Waveguide Frequency Chart

What is a Waveguide?

A waveguide is rectangular, circular, or oval “pipe” filled with air or dielectric material which is capable of conveying RF energy. The physical implementation of the structure determines the frequencies which may be transported. Many Eigenmodes are possible, but the lowest order is almost always used. Equations for the calculation of these modes for rectangular waveguides are detailed below. A chart of common commercially available waveguides is included at the document’s conclusion.

What are the Transverse Electric (TE) and Transverse Magnetic (TM) Modes?

An example of waveguide structure is shown below in Figure *1*:

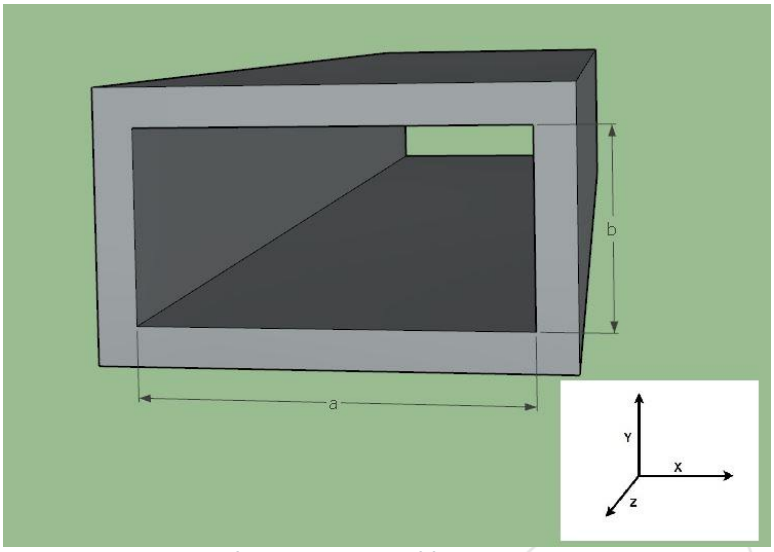

Figure 1 - Waveguide Structure

This structure will support both transverse electric (TE) and transverse magnetic (TM) field modes of propagation. An electromagnetic wave propagating in free space exhibits both conditions – transverse electric and magnetic fields, or TEM mode. For free space propagation, the E and H fields are at right angles to each other, and at right angles to the direction of propagation. The Poynting vector, E X H, points in the direction of signal propagation.

This is not the case for signals in a waveguide. Either the electric field is fully in the XY plane with no Z component, or it is in the magnetic field, but never both.

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What is Waveguide Cutoff?

The lowest frequency that a waveguide can support is called the *cutoff frequency* and is always the transverse electric mode of the lowest order, TE_{10}, also called the *fundamental mode* of the waveguide. The waveguide should be used between its cutoff frequency and the beginning of the range for the next higher order mode, TE_{11}. It is not recommended to operate the waveguide at a frequency where more than one TE mode is supported, since the different modes travel at different speeds and would interfere with each other.

The cutoff frequency for each TE_{mn} mode is given by:

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

Note that for the fundamental TE_{10} mode, the b dimension isn't relevant, and the cutoff equation simplifies to c/2a. The variable b is usually a/2.

The equation for the cutoff of a waveguide propagating TM mode waves is the same as the TE equation, except that neither m nor n can be zero. The lowest cutoff is therefore in the TM_{11} mode.

Waveguides are a dispersive media, meaning that the delay vs frequency is not at all flat. The equations of the phase speed and the group velocity are given below.

The z component of the wave vector, k_z, is given by:

$$k_z = \sqrt{k^2 - \left(\frac{m\pi}{a}\right)^2 - \left(\frac{n\pi}{b}\right)^2} \quad \text{where } k = \frac{\omega}{c} \text{ as usual}$$

The phase speed is therefore:

$$v_f = \frac{\omega}{k_z}$$

And the group velocity is given by:

$$v_g = \left(\frac{dk_z}{d\omega}\right)^{-1} = \frac{k_z c}{k}$$

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This table gives the standard waveguide designations, frequencies, and dimensions.

Frequency Band	Waveguide	Frequency Limits (GHz)		Dimensions (in)		Dimensions (mm)	
		Low	High	a	b	a	b
	WR-2300	0.32	0.49	23.0000	11.5000	584.2000	292.1000
	WR-2100	0.35	0.53	21.0000	10.5000	533.4000	266.7000
	WR-1800	0.41	0.62	18.0000	9.0000	457.2000	228.6000
	WR-1500	0.49	0.74	15.0000	7.5000	381.0000	190.5000
	WR-1150	0.64	0.96	11.5000	5.7500	292.1000	146.0500
	WR-1000	0.75	1.10	9.9750	4.9875	253.3650	126.6825
	WR-975	0.75	1.12	9.7500	4.8750	247.6500	123.8250
	WR-770	0.96	1.45	7.7000	3.8500	195.5800	97.7900
	WR-650	1.12	1.70	6.5000	3.2500	165.1000	82.5500
R band	WR-430	1.70	2.60	4.3000	2.1500	109.2200	54.6100
D band	WR-340	2.20	3.30	3.4000	1.7000	86.3600	43.1800
S band	WR-284	2.60	3.95	2.8400	1.3400	72.1360	34.0360
E band	WR-229	3.30	4.90	2.2900	1.1450	58.1660	29.0830
G band	WR-187	3.95	5.85	1.8720	0.8720	47.5488	22.1488
F band	WR-159	4.90	7.05	1.5900	0.7950	40.3860	20.1930
C band	WR-137	5.85	8.20	1.3720	0.6220	34.8488	15.7988
h band	WR-112	7.05	10.00	1.1220	0.4970	28.4988	12.6238
X band	WR-90	8.20	12.40	0.9000	0.4000	22.8600	10.1600
X-Ku band	WR-75	10.00	15.00	0.7500	0.3750	19.0500	9.5250
Ku band	WR-62	12.40	18.00	0.6220	0.3110	15.7988	7.8994
K band	WR-51	15.00	22.00	0.5100	0.2550	12.9540	6.4770
K band	WR-42	18.00	26.50	0.4200	0.1700	10.6680	4.3180
Ka band	WR-28	26.50	40.00	0.2800	0.1400	7.1120	3.5560
Q band	WR-22	33.00	50.00	0.2240	0.1120	5.6896	2.8448
U band	WR-19	40.00	60.00	0.1880	0.0940	4.7752	2.3876
V band	WR-15	50.00	75.00	0.1480	0.0740	3.7592	1.8796
E band	WR-12	60.00	90.00	0.1220	0.0610	3.0988	1.5494
W band	WR-10	75.00	110.00	0.1000	0.0500	2.5400	1.2700
F band	WR-8	90.00	140.00	0.0800	0.0400	2.0320	1.0160
D band	WR-6	110.00	170.00	0.0650	0.0325	1.6510	0.8255
G band	WR-5	140.00	220.00	0.0510	0.0255	1.2954	0.6477
	WR-4	172.00	260.00	0.0430	0.0215	1.0922	0.5461

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	WR-3	220.00	330.00	0.0340	0.0170	0.8636	0.4318
Y band	WR-2	325.00	500.00	0.0200	0.0100	0.5080	0.2540
	WR-1.5	500.00	750.00	0.0150	0.0075	0.3810	0.1905
	WR-1.5	750.00	1100.00	0.0100	0.0050	0.2540	0.1270