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

TUTORIAL 3—Array Theory and Antennas

Question 1

Two equal isotropic in-phase sources are spaced 1λ apart.

a. Calculate and plot the field pattern and find the directivity. [D=2]
b. Repeat for two sources of opposite phase

Question 2

What are the input impedances of a two element array of $\lambda/2$ dipoles displaced by 0.3λ (parallel to each other) and with $V_1 = V_2$? (Hint, use the laboratory mutual coupling curves).

If the array is supplied with 5W, what is the field strength at 1km and at 45°off the axis of the dipoles? (In the same plane as the array) [15mV/m]

Question 3

A linear array consists of an in-line configuration of 24 $\lambda/2$ dipoles spaced $\lambda/2$ apart. They carry equal amplitude currents with a progressive phase shift of δ. What value of δ is required to put the main lobe maximum 25°from broadside? [$\delta = -76°$]

Question 4

A 12GHz parabolic dish with a diameter of 1m is used with a horn antenna at a distance of 1m away from the rim of the dish. Estimate the gain of the horn antenna itself and also gain of the dish with the horn. State all assumptions, and possible causes of error in your estimates.

Question 5

Using the expression for the E field from a small loop antenna, show that the radiation resistance of a small loop antenna is given by:

$$R_{\text{rad}} = \frac{320\pi^4 A^2}{\lambda^4}$$

where A is the area of the loop. Comment on the input reactance of this antenna by showing it transmission-line like behaviour on a rough sketch of a Smith Chart.

Question 6

An astronomer wishes to distiguish between two radio stars emitting radio waves at 3GHz, which are 0.5°apart. He also requires interferometer lobes which are more than 3°from the main lobe to be 3dB or lower than the main lobe.

a. Suggest a suitable spacing for 2 antennas used as interferometer elements.
b. Estimate the gains of the antenna used as the elements of the interferometer.
c. Choose some antenna type to use as the interferometer element and estimate the major dimensions.

Question 7

If the gain of a half-wave dipole in free space is 2.1dBi, what is the maximum gain which can be obtained when constructing an array consisting of 5 horizontal half-wave dipoles above a ground plane. The measured input impedance of the antennas in the array is 70+j23Ω.

Question 8

Radio communication is required at 100MHz with a helicopter which is hovering directly above a single element, horizontal dipole antenna which is 50% efficient. Suggest without proof or calculations at what height this antenna should be mounted so that maximum radiated energy is directed towards the helicopter.

Question 9

You are operating an interferometer consisting of two 3GHz parabolic dishes each with a gain of 30dBi and spaced 10m apart. The sidelobe levels of the dish are more than 40dB lower than the main beam. It is difficult to ensure that both cables leading from the antenna to the receiver are equally long and hence in-phase. Calculate the cable length difference which will give an angle of arrival error larger than the angle between the interferometer main lobe maximum and the first null.

Question 10

A two element Yagi-Uda antenna consists of a driven element and a reflector, $\lambda/4$ apart. The driven element is exactly $\lambda/2$ long, and the reflector is 0.65λ.

When a source is applied to the driven element the largest current on the reflector is 0.8A(rms) at an angle of $-170°$, while the current on the driven element is 1.5A at an angle of $-50°$relative to the feed voltage. The real part of the antenna input impedance is 42.8Ω.

Calculate the power which would be received by an identical antenna located 1km from this one in the direction of maximum gain of the transmitting antenna. Assume that the receiving antenna is pointing away from the transmitting antenna (They both point in the same direction, in other words). The receiving antenna is attached to a 50Ω receiver.

When calculating pattern parameters the equations applicable to half-wave dipoles may be used for both elements.