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

TUTORIAL 1—Antenna Fundamentals

Question 1

If a transmitting antenna is not perfectly matched to its transmission line the power radiated by the antenna will be reduced from the perfect impedance match case. Compute this reduction, in dB, for mismatch conditions which give VSWRs of 1.01, 1.2, 2 and 10 on the transmission line. Comment on this reduction in power radiated in relation to the reduction due to inefficiency.

Question 2

When integrating the power density over a sphere surrounding an efficient antenna, a value of 100W is obtained. The antenna feedpoint current is 2A (RMS) and the input resistance of the antenna is 50Ω. The antenna has a measured gain of 10dBi. Calculate the antenna radiation efficiency and directivity.

Assuming an axially symmetric beam, estimate the antenna beamwidth. If the antenna was made to be 100% efficient by increasing the conductivity of the materials, what would happen to the beamwidth and the gain.

Question 3

In an informal experiment a 6V battery is applied to a torch globe which seems to emit equal amounts of light in all directions. A reading is taken with a camera light meter of the light striking the meter when it is 10m away from the globe.

The globe is then placed in a torch with a reflector and attached to a 6V battery. A second reading is taken 10m away with the torch pointing to the light meter.

This reading indicates 7 f-stops more light to be available (each f-stop is equal to a doubling of light intensity). The torch illuminates a circle with a 1m diameter on a wall 10m away.

Give estimates of the gain, directivity and efficiency of the torch reflector, assuming that the globe itself is 100% efficient at converting electrical energy to light energy.

Question 4

A slide projector uniformly illuminates a 2m square screen when 15m away. Calculate the directivity of the projector.

Question 5

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

Question 6

Two spacecraft are separated by 100Mm. Each has an antenna with D=1000 operating at 2.5GHz. If craft A's receiver requires 20dB over 1pW, what transmitter power is required on craft B to achieve this signal level? [$\approx$ 11kW]

For the Brave and Courageous:

Question 7

If the earth receives a power from the sun at 2.2kgcal/min/cm^2. (a) Translate this into W/m^2. (b) Assuming the sun to be an isotropic source, what is its power output? Note that the sun is a nuclear power plant that we consider to be sited at a safe distance! (c) What is the sun's rms field (V/m) if all its power is radiated as a single frequency? (14.3 kgcal/min = 1W; Earth-sun distance = 500 light-minutes)

Question 8

Estimate the directivity of an antenna with $\theta_{\text{HP}} = 2^\circ$ and $\phi_{\text{HP}} = 1^\circ$, and find the gain of the antenna if the efficiency $k = 0.5$.

Question 9

What is the required diameter of a parabolic dish antenna operating at 2GHz with 35dBi gain? Aperture efficiency is 50 percent.

Question 10

To communicate with the Mars orbiter (which in turn communicates to the Rovers (Spirit and Opportunity)) an antenna in California, Australia, or Spain is used, depending on which site has Mars above the Earth's horison. If one of these has an effective aperture of 1200m^2 and the spacecraft has an antenna with an effective aperture of 10m^2, (a) determine the transmit power needed at 6GHz (C band) to produce a power of 10^{-11}mW (-110 dBm) at the receiving antenna terminals when Earth is closest to Mars (77 million km) and (b) the time taken for the signal to reach Mars.

Question 11

What is the radio power radiated by quasar OH471? It is at a distance of 14 billion light years. It has a flux density of 1Jy from 1 to 100GHz. Assume radiation is isotropic.