNR of delta modulator --- (4)

7 $H(f) = T\,\mathrm{sinc}(fT)$ --- (2)

$$R_A(n) = \begin{cases} \frac{a^2}{2} & ; \; n=0 \\ \frac{a^2}{4} & , \; n \neq 0 \end{cases}$$ --- (3)

$$S(f) = \frac{a^2}{4} T_b \,\mathrm{sinc}^2(fT_b) + \frac{a^2}{4}\delta(f)$$ --- (5)

8 Block diagram of PAM system --- (3)

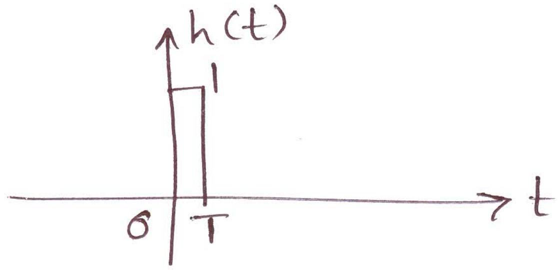
Condition for zero ISI --- (4)

Ideal solution to ISI --- (3)

Solutions

1

$$s(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\, h(t - nT_s)$$



$$s(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\, \delta(t - nT_s) * h(t)$$

$$= x_\delta(t) * h(t)$$

$$\therefore S(f) = X_\delta(f)\, H(f)$$

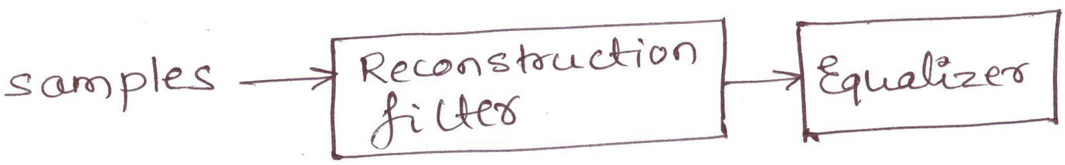
$$= f_s \sum_{k=-\infty}^{\infty} X(f - kf_s)\, T\, \text{sinc}(fT)\, e^{-j\pi f T}$$

$T\,\text{sinc}(fT)$ introduces amplitude distortion.

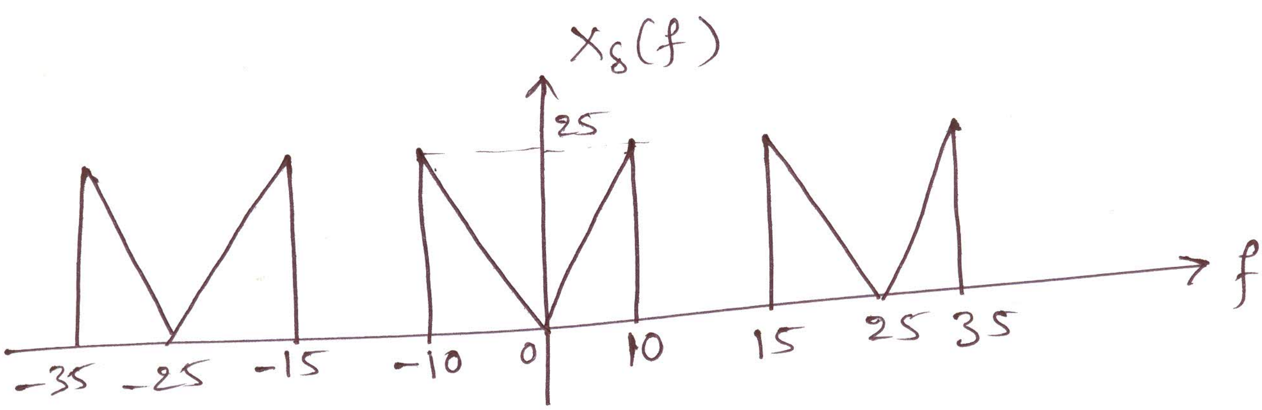
$e^{-j\pi f T}$ introduces delay of $T/2$.

This is called aperture effect.

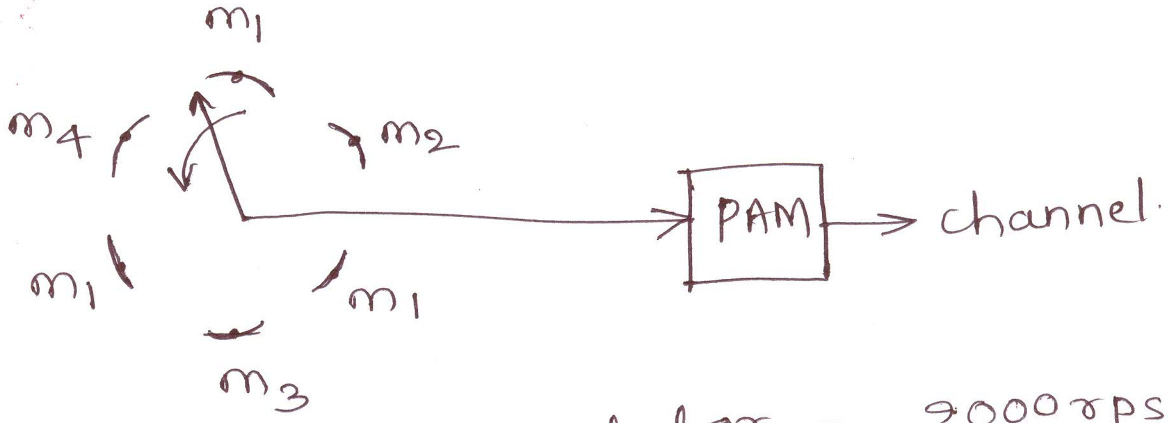
Solution: Equalizer



2a.



2b.



Speed of the commutator = 2000 rps.

BW required = 6 KHz

3a $P = \frac{a^2}{2}$

$$\sigma^2 = \frac{\Delta^2}{12}$$

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

$$\simeq \frac{a}{2^{n-1}}$$

$$\Delta^2 = \frac{a^2 4}{2^{2n}}$$

$$\frac{\Delta^2}{12} = \frac{a^2}{3 2^{2n}}$$

$$\therefore SQNR = \frac{a^2}{2} \div \frac{a^2}{3 2^{2n}}$$

$$= \frac{3}{2} 2^{2n}$$

SQNR in dB = $1.76 + 6.02n$

3b SQNR = $1.76 + 6 \times 16 = 97.76$ dB.

No. of bits = $44.1 \times 10^3 \times 16 \times 2 \times 3600$

= 635 MB.

3/6

4 1. To keep SQNR constant irrespective of input signal power

2. To increase the accuracy of A2D conversion without increasing the bit rate.

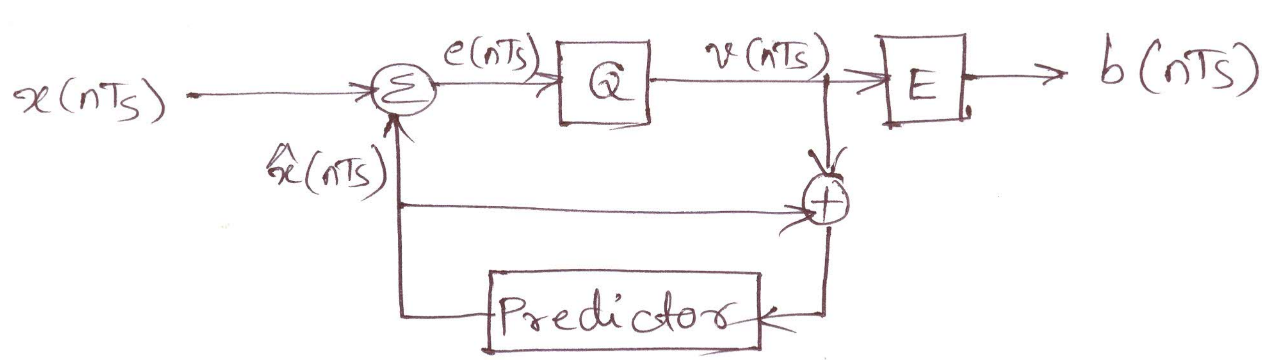
μ-law

$$\frac{c(|x|)}{x_{max}} = \frac{\ln\left(1+\mu\frac{|x|}{x_{max}}\right)}{\ln(1+\mu)}, \quad 0 \le \frac{|x|}{x_{max}} \le 1$$

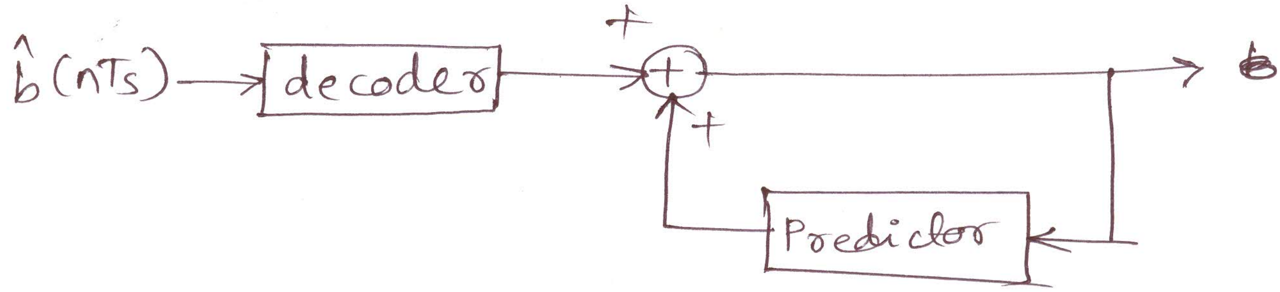
A-law

$$\frac{c(|x|)}{x_{max}} = \begin{cases} \dfrac{\left(\dfrac{A|x|}{x_{max}}\right)}{1+\ln(A)}, & 0 \le \dfrac{|x|}{x_{max}} \le \dfrac{1}{A} \\[2ex] \dfrac{1+\ln\left(\dfrac{A|x|}{x_{max}}\right)}{1+\ln(A)}, & \dfrac{1}{A} \le \dfrac{|x|}{x_{max}} \le 1. \end{cases}$$

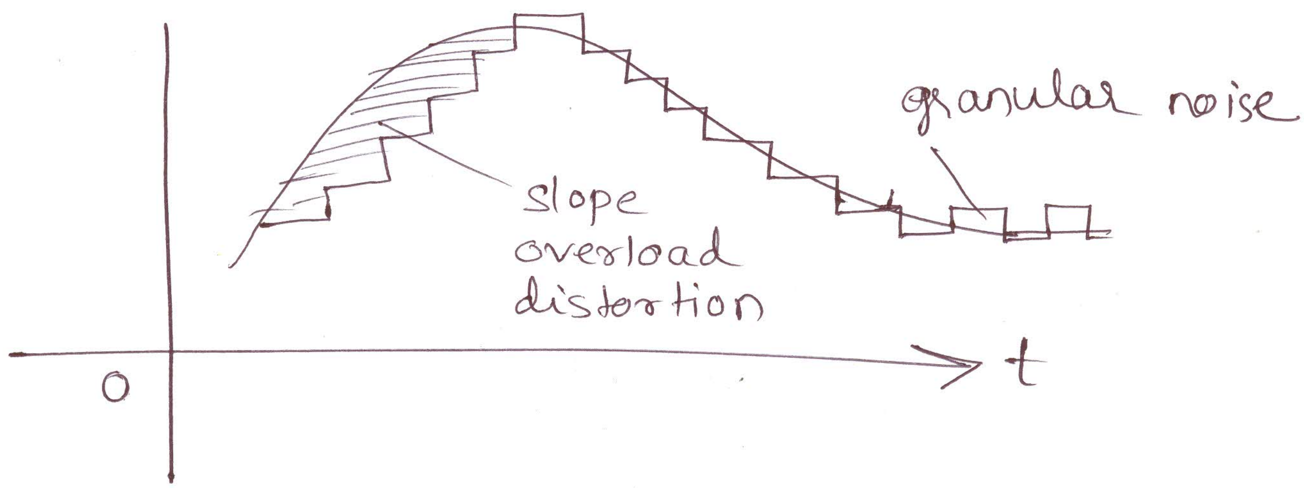
5 DPCM Transmitter



DPCM Receiver



6



$$x(t) = a\cos(2\pi f_0 t)$$

$$\left|\frac{d(x(t))}{dt}\right|_{max} = a_0 2\pi f_0$$

$$\frac{\delta}{T_s} \geq 2\pi f_0 a_0$$

$$\therefore a_0 \leq \frac{\delta}{2\pi f_0 T_s}$$

$$P_{max} = \frac{a^2}{2}$$

$$= \frac{\delta^2}{8\pi^2 f_0^2 T_s^2}$$

$$\sigma_Q^2 = \frac{\Delta^2}{12} = \frac{\delta^2}{3}$$

After filtering,

$$SQNR = \frac{3 f_s^3}{8\pi^2 f_0^2 W}.$$

7.

$$R_A(n) = E[A_K A_{K-n}]$$

$$R_A(0) = E[A_K^2]$$

$$= \frac{1}{2} 0^2 + \frac{1}{2} a^2$$

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

$$R_A(n) = E[A_K A_{K-n}]$$

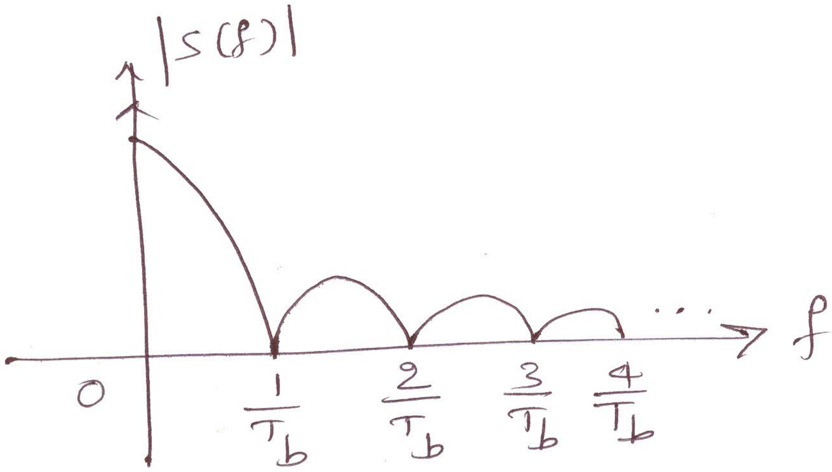
$n \neq 0$

$$= \frac{a^2}{4}$$

$$V(f) = T_b \operatorname{sinc}(f T_b)$$

$$S(f) = \frac{1}{T_b} |V(f)|^2 \sum_{n=-\infty}^{\infty} R_A(n) e^{-j2\pi f n T_b}$$

$$= \frac{a^2}{4} T_b \operatorname{sinc}^2(f T_b) + \frac{a^2}{4} \delta(f)$$



8 $$x(t) = \sum_{k=-\infty}^{\infty} a_k v(t-kT_b)$$

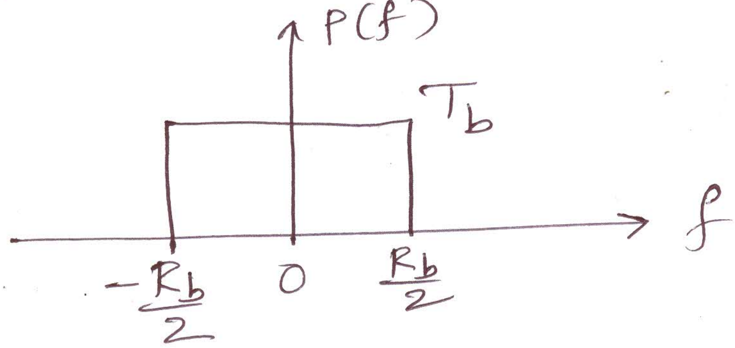
$$y(t) = \mu \sum_{k=-\infty}^{\infty} a_k p(t-kT_b)$$

$$y(iT_b) = \mu \sum_{k=-\infty}^{\infty} a_k p(iT_b-kT_b)$$

For zero ISI,

$$p(iT_b-kT_b) = \begin{cases} 1, & i=k \\ 0, & i\neq k \end{cases}$$

$$\sum_{n=-\infty}^{\infty} P(f-nR_b) = T_b$$



$$p(t) = \text{sinc}(R_b t)$$