Solutions

Q.2 **a.** Explain the Huffman encoding algorithm. Using this algorithm compute the Huffman code for a discrete memoryless source. The source has an alphabet of five symbols with their probabilities given below:

Symbol	s_1	s_2	s_3	s_4	s_5
Probability	0.55	0.15	0.15	0.1	0.05

Find the coding efficiency. **(10)**

Answer: Refer pages from 25 to 27 of Text Book

b. Define channel capacity. Derive an expression for the channel capacity of a binary symmetric channel. **(6)**

Answer: Refer page 35 of Text Book

Q.3 **a.** Compare natural sampling, instantaneous sampling and flat-top sampling techniques. **(8)**

Answer: Refer pages from 154 to 158 of Text Book

b. Write short note on :
(i) Pulse Amplitude Modulation
(ii) TDM **(8)**

Answer: (i) Refer page 161 of Text Book
(ii) Refer pages from 162 & 163 of Text Book

Q.4 a. Represent 0110100010 in NRZ unipolar format, Non return to zero polar format, Non return to zero bipolar format & Manchester. What is the advantage of Manchester coding over other types? **(8)**

Answer: Refer page 234 of Text Book

b. What is Eye Pattern? Explain the eye pattern with the help of distorted binary wave. **(8)**

Answer: Refer page 261 of Text Book

Q.5 a. (i) The BPSK modulation is used in a channel that adds white noise with single-sided PSD $N_0 = 10^{-10}$ W/Hz. Calculate the amplitude A of the carrier signal to give $P_e = 10^{-6}$ for a data rate of 100 Kbps. **(4)**

(ii)Find E_b/N_0 in dB to provide $P_e = 10^{-6}$ for BPSK and coherent FSK.**(4)**

Answer: (i)

$$\therefore A = \left[2N_0\left(\frac{E_b}{N_0}\right)R\right]^{1/2}$$

$$A = [2 \times 10^{-10} \times 11.32 \times 10^5]^{1/2} = 1.505 \text{ mv}$$

(ii)

For BPSK

$$P_e \approx \frac{e^{-E_b/N_0}}{2\sqrt{\pi\left(\frac{E_b}{N_0}\right)}}$$

$$10^{-6} = \frac{e^{-\xi}}{2\sqrt{\pi\xi}}$$

where:

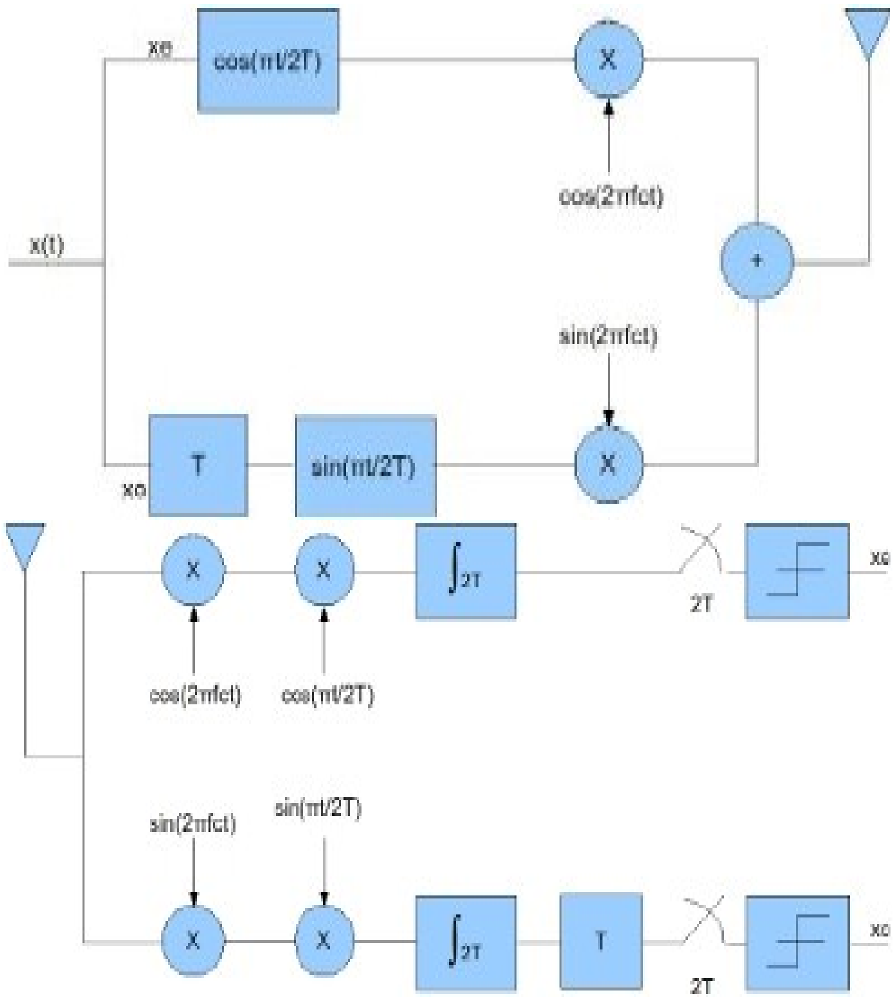
$$\xi = E_b/N_0$$

$$\therefore \xi = 11.32 = 10.54\,\text{dB}$$

FSK requires 3 dB more in terms of E_b/N_0 to give the same P_e as BPSK, i.e., 13.54 dB.

b. What is a CPFSK modulation scheme? How it is related with the MSK modulation scheme? Explain MSK transmission and reception. (8)

Answer: MSK TRANSMITTER AND RECEIVER-



Q.6 a. Explain the quantization error and derive an expression for maximum signal to noise ratio in PCM system that uses linear quantization. **(8)**

Answer: **Refer page 192 of Text Book**

b. Discuss the methods of implementing adaptive equalizers. **(8)**

Answer: **Refer page 265 of Text Book**

Q.7 a. What is frequency hop spread spectrum? Differentiate and illustrate the slow frequency hopping & fast frequency hopping. **(8)**

b. Determine the processing gain & jamming margin in a DSSS system, given T_b = 4.095 m-sec, T_c = 1 μsec. Assume a maximum of $P_e \le 10^{-5}$. Also find number of feedback stages required. **(8)**

Q.8 a. What is a matched filter? Derive the condition for maximum output of a matched filter. **(10)**

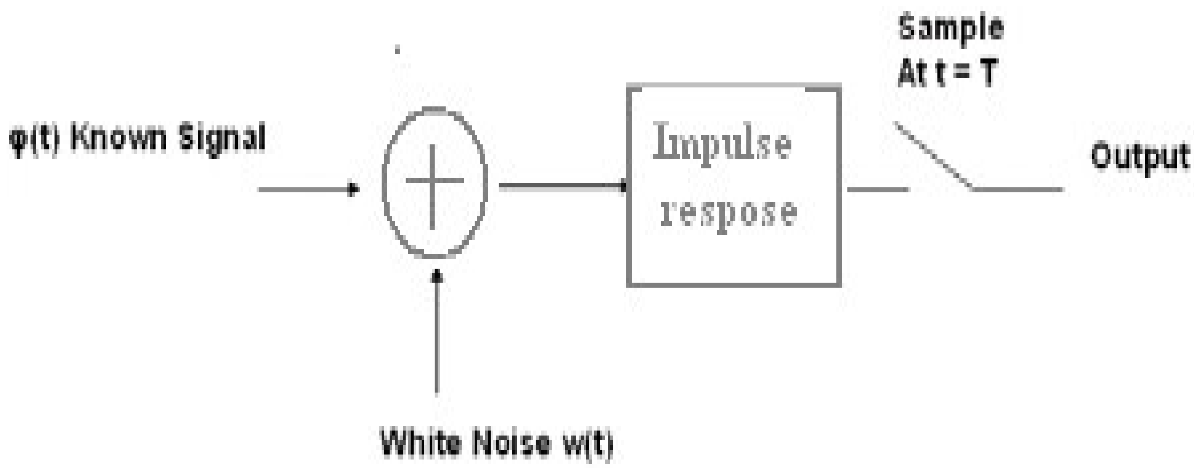
Answer:
Matched filter is an optimum filter which will maximize output SNR to minimize the probability of error.

Let
x(t) = input signal to the matched filter
h(t) = impulse response of the matched filter
w(t) =white noise with power spectral density $N_o/2$
$\phi(t)$ = known signal
Input to the matched filter is given by
$x(t) = \phi(t) + w(t) \quad 0 \le t \le T$

science the filter is linear , the resulting output y(t) is given by

$y(t) = \phi_0(t) + n(t)$

where $\phi_0(t)$ and n(t) are produced by the signal and noise components of the input x(t).



The signal to noise ratio at the output of the matched filter at t = T is

$$(SNR)_0 = \frac{|g_0(T)|^2}{E[n^2(t)]} \quad \cdots (1)$$

aim is to find the condition which maximize the SNR
let

$$g_0(t) \rightleftharpoons G_0(f)$$

$$h(t) \rightleftharpoons H(f)$$

are the Fourier transform pairs, hence the output signal $g_0(t)$ is given by

$$g_0(t) = \int_{-\infty}^{\infty} H(f)G(f)\exp(j2\pi ft)\,df$$

output at t = T is

$$|g_0(T)|^2 = \left|\int_{-\infty}^{\infty} H(f)G(f)\exp(j2\pi fT)\,df\right|^2 \quad \cdots (2)$$

For the receiver input noise with psd (power spectral density) $N_0/2$ the receiver output noise psd is given by

$$S_N(f) = \frac{N_0}{2}|H(f)|^2 \quad \cdots (3)$$

and the noise power is given by

$$E[n^2(t)] = \int_{-\infty}^{\infty} S_N(f)\,df$$

$$= \frac{N_0}{2}\int_{-\infty}^{\infty} |H(f)|^2\,df \quad \cdots (4)$$

substituting the values of eqns (2) & (4) in (1) we get

$$(SNR)_0 = \frac{\left|\int_{-\infty}^{\infty} H(f)G(f)\exp(j2\pi fT)\,df\right|^2}{\frac{N_0}{2}\int_{-\infty}^{\infty} |H(f)|^2\,df} \quad \cdots (5)$$

using Schwarz's inequality

$$\left|\int_{-\infty}^{\infty} X_1(f)X_2(f)\,df\right|^2 \le \int_{-\infty}^{\infty} |X_1(f)|^2\,df \int_{-\infty}^{\infty} |X_2(f)|^2\,df \quad \cdots (6)$$

Eqn (6) is equal when $X_1(f) = kX_2^*(f)$
let $X_1(f) = H(f)$
& $X_2(f) = G(f)\exp(j2\pi fT)$
under equality condition

$H(f) = K\,\Phi^*(f)\exp(-j2\pi fT) \quad \cdots (7)$

Thus substituting in (6) we get the value

$$\left|\int_{-\infty}^{\infty} H(f)\Phi(f)\exp(j2\pi fT)\,df\right|^2 \le \int_{-\infty}^{\infty} |H(f)|^2 df \int_{-\infty}^{\infty} |\Phi(f)|^2 df$$

substituting in eqn (5) and simplifying

$$(SNR)_0 \le \frac{2}{N_0}\int_{-\infty}^{\infty} |\Phi(f)|^2 df$$

Using **Rayleigh's energy** theorem

$$\int_{-\infty}^{\infty} |\phi(t)|^2 dt = \int_{-\infty}^{\infty} |\Phi(f)|^2 df = E, \text{ energy of the signal}$$

$$(SNR)_{0,\max} = \frac{2E}{N_0} \quad \cdots (8)$$

Under maximum SNR condition, the transfer function is given by (k=1), eqn (7)

$$H_{opt}(f) = \Phi^*(f)\exp(-j2\pi fT)$$

The impulse response in time domain is given by

$$h_{opt}(t) = \int_{-\infty}^{\infty} \Phi^*(f)\exp[-j2\pi fT]\exp(j2\pi ft)\,df$$
$$= \phi(T - t)$$

Thus the impulse response is folded and shifted version of the input signal $\phi(t)$

b. Write short note on detection of signals with unknown phase in noise. **(6)**

Answer: **Refer section 3.9, page 96 of Text Book**

Q.9 Write short note on:
(i) Light wave transmission link
(ii) Digital Radio **(8+8)**

Answer: **Refer pages 225 & 350 of Text Book**

TEXT BOOK

Digital communications, Wiley Student Edition, Simon Haykin