UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, 18 APRIL 2001 – 2:00 pm

Fourth Year – Programs 5 and 7

ECE 422S RADIO SYSTEMS

Examiner – J. Erfanian

Specified aids are permitted. Any type of calculator is permitted

Question 1 (8 marks)

A person is using a mobile phone when a long narrow structure 28 m high stands directly between her and the transmitting antenna 2 km away from the person at the same height as the building. The transmitted power is 6 W, transmitter line loss is 2 dB, and the transmitter antenna gain is 8.5 dB. The person is 100 m from the structure, the mobile phone antenna gain is 2.5 dB and its line loss is negligible. The operating frequency is 900 MHz, and the mobile phone's height above the ground is 1.6 m.

If the minimum acceptable received power is –110 dBW, indicate whether the received signal meets the requirement. Ignore the earth curvature and reflections.

Question 2 (10 marks)

(i) In a line-of-sight radiolink design, what key factors determine the location, separation and height of antenna towers? Please identify and describe (how/why) only in a few words! (4 marks)

(ii) What measure can be taken at the receiver antenna site to counteract potential fading of the received signal due to multipath propagation? Please identify and describe (how/why) only in a few words! (1 mark)

(iii) Consider a 24 km line-of-sight radiolink with an operating frequency of 6 GHz, designed to transmit at 155 Mbps. The required performance level demands an E_b/N_0 of 24 dB. The receiver noise figure is 5 dB and the line losses and antenna gain at each end are 1.5 dB and 30 dB, respectively. Find the required transmitter output power. (5 marks)

Question 3 (8 marks)

(i) A total of 44 equal-power mobile stations are to share a frequency band through a CDMA system. Each mobile station transmits information at 14.4 Kbps. Calculate the minimum chip rate in order to maintain an E_b/N_0 of 6.8 dB. Assume that the interference factor from the other base stations is 60%, voice activity is 50%, and power control accuracy factor is 0.8. (4 marks)

(ii) Sometimes the knife-edge diffraction gain is approximated by the formula $G_d = -10 \log_{10}(2\pi^2 v^2)$. For what range of v would you recommend its usage? Please show your reasoning clearly! (4 marks)

Question 4 (8 marks)

Consider a community of 400 homes, each generating 800 minutes of telephone service usage per month, with a call duration average of 4 minutes. Assume 75% of monthly usage is during 20 working days and 1/6 of daily (working day) usage is during busy hour.

(i) If fixed wireless access is used to serve this community, calculate the total number of radio channels required, using a 1% blocking probability. (6 marks)

(ii) Given each base station (antenna) at a fixed EIRP serves multiple homes, what factors determine the number of base stations required? (2 marks)

Question 5 (8 marks)

An earth-based satellite station is located at 50° N, with an antenna gain of 50 dB, operating within a band of 1 MHz at 4 GHz. The equivalent antenna temperature is 40 K, and various components before the input of the first amplifier stage impose losses of 3 dB.

(i) Find the elevation angle of the earth station. (3 marks)

(ii) What EIRP level is required at the satellite to obtain a 30 dB SNR at the input of the first amplifier stage? (5 marks)

Question 6 (8 marks)

(i) The maximum detectable round-trip time for a radar system is twice the time between pulses. What minimum change (in dB) in radar cross-section would result in the maximum radar range to fall within the unambiguous range, under the same conditions? Ignore atmospheric/rain losses. (4 marks)

(ii) A LEO satellite system at 700 km above the earth surface has a period of 98.7 mins. Provide an estimate of the minimum number of satellites required on the same orbit to provide uninterrupted service to a given stationary earth position. State your assumptions clearly. (4 marks)

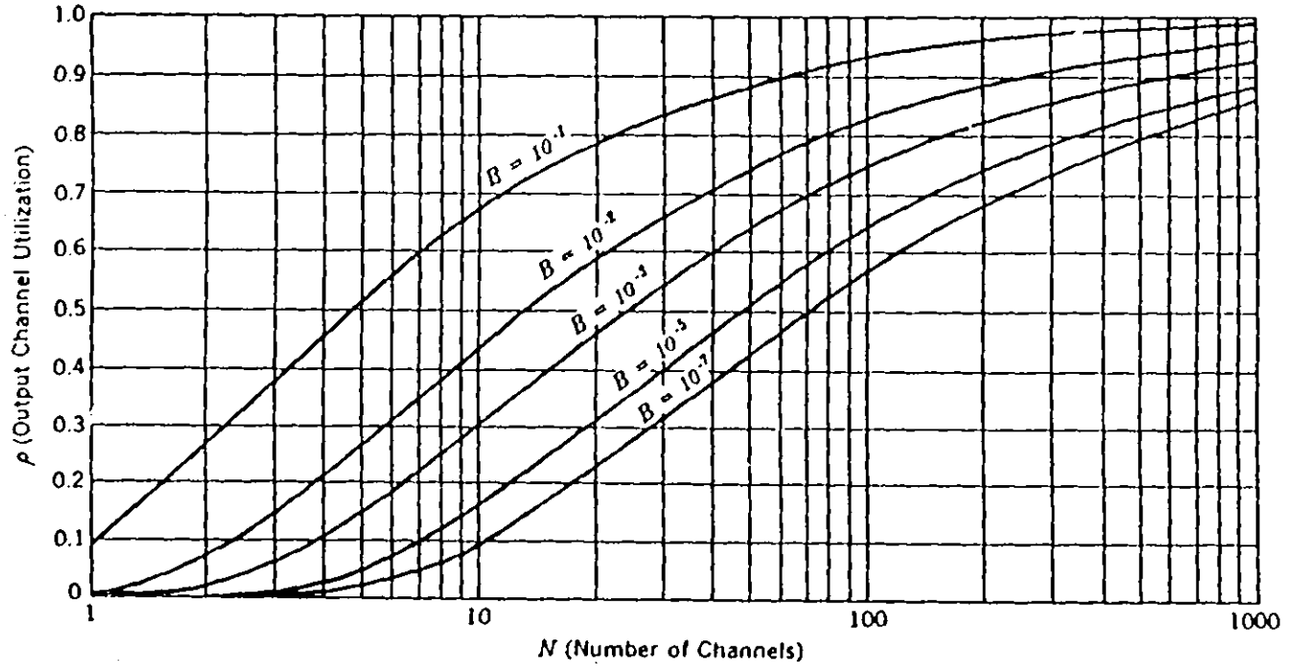

Figure 10.5. Output channel utilization of lost calls cleared system.

TABLE D.1 Maximum Offered Load Versus B and N^*

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.001	.005	.010	.020	.053	.111	.176	.250	.429	.667
2	.014	.032	.046	.105	.153	.223	.381	.595	.796	1.00	1.45	2.00
3	.087	.152	.194	.340	.455	.602	.899	1.27	1.60	1.93	2.63	3.48
4	.235	.362	.439	.701	.869	1.09	1.62	2.05	2.50	2.95	3.89	5.02
5	.452	.649	.762	1.13	1.36	1.66	2.22	2.88	3.45	4.01	5.10	6.60
6	.728	.996	1.15	1.62	1.91	2.28	2.96	3.76	4.44	5.11	6.51	8.19
7	1.05	1.39	1.58	2.16	2.50	2.94	3.74	4.67	5.46	6.23	7.86	9.80
8	1.42	1.83	2.05	2.73	3.13	3.63	4.54	5.60	6.50	7.37	9.21	11.4
9	1.83	2.30	2.56	3.33	3.78	4.34	5.37	6.55	7.55	8.52	10.6	13.0
10	2.26	2.80	3.09	3.96	4.46	5.08	6.22	7.51	8.62	9.68	12.0	14.7
11	2.72	3.33	3.65	4.61	5.16	5.84	7.08	8.49	9.69	10.9	13.3	16.3
12	3.21	3.88	4.23	5.28	5.88	6.61	7.95	9.47	10.8	12.0	14.7	18.0
13	3.71	4.45	4.83	5.96	6.61	7.40	8.83	10.5	11.9	13.2	16.1	19.6
14	4.24	5.03	5.45	6.66	7.35	8.20	9.73	11.5	13.0	14.4	17.5	21.2
15	4.78	5.63	6.08	7.38	8.11	9.01	10.6	12.5	14.1	15.6	18.9	22.9
16	5.34	6.25	6.72	8.10	8.88	9.83	11.5	13.5	15.2	16.8	20.3	24.5
17	5.91	6.88	7.38	8.83	9.65	10.7	12.5	14.5	16.3	18.0	21.7	26.2
18	6.50	7.52	8.05	9.58	10.4	11.5	13.4	15.5	17.4	19.2	23.1	27.8
19	7.09	8.17	8.72	10.3	11.2	12.3	14.3	16.6	18.5	20.4	24.5	29.5
20	7.70	8.83	9.41	11.1	12.0	13.2	15.2	17.6	19.6	21.6	25.9	31.2
21	8.32	9.50	10.1	11.9	12.8	14.0	16.2	18.7	20.8	22.8	27.3	32.8
22	8.95	10.2	10.8	12.6	13.7	14.9	17.1	19.7	21.9	24.1	28.7	34.5
23	9.58	10.9	11.5	13.4	14.5	15.8	18.1	20.7	23.0	25.3	30.1	36.1
24	10.2	11.6	12.2	14.2	15.3	16.6	19.0	21.8	24.2	26.5	31.6	37.8
25	10.9	12.3	13.0	16.0	16.1	17.5	20.0	22.8	25.3	27.7	33.0	39.4
26	11.5	13.0	13.7	15.8	17.0	18.4	20.9	23.9	26.4	28.9	34.4	41.1
27	12.2	13.7	14.4	16.6	17.8	19.3	21.9	24.9	27.6	30.2	35.8	42.8
28	12.9	14.4	15.2	17.4	18.6	20.2	22.9	26.0	28.7	31.4	37.2	44.4
29	13.6	15.1	15.9	18.2	19.5	21.0	23.8	27.1	29.9	32.6	38.6	46.1
30	14.2	15.9	16.7	19.0	20.3	21.9	24.8	28.1	31.0	33.8	40.0	47.7
31	14.9	16.6	17.4	19.9	21.2	22.8	25.8	29.2	32.1	35.1	41.5	49.4
32	15.6	17.3	18.2	20.7	22.0	23.7	26.7	30.2	33.3	36.3	42.9	51.1
33	16.3	18.1	19.0	21.5	22.9	24.6	27.7	31.3	34.4	37.5	44.3	52.7
34	17.0	18.8	19.7	22.3	23.8	25.5	28.7	32.4	35.6	38.8	45.7	54.4
35	17.8	19.6	20.5	23.2	24.6	26.4	29.7	33.4	36.7	40.0	47.1	56.0
36	18.5	20.3	21.3	24.0	25.5	27.3	30.7	34.5	37.9	41.2	48.6	57.7
37	19.2	21.1	22.1	24.8	26.4	28.3	31.6	35.6	39.0	42.4	50.0	59.4
38	19.9	21.9	22.9	25.7	27.3	29.2	32.6	36.6	40.2	43.7	51.4	61.0
39	20.6	22.6	23.7	26.5	28.1	30.1	33.6	37.7	41.3	44.9	52.8	62.7
40	21.4	23.4	24.4	27.4	29.0	31.0	34.6	38.8	42.5	46.1	54.2	64.4
41	22.1	24.2	25.2	28.2	29.9	31.9	35.6	39.9	43.6	47.4	55.7	66.0
42	22.8	25.0	26.0	29.1	30.8	32.8	36.6	40.9	44.8	48.6	57.1	67.7
43	23.6	25.7	26.8	29.9	31.7	33.8	37.6	42.0	45.9	49.9	58.5	69.3
44	24.3	26.5	27.6	30.8	32.5	34.7	38.6	43.1	47.1	51.1	59.9	71.0
45	25.1	27.3	28.4	31.7	33.4	35.6	39.6	44.2	48.2	52.3	61.3	72.7
46	25.8	28.1	29.3	32.5	34.3	36.5	40.5	45.2	49.4	53.6	62.8	74.3
47	26.6	28.9	30.1	33.4	35.2	37.5	41.5	46.3	50.6	54.8	64.2	76.0
48	27.3	29.7	30.9	34.2	36.1	38.4	42.5	47.4	51.7	56.0	65.6	77.7
49	28.1	30.5	31.7	35.1	37.0	39.3	43.5	48.5	52.9	57.3	67.0	79.3
50	28.9	31.3	32.5	36.0	37.9	40.3	44.5	49.6	54.0	58.3	68.5	81.0
51	29.6	32.1	33.3	36.9	38.8	41.2	45.5	50.6	55.2	59.7	69.9	82.7
52	30.4	32.9	34.2	37.7	39.7	42.1	46.5	51.7	56.3	61.0	71.3	84.3
53	31.2	33.7	35.0	38.6	40.6	43.1	47.5	52.8	57.5	62.2	72.7	86.0
54	31.9	34.5	35.8	39.5	41.5	44.0	48.5	53.9	58.7	63.5	74.2	87.6
55	32.7	35.3	36.6	40.4	42.4	44.9	49.5	55.0	59.8	64.7	75.6	89.3