Amateur Radio

Waveguide size for 2.4 GHz

Asked 1 year ago Modified 1 year ago Viewed 383 times

1

I'm thinking to make a wave guide that has diameter 1/8 of the wave length. At 2400mhz the full wave length is about 125mm. I have aluminum pipe that is 16mm. So 8*16 = 128mm (very close to 125mm).

If this pipe is 10 meters long and I transmit 10dBm trough it will it efficiently pass signal to the other end of it that will be detected well by 2.4Ghz receiver antenna? If so, what will be the approx. efficiency (10dBm - **x**dB)? Also how much worse will be if the pipe was 17mm or 15mm ?

I need practical answer, because I'm sure you can go really deep into with free space formulas, thickness of the pipe (its 0.3mm) and etc.

rf-power transmission-line microwave waves

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edited Jun 19, 2023 at 15:43

Mike Waters

8,071 ● 4 ● 18 ● 51

asked Jun 18, 2023 at 13:30

Svetoslav

13 ● 6

2 Answers

Sorted by: Highest score (default)

7

The cutoff frequency for the TE_{11} mode in a circular waveguide of radius a is

$$F_c = \frac{c}{2\pi}\frac{1.841}{a}$$

so for your pipe of 16 mm diameter, $F_c = 10.99\ \text{GHz}$

So as a waveguide this pipe would be most useful from about 11 to 14 GHz. Below cut-off, the power only travels by what is called an *evanescent wave* which has an incredibly high attenuation beyond about one wavelength, effectively no power is transferred. And above 14 GHz, other modes will be excited, which is not ideal for transferring power.

Waveguides below cut-off are not interesting for transmitting power, but we study them to know just how good their shielding will be. For example, your microwave oven has many small holes in the window area and for ventilation, they are 3 or 4 mm diameter, and they leak a small amount.
For your 16 mm pipe, I can give you a quick estimate, based on a lot of experience with

shielding effectiveness of enclosures with holes, that the attenuation will be about *60 dB for every 25 mm of pipe*, or 2400 dB/metre. That's not a typo, it's just a waveguide that doesn't transmit any power (of course other things like leaks into free space will dominate). Another example - a metal box 10 mm thick, with a single 16 mm hole in it, will have a shielding effectiveness of better than 20 dB, maybe 30 dB.

For a circular waveguide to work at 2.4 GHz, you need a pipe of about 8 cm inside diameter.

As for losses *above cut-off*, I found a calculator online that says (at 11 GHz): 0.25 dB/m for copper, and 0.3 dB/m for aluminium . This is lower loss than coaxial cable at this high frequency. It means that about half the power will be lost in a 10 metre waveguide.

Share Improve this answer Follow edited Jun 23, 2023 at 17:28

answered Jun 18, 2023 at 15:03

tomnexus
11.5k ● 16 ● 32

No,no the idea is not to make Pringles cantenna. With 8cm diameter and putting the monopole at correct distance for reflection you probably put the full wave in. Some antennas are build as 1/4 or even 1/8 of the wave length as I saw in google. Now if this is doable for antenna, this possibly means it is doable for a waveguide. By reducing the wavelength, it is true that at above 1/8 you start to lose bandwidth (from article that I read), but I am not quite sure that it will work for 11 to 14Ghz only. This is not cantena just a waveguide. – Svetoslav Jun 18, 2023 at 22:13

2 Physics says a 2.4 GHz waveguide filled with air needs to be 8 cm diameter, no less. Search google for "circuiar waveguide calculator" and see for yourself. – tomnexus Jun 19, 2023 at 3:29

@Svetoslav a cantenna **IS** a waveguide. You may find this wikipedia article helpful. – webmarc Jun 19, 2023 at 14:54

2 @webmarc When I hear *cantenna*, I think of the Heathkit Cantenna dummy load. :-) – Mike Waters Jun 19, 2023 at 15:47

About copper and aluminum losses. Shouldn't the losses be based on the thickness on the material ? This is too much losses to believe for a waveguide (even though better than coax). The waveguide is trapping the signal inside the aluminum cage and it is reflected back and forth until it reaches the other end. If the aluminum is 10mm thick I don't trust that we have 0.3 dB/m rather 0.03. What do you think ? – Svetoslav Jun 22, 2023 at 14:50

-6

I ask the other guys that tell it is not valid (impossible to do).. Well here's what ChatGPT said:

> To calculate the required diameter of a circular waveguide for a 2.4 GHz signal at 1/8 wavelength, we can use the formula:
>
> d = λ / (2 * π * 1/8)
>
> Where: d is the diameter of the circular waveguide, λ is the wavelength of the signal.
>
> First, let's calculate the wavelength:
>
> λ = c / f

> Where: c is the speed of light (approximately 3 * 10^8 meters per second), f is the frequency of the signal (2.4 GHz or 2.4 * 10^9 Hz).
>
> λ = (3 * 10^8) / (2.4 * 10^9) ≈ 0.125 meters or 12.5 cm
>
> Now, we can calculate the required diameter of the circular waveguide:
>
> d = (0.125) / (2 * π * 1/8) ≈ 0.125 / (2 * 3.14 * 1/8) ≈ 1.6 cm
>
> Therefore, the required diameter for a circular waveguide for a 2.4 GHz signal at 1/8 wavelength is approximately 1.6 cm.

Perfect match. Can you confirm that signal propagated as 1/8 wavelength can travel trough the pipe without bad attenuation ?

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answered Jun 22, 2023 at 22:52

Svetoslav
13 • 6

3 You asked it to do something stupid, so it took the values you gave it, put them into some high-school math formulas, dressed them up with some explanation so that it sounded like it knew what it was talking about, and then **gave you exactly the wrong answer that you told it to give**. This is precisely what ChatGPT does best, and why using it is a pointless waste of time. – hobbs - KC2G Jun 22, 2023 at 23:01

4 ChatGPT told you the diameter of a 1/8-wavelength **whatever** at 2.4GHz (anyone with a calculator can do that). It called the whatever a "waveguide" because you told it to. It doesn't understand that a circular waveguide *doesn't function as a waveguide* when it's diameter is 1/8λ. It doesn't care. It just drove a straight line between the phrases you gave it. – hobbs - KC2G Jun 23, 2023 at 0:19

1 @Svetoslav I've added to my answer to say exactly what will happen in such a small waveguide at 2.4 GHz. Not much, because it's 4 times smaller than necessary. – tomnexus Jun 23, 2023 at 17:30

1 You should also take note, @Svetoslav, that ChatGPT generated answers are not permitted. meta.stackoverflow.com/questions/421831/... – David Hoelzer ♦ Jun 24, 2023 at 12:07

2 @Svetoslav when asking about calculations, basic reading comprehension and arithmetic skills are expected. The answer tomnexus gave is pretty detailed and does in fact address that. – Marcus Müller Jul 2, 2023 at 23:17