UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, FIRST SEMESTER DECEMBER 2015

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	TELECOMMUNICATIONS AND WIRELESS SYSTEMS
COURSE CODE:	EE544
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. There are five questions in this paper. Answer any FOUR questions. Each question carries 25 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.

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THIS PAPER CONTAINS EIGHT (8) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(25 marks)***

(a) A satellite link operating in K_a band uses a frequency of $30GHz$. The angle of elevation of the earth station antenna is 40^0 and the latitude of the location is -50^0. The rain rate exceeded for 0.01% of an average year is 60 $\frac{mm}{hr}$. The total outage time of the link throughout a year is required to be less than $15min$. Assuming that the other additional losses are $6dB$, calculate the non diversity fade margin required for the link.

(12 marks)

(b) A satellite station antenna receives signal under a rain, experiencing an attenuation of $8dB$. The cosmic noise temperature, physical temperature of the rain and the physical temperature of the earth are 50 °K, 250 °K and 300 °K respectively. If the efficiency of the antenna is 0.75, calculate the noise power at the output of antenna terminal in dBm. The bandwidth of the signal is $10MHz$. (8 marks)

(c) A satellite receiver operating on $30GHz$ signal has an dish antenna of gain $40dB$ with an efficiency of 0.75. Find the diameter and the beam width of the antenna.

(5 marks)

QUESTION TWO *(25 marks)*

(a) (i) A satellite transponder establishes a single hop link between two earth stations. Derive an expression for the $\frac{C}{N}$ ratio at the receive end in terms of the $\frac{C}{N}$ ratios of the uplink and the downlink. (6 marks)

(ii) In the satellite link mentioned in (i) above, signal is BPSK modulated and the allocated bandwidth is $10MHz$, while the expected BER is less than 10^{-6}. If the downlink $\frac{C}{N}$ is $12dB$, find the uplink $\frac{C}{N}$ ratio at the transponder input and the maximum data rate. You may also assume the following data,

Earth station receiver noise figure = $2dB$

Bandwidth expansion factor = 1.2

FEC code rate = $\frac{2}{3}$

(7 marks)

(b) A geostationary satellite transmits $20GHz$ signal with $85W$ of power. The dish antenna on the earth station is connected to the receiver using a waveguide. Calculate the $\frac{C}{N}$ ratio at the antenna output terminal and hence find the $\frac{C}{N}$ at the receiver output. Use the following data.

Tx antenna gain	= $20dB$
Rx antenna gain	= $45dB$
Bandwidth	= $10MHz$
Rx antenna efficiency	= 0.8
Brightness temperature	= 50 °K
Physical temperature	= 300 °K
Rx noise temperature	= 200 °K
Waveguide loss	= $1dB$

(12 marks)

QUESTION THREE ***(25 marks)***

(a) (i) A mobile service is given $25MHz$ bandwidth for uplink. If the cluster size is 7 and the grade of service is 0.02, find the number of customers that can be served in one cell. Assume that an average user makes two calls of $3min$ duration in one hour. The channel bandwidth is $200KHz$ and the blocked calls cleared is employed.

(10 marks)

(b) (ii) If the number of users per cell in a(i) above is to be increased by 120^0 sectoring, state how this can be implemented. Calculate the number of users per cell after sectoring and the resulting percentage increase of users.

(8 marks)

(c) Calculate the following for a mobile network based on a cluster size of 4 and a cell radius of $0.5km$

(i) the co-channel distance. (2 marks)

(ii) the carrier to co-channel interference ratio. (2 marks)

(iii) the carrier to co-channel interference ratio if 120^0 sectoring is used.

(3 marks)

QUESTION FOUR *(25 marks)*

(a) A received mobile radio signal at a distance of $100m$ from the transmitter antenna is $10^{-5}mW$. At a distance of $1Km$ it is found to be $10^{-8}mW$ and when the distance is $2Km$, it is $3 \times 10^{-10}mW$. Comment on the path loss characteristics in this environment and find expressions for the received signal power in dB.

(10 marks)

(b) During the busy hour, a network receives 800 call requests. If the average call holding time is $3min$ and the grade of service is 2% , calculate

(i) the number of lost calls.

(ii) the offered traffic.

(iii) the carried traffic.

(iv) the lost traffic.

(8 marks)

(c) A switch covering a remote area is having 900 subscribers. The switch is connected with 42 outgoing trunks for national connections. If the 80% of traffic is for local calls, find the probability that a local subscriber will get a busy signal on a national call attempt. Assume that a single user generates a traffic of $0.2E$.

(7 marks)

QUESTION FIVE (25 *marks*)

(a) (i) State the factors related to the signal degradation in an optical fiber. (1 mark)

(ii) State some facts effecting the selection of multimode and single mode fibers for optical links. (1 mark)

(iii) Draw the cross section of an optical fiber.

(2 marks)

(b) The refractive index of the core and cladding of an optical fiber are 1.552 and 1.516 respectively. Calculate,

(i) the critical angle and acceptance angle. (3 marks)

(ii) the numerical aperture and the relative refractive index difference . (3 marks)

(iii) the coupling efficiency when the source-fiber interface is filled with a substance having a refractive index of 1.12. (2 marks)

(c) An optical link operates a distance of $150km$. Splicing is done in every 5 km. An optical amplifier having a gain of $15dB$ is located at the midpoint of the link. The sensitivity of the end point optical receiver is $-30dBm$. Find the required power of the optical transmitter and the input sensitivity of the amplifier. You may use,

Attenuation loss	$= 0.2 \frac{dB}{km}$
Connector loss	= 0.3 dB per connector
Splicing loss	= 0.1 dB per splice
Safety margin	$= 6dB$

(13 marks)

SOME SELECTED USEFUL FORMULAE

Boltsmann constant $= 1.38 \times 10^{-23} \frac{J}{°K}$

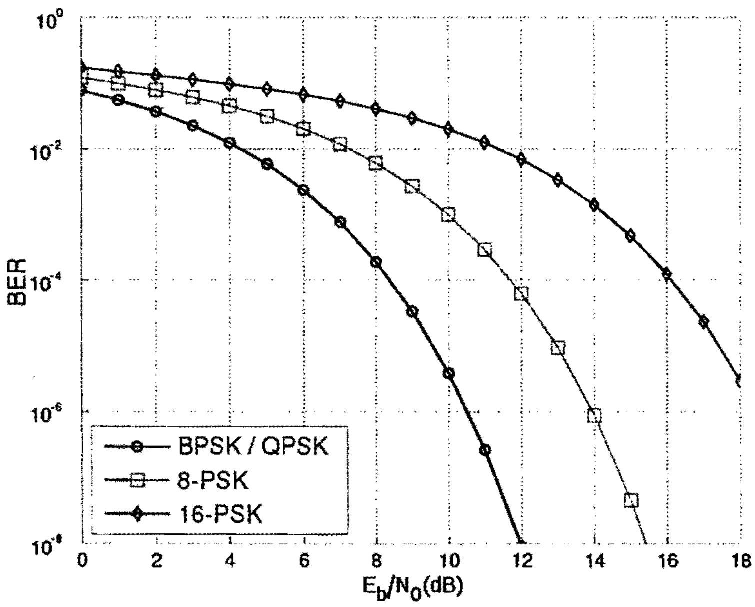
F (GHz)	a	b
1	3.87×10^{-5}	0.912
10	0.0101	1.276
20	0.0751	1.099
30	0.187	1.021
40	0.35	0.939

h_R(km):

$5 - 0.075(\phi - 23)$	$\emptyset > 23^0$
5	$0^0 \le \emptyset \le 23^0$
5	$0^0 \ge \emptyset \ge -21^0$
$5 + 0.1(\emptyset + 21)$	$-71^0 \le \emptyset \le -21^0$
0	$\emptyset < -71^0$

$$S_{0.01} = \frac{1}{1 + \frac{r_R \sin\theta}{35\exp(-0.015 R_{0.01})}}$$

$L_P = L_{0.01} \times 0.12\, P^{-(0.546 + 0.043 \log P)}$ where $0.001 < P < 1\%$



Erlang B Traffic Table

Maximum Offered Load Versus B and N

B is in %

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.0010	.0050	.0101	.0204	.0526	.1111	.1765	.2500	.4286	.6667
2	.0142	.0321	.0458	.1054	.1526	.2235	.3813	.5954	.7962	1.000	1.449	2.000
3	.0868	.1517	.1938	.3490	.4555	.6022	.8994	1.271	1.603	1.930	2.633	3.480
4	.2347	.3624	.4393	.7012	.8694	1.092	1.525	2.045	2.501	2.945	3.891	5.021
5	.4520	.6486	.7621	1.132	1.361	1.657	2.219	2.881	3.454	4.010	5.189	6.596
6	.7282	.9957	1.146	1.622	1.909	2.276	2.960	3.758	4.445	5.109	6.514	8.191
7	1.054	1.392	1.579	2.158	2.501	2.935	3.738	4.666	5.461	6.230	7.856	9.800
8	1.422	1.830	2.051	2.730	3.128	3.627	4.543	5.597	6.498	7.369	9.213	11.42
9	1.826	2.302	2.558	3.333	3.783	4.345	5.370	6.546	7.551	8.522	10.58	13.05
10	2.260	2.803	3.092	3.961	4.461	5.084	6.216	7.511	8.616	9.685	11.95	14.68
11	2.722	3.329	3.651	4.610	5.160	5.842	7.076	8.487	9.691	10.86	13.33	16.31
12	3.207	3.878	4.231	5.279	5.876	6.615	7.950	9.474	10.78	12.04	14.72	17.95
13	3.713	4.447	4.831	5.964	6.607	7.402	8.835	10.47	11.87	13.22	16.11	19.60
14	4.239	5.032	5.446	6.663	7.352	8.200	9.730	11.47	12.97	14.41	17.50	21.24
15	4.781	5.634	6.077	7.376	8.108	9.010	10.63	12.48	14.07	15.61	18.90	22.89
16	5.339	6.250	6.722	8.100	8.875	9.828	11.54	13.50	15.18	16.81	20.30	24.54
17	5.911	6.878	7.378	8.834	9.652	10.66	12.46	14.52	16.29	18.01	21.70	26.19
18	6.496	7.519	8.046	9.578	10.44	11.49	13.39	15.55	17.41	19.22	23.10	27.84
19	7.093	8.170	8.724	10.33	11.23	12.33	14.32	16.58	18.53	20.42	24.51	29.50
20	7.701	8.831	9.412	11.09	12.03	13.18	15.25	17.61	19.65	21.64	25.92	31.15
21	8.319	9.501	10.11	11.86	12.84	14.04	16.19	18.65	20.77	22.85	27.33	32.81
22	8.946	10.18	10.81	12.64	13.65	14.90	17.13	19.69	21.90	24.06	28.74	34.46
23	9.583	10.87	11.52	13.42	14.47	15.76	18.08	20.74	23.03	25.28	30.15	36.12
24	10.23	11.56	12.24	14.20	15.30	16.63	19.03	21.78	24.16	26.50	31.56	37.78
25	10.88	12.26	12.97	15.00	16.13	17.51	19.99	22.83	25.30	27.72	32.97	39.44
26	11.54	12.97	13.70	15.80	16.96	18.38	20.94	23.89	26.43	28.94	34.39	41.10
27	12.21	13.69	14.44	16.60	17.80	19.27	21.90	24.94	27.57	30.16	35.80	42.76
28	12.88	14.41	15.18	17.41	18.64	20.15	22.87	26.00	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	31.00	33.84	40.05	47.74
31	14.94	16.60	17.44	19.85	21.19	22.83	25.77	29.17	32.14	35.07	41.46	49.40
32	15.63	17.34	18.21	20.68	22.05	23.73	26.75	30.24	33.28	36.30	42.88	51.06
33	16.34	18.09	18.97	21.51	22.91	24.63	27.72	31.30	34.43	37.52	44.30	52.72
34	17.04	18.84	19.74	22.34	23.77	25.53	28.70	32.37	35.58	38.75	45.72	54.38
35	17.75	19.59	20.52	23.17	24.64	26.44	29.68	33.43	36.72	39.99	47.14	56.04
36	18.47	20.35	21.30	24.01	25.51	27.34	30.66	34.50	37.87	41.22	48.56	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	59.37
38	19.91	21.87	22.86	25.69	27.25	29.17	32.62	36.64	40.17	43.68	51.40	61.03
39	20.64	22.64	23.65	26.53	28.13	30.08	33.61	37.72	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	42.48	46.15	54.24	64.35
41	22.11	24.19	25.24	28.23	29.89	31.92	35.58	39.86	43.63	47.38	55.66	66.02
42	22.85	24.97	26.04	29.09	30.77	32.84	36.57	40.94	44.78	48.62	57.08	67.68
43	23.59	25.75	26.84	29.94	31.66	33.76	37.57	42.01	45.94	49.85	58.50	69.34