UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

MAIN EXAMINATION, DECEMBER 2011

TITLE OF PAPER: ANTENNAS & WAVE PROPAGATION

COURSE CODE : ECO 510

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS : **ANSWER *QUESTION 1* AND ANY OTHER *THREE* QUESTIONS**

EACH QUESTION CARRIES 25 MARKS

MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT HAND MARGIN

If you think not enough data has been given in any question you may state your assumptions in each case

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

QUESTION 1

(a) How should an antenna be polarized to give the greatest signal strength if it is placed close to the ground? What field of an EM wave determines the polarization? [1]

(b) (i) Sketch a diagram illustrating the relationship between skip zone, skip distance, ground wave and sky wave coverage. (ii) Explain the skip zone and the skip distance. [6]

(c) With the help of a diagram, describe space wave propagation [4]

(d) A station is known to operate at 60 meters. What is the frequency of this station? [1]

(e) Differentiate between a resonant and non-resonant antenna. [2]

(f) Given a receiver for a 15 megasymbols per second, (i) determine the available noise power present with the signal and (ii) find the noise figure of the receiver if the equivalent noise temperature of the receiver is 900 K. [5]

(g) For a point-to-point link with one antenna mounted on a 30-m tower and the other on a 15-m tower, determine the maximum possible line-of-sight link distance. [3]

(h) State the reciprocity principle of antennas and the implication it has on the antenna parameters. [3]

QUESTION 2

(a) A 100 MHz link needs to be established between military vehicle communication systems over a distance of 3 km in a rough terrain with maximum terrain height of 1.5 m. A 1-m whip antenna is mounted on one vehicle and is about 1.5 m above the ground. Assuming that a blockage occurs at the midpoint within the LOS path, (i) how much terrain (median) loss should be expected? (ii) What is the free-space path loss in dB? [12]

(b) The transmitting and receiving antennas are separated by 2 km in a point-to-point communication system operating at 30 GHz. If there is a building 300 m from one end of the communication link, how far must it be in height below the LOS in order not to disturb transmission? [7]

(c) Consider an environment with 12 m of trees and other vegetation present in the LOS. What would be the total predicted median path loss for a communication system operating at 1GHz with the end terminals separated by 1 km? [6]

QUESTION 3

(a) What is the antenna gain of a 20-cm-diameter circular aperture antenna at 40 GHz? Assume an efficiency of 60%. Give your answer in dB. [5]

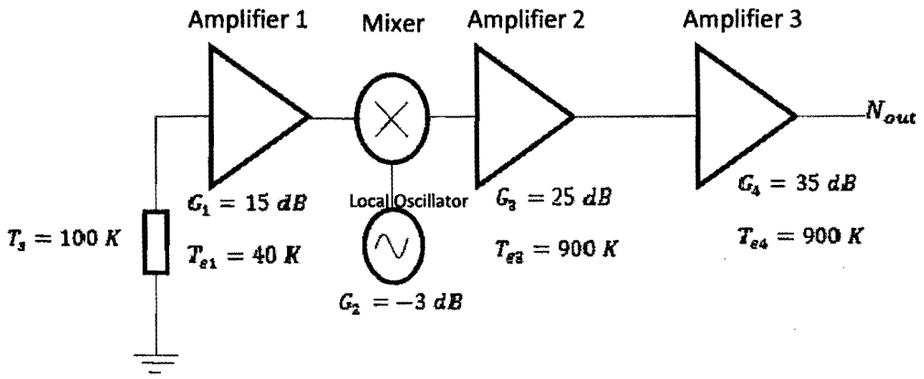
(b) Find the effective height and the effective area of a half-wave dipole at 600 MHz. [7]

(c) Design a Log-periodic dipole array for operation in the range of 100 to 320 MHz. Assume a design ratio, τ, of 0.7 and an angle of 30^{o} [8]

(d) Differentiate between the far-field and near-field antenna radiation regions. How much minimum separation is required between 130 MHz and 410 MHz antennas to avoid near-field coupling? [5]

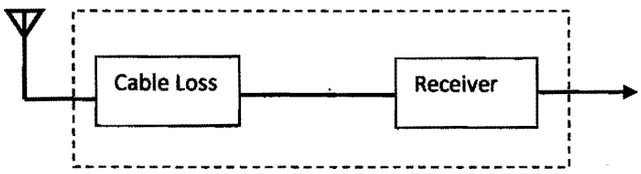
QUESTION 4

(a) Given the following superheterodyne receiver, calculate the noise power (in dBm) at the output of amplifier 3 in a 5 MHz bandwidth. [10]



(b) Calculate the system equivalent input noise temperature for the above superheterodyne receiver when the positions of Amplifier 1 and the Mixer are reversed. [4]

(c) Calculate the noise figure of the communication receiver system shown below. The cable loss is 5 dB and the noise equivalent temperature of the receiver is 600 K. [3]



(d) Given a receiver with a frequency range from 10-KHz to 110 KHz and an effective noise temperature of 600 K, determine the noise power level (in dBm) at the input to the receiver. If the antenna of the receiver is replaced with an input resistance of 50 Ω that is matched to the system impedance, determine the thermal noise. [4]

(e) Consider a 100 m link that operates in free space at 10 GHz. Assume that the transmit power is 0.1 W, and both transmit and receive antennas have 5 dB gain. If the receiver threshold is -85 dBm, what is the available link margin? [4]

QUESTION 5

(a)(i) What are the three layers of the atmosphere? (ii) Which one has relatively little effect on radio waves? [2]

(b) What three factors must be considered in the transmission of a surface wave to reduce attenuation. [3]

(c) Two dipole antennas 150 km apart are aligned and one transmits a 2 kW signal. The frequency is 230 MHz. What is the received power in dBm? [8]

(d) Find the radiation resistance of a very small dipole whose overall length is $\lambda/30$. [3]

(e)(i) Sketch a radiation pattern typical of a dipole antenna that is installed a half-wavelength above the surface. Note: Sketch the vertical extent of the antenna. (ii) Make some comments about the radiation pattern. [4]

(f) Which radio frequency bands use the tropospheric scattering principle? [1]

(g) What is the distance to the radio horizon as viewed from a height of 1 m and from 10 m? [4]