Student Matriculation No: ---------------------------

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EEG 816: Radiowave Propagation
2009

Dr A Ogunsola

This exam consists of 5 problems. The total number of pages is 5, including the cover page. You have 2.5 hours to solve the problems.

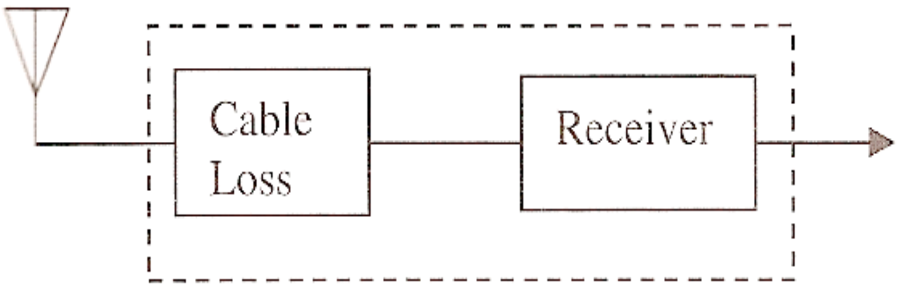
EEG 816 Radiowave Propagation

Problem 1

The effective antenna temperature of an antenna looking towards zenith is approximately 5 K. Assuming that the temperature of the transmission line (waveguide) is 42° C, find the effective temperature at the receiver terminal when the attenuation of the transmission line is 4dB/100m, for a transmission line length of 2m and 100m.

Given a receiver with a 100 kHz bandwidth and an effective noise temperature of 600 K, what is the noise power level at the input to the receiver? Give the units with your answer

Consider the receiver system shown below with a cable loss of 15 dB and an receiver noise equivalent temperature of 890 K, what is the noise figure of the receiver?



Problem 2

a. A mobile phone is located 5 km away from a base station. It uses a vertical $\lambda/4$ monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The free space electric field at 1 km from the transmitter is measured to be 10^{-3} V/m. The carrier frequency used for this system is 900 MHz.

1. Find the length and effective aperture of the receiving antenna.

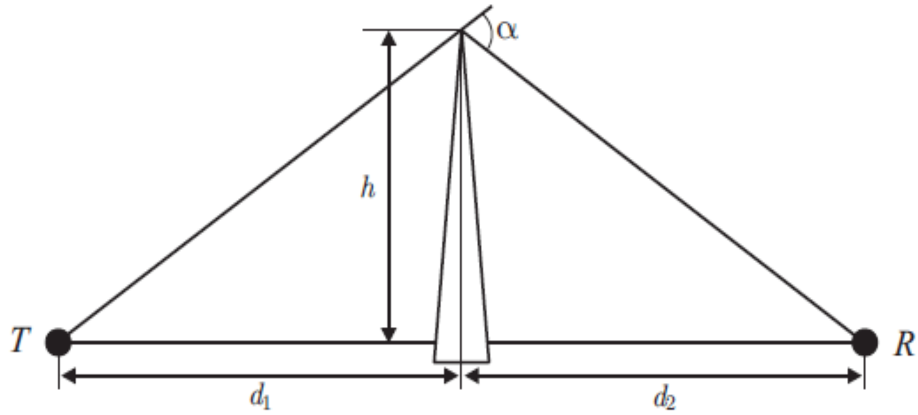
2. Find the received power at the mobile using the 2-ray ground reflection model assuming the height of the transmitting antenna is 50 m, and the receiving antenna is 1.5 m above ground.

b. Compute the diffraction loss for the three cases shown in the figure below. Assume λ = 1/ 3 m, d1 = 1 km, d2 = 1km, and

1. $h = 25m$

2. $h = 0m$

3. $h = -25m$



c. For each of these cases identify the Fresnel zone within which the tip of the obstruction lies

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Problem 3

On the Lagos to Ibadan Road, Car 1 detects Car 2 (radar cross section $\sigma = 3\ \text{m}^2$) at a distance $y_1 + y_2$ (where $y_1 = 15\ \text{m}$ and $y_2 = 6\ \text{m}$) in front of it with the help of a radar system, operating at a frequency $f_{radar} = 24\ \text{GHz}$ with a transmit power, $P_T = 1\ \text{W}$, linearly polarized in the z direction.

Assume the radar system is omni-directional in the xy plane with $G_{radar} = 1$. The two cars drive in two different lanes with a spatial separation of 6m.

In the present instantaneous situation on the highway, the signal can propagate on two different ways from car 1 to car 2 as shown in the figure below:

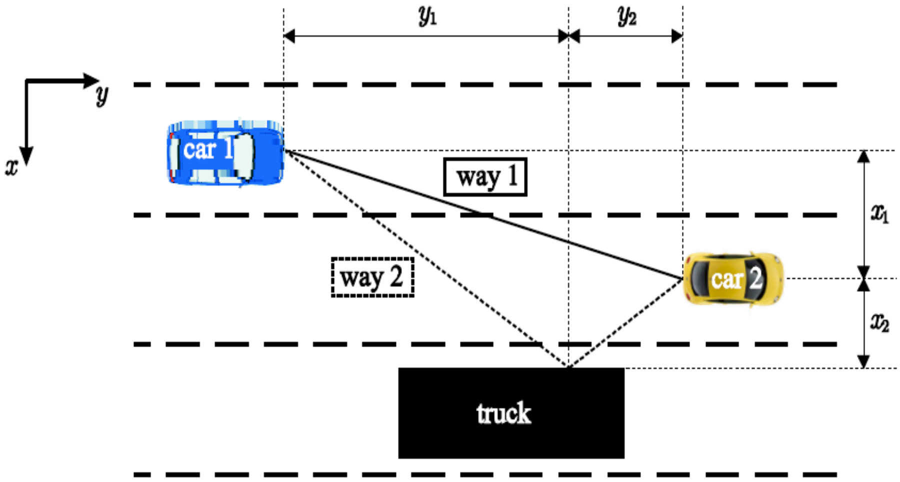
- Way 1: line of sight,
- Way 2: between car 1 and car 2, the signal undergoes a total reflection from a truck driving on the right lane ($x_2 = 4\ \text{m}$; reflection coefficient $\Gamma = -1$).

Note: Ground reflection can be neglected because of a narrow pattern of the radar system in elevation.

1. List the 4 main propagation paths of the radar signal from car 1 to car 2 and back to car 1.
2. Determine the power received by the radar system on each of those paths.
3. Determine the effective area of the radar antenna. Find the amplitudes of the received electric fields for each of the propagation paths.

4. Determine the phases of the received electric fields on each of those paths.

5. How can the total amplitude of the electric field received by the radar system be computed? Give one equation without developing the overall solution.

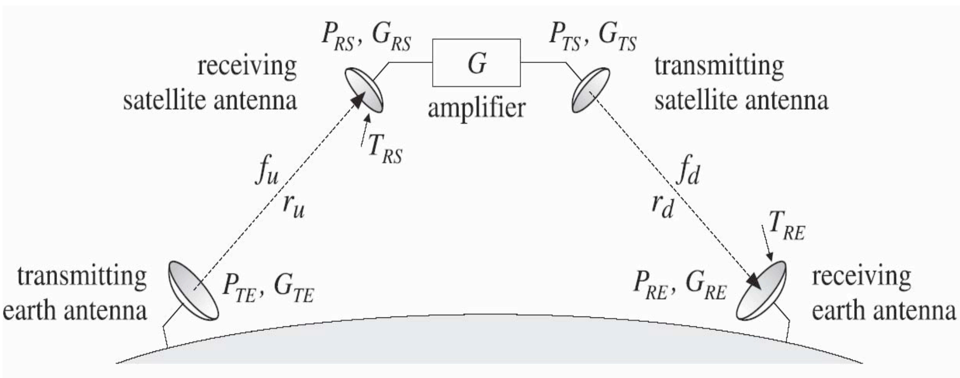


Problem 4

A telecommunication system is being installed in Nigeria using satellite technology and the following data is given as the link budget:

The uplink and downlink distances are $r_u = r_d = 36000$ km. The uplink and downlink frequencies are $f_u = 6.5$ GHz and $f_d = 4.7$ GHz. The diameters of the earth and satellite antennas are 17.5m and 0.7m with 60% aperture efficiencies. The earth antenna transmits power of $P_{TE} = 1.2$ kW and the satellite transponder (the amplifier chain of the satellite) gain is $G = 90$ dB.

Note that the Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K



a. Calculate the up and down free space losses

b. Determine the gain of the antennas

c. How much power in dBW is received at the earth ground station?

The receiving satellite antenna is looking down at an earth temperature of 300 K and has a noisy receiver of effective noise temperature of 2700 K. The receiving earth antenna is looking up at a sky temperature of 50 K and uses a high-gain LNA amplifier of 80 K (feed line losses may be ignored). The bandwidth is 30 MHz.

d. Calculate the system noise temperatures and system noise powers of the satellite and ground receivers (the connection lines are lossless). Give the values in dBW!

e. For the calculation in d), give the Signal to Noise Ratio $SNR = {}^{P}\!/_{N}$ in dB.

Problem 5

UNILAG is considering installing a ground base communication system operating at 1.2 GHz. The initial design suggests one of the terminals would be located 145m inside a wooded area of the campus. As design consultant, you are required to advise the predicted foliage loss using the updated ITU model? Assume the antennas gains are each 3 dB and the antennas are vertically polarized.

In addition to the ground base communication system mentioned above, UNILAG is also considering installing a system with the following characteristics:

$$f = 1.8GHz \text{ and } d = 1km$$

with 12m of trees in the LOS and vegetation present. As par of your design consultancy package, you are required to estimate the total predicted median path loss for this system (excluding antenna gains) using the Weissberger model and the ITU model.