Fayoum University
Faculty of Engineering
Electronics and Communications Dpt.
Subject: (Communications)
Examiner: Dr. Tamer Mohamed Barakat

B.Sc. Communications
Academic year 2008/2009
Time Allowed: 3 Hours

Questions for Final Term Examination

Attempt all questions	No. of questions: 5	No. of pages: 3

First Question (15 marks)

The signal component of a binary FSK system is defined by:

$$s(t) = \begin{cases} A\cos(w_c + w_d)t & b_k = 1 \\ A\cos(w_c - w_d)t & b_k = 0 \end{cases}$$

where $w_i = w_c \pm w_d$ is the instantaneous frequency and $0 \le t \le T_b$.

a) Draw a signal-space diagram for the scheme described here; what observations can you make about this diagram?

b) Show that, in the presence of AWGN (Adaptive White Gaussian Noise) of zero mean and PSD $N_0/2$, the average probability of error is: $P_{e_{min}} = Q\left(\sqrt{\frac{2E_{av}}{N_0}}\right)$

where $E_{av} = E_b/2$, and $E_b = \frac{1}{2} A^2 T_b$

c) Find the probability of error, $P_{e_{min}}$, If the coherent matched filter detection of the equally likely binary FSK signals

$$s_1(t) = 0.5\cos 2000\,\pi t$$

and

$$s_2(t) = 0.5\cos 2020\,\pi t,$$

where the two-sided AWGN power spectral density is $N_0/2 = \mathbf{0.0001\ watts/Hz}$. Assume that the symbol duration is $T = \mathbf{0.01\ s.}$

Second Question (15 marks)

The use of optical fiber as a replacement for copper media is providing for handling enormous of information that must be transmitted across the country.

(5) a) Draw schematic diagram of an optical fiber communication system and explain each element of this system.

(10) b) An optical communication system has the following characteristics:
Photocurrent $\mathbf{I_{ph} = 0.6\ \mu A}$, quantum efficiency $\boldsymbol{\eta = 0.85}$, load resistor $\mathbf{R_L = 10^4\ \Omega}$, bandwidth $\mathbf{B = 15\ kHz}$, and the fiber is **20 km** long and is restricted so that it only operates one mode. Consider a sinsoidally varying **850 nm** signal, which has a modulation index $\mathbf{m = 0.85}$ and an average received power level $\mathbf{P_0 = -50\ dB_m}$, to fall on the detector at room temperature ($\mathbf{T = 300\ K}$ **and** $\mathbf{V_T = 25\ mV}$).

(2) i) What is the maximum signal –to– noise ratio?

(4) ii) Determine the total time delay (Δt_{total}) at the total dispersion and the maximum bit rate if the fiber has dispersion factor of **15 ns/km** inter-modal, **10 ns/km** material, and **0.12 ns/km** waveguide.

(2) iii) If the signal attenuation occurred at **5 dB/km**, calculate the average transmitted power.

(2) iv) Calculate the loss margin if the receiver with sensitivity $\mathbf{-50\ dB_m}$, TX/ RX port losses **8 dB** each, Two connectors with losses **0.5 dB** each, Five splices with losses **0.8 dB** each and Fiber total loss **3 dB/km**.

$q = 1.6 \times 10^{-19}$ Coulombs
$K =$

Third Question (15 marks)

The unique feature of communications satellites is their ability to simultaneously link all users on the earth's surface, thereby providing distance insensitive point-to- multipoint communications.

(3) a) discuss briefly each of the following:

- (1) - Transmission path (slant) distance.
- (1) - Input and output BO.
- (1) - Losses in satellite communication system.

(3) b) Derive an expression for the carrier to noise density ratio as a function of the saturated flux density and then as a function of EIRP.

(9) c) A satellite operating at **11.7GHz** is located in geostationary orbit **38000 km** from an earth station, it transmit a power of **200mW** and feed to an antenna with **18.9 dB** gain towards the earth station. The earth station receiving antenna has a gain of **50 dB**; the overall noise temperature of the earth station is $\mathbf{1250^0}$ ***K***. Determine:

(1.5) (1) The satellite EIRP in dBW
(1.5) (2) The path loss in dB
1.5 (3) The received signal power in dBW
1.5 (4) The figure of merit
1.5 (5) The receiver noise power in a **100Hz** noise bandwidth in dBW
1.5 (6) The receiver carrier to noise ratio in dB

Fourth Question (15 marks)

a) In a given telephone network, discuss the following in details:

i- **Transmitter** and **Receiver** of the D.T.M.F. dialing system.
ii- Transmission impairments in telephone system.
iii- Planning of the international numbering.
iv-Concept of the wireless local loop.

b) For the exchanges in Fig (1), find the overall Grade of Surface (GoS):

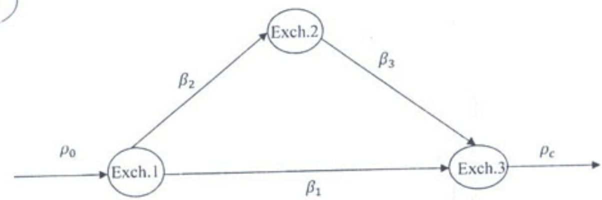


Fig (1)

Fifth question (10 marks)

Spread spectrum is a technique that transmits the data sequence with large bandwidth.

a) Draw a schematic block diagram for a direct sequence spread spectrum communication system (i.e. transmitter and receiver). Sketch also the PSD at each point of the system.

b) A FFH-SS system uses **50 Hz** channels over a continuous **20 MHz** spectrum. Fast frequency hopping is used where **3** hops occur for each bit. Non-Coherent BFSK modulation is used in the system. Determine:

i- The number of hopes/sec if each user transmits at **25 kb/sec**.
ii- The processing gain.
iii- The probability of error for a single user operating at an $E_b/N_0 = 21$ dB.
iv- The probability of error for a user operating at $E_b/N_0 = 21$ dB with **200** other FF-SS users which are independently frequency hopped.

(**Hint:** the probability of error for Non-Coherent BFSK receiver is $P_e = \frac{1}{2}\, e^{-(E_b/2N_0)}$)

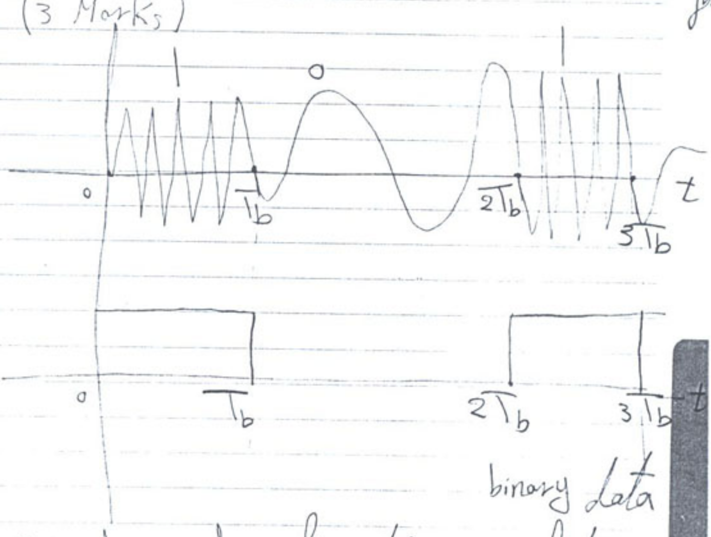
Fayoum University

Final Term Examination

Model Answer

First Question: (15 Marks)

a) (3 Marks)



we can observe from this diagram that the frequency of a high-frequency carrier signal is keyed between two states "0" and "1"

b) (5 Marks)

For FSK the prob. of error can be derived by the following:

$S_1(t) = A \cos w_1 t$, $S_2(t) = A \cos w_2 t$

* Assumption: we assume that $S_1(t)$ and $S_2(t)$ are orthogonal function.

then, $\int S_1(t)\, S_2(t)\, dt = 0$

$$S_{1o}(kT_b) = \int_0^{T_b} S_1(t)\left[S_2(t) - S_1(t)\right] dt$$

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

$$S_{2o}(kT_b) = \frac{A^2 T_b}{2}$$

$$\gamma^2_{max} = \int \frac{|P(f)|^2}{G_n(f)}\, df$$

$$= \frac{2}{N_o} \int^{T_b} p^2(t)\, dt$$

$$p(t) = s_2(t) - s_1(t)$$

$$\gamma^2_{max} = \frac{2}{N_0}\left\{\frac{A^2 T_b}{2} + \frac{A^2 T_b}{2}\right\}$$

$$\therefore \gamma^2_{max} = \frac{2A^2 T_b}{N_0}$$

$$\because P_e\Big|_{min} = Q\left(\frac{\gamma_{max}}{2}\right)$$

$$= Q\left(\sqrt{\frac{A^2 T_b}{2N_0}}\right.$$

$$\because E_b = \frac{1}{2} A^2 T_b \text{ and } E_{av} = \frac{E_b}{2}$$

$$\therefore P_e\Big|_{min} = Q\left(\sqrt{\frac{2E_{av}}{N_0}}\right)$$

c) (7 Marks)

4)

a) $\because P_e\Big|_{min} = Q\left(\sqrt{\dfrac{A^2 T_b}{2N_o}}\right)$

$\because A = 0.5$, $T_b = 0.01$ sec, and

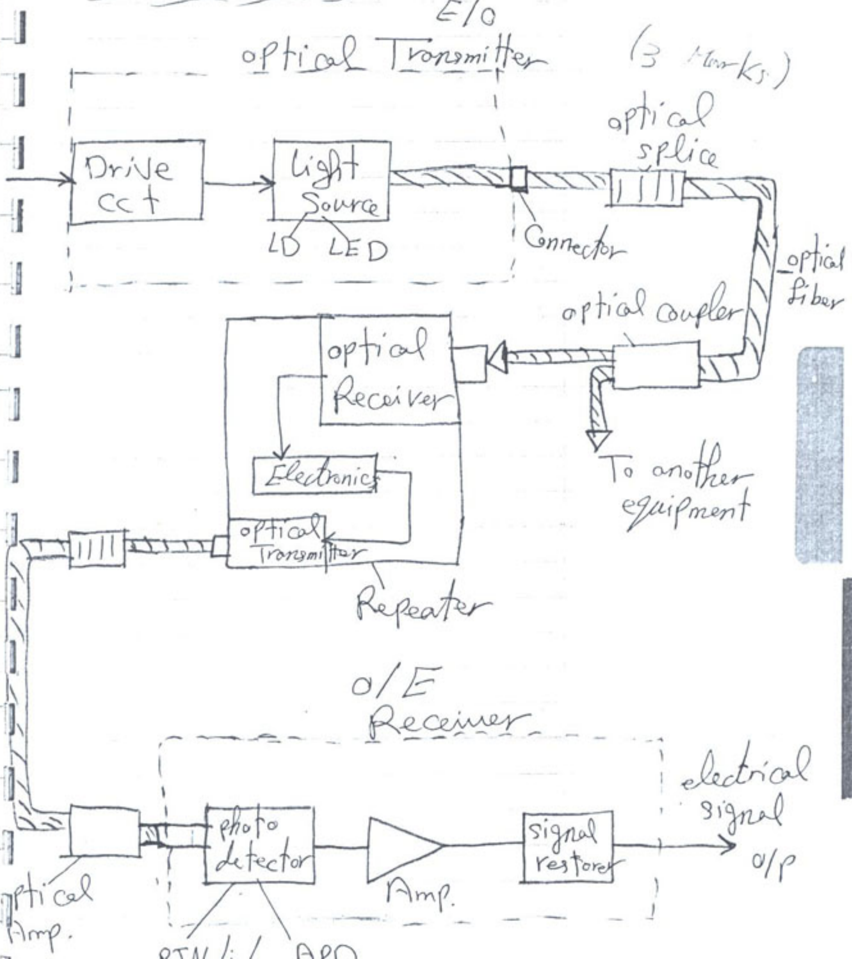
$\dfrac{N_o}{2} = 0.0001$ watts/Hz $\rightarrow N_o = 2\times 10^{-4}$

$\therefore P_e\Big|_{min} = Q\left(\sqrt{\dfrac{(0.5)^2 (0.01)}{(2)(2\times 10^{-4})}}\right)$

$$P_e\Big|_{min} = Q(2.5)$$

Second Question (15 Marks):

a) 5 Marks:



(2 Marks)

- **E/O**: Electric to optical Converter,
  It Contains driving cct and optical Source.
- **optical source**: Convert from E to O but it needs to be driven by driving cct.

- **Beam splitter**: To distribute the optical fiber to multipoints.

- **optical repeater**:

  It Consits of both transmitter and receiver units back to back.

- **O/E**:
  optical to electrical Converter
  it Contains photo dector and amplifier.

b) 10 Marks:

(1) 2 Marks.

$$\therefore SNR\Big|_{PIN} = \frac{\frac{1}{2}\, m^2\, I_{ph}^2}{2q\left(I_{ph} + \frac{2V_T}{R_L}\right)B}$$

$\because m = 0.85$, $I_{ph} = 0.6\times10^{-6}$ Amp.,
$q = 1.6\times10^{-19}$ coulombs, $V_T = 25\times10^{-3}$ V,
$R_L = 10^{+4}\ \Omega$, and $B = 15\times10^{3}$ HZ

$$\therefore SNR\Big|_{PIN} = \frac{\left(\frac{1}{2}\right)(0.85)^2\left(0.6\times10^{-6}\right)^2}{(2)(1.6\times10^{-19})(15\times10^{3})\left[0.6\times10^{-6} + \frac{(2)(25\times10^{-3})}{10^{4}}\right]}$$

$$\therefore SNR\Big|_{PIN} = 4.838\times10^{6}$$

$$= 66.8\ dB$$

(ii) 4 Marks;

∴ The total dispersion is

$$\Delta t\Big|_{total} = \sqrt{\Delta^2 t\Big|_{intermodal} + \Delta^2 t\Big|_{WG} + \Delta^2 t\Big|_{material} + \Delta^2 t\Big|_{Tx} + \Delta^2 t\Big|_{Rx}}$$

$$\therefore \Delta t\Big|_{intermodal} = 15 \times 20 = 300 \text{ nsec}$$

$$\Delta t\Big|_{WG} = 0.12 \times 20 = 2.4 \text{ nsec}$$

(2 Marks)

$$\Delta t\Big|_{material} = 10 \times 20 = 200 \text{ nsec}$$

$$\therefore \Delta t\Big|_{total} = \sqrt{(300)^2 + (2.4)^2 + (200)^2}$$

$$\Delta t\Big|_{total} = 360.56 \text{ n sec}$$

$$\therefore B = \frac{1}{5\Delta t}$$

$$\therefore B = \frac{1}{5 \times 360.56 \times 10^{-9}}$$

2 Marks

$$\therefore B = 554.692 \text{ bit/sec}$$

$$B = 0.554 \text{ M bit/sec}$$

(iii) 2 Marks;

$\alpha = 5$ dB/Km

$-50 = 10 \log P_o$

$\therefore P_o = 10^{-5}$ mW

$$\therefore \alpha = \frac{10}{Z} \log \frac{P_i}{P_o}$$

$$5 = \frac{10}{20} \log \frac{P_i}{P_o}$$

$\therefore P_o = 50$ dB_m

iv) 2 Marks:

∴ Loss budget equation is:

$$P_t - P_R\big|_{min} = M + L_{PT} + L_{PR} + N_c L_c + N_s L_s + Z L_f$$

∴ $P_t =$ ~~-5×10^4~~ 50 dB_m

$P_R\big|_{min} = -50\, dB_m$

$L_{PT} = 8\, dB$, $L_{PR} = 8\, dB$

$L_c = 0.5\, dB$, $N_c = 2$, $N_s = 5$, $L_s = 0.8\, dB$

$L_f = 3\, dB$, and $Z = 20\ Km$

$$\therefore M = P_t - P_R\big|_{min} - L_{PT} - L_{PR} - N_c L_c - N_s L_s - Z L_f$$

$=$ ~~-5×10^4~~ $50 + 50 - 8 - 8 - 1 - 4 - 60$

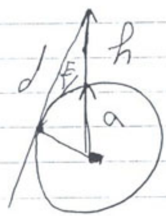
∴ $M =$ ~~-5×10^4~~ 19 dB_m

Third Question 15 Marks;

a) 3 Marks:

- Transmission path (slant) distance.

It is the distance betn the ground station receiving or transmitting and the the satellite.



(1 Mark)

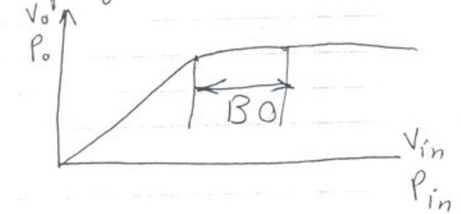
$$\therefore (a+h)^2 = a^2 + d^2 - 2ad\cos(90+E)$$

$$= a^2 + d^2 + 2ad\sin E$$

$$\therefore d = \sqrt{(a+h)^2 - (a\cos E)^2} - a\sin E$$

- I/P and O/P BO; (1 Mark).

It is used to avoid the non linearity in the amplifier characteristic



- Losses in Satellite; (1 Mark);

- Path propagation loss "L" which fun of "d" and "f".
- Scattering and ~~opser~~ absorption losses due to the propagation of the signal through the troposphere and ionosphere.
- Antenna losses; [Feeding losses "L_f" and Pointing losses "L_p"]
- Filter losses.

b) (3 Marks)

∴ the carrier to noise density ratio is defined by:

$$\frac{C}{N_o} = \frac{P_R}{KT}$$

if ϕ_s is the Saturated Flux Density at the I/P of the receiver antenna, therefore:

$$P_R = \phi_s A_{eff} = \phi_s \frac{\lambda^2 G_R}{4\pi}$$

where $G_R \triangleq$ received antenna gain

$\lambda \triangleq$ wave length.

$$\therefore \frac{C}{N_o} = \phi_s * \frac{G_R}{T} * \frac{1}{K} * \frac{1}{\frac{4\pi}{\lambda^2}}$$

$$\left.\frac{C}{N_o}\right|_{dB\,HZ} = \left.\phi_s\right|_{dBW/m^2} + \left.M\right|_{dBW/HZ\,K} - \left.K\right|_{dBW/HZ\,K} - \left.G_1\right|_{dB/m^2}$$

where: $M \triangleq$ the figure of merit of the receiving antenna.

$G_1 \triangleq$ the isotropic power gain.

$$\therefore \frac{C}{N_o}\Big|_{dBHz} = \phi_s\Big|_{dBW/m^2} + M\Big|_{dB/K} - G_1\Big|_{dB/m^2} + 228.6$$

if Effective Isotropic Radiated Power (eirp) is defined by:

$$eirp = P_T * G_T$$

$$\therefore eirp\Big|_{dB} = P_T\Big|_{dB} + G_T\Big|_{dB}$$

$$\because \frac{P_R}{P_T}\Big|_{dB} = G_T\Big|_{dB} + G_R\Big|_{dB} - L\Big|_{dB}$$

$$\therefore P_R\Big|_{dBw} = \left(P_T\Big|_{dBw} + G_{T dB}\right) + G\Big|_{R dB} - L_{dB}$$

$$\therefore P_R\Big|_{dBW} = eirp\Big|_{dB} + G_R\Big|_{dB} - L\Big|_{dB}$$

but:

$$\frac{C}{N_o} = \frac{P_R}{KT} = \frac{P_R}{G_R} * \frac{1}{K} * \frac{G_R}{T}$$

$$\therefore \frac{C}{N_o}\Big|_{dBHz} = P_R\Big|_{dBW} - G_R\Big|_{dB} + M\Big|_{dB/K} + 228.6$$

$$\therefore \frac{C}{N_o} = eirp\Big|_{dBW} + M\Big|_{dB/K} - L\Big|_{dB} + 228.6$$

c) 9 Marks:

(1) 1.5 Mark:

$$\because eirp|_{dBW} = P_T|_{dBW} + G_T|_{dB}$$

$$\because P_T|_{dBW} = 10 \log 200 \times 10^{-3}$$

$$= -6.989 \ dB$$

$$\therefore eirp|_{dBW} = -6.989 + 18.9$$

$$\therefore eirp|_{dBW} = 11.91 \ dBW$$

(2) 1.5 Mark:

$$\because L|_{dB} = 32.5 + 20 \log f|_{MHz} + 20 \log d|_{km}$$

$$= 32.5 + 20 \log 11.7 \times 10^3 + 20 \log 38000$$

$$\therefore L|_{dB} = 205.45 \ dB$$

(3) 1.5 Marks:

$$\because \left.\frac{P_R}{P_T}\right|_{dBW} = G_T\big|_{dB} + G_R\big|_{dB} - L\big|_{dB}$$

~~$\therefore P_R\big|_{dBW} = -0\,6.989\,[18.9 + 50 - 205.45]$~~

~~$\therefore P_R\big|_{dBW} =$~~

$$\therefore P_R\big|_{dBW} = P_T\big|_{dB} + G_T\big|_{dB} + G_R\big|_{dB} - L\big|_{dB}$$

$$= -6.989 + 18.9 + 50 - 205.45$$

$$\therefore P_R\big|_{dBW} = -143.53\,dBW$$

(4) 1.5 Mark:

$$\therefore M = \frac{G_R|_{dB}}{T|_K} = G_R - 10\log T$$

$$\therefore M = 50 - 10\log 1250 = 19.03\ dB/K$$

(5) 1.5 Mark:

$$\therefore P_N = N_o * BW$$

$$= KT * BW$$

$$= 1.38 \times 10^{-23} \times 1250 \times 100 \quad W$$

$$P_N = -177.6\ dB$$

6) 1.5 Mark:

$$\therefore \frac{C}{N_o} = \frac{P_R}{P_N} = -143.5 + 177.6$$

$$= 34.13\ dB\ HZ$$

$$\therefore \left.\frac{C}{N_o}\right|_{dB\,HZ} = 34.13$$

Fourth Question 15 Marks:

a) 10 Marks:

i- (3 Marks):

Dual Tone Multi Function dealing system (DTMF):

	f_1	f_2	f_3	f_4
f_1	①	②	③	A
f_2	④	⑤	⑥	B
f_3	⑦	⑧	⑨	C
f_4	*	⓪	#	D

Each digit is sent using pair of required frequency group:

$\therefore f_1 = 1209$ HZ

$f_2 = 1336$ HZ

$f_3 = 1477$ HZ

$f_4 = 1633$ HZ

advantages;

1- Reliability is high

2- Low Cost

3- Use only 8 frequency instead of 16 frequency.

II- 3 Marks;

Transmission Impairments:

① signal attenuation; the preferred acoustic-to-acoustic loss < 8 dB

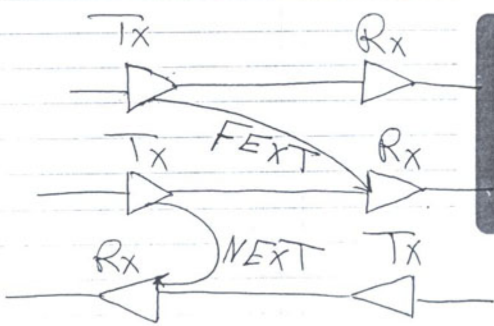
2- Noise:

- White Gaussian Noise due to thermal noise in electrical Components.
- Impulse noise; due to transients in electromechanical switching offices or from rotary dial telephones.
- Quantization noise; due to the digital voice channels.

3- Cross talk (XT):

there are two forms

- NEXT
- FEXT



4- Distorsion; due to the attenuation in the channel is not constant for all frequency.

5- Echo; talk and hear yourself after certain time:

There are two types

- Talker Echo
- listner Echo

III - International Numbering:

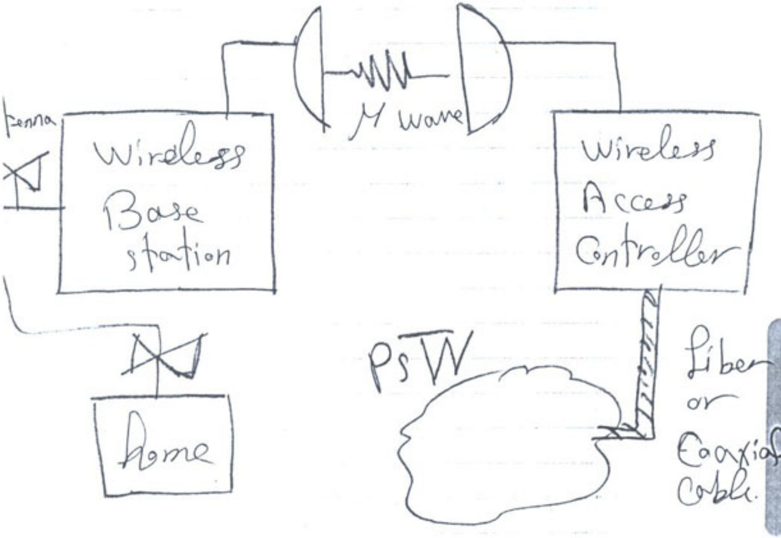
2 Marks

Prefix	Zone Code	Country Code	Trunk Code	Local Exchange code	Sub. No.

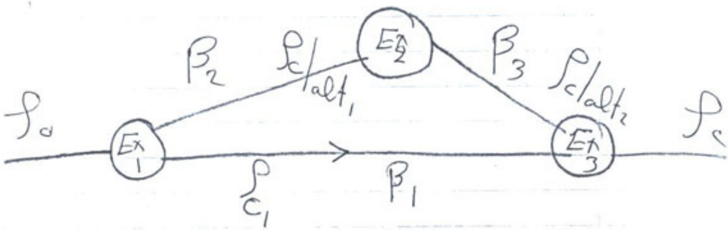
← 12 digit →

IV- 2 Marks;

Wirless local loop (WLL)



b) 5 Marks



$$\therefore f_{c_1}\Big|_{Hi} = f_0\,(1-\beta_1)$$

$$f_c\Big|_{alt_1} = f_b\Big|_{Hi}\,(1-\beta_2)$$

$$= f_0\,\beta_1\,(1-\beta_2)$$

$$\therefore f_c\Big|_{alt_2} = f_c\Big|_{alt_1}\,(1-\beta_3)$$

$$= f_0\,\beta_1\,(1-\beta_2)(1-\beta_3)$$

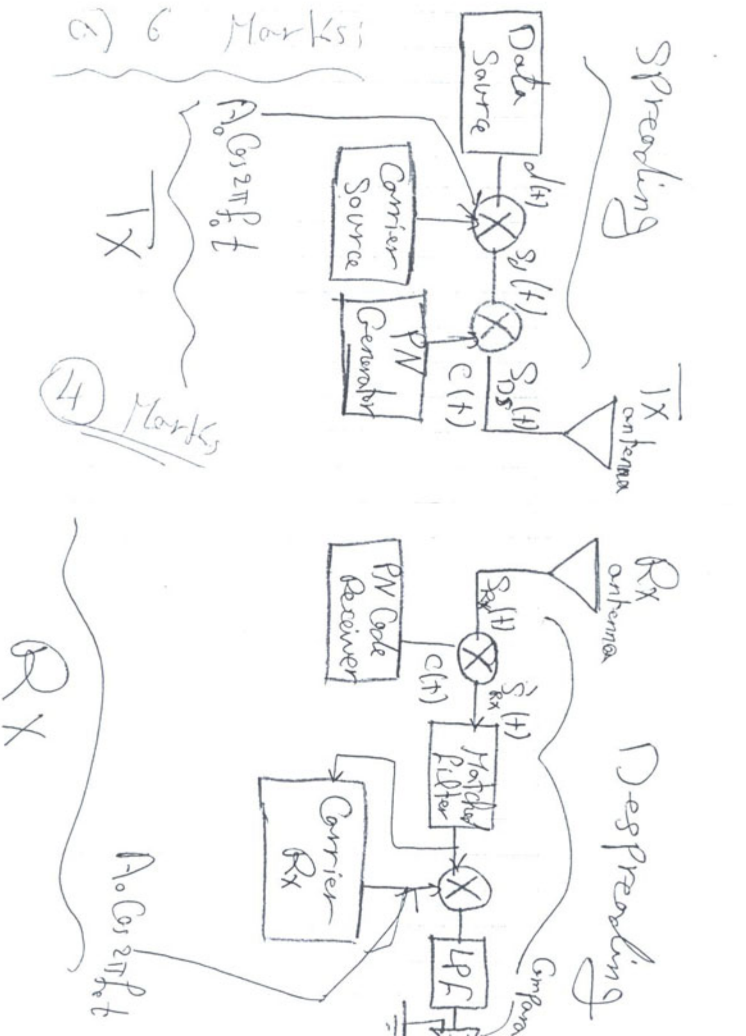
$$\therefore f_c\Big|_{total} = f_0(1-\beta_1) + f_0\,\beta_1(1-\beta_2)$$

$$+ f_0\,\beta_1(1-\beta_2)(1-\beta_3)$$

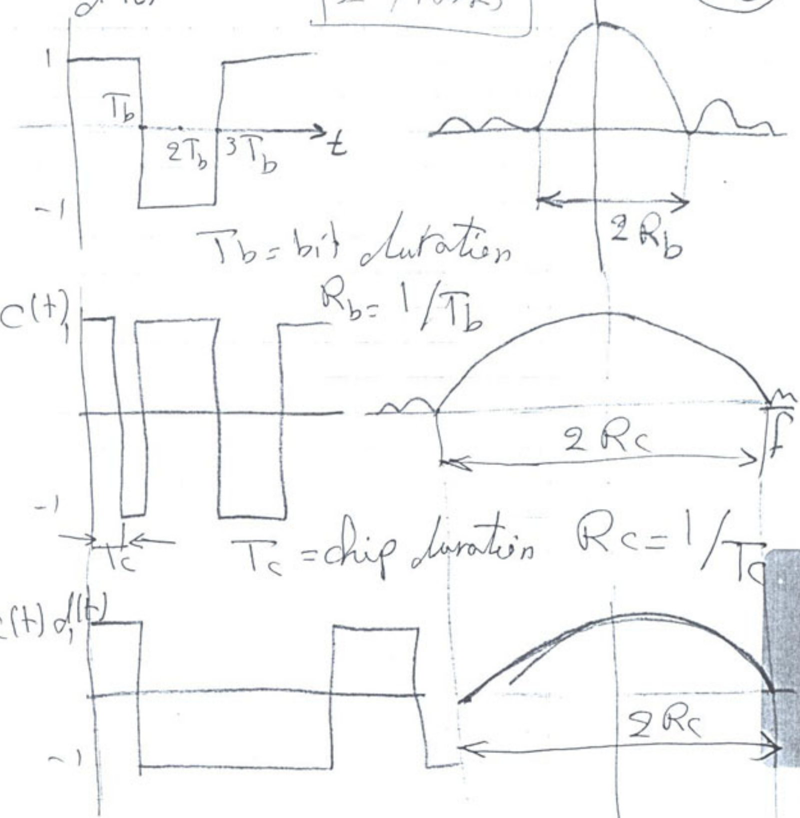
$$= f_0\,(1-\beta_t)$$

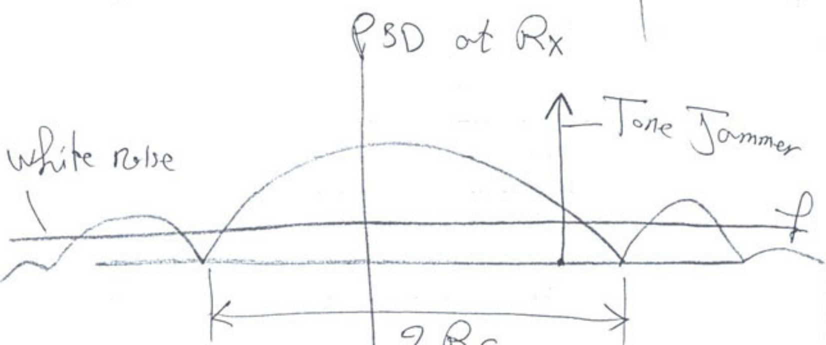
Fifth Question 10 Marks

a) 6 Marks:



2 Marks


d(t)
PSD
1
-1
T_b
$2T_b$
$3T_b$
t
$2R_b$
T_b = bit duration
$R_b = 1/T_b$
c(t)
1
-1
$2R_c$
f
T_c
T_c = chip duration $R_c = 1/T_c$
c(t) d(t)
1
-1
$2R_c$


PSD at Rx
Tone Jammer
white noise
f
$2R_c$

b) 4 Marks;

i- 1 Mark:

The number of hops/sec $= 3 \times 25 \times 10^3$

$\therefore$ The No. of hops $= 75000$ hops/sec

ii- 1 Mark;

$\because$ Processing Gain $= PG = \frac{R_c}{R_b}$

$\because R_c = 20 \times 10^6$ HZ

$R_b = 5$ HZ

$\therefore$ ~~PG~~ =

$\therefore PG = \frac{20 \times 10^6}{5}$

$\therefore PG = 4 \times 10^6$

iii - 1 Mark;

∵ The prob. of error/hop

$$= P_{e/h} = \frac{1}{2} e^{-\frac{E_b/3}{2N_o}}$$

$$P_e\Big|_{FFHSS} = 3 P_{e/h}^2 (1 - P_{e/h}) + P_{e/h}^3$$

$$\because \frac{E_b}{N_o} = 21 \ dB$$

$$\therefore \frac{E_b/3}{2N_o} = \frac{1}{6} \frac{E_b}{N_o} = \frac{1}{6} * 21 = 3.5 dB$$

$$\therefore P_{e/h} = \frac{1}{2} e^{-3.5}$$

$$\therefore P\Big|_{e/h} = 0.015$$

$$\therefore P_e\Big|_{FFHSS} = 3(0.015)^2(1 - 0.015) + (0.015)^3$$

$$\therefore P_e\Big|_{FFHSS} = 6.68 \times 10^{-4}$$

iv - 1 Mark :

The prob. of error with 200 other FFH-SS users is :

$$P_e\Big|_{FFHSS} = 6.68 \times 10^{-4} * 200$$

$$P_e\Big|_{FFHSS} = 0.1336$$