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UNIVERSITY OF TECHNOLOGY, SYNDEY

SURNAME: ____________________________

FIRST NAME: ____________________________

STUDENT NO: ____________________________

COURSE: ____________________________

AUTUMN SEMESTER FINAL EXAMINATION 2011

SUBJECT: 48780 MOBILE COMMUNICATIONS
COURSES: TELECOMMUNICATIONS ENGINEERING DEGREE

DAY & DATE OF EXAMINATION: Friday, 24 June 2011

TIME ALLOWED: 3 hours plus 10 minutes reading time

EXAMINATION COMMENCES: 18.00 hrs FINISHES: 21.10hrs

GENERAL GUIDELINES

- **Total Marks: 100**
- **All questions are compulsory.**
- **Clearly indicate your name and student number on the exam paper.**
- **Non-programmable calculators, drawing instruments and two (2) A4 sized double sided "hand written (only)" student notes are permitted. Photocopied or printed materials other than those supplied with the paper are not allowed. The student notes need to be submitted along with exam paper.**
- **For each question, provide a clear explanation of your reasoning.**

Examiner: A. M. Sanagavarapu
Assessor : R.Braun

Question 1 **[Total marks: 25]**

(a) A base station transmits a power of 10 watts at an operating frequency of 900 MHz. The system loss at base station is 10 dB. The transmit antenna has a gain of 12 dBd (with respect to dipole) in the direction of a mobile receiver. The mobile receiver has an antenna gain of 0 dBd and a system loss of 2 dB. The mobile receiver has sensitivity of -104 dBm. Determine:

(i) The effective isotropic radiated power. [2 marks]

(ii) The maximum acceptable path loss. [2 marks]

(iii) Assuming transmitting and receiving antennas are located on a flat and perfect ground with a separation of 'd' meters, determine for the following cases, whether the 2-ray ground reflection model could be applied: (A) the height of transmitter base station antenna h_t = 35m, and the height of mobile receiver antenna h_r = 3m, d = 250m and (B) the height of transmitter base station antenna h_t = 30m, and the height of mobile receiver antenna h_r=1.5m,d=450m. [4 marks]

(iv) What insight does the 2-ray ground reflection model provide about large-scale path loss that is useful for the design of cellular systems? [2 marks]

(b) A total of 24MHz of bandwidth is allocated to a particular FDD cellular telephone system that uses two 20 KHz simplex channels to provide full duplex voice and control channels. It is given that each cell phone user generates 0.1 Erlangs of traffic. Assume Erlang B model.

(i) Find the number of channels in each cell for a four-cell reuse system.[3 marks]

(ii) If each cell is to offer capacity that is 90% of perfect scheduling, find the maximum number of users that can be supported per cell where Omni-directional antennas are used at each base station.[5 marks]

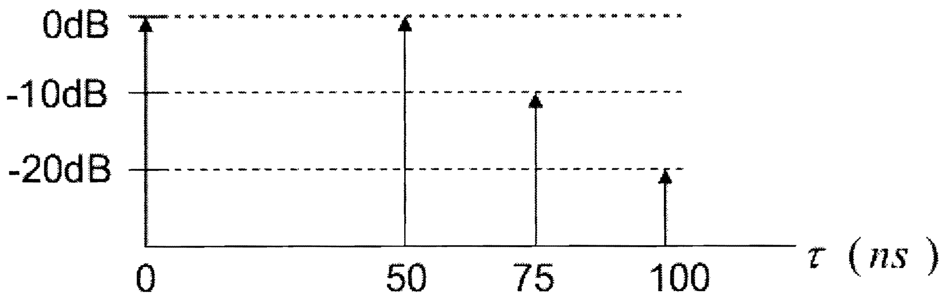
(iii) What is the blocking probability of the system (for 90% offered capacity with perfect scheduling) when the maximum numbers of users are available in the user pool? [4 marks]

(iv) If each cell covers five square kilometers, then how many subscribers could be supported in an urban market that is 50km × 50km for the case of Omni-directional base station antennas? [3 marks]

Question 2 [Total marks: 25]

a) Find the diffraction gain when the propagation path is obstructed by an obstruction at a wavelength of 25cm. The distance from the obstruction to the mobile is d_1 = 1km, the distance from the base station to the obstruction is d_2 = 6km, and the height of the obstruction is h = 10m. [6 Marks]

b) If a particular modulation provides suitable BER performance whenever $\{\sigma_t / T_s\} \leq 0.1$where σ_t is the RMS delay spread and T_s is the symbol period , determine the smallest symbol period T_s (and thus the highest symbol rate) that may be sent through a RF channel whose impulse response shown below, without using an equalizer. [10 marks]



c) A flat Rayleigh fading signal at 6GHz is received by a mobile travelling at 80km/hr. Determine (i) the number of positive-going zero crossings about the rms value that occurs over a 5s interval, (ii) the average duration of a fade below the rms level, (iii) the average of a fade at a level of 20dB below the rms value. [9 marks]

Question 3 [Total marks: 25]

(a) If the received power at a reference distance d_0 = 1 km is equal to 1 microwatt, find the received power at distances of 10 km from the same transmitter for the following path loss models:
(i) Free space [2 marks]
(ii) n=3 [2 marks]
(iii)PCS Extension to Hata model (COST-231) for large city environment (Consider the constant C_M = 3 dB). [6 marks]
Assume freq. = 1600 MHz, h_{te} = 40 m, h_{re} = 3 m, $G_t = G_r$ = 0 dB.

(b) Four received power measurements were taken at distances of 100m, 200m, 1km, and 2km from a mobile transmitter. The measured values at these distances are 0dBm, -25dBm, -35dBm, and -38dBm, respectively. It is assumed that the path loss for these measurements follows the model

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

where d_0 = 100 m.

(i) Find the minimum mean square error (MMSE) estimate for the path loss exponent n. [6 marks]

(ii) Calculate the standard deviation of the shadowing about the mean value. Estimate the received power at d = 2km using the resulting model. [5 marks]

(iii) Predict the likelihood that the received signal at 2km will be greater than -35dBm. Express your answer in terms of Q-function.[4 marks]

QUESTION 4 [Total marks: 25]

a) A system should transmit as high a data rate as possible within a 1-MHz bandwidth, where out-of-band emissions of -50 dBm are admissible. The transmit power used is 20 W. Calculate and compare between MSK and BPSK with root-raised cosine filter with $\alpha = 0.35$, as to which modulation scheme satisfies the above requirement? Note: this question concentrates on spectral efficiency, and avoids other considerations like the peak-to-average ratio of the signal. [8 Marks]

b) For a mobile link, assume that the transmit (TX) antenna to be a vertical $\lambda/2$ dipole, and the receive antenna (RX) to be a vertical $\lambda/20$ dipole.

(i) What are the radiation resistances of above mentioned TX and RX antennas? [3 marks]

(ii) Assuming that the resistance due to ohmic losses is $R_{ohmic} = 10\ \Omega$, calculate their radiation efficiencies? [4 marks]

c) Provide descriptive answers for the following questions not exceeding 15 lines, with the help of either schematic diagrams or mathematical equations if necessary: [10 marks]

(i) Discuss TDMA with frame structure?
(ii) Define and discuss about the band pass signals?
(iii) Discuss Nyquist pulse shaping filters at base band for ISI reduction?
(iv) Discuss CDMA power control?
(v) Discuss QPSK Transmitter and coherent receiver using schematic block diagrams?

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Figure 1: Okumura-Hata Model

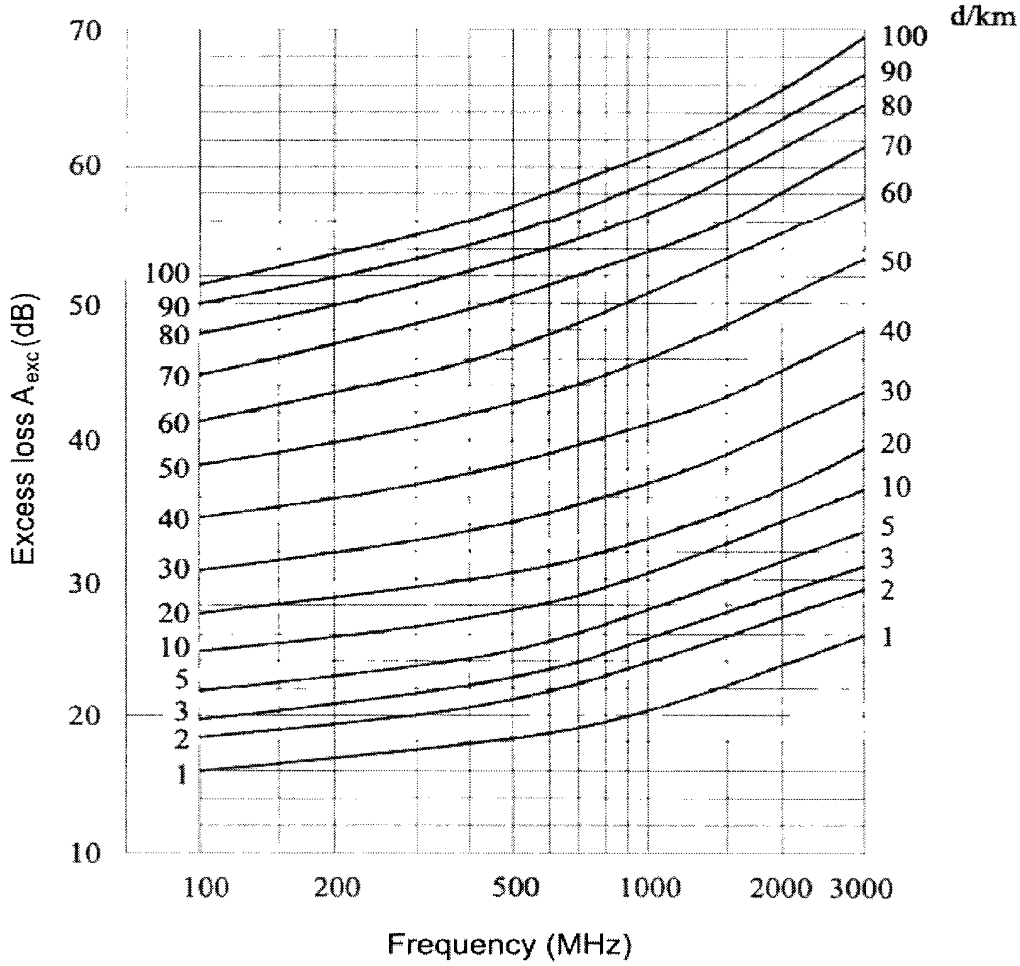

Figure 2: Okumura-Hata Model

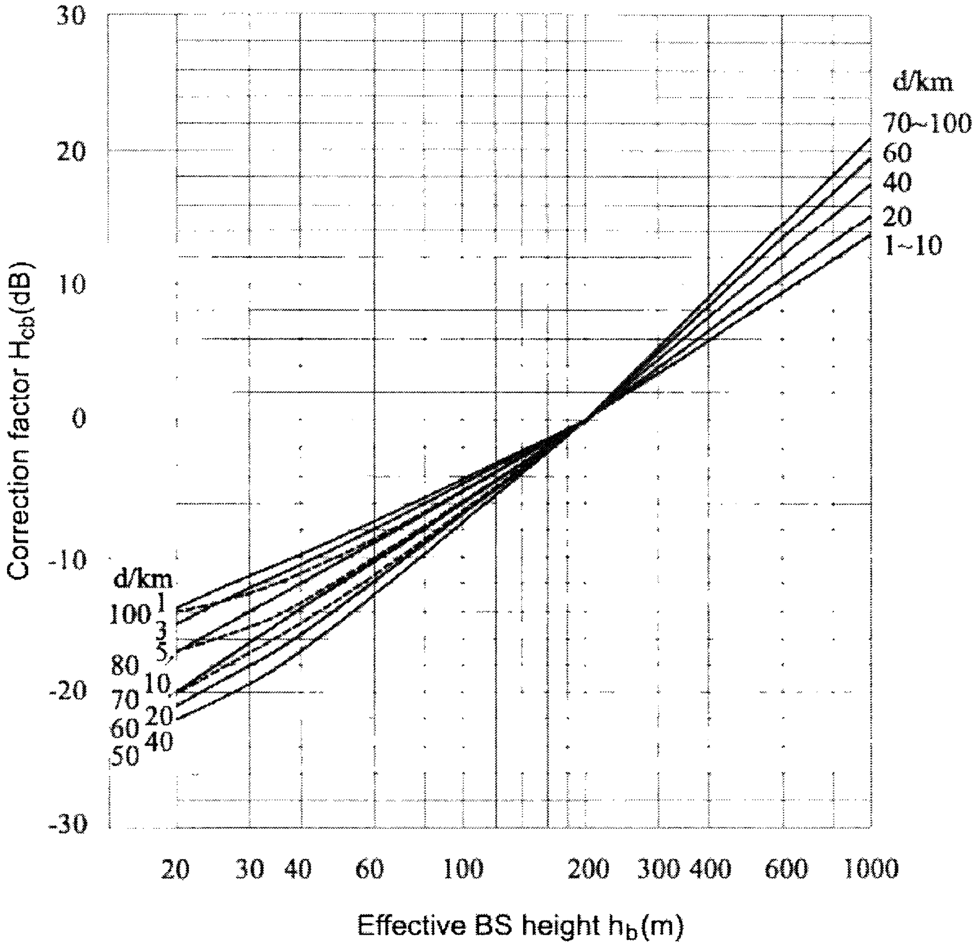

Figure 3: Okumura-Hata Model

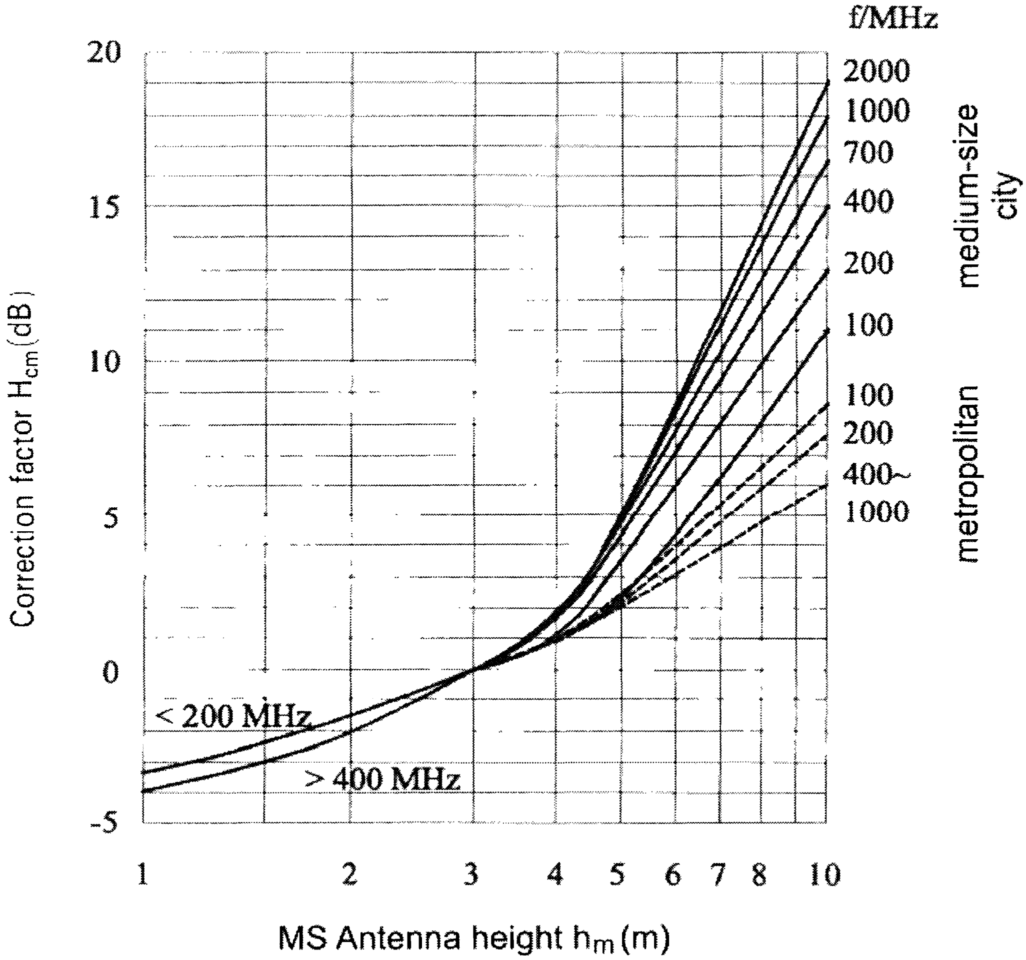

Figure 4: Determination of Percentage of Coverage Area

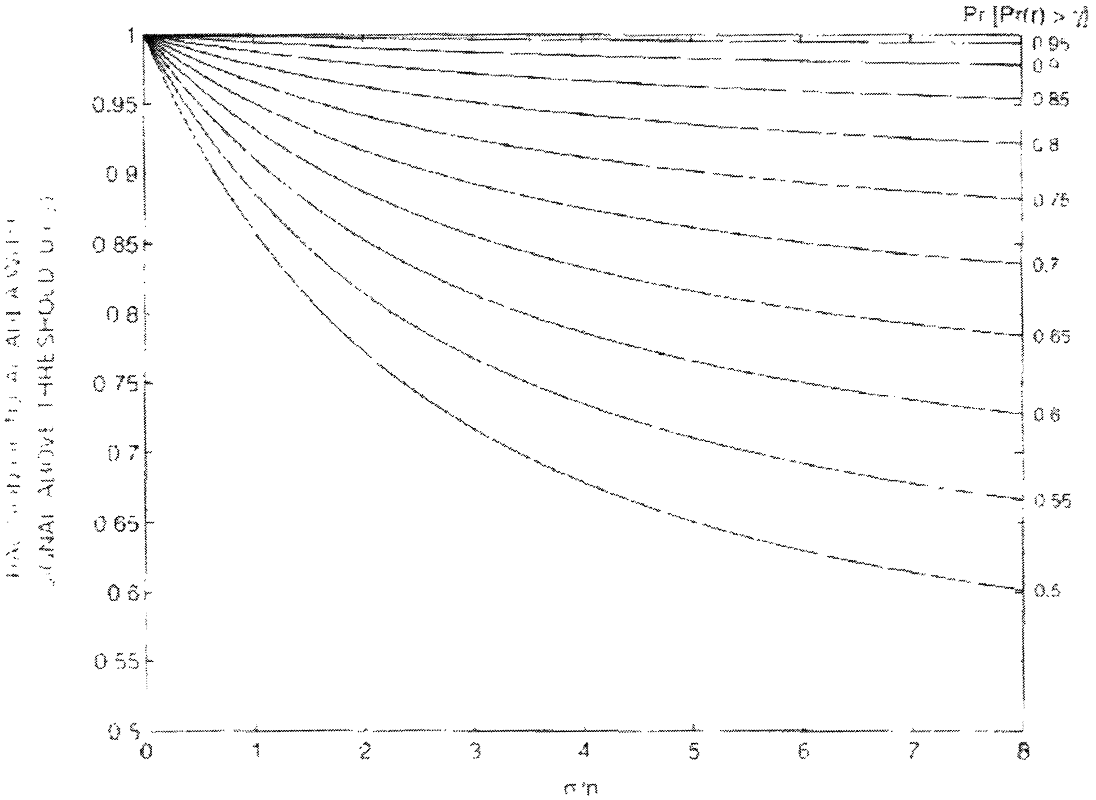

Figure 5: Knife-edge diffraction gain as a function of Fresnel diffraction parameter υ.

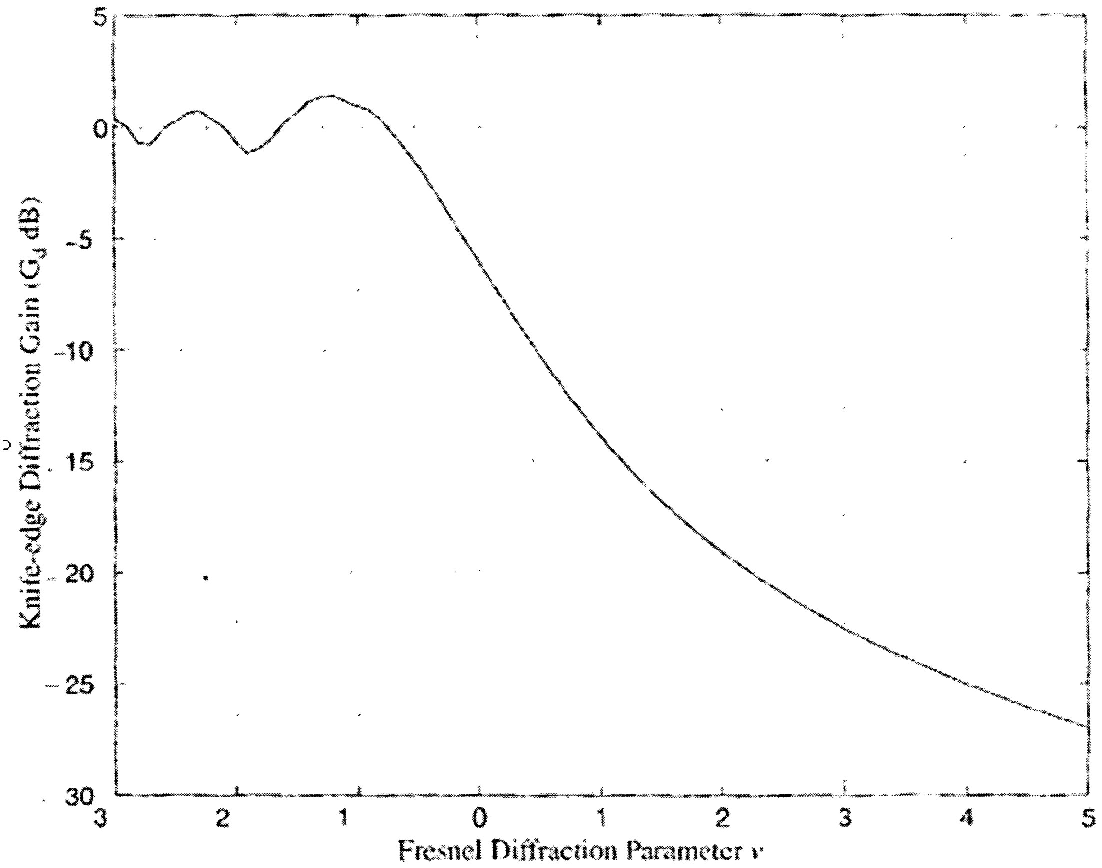

Figure 6: ERLANG-B chart

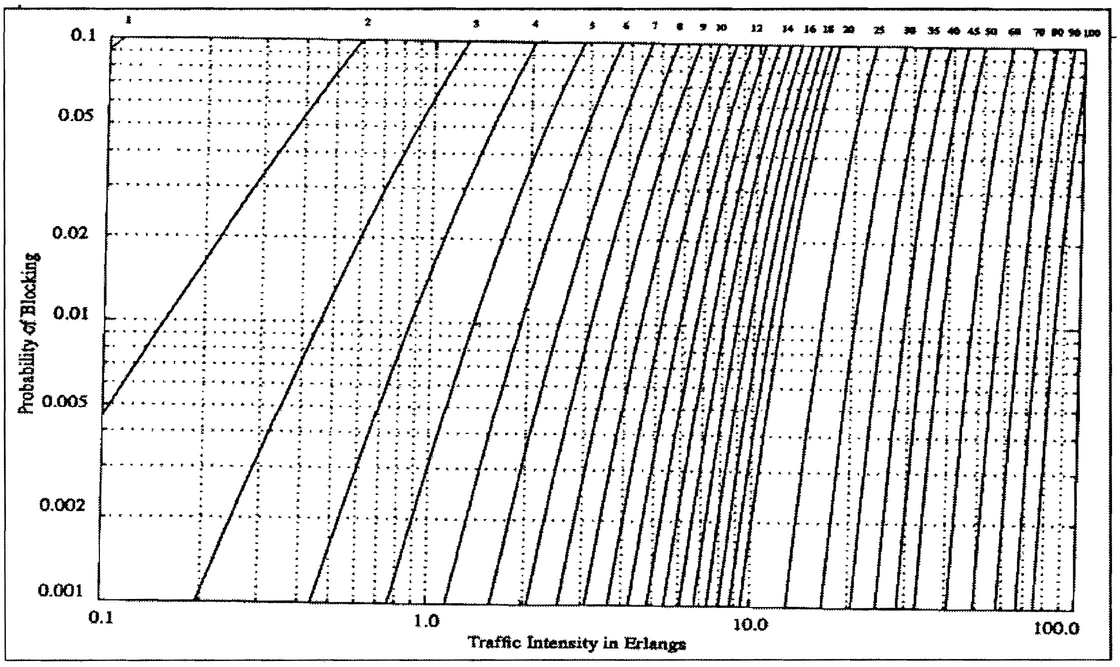

Figure 7 Tabulation of Q-function

Tabulation of the Q-function

z	$Q(z)$	z	$Q(z)$
0.0	0.50000	2.0	0.02275
0.1	0.46017	2.1	0.01786
0.2	0.42074	2.2	0.01390
0.3	0.38209	2.3	0.01072
0.4	0.34458	2.4	0.00820
0.5	0.30854	2.5	0.00621
0.6	0.27425	2.6	0.00466
0.7	0.24196	2.7	0.00347
0.8	0.21186	2.8	0.00256
0.9	0.18406	2.9	0.00187
1.0	0.15866	3.0	0.00135
1.1	0.13567	3.1	0.00097
1.2	0.11507	3.2	0.00069
1.3	0.09680	3.3	0.00048
1.4	0.08076	3.4	0.00034
1.5	0.06681	3.5	0.00023
1.6	0.05480	3.6	0.00016
1.7	0.04457	3.7	0.00011
1.8	0.03593	3.8	0.00007
1.9	0.02872	3.9	0.00005

Figure 8 Erlang B Table

Trunks	Blocking Probability: 0.01	Blocking Probability: 0.1	Blocking Probability: 0.5
1	0.010	0.111	1.000
2	0.153	0.595	2.732
3	0.455	1.271	4.591
4	0.869	2.045	6.501
5	1.361	2.881	8.437
6	1.909	3.758	10.389
7	2.501	4.666	12.351
8	3.128	5.597	14.320
9	3.783	6.546	16.294
10	4.461	7.511	18.273
15	8.108	12.484	28.201
20	12.031	17.613	38.159
25	16.125	22.833	48.132
30	20.337	28.113	58.113
35	24.638	33.434	68.099
40	29.007	38.787	78.088
45	33.432	44.165	88.079
50	37.901	49.562	98.072
55	42.409	54.975	108.066
60	46.950	60.401	118.061
65	51.518	65.839	128.057
70	56.112	71.286	138.053
75	60.728	76.741	148.050
80	65.363	82.203	158.047
85	70.016	87.672	168.044
90	74.684	93.146	178.042
95	79.368	98.626	188.040
100	84.064	104.110	198.038
150	131.576	159.122	298.026
200	179.738	214.323	398.019

Figure 9 Erlang C chart