SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

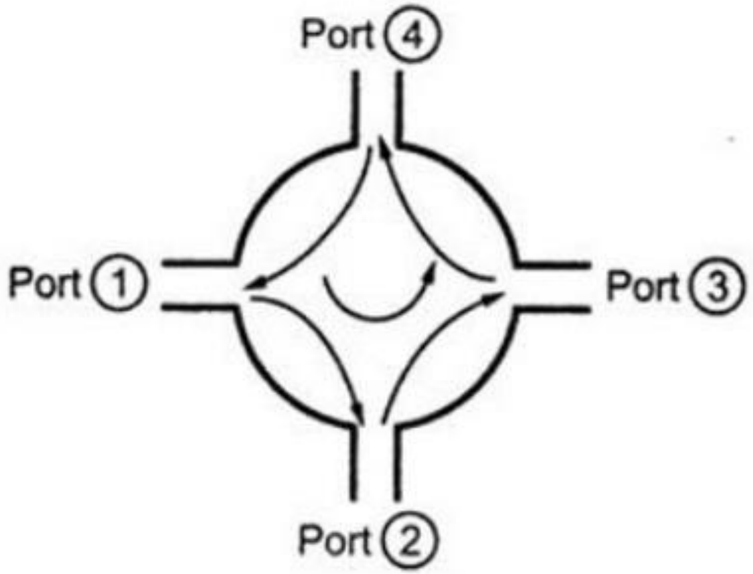
OPTICAL AND MICROWAVE ENGINEERING

III YEAR/ VI SEMESTER

UNIT 1 – MICROWAVE PASSIVE DEVICES

TOPIC– Circulator and Isolator

Microwave circulators



4-port Circulator Symbol

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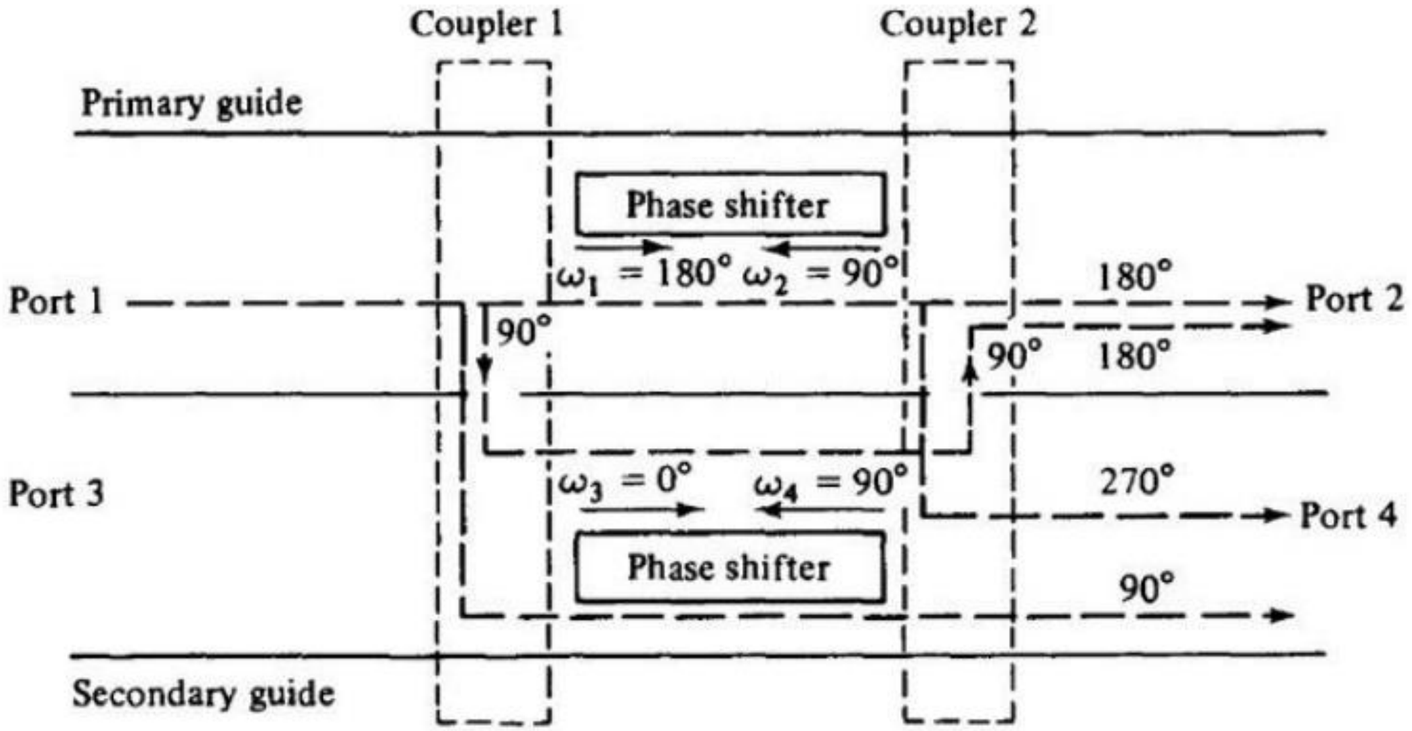
- Circulator is a combination of 2 3dB couplers and a rectangular waveguide with 2 non-reciprocal phase shifters.
- Each of the two 3dB couplers in the circulator introduce phase shift 90 degree.
- Consider a wave incident on port 1. This wave is split into two waves by first 3dB coupler.
- This wave (in upper guide) shall reach port 2 within lower waveguide at port 4 with a phase 90 degree.
- The second coupler again splits the waves such that resultant waves go out of phase and hence cancel out in port 4, while they go in phase and hence add in port 2.
- A similar analysis may be carried out to show that ports coupled as 1-2-3-4-1 and not in the reverse direction.

Microwave circulators



Four-port Circulator Schematic

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A perfectly matched, lossless, and nonreciprocal four-port circulator has an **S** matrix of the form

$$\mathbf{S} = \begin{bmatrix} 0 & S_{12} & S_{13} & S_{14} \\ S_{21} & 0 & S_{23} & S_{24} \\ S_{31} & S_{32} & 0 & S_{34} \\ S_{41} & S_{42} & S_{43} & 0 \end{bmatrix}$$

Using the properties of S parameters as described previously, the **S** matrix in Eq.

$$\mathbf{S} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

- Performance of microwave circulator is limited by finite isolation and non-zero insertion loss.

Typical Characteristics:

Insertion loss < 1 dB

Isolation ~= 30 – 40 dB

VSWR < 1.5

Applications:

- Used as Duplexer for a RADAR Antenna system.
- 3 port circulators are used in tunnel diode or parametric Amplifiers
- Low power devices.

Microwave Isolators

- An *isolator* is a nonreciprocal transmission device that is used to isolate one component from reflections of other components in the transmission line.
- An ideal isolator completely absorbs the power for propagation in one direction and provides lossless transmission in the opposite direction.
- Thus the isolator is usually called *uniline*.
- Isolators are generally used to improve the frequency stability of microwave generators, such as klystrons and magnetrons, in which the reflection from the load affects the generating frequency.

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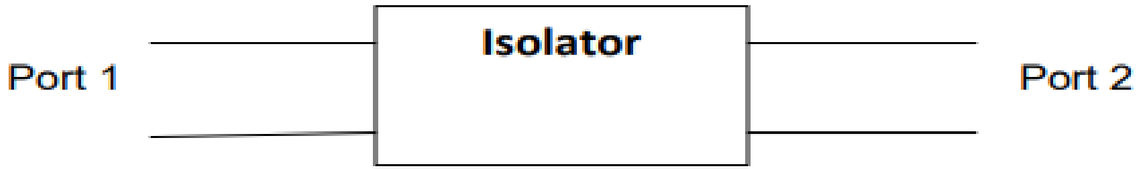
Isolator

Isolator is a two port non-reciprocal lossy device having unidirectional transmission characteristics.



The important aspects of this passive device are

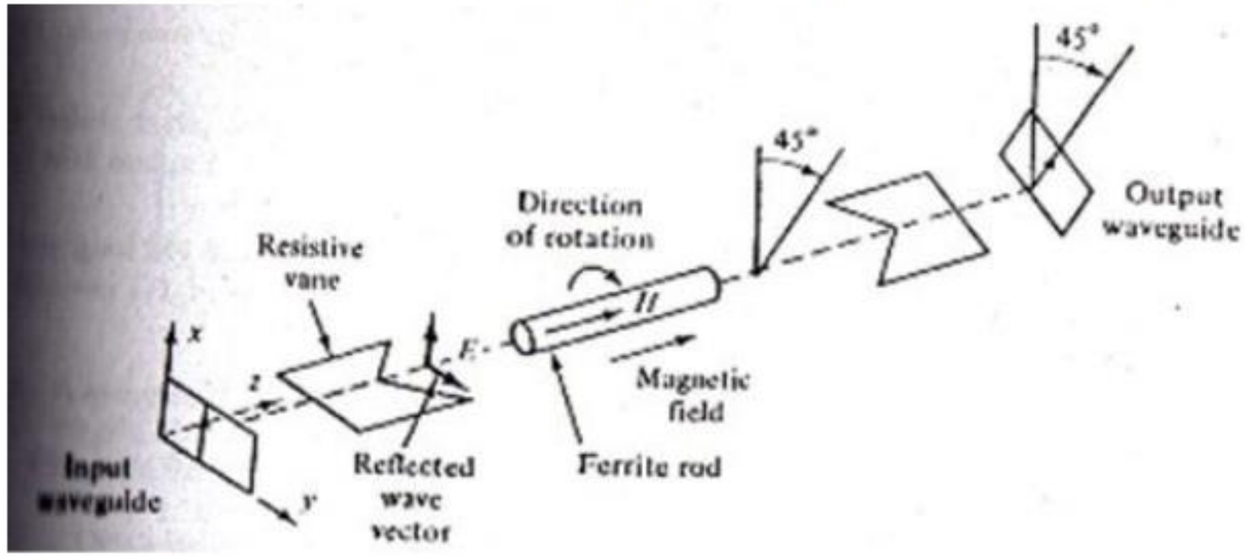
1. When the wave propages from port 1 to port 2 there is no attenuation.
2. When the wave propages from port 1 to port 1 the attenuation is infinity.

The scattering matrix of isolator is

$$[S] = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$$

Working Principle

- The input resistive card is in the y-z plane, and output resistive card is displaced 45 degree with respect to the input card.
- The DC magnetic field, which is applied longitudinally to the ferrite rod, rotates the wave plane of polarization by 45 degree.



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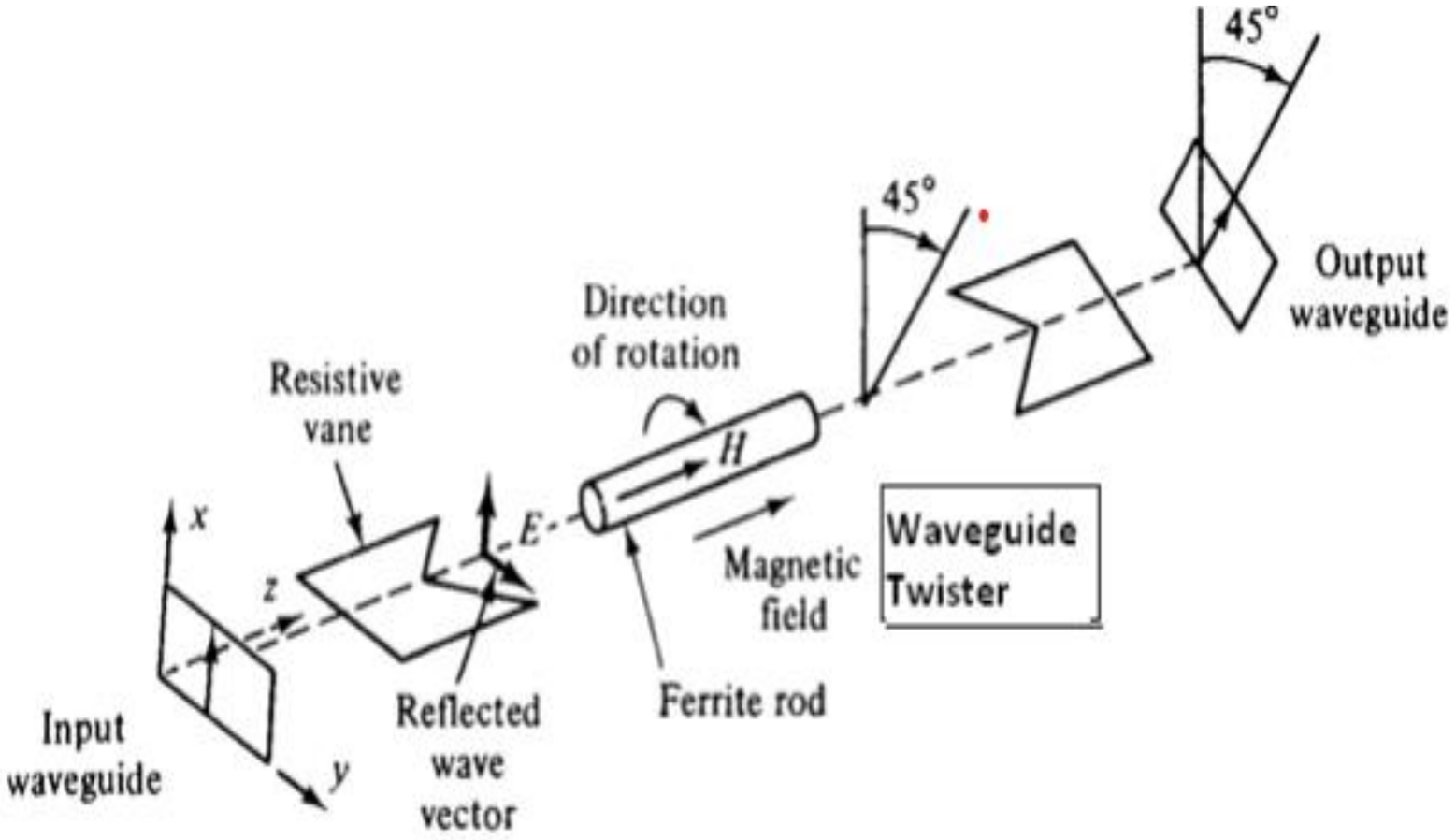
45°
45°
Output
waveguide
Direction
of rotation
Resistive
vane
H
E
x
z
y
Magnetic
field
Waveguide
Twister
Input
waveguide
Reflected
wave
vector
Ferrite rod

Faraday Rotation

A linearly polarized wave when propagates through the ferrite in the direction of bias, the polarization undergoes rotation proportional to the length of the ferrite. This phenomenon is called Faraday rotation. Faraday rotation is a non-reciprocal effect.

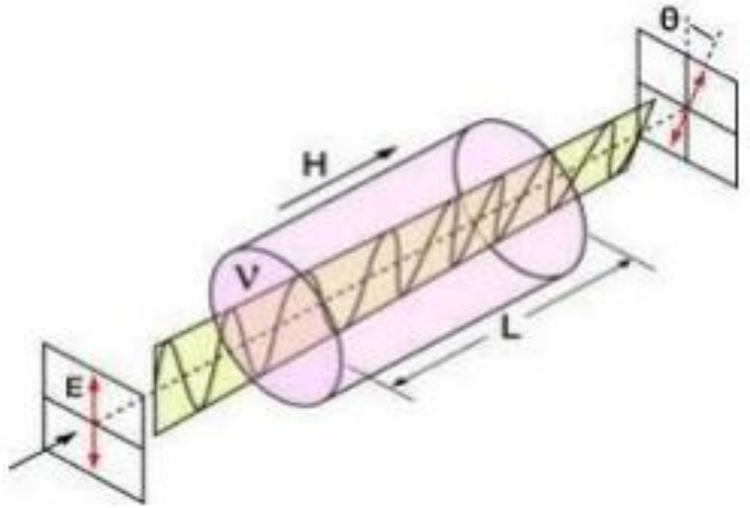

Fig 4.1: Faraday rotation

- The input card is in y-z plane¸ the dominant mode wave wherin the E-field vector is vertical travelling from left to right passes through resisitive vane with out attenduation and enters the ferrite rod where it undergoes faraday rotation of 450 clockwise.
- The wave again undergoes a rotation 450 in the anti-clockwise direction due to twisted waveguide and E-field vector at the output is vertical.
- The horizontal resistive vane has no effect on the E-field as the same is vertical to its plane.
- Therefore the wave travelling from left to right pass though without any attenuation.

- Where as the dominant mode wave entering from right and travelling to left undergoes a rotation 450 in the anti-clockwise direction due to the twisted waveguide.
- As it passes though the ferrite rod it again undergoes a rotation 450 in the anticlockwise direction and E-field vector becomes horizontal.
- The resistive vane at the output which is in the horiaontal plane obosbes the enegy as E-filed vecor is parallel to it. Therefore there is no output

Applications:

Used to improve the frequency stability of microwave generators, Klystrons and magnetrons.

THANK YOU