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Design and Analysis of Waveguide for Microwave Applications

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Abstract
This research presents the design and analysis of rectangular and circular waveguide for microwave applications. The cut off frequency for waveguide is chosen to as 10 GHz. Waveguide here is designed and analyzed for Transverse electric (TE_{10}) mode of operation. High frequency structure simulator is used to design and simulate the structure of waveguide.
Index Terms — Rectangular waveguide, Transverse electric mode, High Frequency Structure Simulator.

Introduction

The attenuation loss in transmission line increases with increase in frequency. So, transmission lines cannot be used for transmitting signals of high frequencies. One of the alternates of transmission line at high frequencies is wave guide. Cut of frequency of waveguide signify under this situation. Cut of frequency of waveguide is the minimum frequency above which waveguide provides zero attenuation. However below cut off frequency waveguide offers infinite attenuation. A waveguide is a hollow metallic conductor in which conduction of energy takes place through a mechanism called total internal reflection. Role of conducting walls of waveguide is to confine the energy with in waveguide. Depending on the area of cross section waveguides are classified in Rectangular Waveguide Fig (1) and circular wave guide Fig (2).
Waveguides do not support Transverse Electromagnetic wave (TEM) mode of propagation.

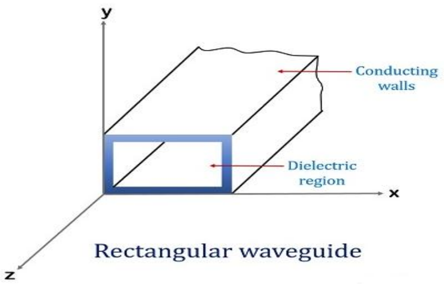

Figure1 Rectangular waveguide

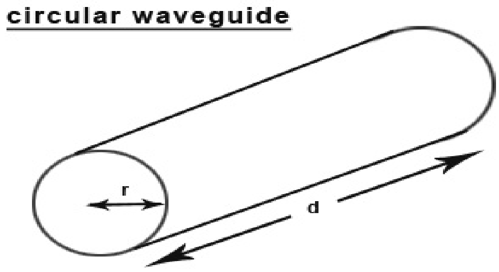

Figure2 Circular waveguide

Either electric field or magnetic field is aligned in the direction of propagation. Accordingly, the mode of propagation in waveguide is either Transverse electric (TE) or Transverse magnetic (TM) mode. TE or TM modes are further classified as TE_{mn} or TM_{mn} mode of propagation. Here m,n represents the number of half wavelengths applied across length and width of waveguide. Waveguides are extensively used in Radars, Satellites, couplers etc for the transmission of electromagnetic signals. The advantages of wave guide include capability to transfer high powered signal at high frequencies. The cut off frequency of waveguide for TE mode of propagation as proposed by References [1-5] is given by

$$f = \frac{1}{2\pi\sqrt{\epsilon\mu}}\sqrt{\frac{m\pi^2}{a^2} + \frac{n\pi^2}{b^2}}$$

Here a, b signifies the length and width of waveguide.

For TE_{10} mode of propagation the expression of cut off frequency is

$$f = \frac{1}{2\pi\sqrt{\epsilon\mu}}\sqrt{\frac{\pi^{\,2}}{a^2}}$$

The expression of cut off frequency of circular waveguide is

$$f = \frac{1.8412 * C}{2\,\pi\,r}$$

Here r is the radius of circular waveguide.

In this research a rectangular waveguide for TE_{10} mode is designed at 10 GHz. As per above mentioned equation Dimensions of Rectangular wave guide are given below.

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Table 1 Dimensions of Rectangular waveguide

S.No.	Parameter	Value
1	Cut of frequency	10 GHz
1	Length	2.286 cm
2	Width	1.01 cm
3	Thickness	.05 cm

Table 2 Dimensions of Circular waveguide

S.No.	Parameter	Value
1	Cut of frequency	10 GHz
1	Radius	1.143 cm
3	Wall Thickness	.05 cm

Waveguide of above dimension is designed and analyzed using High frequency structure simulator.

2. Results and Discussion

Rectangular waveguide designed in HFSS is shown in Fig (3).

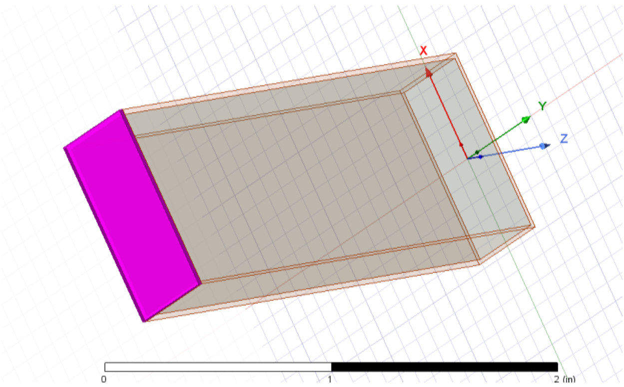

Figure 3 Structure of Rectangular waveguide

Transmission scattering parameters of rectangular waveguide are shown in Fig (4). Transmission parameters indicate a loss of zero above cut off frequency of 10 GHz when signal propagates from input port to the output port of waveguide.

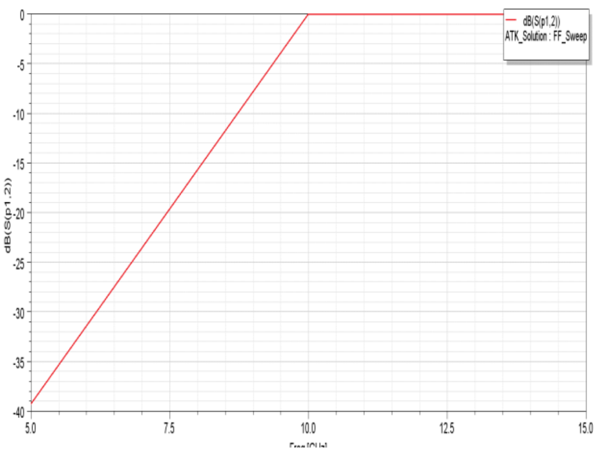

Figure 4 S_{12} of Rectangular waveguide

Circular waveguide designed in HFSS is shown in Fig (5).

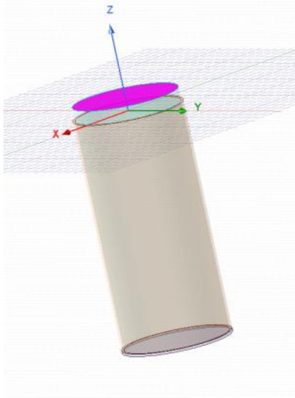

Figure 5 Structure of Circular waveguide

Transmission scattering parameters of circular waveguide are shown in Fig (6). Transmission parameters indicate a loss of 1 dB above cut off frequency of 10 GHz when signal propagates from input port to the output port of waveguide.

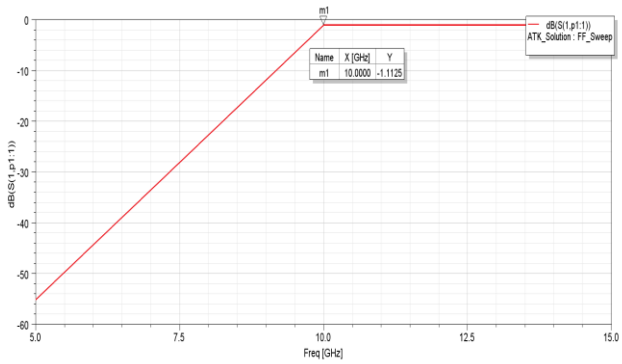

Figure 6 S_{12} of Circular waveguide

Conclusion

A Rectangular and circular waveguide for 10 GHz cut off frequency is designed and simulated in this research. Above cut off frequency both circular and rectangular waveguide offers negligibly small loss when signal propagates from input terminal to output terminal.

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