UNIVERSITY OF ESWATINI

MAIN EXAMINATION, FIRST SEMESTER

DECEMBER 2018

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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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.

(10 marks)

(b) (i) Show that the noise temperature of an antenna when effected by rain is given by $T_A = T_m\left(1 - 10^{-\frac{L}{10}}\right) + T_c 10^{-\frac{L}{10}}$ where L is the attenuation due to rain in dB, T_m is the physical temperature of the rain and T_c is the cosmic noise temperature in ^0K. Assume that the efficiency of the antenna is 100%.

(5 marks)

(ii) Find the noise temperature of an antenna having an efficiency of 0.7 and experiencing a rain attenuation of $9dB$. You may assume that the cosmic noise temperature, physical temperature of the rain and the temperature of the earth are 60 °K, 270 °K and 300 °K respectively.

(5 marks)

(c) A satellite receiver operating on $25GHz$ signal has an dish antenna of gain $45dB$ with an efficiency of 0.8. 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 $25GHz$ signal with $80W$ 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. You may use the following data.

Tx antenna gain	$= 25dB$
Rx antenna gain	$= 45dB$
Bandwidth	$= 10MHz$
Rx antenna efficiency	$= 0.8$
Brightness temperature	$= 60\ ^{o}K$
Physical temperature	$= 300\ ^{o}K$
Rx noise temperature	$= 250\ ^{o}K$
Waveguide loss	$= 2dB$

(12 marks)

QUESTION THREE *(25 marks)*

(a) (i) A mobile service is given $50MHz$ total bandwidth. 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 (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 $0.8km$. Find the,

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

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

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

(3 marks)

QUESTION FOUR (*25 marks*)

(a) At a distance of $100m$ from the transmitter antenna of a base station, the received signal power 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 750 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 850 subscribers. The switch is connected with 40 outgoing trunks for national connections. Assume that a single user generates a traffic of $0.3E$. If the 75% of traffic is for local calls, find the probability that a local subscriber will get a busy signal on a national call attempt.

(7 marks)

QUESTION FIVE (25 *marks*)

(a) The refractive indices of the core and cladding of an optical fiber are 1.452 and 1.416 respectively.

(i) Calculate the critical angle and the acceptance angle.

(3 marks)

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

(3 marks)

(iii) What is the coupling efficiency if the source-fiber interface is filled with a filler of refractive index 1.12 ?

(2 marks)

(b) (i) A multimode optical fiber cable of $15km$ length has a model dispersion of $0.7\ \frac{ns}{km}$. Calculate the maximum bit rate if NRZ format is employed for the transmission.

(5 marks)

(ii) An optical link is to be designed for a distance of $120km$. The splicing is done in every$10\ km$. The optical power of the transmitter and the sensitivity of the end point optical receiver are $1.2mW$ and $-20dBm$ respectively. Complete the design of the link indicating the important specifications of any additional component/s. You may assume that there is an access to the link at the mid-point.

Attenuation loss	$= 0.22\ \frac{dB}{km}$
Connector loss	$= 0.2\ dB$ per connector
Splicing loss	$= 0.1\ dB$ per splice
Link margin	$= 6dB$

(12 marks)

SOME SELECTED USEFUL FORMULAE

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

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):

$5 - 0.075(\phi - 23)$ $\quad \phi > 23^0$

5 $\quad 0^0 \leq \phi \leq 23^0$

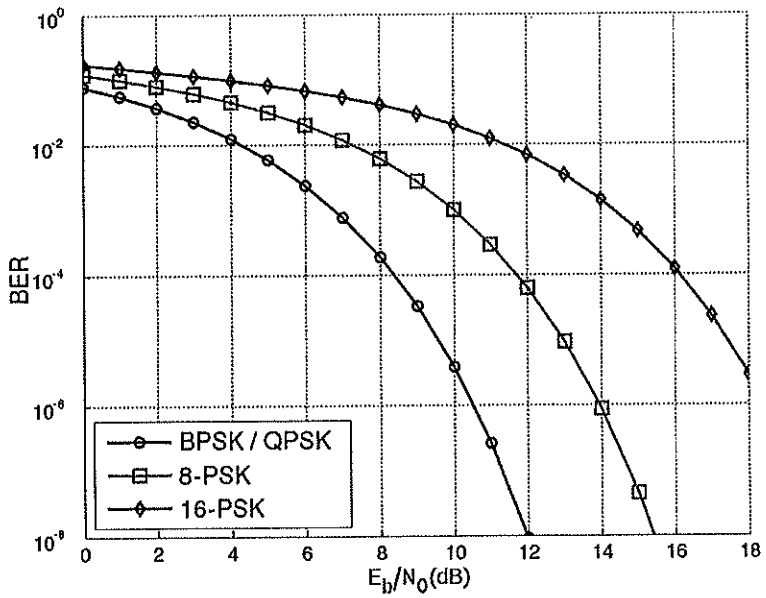
5 $\quad 0^0 \geq \phi \geq -21^0$

$5 + 0.1(\phi + 21)$ $\quad -71^0 \leq \phi \leq -21^0$

0 $\quad \phi < -71^0$

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

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