UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

Module Number: EE6208 **Module Name: Wireless and Mobile Communication**

[Three Hours]

[Answer **all questions**, each question carries **10 marks**]

Notations and symbols have their usual meaning unless otherwise stated.
If necessary, you may use the provided Erlang B traffic table.

Q1 Multiple access techniques allow many users to share a finite amount of radio spectrum simultaneously.

a) Compare code division multiple access (CDMA), frequency division multiple access (FDMA) and time division multiple access (TDMA) in terms of sharing resources, bandwidth and system complexity.

[3.0 Marks]

b) What is referred to as frequency division duplexing (FDD)?

[1.0 Mark]

c) TDMA utilizes bandwidth more efficiently than FDMA. Do you agree with this statement? Why?

[1.0 Mark]

d) In a cellular system, the system bandwidth is 12.5 MHz, the channel spacing is 30 kHz, and the guard band at each boundary of the spectrum is 10 kHz. In addition, the following details are provided.

- The cell area is 6 km^2
- The frequency reuse factor (cluster size) is 7
- 21 of the available channels are used to handle control signaling

Calculate the following using above details.

i) The total number of available channels per cluster.
ii) The number of available data channels per cell.
iii) The system spectral efficiency in units of channels/MHz/km^2.

[5.0 Marks]

Q2 a) Consider a hexagonal idealization of a cellular system (see Figure Q2) where D is the distance between the center of a cell and the center of its nearest co-channel

cell, and R is the radius of the cell. Show that the co-channel reuse ratio is equal to $\sqrt{3N_s}$, where N_s denotes the cluster size.

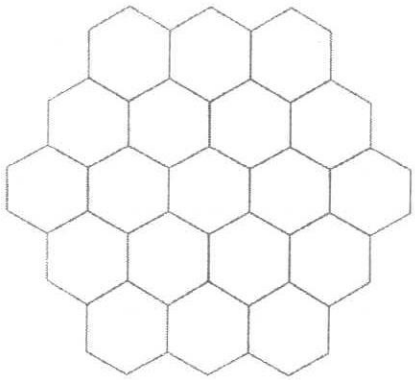

Figure Q2

[3.0 Marks]

b) Show that the signal-to-interference ratio for a mobile receiver which monitors a forward channel can be obtained as $SIR = \frac{1}{n}\left(\sqrt{3N_s}\right)^{\alpha}$ where α is the path loss exponent and n is the number of co-channel interfering cells. State any assumptions you make.

[3.0 Marks]

c) A cellular system has 317 channels of which 20 are control channels. The average number of calls per hour per cell is 343.5. The grade of service, as measured by the blocking probability, is 1% and the frequency reuse factor is 9. What is the average call holding time of a user in minutes?

[2.0 Marks]

d) An urban area has a population of one million residents. A trunked mobile network provides cellular service in this area. This system has 98 cells, each with 57 channels. Find the number of users that can be supported at 2% blocking if each user averages two calls per hour at an average call duration of three minutes.

[2.0 Marks]

Q3 a) Briefly explain what is meant by small scale fading. Mention 4 factors that affect small scale fading.

[3.0 Marks]

b) A local spatial average of a power delay profile is shown in Figure Q3.

i) Calculate the mean excess delay and the rms delay spread for the multipath profile given in Figure Q3. The signalling bandwidth is 200 kHz.

ii) Determine the maximum excess delay (-25 dB).

iii) Estimate the 50% coherence bandwidth of the channel.

iv) Given that the signal bandwidths of global system for mobile communications (GSM) and IS-95 are 200 kHz and 1.25 MHz, determine if a signal under those systems will experience frequency selective or flat fading.

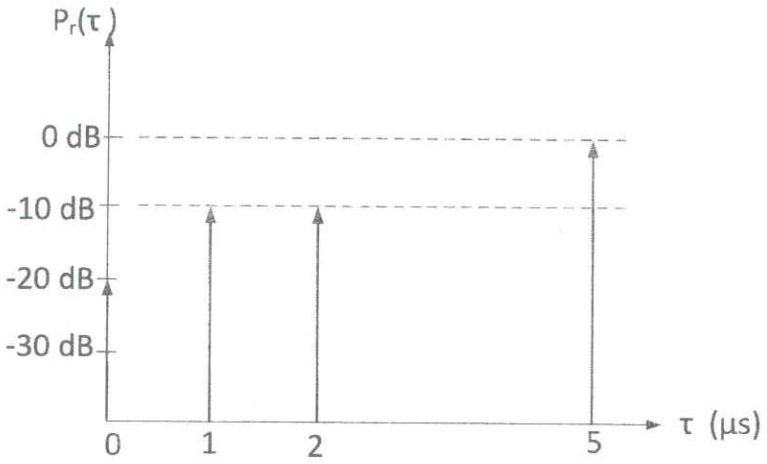

Figure Q3

[5.0 Marks]

c) i) Briefly explain the Doppler effect in wireless communication.

ii) Consider a transmitter which radiates a sinusoidal carrier frequency of 1850 MHz. For a vehicle moving at 26.82 m/s, compute the received carrier frequency if the mobile is moving directly towards the transmitter.

[1 × 2 = 2.0 Marks]

Q4 a) The following access techniques are used in GSM systems: TDMA and FDMA. How are they used, and what is the purpose in each case?

[2.0 Marks]

b) Assuming that a GSM operator owns a 25 MHz band (for both uplink and downlink) and all channels can be allocated to end users in a cell, what is the maximal number of voice users the cell can serve? List three techniques which can increase this number.

[2.5 Marks]

c) How many bits are there for a normal burst in a GSM frame and how many bits are used for transmitting user data in a normal burst? Explain each field in the normal burst.

[2.0 Marks]

d) What is the gross data rate for a channel in GSM? Briefly explain how it is achieved by using GSM normal burst.

[2.0 Marks]

e) Name the algorithms used for the following purposes of the GSM system.

i) Ciphering

ii) Authentication

iii) Key generation

[1.5 Marks]

Q5 a) Why power control is considered as a major factor for the efficient operation of CDMA? Briefly explain the process of open-loop power control.

[2.0 Marks]

b) Show that the energy per bit (E_b) to the noise density (N_0) ratio (E_b/N_0) of the reverse link in the CDMA system is given by $\frac{(S/R)}{\frac{(N-1)S}{w}+\frac{n}{w}}$,

where

S - the power of the received signal from each user,

N - the number of users in the cell,

n - background noise power,

w - spreading bandwidth,

R - the information bit rate.

State all assumptions that use to determine the above expression.

[2.0 Marks]

c) Explain two methods for increasing the reverse link E_b/N_0 in CDMA system.

[2.0 Marks]

d) What is frequency-selective fading? How does orthogonal frequency division multiplexing (OFDM) minimize the frequency-selective fading problem?

[2.0 Marks]

e) Given that the gross rate in GSM is 270.83 kbps with 200 kHz bandwidth and the downlink data rate in LTE-A is 1 Gbps with 100 MHz bandwidth, calculate the spectrum efficiency for GSM and LTE-A.

[2.0 Marks]

S/B	0.01%	0.05%	0.1%	0.5%	1%	2%	5%	10%	15%	20%	30%	40%
51	29.63	32.09	33.33	36.85	38.80	41.19	45.53	50.64	55.18	59.75	69.88	82.65
52	30.40	32.90	34.15	37.72	39.70	42.12	46.53	51.72	56.34	60.98	71.30	84.31
53	31.17	33.70	34.98	38.60	40.60	43.06	47.53	52.80	57.50	62.22	72.73	85.98
54	31.94	34.51	35.80	39.47	41.50	44.00	48.54	53.89	58.66	63.46	74.15	87.64
55	32.71	35.32	36.63	40.35	42.41	44.93	49.54	54.97	59.82	64.70	75.57	89.30
56	33.49	36.13	37.46	41.23	43.31	45.88	50.54	56.06	60.98	65.94	77.00	90.97
57	34.27	36.95	38.29	42.11	44.22	46.81	51.55	57.14	62.14	67.18	78.42	92.63
58	35.05	37.76	39.12	42.99	45.13	47.75	52.55	58.23	63.30	68.42	79.84	94.30
59	35.84	38.58	39.96	43.87	46.04	48.70	53.56	59.31	64.46	69.66	81.27	95.96
60	36.62	39.40	40.79	44.75	46.95	49.64	54.56	60.40	65.63	70.90	82.70	97.63
61	37.41	40.22	41.63	45.64	47.86	50.59	55.57	61.48	66.79	72.14	84.12	99.30
62	38.20	41.04	42.47	46.53	48.77	51.53	56.58	62.57	67.95	73.38	85.55	101.0
63	38.99	41.87	43.31	47.41	49.69	52.48	57.59	63.66	69.11	74.63	86.97	102.6
64	39.78	42.70	44.15	48.30	50.60	53.43	58.60	64.75	70.27	75.86	88.39	104.3
65	40.58	43.52	45.00	49.19	51.52	54.38	59.61	65.84	71.44	77.11	89.82	106.0
66	41.38	44.35	45.84	50.09	52.43	55.32	60.62	66.93	72.60	78.34	91.24	107.6
67	42.17	45.18	46.69	50.98	53.35	56.27	61.63	68.02	73.77	79.59	92.67	109.3
68	42.97	46.01	47.54	51.87	54.27	57.22	62.64	69.11	74.93	80.83	94.09	110.9
69	43.77	46.85	48.39	52.77	55.19	58.18	63.65	70.20	76.09	82.07	95.52	112.6
70	44.57	47.68	49.24	53.66	56.11	59.13	64.66	71.29	77.26	83.31	96.95	114.3
71	45.38	48.52	50.09	54.55	57.03	60.08	65.68	72.38	78.42	84.55	98.37	115.9
72	46.19	49.36	50.94	55.45	57.95	61.04	66.69	73.46	79.59	85.80	99.80	117.6
73	46.99	50.19	51.80	56.35	58.88	61.99	67.71	74.55	80.75	87.04	101.2	119.3
74	47.80	51.04	52.65	57.25	59.80	62.94	68.72	75.65	81.91	88.29	102.6	120.9
75	48.61	51.88	53.51	58.15	60.73	63.90	69.73	76.74	83.08	89.53	104.1	122.6
76	49.43	52.72	54.37	59.05	61.65	64.86	70.75	77.83	84.24	90.77	105.5	124.3
77	50.24	53.56	55.23	59.95	62.58	65.81	71.77	78.92	85.41	92.02	106.9	125.9
78	51.05	54.41	56.09	60.86	63.50	66.77	72.79	80.02	86.58	93.26	108.4	127.6
79	51.87	55.25	56.95	61.76	64.43	67.73	73.80	81.11	87.74	94.50	109.8	129.3
80	52.68	56.10	57.81	62.66	65.36	68.69	74.82	82.20	88.91	95.74	111.2	130.9
81	53.50	56.95	58.67	63.57	66.29	69.64	75.84	83.29	90.07	96.99	112.6	132.6
82	54.32	57.80	59.54	64.48	67.22	70.61	76.86	84.38	91.24	98.23	114.1	134.3
83	55.14	58.65	60.40	65.38	68.15	71.57	77.87	85.48	92.41	99.48	115.5	135.9
84	55.96	59.50	61.27	66.29	69.08	72.53	78.89	86.57	93.57	100.7	116.9	137.6
85	56.79	60.35	62.13	67.20	70.01	73.49	79.91	87.67	94.74	102.0	118.3	139.3
86	57.61	61.20	63.00	68.11	70.95	74.45	80.93	88.77	95.91	103.2	119.8	140.9
87	58.44	62.06	63.87	69.02	71.88	75.41	81.95	89.86	97.07	104.5	121.2	142.6
88	59.27	62.91	64.74	69.93	72.81	76.38	82.97	90.95	98.24	105.7	122.6	144.3
89	60.09	63.77	65.61	70.84	73.75	77.34	83.99	92.05	99.41	106.9	124.0	145.9
90	60.92	64.63	66.48	71.75	74.68	78.30	85.01	93.14	100.6	108.2	125.5	147.6
91	61.75	65.48	67.36	72.66	75.62	79.27	86.03	94.23	101.7	109.4	126.9	149.3
92	62.58	66.34	68.23	73.58	76.55	80.23	87.05	95.34	102.9	110.7	128.3	150.9
93	63.41	67.20	69.10	74.49	77.49	81.20	88.08	96.43	104.1	111.9	129.7	152.6
94	64.25	68.07	69.98	75.41	78.43	82.16	89.09	97.52	105.3	113.2	131.2	154.3
95	65.08	68.93	70.85	76.32	79.37	83.13	90.12	98.63	106.4	114.4	132.6	155.9
96	65.91	69.79	71.73	77.24	80.30	84.09	91.14	99.72	107.6	115.7	134.0	157.6
97	66.75	70.65	72.61	78.16	81.24	85.06	92.16	100.8	108.8	116.9	135.5	159.3
98	67.59	71.52	73.48	79.07	82.18	86.03	93.19	101.9	109.9	118.1	136.9	160.9
99	68.43	72.38	74.36	79.98	83.12	87.00	94.21	103.0	111.1	119.4	138.3	162.6
100	69.26	73.25	75.24	80.91	84.06	87.97	95.23	104.1	112.3	120.6	139.7	164.3

*End of **Erlang B** Traffic Table*

Erlang B Traffic Table: *Maximum offered load versus B and S*

S/B	0.01%	0.05%	0.1%	0.5%	1%	2%	5%	10%	15%	20%	30%	40%
1	.0001	.0005	.0010	.0050	.0101	.0204	.0526	.1111	.1765	.2499	.4285	.6666
2	.0142	.0321	.0457	.1053	.1526	.2234	.3813	.5954	.7962	.9999	1.449	2.000
3	.0868	.1517	.1938	.3490	.4554	.6022	.8994	1.271	1.602	1.930	2.633	3.480
4	.2347	.3623	.4393	.7012	.8694	1.092	1.525	2.045	2.501	2.945	3.890	5.021
5	.4519	.6486	.7621	1.132	1.361	1.657	2.218	2.881	3.454	4.010	5.188	6.595
6	.7282	.9956	1.146	1.622	1.909	2.276	2.960	3.758	4.444	5.108	6.513	8.190
7	1.054	1.392	1.578	2.157	2.501	2.935	3.738	4.666	5.461	6.230	7.856	9.799
8	1.422	1.830	2.051	2.730	3.127	3.627	4.543	5.597	6.498	7.369	9.212	11.42
9	1.826	2.302	2.557	3.333	3.782	4.345	5.370	6.546	7.551	8.521	10.58	13.04
10	2.260	2.803	3.092	3.960	4.461	5.084	6.215	7.510	8.616	9.685	11.95	14.68
11	2.721	3.329	3.651	4.610	5.160	5.841	7.076	8.487	9.691	10.86	13.33	16.31
12	3.207	3.878	4.231	5.279	5.876	6.614	7.950	9.474	10.78	12.04	14.72	17.95
13	3.713	4.446	4.830	5.963	6.607	7.401	8.834	10.47	11.87	13.22	16.11	19.60
14	4.239	5.032	5.446	6.663	7.352	8.200	9.729	11.47	12.96	14.41	17.50	21.24
15	4.781	5.634	6.077	7.375	8.108	9.009	10.63	12.48	14.07	15.61	18.90	22.89
16	5.339	6.250	6.721	8.099	8.875	9.828	11.54	13.50	15.18	16.81	20.30	24.54
17	5.911	6.878	7.378	8.833	9.651	10.66	12.46	14.52	16.29	18.01	21.70	26.19
18	6.496	7.519	8.045	9.578	10.44	11.49	13.38	15.55	17.40	19.21	23.10	27.84
19	7.092	8.169	8.724	10.33	11.23	12.33	14.31	16.58	18.52	20.42	24.51	29.50
20	7.700	8.831	9.411	11.09	12.03	13.18	15.25	17.61	19.65	21.63	25.92	31.15
21	8.318	9.501	10.11	11.86	12.84	14.04	16.19	18.65	20.77	22.85	27.32	32.81
22	8.946	10.18	10.81	12.63	13.65	14.90	17.13	19.69	21.90	24.06	28.73	34.46
23	9.583	10.87	11.52	13.42	14.47	15.76	18.08	20.74	23.03	25.28	30.14	36.12
24	10.23	11.56	12.24	14.20	15.29	16.63	19.03	21.78	24.16	26.50	31.56	37.78
25	10.88	12.26	12.97	15.00	16.12	17.50	19.98	22.83	25.30	27.72	32.97	39.43
26	11.54	12.97	13.70	15.79	16.96	18.38	20.94	23.88	26.43	28.94	34.38	41.09
27	12.21	13.69	14.44	16.60	17.80	19.26	21.90	24.94	27.57	30.16	35.80	42.75
28	12.88	14.41	15.18	17.41	18.64	20.15	22.87	25.99	28.71	31.39	37.21	44.41
29	13.56	15.13	15.93	18.22	19.49	21.04	23.83	27.05	29.85	32.61	38.63	46.07
30	14.25	15.86	16.68	19.03	20.34	21.93	24.80	28.11	30.99	33.84	40.05	47.73
31	14.94	16.60	17.44	19.85	21.19	22.83	25.77	29.17	32.14	35.07	41.46	49.39
32	15.63	17.34	18.20	20.68	22.05	23.72	26.74	30.24	33.28	36.29	42.88	51.05
33	16.33	18.08	18.97	21.50	22.91	24.63	27.72	31.30	34.43	37.52	44.30	52.71
34	17.04	18.83	19.74	22.33	23.77	25.53	28.70	32.37	35.57	38.75	45.71	54.38
35	17.75	19.59	20.52	23.17	24.64	26.43	29.68	33.43	36.72	39.98	47.14	56.04
36	18.47	20.35	21.29	24.01	25.51	27.34	30.66	34.50	37.87	41.21	48.55	57.70
37	19.19	21.11	22.08	24.85	26.38	28.25	31.64	35.57	39.02	42.45	49.98	59.36
38	19.91	21.87	22.86	25.69	27.25	29.17	32.62	36.64	40.17	43.68	51.39	61.03
39	20.64	22.64	23.65	26.53	28.13	30.08	33.61	37.71	41.32	44.91	52.82	62.69
40	21.37	23.41	24.44	27.38	29.01	31.00	34.60	38.79	42.47	46.14	54.23	64.35
41	22.11	24.19	25.24	28.23	29.89	31.91	35.58	39.86	43.63	47.38	55.66	66.02
42	22.84	24.97	26.04	29.08	30.77	32.84	36.57	40.93	44.78	48.61	57.08	67.68
43	23.59	25.75	26.84	29.94	31.65	33.76	37.56	42.01	45.93	49.85	58.50	69.34
44	24.33	26.53	27.64	30.80	32.54	34.68	38.56	43.09	47.09	51.09	59.92	71.00
45	25.08	27.32	28.45	31.65	33.43	35.61	39.55	44.16	48.24	52.32	61.34	72.67
46	25.83	28.11	29.25	32.52	34.32	36.53	40.54	45.24	49.40	53.56	62.77	74.33
47	26.59	28.90	30.06	33.38	35.21	37.46	41.54	46.32	50.55	54.79	64.19	76.00
48	27.34	29.70	30.88	34.24	36.11	38.39	42.54	47.40	51.71	56.03	65.61	77.66
49	28.10	30.49	31.69	35.11	37.00	39.32	43.53	48.48	52.87	57.27	67.04	79.32
50	28.87	31.29	32.51	35.98	37.90	40.25	44.53	49.56	54.03	58.51	68.46	80.98