Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2013-14 (2.0 hours)

EEE6420 RF and Optical Telecommunications

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

i. Coverage footprint;

ii. Orthogonally polarised beams;

iii. Antenna noise temperature. **(6)**

b. Describe two types of multiple access systems used for satellite links. **(6)**

c. Given the following information about a satellite communications link, determine the earth station receiver noise temperature T_e.

Earth station: P_t = 250 W; G_e = 55 dB; T_e = ?K

Satellite : G_s = 25 dB; P_s = 20 W; T_s = 1250K

Overall: Path losses – uplink = 204 dB, down link = 199 dB

Bandwidth = 16 MHz Operating margin = 4 dB

C/N = 21 dB $k = 1.38 \times 10^{-23}$ J/K **(8)**

2. **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 factor or noise temperature 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 4.2 GHz. The measured carrier-to-noise ratio was 5 dB. A GaAsFET amplifier was inserted between the receiver and receiving antenna resulting in an increase in the carrier-to-noise ratio to 21 dB. If the amplifier has a gain of 25 dB and a noise figure of 2 dB, calculate the noise figure of the receiver alone. **(8)**

Note: $C_o / N_o = C_i/(N_i F)$ and $F = 1 + T/290$

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

(ii) Which optical transmitter would you choose for long distance communications and why? **(2)**

b. A bus network of N stations uses passive optical couplers. Derive an expression for the total loss in the network. **(6)**

Hence determine the dynamic range of the network if N = 12, the stations are 600m apart, the fibre loss = 0.3 dB/km, and the couplers have the following parameters: **(6)**

Tap loss L_{tap} = 10 dB
Connector loss L_c = 1 dB
Intrinsic transmission loss L_i = 0.5 dB

4. **a.** Describe the geometry and the propagation mechanism for the following optical fibre types:

i. step index fibre;
ii. graded index fibre;
iii. single mode fibre. **(6)**

b. Describe the origins of chromatic dispersion in a single-mode fibre and intermodal dispersion in a multi-mode fibre. Comment on the relative magnitudes of these two forms of dispersion (stating any assumptions you make), and how chromatic dispersion affects the choice of a transmitter. **(6)**

c. An optical fibre link operating at 1300 nm transmits a train of pulses in NRZ format with a 1:1 mark space ratio. The optical receiver needs at least 1200 photons to detect 1 bit accurately. The optical fibre loss is 0.8 dB/km. What is the maximum possible length of the fibre link for a 2 Gb/s lightwave system designed to transmit 6 dBm of average power? **(6)**
The energy of 1 photon $E = 6.6 \times 10^{-34} c/\lambda$ J.

How would a system designer upgrade an optical fibre system to operate up to 10 Gb/s? **(2)**

RJL