UNIT III

Waveguide Components

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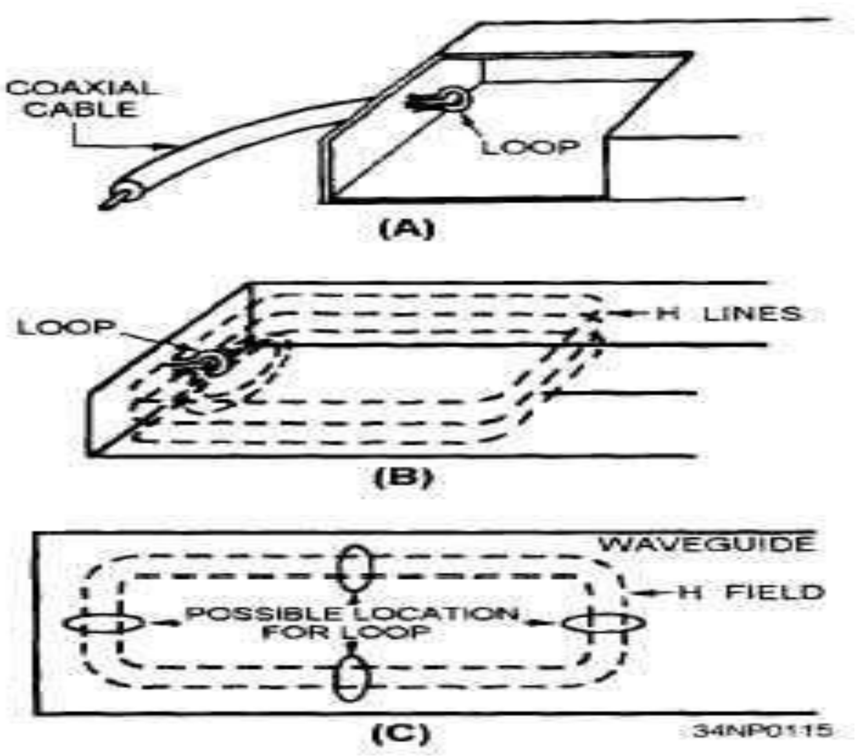
UNIT-III

Waveguide Components

Waveguide Components: Coupling Mechanisms – Probe, Loop, Aperture types. Waveguide Discontinuities – Waveguide Windows, Tuning Screws and Posts, Matched Loads. Waveguide Attenuators – Different Types, Resistive Card and Rotary Vane Attenuators; Waveguide Phase Shifters Types, Dielectric and Rotary Vane Phase Shifters, Waveguide Multiport Junctions - E plane and H plane Tees. Ferrites– Composition and Characteristics, Faraday Rotation, Ferrite Components – Gyrator, Isolator,

COUPLING MECHANISMS

- LOOP COUPLING



COUPLING MECHANISMS

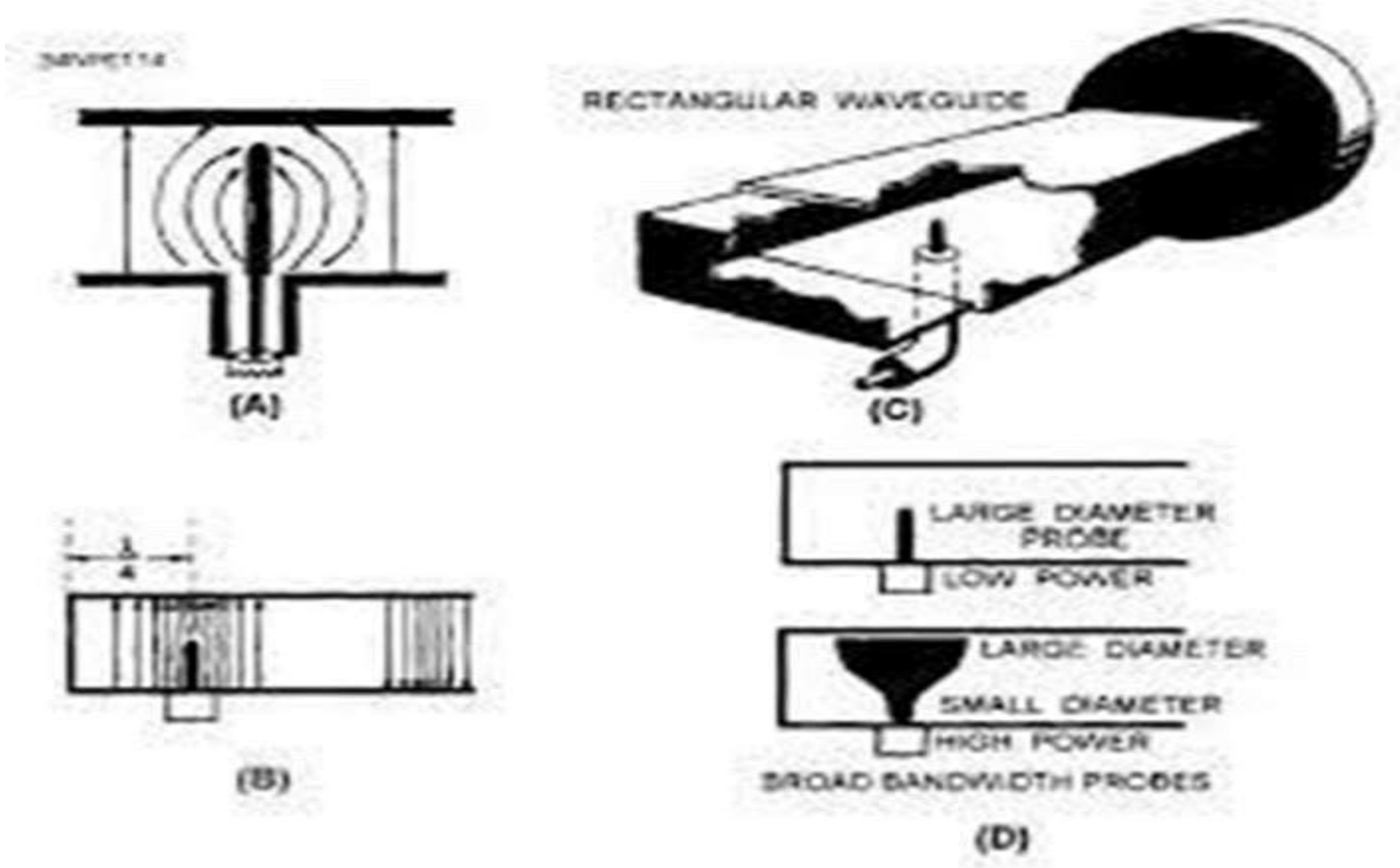
- For the most efficient coupling to the waveguide, the loop is inserted at

One of several points where the magnetic field will be of greatest strength.

- When less efficient Coupling is desired you can rotate or move the loop until it encircles a smaller number of H lines.When the diameter of the loop is r incresead, its power –handling capability also increases.

The bandwidth can be increased by increasing the size of the wire used to make the loop

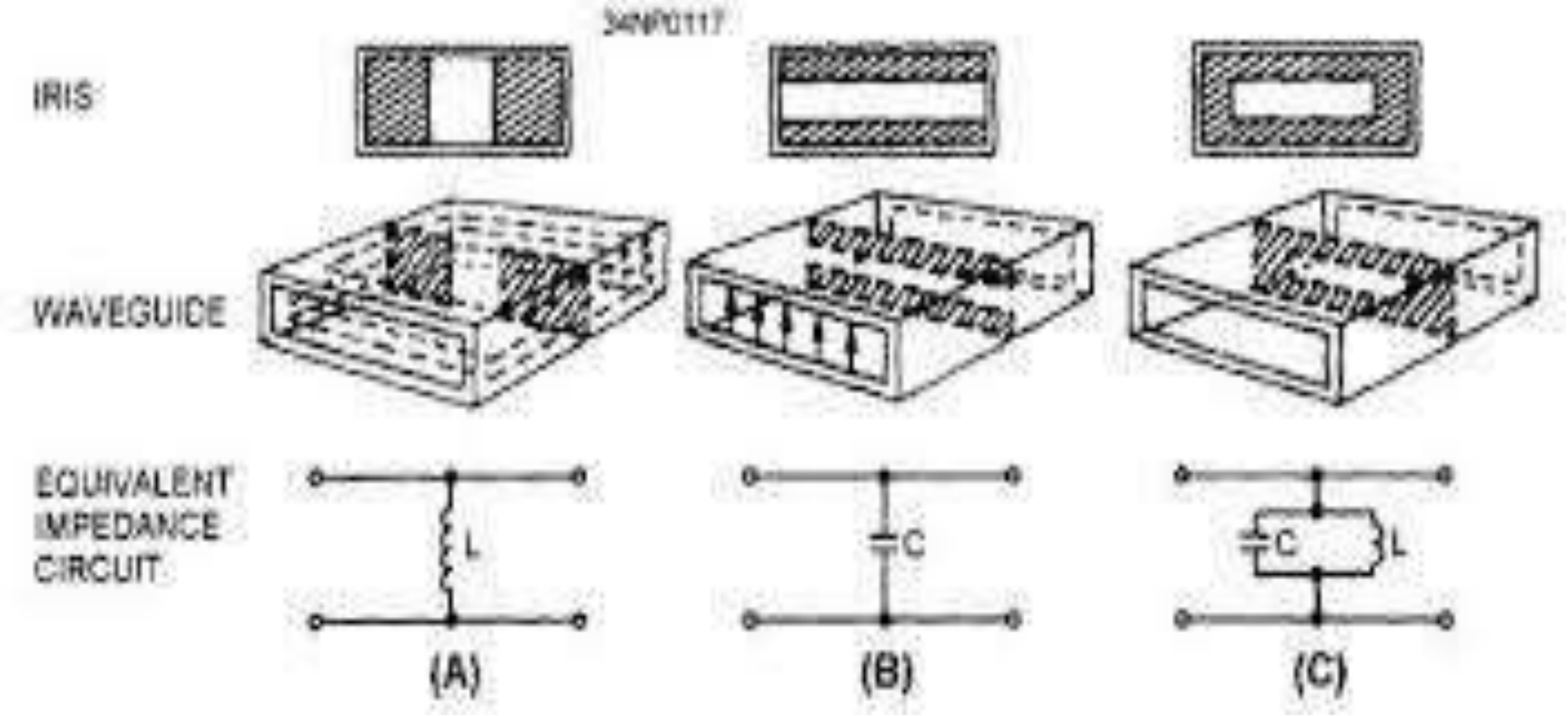
PROBE COUPLING



WAVEGUIDE DISCONTINUITIES

- An iris is a thin metal plate across the waveguide with one or more holes in it. It is used to couple together two lengths of waveguide and is a means of introducing a discontinuity. Some of the possible geometries of irises are shown in figure
- An iris which reduces the width of a rectangular waveguide has an equivalent circuit of a shunt inductance, whereas one which restricts the height is equivalent to a shunt capacitance.
- An iris which restricts both directions is equivalent to a parallel LC resonant circuit A series LC circuit can be formed by spacing the conducting portion of the iris away from the walls of the waveguide.
- Narrowband filters frequently use irises with small holes. These are always inductive regardless of the shape of the hole or its position on the iris. Circular holes are simple to machine, but elongated holes, or holes in the shape of a cross, are advantageous in allowing the selection of a particular mode of coupling.

WAVEGUIDE DISCONTINUITIES



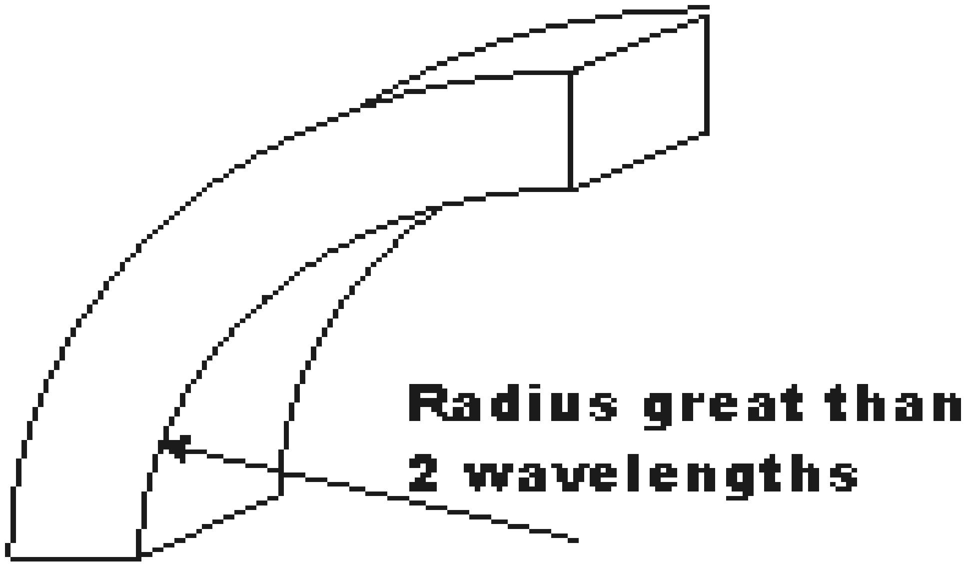
TUNING SCREWS AND POSTS

- Tuning screws and posts
- Tuning screws are screws inserted into resonant cavities which can be adjusted externally to the waveguide. They provide fine tuning of the resonant frequency by inserting more, or less thread into the waveguide
- For screws inserted only a small distance, the equivalent circuit is a shunt capacitor.
- Increasing in value as the screw is inserted. However, when the screw has been inserted a distance $\lambda/4$ it resonates equivalent to a series LC circuit.
- it further it causes the impedance to change from capacitive to inductive, that is, the arithmetic sign changes

WAVEGUIDE BENDS

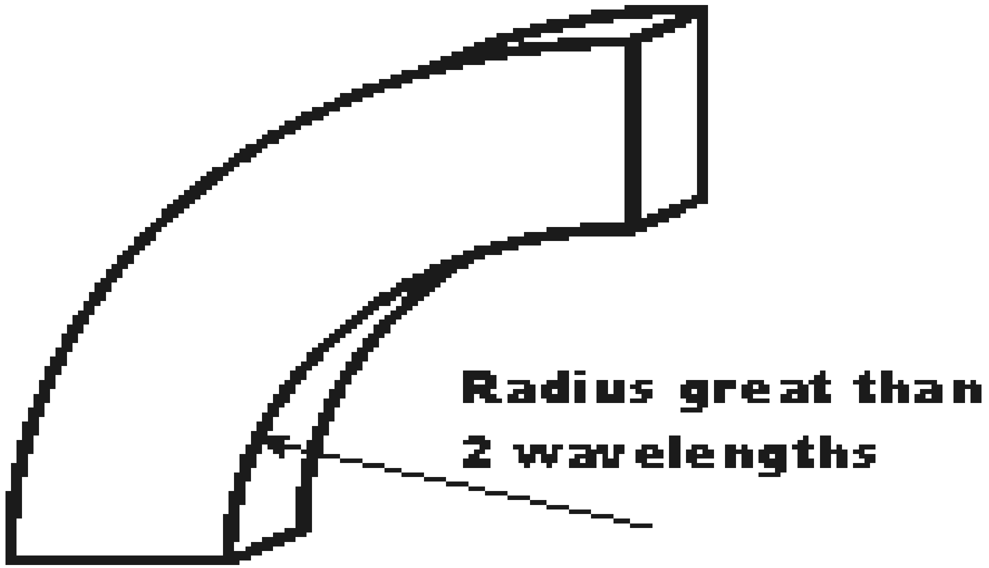
- Types of waveguide bend
- There are several ways in which waveguide bends can be accomplished.
- They may be used according to the applications and the requirements.
- Waveguide E bend
- Waveguide H bend
- Waveguide sharp E bend
- Waveguide sharp H bend
- WAVEGUIDE E BEND
- This form of waveguide bend is called an E bend because it distorts or changes the electric field to enable the waveguide to be bent in the required direction.

WAVEGUIDE BENDS



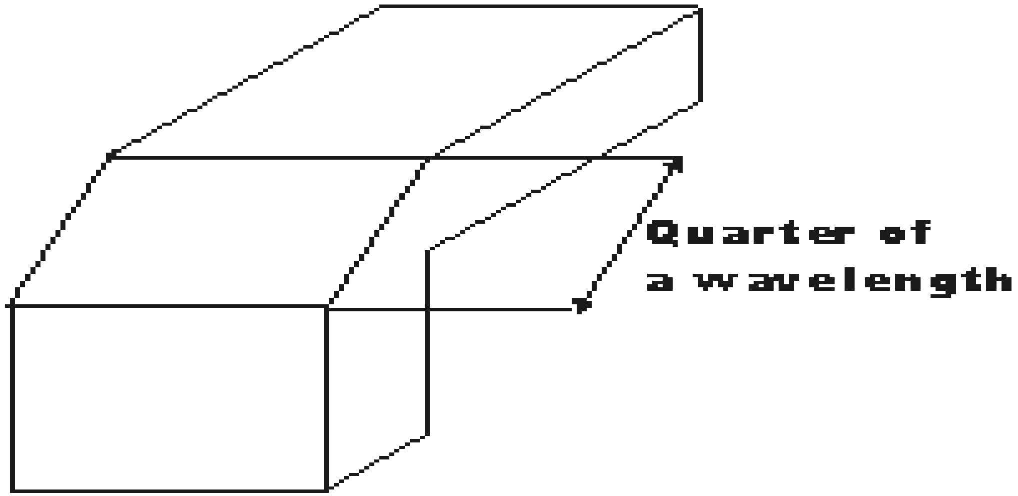
WAVEGUIDE H BENDS

- This form of waveguide bend is very similar to the E bend, except that it distorts the H or magnetic field. It creates the bend around the thinner side of the waveguide.



WAVEGUIDE SHAPE E BEND

- In some circumstances a much shorter or sharper bend may be required. This can be accomplished in a slightly different manner. The techniques is to use a 45° bend in the waveguide. Effectively the signal is reflected, and using a 45° surface the reflections occur in such a way that the fields are left undisturbed, although the phase is inverted and in some applications this may need accounting for or correcting.



WAVEGUIDE ATTENUATORS

- A device, such as an interposed energy-absorbing plate, that is used for signal attenuation in a waveguide.
- There are two types
  - Fixed and variable attenuators

ROTARY VANE TYPES

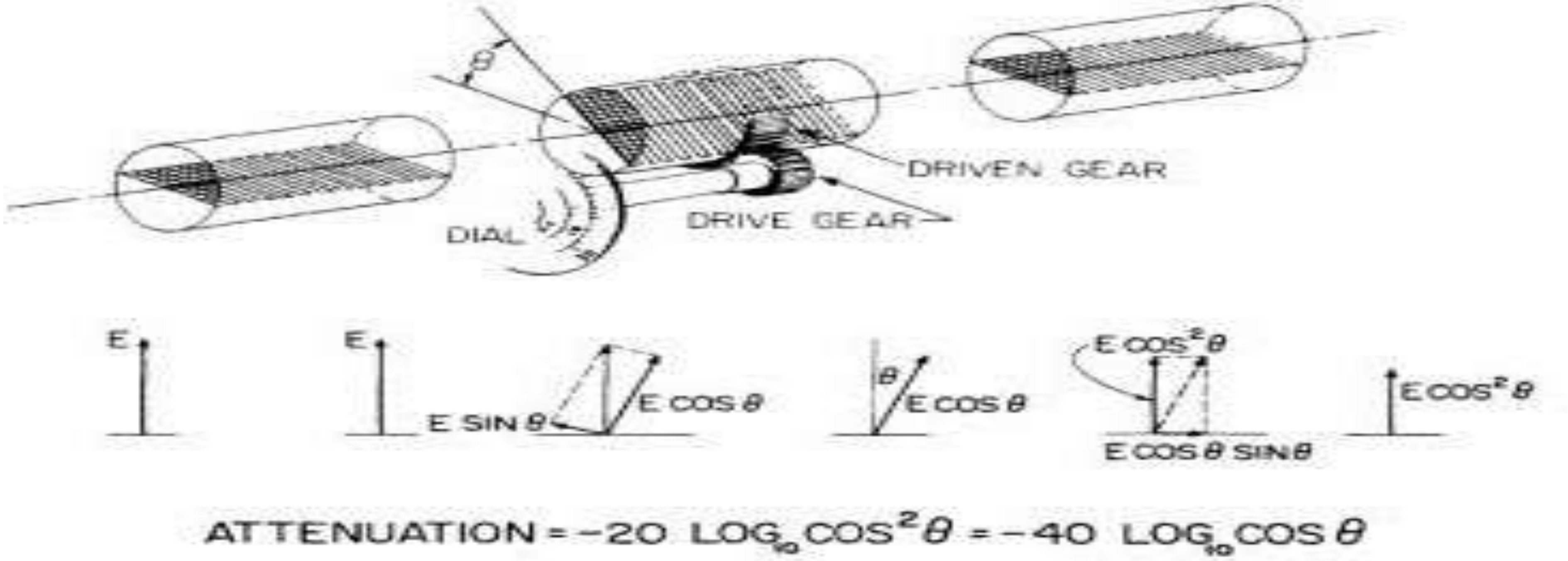


FIGURE 1. *Pictorial diagram of the rotary-vane attenuator.*

WAVEGUIDE PHASE SHIFTERS

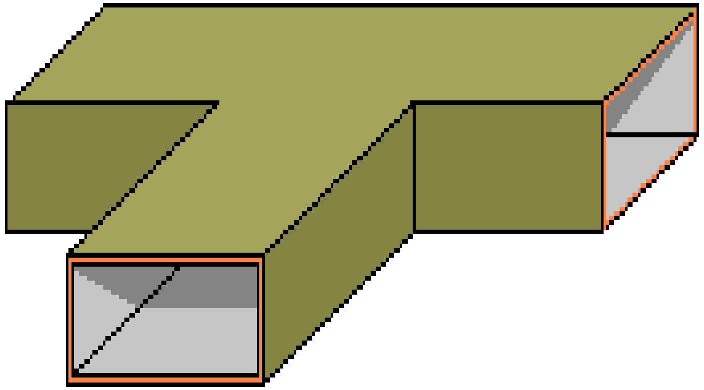
- There two types of phase shifters
  - Dielectric and Rotary Vane types

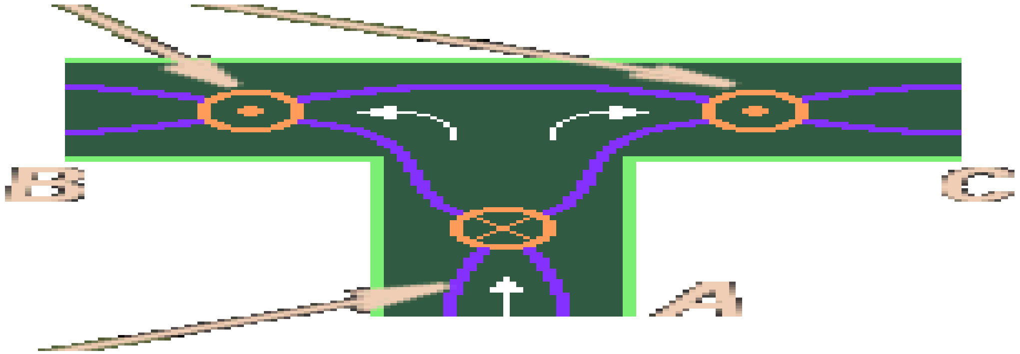
- Dielectric shifter is movable by means of a micrometer inside the waveguide**.** These Phase Shifters provides a phase-shift of around 180°.

WAVEGUIDE MULTIPORT JUNCTIONS

- Different types of junctions affect the energy in different ways. The "T–Junction" is the most simple of the commonly used waveguide junctions. T–junctions are divided into two basic types, the E–TYPE and the H–TYPE.
- H-TYPE T-JUNCTION

•An H-type T-junction is illustrated in the beside figure. It is called an H- type T-junction because the long axis of the "B" arm is parallel to the plane of the magnetic lines of force in the waveguide. The E-field is fed into arm A and in-phase outputs are obtained from the B and C arms. The reverse is also true.

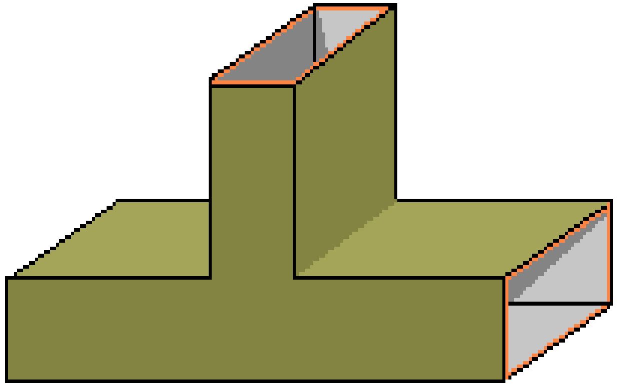


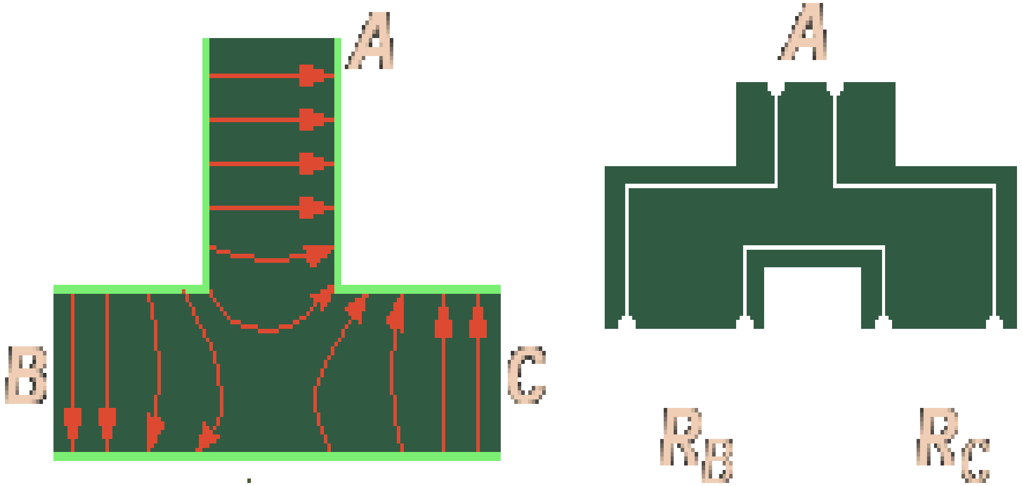

B
C
A


R_B
R_C

E TYPE T-JUNCTION

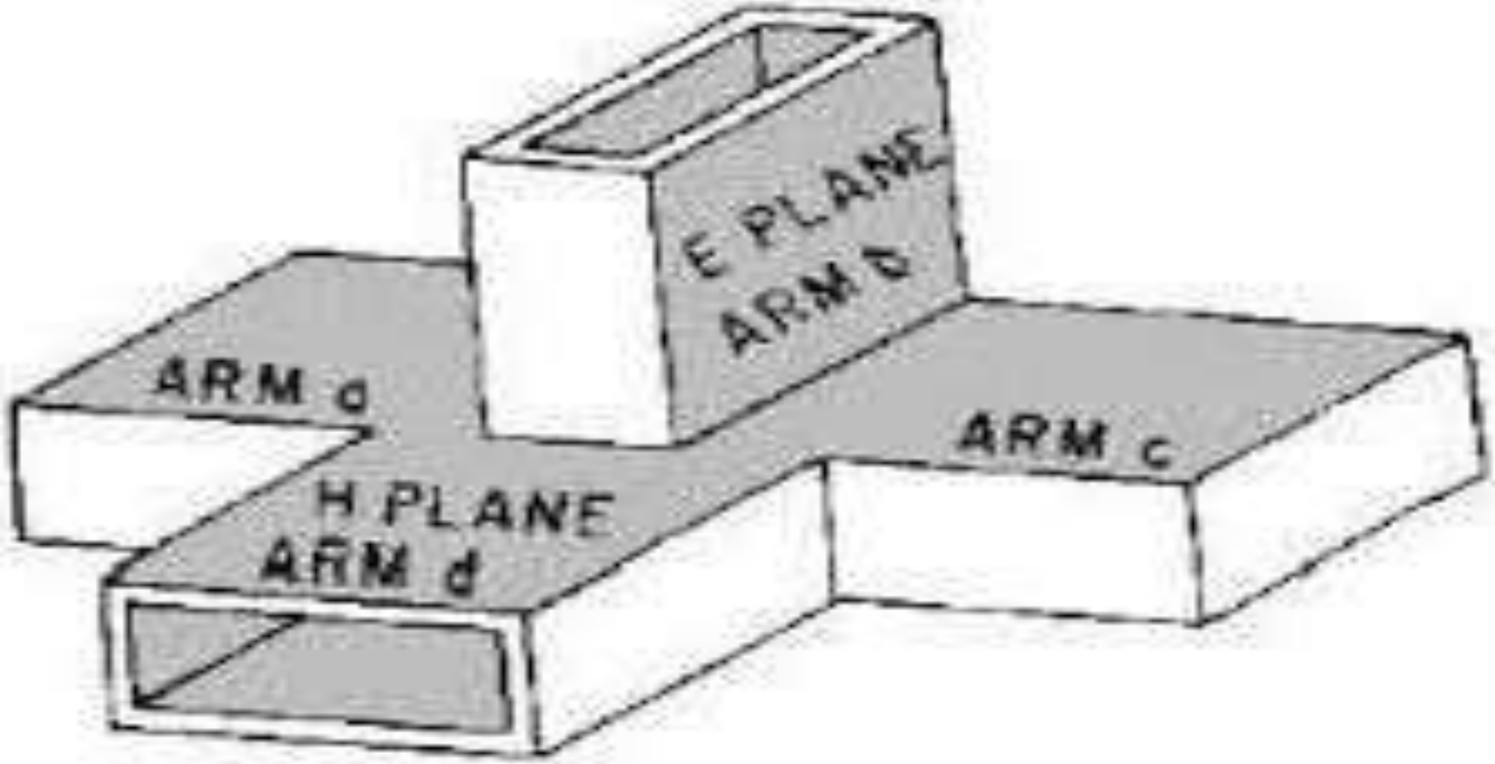
- This junction is called an E- type T junction because the junction arm extends from the main waveguide in the same direction as the E-field in the waveguide. The outputs will be 180° out of phase with each other.





MAGIC T-HYBRID JUNCTION

- A simplified version of the magic-T-hybrid junction is shown in the figure. The magic-T junction can be described as a dual electromagnetic plane type of T-junction. It is a combination of the H-type and E-type T.junction therefore. The most common applications of this type of junction are for example as the mixer section for microwave radar receivers or as a part of a measurement system.
- If a signal is fed into the E-plane arm of the magic-T, it will divide into two out-of-phase components (arm B and C). The signal entering the E-arm will not enter the H-plane arm because of the zero potential existing at the entrance of the H-plane arm. The potential must be zero at this point to satisfy the boundary conditions of the E-plane arm.
- Normally a magic-T needs an impedance matching (shown in the figure as matching screws).


E PLANE
ARM b
ARM a
ARM c
H PLANE
ARM d

FERRITES

Ferrites are used in digital computers and data processing circuits. Ferrites are used to produce low frequency ultra sonic waves by magnetostriction principle.

Ferrites are widely used in non-reciprocal microwave devices. Examples for non-reciprocal microwave devices are Gyrator, Isolator and Circulator.

Ferrites are also used in power limiting and harmonic gyration devices.

Ferrites can also be used in the design of ferromagnetic amplifiers of microwave signals.

FERRITES

Ferrite core can be used as a bitable element.

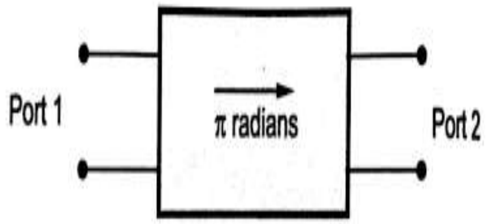
The rectangular shape ferrite cores can be used as a magnetic shift register.

Hard ferrites are used to make permanent magnets.

The permanent magnets (hard ferrites) are used in instruments like galvanometers, ammeter, voltmeter, flex meters, speedometers, wattmeter, compasses and recorders.

GYRATOR

Gyrator is two port device that has the relative phase difference of 180º for transmission from port 1 to port 2 and “no phase shift” for transmission from port 2 to port 1.



Construction:

It consists of a piece of circular waveguide carrying the dominant TE_{11} mode with transitions to a standard rectangular waveguide with dominant mode TE_{10} at both ends.

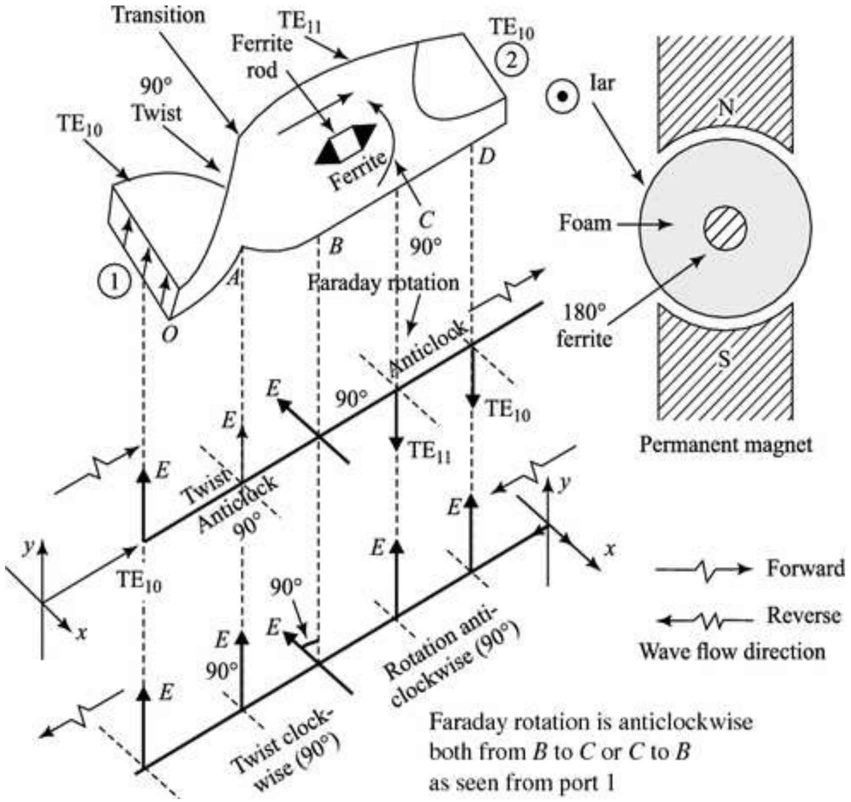
A thin circular ferrite rod tapered at both ends is located inside the circular waveguide supported by a polyfoam.

The waveguide is surrounded by a permanent magnet which generates dc magnetic field for proper operation of ferrite.

To the input end a 90º twisted rectangular waveguide is connected.

GYRATOR

- The ferrite rod is tapered at both ends to reduce the attenuation and also for smooth rotation of polarized wave.



GYRATOR

Operation

- When a wave enters port 1 its plane of polarization rotates by 90º because of the twist in the waveguide.
- It again undergoes faraday rotation through 90º because of the ferrite rod and the wave which comes out of port 2 will have a phase shift of 180º compared to the wave entering at port 1.
- When the same wave enters at port 2, it undergoes faraday rotation through 90º in the same direction.
- Because of the twist this wave gets rotated back by 90º comes out of port 1 with 0º phase shift.

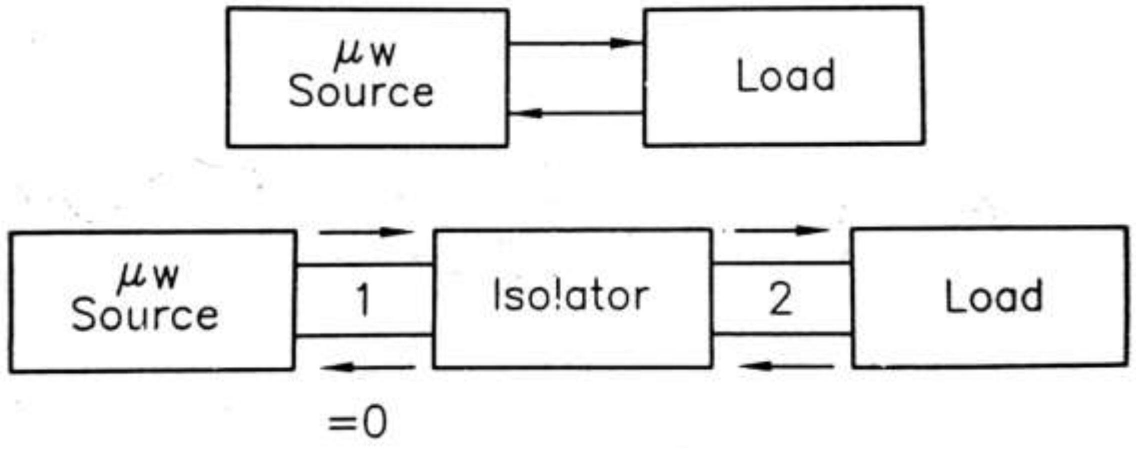
ISOLATOR

- An isolator is a 2-port device which provides a very small amount of attenuation for transmission from port 1 to port 2 but provides maximum attenuation for transmission from port 2 to port 1.
- This requirement is very much desirable when we want to match a source with a variable load.
- In most microwave generators, the output amplitude and frequency tend to fluctuate very significantly with changes in load impedance.
- Due to mismatch of generator output to the load resulting in reflected wave from load.
- These reflection will cause amplitude and frequency instabilities of the microwave generator.

ISOLATOR

- When the isolator is inserted between generator and load, the generator is coupled to the load with zero attenuation and if any reflection from the load are completely absorbed by the isolator without affecting the generator output.

ISOLATOR



ISOLATOR

Construction

- Isolator makes use of 45º twisted rectangular waveguide and 45º faraday rotation ferrite rod.
- A resistive card is placed along the larger dimension of the rectangular waveguide, so as to absorb any wave whose plane of polarization is parallel to the plane of resistive card.
- The resistive card doe not absorb any wave whose plane of polarization is perpendicular to the plane of its own.

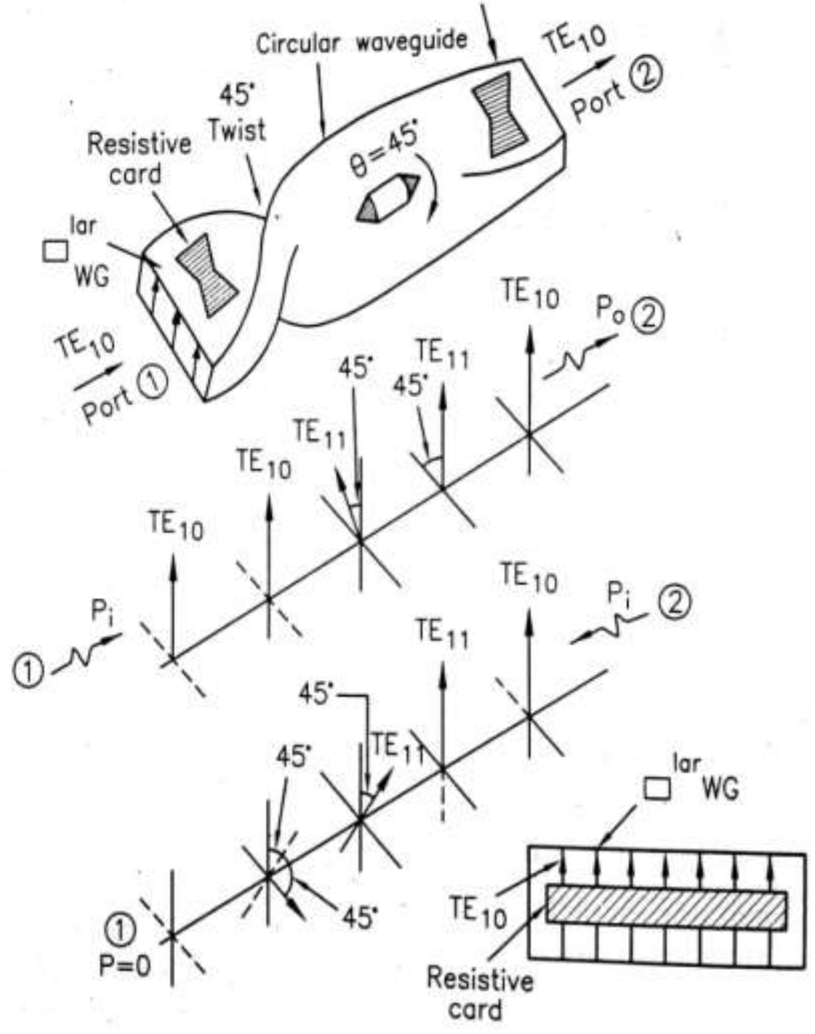
ISOLATOR

Operation

A TE_{10} wave passing from port 1 through the resistive card and is not attenuated.

After coming out of the card, the wave gets shifted by 45º because of the twist in anticlockwise direction and then by another 45º in clockwise direction because of the ferrite rod and hence coming out of port 2 with the same polarization as at port 1 without any attenuation.

But a TE_{10} wave fed from port 2 gets a pass from the resistive card placed near at port 2 because plane of polarization of the wave is perpendicular to the plane of the resistive card



ISOLATOR

- Then the wave gets rotated by 45º in clockwise direction due to ferrite rod and rotated by another 45º due to the twist in the waveguide.
- Now the plane of polarization of the wave is parallel with the plane of resistive card and hence the wave will be completely absorbed by the resistive card and the output at port 1 will be zero.
- This power is dissipated in the card as a heat.
- In practice 20 to 30 dB isolation is obtained for transmission from port 2 to port 1.