Waveguides for EMI and RF Shielding

European EMC Products

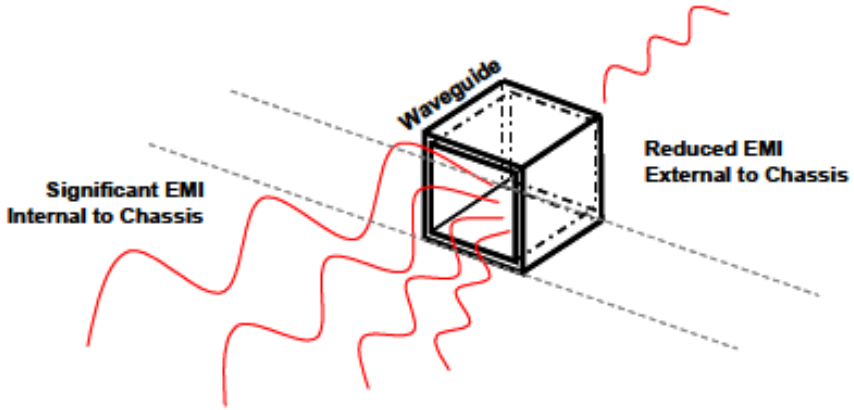
Technical Datasheet

Shielding Effectiveness Calculations for WGBC (Wave Guide Beyond Cutoff)

Basic Waveguide Operation

For the purposes of this document, a waveguide is essentially a hollow conducting tube that acts as a filter for EMI. Only EMI energy at very high frequencies can pass through it with little attenuation. When used to contain EMI in a chassis enclosure, a waveguide is generally designed such that all frequencies of interest are greatly attenuated by the waveguide (see below).

The EMI performance of a waveguide is governed by the surface geometry of the apertures (length and width), the aperture depth, the shape, and total number of apertures. This document describes how the waveguide aperture geometry can be varied to affect their ability to contain EMI.

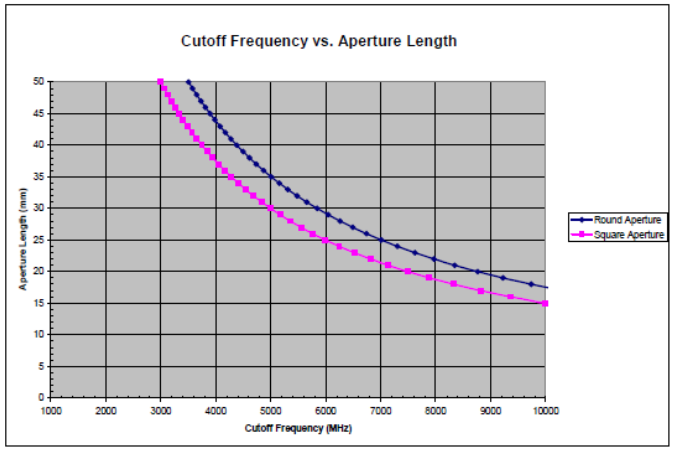


Calculating EMI Performance of a Waveguide

The metric of waveguide EMI performance is determined by a combination of two parameters:

1. Cutoff Frequency (fc), which determines the maximum possible frequency of effectiveness.
2. Shielding Effectiveness (SE), which determines the magnitude of the EMI attenuation and is a function of frequency.

These parameters are described in the following sections.



Cutoff Frequency

The Cutoff Frequency (fc) is the frequency beyond which the waveguide no longer effectively contains EMI. This frequency is determined by the outside dimensions of the apertures.

This can be theoretically calculated as shown below:

- For round apertures: fc = (6900*25.4)/length = 175260/length (MHz)
- For square apertures: fc = (5900*25.4)/length = 149860/length (MHz)

Below shows how the Cutoff Frequency for round and square apertures varies as the outside aperture dimensions (length and width) are varied.

Shielding Effectiveness

The Shielding Effectiveness (SE) of a waveguide represents the amount of EMI attenuation that the waveguide offers at a given frequency. This is dependent on several factors. These include the surface geometry of the aperture (length and width), depth, shape of aperture, and the total number of apertures.

The formula below is used, this shows the calculation for the EEP waveguide vents with 1 cm width and 5 cm depth.

EMP Pipe Penetration Attenuation Calculation Sheet

Pipe penetration inside diameter (u) in cm	1
Pipe penetration length (t) in cm	5

For Circular Waveguides where the diameter is less than the length the cut off frequency (fc in GHz) can be calculated:

fc = 1.76 x 10 /u cm

fc = 17.6 GHz

Waveguides for EMI and RF Shielding

The shielding effectiveness in decibels (SE) can be calculated as follows:

SE = 32(t/u)(1-(f/fc)2)1/2

t =	Pipe penetration length in cm	5
u =	Pipe penetration inside diameter in cm	1
f =	Highest frequency of specification in GHz	1
fc =	Cut of frequency for pipe in GHz	17.6
	1-(f/fc)2 =	0.996772
	(1-(f/fc)2)1/2 =	0.998385
SE =	159.7 dB	

Note

These figures are for individual pipe or cells, consideration must be taken when using these figures for a complete waveguide. For example, a 300 x 300mm waveguide would have a 20 - 30 dB reduction in SE when compared to an individual cell.

All figures assume perfect joints etc

The theoretical performance is always MUCH higher than will actually be achieved, hence we reduce from this potential SE figure by 30 dB.

Mounting of WGBC

The installation of an effective WGBC must have a continuous conductive connection to the host building around the total perimeter. Without this EMI will leak.

This connection can be welding, soldering or suitable gaskets.

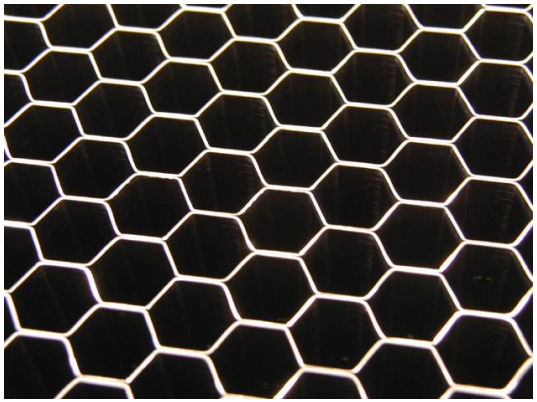
WGBC Design

It must not be forgotten the purpose of the WGBC will be to allow air, fluid, water or fibre optic cables to be used.

So as long as all the EMC requirements of length and diameter are meet the final design and material can vary depending on the purpose needed. For example, copper pipe WGBC for water, steel square matrix for AC or steel plated pipes for water of fuel. See examples below:

Steel square matrix 10 mm x 50mm used to form WGBC for air ventilation

Stainless steel hexagonal WGBC for shipborne air vents



About Us

European EMC Products Ltd was formed in July 1996 to supply high quality products and services to the Electro-Magnetic Compatibility (EMC) market. The emphasis being on EMP and RF Shielded Chambers and associated products and services such as RF Shielded Windows, Shielded Doors and Shielding Effectiveness and EMP Testing.

Quality

European EMC Products are registered to BS EN ISO 9001:2015, Certificate No. FS 38901. License scope: The design, assembly, servicing and testing of RF Shielded structures and equipment including EMI shielding and thermal management materials; Gas tight doors; and specialised mobile electromagnetic pulse protected (EMPP) containers.

Disclaimer

NB: All of the information provided within this datasheet is for reference only. Product specifications are subject to change without notice.