

PRINCE OF SONGKLA UNIVERSITY  
FACULTY OF ENGINEERING

Final Examination: Semester II  
Date: March 3, 2011  
Subject: 210-463 Telecommunication Engineering

Academic Year: 2010  
Time: 13.30-16.30  
Room: A401

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**Instructions:**

- Allow a student to use his/her own calculator and dictionary.
- Grading policy
  - There will be no credit for vague answers or unclear steps.
  - A grader should be able to understand what you were trying to do without your verbal explanation later.
  - Give all your assumptions for your answer if necessary.

**Attempt all problems**

1. *Wireless communications*

Find the spectrum efficiency (unit: conversations/cell/MHz) of the IS-95 CDMA cellular system if it has the SIR requirement of 6 dB for the transmission rate of 9.6 kbps. Note that each IS-95 voice channel requires a transmission bandwidth of 1.23 MHz.

(5 points)

2. *Satellite communications*

Below is the link budget analysis for the uplink (6.175 GHz, C-band). Calculate this satellite link budget and answer Questions 2.1) to 2.6).

2.1) Transmit power (850W)  dBW  
**What is the transmit power in dBW?**

Transmit waveguide losses 2.0 dB  
Transmit antenna gain (7m) 50.6 dBi

2.2) Uplink EIRP  dBW  
**What is the uplink EIRP in dBW?**

Atmospheric attenuation 0.1 dB  
Free-space loss 200.4 dB  
Receive antenna gain 26.3 dBi  
Receive waveguide loss 0.5 dB

2.3) System noise temperature (450K)  dB(K)  
**What is the system noise temperature in dB(K)?**

2.4) Spacecraft G/T  dB/K

**What is the Spacecraft G/T in dB/K?**

2.5) Boltzmann's constant  $-228.6$  dBW/Hz/K  
Bandwidth (25 MHz)  dB Hz

**What is the bandwidth in dB Hz?**

2.6) Carrier-to-noise ratio  dB

**What is the carrier to noise ratio in dB?**

(10 points)

3. *Fiber-optic communications*

Below is the list of parameters for the fiber-optic communication link operating at 1330 nm wavelength to support the data rate of 140 Mbps. The desired BER is  $1 \times 10^{-9}$ .

- The light source is a laser diode with a  $-0.3$  dBm output.
- The optical fiber amplifier gain is 40 dB.
- The receiver threshold of a PIN type is  $-46$  dBm.

a) Find the power budget

(5 points)

Allocate the power budget in a) as follows:

- Connectors are used at the output of the source and at the input to the detector. The connector loss is at 0.5 dB each.
- Fusion splices every kilometer; allows 0.25 dB per splice
- Fiber attenuation loss at 0.25 dB/km
- A margin of 4 dB

b) What will be the maximum distance achievable without the use of repeaters?

(5 points)

4. *Telephony*

4.1) On average, during the busy hour, a company makes 120 outgoing calls of average duration 2 min. It receives 200 incoming calls of average duration 3 min. Find

- (a) outgoing traffic
- (b) incoming traffic
- (c) total traffic

(3 points)

4.2) Let's consider connecting 100 incoming trunks to 100 outgoing trunks using multiple stages of 10\*10 switches.

(a) Find the total number of crosspoints for

- i. a two-stage network
- ii. a three-stage network

(3 points)

(b) Discuss the advantage and disadvantage of using a two-stage network compared to a single-stage network.

(2 points)

4.3) Consider a single analog cellular telephone base station tower. It can typically has capacity to support 64 calls and blocks requests for channels when all channels are busy. Calls arrive according to a Poisson process with mean rate 1 call per hour per active user in the cell. Measurements show that during the busy hour about  $\frac{1}{2}$  of the users in a cell are active. The call holding time is exponentially distributed with mean 104.4 sec. Determine the maximum number of users can be supported in a cell while providing a 1% call blocking rate.

(5 points)

Appendix 1.1  
Blocked-Calls-Cleared  
(Erlang B) (Continued)

N	A, erlangs												
	B												
	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
21	12.8	13.1	13.5	14.0	14.9	16.2	17.3	18.7	20.8	22.8	27.3	32.8	40.2
22	13.7	14.0	14.3	14.9	15.8	17.1	18.2	19.7	21.9	24.1	28.7	34.5	42.1
23	14.5	14.8	15.2	15.8	16.7	18.1	19.2	20.7	23.0	25.3	30.1	36.1	44.1
24	15.3	15.6	16.0	16.6	17.6	19.0	20.2	21.8	24.2	26.5	31.6	37.8	46.1
25	16.1	16.5	16.9	17.5	18.5	20.0	21.2	22.8	25.3	27.7	33.0	39.4	48.1
26	17.0	17.3	17.8	18.4	19.4	20.9	22.2	23.9	26.4	28.9	34.4	41.1	50.1
27	17.8	18.2	18.6	19.3	20.3	21.9	23.2	24.9	27.6	30.2	35.8	42.8	52.1
28	18.6	19.0	19.5	20.2	21.2	22.9	24.2	26.0	28.7	31.4	37.2	44.4	54.1
29	19.5	19.9	20.4	21.0	22.1	23.8	25.2	27.1	29.9	32.6	38.6	46.1	56.1
30	20.3	20.7	21.2	21.9	23.1	24.8	26.2	28.1	31.0	33.8	40.0	47.7	58.1
31	21.2	21.6	22.1	22.8	24.0	25.8	27.2	29.2	32.1	35.1	41.5	49.4	60.1
32	22.0	22.5	23.0	23.7	24.9	26.7	28.2	30.2	33.3	36.3	42.9	51.1	62.1
33	22.9	23.3	23.9	24.6	25.8	27.7	29.3	31.3	34.4	37.5	44.3	52.7	64.1
34	23.8	24.2	24.8	25.5	26.8	28.7	30.3	32.4	35.6	38.8	45.7	54.4	66.1
35	24.6	25.1	25.6	26.4	27.7	29.7	31.3	33.4	36.7	40.0	47.1	56.0	68.1
36	25.5	26.0	26.5	27.3	28.6	30.7	32.3	34.5	37.9	41.2	48.6	57.7	70.1
37	26.4	26.8	27.4	28.3	29.6	31.6	33.3	35.6	39.0	42.4	50.0	59.4	72.1
38	27.3	27.7	28.3	29.2	30.5	32.6	34.4	36.6	40.2	43.7	51.4	61.0	74.1
39	28.1	28.6	29.2	30.1	31.5	33.6	35.4	37.7	41.3	44.9	52.8	62.7	76.1
40	29.0	29.5	30.1	31.0	32.4	34.6	36.4	38.8	42.5	46.1	54.2	64.4	78.1
41	29.9	30.4	31.0	31.9	33.4	35.6	37.4	39.9	43.6	47.4	55.7	66.0	80.1
42	30.8	31.3	31.9	32.8	34.3	36.6	38.4	40.9	44.8	48.6	57.1	67.7	82.1
43	31.7	32.2	32.8	33.8	35.3	37.6	39.5	42.0	45.9	49.9	58.5	69.3	84.1
44	32.5	33.1	33.7	34.7	36.2	38.6	40.5	43.1	47.1	51.1	59.9	71.0	86.1
45	33.4	34.0	34.6	35.6	37.2	39.6	41.5	44.2	48.2	52.3	61.3	72.7	88.1
46	34.3	34.9	35.6	36.5	38.1	40.5	42.6	45.2	49.4	53.6	62.8	74.3	90.1
47	35.2	35.8	36.5	37.5	39.1	41.5	43.6	46.3	50.6	54.8	64.2	76.0	92.1
48	36.1	36.7	37.4	38.4	40.0	42.5	44.6	47.4	51.7	56.0	65.6	77.7	94.1
49	37.0	37.6	38.3	39.3	41.0	43.5	45.7	48.5	52.9	57.3	67.0	79.3	96.1
50	37.9	38.5	39.2	40.3	41.9	44.5	46.7	49.6	54.0	58.5	68.5	81.0	98.1
51	38.8	39.4	40.1	41.2	42.9	45.5	47.7	50.6	55.2	59.7	69.9	82.7	100.1
52	39.7	40.3	41.0	42.1	43.9	46.5	48.8	51.7	56.3	61.0	71.3	84.3	102.1
53	40.6	41.2	42.0	43.1	44.8	47.5	49.8	52.8	57.5	62.2	72.7	86.0	104.1
54	41.5	42.1	42.9	44.0	45.8	48.5	50.8	53.9	58.7	63.5	74.2	87.6	106.1
55	42.4	43.0	43.8	44.9	46.7	49.5	51.9	55.0	59.8	64.7	75.6	89.3	108.1
56	43.3	43.9	44.7	45.9	47.7	50.5	52.9	56.1	61.0	65.9	77.0	91.0	110.1
57	44.2	44.8	45.7	46.8	48.7	51.5	53.9	57.1	62.1	67.2	78.4	92.6	112.1
58	45.1	45.8	46.6	47.8	49.6	52.6	55.0	58.2	63.3	68.4	79.8	94.3	114.1
59	46.0	46.7	47.5	48.7	50.6	53.6	56.0	59.3	64.5	69.7	81.3	96.0	116.1
60	46.9	47.6	48.4	49.6	51.6	54.6	57.1	60.4	65.6	70.9	82.7	97.6	118.1
61	47.9	48.5	49.4	50.6	52.5	55.6	58.1	61.5	66.8	72.1	84.1	99.3	120.1
62	48.8	49.4	50.3	51.5	53.5	56.6	59.1	62.6	68.0	73.4	85.5	101.0	122.1
63	49.7	50.4	51.2	52.5	54.5	57.6	60.2	63.7	69.1	74.6	87.0	102.6	124.1
64	50.6	51.3	52.2	53.4	55.4	58.6	61.2	64.8	70.3	75.9	88.4	104.3	126.1
65	51.5	52.2	53.1	54.4	56.4	59.6	62.3	65.8	71.4	77.1	89.8	106.0	128.1
66	52.4	53.1	54.0	55.3	57.4	60.6	63.3	66.9	72.6	78.3	91.2	107.6	130.1
67	53.4	54.1	55.0	56.3	58.4	61.6	64.4	68.0	73.8	79.6	92.7	109.3	132.1
68	54.3	55.0	55.9	57.2	59.3	62.6	65.4	69.1	74.9	80.8	94.1	111.0	134.1
69	55.2	55.9	56.9	58.2	60.3	63.7	66.4	70.2	76.1	82.1	95.5	112.6	136.1
70	56.1	56.8	57.8	59.1	61.3	64.7	67.5	71.3	77.3	83.3	96.9	114.3	138.1