Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2010-2011 (2 hours)

EEE6420 Radio Frequency and Optical Communications 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** Describe the challenges facing a communications satellite from launch to life in orbit and how these are alleviated in spacecraft design. **(6)**

b. Derive an expression for the noise figure of a cascade of three amplifier stages in a receiver. Comment on the design of the first amplifier (pre-amplifier) that would be suitable for use in a satellite receiver. **(6)**

c. A satellite receiver was used to receive signals from a satellite operating at 3.6 GHz. The measured carrier-to-noise ratio was 4 dB. A GaAsFET amplifier was inserted between the receiver and receiving antenna resulting in an increase in the carrier-to-noise ratio to 18 dB. If the amplifier has a gain of 20 dB and a noise figure of 2 dB, calculate the noise figure of the receiver alone. **(8)**

2. **a.** Explain the following with respect to satellite communication systems:

i. Coverage footprint;
ii. Orthogonally polarised beams;
iii. Antenna noise temperature. **(6)**

b. Describe with the aid of diagrams the design of a large earth station antenna and receiver. **(6)**

c. Given the following information about a satellite communications link, determine the earth station receiver noise temperature. **(8)**

Earth station: P_t = 200 W; G_e = 55 dB; T_e = ?K
Satellite : G_s = 25 dB; P_s = 10 W; T_s = 1500K
Overall: Path losses – uplink = 201 dB, down link = 199 dB
Bandwidth = 8 MHz Operating margin = 4 dB
C/N = 21 dB $k = 1.38 \times 10^{-23}$ J/K

3. **a.** Describe using diagrams the propagation of light down an optical fibre and derive an expression for the acceptance angle. **(6)**

b. Describe how a single mode optical fibre is manufactured and how loss can be minimised within the manufacturing process. **(4)**

c. Explain with the aid of diagrams the operation of an erbium doped optical fibre amplifier. **(7)**

d. Discuss the advantages and disadvantages of an erbium type amplifier compared with a repeater consisting of a receiver, signal conditioning electronics and optical transmitter. **(3)**

4. **a.** Describe the operation of a Light Emitting Diode (LED) and a Laser as optical transmitters. **(6)**

b. Discuss the chromatic dispersion in a single mode optical fibre and its consequences for a transmitted signal. **(6)**

c. An optical fibre link consists of a semiconductor laser, single mode fibre and a p-i-n photodetector.

The laser operates at a wavelength of λ = 1550 nm and has a spectral width of $\Delta\lambda$ = 1 nm. The maximum power launched into the fibre is P_T = 2 dBm. A non-return to zero amplitude modulated signal is transmitted with a 1:1 mark space ratio at a data rate of 500 MBits/s.

The single mode fibre has an optical loss of α = 0.2 dB/km and a chromatic dispersion coefficient of D = 15 ps/(km.nm).

The p-i-n photodetector captures all the light reaching the end of the fibre and requires a minimum received power of P_R = -40 dBm to operate at this data rate.

Derive expressions for the two factors that limit transmission distance and hence calculate the maximum transmission length of the optical fibre if a margin of M = 20 dB is assumed.
Which parameter of the fibre should be changed to extend the range? **(8)**

RJL