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UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, FIRST SEMESTER DECEMBER 2017

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 earth station is located at an altitude of 30^0. The elevation angle of the antenna is 50^0 with a signal receiving at $20GHz$. The rain rate exceeded for 0.01% of an average year is 80 $\frac{mm}{hr}$. If the link failure due to rain is required to be less than $20min$ in a year, estimate the non diversity fade margin.

(12 marks)

(b) A geo-stationary satellite transmits $10GHz$ signal with $60W$ of power. The receiver system consists of a dish antenna, which connects to the receiver through a waveguide. Calculate the carrier to noise ratio at the output of the receiver. You may assume the following data.

Transmitter antenna gain	$= 20\ dB$
Receiver antenna gain	$= 45\ dB$
Bandwidth	$= 1MHz$
Receiver antenna efficiency	$= 0.8$
Transmitter antenna efficiency	$= 1$
Physical temperature	$= 300^0K$
Brightness temperature	$= 70^0K$
Waveguide loss	$= 2dB$
Receiver Noise Figure	$= 4dB$

(13 marks)

QUESTION TWO ***(25 marks)***

(a) A satellite receiver in an earth station has an antenna with an efficiency of 0.75. Find the noise temperature of the antenna when it is under a rain of $8dB$ attenuation. You may assume that the cosmic noise temperature, physical temperature of the rain and the temperature of the earth are 50 °K, 285 °K and 300 °K respectively.

(7 marks)

(b) A receiver operating at $290^0 K$ has a Noise Figure of $8dB$. The signal data rate is $2\frac{Mb}{s}$, and QPSK modulated. If the carrier to noise ratio at the input of the receiver is $18.3dB$, estimate the bit error rate at the output of the receiver. What is the received signal power at the input of the receiver?

Bandwidth expansion factor = 1.11 FEC code rate = $\frac{2}{3}$

(12 marks)

(c) A link between two earth stations is maintained through a satellite transponder. 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)

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

(a) A mobile network is using a cluster size of 7 and a cell radius of $0.5km$

(i) Find the distance between the two base stations using the same frequency bands. (2 marks)

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

(iii) If a minimum co-channel interference ratio of $19dB$ is required and a cluster size of 3 to be used, show a cost effective way of implementing it. (4 marks)

(b) For a mobile service, a $30MHz$ bandwidth is allocated for the forward channels. You may assume a cluster size of 7 and the GSM channel bandwidth. If 1225 users per cluster to be served with a grade of service 2%, estimate the expected average call holding time. An average user makes two calls in an hour and the blocked calls are cleared. (9 marks)

(c) A mobile base station covering a large city area operates at $900MHz$. The cell radius is $1.5km$. The sensitivity of the receiver of a mobile device at the cell radius is $-90dm$. Estimate the path loss experienced by the mobile device. Hence find the transmitter power in Watts, required at the base station if it uses an omni-directional antenna. You may use,

The height of the base station tower = $25m$

The height of the mobile receiver = $1m$

(8 marks)

QUESTION FOUR *(25 marks)*

(a) The refractive indices of the core and the cladding of an optical fiber are 1.556 and 1.526 respectively.

(i) An incident light ray which makes an angle $\propto$ with the axis of the fiber is propagated throughout. Calculate the maximum possible value for $\propto$, deriving any formula you use.

(6 marks)

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

(4 marks)

(b) (i) Draw the block diagram of an optical digital link and state the factors related to the signal degradation in an optical fiber.

(3 marks)

(ii) An optical link operates a distance of $200km$ with splicing in every5 km. An optical amplifier having a gain of $15dB$ and a sensitivity of $-25dBm$ is used in the link. If the sensitivity of the optical receiver is $-30dBm$, find the power of the optical transmitter required. Determine the location at which the amplifier must be placed.

Attenuation loss	$= 0.2\frac{dB}{km}$
Connector loss	= 0.3 dB per connector
Splicing loss	= 0.1 dB per splice
Safety margin	$= 5dB$

(12 marks)

QUESTION FIVE (25 *marks*)

(a) With the aid of suitable diagrams, show the following with respect to SDH network.

(i) Network elements.

(ii) Network configurations.

(iii) STM-1 frame structure.

(9 marks)

(b) Show the following with respect to ATM using suitable diagrams.

(i) Structure of the ATM cells.

(ii) Network elements.

(iii) Application with the ADSL users.

(9 marks)

(c) There are 130 internal extension lines are connected to a PABX. The PABX is connected to the PSTN with 5 lines. The busy hour calling rate per extension is 2 and the external call traffic is 40% of the total. If the average call holding time is three minutes, find the probability that an outgoing call may find the lines busy.

(7 marks)

SOME SELECTED USEFUL FORMULAE

$L_P = 69.55 + 26.16 \log F_c - 13.82 \log h_b - a(h_m) + (44.9 - 6.55 \log h_b) \log R$

$a(h_m) = 3.2(\log 11.75\, h_m)^2 - 4.97$

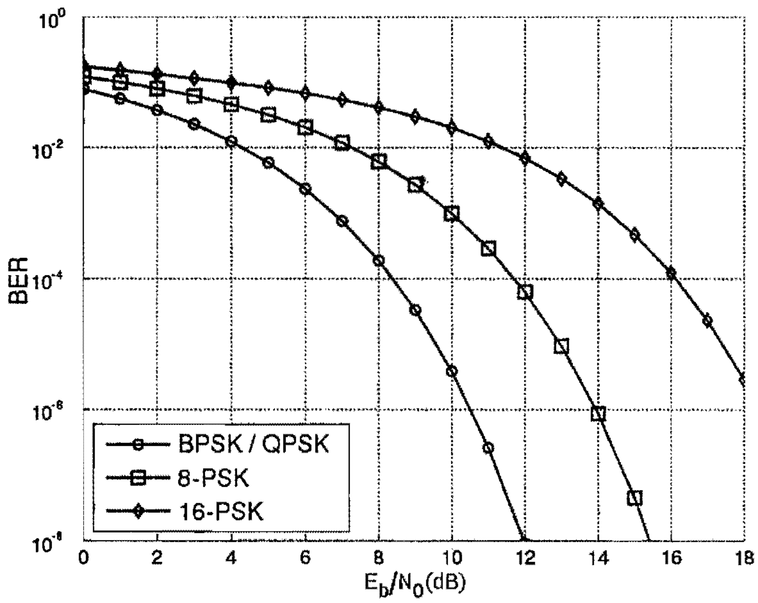
F (GHz)	a	b
1	$3.87\text{x}10^{-5}$	0.912
10	0.0101	1.276
20	0.0751	1.099
30	0.187	1.021
40	0.35	0.939

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 $0.001 < P < 1\%$



Boltzmann's Constant = 1.38×10^{-23} J / ^{0}K

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