UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2012

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	TELECOMMUNICATION SYSTEMS AND OPTICAL AND MICROWAVE TRANSMISSION
COURSE CODE:	ECO530
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.
3. Erlang-B table is attached.

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE (*25 marks*)

(a) A radio link is to operate at 4 GHz and has a hop distance of 25km. A hill with elevation 150m is situated 10 km from the transmitter site on the line of sight path with the receiver. The elevation of the transmitter site and the receiver site are 100m and 170m respectively. Assuming equal antenna heights find the minimum required height for the antennas.

$R_e = 6370km$ $k = 2/3$

(15 marks)

(b) If the above mentioned link to meet the performance target of outage in the worst month $< 10^{-4}$ with the following data, find the non diversity fade margin required. If the system is provided with diversity find the resulting fade margin for the same performance target and estimate the separation between the main and the diversity antenna.

Ground roughness = 10mRad Terrain factor = 4dB

(10 marks)

QUESTION TWO *(25 marks)*

(a) A satellite transponder transmits a 11GHz, DQPSK signal to an earth station. It is required to have a BER of 10^{-6} at the output for satisfactory operation. If the bit rate is 2Mbps, find the carrier to noise ratio required. Assume a FEC code rate of 2/3 and a bandwidth expansion factor of 1.2.

(5 marks)

(b) A microwave receiver consists of a RF amplifier, mixer and an IF filter with IF amplifier. Evaluate the receiver noise temperature for the data given below. Note that the 'G', 'L' and 'F' denote the gain, the loss and the noise figure respectively.

$G_{RF} = 21dB$ $L_{mixer} = 5dB$ $G_{IF} = 28dB$

$F_{RF} = 3dB$ $F_{mixer} = 8dB$ $F_{IF} = 2dB$

(5 marks)

(c) A geostationary satellite transmits a 11GHz signal to an earth receiver station. The receiver is connected to the antenna by a waveguide. If the receiver needs a minimum (C/N) ratio of 12dB, find the transmitter power required in the satellite transponder. You may assume the following data.

Transmitter antenna gain	= 30dB
Receiver antenna gain	= 40dB
Bandwidth	= 3MHz
Receiver antenna efficiency	= 0.8
Physical temperature	= 300 °K
T_{sky}	= 100 °K
Waveguide loss	= 1dB
Receiver nose temperature	= 400 °K

(15 marks)

QUESTION THREE *(25 marks)*

(a) A mobile network is based on a 7 cells per cluster and operating in the 900MHz band.

(i) Find the mean re-use distance if the cell radius is 0.5km.

(2 marks)

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

(4 marks)

(iii) If 4 cells per cluster is used with 60^0 sector antennas, what is the carrier to co-channel interference ratio?

(4 marks)

(b) A mobile service is allocated 30 MHz bandwidth. If 7 cells per cluster is used width a channel bandwidth of 200kHz, find the number of users that can be served per cluster for a GOS of 1%. Assume it is a blocked calls cleared system and a user makes 2 calls of 3min in one hour.

(10 marks)

(c) Calculate the propagation loss in the 900MHz band if the distance from the base station to a mobile station is 2km. The height of the tower is 30m and the height of the mobile is 1m.

(5 marks)

QUESTION FOUR (*25 marks*)

(a) (i) State the factors leading to signal degradation in a optical fiber.

(2 marks)

(ii) State some of the key factors related to the use of multi mode and single mode fiber.

(2 marks)

(b) The refractive index of the core and the cladding of a optical fiber are 1.457 and 1.427 respectively. Calculate the critical angle and the numerical aperture of the cable.

(6 marks)

(c) An optical fiber link to be designed to operate between 180km distance. The laser transmitter power is 1mW and the receiver sensitivity is -25dBm. Splicing is needed in every 4 km. An optical amplifier having a minimum input signal level of -30dBm is available. Find the location at which the amplifier is required to be placed. What is the required gain of the amplifier?

Attenuation loss	= 0.25 dB/km
Connector loss	= 0.2dB per connector
Splicing loss	= 0.1 dB per splice
Safety margin	= 6 dB

(15 marks)

QUESTION FIVE (25 *marks*)

(a) (i) An analogue telephone voice channel is converted to PCM signal for digital transmission. Derive the output PCM bit rate.

(4 marks)

(ii) Give the E1 frame structure used in PCM.

(2 marks)

(iii) Show the higher order multiplexing scheme starting with E1 signal giving the no of voice channels and the bit rates.

(2 marks)

(b) During the busy hour, 1500 calls are attempted on a trunk group and 200 calls are lost. If the average call duration is 3min, find the

(i) Offered traffic

(ii) Carried traffic

(iii) Lost traffic

(iv) Grade of service.

(7 marks)

(c) For an observation period of 10min, 50 calls are offered on a group of 20 trunks. If the total traffic handled is 10 Erlangs, calculate the holding time and the grade of service.

(3 marks)

(d) A PABX having 50 extensions is connected to the PSTN with 5 lines for outgoing calls. Assuming 75% of the PABX traffic is local and each extension generates 0.23Erlangs, find the probability of outgoing calls finding lines busy.

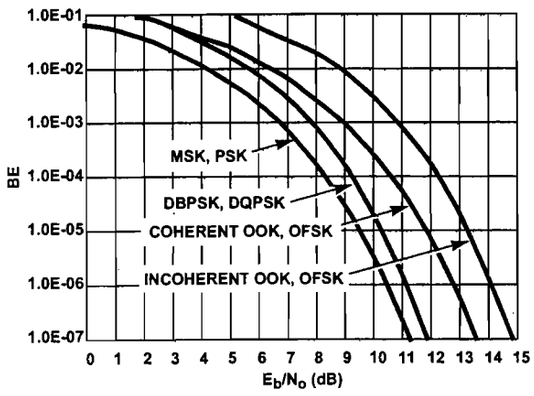
(7 marks)

SOME SELECTED USEFUL FORMULAE

$$F_{0.1} = -28 + 35 \log d + 8.5 \log F - 14 \log R + G$$

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

$$a(h_m) = (1.1 \log F_c - 0.7)h_m - (1.56 \log F_c - 0.8)$$



PROBABILITY OF BIT ERROR FOR COMMON MODULATION METHODS

Erlang - B Table.

n = 1 - 51

Offered traffic flow A in erlang

n	Loss probability (E)										n
	0.00001	0.00005	0.0001	0.0005	0.001	0.002	0.003	0.004	0.005	0.006	
1	.00001	.00005	.00010	.00050	.00100	.00200	.00301	.00402	.00503	.00604	1
2	.00448	.01005	.01425	.03213	.04576	.06534	.08064	.09373	.10540	.11608	2
3	.03980	.06849	.08683	.15170	.19384	.24872	.28851	.32099	.34900	.37395	3
4	.12855	.19554	.23471	.36236	.43927	.53503	.60209	.65568	.70120	.74124	4
5	.27584	.38851	.45195	.64857	.76212	.89986	.99446	1.0692	1.1320	1.1870	5
6	.47596	.63923	.72826	.99567	1.1459	1.3252	1.4468	1.5421	1.6218	1.6912	6
7	.72378	.93919	1.0541	1.3922	1.5786	1.7984	1.9463	2.0614	2.1575	2.2408	7
8	1.0133	1.2816	1.4219	1.8298	2.0513	2.3106	2.4837	2.6181	2.7299	2.8266	8
9	1.3391	1.6595	1.8256	2.3016	2.5575	2.8549	3.0526	3.2057	3.3326	3.4422	9
10	1.6970	2.0689	2.2601	2.8028	3.0920	3.4265	3.6480	3.8190	3.9607	4.0829	10
11	2.0849	2.5059	2.7216	3.3294	3.6511	4.0215	4.2661	4.4545	4.6104	4.7447	11
12	2.4958	2.9671	3.2072	3.8781	4.2314	4.6368	4.9038	5.1092	5.2789	5.4250	12
13	2.9294	3.4500	3.7136	4.4465	4.8306	5.2700	5.5588	5.7807	5.9638	6.1214	13
14	3.3834	3.9523	4.2388	5.0324	5.4464	5.9190	6.2291	6.4670	6.6632	6.8320	14
15	3.8559	4.4721	4.7812	5.6339	6.0772	6.5822	6.9130	7.1665	7.3755	7.5552	15
16	4.3453	5.0079	5.3390	6.2496	6.7215	7.2582	7.6091	7.8780	8.0995	8.2898	16
17	4.8502	5.5583	5.9110	6.8782	7.3781	7.9457	8.3164	8.6003	8.8340	9.0347	17
18	5.3693	6.1220	6.4959	7.5186	8.0459	8.6437	9.0339	9.3324	9.5780	9.7889	18
19	5.9016	6.6980	7.0927	8.1698	8.7239	9.3515	9.7606	10.073	10.331	10.552	19
20	6.4460	7.2854	7.7005	8.8310	9.4115	10.068	10.496	10.823	11.092	11.322	20
21	7.0017	7.8834	8.3186	9.5014	10.108	10.793	11.239	11.580	11.860	12.100	21
22	7.5680	8.4926	8.9462	10.180	10.812	11.525	11.989	12.344	12.635	12.885	22
23	8.1443	9.1095	9.5826	10.868	11.524	12.265	12.746	13.114	13.416	13.676	23
24	8.7298	9.7351	10.227	11.562	12.243	13.011	13.510	13.891	14.204	14.472	24
25	9.3240	10.369	10.880	12.264	12.969	13.763	14.279	14.673	14.997	15.274	25
26	9.9265	11.010	11.540	12.972	13.701	14.522	15.054	15.461	15.795	16.081	26
27	10.537	11.659	12.207	13.686	14.439	15.285	15.835	16.254	16.598	16.893	27
28	11.154	12.314	12.880	14.406	15.182	16.054	16.620	17.051	17.406	17.709	28
29	11.779	12.976	13.560	15.132	15.930	16.828	17.410	17.853	18.218	18.530	29
30	12.417	13.644	14.246	15.863	16.684	17.606	18.204	18.660	19.034	19.355	30
31	13.054	14.318	14.937	16.599	17.442	18.389	19.002	19.470	19.854	20.183	31
32	13.697	14.998	15.633	17.340	18.205	19.176	19.805	20.284	20.678	21.015	32
33	14.346	15.682	16.335	18.085	18.972	19.966	20.611	21.102	21.505	21.850	33
34	15.001	16.372	17.041	18.835	19.743	20.761	21.421	21.923	22.336	22.689	34
35	15.660	17.067	17.752	19.589	20.517	21.559	22.234	22.748	23.169	23.531	35
36	16.325	17.766	18.468	20.347	21.296	22.361	23.050	23.575	24.006	24.376	36
37	16.995	18.470	19.188	21.108	22.078	23.166	23.870	24.406	24.846	25.223	37
38	17.669	19.178	19.911	21.873	22.864	23.974	24.692	25.240	25.689	26.074	38
39	18.348	19.890	20.640	22.642	23.652	24.785	25.518	26.076	26.534	26.926	39
40	19.031	20.606	21.372	23.414	24.444	25.599	26.346	26.915	27.382	27.782	40
41	19.718	21.326	22.107	24.189	25.239	26.416	27.177	27.756	28.232	28.640	41
42	20.409	22.049	22.846	24.967	26.037	27.235	28.010	28.600	29.085	29.500	42
43	21.104	22.776	23.587	25.748	26.837	28.057	28.846	29.447	29.940	30.362	43
44	21.803	23.507	24.333	26.532	27.641	28.882	29.684	30.295	30.797	31.227	44
45	22.505	24.240	25.081	27.319	28.447	29.708	30.525	31.146	31.656	32.093	45
46	23.211	24.977	25.833	28.109	29.255	30.538	31.367	31.999	32.517	32.962	46
47	23.921	25.717	26.587	28.901	30.066	31.369	32.212	32.854	33.381	33.832	47
48	24.633	26.460	27.344	29.696	30.879	32.203	33.059	33.711	34.246	34.704	48
49	25.349	27.206	28.104	30.493	31.694	33.039	33.908	34.570	35.113	35.578	49
50	26.067	27.954	28.867	31.292	32.512	33.876	34.759	35.431	35.982	36.454	50
51	26.789	28.706	29.632	32.094	33.332	34.716	35.611	36.293	36.852	37.331	51
	0.00001	0.00005	0.0001	0.0005	0.001	0.002	0.003	0.004	0.005	0.006	
n	Loss probability (E)										n

n = 1 - 51

Offered traffic flow A in erlang

n	Loss probability (E)										n
	0.007	0.008	0.009	0.01	0.02	0.03	0.05	0.1	0.2	0.4	
1	.00705	.00806	.00908	.01010	.02041	.03093	.05263	.11111	.25000	.66667	1
2	.12600	.13532	.14416	.15259	.22347	.28155	.38132	.59543	1.0000	2.0000	2
3	.39664	.41757	.43711	.45549	.60221	.71513	.89940	1.2708	1.9299	3.4798	3
4	.77729	.81029	.84085	.86942	1.0923	1.2589	1.5246	2.0454	2.9452	5.0210	4
5	1.2362	1.2810	1.3223	1.3608	1.6571	1.8752	2.2185	2.8811	4.0104	6.5955	5
6	1.7531	1.8093	1.8610	1.9090	2.2759	2.5431	2.9603	3.7584	5.1086	8.1907	6
7	2.3149	2.3820	2.4437	2.5009	2.9354	3.2497	3.7378	4.6662	6.2302	9.7998	7
8	2.9125	2.9902	3.0615	3.1276	3.6271	3.9865	4.5430	5.5971	7.3692	11.419	8
9	3.5395	3.6274	3.7080	3.7825	4.3447	4.7479	5.3702	6.5464	8.5217	13.045	9
10	4.1911	4.2889	4.3784	4.4612	5.0840	5.5294	6.2157	7.5106	9.6850	14.677	10
11	4.8637	4.9709	5.0691	5.1599	5.8415	6.3280	7.0764	8.4871	10.857	16.314	11
12	5.5543	5.6708	5.7774	5.8760	6.6147	7.1410	7.9501	9.4740	12.036	17.954	12
13	6.2607	6.3863	6.5011	6.6072	7.4015	7.9667	8.8349	10.470	13.222	19.598	13
14	6.9811	7.1155	7.2382	7.3517	8.2003	8.8035	9.7295	11.473	14.413	21.243	14
15	7.7139	7.8568	7.9874	8.1080	9.0096	9.6500	10.633	12.484	15.608	22.891	15
16	8.4579	8.6092	8.7474	8.8750	9.8284	10.505	11.544	13.500	16.807	24.541	16
17	9.2119	9.3714	9.5171	9.6516	10.656	11.368	12.461	14.522	18.010	26.192	17
18	9.9751	10.143	10.296	10.437	11.491	12.238	13.385	15.548	19.216	27.844	18
19	10.747	10.922	11.082	11.230	12.333	13.115	14.315	16.579	20.424	29.498	19
20	11.526	11.709	11.876	12.031	13.182	13.997	15.249	17.613	21.635	31.152	20
21	12.312	12.503	12.677	12.838	14.036	14.885	16.189	18.651	22.848	32.808	21
22	13.105	13.303	13.484	13.651	14.896	15.778	17.132	19.692	24.064	34.464	22
23	13.904	14.110	14.297	14.470	15.761	16.675	18.080	20.737	25.281	36.121	23
24	14.709	14.922	15.116	15.295	16.631	17.577	19.031	21.784	26.499	37.779	24
25	15.519	15.739	15.939	16.125	17.505	18.483	19.985	22.833	27.720	39.437	25
26	16.334	16.561	16.768	16.959	18.383	19.392	20.943	23.885	28.941	41.096	26
27	17.153	17.387	17.601	17.797	19.265	20.305	21.904	24.939	30.164	42.755	27
28	17.977	18.218	18.438	18.640	20.150	21.221	22.867	25.995	31.388	44.414	28
29	18.805	19.053	19.279	19.487	21.039	22.140	23.833	27.053	32.614	46.074	29
30	19.637	19.891	20.123	20.337	21.932	23.062	24.802	28.113	33.840	47.735	30
31	20.473	20.734	20.972	21.191	22.827	23.987	25.773	29.174	35.067	49.395	31
32	21.312	21.580	21.823	22.048	23.725	24.914	26.746	30.237	36.295	51.056	32
33	22.155	22.429	22.678	22.909	24.626	25.844	27.721	31.301	37.524	52.718	33
34	23.001	23.281	23.536	23.772	25.529	26.776	28.698	32.367	38.754	54.379	34
35	23.849	24.136	24.397	24.638	26.435	27.711	29.677	33.434	39.985	56.041	35
36	24.701	24.994	25.261	25.507	27.343	28.647	30.657	34.503	41.216	57.703	36
37	25.556	25.854	26.127	26.378	28.254	29.585	31.640	35.572	42.448	59.365	37
38	26.413	26.718	26.996	27.252	29.166	30.526	32.624	36.643	43.680	61.028	38
39	27.272	27.583	27.867	28.129	30.081	31.468	33.609	37.715	44.913	62.690	39
40	28.134	28.451	28.741	29.007	30.997	32.412	34.596	38.787	46.147	64.353	40
41	28.999	29.322	29.616	29.888	31.916	33.357	35.584	39.861	47.381	66.016	41
42	29.866	30.194	30.494	30.771	32.836	34.305	36.574	40.936	48.616	67.679	42
43	30.734	31.069	31.374	31.656	33.758	35.253	37.565	42.011	49.851	69.342	43
44	31.605	31.946	32.256	32.543	34.682	36.203	38.557	43.088	51.086	71.006	44
45	32.478	32.824	33.140	33.432	35.607	37.155	39.550	44.165	52.322	72.669	45
46	33.353	33.705	34.026	34.322	36.534	38.108	40.545	45.243	53.559	74.333	46
47	34.230	34.587	34.913	35.215	37.462	39.062	41.540	46.322	54.796	75.997	47
48	35.108	35.471	35.803	36.109	38.392	40.018	42.537	47.401	56.033	77.660	48
49	35.988	36.357	36.694	37.004	39.323	40.975	43.534	48.481	57.270	79.324	49
50	36.870	37.245	37.586	37.901	40.255	41.933	44.533	49.562	58.508	80.988	50
51	37.754	38.134	38.480	38.800	41.189	42.892	45.533	50.644	59.746	82.652	51
	0.007	0.008	0.009	0.01	0.02	0.03	0.05	0.1	0.2	0.4	
n	Loss probability (E)										n