UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
School of Electrical and Information Engineering
ELEN4001 High Frequency Techniques

TUTORIAL 4—Covering all material

Question 1

You have to design a uni-directional satellite communication system between Europe and South Africa using a geostationary satellite. A few calculations are required to estimate various important system parameters. The following are known:

- Receivers with a noise temperature of 35K are available.
- Solar panels with a 1kW ability are fitted to satellite.
- Television signals will be transmitted using AM modulation.
- A 25dB signal-to-noise ratio will be required at the receiver.
- Two satellite antennas with maximum apertures of $3m^2$ each are possible. If linear antennas are used, the maximum length will be 1.5m.

You are required to estimate the transmitter powers (satellite and ground station), all antenna gains, beamwidths and sizes. Also suggest antenna types for all system components. Do for 4GHz and 12GHz centre frequencies.

Question 2

Design a two element Yagi-Uda array and calculate the gain and input impedance of this antenna. Make use of your laboratory information sheets to obtain approximate values for input and mutual impedances. Do not iterate to optimize the design, but consider the results critically.

Question 3

Assume that the spectral density of the current in lightning is uniform and equal to 1A/Hz up to 100kHz. An E-field measurement receiver is positioned 5km from a lightning strike between clouds at 500m height above ground. The conductance of the ionized air during the strike is $1\times10^5\mho$.

a. A receiver bandwidth of 3kHz is selected on the receiver with a centre frequency of 95kHz. Estimate the E-field measured by the receiver.

b. An electric detonator fuse is being used in an open-cast mine 5km away, and is wired up at the time of the lightning strike. The leads to the detonator can be modelled as small loop, with an inductance of 1.76mH. The stray capacitance at the feed end of the loop is 1.76nF.

Estimate the power delivered to the detonator by the lightning strike. Will this pose a safety hazard if the detonator is usually detonated using a 12V battery? For safety reasons you must assume maximum power transfer, no polarization mismatch and lossless conductors.

Question 4

A 5 element Yagi-Uda antenna operating at 10MHz is available for HF communications. The HPBW of the antenna main beam in two perpendicular cuts are measured to be 60°for both cuts. The antenna will be used as a component of an array of 10 antennas. Propose a broadside array using these antennas mounted horizontally and parallel to the earth.

a. Estimate the azimuth beamwidth of the antenna array.
b. Calculate the antenna heights which must be used to achieve a take-off angle of 15°with respect to the horizon.
c. Estimate the gain of the array
d. Estimate the one-hop communication distance when using the array in daytime. (During the day, the sun's energy is sufficient to ionize the so-called 'D' layer of the ionosphere, which is at a height of only 110km above the earth's surface. HF signals are reflected by the ionosphere.)