

Microwaves

Series 5

Problem 1

We want to use a rectangular waveguide for the frequency band between 12.5 and 19 GHz. Give the dimensions of an adequate waveguide, supposing it is filled with air

The guide has to have a cutoff frequency below 12.5 GHz, so let us choose for instance 10 GHz. The first higher order mode has to have a cutoff frequency above 19GHz, so let us choose 20 GHz. The first indications tells us that $a=1.5$ cm, the second that $b=0.75$ cm. Other dimensions are of course possible.

Problem 2

An attenuator can be made using a section of waveguide below cutoff. Consider the following set up : a waveguide of width a is connected to a waveguide of width $a/2$ and of length l . The latter is again connected to waveguide of width a . The height of all the guides is b .

If $a=2.286$ cm and the frequency is 12GHz, find the length l to get an attenuation of 100dB between the input and output guides. Ignore the reflection at the interfaces.

On the section of width $a/2$, the dominant mode (TE_{10}) is below cutoff. The attenuation constant is given by :

$$\alpha = \sqrt{\left(\frac{\pi}{a/2}\right)^2 - k^2} = 111.3 \text{ Np/m}$$

To obtain 100 dB of attenuation (ignoring the reflection), we need :

$$-100\text{dB} = 20\log_{10} e^{-\alpha l}$$

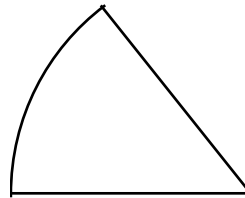
$$10^{-5} = e^{-\alpha l}$$

$$l = \frac{11.5}{111.3} = 0.103[m] = 10.3[cm]$$

Problem 3

A waveguide made by a perfect electric conductor has a section formed by the sector of circle having an angle of 60° (see figure). The radius is given by a . Find (depending on a) the value of the cutoff frequency of the dominant mode, and of the first higher order mode.

Indication: start from the results of the circular waveguide. And remember that you are free to choose the excitation



a

Note : Zeros of the Bessel function of the first kind

n	p_{n1}	p_{n2}	p_{n3}
0	2.405	5.520	8.654
1	3.832	7.016	10.174
2	5.135	8.417	11.620
3	6.38016	9.76102	13.01520
4	7.58834	11.06471	14.37254
5	8.77142	12.33860	15.70017
6	9.93611	13.58929	17.0038

Zeros of the derivative of the Bessel function of the first kind :

n	p'_{n1}	p'_{n2}	p'_{n3}
0	3.832	7.016	10.174
1	1.841	5.331	8.536
2	3.054	6.706	9.970
3	4.2012	6.0152	11.3459
4	5.3175	9.2824	12.6819
5	6.4156	10.5199	13.9872
6	7.5013	11.7349	15.2682

This waveguide can be looked at as a circular waveguide having two additional boundary conditions imposing a zero tangential electric field at $\varphi = 0^\circ$ and $\varphi = 60^\circ$. The modes supported by this guide will thus be the modes supported by a circular guide of radius a but also satisfying the two additional boundary conditions $E_\varphi = 0$ at $\varphi = 0^\circ$ and $\varphi = 60^\circ$. Looking at table @@@ in the course, we find that the modes TE_{01} and TE_{31} abide these conditions. The corresponding cutoff frequencies are given by

$$f_c(TE_{01}) = 182.828/a(\text{mm})$$

$$f_c(TE_{31}) = 200.459/a(\text{mm})$$

The relative mono-mode bandwidth of this guide is thus given by

$$\frac{f_c(TE_{01}) - f_c(TE_{31})}{0.5 * (f_c(TE_{01}) + f_c(TE_{31}))}$$

Which yields a bandwidth of about 9%, which is rather low for a waveguide.