UNIVERSITY OF ESWATINI

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION 2021

Title: TELECOMMUNICATIONS AND WIRELESS SYSTEMS

Course Code: EEE541

Time Allowed: THREE (3) HOURS

Instructions:

1. Answer any **four (4)** questions
2. Each question carries **25** marks

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This paper consists of five (5) pages

QUESTION 1

(a) A satellite is in a 322 km high circular orbit. Determine the following:

i) The orbital velocity in meters per second. [2]

ii) The orbital period in minutes. [2]

iii) The orbital angular velocity in radians per second. [2]

Assume the average radius of the earth is 6378.137 km and Kepler's constant has the value $3.989004418 \times 10^5\,\text{km}^3/\text{s}^2$.

(b) Discuss the Non-standalone architecture options in 5G, with illustrations, i.e., option 3, 3a, 3x. [9]

(c) Differentiate between network function virtualization (NFV) and software-defined networking (SDN). [2]

(d) Discuss the process of how a mobile terminal is able to discover the mobility agents. [5]

(e) State the advantages of the passive-star WDM LAN? [3]

QUESTION 2

(a) What is the purpose of the gratuitous ARP in MIPv4 and how it is performed in mobile networks. [3]

(b) Describe the following terms: (i) optical crossconnect (OXC), Optical burst switching (OBS), and Optical packet switching (OPS). [7]

(c) Figure 1 shows the geometry of the downlink. It is assumed that the receiving earth station is located on the edge of the 3 dB covergare area of the satellite receiving antenna. Calculate C/N_0. [10]

The data is as follows:

- Frequency: $f_D = 12$ GHz
- For the satellite (SL)

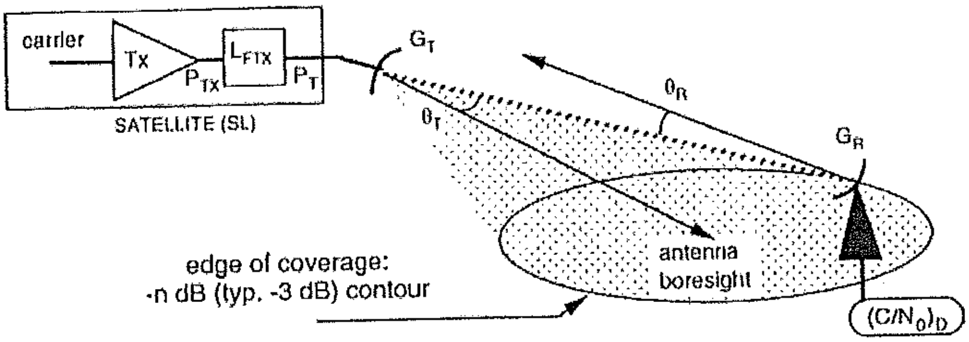

Fig. 1: The geometry of a downlink.

  - Transmitting amplifier power: $P_{TX} = 10W$, Loss between amplifier and antenna: $L_{FTX} = 1$ dB, Transmitting beam half power angular width: $\theta_{3dB} = 2°$, Antenna efficiency: $\eta = 0.55$
- Earth station-satellite distance: R = 40 000 km
- Atmospheric attenuation: $L_A = 0.3$ dB (typical attenuation by atmospheric gases at this frequency for an elevation angle of 10°)
- For the earth station (ES)
  - Receiver noise figure: $F = 1$ dB, Loss between antenna and receiver: $L_{FRX} = 0.5$ dB, thermodynamic temperature of the feeder: $T_F = 290$ K, Antenna diameter: D = 4 m,Antenna efficiency: $\eta = 0.6$, Maximum pointing error: $\theta_R = 0.1°$, Ground noise temperature: $T_{GROUND} = 45K$

(d) Discuss the different types of CoMP. [5]

QUESTION 3

(a) A satellite in an elliptical orbit around the earth has an apogee of 39152 km and a perigee of 500 km. What is the orbital period of this satellite? Give your answer in hours. Assume the average radius of the earth is 6378.137 km and Kepler's constant has the value $3.989004418 \times 10^5\,\text{km}^3/\text{s}^2$. [4]

(b) State the differences between static local and dynamic local anchoring. [4]

(c) In order to take full advantage of the huge bandwidth available on fiber, various multiplexing techniques such as WDM, TDM, and CDM can be used which allow multiple users to share the bandwidth on a single fiber. Compare and contrast these multiplexing techniques. Why is WDM the most promising choice for optical communication networks. [10]

(d) Discuss the licence-assisted access technique in LTE. [7]

QUESTION 4

(a) Discuss the radio node location lookup procedure in MEC. [5]

(b) What is the difference between FDMA and FDD. [2]

(c) A SpaceX mission to the ISS is an example of a LEO satellite mission. Before rendezvousing with the ISS on this mission, SpaceX inserted the Dragon capsule into an initial circular orbit 250 km above the Earth's surface, where there are still a finite number of molecules from the atmosphere. The mean Earth's radius, r, is approximately 6378.14 km. Using these numbers, calculate the period of the Dragon capsule of SpaceX in its 250 km orbit. Find also the linear velocity of the Dragon capsule along this orbit. [5]

(d) Given the following parameters, calculate the effective input noise temperature [2]:

$$\text{Low noise amplifier (LNA): } T_{LNA} = 150K, G_{LNA} = 50dB$$

$$\text{Mixer: } T_{MX} = 800K, G_{MX} = -10dB(L_{MX}10dB)$$

$$\text{IF amplifier: } T_{IF} = 400K, G_{IF} = 30dB$$

(e) Describe the wavelength Add/Drop Multiplexer. [5]

(f) Why does automated driving require 5G. [6]

QUESTION 5

(a) Discuss how the architecture for option 7,7a,7x will work in 5G, with illustrations. [9]

(b) Consider the transmitting antenna of an Earth station equipped with an antenna of diameter $D = 4$ m. This antenna is fed with a power P_T of 100 W, that is 20 dBW, at a frequency $f = 14$ GHz. It radiates this power towards a geostationary satellite situated at a distance of 40000 km from the station on the axis of the antenna. The beam of the satellite receiving antenna has a width $\theta_{3dB} = 2°$. It is assumed that the Earth station is at the centre of the region covered by the satellite antenna and consequently benefits from the maximum gain of this antenna. The efficiency of the satellite antenna is assumed to be $\eta = 0.55$ and that of the Earth station to be $\eta = 0.6$. Calculate the uplink received power. [9]

(c) Describe the direct sequence spread spectrum principle in CDMA system. [5]

(d) Consider a receiving system with the following parameters and calculate the system noise temperature. [2]

Antenna noise temperature: 50K
Thermodynamic temperature of the feader: 290K
Effective input noise temperature of the receiver: 50K

I. Appendix

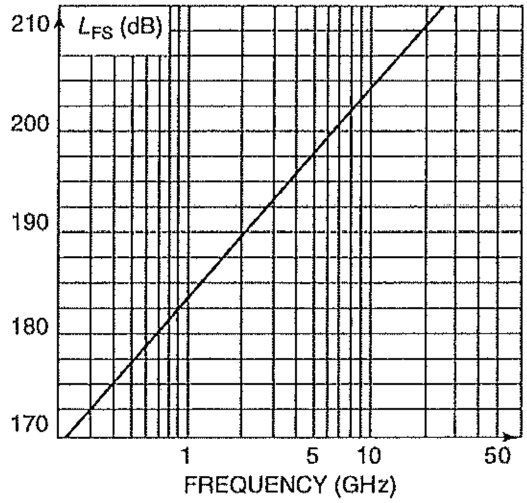

Fig. 2: Free space loss attenuation at geostationary sub-satellite point:$L_{\mathrm{FS}}(R_0)$