S-72.232 RADIO COMMUNICATION SYSTEMS
EXERCISE 1/2005, 10.2.2005

1. On a certain time the ionospheric F-layer height is 350 km and the critical frequency f_O = 8 MHz.
   a) Determine MUF as a function of path length d.
   b) Calculate MUF for the longest single-hop path.
   c) Determine the path length in b).
   d) How long is the minimum single-hop (skip-zone) at 20 MHz?

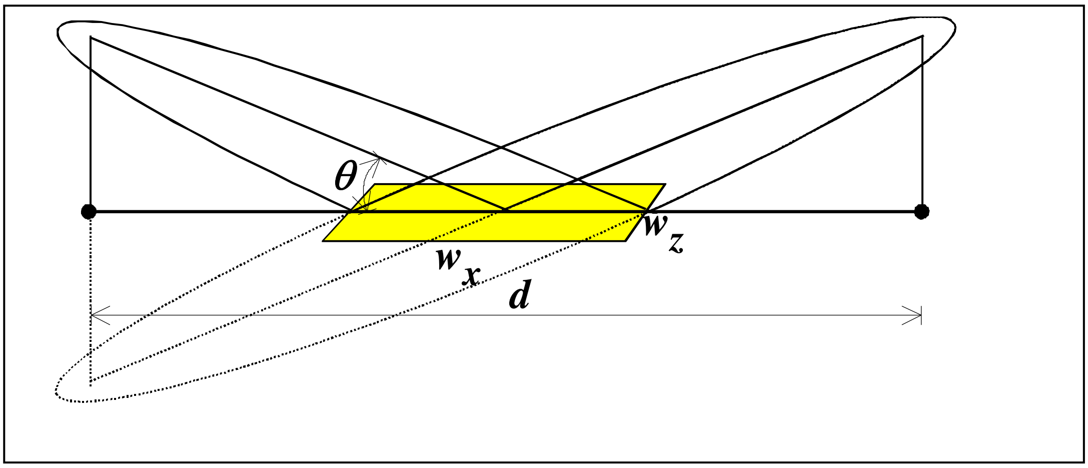
2. Determine the width (±°) of the Earth zone where an Earth station antenna elevation angle in a three GEO-satellite system is at least 5°.

3. On which value of the refractivity gradient an ideal spherical Earth will touch the line of sight on a 50 km path, when both antenna heights above ground is 100 m?

4. In the middle of a 40 km, 3 GHz:n radio path is a rounded transversal obstacle with 40 m diameter covering the 1st Fresnel zone.
   a) Calculate the additional diffraction loss (dB) compared to free space loss, when the refractivity gradient is – 40 NU/km.
   b) How much larger is this loss than that of a knife-edge obstacle?

5. It can be assumed that Fresnel's reflection coefficients for an infinite plane boundary are good approximations for the reflection coefficients of a limited plane boundary if it contains the first Fresnel zone.

a) Determine the minimum size of a rectangular reflector fulfilling this condition given the radius of the 1st Fresnel zone r_{F1}, the radio path length d, and the reflection path incidence angle θ.



b) Calculate the minimum reflector size when d = 40 km, antenna heights above the reflector are 2 r_{F1} ,and the frequency is 6 GHz. (typical parameters for a terrestrial radio relay hop)

c) Calculate the minimum reflector size when d = 2.5 km, reflector distance from l.o.s. path 0.5 km and the frequency is 2 GHz. (typical parameters for a macrocell in a cellular network).

6. In reflection from a spherical boundary the absolute value of the effective reflection constant $\rho_{eff} = D\rho$ where r is the absolute value of the reflection constant for a corresponding plane reflector and D is the spherical reflector divergence given by

$$D = \left[1 + \frac{2d_1 d_2}{R_e (d_1 + d_2)\sin\theta}\right]^{-1/2},$$

where d_1 and d_2 are the distances along the spherical surface from the reflection point to the transmitter and receiver sites, R_e is the equivalent Earth radius, and θ is the incidence angle of the reflection path. Assume the total distance to be 40 km, the frequency 6 GHz, and the antenna heights over the reflection point to be i) r_{F1} and ii) 2 r_{F1}.

a) Calculate the incidence angle θ for the two cases, and

b) the loss in dB caused by the spherical reflecting surface with radius R_e = 8500 km compared to the situation with plane reflecting surface for the two cases.

HOMEWORK 1, return time 1 month, at latest before the May 2005 exam.

a) How far away is the radio horizon when the transmitter antenna is 55 m above the spherical Earth and the refractivity gradient is
i) -39 NU/km (standard atmosphere) and
ii) Any value between -100 and -150 NU/km
(superrefractive atmosphere) in each point of the ray path?

b) Over which interval does the arrival angle of the received signal vary when the refractivity gradient varies between +150 NU/km and -300 NU/km along the entire path? The path length is 40 km and the transmitter and receiver antennas are at the same height above the spherical Earth. Keep the arrival angle in the standard atmosphere as the reference value

c) Which refractivity gradient will causes a non-line-of-sight situation on the 40 km path, if the antenna heights are 55 m?