WAVEGUIDE SIZES for MICROWAVE AMATEUR RADIO

Retangular Waveguide

Preface by Dick Knadle, K2RIW

Enclosed is some additional cut-off frequency info that is "calculated". The WG manufacturers will not approve operation on these frequencies -- hi! The calculated absolute minimum cut-off frequencies are where the WG loss goes to almost infinity, as you approach that frequency, from the high side. WG is the world's best high pass filter. The added data is shown inside a parenthesis.

The calculation assumes that the guide has the exact inside dimension of the WG number. Also, if you double the parenthesis (cut-off) frequency, you will know the absolute maximum WG frequency; above that frequency the next higher mode is possible to propagate. Naturally, the calculated absolute max or min frequencies include no guard band; but with care, we amateurs should be able to use frequencies that are almost at these numbers, in a pinch.

The low freq min occurs when the guide max dimension is 1/2 wavelength or greater (TE10 mode possible). The next higher mode, in rectangular guide, occurs when either the max guide dimension approaches 1.0 wavelength or greater (TE20 mode possible) or the guide min dimension approaches 1/2 wavelength or greater (TE01 mode possible). "Flat Guide" (less than half height guide) is useful to suppress the TE01 mode or to form a lower impedance match.

Also, I feel that we shouldn't be too afraid of the next higher mode. In wide bandwidth commercial/military operations it is troublesome because the dual mode signals can beat against each other and create insertion loss ripple versus swept frequencies (the defferent modes have different propagation constants). However, we usually use the WG at a fixed frequency where we can tune the system for optimum response of the dual modes. The net benefit is considerably lower WG loss when "oversized" WG is being used.

Double ridged WG uses the extra capacitance of the ridges to both lower the cut-off frequency (for the same max guide dimension) and to increase the WG bandwidth. Therefore, in a pinch, we could add ridge material to a short piece of WG as a way of using it at lower frequencies. Even placing a piece of low loss dielectric material down the center of a WG can have this effect.

At a later time, I believe Tom and I should give all the magic frequencies for various diameters of round WG. The advantages of round WG are: lower loss than rectangular (of the same dimension); it supports circular polarization; and we can buy it at a Home Depot Store. The disadvantage is round WG has a smaller frequency range between the max and min frequencies. But, since we usually use only a fixed frequency, that usually is no problem. Also, round WG types often make a superior feed horn for illuminating a dish.

Background by Tom Williams, WA1MBA:

One of the definitions of a waveguide is that it is a transmission line with only one conductor. It is possible to construct waveguides with two conductors, but such systems will support modes other than waveguide modes of transmission. Free space transmission is TEM, or Transverse Electro-Magentic. This is also the type of propogation supported in multiple conductor transmission lines such as coaxial and twin-lead. Waveguides do not normally support TEM, but instead support TE and TM modes. There are many modes, and they are numbered with two digits (actually, two numbers, and some very high mode numbers are used in some applications where very high power has to be transmitted). Some mode numbers don't exist in some types of waveguides. As Dick mentioned, the most common rectangular mode is TE10, which is a fairly low loss mode and which is easily launched and permits waveguide twists and bends with very predictable results.

There are loads of waveguide sizes. And it is possible to use some waveguide sizes on ham bands that are outside of the normal operating frequency. The easiest way to tell a waveguide size is to bring along a ruler or a caliper when you go to a hamfest. I cut out an index card with the widths of the waveguide that I am interested in and jam it into the waveguide to decide what size/frequency it is.

The wide dimension of the inside of rectangular waveguide in hundredths of an inch is the

There are various sources for waveguide dimensions and frequency ranges, including ARRL and RSGB manuals on microwaves & UHF.The cutoff frequencies are usually a little below 0.8 times the low frequency of the standard range. Two sources were used for cutoff information. The first is a practical guide, the last is a theoretical cutoff. The smallest flaw can increase the frequency of cutoff.

Another interesting parameter is loss. There are various formulae floating around, and they do not produce the same results. The "Wave Guide Handbook" is a half-century old, and various physics/electomagentic books provide formulae that disagree with all published values from the waveguide manufacturers. The best hint I have heard regarding these differences is that the math does not take into account surface imperfections on the order of skin depth. Because skin depth gets very very small at EHF, the difference between calculated and measured loss in the smaller waveguides becomes significant. Fortunately, some manufacturers measure actual waveguide rather than publish theoretical data. So, for now, I have used a manufacturer's set of data for millimeter wave (EHF) waveguides, and refer the reader to the Andrew page for the DC bands (

If there are any other data you want, or have that you feel are worth sharing, let me know. WA1MBA.

EIA designation (Standard US) and /RG number	RCSC Designation (Standard UK)	Band	Inside Dimensions inches	Outside Dimensions inches (typ)	Standard Freq Range, GHz	Cutoff Freq GHz, Source #1, (Source #2)	Loss per foot Low end - High end of waveguide band	Power Handling Low to High freq MW=Megawatts, kW=Kilowatts
	WG 6	-	6.50, 3.25	6.66, 3.41	1.12 to 1.70	? (0.91)	-	-
	WG 8	-	4.30, 2.15	4.46, 2.31	1.70 to 2.60	? (1.37)	-	-
	WG 9A	-	3.40, 1.70	3.56, 1.86	2.10 to 3.00	? (1.6)	-	-

	WG 10	-	2.84, 1.34	3.00, 1.50	2.60 to 3.95	? (2.08)	-	2.2 - 3.2 MW
	WG11A	-	2.29, 1.145	2.418, 1.273	3.30 to 4.90	? (2.58)	-	1.6 - 2.2 MW
	WG12	-	1.872, 0.872	2.000, 1.000	3.95 to 5.85	? (3.16)	-	1.4 - 2.0 MW
	WG13	-	1.590, 0.795	1.718, 0.923	4.90 to 7.05	? (3.71)	-	0.79 - 1.0 MW
	WG14	-	1.372, 0.	1.500, 0.750	5.85 to 8.20	? (4.31)	-	560 - 710 kW
	WG15		1.122, 0.497	1.250, 0.	7.05 to 10.00	? (5.27)	-	350 - 460 kW
	WG16	X	0.900, 0.400	1.000, 0.500	8.20 to 12.4	? (6.56)	-	200 - 290 kW
	WG17	-	0.750, 0.375	0.850, 0.475	10.0 to 15.0	? (7.87)	-	170 - 230 kW
	WG18	Ku	0.	0.702, 0.391	12.4 to 18.0	9.50 (9.52)	-	120 - 160 kW
	WG19	-	0.510, 0.255	0.590, 0.335	15.0 to 22.0	? (11.57)	-	80 - 107 kW
	WG20	K	0.420, 0.170	0.500, 0.250	18.0 to 26.5	14.08 (14.05)	0.26 - 0.20 dB	43 - 58 kW one source
	WG22	Ka	0.280, 0.140	0.360, 0.220	26.5 to 40.0	21.08 (21.08)	0.44 - 0.30 dB	96 - 146 kW
	WG23	Q	0.224, 0.112	0.304, 0.192	33.0 to 50.0	26.34 (26.82)	0.	64 - 97 kW
	WG24	U	0.188, 0.094	0.268, 0.174	40.0 to 60.0	31.36 (31.06, 30.69)	0.77 - 0.54 dB	48 - 70 kW
	WG 25	V	0.148, 0.074	0.228, 0.154	50.0 to 75.0	39.87 (39.90, 39.34)	0.10 - 0.80 dB	30 - 40 kW
	WG 26	E	0.122, 0.061	0.202, 0.141	60.0 to 90.0	48.35 (48.40, 49.18)	1.8 - 1.0 dB	? kW
	WG 27	W	0.100, 0.050	0.180, 0.130	75.0 to 110.0	59.01 (58.85)	2.0 - 1.4 dB	14 - 25 kW
	WG 28	F	0.080, 0.040	0.160, 0.120	90.0 to 140.0	73.77 (73.84)	3.0 - 2.0 dB	8.8 - 13 kW
	WG ?	D	0.065, 0.0325	0.145, 0.112	110 to 170	90.79 (90.48, 84.31)	3.8 - 3.0 dB	5.9 - 9.3 kW
	WG ?	G	0.0510, 0.0255	0.131, 0.105	140 to 220	115.7 (118.03)	6.1 - 3.8 dB	3.7 - 6.1 kW
	WG ?	Y	0.034, 0.0170	0.114, 0.097	220 to 325	196.71 (196.71)	10.0 - 7.0 dB	1.9 - 2.6 kW

Other Links
One good reference for attenuation for most popular waveguide sizes
Press here And then select page 230 and 231

If those pages are

Press here for DG6RBP's Adobe PDF page of tables where more information is available for some of the waveguide sizes.

Waveguide Calculator

If you would like to calculate a waveguide loss or cutoff frqeuency for a particular size of rectangular waveguide and frequency **press here** and fill in the values. It includes loss below cutoff. Accuracy of a model depends on many things, and this one provides inaccuracies right around cutoff of about 5%. Also, it does not account for surface roughness above 20GHz, and so for above cutoff conditions, loss values calculated in that range are less than what you would expect from an actual piece of waveguide.

This page is based on equations from engineering texts which I first put into a spreadsheet, and then gave to **Paul ND2X** who skillfully fashioned them into this JavaScript calculator. Have fun!!

Waveguide to Coax Transition

If you need to construct your own waveguide to coax transition, **here is an article** published by Richard M. Kurzrok (RMK Consultants) which appeared in *Applied Microwave and Wireless* magazine.

Circular (cylinderical) Waveguide

Cicrular cross section waveguide is the same and different from rectangular. First of all, it is the same in that both are waveguides. However, the rules for modes are different, depending only on diameter. Launches can also be tricky. Furhtermore, circular modes support two orthogonal signals, so two polarizations can be kept separated over a length waveguide. This can be very helpful in commercial, radar and military systems where two polarizations can enter a circular feed and be separated for two way communications, cross polarization information extraction, or some other bizzare effect. Also, circular waveguide, when run at very high modes, much like a high mode rectangular guide, can support very high power without arcing. Also, circular waveguide, when operating in the TMXX mode can have surprizingly low loss.

Quite often, manufacturers of circular waveguide will publish several frequency ranges of operation. Below I will try to compile the typical circular waveguide parameters.

UNDER CONSTRUCTION

The weak signal calling frequencies that hams use in the US above 1 GHz are usually

MHz
1,296.1
2,304.1
3,456.1
5,760.1
10,368.1
24,192.1
47,088.1
GHz
80 Several sets of contacts in US, in the Northeast we use 78,192.1. Other areas of the country use other frequencies. Amateurs are primary in 77.5 to 78 GHz, secondary in the rest of the band.
The 120 and 145 GHz bands have been replaced. As soon as I get some accurate information I will post it.
120.0 Several sets of contacts in US
145 Several sets of contacts in US, including VUCC
241 One pair of amateurs made contacts in US, including VUCC

Ever wonder about those letter band designators? Like just what is S band and what is X band anyway? Well, press here and read about the many varieties of band designations.

If you have advice, corrections additions, or some other useful tables,
please send mail to tomw@wa1mba.org

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