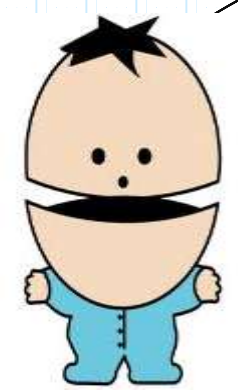
WAVE GUIDE CHARACTERISTICS

A Quick Recap: WAVEGUIDE

Waveguide is the type of transmission line which carries microwave frequencies from source to load. The energy is in the form of electric field and magnetic field which are perpendicular to each other the electric field and magnetic field inside..



Q Why there are less losses when using Wave Guides

The large surface area of waveguides greatly reduces COPPER (I2R) LOSSES. Two-wire transmission lines have large copper losses because they have a relatively small surface area. The surface area of the outer conductor of a coaxial cable is large, but the surface area of the inner conductor is relatively small. At microwave frequencies, the current-carrying area of the inner conductor is restricted to a very small layer at the surface of the conductor by an action called SKIN EFFECT

Types of Wave guide:

There are the basic two types of the wave guide.

1. Circular wave guide
2. Rectangular wave guide

Construction:

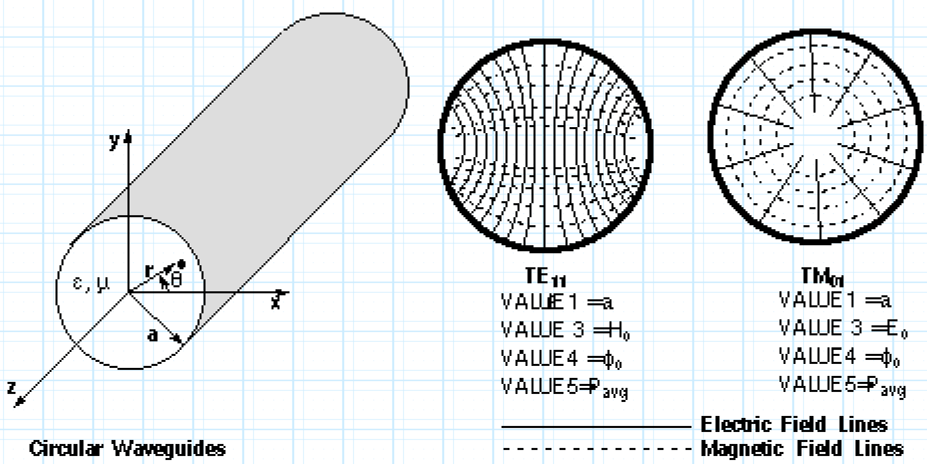
1. Circular wave Guide:

As shown in the given diagram the circular waveguide is designed from a **<u>conducting pipe</u>** which is **<u>hollow from the center</u>** and **<u>polished from interior portion</u>**. The outer surface of the wave guide is **<u>coded with the insulated paint</u>** in order to avoid dust and rust. These types of wave guide are available in different lengths and sizes in order to fulfill the requirement of the circuit.

<u>Advantages and Applications of Wave Guides</u>

1. Easy to Manufacture
2. Easy to Join

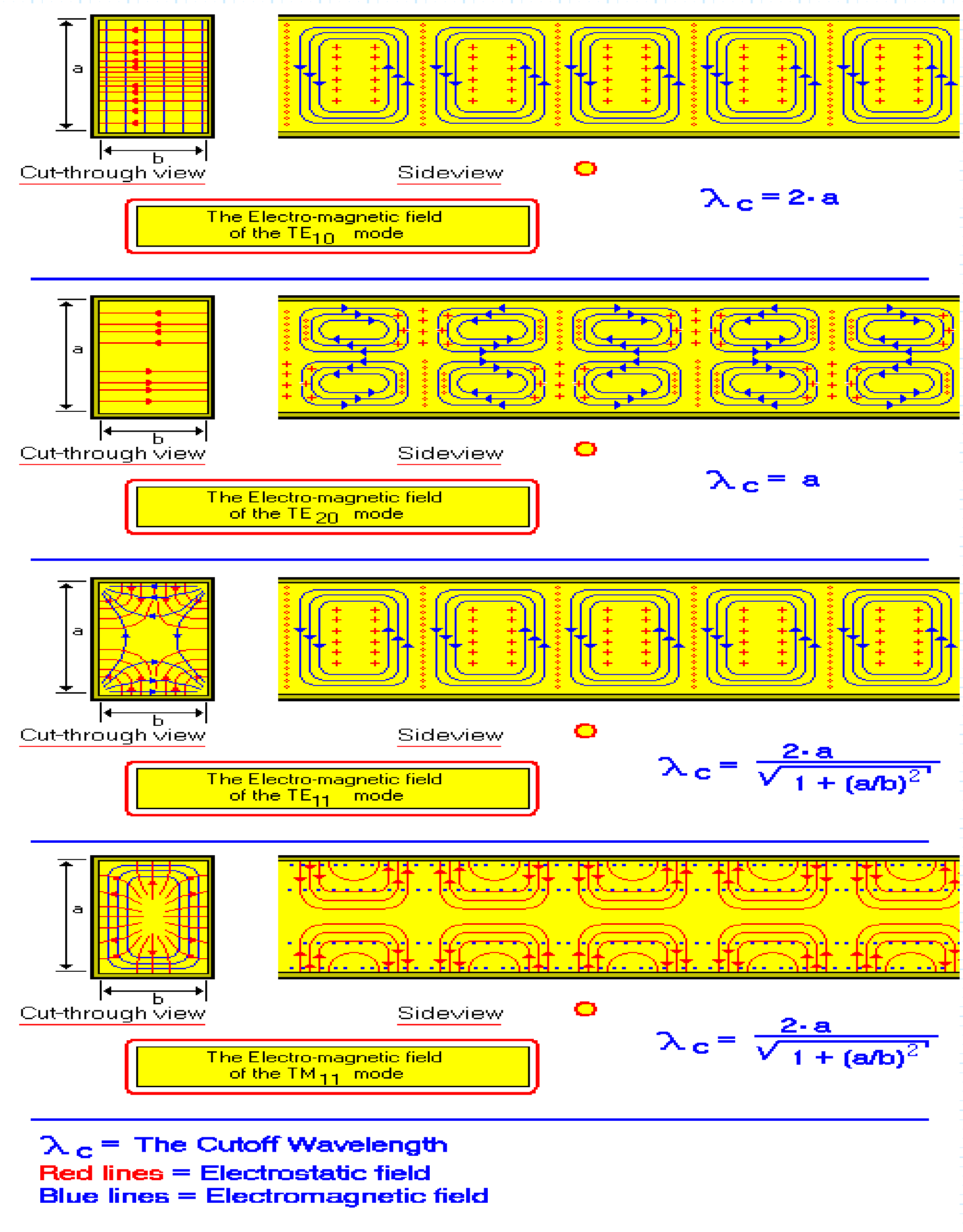
<u>Filed Patterns</u>



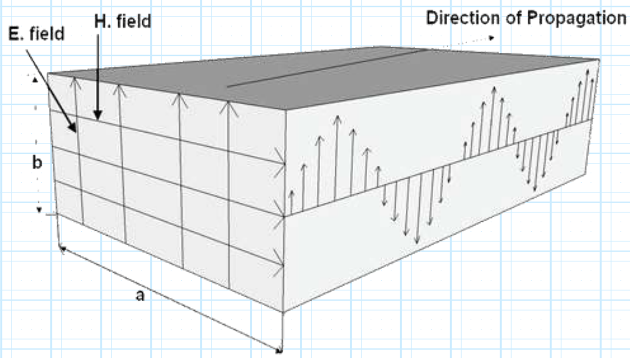
2. Rectangular Wave Guide:

As shown in the given diagram, the rectangular wave guide is designed from **<u>conducting material in rectangular shape</u>** which is hollow from the center and **<u>fully polished from interior</u>**. The outer surface of the wave guide is coded with insulating material or paint in order to avoid dust and rust. These types of wave guides are available in different lengths and sizes in order to fulfill the requirements of the circuit.

Filed Patterns for Rectangular Wave Guides



Direction of Propagation:

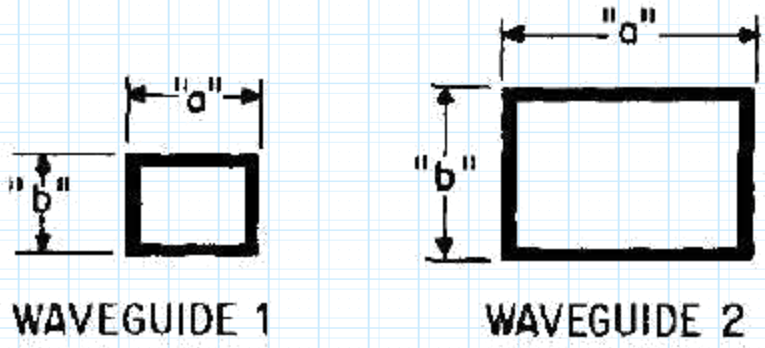


As shown in the given diagram, there are two dimensions of the rectangular waveguide the **broad dimension** and the second is **the narrow dimension**.

- The **broad dimension is denoted by "a**
- **Narrow is by "b"**.
- In the wave guide the electric-field and the magnetic-field carry the signal from source to load.
- In this case electric-filed and the magnetic-field is perpendicular to each other and at the same time. These fields are perpendicular to the direction of propagation

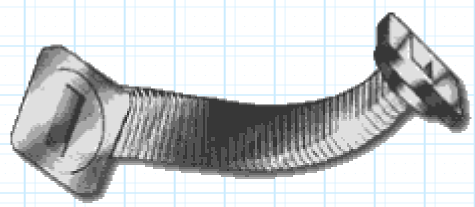
What is determined by "a" and "b"

The widest dimension of a waveguide is called the "a" dimension and determines the range of operating frequencies. The narrowest dimension determines the power-handling capability of the waveguide and is called the "b" dimension



<u>There is also another type of special sub type of wave guide</u>

Flexible Waveguide



It is the type of waveguide which **can be easily turn and twisted** in circuits to connect the source with the load. This type of wave guide is designed in such a way that internal portion is made of conducting material in spring shape. The external portion is covered with the rubber to avoid dust, rust and humidity.

<u>Uses of Flexible waveguide</u>

1. The flexible waveguide is used in such microwave equipment's where the **<u>path from load to the source is twisty</u>**.
2. This waveguide is also used to **<u>minimize the size and design of the microwave equipment's.</u>**
3. We also used the flexible waveguide **<u>to reduce the weight</u>** due to reduction in size and to reduce the space occupied by the microwave equipment's.

<u>Uses of Wave Guide:</u>

There are the following uses of Wave Guide.

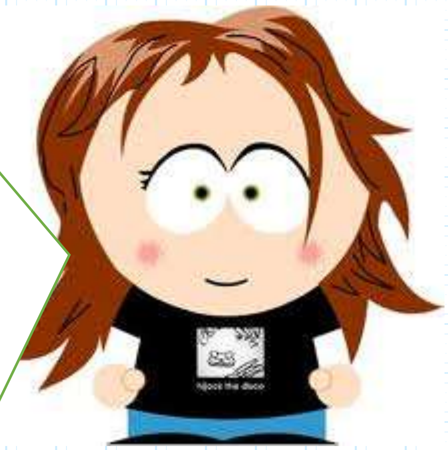
1. It is used where the transmission or reception is in the range of microwave frequencies.
2. It is also used for handling the high power of energy.
3. The circular wave guide is mostly used in the ground radar to transmit or receive the energy from antenna. Which revolves in 360o bearing continuously.
4. The wave guide is also used in communication system.
5. In satellite communication the wave guide is mostly used.
6. We also use the wave guide in the devices of navigation aids.
7. In some cases the wave guide is used as attenuator where very high frequencies are involved.
8. The wave guides are also used with the cavity resonators to carry the input and out put signals.

So if wave Guides are so good, than why we do not only use them?

Physical size is the primary lower-frequency limitation of waveguides. The width of a waveguide must be approximately a half wavelength at the frequency of the wave to be transported. For example, a waveguide for use at 1 megahertz would be about 500 feet wide. This makes the use of waveguides at frequencies below 1000 megahertz increasingly impractical.

Waveguides are difficult to install because of their rigid, hollow-pipe shape.

Special couplings at the joints are required to assure proper operation. Also, the inside surfaces of waveguides are often plated with silver or gold to reduce skin effect losses. These requirements increase the costs and decrease the practicality of waveguide systems at any other than microwave



Impedance Matching Wave Guides

Waveguide impedance definition

The waveguide impedance can be determined by taking the ratio of the electric field to the magnetic field at the center of the waveguide.

Waveguide impedance and reflection coefficient

As is transmission lines there is a need of matching Impedance for maximum power transfer. Similarly, If the waveguide impedance is matched to the source or load, then a greater level of power transfer will occur.

When waveguides are not accurately matched to their loads, standing waves result, and not all the power is transferred.

To overcome the mismatch it is necessary to use some waveguide impedance matching techniques.

Waveguide Impedance Matching

In order to ensure the optimum **waveguide impedance matching is obtained**, small devices are placed into the waveguide close to the point where the matching is needed to change its characteristics.

There are a number of ways in which waveguide impedance matching can be achieved:

1. Use of gradual changes in dimensions of waveguide.
2. Use of a waveguide iris
3. Use of a waveguide post or screw

Use of gradual changes in dimensions of waveguide.

It is found that abrupt changes in a waveguide will give rise to a discontinuity that will create standing waves. However gradual changes in impedance do not cause this.

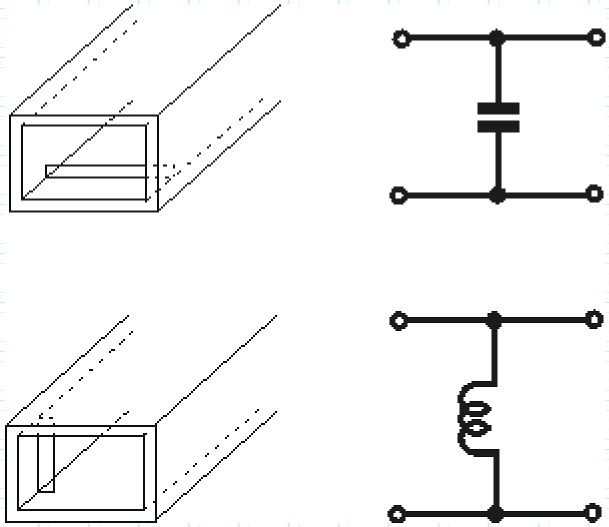
This approach is used with horn antennas - these are funnel shaped antennas that provide the waveguide impedance match between the waveguide itself and free space by gradually expanding the waveguide dimensions.

Impedance matching using a waveguide iris

Irises are effectively obstructions within the waveguide that provide a capacitive or inductive element within the waveguide. This enables the waveguide impedance matching to occur.

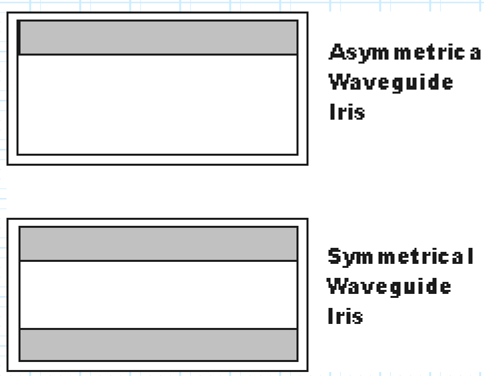
The obstruction or waveguide iris is located in either the transverse plane of the magnetic or electric field. A waveguide iris places a shunt capacitance or inductance across the waveguide and it is directly proportional to the size of the waveguide iris.

An **inductive waveguide** iris is placed within the **magnetic field,** and a **capacitive waveguide iris is** placed within the **electric field.**



<u>Configurations of Iris</u>

The waveguide iris may either be on only one side of the waveguide, or there may be a waveguide iris on both sides to balance the system. A single waveguide iris is often referred to as an **asymmetric waveguide iris or diaphragm** and one where there are two, one either side is known as a **symmetrical waveguide** iris.

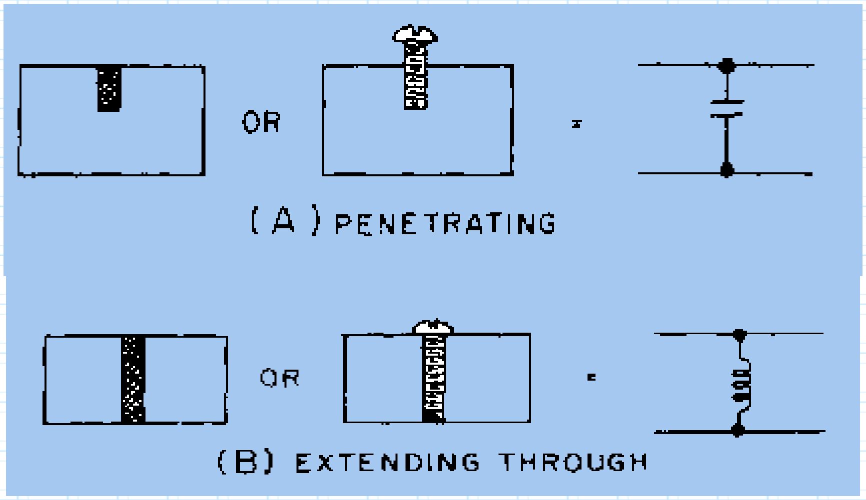


<u>Impedance matching using a waveguide post or screw</u>

In addition to using a waveguide iris, post or screw can also be used to give a similar effect and thereby provide waveguide impedance matching.

The waveguide post or screw is made from a conductive material. To make the post or screw inductive, it should extend through the waveguide completely making contact with both top and bottom walls. For a capacitive reactance the post or screw should only extend part of the way through.

When a screw is used, the level can be varied to adjust the waveguide to the right conditions

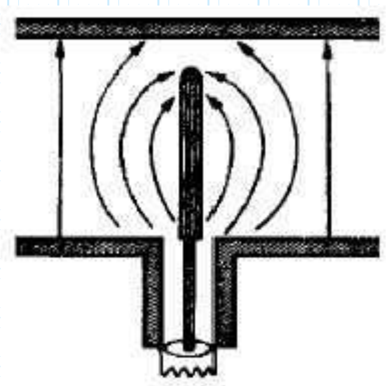


Exciting Wave Guides

Waveguide, as explained earlier in this chapter, operates differently from an ordinary transmission line. Therefore, special devices must be used to put energy into a waveguide at one end and remove it from the other end. The three devices used to inject or remove energy from waveguides are PROBES, LOOPS, and SLOTS and Direct Coupling

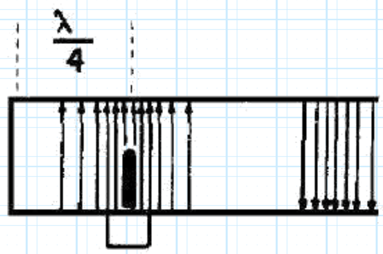
By Antenna

As previously discussed, when a small probe is inserted into a waveguide and supplied with microwave energy, it acts as a quarter-wave antenna. Current flows in the probe and sets up an E field .The E lines detach themselves from the probe. When the probe is located at the point of highest efficiency, the E lines set up an E field of considerable intensity



Probe Position

The most efficient place to locate the probe is in the center of the "a" wall, parallel to the "b" wall, and one quarter-wavelength from the shorted end of the waveguide, keeping in mind the frequency



This is the point at which the E field is maximum in the dominant mode. Therefore, energy transfer (coupling) is maximum at this point.

Effects of Size and Position of Probe

In many applications a lesser degree of energy transfer, called loose coupling, is desirable. The amount of energy transfer can be reduced by **decreasing the length of the probe**, by **moving it out of the center of the E field**, or **by shielding it**.

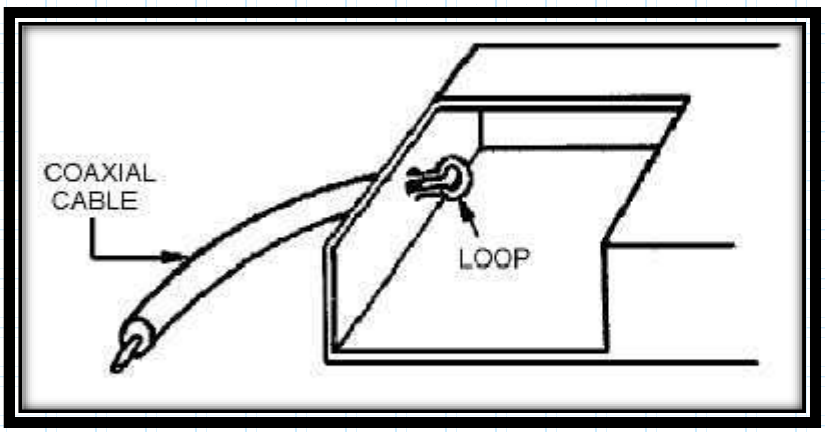
The size and shape of the probe determines its frequency, bandwidth, and power-handling capability. **As the diameter of a probe increases, the bandwidth increases**.

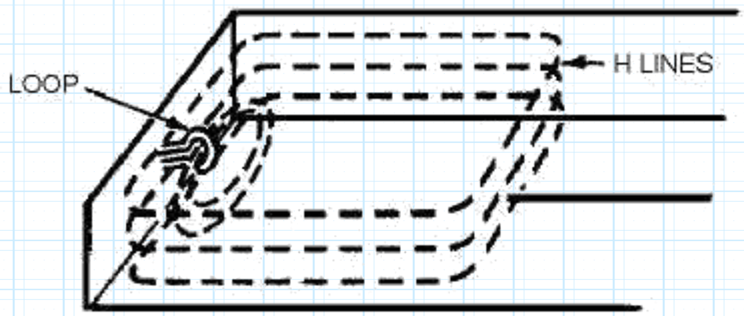
The greater power-handling capability is directly related to the increased surface area.

By Loop- Setting up H Field

Another way of injecting energy into a waveguide is by setting up an H field in the waveguide. This can be accomplished by inserting a small loop which carries a high current into the waveguide. A magnetic field builds up around the loop and expands to fit the waveguide

If the frequency of the current in the loop is within the bandwidth of the waveguide, energy will be transferred to the waveguide. For the most efficient coupling to the waveguide, the loop is inserted at one of several points where the magnetic field will be of greatest strength.





Slot Coupling :

Slots or apertures are sometimes used when very loose (inefficient) coupling is desired, . In this method energy enters through a small slot in the waveguide and the E field expands into the waveguide. The E lines expand first across the slot and then across the interior of the waveguide. Minimum reflections occur when energy is injected or removed if the size of the slot is properly proportioned to the frequency of the energy.