Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	WIRELESS AND MOBILE COMMUNICATION
COURSE CODE	:	BEB 41203
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

Q1 Based on the following cases:

(a) An average call lasts 200 seconds and there are 100 call attempts per minute. Calculate traffic intensity for a user, $\mathbf{A_u}$.

(2 marks)

(b) There are 400 mobile users in a particular cell. Each user makes a call attempt every 15 minutes, on the average. Each call lasts an average of 3 minutes. Calculate total traffic intensity, **A** generates in the cell.

(3 marks)

(c) A trunked cellular system (Blocked Call Delayed system) is expected to provide a Grade of Services (GOS) with probability of a call being delayed, P_r (Delay > 0) is 10%. Each cell is allocated with 50 channels. Determine total traffic intensity generated in the cell. (Refer **Figure Q1(c)** for Erlang C graph)

(2 marks)

(d) Based **Q1(c)**, calculate probability of a call being delayed for more than 5s when an average call duration is 2 minutes.

(3 marks)

Q2 Consider a trunked mobile system supporting 100 channels per cell. A call blocking probability of 1% is desired. Mobile users typically make a call once per 1 hour on the average. Their calls lasting an average of 1 minutes. The system is concentrated in an urban area with a density of 500 mobile users per km^2.

(a) Calculate the required cell radius to support the mobile users in the area if a hexagonal topology is assumed.

(4 marks)

(b) If the mobile users calls lasting of 4 minutes, on the average. Predict what happen to the cell size.

(6 marks)

Q3 The US Digital Celullar TDMA system uses a 60 kbps data rate to support three users per frame. Each user occupies two of the six time slots per frame. Assume each reverse channel frame contains six time slots with 324 bits per time slots, and within each time slot, assume there are 6 guards bits, 6 bits reserved for ramp-up, 28 synchronization bits, 12 control channel bits for supervisory control signals and 260 data bits.

(a) Explain why TDMA provides a higher capacity when compared to FDMA.

(5 marks)

(b) Determine the frame efficiency for the US Digital Cellular standard.

(5 marks)

Q4 **Figure Q4(a)** shows one cluster of 19-cell frequency reuse has been gone through a process of cell splitting to expand the mobile communication channel in a particular area. There are two different sizes of cell which are macrocell and microcell. Each cell supported a traffic intensity of 10E.

(a) Discuss two possible reasons of having different cell size in the local network topology as illustrated in **Figure Q4(a).** Explain the design strategy of the chosen reason.

(2 marks)

(b) Calculate the total traffic intensity that can be supported by the system before and after the cell splitting.

(6 marks)

(c) The total number of user that can be supported by the system after the cell splitting if the traffic intensity per user Au is 0.01.

(2 marks)

Q5 An engineer is assigned to deploy a GSM cellular communication in a rural area has an area of 1594.32km^2 with current population 2 million residents. The GSM cellular network is served by 5MHz spectrum with a duplex channel bandwidth of 20kHz operates at frequency 2100MHz. **Figure Q5** shows the topology of hexagonal cells deployed in the area. Consider for forward link Free Space Propogation Loss (FSPL) model:

(a) Calculate FSPL (in dB) at distance d=1km from the base station (BS).

(4 marks)

(b) Calculate the power received signal at mobile station at d=1km form the BS.

(2 marks)

(c) If the minimum received signal strength (RSS) at the edge of the hexagonal cell is -75dBm, calculate the optimum radius, R of the cell.

(6 marks)

(d) Conclude your findings in **Q5(b)** and **Q5(c)** related to large scale propagation loss.

(4 marks)

(e) If the requirement of co-channel interference ratio, S/I is 7.5dB, prove that the minimum cluster size is N=12

(4 marks)

(f) Based on answer in **Q1(c)** and **Q1(e),** calculate the number of clusters need to cover the area.(Hint: An area of hexagon cell is 2.598R^2)size,

(4 marks)

(f) Based on answer in **Q1(d),** calculate the traffic intensity in Batu Pahat area based on the grade of service (GoS) =2% of probability of blocking. Refer to **Figure Q5(f)** for Erlang B table

(4 marks)

(g) Calculate the number of users that can be served in the area, if each user is predicted to make 3 calls per hour with average holding time of 2 minutes

(2 marks)

(h) Criticise whether the answer obtained in **Q1(f)** is in line with the actual population in the metropolitan area.

(2 marks)

(i) Suggest **TWO(2)** possible techniques that can be taken by the telcos to further improve the capacity on the network.

(2 marks)

Q6 Antenna tower of **BS1, BS2** and **BS3** are placed in different areas as the following:

BS1: KLCC, Kuala Lumpur (Urban area)
BS2: Clearwater Sanctuary Golf Resort, Alor Gajah (Open area)
BS3: Kampung Parit Kuda, Semerah, Batu Pahat (Suburban area)

Assume all base stations (BS) cover the same size of cell that transmit radio signal at 950MHz. The height of each BS and Mobile station (MS), which each has the same electrical parameters at all areas, is 200m and 3m. Consider where a MS is located at 5km away from BS at all three different areas correspondingly. (Assume a unity gain receiving antenna)

(a) Analyze the median path loss at the receiver in the **THREE(3)** different areas using Okumura Model. (refer to **Figure 6(a)** and **Figure 6(b)** for median attenuation and correction factor graph accordingly)

(10 marks)

(b) Evaluate the answer in **Q6(b)** in term of median path loss in different type of environment based on possible occurrence of multipath

(4 marks)

(c) Analyse the median path loss in the **THREE(3)** different areas using Hata Model.

(10 marks)

(d) Based your answer in **Q6(b)**, calculate the received power that received by the MS for each area if the transmit power of each BS is 50 W.

(6 marks)

-END OF QUESTIONS –

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Erlang C

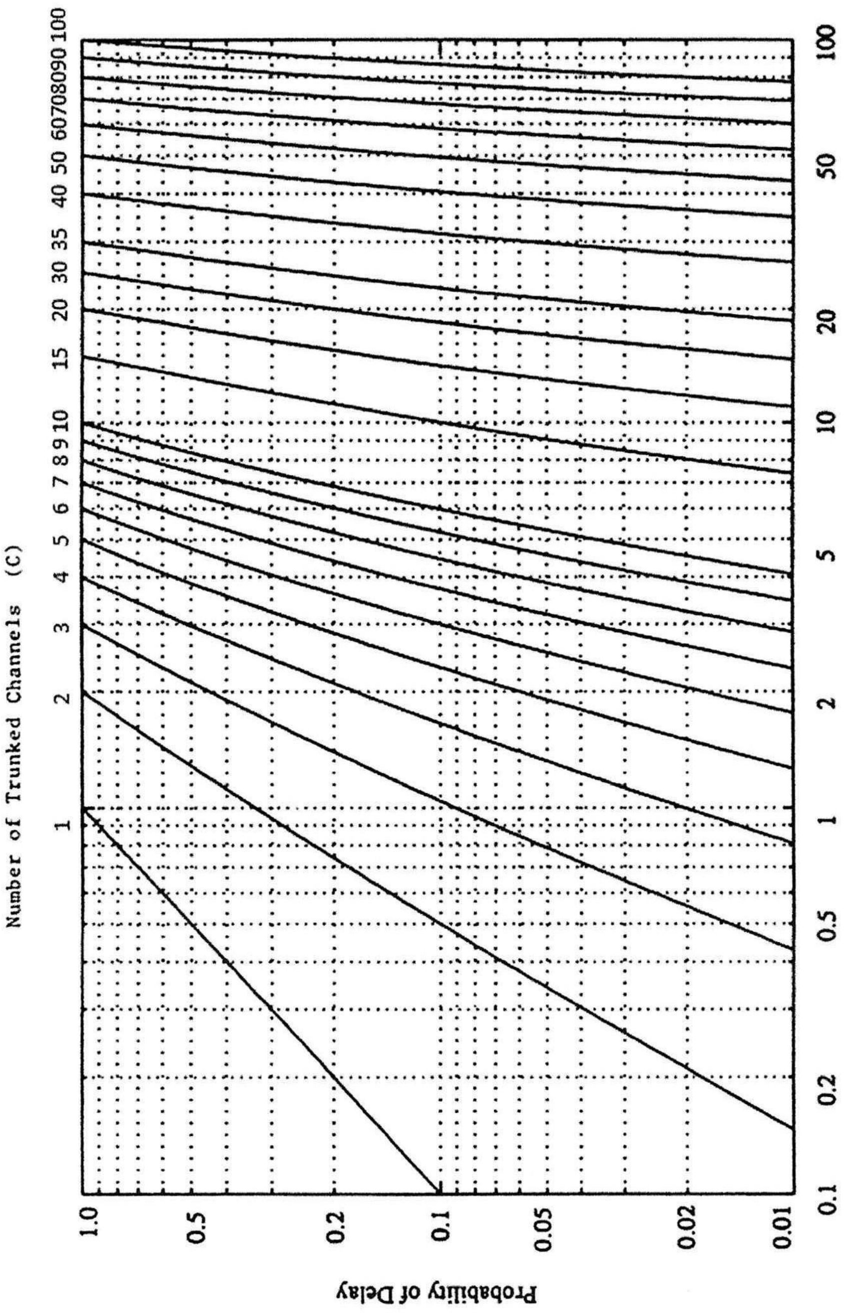

Figure Q1(c)

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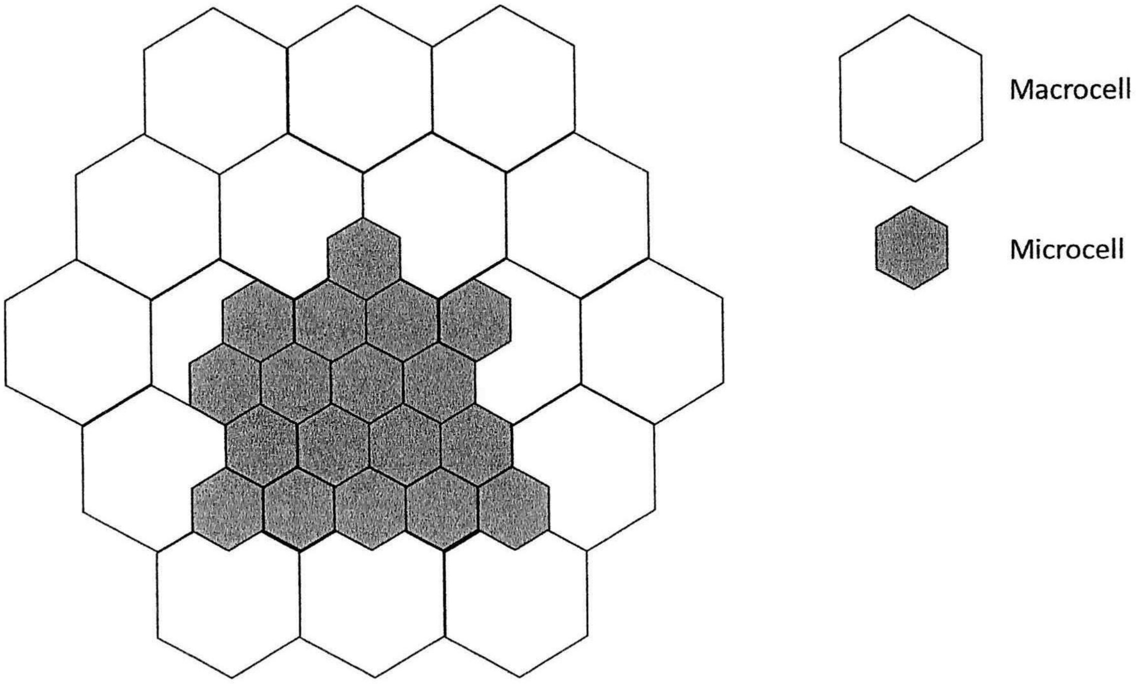

Figure Q4(a)

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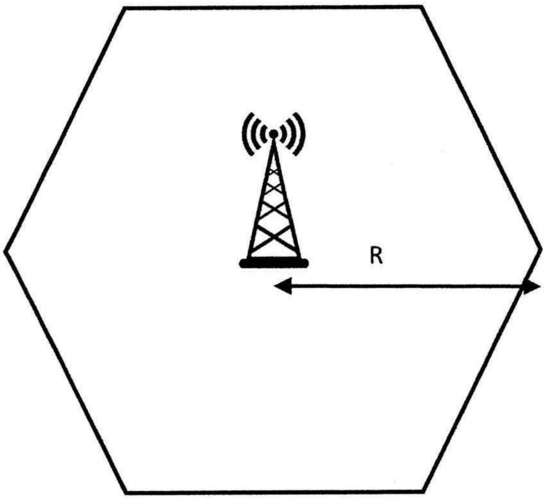

Parameters	Value
Power transmitted, P_t	15dBm
Antenna gain at transmitter, G_t	8dB
Antenna gain at receiver, G_r	5dB
Cable Loss, L_{cable}	1.5dB
Frequency	2100MHz

Figure Q5

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Erlang B

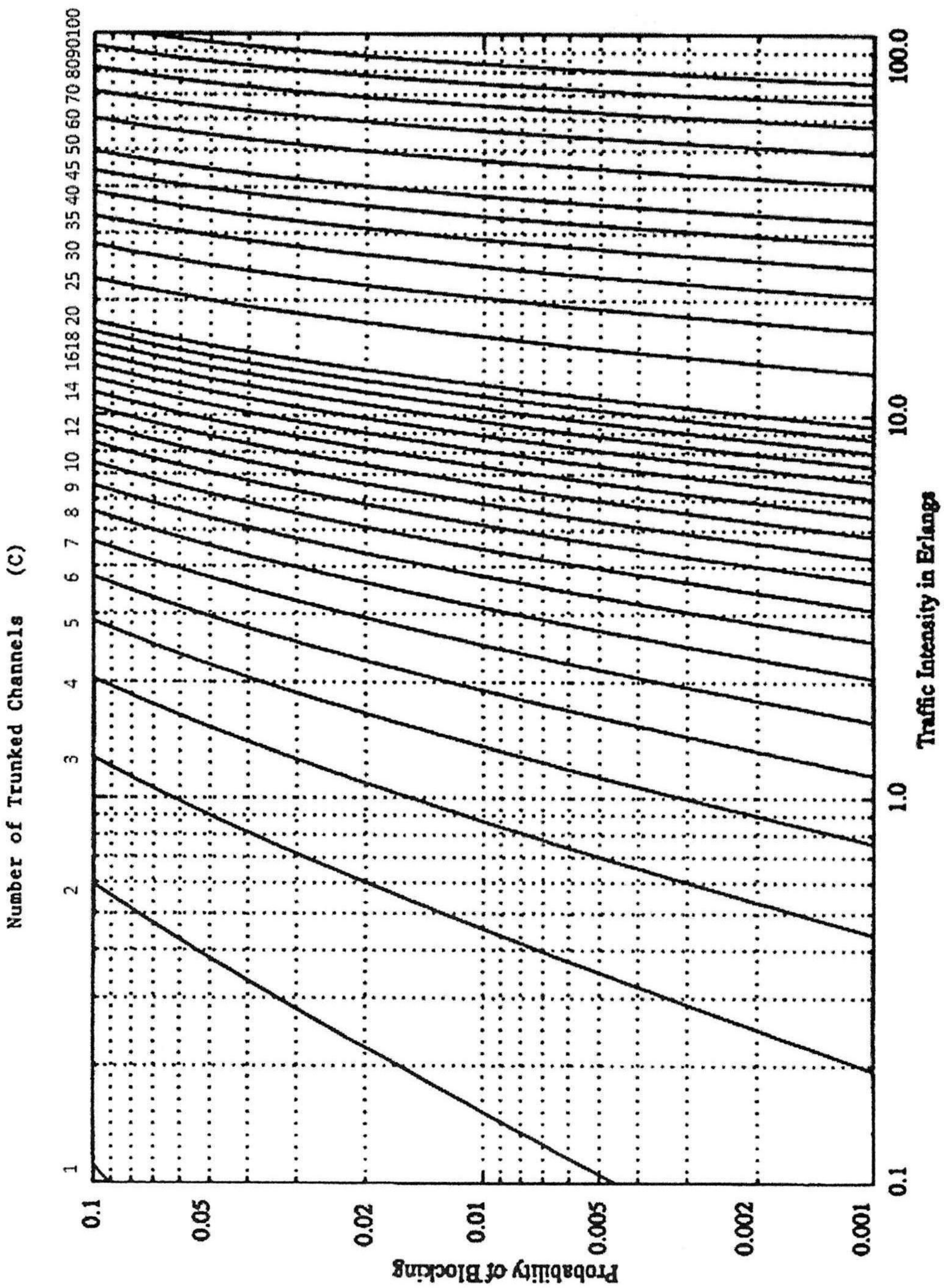

Figure 5(f)

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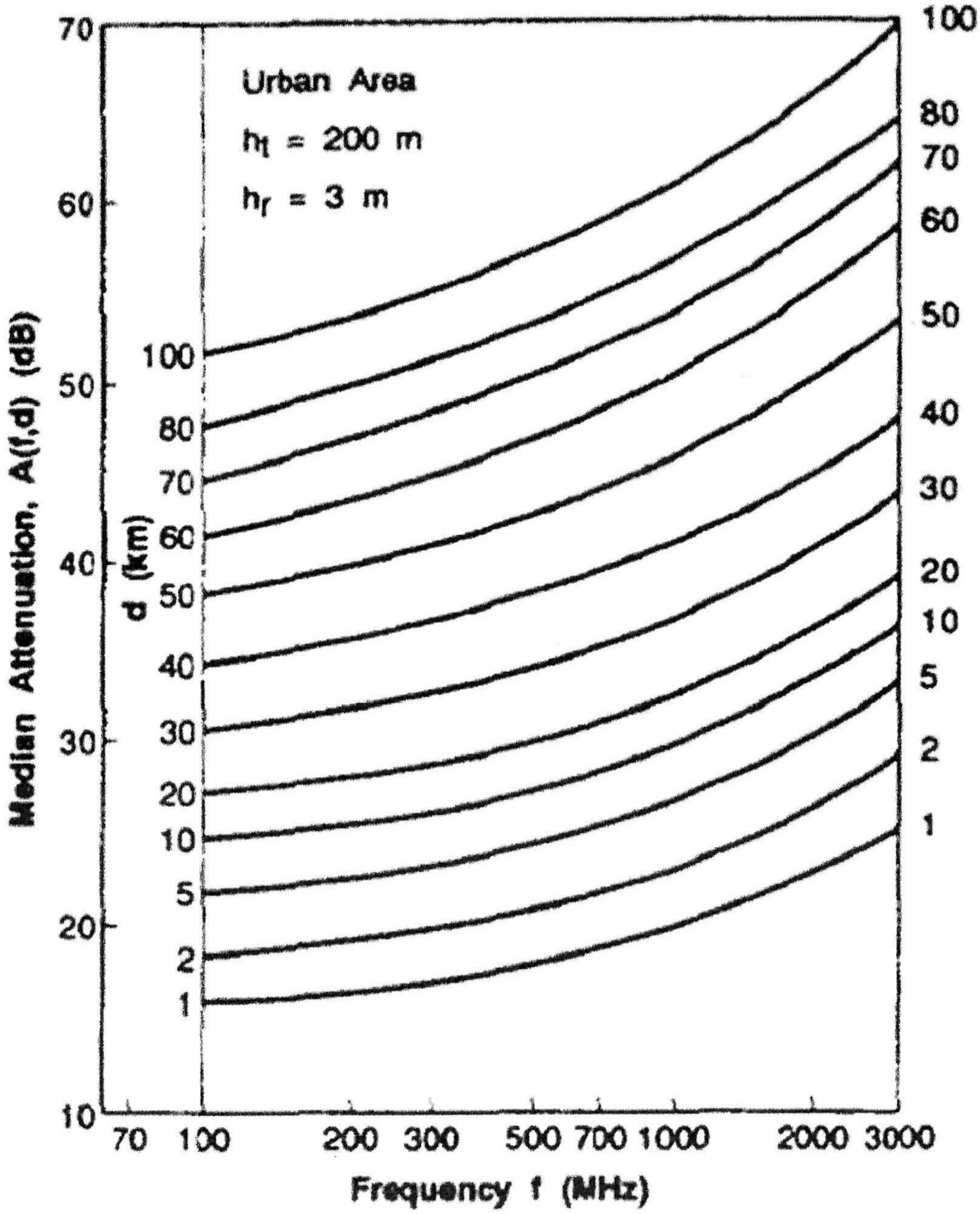

Figure Q6(a)

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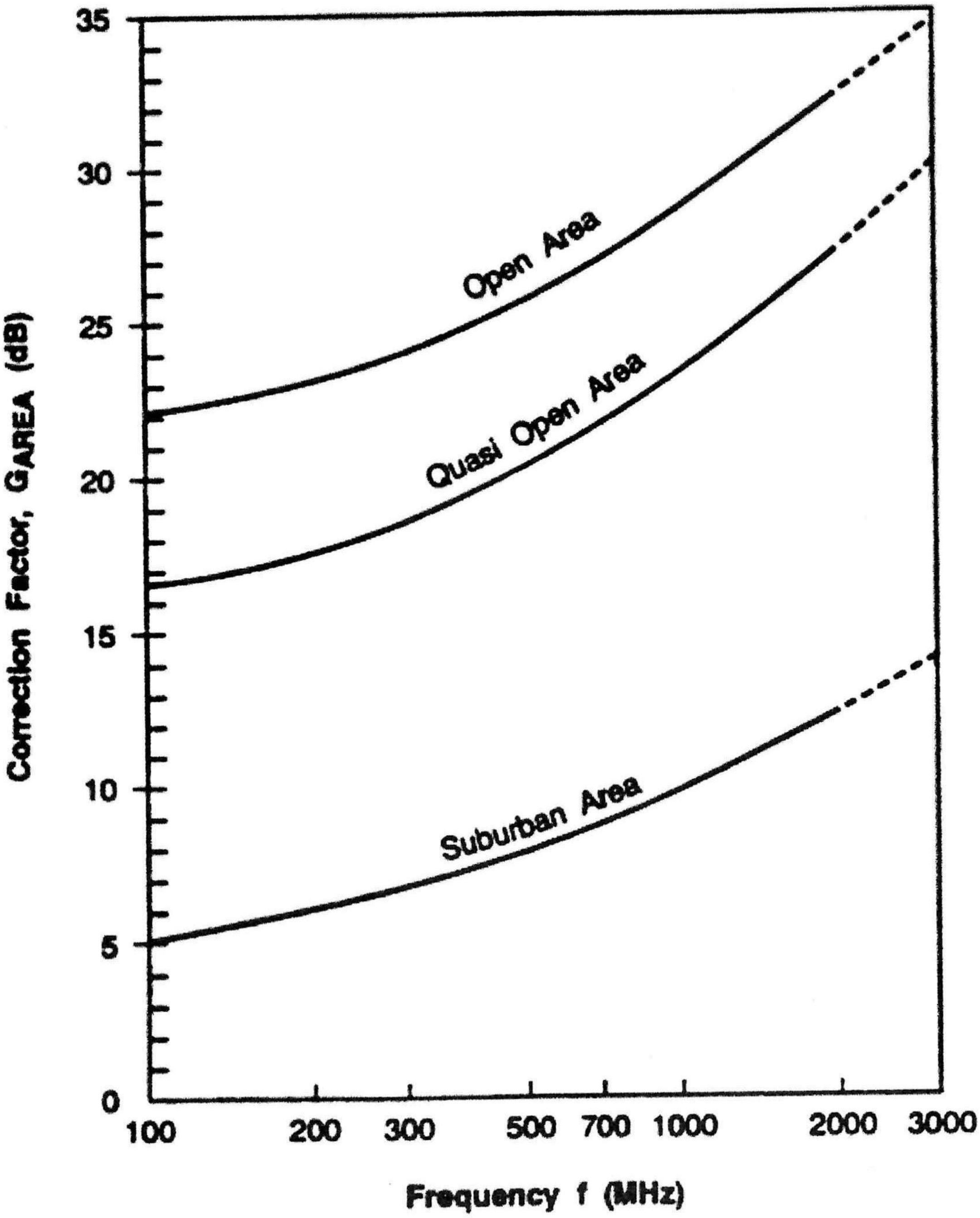

Figure Q6(b)

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Formula

Area of hexagon, A

$$A = 1.5\sqrt{3}\, R^2$$

Number of cells per cluster (Hexagons shape)

$$N = i^2 + ij + j^2$$

Co-channel reuse ratio

$$Q = \frac{D}{R} = \sqrt{3N}$$

Signal to interference ratio (SIR)

$$\frac{S}{I} = \frac{(D/R)^n}{i_0} = \frac{\left(\sqrt{3N}\right)^n}{i_0}$$

Friis free space propagation model

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

$$P_r(d) = \frac{EIRP\ G_r \lambda^2}{(4\pi)^2 d^2 L}$$

$$PL(d) = 10 \log \frac{P_t}{P_r} = -10 \log \frac{G_t G_r \lambda^2}{(4\pi)^2 d^2}$$

$$PL(d) = PL(d_0) + 10\log \left(\frac{d}{d_0}\right)^2$$

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Formula

Trunking

$$P_r(delay > t) = P_r(delay > 0) \times P_r(delay > t|delay > 0)$$

Where $P_r(delay > t|delay > 0) = e^{(-(C-A)t/H)}$

Log-distance path lost model

$$\overline{PL}(d) = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right)$$

Log-normal shadowing

$$\overline{PL}(d) = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right) + X_\sigma$$

$$P_r[P_r(d) > \gamma] = Q\left(\frac{\gamma - \overline{P_r(d)}}{\sigma}\right)$$

$$P_r[P_r(d) < \gamma] = Q\left(\frac{\overline{P_r(d)} - \gamma}{\sigma}\right)$$

Okumura Model

$$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA}$$

$$G(h_{te}) = 20\log\left(\frac{h_{te}}{200}\right) \qquad 1000m > h_{te} > 30m$$

$$G(h_{re}) = 10\log\left(\frac{h_{re}}{3}\right) \qquad h_{re} \leq 3m$$

$$G(h_{re}) = 20\log\left(\frac{h_{re}}{3}\right) \qquad 10m > h_{re} > 3m$$

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Formula

Hata Model

For urban area

$$L_{50}(Urban)(dB) = 69.55dB + 26.16\log(f_c) - 13.82\log(h_t) - a(h_r) + (44.9 - 6.55\log(h_t)\log(d)$$

$a(h_r)$ is the correction factor for effective mobile antenna height
For small medium sized city,

$$a(h_r) = (1.1\log f_c - 0.7)h_r - (1.56\log f_c - 0.8)\ dB$$

and for a large city is given by

$$a(h_r) = 8.29(\log 1.54h_r)^2 - 1.1\text{ dB} \qquad f_c \le 300\text{MHz}$$

$$a(h_r) = 3.2(\log 11.754h_r)^2 - 4.97\text{ dB} \qquad f_c \ge 300\text{MHz}$$

Where $h_t, h_r =$ meter, $f_c =$ MHz, $d =$ km,

For suburban area

$$L_{50}(dB) = L_{50}(Urban) - 2[\log(\frac{f_c}{28})]^2 - 5.4$$

For open area

$$L_{50}(dB) = L_{50}(Urban) - 4.78(\log f_c)^2 - 18.33\log f_c - 40.98$$