Helsinki Unversity of Technology
S-26.3301 Tietoliikenteen radiolaitteet 1
Examination 11.05.2009, literature " ITU Handbook: Digital radio-relay systems"

These questions are intended for those who have completed the home-work and have not attended the lectures.

Answer to all four (4) questions. If you have completed this spring home-work succesfully, you only need to answer to three (3) or to two (2) questions, depending on your points.

1. Base-band (6 p.):

Explain the CEPT (mostly used in Europe) PDH multiplexing hierarchy by explaining how a single 64 kbit/s channel (timeslot) is extracted from the highest defined hierarchy level.

2. Modem (6 p.):

What kind of modulation and demodulation errors and error sources exist in digital radio systems (assuming QAM modulation)?

3. RF-parts (6 p.):

Draw a block diagram of a typical heterodyne MW transmitter (from baseband parts to the antenna). Describe the function of each component or block in the diagram.

4. Propagation and link design (6 p.):

Below there is a list of radio link hops for Central Europe area (rain intensity 42 mm/h 0.01%).

1. Select the most suitable system (1...8) for each radio link hop (case a...d) from the table. Give justification for your selection.
2. Select the most suitable radio-channel for each case from the table.
3. What is the minimum antenna height to guarantee First Fresnel zone free in each case?
4. In which cases (a...d) space diversity would give significant improvement in transmission quality?

Case	Hop length	Transmission capacity	Network level	System ?
a)	15 km	40x2 Mbit/s (PDH)	SH	
b)	50 km	STM-1 (SDH)	LH	
c)	1km	600Mbit/s (Ethernet)	Access	
d)	5 km	16x2 Mbit/s (PDH)	SH	

Available microwave systems:

System no.	Frequency band	Modulation	Available radio channels MHz
1	7	128QAM	28, 14 or 7
2	7	16QAM	28, 14 or 7
3	15	16QAM	28, 14 or 7
4	15	QPSK	28, 14 or 7
5	38	16QAM	14 or 7
6	38	QPSK	14 or 7
7	58	MSK (2-level)	100 or 50
8	71	BPSK	1000, 500 or 250

Guidance:
Earth-curve parabel when radio ray is "straightened" (at distance d_1 (km), earth radius R=6370 km and k is the k-value of normal atmosphere)

$$h = \frac{d_1^2}{2kR}$$

Fresnel-zone radius r_F, at the middle of the hop (hop length =d, wave length=λ):

$$r_F = \frac{\sqrt{\lambda \cdot d}}{2}$$