Paper Number(s): **E4.03**
AS5
SO10
ISE4.3

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE
UNIVERSITY OF LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2001

MSc and EEE/ISE PART IV: M.Eng. and ACGI

MOBILE RADIO COMMUNICATION

Tuesday, 8 May 10:00 am

There are SIX questions on this paper.

Answer FOUR questions.

Time allowed: 3:00 hours

Corrected Copy

Examiners: Gurcan,M.K. and Mamdani,E.H.

Special instructions for invigilators:	None
Information for candidates:	None

1. a) A radio system, with the transmitter and receiver antenna heights 143 m above a flat reflecting surface, operates at 900 MHz and the distance between the two antennas is 10 km. The received signal area-mean power, $P_{am}(R)$, is given by [6]

$$P_{am}(R) = P_{FSR}(R)\left|1 - \exp(j\Delta\phi)\right|^2$$

where $\Delta\phi$ is the phase difference caused by the path difference between the direct and reflected signals, and $P_{FSR}(R)$ is the free-space received signal power. What is the ratio of the received signal area-mean power to free-space power?

b) Prove that in the 2-ray ground reflection model shown in Figure 1, the path-length difference is approximately equal to $2\dfrac{h_t h_r}{d}$. [6]

c) In a narrow-band cellular radio system, the transmitter and receiver antenne have heights of 40 m and 3m respectively. The cell radius is 2 km. The system transmits at 1800 MHz. If the received free-space power at a reference distance $d_0 = 1\,\text{km}$ is equal to 1 microwatt, what is the area-mean power at the cell boundary? [6]

d) In the radio system described in part (b), the total interfering signal area-mean power at the cell boundary is measured to be 0.07 microwatt. What is the cluster size of the radio system? [7]

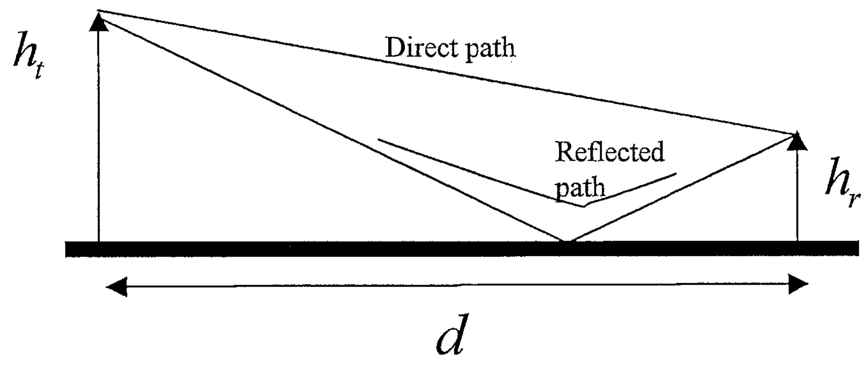

Figure 1: 2 ray ground reflection model.

2. a) Explain how the Rayleigh and shadowing fading margins are incorporated into the link budget analysis for a narrow-band radio system. [6]

b) For the knife-edge geometry in Figure 2.a, show that the Fressnel-Kirchoff diffraction parameter is [6]

$$\upsilon = \alpha\sqrt{\frac{2\,d_1\,d_2}{\lambda(d_1 + d_2)}},$$

where λ is the wavelength, $\phi = \frac{\pi}{2}\upsilon^2$, and $d_1, d_2 >> h$, and also $h >> \lambda$.

c) Given the geometry shown in Figure 2.b, and using the diffraction gain $G_d(dB) = 20\log\left(\frac{0.225}{\upsilon}\right)$, determine the loss due to knife-edge diffraction. for $\lambda = 1/3$ m. [7]

d) Transmissions from a base station to a mobile are obstructed by a building of height $h = 15$ m above the line joining them. The distance between the transmitter and the building is 7.5 km. Assuming that the transmission wavelength is $\lambda = 0.1$ m and the receiver is 2.5 km away from the building, calculate the diffraction loss using the approximate gain equation $G_d(db) = 20\log_{10}\left(0.4 - \sqrt{0.1184 - (0.38 - 0.1\upsilon)^2}\right)$. [6]

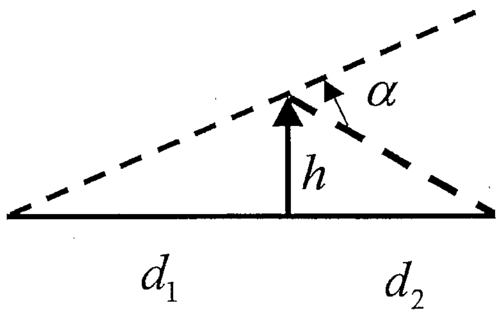

Figure 2.a: Knife edge geometry for problem 2.b.

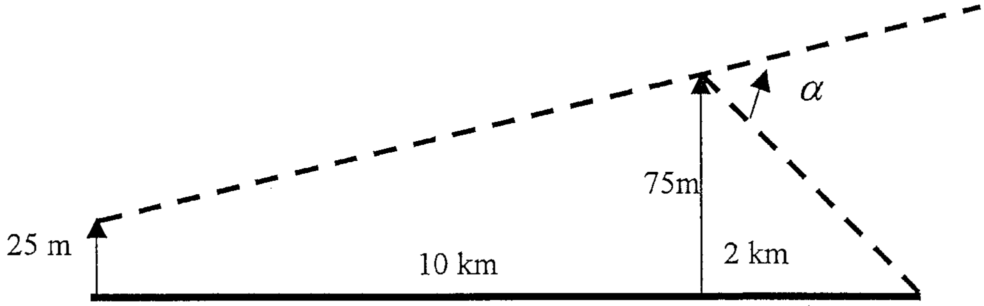

Figure 2.b: Diffraction Model for problem 2.c.

3. a) A narrow-band mobile radio system transmits at 1800 MHz. Assuming that the mobile receiver travels at a steady speed of $V = 6$ m/s, calculate the average duration of the fades (ADF) for the threshold level $R_0^2 = 0.01$, using the normalised ADF curve given in Figure 3. [6]

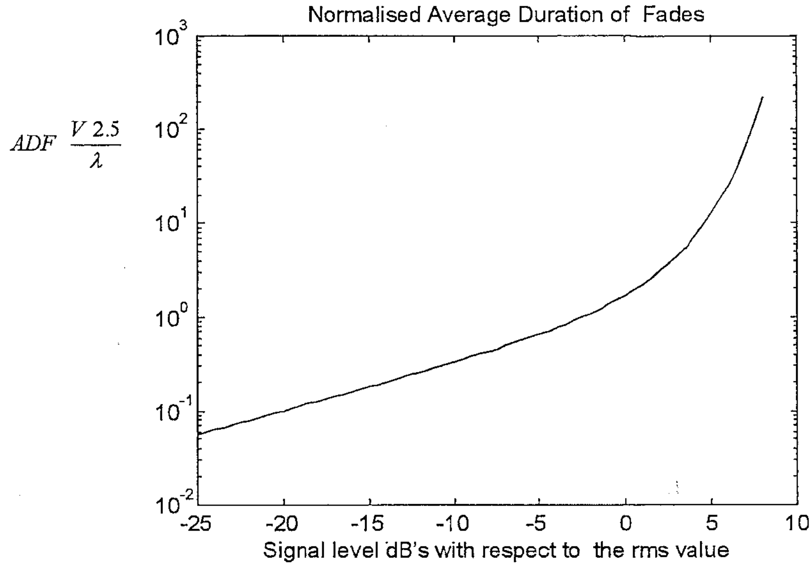

Figure 3 Normalised ADF diagram

b) In a narrow-band radio system, the probability of success is given by $\Pr(P_i(R) \geq x\,6P_{am}(D))$, where $P_i(R)$ is the power of Rayleigh fading received signal and $P_{am}(D)$ is the area-mean power of the interfering signal at a point that is D metres away from its transmitter. What is the protection ratio, x, if the cluster size is 19 and the probability of success is 0.97? [7]

c) In a narrow-band mobile radio system transmissions are at 875 MHz and the mobile receiver travels at a steady speed of 3 m/s. The ADF is measured to be 4.57 ms at a set threshold of $10\log_{10} R_0^2$. Using Figure 3, determine [6]

i) the value of the threshold,

ii) the probability of successfully receiving signals above this threshold.

d) Describe the meaning of following terms: [6]

i) level crossing rate,

ii) Rayleigh fading and shadowing margins,

iii) Fresnel zone circles.

4. a) In a wide-band mobile radio system, the receiver operates satisfactorily at a signal-to-noise ratio of 12 dB. The average equaliser gain is measured to be -3 dB at the cell boundary. What is the cluster size? [6]

b) Describe [6]

i) the characteristics of a wide-band mobile radio channel,

ii) the operating principles of wide-band radio receivers in the Global Systems Mobile (GSM) system,

iii) how equaliser coefficients are calculated using the training sequences contained in the normal bursts encountered in GSM.

c) Describe the meaning of following terms: [7]

i) linear equaliser,

ii) decision-feedback-equaliser,

iii) Viterbi equaliser,

iv) channel impulse response,

v) equaliser correlation matrix,

vi) equaliser mean-square-error.

d) A data block of 736 bits is to be transmitted over a radio channel. A cyclic (228,184) Fire code is used to generate parity-check bits. The resultant data is fed to a rate ½ convolution encoder. A block interleaver is used to process the encoded data and to produce sub-blocks of length 114 bits. One sub-block is transmitted every 4 msec. Calculate the minimum expected delay involved in transmitting 736 bits of data. [6]

5. a) In a mobile radio system, the cell radius is 500 metres and there are 768,000 mobile users in an area of 2 km^2 , and 90 percent of the mobile users are active during a 24 hour period. A slotted Aloha system with packet duration of 0.1 second is used for the access control. Determine [7]

i) the call arrival rate per slot,

ii) the probabilities of having zero, one or two (or more) new packet arrivals during a single slot period.

b) In connection with a Deferred-First Transmission slotted Aloha system, [12]

i) describe how the optimum offered load is estimated so as to achieve maximum throughput,

ii) explain the meaning of the following terms:

(1) real number of back-logged users,

(2) estimated number of back-logged users,

(3) the drift of real number of back-logged users,

(4) the drift of estimated number of back-logged users,

(5) the joint drift term,

iii) explain how the system is stabilised by means of a joint-drift equation.

c) A common radio link is used by four groups of users in a mobile radio system. Given that average bit rates for the four groups are: 10, 12.5, 17.5 and 20 kbit/s, packets are of size of 125 bits and each user transmits on average one packet per second what is the total data rate for the common channel? [6]

6. a) In connection with the Global Systems Mobile (GSM) radio system, explain [11]

i) how the logical control channels are multiplexed over the physical channel,

ii) how the home and visitors' location registers are used to keep track of mobile users,

iii) how the broadcast and common control channels are used to initiate handover and access control,

iv) what measurements are taken by both the mobile unit and the base station before the hand-over decisions are made.

b) In connection with the third generation wideband UTRA/FDD radio system, describe

i) the physical layer structure, paying particular attention to: [7]

- the key radio system parameters,
- transport channels, including the broadcast-control channel, the paging channel, the forward access channel, the random access channel, the synchronisation channel and the dedicated channel;

ii) the frame structure, paying particular attention to [7]

- the uplink DPCCH / DPDCH frame structure,
- orthogonal variable spreading factor codes.

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MODEL ANSWER and MARKING SCHEME

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1-a) $R = 10^4 m$, $h_1 = h_2 = 143\ m$, $\Delta\phi = \beta \Delta R = \frac{4\pi h_1 h_2}{\lambda R}$

$$\lambda = \frac{3.10^8}{9.10^8} = 0.33 m$$

$$\Delta\phi = \frac{4\pi . (143)^2}{0.33 . 10^4} = 77.87 \text{ radians}$$

$$\frac{P_{am}(R)}{P_{FSR}(R)} = |1 - \exp(j\Delta\phi)|^2$$

$$= |1 - \cos(77.87) - j \sin(77.87)|^2$$

$$= |1 + 0.784 - j\ 0.623|^2$$

$$= (1.784)^2 + (0.623)^2 = 3.57$$

—///—

1-b

$$d_1 = \sqrt{d^2 + (h_t - h_r)^2} \quad , \quad d_2 = \sqrt{d^2 + (h_t + h_r)^2}$$

$$d_2 - d_1 = d\sqrt{1 + \frac{(h_t + h_r)^2}{d^2}} - d\sqrt{1 + \frac{(h_t - h_r)^2}{d^2}}$$

$$= d\left(1 + \frac{(h_t + h_r)^2}{2d^2}\right) - d\left(1 + \frac{(h_t - h_r)^2}{2d^2}\right)$$

$$= \frac{1}{2d}\left((h_t + h_r)^2 - (h_t - h_r)^2\right)$$

$$= \frac{1}{2d}\left(h_t^2 + 2h_t h_r + h_r^2 - h_t^2 + 2h_t h_r - h_r^2\right)$$

$$\boxed{d_2 - d_1 = 2\frac{h_t h_r}{d}}$$

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1.c

$$P_{am}(R) = P_{FSR}(d_0)\left(\frac{d_0}{R}\right)^2 \cdot \left(\frac{4\pi}{\lambda} \frac{h_1 h_2}{R}\right)^2$$

$$P_{am}(R) = P_{FSR}(d_0) \cdot (d_0)^2 \left(\frac{4\pi}{\lambda}\right)^2 \frac{h_1^2 \cdot h_2^2}{R^4}$$

$d_0 = 1\ km = 10^3\ m$

$P_{FSR}(d_0) = 1 \cdot 10^{-6}\ W$

$R = 2 \cdot 10^3\ m$

$$\lambda = \frac{3 \cdot 10^8}{18 \cdot 10^2 \cdot 10^6} = \frac{3}{18} = 0.166\ m$$

$h_1 = 40m$, $h_2 = 3m$

$$P_{am}(R) = 10^{-6} \cdot (10^3)^2 \left(\frac{4\pi}{0.166}\right)^2 \frac{(40)^2 \cdot (3)^2}{(2 \cdot 10^3)^4}$$

$= 5.1576$ micro watt

1.d

$$\frac{P_{am}(R)}{6 \cdot P_{am}(D)} = \frac{5.1576 \cdot 10^{-6}}{7 \cdot 10^{-8}} = 73.6797$$

$$\frac{3N^2}{2} = 73.6797$$

$$N^2 = 49.1198$$

$$\boxed{N = 7}$$

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2.a

$$P_i(R) = P_{am}(R) \cdot R_o^2 \, |F(v)|^2$$

$$P_i(R) = P_{am}(d_o)\left(\frac{d_o}{R}\right)^4 R_o^2 \, |F(v)|^2$$

$$P_{am}(d_o) = \frac{P_T}{P_L(d_o)}$$

$$P_i(R) = \frac{P_T}{P_L(d_o) \cdot \left(\frac{R}{d_o}\right)^4 \frac{1}{R_o^2} \frac{1}{|F(v)|^2}} = \frac{P_T}{P_L(R)}$$

$$P_L(R) = P_L(d_o)\left(\frac{R}{d_o}\right)^4 \frac{1}{R_o^4} \frac{1}{|F(v)|^2}$$

Take logarithm

$$P_L(R) = P_L(d_o) + 10\log_{10}\left(\frac{R}{d_o}\right)^4 - \underbrace{10\log_{10} R_o^2}_{\text{Rayleigh Fading Margin}} - \underbrace{10\log_{10}|F(v)|^2}_{\text{shadowing loss.}}$$

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MODEL ANSWER and MARKING SCHEME

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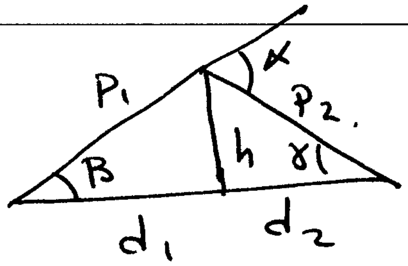
2.b)



$$d_1+d_2 = \sqrt{P_1^2-h^2} + \sqrt{P_2^2-h^2} = P_1\sqrt{1-\sin^2\beta} + P_2\sqrt{1-\sin^2\gamma}$$

$$= P_1\sqrt{\left(1-\frac{\sin^2\beta}{2}\right)^2} + P_2\sqrt{\left(1-\frac{\sin^2\gamma}{2}\right)^2}$$

$$= P_1\left(1-\frac{\sin^2\beta}{2}\right) + P_2\left(1-\frac{\sin^2\gamma}{2}\right)$$

$$= P_1+P_2 - P_1\cdot\frac{\sin^2\beta}{2} - P_2\cdot\frac{\sin^2\gamma}{2}$$

$$= P_1+P_2 - \frac{h}{2}\cdot\sin\beta - \frac{h}{2}\sin\gamma$$

$\therefore$

$$\Delta = P_1+P_2-d_1-d_2 = \frac{h}{2}(\sin\beta+\sin\gamma)$$

$$= \frac{h}{2}\left(\frac{h}{d_1}+\frac{h}{d_2}\right)$$

as $\sin\beta = \tan\beta = \frac{h}{d_1}$, $\sin\gamma = \frac{h}{d_2} = \tan\alpha$

$$\Delta : \frac{h^2}{2}\left(\frac{1}{d_1}+\frac{1}{d_2}\right) = \frac{h^2}{2}\frac{(d_1+d_2)}{d_1\cdot d_2}$$

—///—

$\tan\alpha = \alpha$, also $\alpha = \beta+\alpha$

$$\therefore \quad \alpha = \frac{h}{d_1}+\frac{h}{d_2} = \frac{h(d_1+d_2)}{d_1\cdot d_2}$$

$$h = \alpha\cdot\frac{d_1\cdot d_2}{d_1+d_2}$$

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$$\Delta = \frac{h^2}{2} \cdot \frac{d_1 + d_2}{d_1 \cdot d_2} = \frac{\alpha^2}{2}\left(\frac{d_1 \cdot d_2}{d_1 + d_2}\right)^2 \cdot \frac{d_1 + d_2}{d_1 \cdot d_2}$$

$$\Delta = \frac{\alpha^2}{2} \frac{d_1 \cdot d_2}{d_1 + d_2}$$

$$V = \sqrt{\frac{4\Delta}{\lambda}} \quad \text{as} \quad \phi = \frac{2\pi}{\lambda} \cdot \Delta = \frac{\pi}{2} \cdot V^2$$

$$V = \alpha \sqrt{\frac{2}{\lambda} \cdot \frac{d_1 \cdot d_2}{d_1 + d_2}} = h \cdot \sqrt{\frac{2}{\lambda} \frac{d_1 + d_2}{d_1 \cdot d_2}}$$

2.c

$$\beta = \tan^{-1}\left(\frac{75-25}{10000}\right) = 0.2865^\circ$$

$$\gamma = \tan^{-1} \frac{75}{2000} = 2.15^\circ$$

$$\alpha = \beta + \gamma = 2.434^\circ = 0.0424 \text{ rad.}$$

$$V = 0.0424 \sqrt{\frac{2}{1/3} \frac{10000 \times 2000}{10000 + 2000}} = 4.24$$

$$G_d\,(dB) = 20 \log\left(\frac{0.225}{V}\right) = -25.5 \text{ dB.}$$

$$\boxed{G_d\,(dB) = 25.5 \text{ dB.}}$$

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2.d)

$$v = h\sqrt{\frac{2}{\lambda} \cdot \frac{d_1+d_2}{d_1 \cdot d_2}}$$

$$= 15\sqrt{\frac{2}{0.1} \frac{7500+2500}{7500 \cdot 2500}} = 1.549.$$

$$G_d(dB) = 20\log\left(0.4 - \sqrt{0.1184 - (0.38 - 0.1v)^2}\right)$$

$$= 20\log\left(0.4 - \sqrt{0.1184 - (0.38 - 0.1549)^2}\right)$$

$$= -17\ dB$$

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Q3 a)

$R_o^2 = 0.01$

$10 \log_{10} R_o^2 = -20$ dB

$\frac{V \cdot 2.5}{\lambda} \cdot ADF = 9.10^{-2}$

$ADF = \frac{9.10^{-2}}{V} \cdot \frac{\lambda}{2.5} = \frac{9.10^{-2}}{6 \times 2.5}$ 0.166

ADF = 1 ms

—//—

Q3. b)

$$P(P_i(R) > x P_{am}(D)) = \int_{x P_{am}(D)} f(P_i(R))\, dP_i$$

$$f(P_i(R)) = \frac{1}{P_{am}(R)} \exp\left(-\frac{P_i(R)}{P_{am}(R)}\right)$$

$$P_r(P_i(R) > x\, 6 P_{am}(D)) = \int_{x \cdot 6 P_{am}(D)} \frac{1}{P_{am}(R)} \exp\left(-\frac{P_i(R)}{P_{am}(D)}\right) dP_i$$

$$= \exp\left(-x \frac{6 P_{am}(D)}{P_{am}(R)}\right)$$

$$\exp\left(-x \cdot \frac{6 P_{am}(D)}{P_{am}(R)}\right) = 0.97$$

$$x = -\ln 0.97 \times \frac{P_{am}(R)}{6 P_{am}(D)}$$

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$$\frac{Pam(R)}{6\,Pam(D)} = \frac{3N^2}{2}.$$

$N = 19$

$$X = -\ln 0.97 \times \frac{3N^2}{2}$$

$$\boxed{X = 16.5}$$

Q3-c)

ADF = 4.57 msec

$c = 3.10^8$ m/s, $V = 3$ m/s, $\lambda = \frac{3.10^8}{875.10^6} = 3.429$ m

$$\frac{\lambda}{V.\,2.5} = 0.0457 = 45.7\,10^{-3}$$

$$ADF \times \frac{V.\,2.5}{\lambda} = \frac{4.57 \,.\, 10^{-3}}{45.7\,10^{-3}} = 0.1$$

From figure 3

$ADF \cdot \frac{V.\,2.5}{\lambda} = 0.1$ gives $\boxed{R_0^2 = 0.01}$

$$Prob(success) = \exp(-R_0^2) = \exp(-0.01)$$

$$= 0.99.$$

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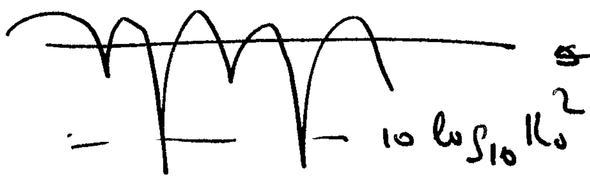
Q-3d

Level crossing Rate = LCR



Number of crossings per second = LCR

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$$\text{Path loss} = P_L(d_0)\left(\frac{d_0}{R}\right)^4 R_0^2 \cdot |F(v)|^2$$

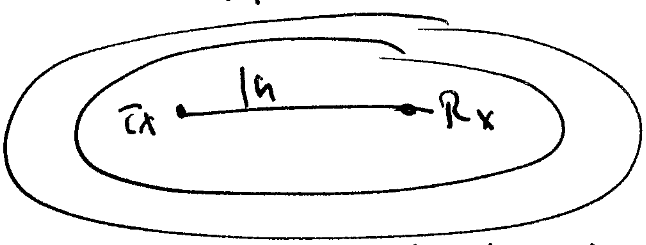
in dB

$$\text{Path loss} = P_L(d_0)_{dB} + 40\log_{10} d_0 - 40\log_{10} R + 10\log_{10} R_0^2 + 10\log_{10}|F(v)|^2$$

$$\text{Rayleigh Fading Margin} = -10\log_{10} R_0^2$$

$$\text{Shadowing Margin} = -10\log_{10}|F(v)|^2$$

—///—



Loss around an obstruction is related to Fresnel zones. They represent successive regions where secondary waves have a path length from transmitter to receiver which are $n\lambda/2$ greater than the total path length of a line of sight path.

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Q4 a)

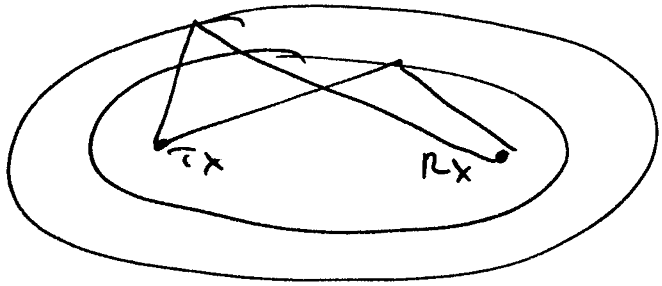
SNR = 15 dB

$10^{15/10} = 31.622$

$\frac{3N^2}{2} = 31.622$, $N^2 = 21.08$

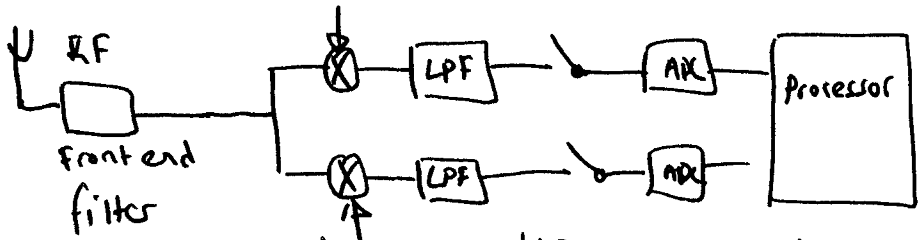
$\therefore N = 4.59$ nearest cluster size $\boxed{N = 7}$

Q.4 b)



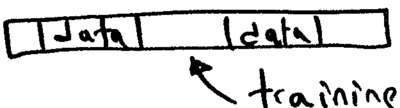
i.) Assume that Tx and Rx are placed at the foci of concentric elipses. At the receiver, multiple reflections arrive with different delays. Due to excess delay, the channel impulse response lasts several bit periods.

ii.)



A brief description of this block diagram is required.

iii) Normal burst for GSM is shown below



The training sequence is correlated with tx training sequence. Channel impulse response is extracted and used to obtain coefficients for the equaliser.

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Q4 c)

i.) Linear equaliser: A feed forward filter coefficients of which are calculated using optimum filter theory equations.

ii) Decision Feedback Equaliser: A digital filter with feedback and feedforward filter used to remove intersymbol interference from received signals.

iii) Viterbi Equaliser: A maximum likelihood receiver used to deal with intesymbol interference.

iv.) Channel impulse response: the response of the radio channel when the excitation function is a impulse.

v) Equaliser correlation matrix: signal samples are correlated with the transmitted desired signal samples and correlation coefficients are used to produce a matrix.

vi) Equaliser mean square error: mean value of the difference square of the signals corresponding to the desired and equalised signals.

Q4 d)

$$\frac{736}{184} = 4$$

$$4 \times 228 = 912$$

$$912 \times 2 = 1824$$

$$\frac{1824}{114} = 16$$

$$16 \times 4 = 64$$

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Q5.a)

$R = 500$, $N = 768000$ in $2\ km^2$

$N = 384000$ per km^2

Area $= \pi R^2 = \pi . (0.5)^2 = 0.7854$

Total number $= 301593$

Active users over an hour $= \dfrac{0.9 \times 301593}{24}$

$= 11309.7$

Call arrival rate per second $= \dfrac{11309.7}{3600} = 3.1416$

Normalised call arrival rate per slot $= 0.31416$

$P(z_0) = \exp(-0.31416) = 0.73$

$P(z_1) = 0.31416 \times \exp(-0.31416) = 0.2249$

$P(z_c) = 1 - 0.73 - 0.2294 = 0.04065$

Q5.b i)

$P(z_1) = S =$ probability of success = throughput

$P(z_1) = G . \exp(-G)$

$\dfrac{dS}{dG} = 0$, $G = 1$ = optimum offered load.

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Q.5.b)

ii)

(1) Real Number of back-logged users: Number of users in the back-logged states in Slotted Aloha Systems.

(2.) Estimated Number of back-logged users: estimation of real number of backlogged users.

(3) Drift of real number of back logged users = $dn = \lambda - G.\exp(-G)$.

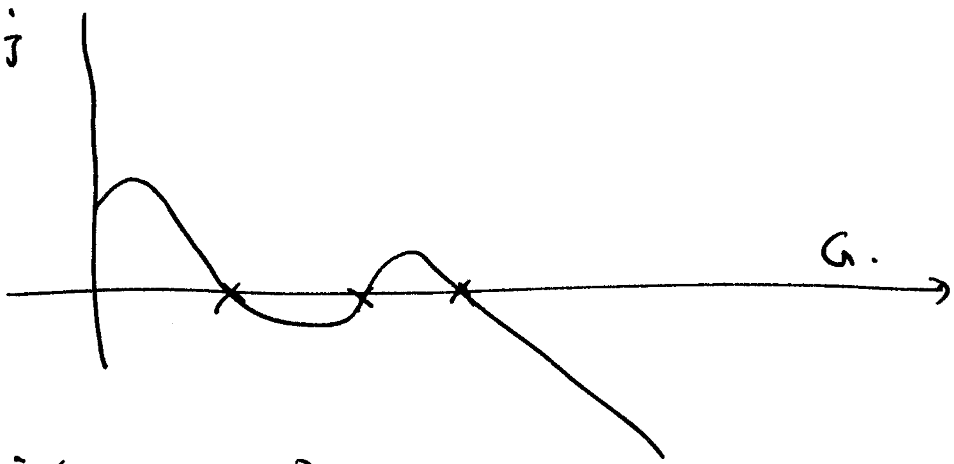
(4.) Drift of the estimated number of back-logged users. $= ds$

$$ds = u_0 P(z_0) + u_1 P(z_1) + u_c \cdot P(z_c)$$
$$= u_0 \cdot \exp(-G) + u_1 G \exp(-G) + u_c (1 - \exp(-G) - G.\exp(-G))$$

(5.) Joint drift $= d\bar{J}$

$$\boxed{d\bar{J} = dn - G.ds.}$$

iii



$d\dot{j}(G=0) = \lambda.$

$\lim_{G \to \infty} d\dot{j}(G) = -\infty$

$\therefore$ $d\dot{j}$ has at least one, at most three roots. Roots with positive going slopes are the settling points. In order to avoid bistable operation. we must have one root with positive going slope at the optimum operating point.

—///—

c) Total arrival rate

$10 + 12.5 + 16.5 + 20 = 59$ kbps.

$\frac{50 \cdot 10^3}{125} = 472$ packets per second.

472 user sharing the link.

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MODEL ANSWER and MARKING SCHEME

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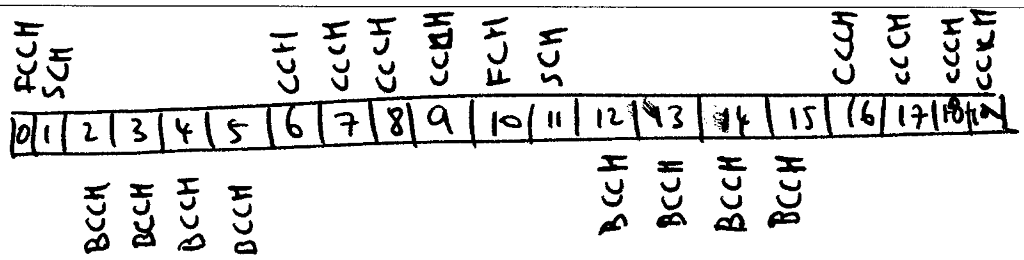
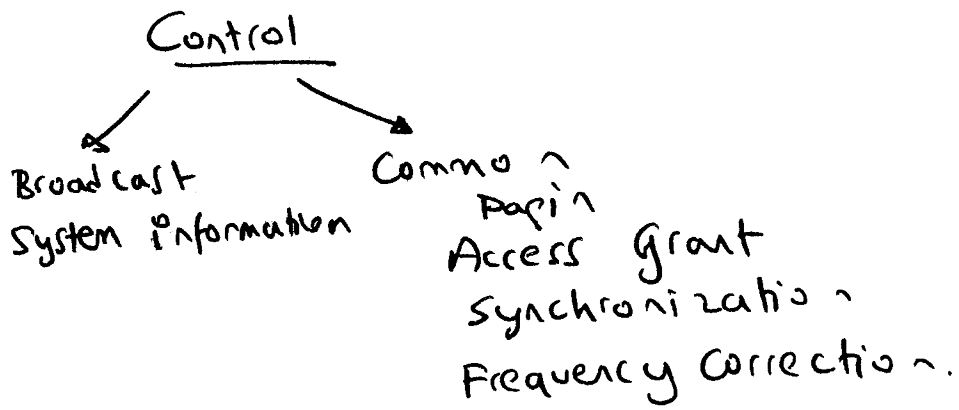
Q.6.a)

(i)





ii.) **Home location Register:** keeps user information and knows in which VLR the mobile is.

Visitor Location Register = keeps the mobile information about its current status and position.

iii.) Broadcast channel information is used to transmit system information. Mobiles use system information to determine received signal strength from adjacent cells. Slow associated control channel is used to transmit information between the mobile and base stations.

Common control channels are used to provide paging and random access channels.

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MODEL ANSWER and MARKING SCHEME

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Q6b) i

UTRA/FDD key system parameters

Based on 5MHz W-CDMA with a basic chip rate 4.096 Mchips/s corresponding to a bandwidth of appoximately 5MHz. Higher chip rates 8.192 and 16.384 Mchips/s are also specified. Basic frame length is 10 ms. WCDMA carriers are located on a 200 kHz grid with carrier spacing in the range 4.2-5.0 MHz

Transport channels: are the services offered by the W-CDMA physical layer to higher layers.

<u>Broadcast Channel</u>: A down link common transport channel used to broadcast system and cell specific information.

<u>Forward Access channel</u>: A down link common transport channel used to carry control information and short user packets to a mobile station the location cell of which is known to the system.

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MODEL ANSWER and MARKING SCHEME

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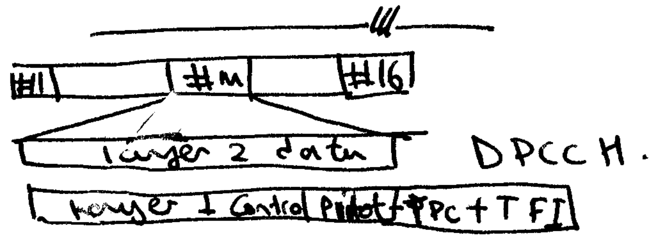
6.b i.) UTRA/FDD key system parameters: Based on 5MHz WCDMA with a basic chip rate 4.096 Mchips/s corresponding to a bandwidth of approximately 5MHz. Higher chip rates 8.192 and 16.384 Mchips/s are also specified. Basic frame length is 10ms. WCDMA carriers are located on a 200 kHz grid with carrier spacing in the range 4.2–5.0 MHz.

Transport channels: are the services offered by the W-CDMA physical layer to higher layers.

- Broadcast channel: A down link common transport channel used to broadcast system and cell specific control information.
- Forward Access Channel: A down link common transport channel used to carry control information and short user packets to a mobile station the location cell of which is known to the system.
- Paging channel: A down link common transport channel used to carry control information to a mobile station, the location cell of which is not know to the system
- Random Access Channel: A down link or uplink common transport channel used to carry control or user data

6-b(ii)



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MODEL ANSWER and MARKING SCHEME

First Examiner	M.K. GURCAN	Paper Code	E.4.03, AS5, SO10, ISE4.3
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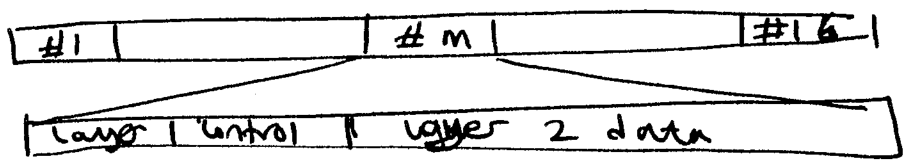
TPC = Transmit power control.

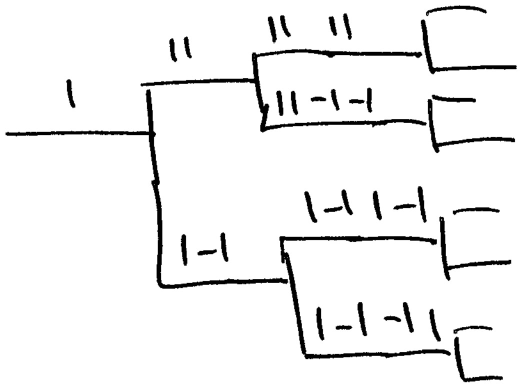
TFI = Transport format indicator.



Pilot+TPC+TFI

0.625 ms 20×2^k bits.

Frame structure for the down link dedicated physical channel.



OVSF codes