EEC 603
MICROWAVE ENGINEERING

UNIT-1

Applications of circular waveguide

- Rotating joints in radars to connect the horn antenna feeding a parabolic reflector (which must rotate for tracking)
- TE_{01} mode suitable for long distance waveguide transmission above 10 GHz.
- Short and medium distance broad band communication (could replace / share coaxial and microwave links)

Example 1

- ***The dimensions of the waveguide are 2.5 cm $\times$ 1 cm. The frequency is 8.6 GHz. Find (i) possible modes and (ii) cut – off frequency for TE waves.***

Solution:

Given a = 2.5 cm , b = 1 cm and f = 8.6 GHz
Free space wavelength

$$\lambda_0 = \frac{C}{f} = \frac{3\times10^{10}}{8\times10^{9}} = 3.488 \text{ cm}$$

Solution

The condition for the wave to propagate is that $\lambda_C > \lambda_0$

For TE_{01} mode

$$\lambda_C = \frac{2ab}{\sqrt{m^2b^2 + n^2a^2}} = \frac{2ab}{\sqrt{a^2}} = 2b = 2 \times 1 = 2 \text{ cm}$$

Since $\lambda_C < \lambda_0$, TE_{01} *does not* propagate

- For TE_{10} mode, $\lambda_C = 2a = 2 \times 2.5 = 5$ cm
- Since $\lambda_C > \lambda_0$, TE_{10} mode is a possible mode.

Cut – off frequency = $$f_C = \frac{C}{\lambda_C} = \frac{3 \times 10^{10}}{5} = 6 \text{ GHz}$$

Cut-off wavelength for TE_{11} mode = $$\frac{2ab}{\sqrt{a^2 + b^2}}$$

$$= \frac{2 \times 2.5 \times 1}{\sqrt{(2.5)^2 + (1)^2}} = 1.856 \text{ cm}$$

For TE_{11} $\lambda_C < \lambda_0$, TE_{11} is not possible.

- The possible mode is TE_{10} mode.
- The cut – off frequency = 6 GHz

Example 2

- ***For the dominant mode propagated in an air filled circular waveguide, the cut – off wavelength is 10 cm. Find (i) the required size or cross sectional area of the guide and (ii) the frequencies that can be used for this mode of propagation***

The cut – off wavelength = λ_C = 10 cm

The radius of the circular waveguide ,

$$r = \frac{10 \times 1.841}{2\pi} = 2.93\,\text{cm}$$

$$\pi r^2 = \pi(2.93)^2 = 26.97\ \text{cm}^2$$

The cut – off frequency

$$= \quad f_c = \frac{C}{\lambda_c} = \frac{3\times10^{10}}{10} \quad = 3\ \text{GHz}$$

➢**Therefore the frequency above 3 GHz can be propagated through the waveguide.**

Area of cross section = 26.97 cm²

Cut – off frequency = 3 GHz

Exercise Problem *2.2*

- ***A rectangular waveguide has a = 4 cm and b = 3 cm as its sectional dimensions. Find all the modes which will propagate at 5000 MHz.***

Hint:

The condition for the wave to propagate is that $\lambda_C > \lambda_0$
Here λ_0 = 6 cm ; λ_C for TE_{01} mode = 6 cm
Hence λ_C is not greater than free space wavelength λ_0 .
TE_{01} mode is not possible.

Exercise problem 2.3

- ***For the dominant mode of operation is an air filled circular waveguide of inner diameter 4 cm. Find (i) cut – off wavelength and (ii) cut – off frequency.***

Hint: $\lambda_C = 6.8148$ cm and $f_c = 4.395$ GHz