The University Of Sheffield.

Data Provided: None

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2011-12 (2.0 hours)

EEE6420 Radio Frequency and Optical Communications

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. Discuss the orbits available to satellite system designers and typical uses for each. **(6)**

b. What advantages do satellite communications have over terrestrial systems and what are the challenges faced by designers? **(6)**

c. Explain the terms:

i. Noise power;
ii. Noise factor;
iii. Noise figure.

(3)

d. An antenna with a noise temperature 100 K is connected to a receiver using a cable with a loss of 2 dB. If the receiver noise figure is 2 dB what is the overall noise temperature for the system?
Assume the cable temperature is 290 K. **(5)**

2. a. Describe the main building blocks of a domestic system for receiving TV signals from a direct broadcasting satellite such as ASTRA 2C. **(6)**

b. Describe how the channel capacity of a satellite can be optimized. **(4)**

c. Design a domestic satellite receiving antenna for the ASTRA 2C TV broadcast system given the following information. Discuss the type, size and performance of the antenna. State any assumptions you make. **(10)**

Satellite transmitted power	= 100 W
Satellite antenna gain	= 31 dBi
Transponder bandwidth	= 26 MHz
Boltzmann's constant k	= 1.38×10^{-23} W/Hz/K
Downlink distance	= 39,238 km
Frequency	= 10.8175 GHz
Receiving C/N	= 11 dB
Receive antenna noise temperature	= 55 K
Receiver noise temperature	= 75 K

3. **a.** 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)**

b. Discuss what is meant by the normalised frequency V in an optical fibre. What is the value of V for single mode operation in a stepped index fibre and why? **(4)**

c. An optical fibre link operating at 1550 nm transmits a train of pulses in NRZ format with a 1:1 mark space ratio. The optical receiver needs at least 1000 photons to detect 1 bit accurately. The optical fibre loss is 2 dB/km. What is the maximum possible length of the fibre link for a 1Gb/s lightwave system designed to transmit -10dBm of average power? **(7)**
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? **(3)**

4. **a.** Describe wavelength division multiplexing (WDM) in fibre optic communications. Explain the function of multiplexers and de-multiplexers within the system. What constraints does a dense WDM system place upon the optical transmitter and de-multiplexers? **(10)**

b. Explain the operating principles and design of a WDM channel add/drop de-multiplexer. **(10)**