UNIVERSITY OF ESWATINI

FACULTY OF SCIENCE & ENGINEERING

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

RESIT EXAMINATION

JANUARY 2020

TITLE OF PAPER: TELECOMMUNICATIONS AND WIRELESS SYSTEMS

COURSE CODE: EEE541/EE544

DURATION: 3 HOURS

INSTRUCTIONS:

1. There are five (5) questions in this paper. Answer any FOUR (4) questions.
2. Each question carries 25 marks.
3. Start each question in a new page.

This paper should not be opened until permission has been given by the invigilator.

This paper contains NINE (9) pages including this page.

QUESTION ONE *(25 marks)*

(a) Describe briefly three multiple access methods used in digital satellite links.

(5 marks)

(b) An earth station antenna receives signal with an attenuation of $9dB$ under rain. The cosmic noise temperature, physical temperature of the rain and the physical temperature of the earth are 60 °K, 280 °K and 300 °K respectively. If the efficiency of the antenna is 0.8, calculate the noise power at the output of antenna terminal in dBm. The signalbandwidth is $12MHz$.

(8 marks)

(c) A satellite link operating at $25GHz$ use an antenna having an elevation angle of 45^0. The latitude of location is -40^0. The 0.01% rain rate of an average year is 70 $\frac{mm}{hr}$. If the total link outage time throughout a year to be less than $25min$, find the non diversity fade margin of the link. Assume that the other additional losses are $5dB$.

(12 marks)

QUESTION TWO *(25 marks)*

(a) (i) A geostationary satellite transmits $15GHz$, signal using an antenna of gain $25dB$. The gain of the earth receiver station antenna is $45dB$. If the fade margin and the received signal strength are $8dB$ and $-90dBm$ respectively, find the transmitter power of the satellite in watts.

(8 marks)

(ii) Estimate the Figure of Merit of the earth station receiver if it is connected to the antenna through a rectangular waveguide. You may use,

Brightness temperature $= 80^0K$

Antenna efficiency $= 0.85$

Waveguide loss $= 2dB$

Physical temperature $= 25^0C$

Receiver noise figure $= 5dB$

(8 marks)

(b) The BER required at the output of a digital receiver is 10^{-5}. Find the signal power required at the input of the receiver if the data rate is $1.8\frac{Mb}{s}$ and 8-PSK modulated.

Assume the following data,

Signal to noise ratio at the receiver input $= 17dB$.

Receiver noise figure $= 5dB$

Bandwidth expansion factor $= 1.23$

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

(9 marks)

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

(a) In a mobile service, the cell radius and the cluster size used are $0.75km$ and 4.

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

(ii) Calculate the $\frac{C}{I}$ ratio in dB. (2 marks)

(iii) Assuming 120^0 sectoring is used, find the carrier to co-channel interference ratio. (3 marks)

(b) A $30MHz$ bandwidth is used for the forward channels of a mobile network. The cluster size is 4 and the GSM channel bandwidth is assumed. If BCC applies and the grade of service expected is 1% , estimate the number of customers that can be served in a cell. An average user makes a one call of 2min in a hour.

(9 marks)

(c) A mobile network covering large city area is operating in $900MHz$ band. If the transmitter power of the base station is $30W$, find the path loss and the signal power received at a distance of $1.8km$. Assume that the base station antenna is omni-directional. You may also use,

The height of the base station tower = $22m$

The height of the mobile receiver = $1m$

(9 marks)

QUESTION FOUR (*25 marks*)

(a) (i) A mobile network has cells of radius $1.2km$. The received signal power at a distance of $15m$ from the base station is $955mW$ and on the edge of the cell it is $1.1 \times 10^{-5}mW$. Find the path loss exponent.

(6 marks)

(ii) For the case shown in (i) above, assume that the signal undergoes shadow fading with a standard deviation of $8.5dB$. Find the lowest signal power received at the edge of the cell over 88% of the time.

(9 marks)

(b) An optical fiber consists with a core and cladding having refractive indices of 1.356 and 1.326 respectively.

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

(6 marks)

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

(2 marks)

(iii) If this fiber is coupled to a laser diode and the interface is filled with a material having refractive index of 1.11, find the efficiency of the coupling.

(2 marks)

QUESTION FIVE (25 *marks*)

(a) (i) A remote switch serving 650 subscribers is connected to an exchange serving national calls through a one $E1$ line. A subscriber makes 2 calls of $3min$ in the busy hour. If 30% of the traffic in the switch are national calls, find the blocking probability for the national call traffic. Assume that the BCC is employed.

(10 marks)

(ii) A network receives 600 call requests during the busy hour. The average call duration per user is $2min$ and the grade of service is 5%. Find,

(i) Number of network trunks available.

(ii) Number of lost calls.

(iii) Amount of offered traffic.

(iv) Amount of carried traffic.

(8 marks)

(b) (i) Describe briefly a STM-1 frame ($155.52\ \frac{Mb}{s}$) in SDH with useful data.

(4 marks)

(ii) Identify SSP, STP, and SCP network parts in a SS7 network showing their interconnectivity.

(3 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	3.87×10^{-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 $\quad 0^0 \leq \phi \leq 23^0$

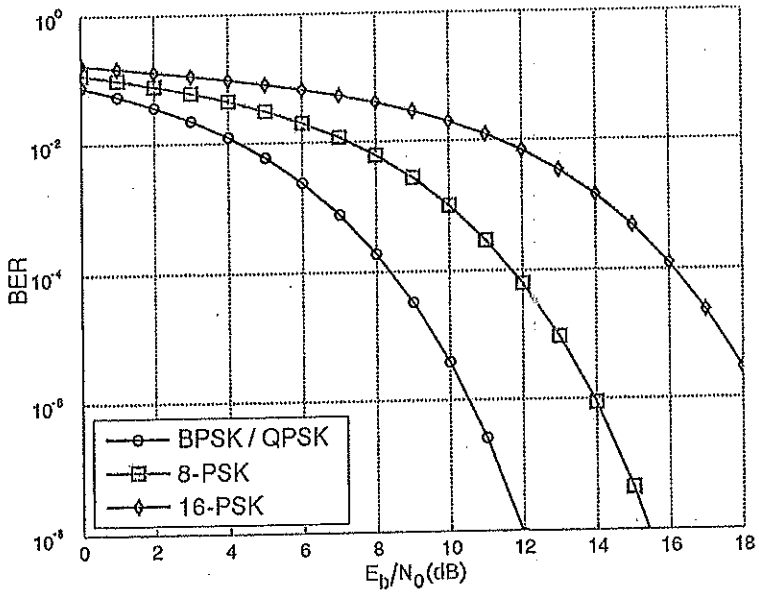
5 $\quad 0^0 \geq \phi \geq -21^0$

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

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 $0.001 < P < 1\%$



z	$erf(z)$	z	$erf(z)$
0.1	0.11246	1.6	0.97635
0.2	0.22270	1.7	0.98379
0.3	0.32863	1.8	0.98909
0.4	0.42839	1.9	0.99279
0.5	0.52049	2.0	0.99532
0.6	0.60385	2.1	0.99702
0.7	0.67780	2.2	0.99814
0.8	0.74210	2.3	0.99885
0.9	0.79691	2.4	0.99931
1.0	0.84270	2.5	0.99959
1.1	0.88021	2.6	0.99976
1.2	0.91031	2.7	0.99987
1.3	0.93401	2.8	0.99993
1.4	0.95228	2.9	0.99996
1.5	0.96611	3.0	0.99998

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