Department: Electronics and Communications
Lecturer: Dr. Mohab Mangoud
Course: Wave Propagation and Antennas I
Course Code: EC 443

Marks: 40
Time: 2 hours
Final exam
Date : 6/6/2002

Answer the following questions:

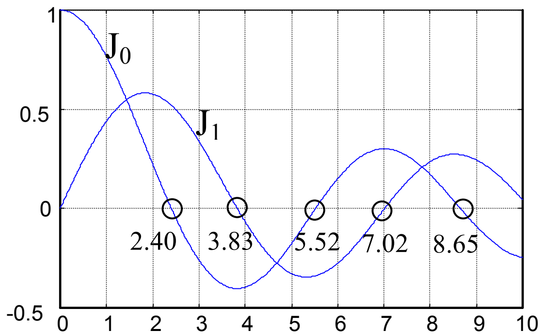
Q1) I. Write down expressions for the electric and magnetic field components in a rectangular waveguide of dimensions (0.8 x 1.2) cm^2 at the dominant mode and then write down expressions for the next higher mode.

II. Design a rectangular waveguide to operate at 12 GHz in the dominant mode. For the designed WG, what modes (TE and TM) are allowed to propagate if the frequency is raised to 35 GHz?

III. For a circular waveguide, considering E_z on the form: $B \cos(m\,\phi)\, J_m(k_c\rho)\, e^{-j\beta z}$

a) Write Down Expressions for the first two modes (either TE or TM)

b) Find the cut off frequencies for the first five TE and TM modes for circular waveguide.



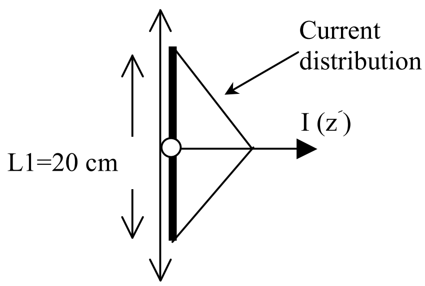
Zeros and first order of the Bessel function of first kind

Order 1	1.841	5.330	8.54
Order 2	3.054	6.706	9.97

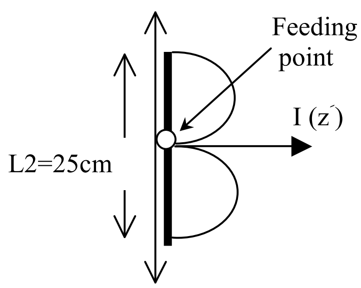
Extrema of Bessel function of 1st kind.

IV. If circular WG with diameter 1 cm is plated with perfectly conductor material and filled with dielectric material has ε_r =2.25 and loss tangent =0.001, calculate the attenuation in dB in 50 cm length of the WG operating at 13.0 GHz for the dominant mode of propagation.

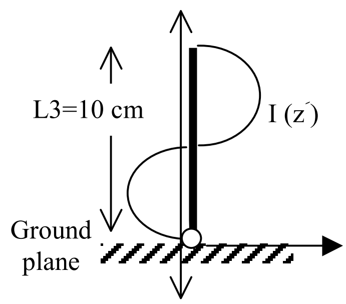
VI. Calculate the lowest resonance frequency of a rectangular cavity resonator of dimensions (4 cm ×2 cm ×5 cm), if it is filled with dielectric material of dielectric constant ε_r =4.



Antenna 1



Antenna 2



Antenna 3

Q2) Consider the given current distributions I(z´) on the above three antennas

a) Find the operating frequency range of antenna 1 and find the exact operating frequency of antenna 2 and antenna 3.

b) Write down expressions for the spherical electrical and magnetic field components of antenna 1.

c) Drive an expression for the power radiated from antenna 1 and find its value, if the root mean square value of the input current at the feeding point equals 5 mA.

d) Plot the radiation pattern in both E-plane and H-plane for antenna 2 and antenna 3.

Q3) I. The current distribution on a matched linear antenna of length L=0.25 m operated at frequency = 600 MHz and positioned along the z axis and fed at its center is given by:

$$\bar{\mathbf{I}}(z') = I_o \cos(\beta z')\hat{\mathbf{z}}, \qquad -12.5 \le z' \text{ (cm)} \le 12.5$$

Where: I_o is a constant and β is the free space propagation constant.

a) Find the potential vector **A.**
b) Write down expressions for spherical electrical and magnetic field components.
c) Drive the radiated power in (w) and the radiation Resistance of this antenna.
d) Find the directivity in (dB) and the effective length in (cm).
e) If the same antenna has input impedance equals the radiation resistance and it is connected to a coaxial cable with characteristic impedance of 50 Ω, find the overall gain of this antenna.

II. a) Compare using neat sketches the azimuth and the elevation radiation pattern of the electric field in the far zone for the following monopole wire antennas with the following lengths: $\lambda/50$, $\lambda/12$, $\lambda/2$, λ , 2λ , 2.5λ, 3.5λ, 4λ, 7λ, 10λ.

b) Show the differences of the beam width and main beam direction between the above antennas. From the above list, select an antenna suitable for GSM mobile phone handset (discuss).

Q4) I. Design a linear electronic-scanning array with the main beam directed at 45^o, such that no grating lobes appear in the array factor and the peak value of the side lobes levels is less than 0.24. Calculate the minimum number of elements as well as the phase shift and spacing between elements and plot the array factor of the array. Plot the total pattern of the array in the 3 principles assuming the array line to be along the Z-axis and the element s to be 2λ dipoles oriented toward the Y-direction.

II. If array factors (AF) for two different UESLA are as shown in the following Fig. (1) and (2)

a) Find the number of array elements to get peak side lobe levels as shown (for each case).
b) Find distance between elements (for each case of array 1 and array 2).
c) Find the phase shift between currents of the elements (for each case of array 1 and array 2)..
d) Plot AF (ψ) as function of total phase shift (ψ) only on the range of the visible region, where the array line is assumed to be along Z-axis. (for each case of array 1 and array 2).

Fig (1), PSLL (Array 1) = $\boxed{0.2472}$

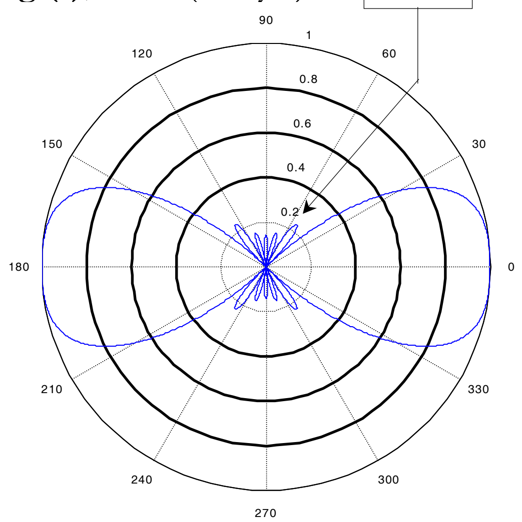
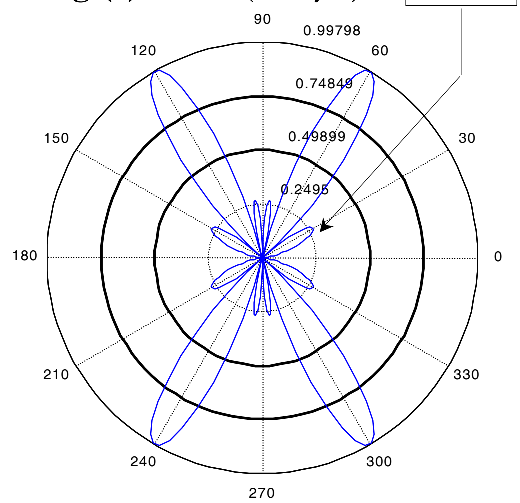


Fig (2), PSLL (Array 2) = $\boxed{0.2706}$



Good Luck
Dr. Mohab Mangoud