SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

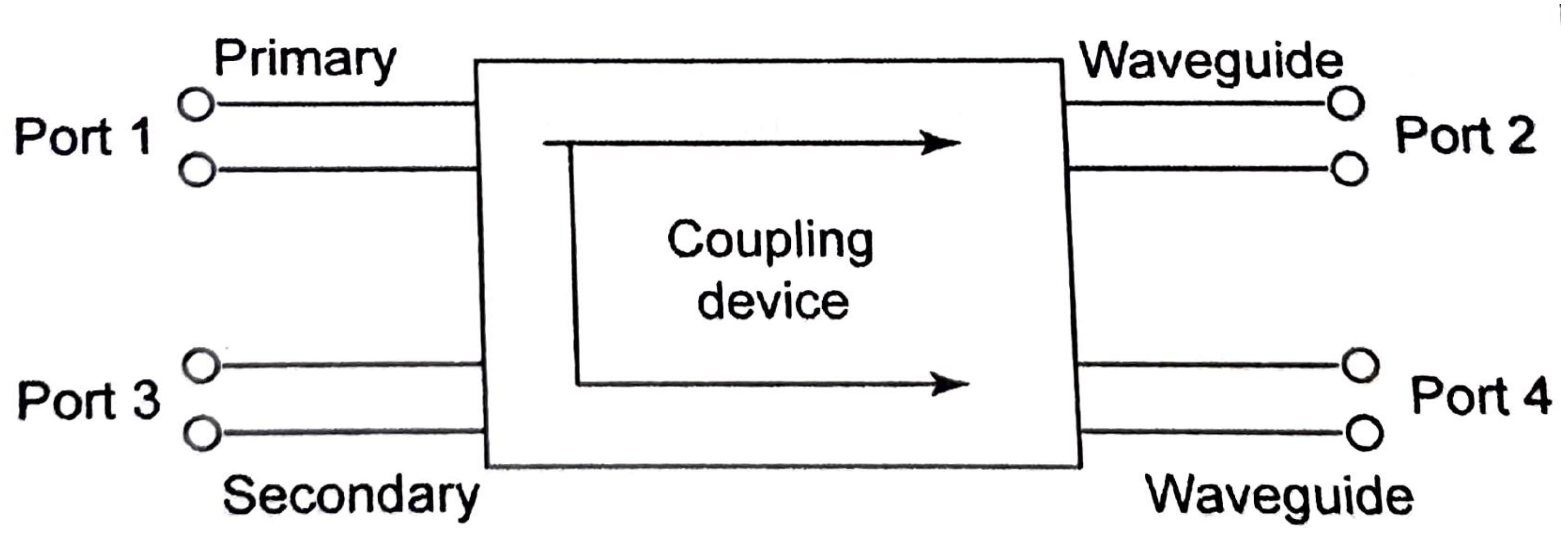
19ECB311 – OPTICAL AND MICROWAVE ENGINEERING

III YEAR/ VI SEMESTER

TOPIC– DIRECTIONAL COUPLERS

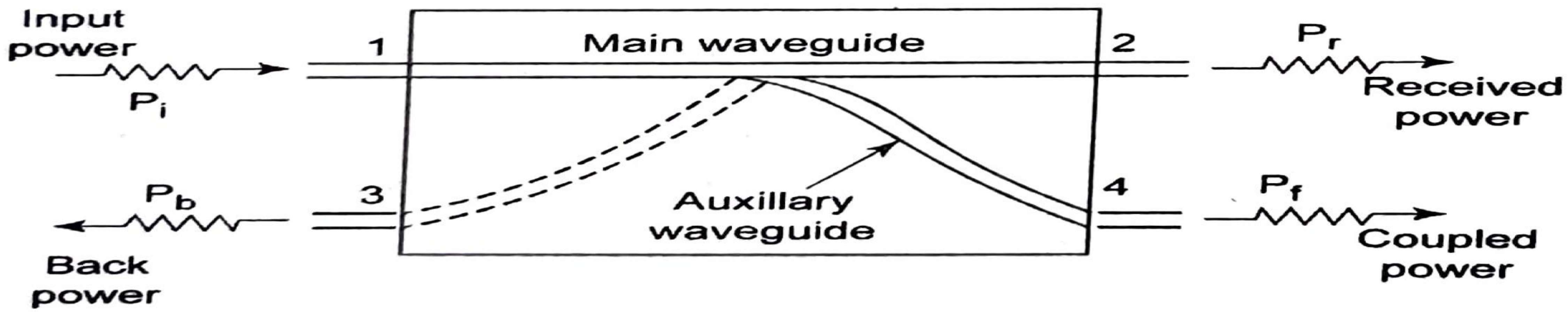
Directional coupler

- A directional coupler is a four port passive device commonly used for coupling a known fraction of the microwave power to a port (coupled port) in the auxiliary line while flowing from input port to an output port in the main line.
- The remaining port is ideally isolated port and matched terminated.
- They can be designed to measure incident and/or reflected power, SWR



Properties of a directional coupler

- With matched terminations at all its ports, the properties of an ideal directional coupler can be summarized as follows:
- A portion of power travelling from port 1 to port 2 is coupled to port 4 but not to port 3.
- A portion of power travelling from port 2 to port 1 is coupled to port 3 but not to port 4.



Performance of a directional coupler

- COUPLING FACTOR (C)
- DIRECTIVITY (D)
- ISOLATION (I)

- Coupling factor: The coupling factor of a directional coupler is defined as the ratio of the incident power Pi to the forward power Pf measured in dB.

$$\text{Coupling factor (dB)} = 10 \log_{10} \frac{P_1}{P_4}$$

$$\boxed{C\ (\text{dB}) = 10 \log_{10} \frac{P_i}{P_f}}$$

Performance of a directional coupler

- Directivity (D): The directivity of a directional coupler is defined as the ratio of forward power Pf to the backward power Pb expressed in dB

$$\text{Directivity (dB)} = 10 \log_{10} \frac{P_4}{P_3}$$

$$\boxed{D\ (\text{dB}) = 10 \log_{10} \frac{P_f}{P_b}}$$

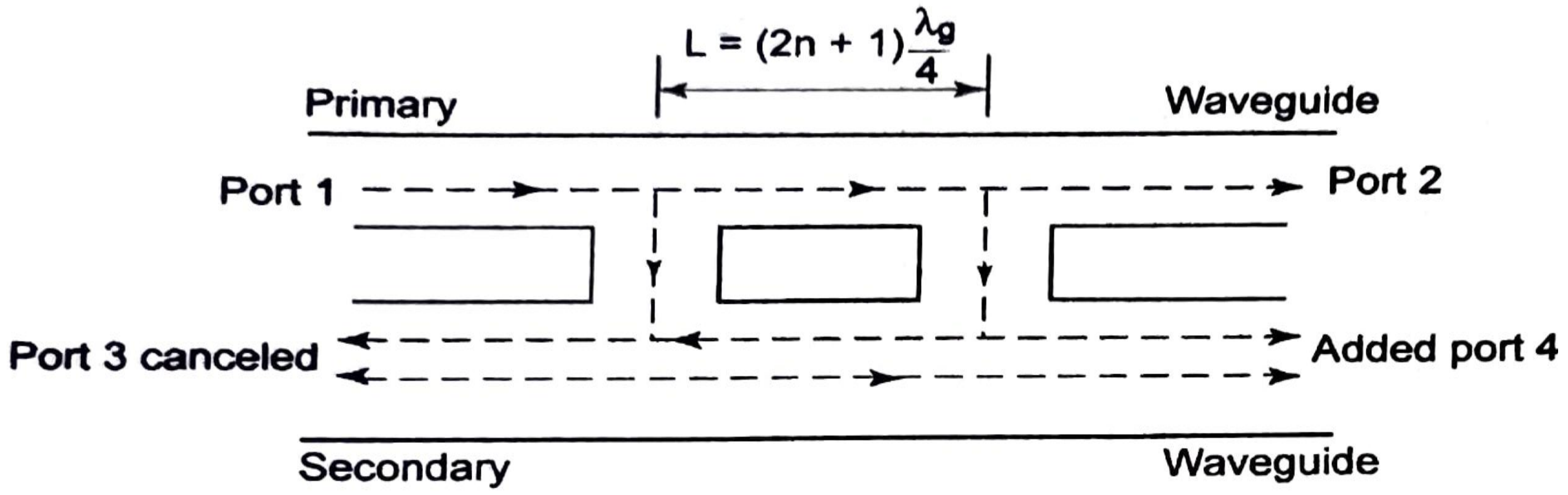
- Isolation is defined as the ratio of the incident power Pi to the back power Pb expressed in dB

$$\text{Isolation (dB)} = 10 \log_{10} \frac{P_1}{P_3}$$

$$\boxed{I\ (\text{dB}) = 10 \log_{10} \frac{P_i}{P_b}}$$

Two- hole Directional Couplers

- A two-hole directional coupler consists of two waveguides namely, the primary and the secondary with tiny holes in between them
- The two holes are at a distance of λg/4 where, λg is the guide wavelength.



Two- hole Directional Couplers

- Fraction of the wave energy entered into port 1 passes through the holes and is radiated into the secondary guide as the holes act as slot antennas.
- The forward waves in the secondary guide are in same phase, regardless of the hole space, and are added at port 4.
- The backward waves in the secondary guide are out of phase by 180° at the position of the 1^{st} hole and are cancelled at port 3.

SCATTERING MATRIX OF A DIRECTIONAL COUPLER

- Directional coupler is a four port network. Hence [S] is a 4 x4 matrix

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

$$S_{11} = S_{22} = S_{33} = S_{44} = 0$$

From symmetric property, $S_{ij} = S_{ji}$

$$\boxed{S_{12} = S_{21}, S_{23} = S_{32}, S_{13} = S_{31}, S_{24} = S_{42}, S_{34} = S_{43}, S_{41} = S_{14}}$$

SCATTERING MATRIX

- There is no coupling between port 1 and port 3.

$$S_{13} = S_{31} = 0$$

Also there is no coupling between port 2 and port 4.

$$S_{24} = S_{42} = 0$$

By substituting the values of scattering parameters as per equations

$$[S] = \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{12} & 0 & S_{23} & 0 \\ 0 & S_{23} & 0 & S_{34} \\ S_{14} & 0 & S_{34} & 0 \end{bmatrix}$$

SCATTERING MATRIX

- By applying an unity property of [S] matrix

$$\begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{12} & 0 & S_{23} & 0 \\ 0 & S_{23} & 0 & S_{34} \\ S_{14} & 0 & S_{34} & 0 \end{bmatrix} \begin{bmatrix} 0 & S_{12}^* & 0 & S_{14}^* \\ S_{12}^* & 0 & S_{23}^* & 0 \\ 0 & S_{23}^* & 0 & S_{34}^* \\ S_{14}^* & 0 & S_{34}^* & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

R_1C_1: $|S_{12}|^2 + |S_{14}|^2 = 1$

R_2C_2: $|S_{12}|^2 + |S_{23}|^2 = 1$

R_3C_3: $|S_{23}|^2 + |S_{34}|^2 = 1$

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

THANK YOU