

1) A half wave dipole operates at a frequency of 100 MHz. Calculate the wavelength.

Soln.

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{100 \times 10^6}$$

$$\lambda = 2.99 \text{ m}$$

2) Half wave dipole antenna has a length of 1m. Calculate the Resonant frequency.

Soln.

$$\text{Resonant freq} = \frac{c}{2L}$$

$$= \frac{3 \times 10^8}{2 \times 1}$$

$$f_r = 1.5 \times 10^8 \text{ Hz}$$

3) The resonant frequency of a half wave dipole antenna is 155 MHz. Calculate the corresponding length of the antenna.

Soln

$$L = \frac{c}{2f} = \frac{3 \times 10^8}{2 \times 155 \times 10^6}$$

$$L = 0.967 \text{ m}$$

4) A monopole antenna operates at a frequency of 250 MHz. Calculate the length of the antenna.

Soln.

$$f = \frac{c}{4L}$$

$$L = \frac{c}{4f}$$

$$L = \frac{3 \times 10^8}{4 \times 250 \times 10^6}$$

$$L = 0.3 \text{ m}$$

5) A dipole antenna with a length $L = 1.5\text{ m}$ operating at a frequency of 300 MHz . Determine the near-field and far-field transition.

$$\text{Transition} = \frac{2D^2}{\lambda}$$

$$\lambda = \frac{c}{f} = 1\text{ m}, \quad D = 1.5\text{ m}$$

$$\text{Transition: } \frac{2 \times (1.5)^2}{1} = 4.5\text{ m}$$

6) Calculate the SWR of a half-wave dipole antenna with a input impedance of $73 + j42 \Omega$, when connected to a 50Ω transmission line.

7) A Rectangular waveguide with dimensions $a = 2\text{cm}$ and $b = 1\text{cm}$, Operating in the dominant TE_{10} mode, Calculate the cutoff frequency for this waveguide.

Soln. $a = 2\text{cm}$, $b = 1\text{cm}$.

TE_{10} , $m = 1$, $n = 0$

$$f_c = \frac{c}{2} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$f_c = \frac{3 \times 10^8}{2} \sqrt{\left(\frac{1}{0.02}\right)^2 + \left(\frac{0}{0.01}\right)^2}$$

$$f_c = 1.5 \times 10^8 \sqrt{(50)^2}$$

$$= 1.5 \times 10^8 \times 50$$

$$= 75 \times 10^8$$

$$f_c = 7.5 \times 10^9 \text{ GHz}$$

8) A Rectangular waveguide with dimension $b = 3\text{cm}$, The waveguide operates in TE mode, with a cut off frequency of 6GHz . Calculate the width of the waveguide if $m=1, n=2$

Soln: $b = 3\text{cm}$, $a = ?$

$$f_c = 6\text{GHz}$$

$$m=1, n=2$$

$$f_c = \frac{c}{2} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$6 \times 10^9 = \frac{3 \times 10^8}{2} \sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{2}{0.03}\right)^2}$$

$$6 \times 10^9 = 1.5 \times 10^8 \sqrt{\left(\frac{1}{a}\right)^2 + (66.67)^2}$$

$$\frac{6 \times 10^9}{1.5 \times 10^8} = \sqrt{\left(\frac{1}{a}\right)^2 + (66.67)^2}$$

$$4 \times 10 = \sqrt{\left(\frac{1}{a}\right)^2 + (66.67)^2}$$

Squaring both the sides.

$$(40)^2 = \left(\frac{1}{a}\right)^2 + (66.67)^2$$

$$1600 = \frac{1}{a^2} + 4444.89$$

8) A rectangular waveguide is designed to operate in the TE mode with $f_c = 10 \text{ GHz}$. Calculate the cut off wavelength.

Solution:

$$\lambda_c = \frac{c}{f_c} = \frac{3 \times 10^8}{10 \times 10^9}$$

$$\lambda_c = 3 \text{ cm}$$

a) A Rectangular waveguide has a dimension $a = 4 \text{ cm}$ and $b = 2 \text{ cm}$. The waveguide operates in the TE mode with mode numbers $m = 1$ and $n = 2$. Calculate the cut off wavelength (λ_c).

$$\begin{aligned} \lambda_c &= \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}} \\ &= \frac{2}{\sqrt{\left(\frac{1}{0.04}\right)^2 + \left(\frac{2}{0.02}\right)^2}} \end{aligned}$$

$$\lambda_c = 1.94 \text{ cm}$$

(i) A Circular Waveguide with radius $r = 5 \text{ cm}$ Operates in a mode characterised by $P_{mn} = 1.8$. Calculate the cutoff frequency (f_c) for the Circular waveguide.

Soln::

$$f_c = \frac{P_{mn} c}{2\pi r}$$

$$f_c = \frac{1.8 \times 3 \times 10^8}{2 \times \pi \times 0.05}$$

$$f_c = 1.72 \text{ GHz}.$$

(1) A circular waveguide with radius $r = 6.5 \text{ cm}$ operates in a mode characterized by $p_{mn} = 3$. Calculate the cutoff wavelength (λ_c).

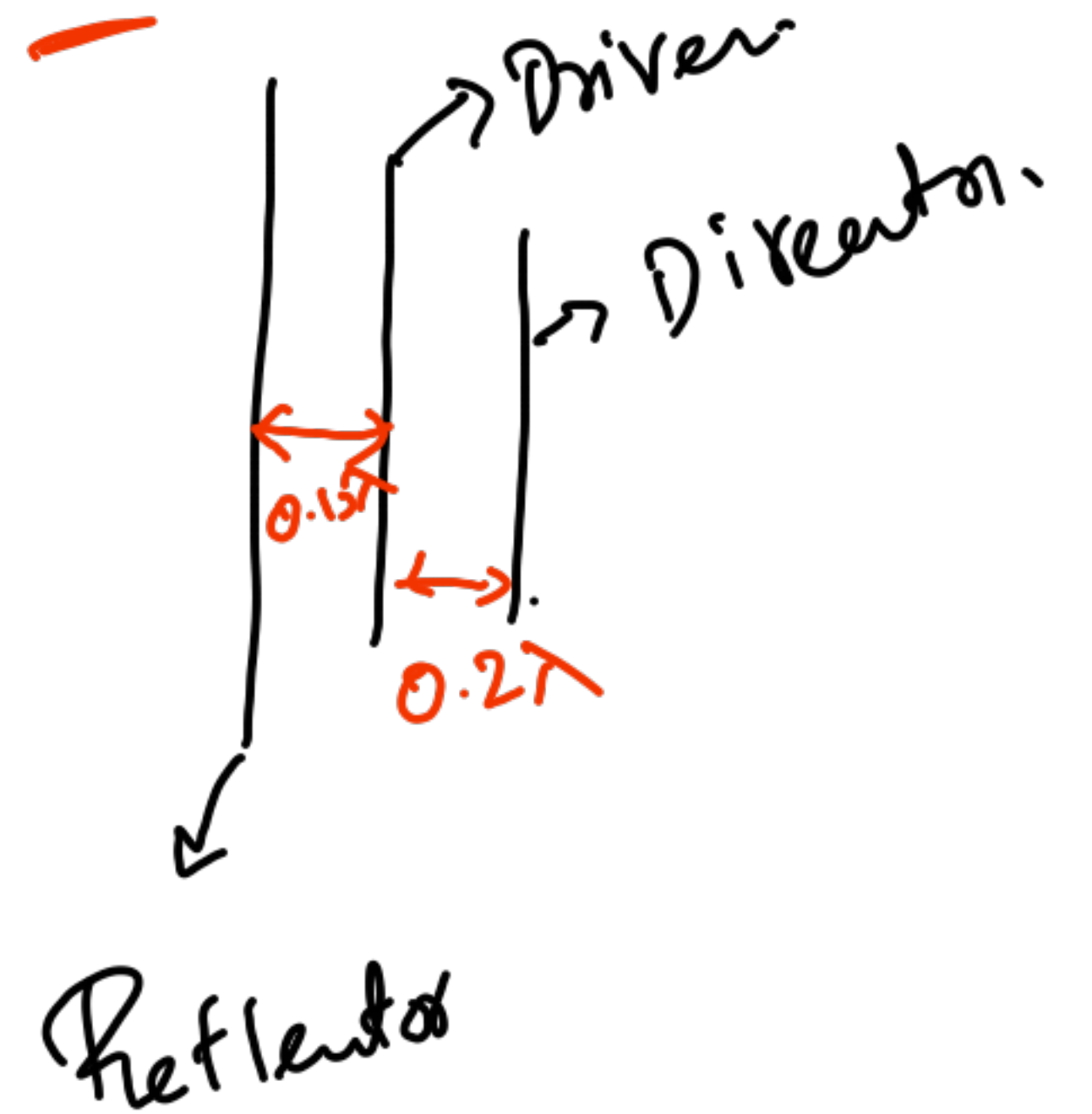
$$\lambda_c = \frac{2\pi r}{p_{mn}} = \frac{2 \times \pi \times 0.065}{3}$$

$$\lambda_c = 13.6 \text{ cm}$$

(2) Calculate the length of the driven element, director and reflector for a 3 element Yagi-Uda antenna designed to operate at 250 MHz.

Also calculate the distance between antenna elements, if the distance from the driven element to the reflector is 0.15λ and the distance from the driven element to the director is 0.2λ . Note the difference between

the length of each element is 5%.



$$f = 250 \text{ MHz}$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{250 \times 10^6} = 1.2 \text{ m.}$$

Length of driven element.

$$L = \frac{\lambda}{2} = \frac{1.2}{2} = 0.6 \text{ m}$$

length of the Reflector.

$$L_R = 0.6 \times 1.05$$

$$L_R = 0.63 \text{ m}$$

Length of director.

$$L_d = 0.95 \times 0.6$$

$$L_d = 0.57 \text{ m}$$

Distance between reflector & driven element.

$$\text{driven element} = 0.15 \lambda$$

$$= 0.15 \times 1.2$$

$$= 0.18 \text{ m}$$

Distance between driven element
and director = 0.2λ

$$= 0.2 \times 1.2$$

$$= 0.24 \text{ m.}$$

13) A helical antenna is designed
to operate at a frequency of 1.5 GHz .
It has a diameter of 10 cm and pitch
of 3 cm . Calculate the transition distance
from the near field to the far field
for this helical antenna.

$$f = 1.5 \text{ GHz.}$$

$$\text{diameter} = 10 \text{ cm.}$$

$$\text{Pitch} = 3 \text{ cm}$$

$$T_d = \frac{20^2}{\lambda}$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1.5 \times 10^9}$$

$$\lambda = 0.2 \text{ m}$$

$$T_d = \frac{2 \times (0.1)^2}{0.2}$$

$$T_d = 0.1 \text{ m}$$

14) Write the S-Matrix for a two port network, with two ports are perfectly matched.

$$S = \begin{vmatrix} \textcircled{S_{11}} & S_{12} \\ S_{21} & \textcircled{S_{22}} \end{vmatrix}$$

$$S_{11} = S_{22} = 0$$

$$S = \begin{vmatrix} 0 & S_{12} \\ S_{21} & 0 \end{vmatrix}$$

15) A two port network has the following scattering matrix.

$$[S] = \begin{bmatrix} 0.15 \angle 0^\circ & 0.85 \angle -40^\circ \\ 0.85 \angle 40^\circ & 0.3 \angle 0^\circ \end{bmatrix}$$

Determine the following

- i) If the network is Reciprocal.
- ii) If the network is a lossless network.
- iii) Calculate the return loss at port 1 when port 2 is terminated with a load that matches the network impedance.

$$S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

$$S_{11} = 0.15 \angle 0^\circ$$

$$S_{12} = 0.85 \angle -40^\circ$$

$$S_{21} = 0.85 \angle 40^\circ$$

$$S_{22} = 0.3 \angle 0^\circ$$

$$\boxed{S_{12} = S_{21}}$$

$$i) S_{12} = 0.85 \angle -40^\circ$$

$$S_{21} = 0.85 \angle 40^\circ$$

$$S_{12} \neq S_{21}$$

It is not a Reciprocal Network

$$ii) |S_{11}|^2 + |S_{21}|^2 = 1$$

$$|0.15|^2 + |0.85|^2 = 1$$

$$0.745 \neq 1$$

It is not a lossless network

$$ii) \text{Return loss} = -20 \log_{10} |S_{11}|$$
$$= -20 \log_{10} |0.15|$$

$$\text{Return loss} = 16.478 \text{ dB}$$

