ACE Engineering Academy
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ESE – 2019 MAINS
OFFLINE TEST SERIES

ELECTRONICS & TELECOMMUNICATION ENGINEERING (E&T)

TEST – 4
SOLUTIONS

All Queries related to **ESE – 2019 MAINS Test Series** Solutions are to be sent to the following email address
testseries@aceenggacademy.com | **Contact Us : 040 – 48539866 / 040 – 40136222**

01. (a)

Sol: **i)** Let f represent the system failure. Then

$$P(\bar{f}) = (1-0.01)^{10} = 0.90438$$

$$P(f) = 1 - P(\bar{f}) = 0.0956$$

ii) $P(\bar{f}) = 0.99$ and $p(f) = 0.01$

If the probability of failure of a subsystem S_1 is P, then

$$P(\bar{f}) = (1-P)^{10}$$

$$0.99 = (1 - P)^{10}$$

$$P = 0.0010045$$

01. (b)

Sol: **Key generation**

1. Choose two large prime numbers p and q
2. Calculate $n = p\times q$ and $\varnothing(n) = (p-1) \times (q-1)$
3. Choose public key e, where $1< e< \varnothing(n)$ and GCD $(\varnothing(n), e) =1$
4. Calculate private key d, where $e\times d = \text{mod}\ (\varnothing(n))$

Encryption and Decryption:

Public key = (e, n), Private key = (d, n)

Plain text (message) = M, Cipher text = C

Encryption = E, Decryption = D

Encryption:

$$C = E_{(e,\ n)}\ (M)$$

$$C = (M^e) \bmod n$$

Decryption:

$$M = D_{(d,\ n)}\ (C)$$

$$M = (C^d) \bmod n$$

01. (c)

Sol: **i)** N = 1 pulse occurs in $T_o = 0.3452$ ms

$$\text{Baud rate} = (D) = \frac{N}{T_o} = \frac{1}{0.3472\times 10^{-3}} = 2880\ \text{baud}$$

ii) $L = 32 = 2^{\ell} \Rightarrow \ell = 5$

$$R = \ell D = 5\times 2880 = 14{,}400\ \text{bits / S}$$

iii) $B_{null} = \dfrac{R}{\ell} = 2880\ \text{Hz}$

iv) For the unipolar NRZ line code,

There are N = 5 pulses in $T_o = 0.3472$ ms

$$D = \frac{5}{0.3472\times 10^{-3}} = 14400\ \text{baud}$$

R = D because the unipolar NRZ line code is binary thus R = 14,400 bits/S

The Null bandwidth $B_{null} = \dfrac{R}{\ell}$ = 14,400 Hz

01. (d)

Sol: **(i)** For (18,7) code to correct up to 3 errors

$$2^{n-k} \geq \sum_{i=0}^{3} {}^{n}c_i \quad \text{(Hamming bound for correcting 3 errors)}$$

$$2^{18-7} \geq \sum_{i=0}^{3} {}^{18}c_i$$

$$2^{11} \geq {}^{18}c_0 + {}^{18}c_1 + {}^{18}c_2 + {}^{18}c_3$$

$$2^{11} \geq 1 + 18 + 153 + 816$$

$$2048 \geq 988$$

$\therefore$ there exists a possibility of 3 error correcting (18,7) code.

(ii) 1. Power required to achieve the desired SNR ratio.
2. Bandwidth of the channel
3. Amplitude and phase response of channel
4. Type of channel (linear or non-linear)
5. Effects of external interference on the channel.

01. (e)

Sol: $P_r = \text{EIRP} + G_r - P_L$ (dBw)

Where,

$\text{EIRP} = 10\log(P_tG_t)$

$$P_L = 20\log\left(\frac{4\pi R}{\lambda}\right)$$

$\text{EIRP} = 10\log(5) + 16$

$\text{EIRP} = 23\text{dB}$

$$\lambda = \frac{C}{f} = \frac{3\times10^8}{11\times10^9}$$

$\lambda = 0.0273\text{m}$

$$P_L = 20\log\left(\frac{4\pi\times3.6\times10^7}{0.0273}\right)$$

$P_L = 204.38\text{dB}$

$P_r = \text{EIRP} + G_r - L_P$

$= 23 + 45 - 204.38$

$P_r = -136.38\text{dBw}$

$10\log P_r = -136.38$

$P_r = 10^{-13.638}$

$P_r = 2.3\times10^{-14}\text{W}$

02. (a)

Sol: **i)** $R_{xy}(\tau) = E[X(t+\tau)\,Y(t)]$

Replacing τ with "$-\tau$":

$R_{xy}(-\tau) = E[X(t-\tau)\,Y(t)]$

Now, replace $t - \tau$ with z, we get

$R_{xy}(-\tau) = E[X(z)\,Y(z+\tau)]$

$= R_{yx}(\tau)$

ii) Form the non-negative quantity

$$E[\{X(t+\tau) \pm Y(t)\}^2] = E[X^2(t+\tau) \pm 2\,X(t+\tau)\,Y(t) + Y^2(t)]$$

$$E[X^2(t+\tau)] \pm 2E[X(t+\tau)\,Y(t)] + E\,[Y^2(t)] = R_x(0) \pm 2R_{xy}(\tau) + R_y(0)$$

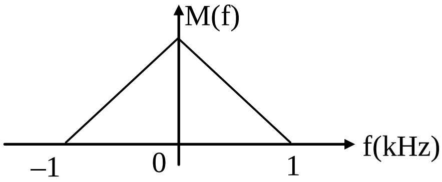
Hence : $R_x(0) \pm 2R_{xy}(\tau) + R_y(0) \geq 0$

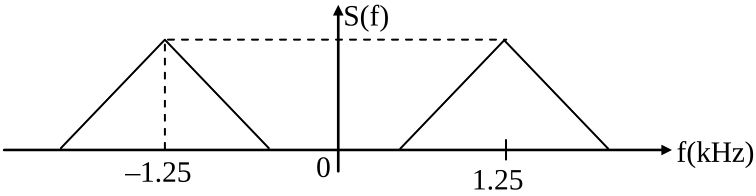
$\Rightarrow |R_{xy}(\tau)| \leq \frac{1}{2}\,[R_x(0) + R_y(0)]$

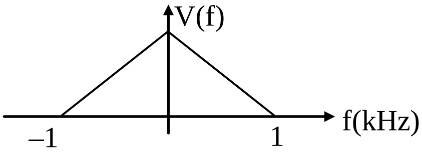
02. (b)

Sol:

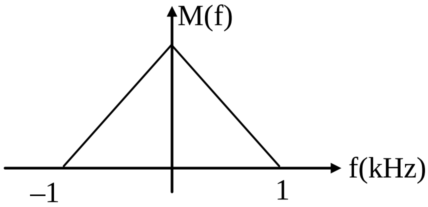
(i) For f_c = 1.25kHz, the spectra of the message signal m(t), the product modulator output S(t), and the coherent detector output V(t) are as follows, respectively:

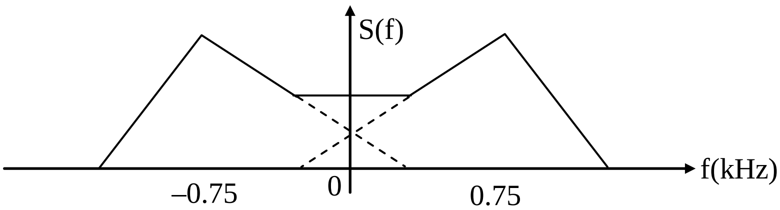


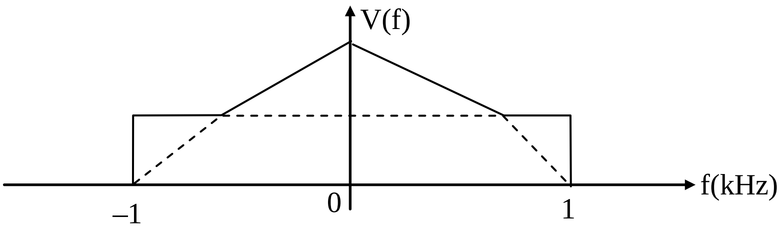




(ii) For the case when f_c = 0.75, the respective spectra are as follows







To avoid sideband overlap, the carrier frequency f_c must be greater than or equal to 1kHz. The lowest carrier frequency is therefore 1kHz for each sideband of the modulated wave S(t) to be uniquely determined by m(t)

02. (c)

Sol: Optical fibre cables:-

i) Definition and construction:

Optical fiber consists of an inner glass core surrounded by a glass cladding which has a lower refractive index. Digital signals are transmitted in the form of intensity modulated light signal which is trapped in the glass code.

Light launched into the fiber using a light source such as a LED or laser. It is detected on the other side using a phototransistor.

ii) Special characteristics:

1) Higher bandwidth, so can operate at higher data rates
2) Reduced losses as the signal attenuation is low
3) Distortion is reduced hence better quality is assured
4) They are immune to electromagnetic interferences
5) Small size and light weight
6) used for point-to-point communication

iii) Applications:

1) Optical fiber transmission systems are widely used in the backbone of networks. Current optical fiber systems provide transmission rates from 45 Mb/s to 9.6 Gb/s using a single wavelength transmission.
2) The installation cost of optical fibres is higher than that for the co-axial or twisted wire cables
3) In the local area networks (LANs)
4) Optical fibers are now used in the telephone systems

iv) Advantages of optical fibers:

1) Small size and light weight: The size (diameter) of the optical fibers is very small. So, a large number of optical fibers can fit into a cable of small diameter
2) Easy availability and low cost: The material used for the manufacturing of optical fibers is silica glass. This material is easily available. Hence optical fibers cost lower than the cables with metallic conductors.
3) No electrical or electromagnetic interference: since transmission takes place in the form of light rays the signal is not affected due to any electrical or EM interference.
4) Large BW:
5) No crosstalk inside the optical fiber cable
6) signal can be transmitted up to 100 times faster
7) intermediate amplifiers are not required
8) Ground loops are absent
9) not affected by the drastic environmental conditions.

v) Drawbacks:

1) Sophisticated plants are required for manufacturing fibers
2) The initial cost incurred is high
3) Joining the optical fibers is a difficult job

02. (d)

Sol:

(i) Half-power bandwidth is the bandwidth from half-power point to half-power point. BW=2f_0

Where

$$\frac{1}{2}=\left[\frac{\sin(\pi f_0 10^{-4})}{\pi f_0 10^{-4}}\right]^2$$

$$0.707=\frac{\sin X_0}{X_0}, \quad X_0 = \pi f_0\, 10^{-4}$$

$X_0 \cong 1.4 \Rightarrow f_0 = 4.46$ kHz $\Rightarrow$ BW $\cong$ 9 kHz

(ii) Null-to-null bandwidth: BW = 2f_0

where f_0 is the frequency where $\frac{\sin(\pi f_0 10^{-4})}{\pi f_0 10^{-4}}=0$

The minimum f_0 corresponding to the first null is found by:

$$\pi f_0 10^{-4} = \pi$$

$$f_0 = 1\text{kHz}$$

$$\text{BW} = 2f_0 = 20\text{kHz}$$

02. (e)

Sol: As the network is linear, output voltage y(t) can be expressed as,

$y(t) = y_1(t) + y_2(t)$

where $y_1(t)$ is output from input $x_1(t)$ [assuming $x_2(t) = 0$] and $y_2(t)$ is output from input $x_2(t)$ [assuming $x_1(t) = 0$]

Transfer functions relating y(t) to $x_1(t)$ and y(t) to $x_2(t)$ are $H_1(\omega)$ & $H_2(\omega)$.

$$H_1(w)=\frac{1}{3(3jw+1)} \qquad H_2(w)=\frac{1}{2(3jw+1)}$$

Hence,

$$S_{y_1}(w)=|H_1(w)|^2 S_{x_1}(w)=\frac{K}{9(9w^2+1)}$$

and

$$S_{y_2}(w)=|H_2(w)|^2 S_{x_2}(w)=\frac{\alpha}{2(9w^2+1)(\alpha^2+w^2)}$$

As input processes are independent, the output processes generated are also independent.

$$\therefore S_y(w)=S_{y_1}(w)+S_{y_2}(w)$$

$$=\frac{2k(\alpha^2+w^2)+9\alpha}{18(9w^2+1)(\alpha^2+w^2)}$$

The power p_y can be determined by: taking inverse Fourier transforms of $S_{y_1}(w)$ & $S_{y_2}(w)$ as

$$\underset{(\text{auto correlation of } y(t))}{R_y(t)} = \underbrace{\frac{k}{54}e^{-|\tau|/3}}_{R_{y1}(\tau)} + \underbrace{\frac{3\alpha e^{-|\tau|/3}-e^{-\alpha|\tau|}}{4(9\alpha^2-1)}}_{R_{y2}(\tau)} \quad \left[\because \frac{2\alpha}{\alpha^2+w^2} \xleftrightarrow{FT} e^{-\alpha|\tau|}\right]$$

and $p_y = R_y(0)=\frac{k}{54}+\frac{3\alpha-1}{4(9\alpha^2-1)}$

03. (a)

Sol:

(i) 1) The bandwidth required for the transmission of a PAM signal is very large in comparison to the maximum frequency present in the modulated signal.

2) Since the amplitude of the PAM pulses varies in accordance with the modulating signal, therefore the interference of noise is maximum in a PAM signal. This noise cannot be removed easily.

3) Since the amplitude of the PAM signal varies, therefore, this also varies the peak power required by the transmitter with modulating signal.

(ii)

1) Less effect of noise i.e., very good noise immunity

2) Synchronization between the transmitter and receiver is not essential. (which is essential in PPM)

3) It is possible to reconstruct the PPM signal from a noise, contaminated PWM. Thus, it is possible to separate out signal from noise (which is not possible in PAM).

(iii) 1) Due to variable pulse width, the pulses have variable power contents. Hence, the transmission must variable power contents. Hence, the transmission must be powerful enough to handle the maximum width, Pulse, though the average power transmitted can be as low as 50% of this maximum power.

2) In order to avoid any waveform direction, the bandwidth required for the PWM communication is large as compared to bandwidth of PAM.

(iv) 1) Due to constant amplitude of PPM pulses, the information is not contained in the amplitude. Hence, the noise added to PPM signal does not distort the information. Thus, it has good noise immunity.

2) It is possible to reconstruct PPM signal from the noise contaminated PPM signal. This is also possible in PWM but not possible in PAM.

3) Due to constant amplitude of pulses, the transmitted power remains constant. It does not change as it used to, in PWM.

(v) 1) As the position of the PPM pulses is varied with respect to a reference pulse, a transmitter has to send synchronizing pulses to operate the timing circuits in the receiver. Without them, the demodulation would not be possible to achieve.

2) Large bandwidth is required to ensure transmission of undistorted pulses.

03. (b)

Sol:

(i) c = mG

messages	code vectors
0 0 0 0	0 0 0 0 0 0 0
0 0 0 1	1 1 0 0 0 0 1
0 0 1 0	0 1 1 0 0 1 0
0 0 1 1	1 0 1 0 0 1 1
0 1 0 0	1 0 1 0 1 0 0
0 1 0 1	0 1 1 0 1 0 1
0 1 1 0	1 1 0 0 1 1 0
0 1 1 1	0 0 0 0 1 1 1
1 0 0 0	1 1 1 1 0 0 0
1 0 0 1	0 0 1 1 0 0 1

1 0 1 0	1 0 0 1 0 1 0
1 0 1 1	0 1 0 1 0 1 1
1 1 0 0	0 1 0 1 1 0 0
1 1 0 1	1 0 0 1 1 0 1
1 1 1 0	0 0 1 1 1 1 0
1 1 1 1	1 1 1 1 1 1 1

(ii) $H = \left[I_{m-k} \vdots P^T\right] = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$

(iii) $s = r\,H^T = \begin{bmatrix} 1 & 1 & 0 & 1 & 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}$

Thus, 1101101 is not a valid codeword

(iv) d_{min} = minimum weight = 3

$t = \dfrac{d_{min} - 1}{2} = 1$

(v) $m = d_{min} - 1 = 2$

03. (c)

Sol: We know that fade margin (F_m)

$F_m = 30 \log D + 10\log(6ABf) - 10\log(1 - R) - 70$

where D – distance (km)

A = roughness factor

= 4 for over water or smooth terrain

B = factor to convert worst month probability to an annual probability

= 0.5 for humid areas

f = frequency (GHz)

R = Reliability

$F_m = 30 \log(40) + 10\log(6\times4\times0.5\times1.8) - 10\log(1 - 0.999) - 70$

$= 48.06 + 13.34 - (-40) - 70$

$= 48.06 + 13.34 + 40 - 70$

$F_m = 31.4$ dB

Path loss $P_L = 92.4 + 20\log(f_{GHz}) + 20\log D$

$= 92.4 + 20\log(1.8) + 20\log(40)$

$= 92.4 + 5.11 + 32.04$

$P_L = 129.55$ dB

For air filled coaxial cable, at f = 1.8 GHz

Branching loss L_p = 4 dB (2 + 2)

Feeder loss L_f = 10.8 dB (5.4 + 5.4)

Antenna gain $A_t = A_r$ = 31.2 dB

The system gain,

$G_s(dB) = F_m(dB) + P_L(dB) + L_f(dB) + L_P(dB) - A_t(dB) - A_r(dB)$

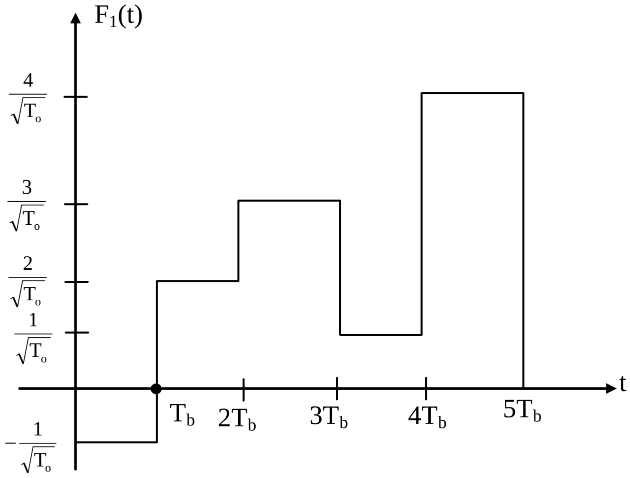
$= 31.4 + 129.55 + 10.8 + 4 - 31.2 - 31.2$

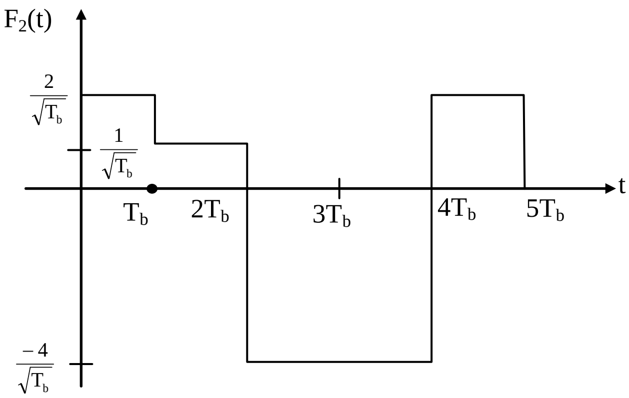
$G_s(dB) = 113.35$ dB

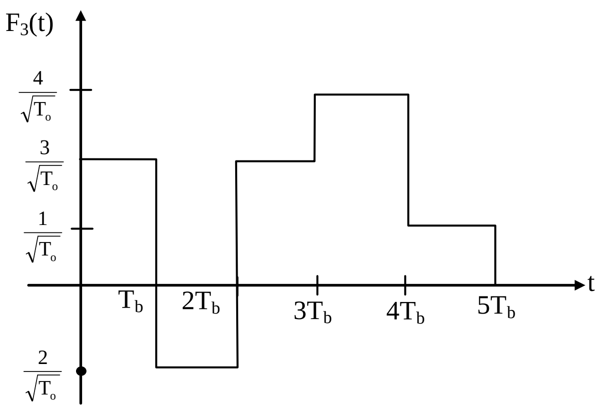
04. (a)

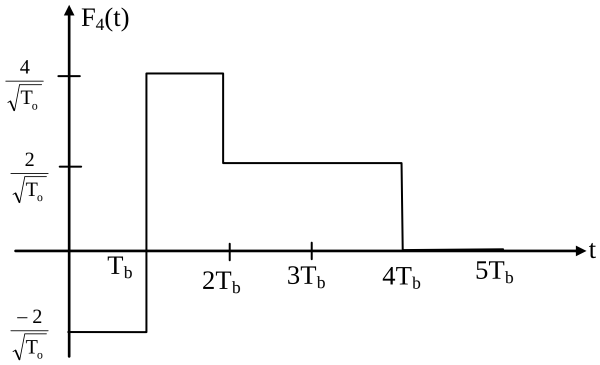
Sol:

i)









ii) The energy of each signal is:

$$E_1 \frac{1+4+9+1+16}{T_o} T_o = 31$$

$$E_2 = \frac{4+1+16+16+4}{T_o} T_o = 41$$

$$E_3 = \frac{9+4+9+16+1}{T_o} T_o = 39$$

$$E_4 = \frac{4+16+4+4+0}{T_o} T_o = 28$$

iii) $F_3.F_4 = -6-8+6+8 = 0$

$\therefore$ F_3 and F_4 are orthogonal to each other.

04. (b) (i)

Sol:

0	16 31
Source Port	Destination Port
UDP Length	UDP Checksum
Data	

Source port Number (16 bits):
Sending application port number.

Destination port Number (16 bits):
Receiving application port number.

UDP length (16 bits):
UDP packet size in bytes

UDP checksum:
Used for error detection in UDP packet, it is optional.

(ii) $T_t = \frac{\text{Frame size}}{\text{DTR}} = \frac{4000 \text{ bits}}{2 \text{ Mbps}} = 2 \text{ ms}$

RTT = 100 ms

$\eta = \frac{N \times T_t}{RTT}$

When $\eta = 1$ then optimal window size (N) = $\frac{RTT}{T_t}$

$= \frac{100 \text{ ms}}{2 \text{ ms}} = 50$

04.(c)

Sol:

(i) The minimum distance between any two adjacent signal points in the constellation of Fig.(a) is $d_{min}^{(a)} = 2\alpha$

The minimum distance between any two adjacent signal points in the constellation of Fig. (b) of the textbook is

$$d_{min}^{(b)} = \sqrt{\left(\sqrt{2}\alpha\right)^2 + \left(\sqrt{2}\alpha\right)^2} = 2\alpha$$

Which is the same as $d_{min}^{(a)}$. Hence, the average probability of symbol error using the constellation of Fig.(a) is the same as that of Fig.(b).

(ii) $R_X(\tau) = \langle A\cos(2\pi f_0 t + \phi) A\cos(2\pi f_0 t + 2\pi f_0 \tau + \phi)\rangle$

where $\langle\ .\ \rangle$ is the time averaging operator $\frac{1}{T_0}\int_{-T_0/2}^{T_0/2} dt$

upon expanding

$R_x(\tau)$ become:

$$R_X(\tau) = A^2\left[\cos 2\pi f_0 \tau \langle \cos^2(2\pi f_0 t + \phi)\rangle - \sin 2\pi f_0 \tau \langle \cos(2\pi f_0 t + \phi) A\sin(2\pi f_0 t + \phi)\rangle\right]$$

the negative term in the above expression goes to zero, and hence

$$R_x(\tau) = \frac{A^2}{2}\cos 2\pi f_0 \tau$$

$$P_x = R_x(0) = \frac{A^2}{2}$$

04. (d)

Sol: The orbital period of the sidereal day is 23 hours 56 minutes 4.10 seconds

$= 23\times60\times60 + 56\times60 + 4.1$ sec

$= 86164.1$ sec

Given that satellite orbital period is half of sidereal day length

i.e., $T = \frac{86164.1}{2}$

T = 43,082.05 sec

We know that,

$$T^2 = \frac{4\pi^2 a^3}{\mu}$$

Where,

T - Period of satellite

a - Altitude of satellite from center of earth

$\mu = 3.986004418\times10^5\ km^3/s^2$

= (kepler's constant)

$$a^3 = \frac{T^2\mu}{4\pi^2}$$

$a^3 = 7.496\times10^{13} km^3$

a = 26,561.764 km

We know that radius of earth r_e = 6378.14km

The orbital altitude above the surface of earth

= 26561.764km – 6378.14km

= 20,183.62 km

SECTION-B

05. (a)

Sol: **At sender**

1. Generate message digest H(M) from message file M, using hash function H.

Message (M) → [Hash function H] → Message Digest H(M)

2. Encrypt the generated message digest H(M) using sender's (own) private key to generate digital signature

Message Digest H(M) → [Encryption (sender's private key)] → Z (Digital signature)

3. Append encrypted message digest Z in the end of message file M, encrypt it using receiver's public key and send encrypted file C to the receiver

[M,Z] (Plain text) → [Encryption (Receiver's public key)] → C (Cipher text)

At Receiver

1. After receiving cipher text file C, receiver decrypt it using Receiver's (own) private key

$$C \longrightarrow \boxed{\begin{array}{c}\text{Decryption}\\ \text{(Receiver's private key)}\end{array}} \longrightarrow [M, Z]$$

2. After decryption, remove fixed length encrypted message digest Z from end of file and decrypt it using sender's public key

$$Z \longrightarrow \boxed{\begin{array}{c}\text{Decryption}\\ \text{(Sender's public key)}\end{array}} \longrightarrow H(M)$$

3. Generate message digest H (M) from received message file M, using same cryptographic hash function H.

$$\text{Message }(M) \longrightarrow \boxed{\text{Hash function H}} \longrightarrow H^1(M)$$

4. If ($H(M) = = H^1(M)$)
   *Accept the message file (M)
   else
   * Reject the file, atleast one is violated among confidentiality, integrity and authentication.

05. (b)

Sol:

(i) We know that the sampling period T_s is expressed as

$$T_S = \frac{1}{f_s} = \frac{1}{8\times10^3}\text{sec}$$

$$= 0.125 \times 10^{-3} \text{ sec}$$

$$= 125\ \mu s$$

$$\tau = 0.1\ T_S$$

$$= 12.5\ \mu s$$

Transmission bandwidth for PAM signal is expressed as

$$BW \geq \frac{1}{2\tau}$$

$$BW > \frac{1}{2\times12.5\times10^{-6}}$$

BW > 40 kHz

(ii) $M = 64 \Rightarrow n = \text{no. of bits} = \log_2^{64} = 6$

$$B_{null} = nf_s = 6 \times 7000$$

$$= 42 \text{ kHz}$$

05. (c)

Sol: Given that,

Number of clusters = 10

Number of cells = 7

Number of channels in each cell = 10

The total number of channels per cluster

$F = G.N$

Where, G = number of channels in a cell

N = number of cells in a cluster

$F = 10\times7$

F = 70 channels per cluster

Total channel capacity is

$C = MGN$

$C = MF$ where M = number of clusters in a given area

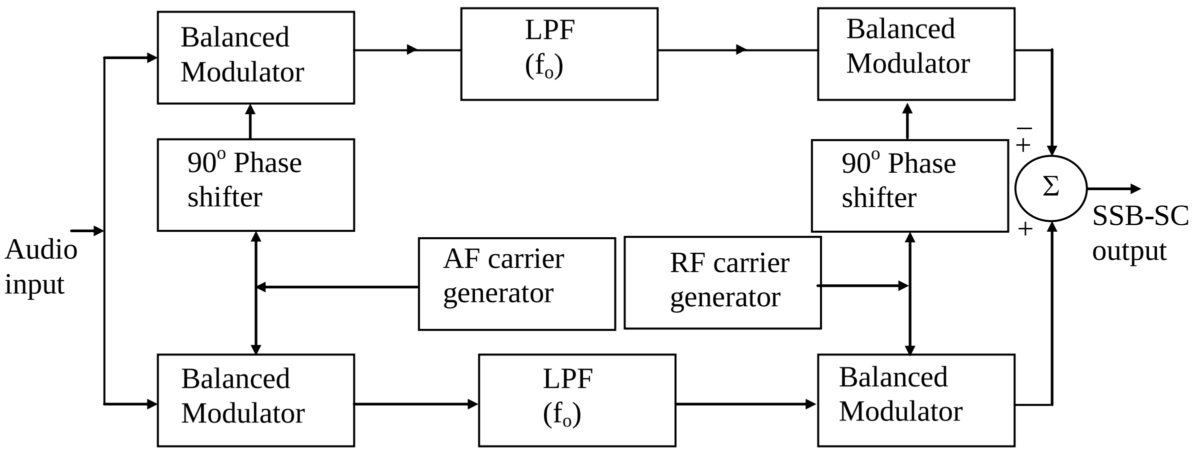
$= 10\times70$

C = 700 channels total

05.(d)

Sol:

(i) This method is a variant of the phasing method. It was invented in 1950 by DK weaver. It avoids the need for wideband phase-shifters which are difficult to construct and expensive and instead, uses an AF subcarrier at an audio frequency, say f_o.



Weaver's method of generation of SSB-SC signals

(ii) The important feature of a PCM system lies in its ability to control the effect of distortion and noise introduced in the channel. This is done by using regenerative repeaters

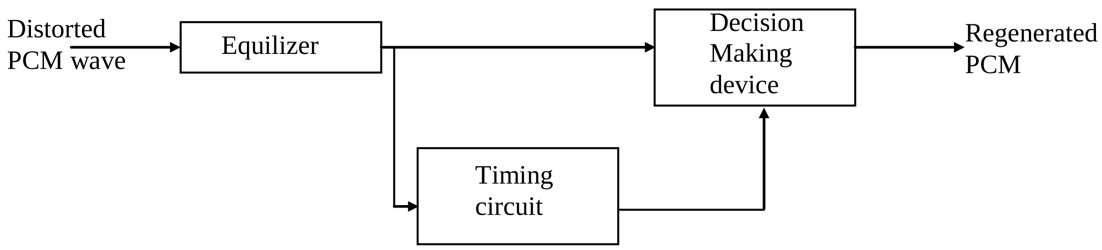


Fig: block diagram of regenerative repeater

A Regenerative repeater performs three operations

(1) Amplitude equilizer: It shapes the distorted PCM wave so as to compensate for the effects of amplitude and phase distortions.

(2) Timing circuit: It produces a periodic train of pulses derived from input PCM pulses. This is applied to decision making device.

(3) Decision making device: it uses the pulse train for sampling equalized PCM pulses.

The sampling is carried at instants where SNR is maximum. The decision making device decides whether equalized PCM wave has a '0' or '1' such a decision is made by comparing equalized PCM with a reference value. At the output we get clean PCM.

05. (e)

Sol: Probability of symbol error for coherently detected M-ary FSK is $P_E = (M-1)\,Q\left(\sqrt{\frac{E_s}{N_0}}\right)$

$$E_s = \frac{A^2}{2}T = \frac{(10^{-3})^2 \times 0.2\times 10^{-3}}{2} = 10^{-10}$$

$$P_E = (8-1)\,Q\left(\sqrt{\frac{10^{-10}}{2\times 10^{-11}}}\right) = 7Q(2.236)$$

$P_E = 7 \times 0.0127$

$= 8.89 \times 10^{-2}$

Probability of bit error for coherently detected M-ary FSK is $P_B = \frac{2^{k-1}}{2^k - 1}P_E = \frac{2^2}{2^3-1}P_E = \frac{4}{7}P_E$

$= 5 \times 10^{-2}$

05. (f)

Sol:

(i) $S(t) = A_C\,(1 + k_a\, m(t))\cos(2\pi f_c t)$

$$= A_C\left(1 + \frac{k_a}{1+t^2}\right)\cos(2\pi f_c t)$$

The ensure 50% modulation, $k_a = 1$, in which case we get

$$S(t) = A_C\left[1 + \frac{1}{1+t^2}\right]\cos(2\pi f_c t)$$

(ii) $S(t) = A_C\, m(t)\cos(2\pi f_c t)$

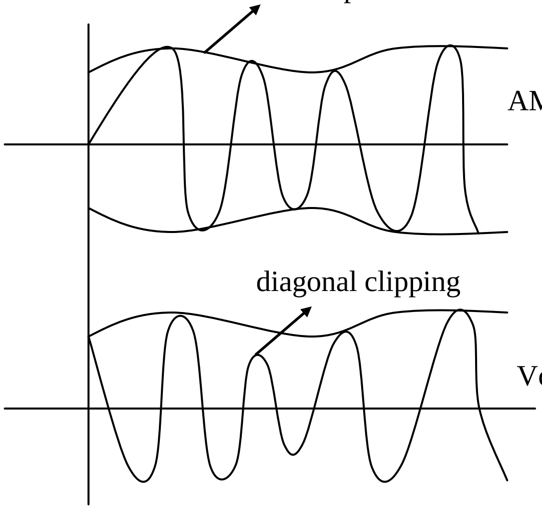
$$= \frac{A_C}{1+t^2}\cos(2\pi f_c t)$$

(iii) $S(t) = \frac{A_C}{2}\left[m(t)\cos(2\pi f_c t) - \hat{m}(t)\sin(2\pi f_c t)\right]$

$$= \frac{A_C}{2}\left[\frac{1}{1+t^2}\cos(2\pi f_c t) - \frac{t}{1+t^2}\sin(2\pi f_c t)\right] \qquad \because \frac{1}{1+t^2} \overset{H.T}{\leftrightarrow} \frac{t}{1+t^2}$$

(iv) $S(t) = \frac{A_C}{2}\left[\frac{1}{1+t^2}\cos(2\pi f_c t) + \frac{t}{1+t^2}\sin(2\pi f_c t)\right]$

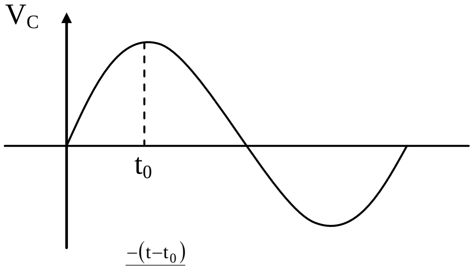
06. (a)
Sol:



In order to avoid diagonal clipping;
Rate of fall of voltage across capacitor ≥ rate of fall of Envelope voltage.
Finding rate of fall of voltage across the capacitor:

$V_c = V_0 e^{\frac{-t}{RC}}$ (General equation for capacitor voltage)

till t_0 capacitor get charges, after t_0 discharges



$$V_C = V_0 e^{\frac{-(t-t_0)}{R_L C}}$$

$$\frac{dV_C}{dt} = \frac{-V_0}{R_L C} e^{\frac{-(t-t_0)}{R_L C}}$$

$\frac{dV_C}{dt}$ maximum value occurs at $t = t_0$

$$\left.\frac{dV_C}{dt}\right|_{t=t_0} = -\frac{V_0}{R_L C}$$

where V_0 is initial voltage across capacitor.
General equation of AM-Modulated wave:

$$\underbrace{[A_C + A_m \cos\omega_m t]}_{\text{Envelop}} \underbrace{\cos\omega_c t}_{\text{Carrier}}$$

$$= A_C\left[1 + \frac{A_m}{A_C}\cos\omega_m t\right]\cos\omega_c t$$

$$= A_C[1 + \mu\cos\omega_m t]\cos\omega_c t$$

voltage of Envelope at $t = t_0$: $V_e = A_C [1 + \mu \cos\omega_m t_0] = V_0$

Calculating rate of fall of envelope voltage:

$$\frac{dV_e}{dt} = -A_C \mu\omega_m \sin \omega_m t$$

$$\Rightarrow \frac{-V_0}{R_L C} \geq -\mu\omega_m A_C \sin \omega_m t_0$$

Where, $V_0 = A_C[1 + \mu\cos\omega_m t_0]$

$$\frac{A_C[1+\mu\cos\omega_m t]}{R_L C} \geq \mu\omega_m A_C \sin \omega_m t_0$$

$$R_L C \leq \frac{1+\mu\cos\omega_m t_0}{\mu\omega_m \sin\omega_m t_0}$$

$$R_L C \leq \frac{1}{\dfrac{\mu\omega_m \sin\omega_m t_0}{1+\mu\cos\omega_m t_0}} \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_(1)}$$

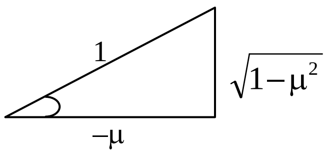
The worst case value of $R_L C$ is occurs when the denominator $\dfrac{\mu\omega_m \sin\omega_m t_0}{1+\mu\cos\omega_m t_0}$ value is maximum.

Differentiate $\dfrac{\mu\omega_m \sin\omega_m t_0}{1+\mu\cos\omega_m t_0}$ and equate it to zero.

$$\frac{(1+\mu\cos\omega_m t_0)\mu\omega_m^2\cos\omega_m t_0 + \mu^2\omega_m^2 \sin\omega_m t_0 \sin\omega_m t_0}{(1+\mu\cos\omega_m t_0)^2} = 0$$

$$\frac{\mu\omega_m^2\cos\omega_m t_0 + \mu^2\omega_m^2\cos^2\omega_m t_0 + \mu^2\omega_m^2\sin^2\omega_m t_0}{(1+\mu\cos\omega_m t_0)^2} = 0$$

$$\mu\omega_m^2\cos\omega_m t_0 + \mu^2\omega_m^2 = 0$$



$$\mu\omega_m^2\cos\omega_m t_0 = -\mu^2\omega_m^2$$

$\cos\omega_m t_0 = -\mu$

$$\sin\omega_m t_0 = \sqrt{1-\mu^2}$$

put $\cos\omega_m t_0$ and $\sin\omega_m t_0$ values in equation(1)

$$R_L C \leq \frac{1}{\dfrac{\mu\omega_m\sqrt{1-\mu^2}}{1-\mu^2}}$$

$$R_L C \leq \frac{1}{\dfrac{\mu\omega_m}{\sqrt{1-\mu^2}}}$$

$$R_L C \leq \frac{\sqrt{1-\mu^2}}{\mu\omega_m}$$

06. (b)
Sol:

(i) **(A)** $\langle X(t)\rangle = \dfrac{1}{T_0}\displaystyle\int_{-T_0/2}^{T_0/2} A\cos(2\pi f_0 t+\phi)\,dt = 0$

$$\langle X^2(t)\rangle = \frac{1}{T_0}\int_{-T_0/2}^{T_0/2} [A\cos(2\pi f_0 t+\phi)]^2\,dt = 0$$

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

(B) $E\{X\} = \displaystyle\int_{-\infty}^{\infty} X(\phi)\,P(\phi)\,d\phi$

$P(\phi) = \dfrac{1}{2\pi}$ since ϕ is uniformly distributed over $(0, 2\pi)$

$$E\{X\} = \int_0^{2\pi} [A\cos(2\pi f_0 t+\phi)]\frac{1}{2\pi}\,d\phi = 0$$

$$E\{X^2\} = \int_0^{2\pi} [A\cos(2\pi f_0 t+\phi)]^2\,\frac{1}{2\pi}\,d\phi$$

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

(ii) **(A)** $X(f) = \delta(f) + \cos^2 2\pi f$

1. always real
2. $P_x(f) \ge 0$
3. $P_x(-f) = P_x(f)$

$\therefore$ This is a valid PSD.

(B) $X(f) = 10 + \delta(f - 10)$

1. always real
2. $P_x(f) \ge 0$
3. $P_x(-f) \ne P_x(f)$

$\therefore$ This is NOT a valid PSD.

(C) $X(f) = \exp(-2\pi\,|f - 10|)$

1. always real
2. $P_x(f) \ge 0$
3. $P_x(-f) \ne P_x(f)$

$\therefore$ This is NOT a valid PSD.

(D) $X(f) = \exp[-2\pi(f^2 - 10)]$

1. always real
2. $P_x(f) \ge 0$
3. $P_x(-f) = P_x(f)$

$\therefore$ This is a valid PSD.

06. (c)
Sol:

Category	Circuit Switching	Packet switching
1. Resource reservation	Need to establish connection (path reservation) between end communication points before communication start	No need to reserve the path
2. Congestion	Congestion may occur during path reservation No congestion will occur during transmission	Congestion may occur during routing only
3. Routing path	Every packets of same session follow each other in fixed routing path	Packets of same session may routed through different paths
4. End to end delay	Packets of same session must have same end to end delay	Packets of same session may have different end to end delay
5. Processing overhead	Very less processing overhead at intermediate switches	Every packet is treated independently at every intermediate router in routing path More processing overhead
6. Order of packets	Provide connection oriented services like voice call	Provide connectionless services like internet
7. Resource utilization	Poor resource utilization because path is reserved	Better resource utilization in sharing mode
8. Cost	More costly due to reservation	less costly due to sharing
9. Speed	Relatively slow due to poor utilization	Relatively faster due to better utilization

06. (d)

Sol: T_P = Distance * signal speed = 2 km ×5ms/km

= 10 ms

$T_t \geq 2T_P$

Minimum Frame size = $2T_P \times$ DTR

= 10ms × 1 mbps

= 10^4 bits

= 1250 Bytes

07. (a)

Sol: The equivalent noise temperature of each device

$$T_e = 290\left(10^{\frac{NF}{10}} - 1\right) \text{ if NF in dB}$$

(or)

$T_e = T_A (NF - 1)$ ($T_A = 290k$)

$$T_{eLN} = 290\left(10^{\frac{4}{10}} - 1\right) \qquad T_{eLN} = 290\left(10^{\frac{3}{10}} - 1\right)$$

$T_{eLN} = 438k$ $\qquad$ $T_{eLN} = 289k$

$$T_{eDC} = 290\left(10^{\frac{10}{10}} - 1\right)$$

$T_{eDC} = 2610k$

$$T_{e1F} = 290\left(10^{\frac{20}{10}} - 1\right)$$

$T_{e1F} = 28710k$

The numerical values for each of the gains is

$$G_{LA} = 10^{\frac{30}{10}} = 1000 \qquad \frac{1}{L} = \frac{1}{10^{\frac{3}{10}}} = \frac{1}{2}$$

$$G_{DC} = 10^{\frac{10}{10}} = 10 \qquad G_{IF} = 10^{\frac{40}{10}} = 10{,}000$$

The total system noise temperature is

$$T_s = T_A + T_{LA} + \frac{290(L-1)}{G_{LA}} + \frac{T_{DC}}{\left(\frac{1}{L}\right)\times G_{LA}} + T_{IF}$$

$$= 60 + 438 + 0.29 + 5.22 + 5.74$$

$T_s = 509.3k$

Noise figure

$$NF = 10\log\left(1 + \frac{T_s}{290}\right)$$

$$= 10\log\left(1 + \frac{509.3}{290}\right)$$

NF = 4.4dB

07. (b)
Sol:

(i) The number of repeaters used in the system is K = 100. If regenerative repeaters used, the $\frac{E_b}{N_0}$ obtained from the equation given below

$$P_e = KQ\left[\sqrt{\frac{2E_b}{N_0}}\right]$$

$$10^{-5} = 100\ Q\left[\sqrt{\frac{2E_b}{N_0}}\right]$$

$$Q\left[\sqrt{\frac{2E_b}{N_0}}\right] = 10^{-7}$$

$$\sqrt{\frac{2E_b}{N_0}} = 5.15$$

$$\frac{E_b}{N_0} = 13.26\ = 11.22\text{ dB}$$

(ii) If analog repeaters are used, the $\frac{E_b}{N_0}$ can be obtained by,

$$P_e = Q\left[\sqrt{\frac{2E_b}{KN_0}}\right] \qquad [\because Q\,(4.25) = 10^{-5}\,]$$

$$10^{-5} = Q\left[\sqrt{\frac{2E_b}{100\ N_0}}\right]$$

$$\left[\sqrt{\frac{2E_b}{100\ N_0}}\right] = 4.25$$

$$\frac{E_b}{N_0} = 903.125\ = 29.55\text{ dB}$$

07. (c)
Sol:

(i) $G(x) = x^3 + 1 = 1.\,x^3 + 0.\,x^2 + 0.x + 1.x^0$

Divisor = 1001, Frame = $110110011\underline{0}\ \underline{1}\ \underline{1}$

```
          1001) 1 1 0 1 1 0 0 1 1 0 1 1
Bitwise         1 0 0 1
X-OR              1 0 0 1
                  1 0 0 1
                ------------------------
                            1 1 0 1
                            1 0 0 1
                            ---------
                              1 0 0 1
                              1 0 0 1
                            ---------
                                    0
```

If receiver find remainder is zero after modulo 2 division it means no any error detected in the frame, receiver accept the received frame.

(ii)

Category	**User Datagram protocol (UDP)**	**Transmission control protocol (TCP)**
Complexity	Light weight protocol Provide very minimal (basic) services for end to end connectivity	Provides some more additional services over UDP
Speed	Faster communication less processing overhead	More processing overhead
Connection establishment and Release	No need to establish connection for communication	Need to establish connection before transmission Once communication is over need to release the connection
Communication type	Preferred for shorter communication like query and response (question-answer)	Preferred for longer communication
Order of delivery of packets	Provides connectionless services Packet can be delivered in any order at receiver side	Provides connection oriented services Packets are delivered in same order at receiver side as sender sent
Reliability	Provides unreliable services No guarantee of data delivery	Provides reliable services Sender retransmit the data if it gets timeout for ACK
Error control	Very minimal error control (detection) Optional	Error detection is compulsory
Flow control	Provide no any flow control	Provide flow control
Congestion control	Provide no any congestion control	Provide congestion control

07. (d)
Sol:

(i) Free space loss $= 10\log_{10}\left(\frac{4\pi d}{\lambda}\right)^2$

$$= 20\log_{10}\left(\frac{4\times\pi\times150}{3\times10^8/4\times10^9}\right)\text{ dB}$$

= 88 dB

(ii) The power gain of each antenna is

$$10\log_{10} G_r = 10\log_{10} G_t = 10\log_{10}\left(\frac{4\times\pi\times A}{\lambda^2}\right)$$

$$= 10\log_{10}\left(\frac{4\times\pi\times\pi\times0.6}{(3/40)^2}\right)$$

= 36.24 dB

(iii) Received Power = Transmitted power + G_r – Free space loss

= 1 + 36.24 – 88

= –50.76 dBW

08.(a)

Sol:

(i) Given, L = 10km, Δt = 5ns/km

(A) For return to zero pulse, maximum digital transmission rate

$$R_b = \frac{1}{\Delta t \times L}$$

$$R_b = \frac{1}{5n \times 10} = 20\text{Mbps}$$

R_b = 20 Mbps

(B) For non return - to - zero

$$R_b = \frac{1}{2\Delta t \times L}$$

$$= \frac{1}{2 \times 5n \times 10}$$

R_b = 10 Mbps

(ii) LED output power in dBm,

$$P_t = 10\log\left(\frac{30\text{mW}}{1\text{mW}}\right)$$

P_t = 14.8 dBm

The cable loss is simply the product of the total cable length in km and the loss in dB/km.

Four 5km sections of cable is a total cable length of 20km,

Total cable loss = 20 km × 0.5 dB/km

= 10 dB.

Total connector loss = 3 connectors × 2 dB/connector = 6 dB

Total loss = cable loss + connector loss + light source to cable loss + cable to light detector loss

= 10 dB + 6 dB + 2.9 dB + 3.1 dB

Total loss (P_L) = 22 dB

Power received P_r (dBm) = P_t(dBm) – P_L

= 14.8(dBm) – 22 (dB)

P_r(dBm) = – 7.2 dBm

P_r(dB) = – 7.2 – 30

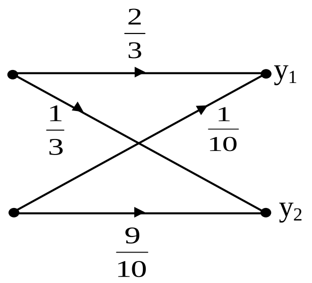
P_r(dB) = – 37.2 dB

08. (b)

Sol:

$P(x_1) = \frac{1}{3}$, x_1

$P(x_2) = \frac{2}{3}$, x_2



$$P(y_1) = \left(\frac{1}{3} \times \frac{2}{3}\right) + \left(\frac{2}{3} \times \frac{1}{10}\right) = \frac{13}{45}$$

$$P(y_2)=\left(\frac{1}{3}\times\frac{1}{3}\right)+\left(\frac{2}{3}\times\frac{9}{10}\right)=\frac{32}{45}$$

i) $H(x)=P(x_1)\log_2^{\frac{1}{P(x_1)}}+P(x_2)\log_2^{\frac{1}{P(x_2)}}$

$$=\frac{1}{3}\log_2^3+\frac{2}{3}\log_2^{(3/2)}$$

= 0.528 + 0.389

H(x) = 0.917 bits

ii) $P(x_1/y_1)=\dfrac{P(y_1/x_1)P(x_1)}{p(y_1)}=\dfrac{\frac{2}{3}\times\frac{1}{3}}{\frac{13}{45}}=\dfrac{10}{13}$

$$P(x_1/y_2)=\frac{P(y_2/x_1)P(x_1)}{P(y_2)}=\frac{\frac{1}{3}\times\frac{1}{3}}{\frac{32}{45}}=\frac{5}{32}$$

$$P(x_2/y_1)=\frac{P(y_1/x_2)P(x_2)}{P(y_1)}=\frac{\frac{1}{10}\times\frac{2}{3}}{\frac{13}{45}}=\frac{3}{13}$$

$$P(x_2/y_2)=\frac{P(y_2/x_2)P(x_2)}{P(y_2)}=\frac{\frac{9}{10}\times\frac{2}{3}}{\frac{32}{45}}=\frac{27}{32}$$

$$H(x/y_1)=P(x_1/y_1)\log_2\frac{1}{p(x_1/y_1)}+P(x_2/y_1)\log_2\frac{1}{P(x_2/y_1)}$$

= 0.291 + 0.4881

= 0.7791

$$H(x/y_2)=P(x_1/y_2)\log_2\frac{1}{P(x_1/y_2)}+P(x_2/y_2)\log_2\frac{1}{P(x_2/y_2)}$$

= 0.418 + 0.206 = 0.624

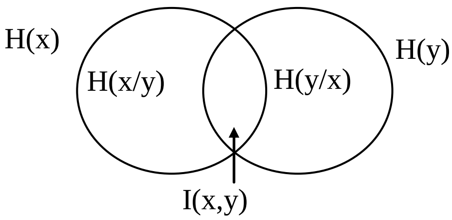
$H(x/y) = P(y_1)\,H(x/y_1) + P(y_2)H(x/y_2)$

$$=\frac{13}{45}(0.7791)+\frac{32}{45}(0.624)$$

= 0.225 + 0.443

H(x/y) = 0.668

iii)



I(x,y) = H(x) – H(x/y)

= H(y) – H(y/x)

I(x,y) = H(x) – H(x/y)

= 0.917 – 0.668

= 0.249

iv) $H(y) = P(y_1)\log_2^{\frac{1}{P(y_1)}} + P(y_2)\log_2^{\frac{1}{P(y_2)}}$

$= \frac{13}{45}\log_2^{(45/13)} + \frac{32}{45}\log_2^{(45/32)}$

= 0.517 + 0.349

= 0.866 bits/symbol

v) H(y/x) = H(y) – I(x,y)

= 0.866 – 0.249

= 0.617

08. (c)

Sol: Certain structural modification and simplifications of the correlation receiver are possible by observing that,

(i) All orthonormal basis functions θ_j – S are defined between $0 \le t \le T_b$ and they are zero outside this range.

(ii) Analog multiplication, which is not always very simple and accurate to implement, of the received signal r(t) with time limited basis functions may be replaced by some filtering operation.

Let, $h_j(t)$ represent the impulse response of a linear filter to which r(t) is applied.
Then the filter output $y_j(t)$ may be expressed as:

$$y_j(t) = \int_{\infty}^{\infty} r(\tau)h_j(t-\tau)d\tau$$

Now, let, $h_j(t) = \varphi_j(T - t)$, a time reversed and time-shifted version of $\varphi_j(t)$.

Now, $y_j(t) = \int_{-\infty}^{\infty} r(\tau).\varphi_j[T-(t-\tau)]d\tau$

$$= \int_{-\infty}^{\infty} r(\tau).\varphi_j[T+t-\tau]d\tau$$

If we sample this output at t = T,

$$y_j(T) = \int_{-\infty}^{\infty} (\tau).\varphi_j(\tau)d\tau$$

Let us recall that $\varphi_j(t)$ is zero outside the interval $0 \le t \le T$. Using this, the above equation may be expressed as,

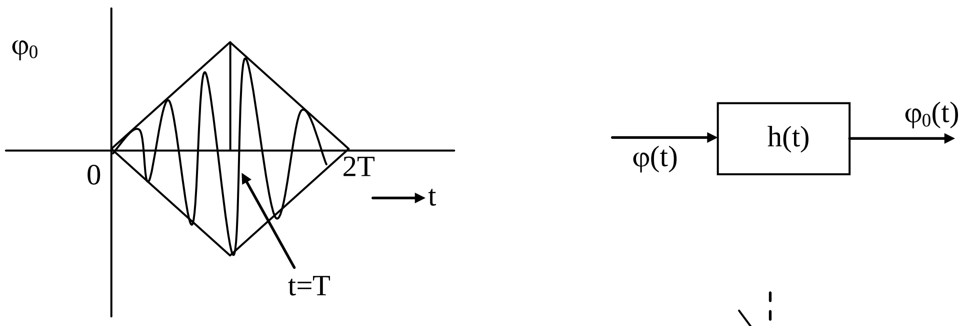
$$y_j(T) = \int_0^T r(\tau).\varphi_j(\tau)d\tau$$

From our discursion on correlation receiver, we recognize that,

$$r_j = \int_0^T r(\tau)\varphi_j(\tau)d\tau = y_j(\tau)$$

The important expression of (Eq.4.20.4) tells us that the j – th correlation output can equivalently be obtained by using a filter with $h_j(t) = \varphi_j(T–t)$ and sampling its output at t = T.

The filter is said to be matched to the orthonormal basis function $\varphi_j(t)$ and the alternation receiver structure is known as a matched filter receiver. The detector part of the matched filter receiver is shown below



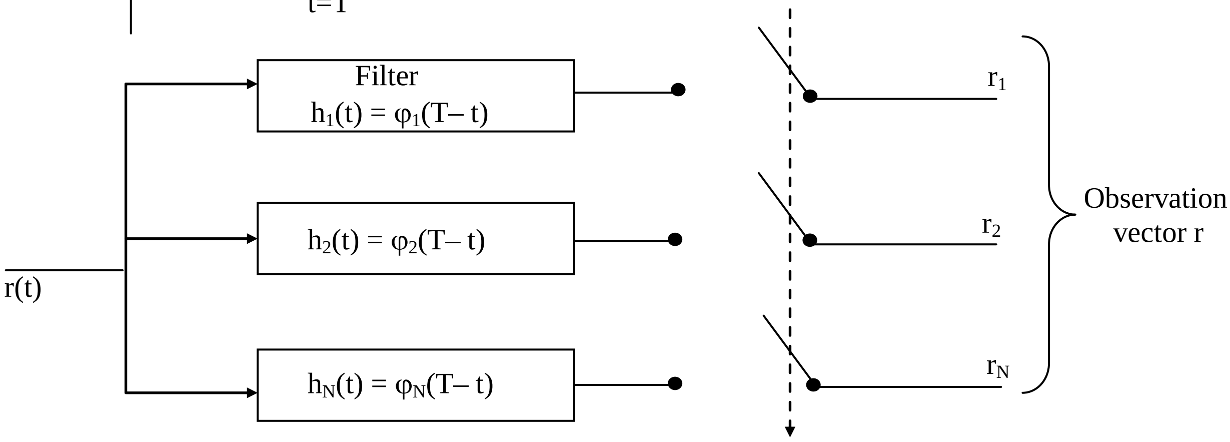


Fig:The block diagram of a matched filter bank that is equivalent to a Correlation Detector.

A physically realizable matched filter is to be causal and $h_j(t) = 0$ for $t < 0$. Note that if $\varphi_j(t)$ is zero outside $0 \le t \le T$, $h_j(t) = \varphi_j(T–t)$ is a causal impulse response.