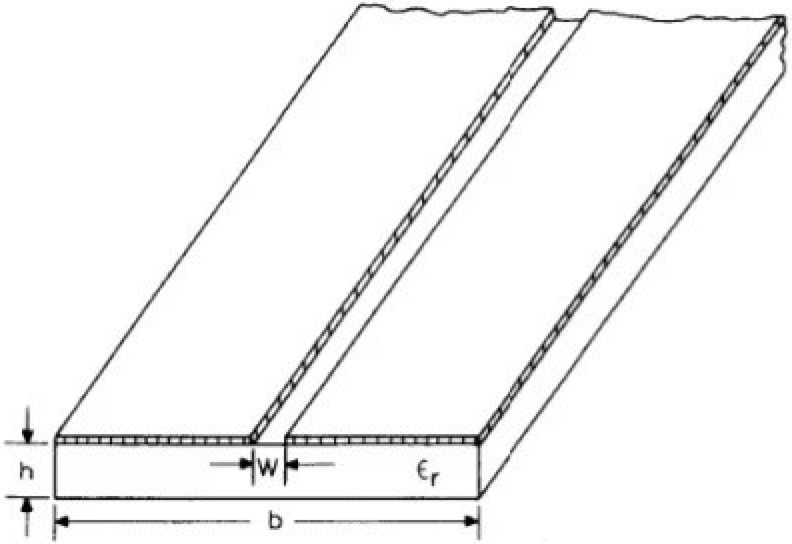
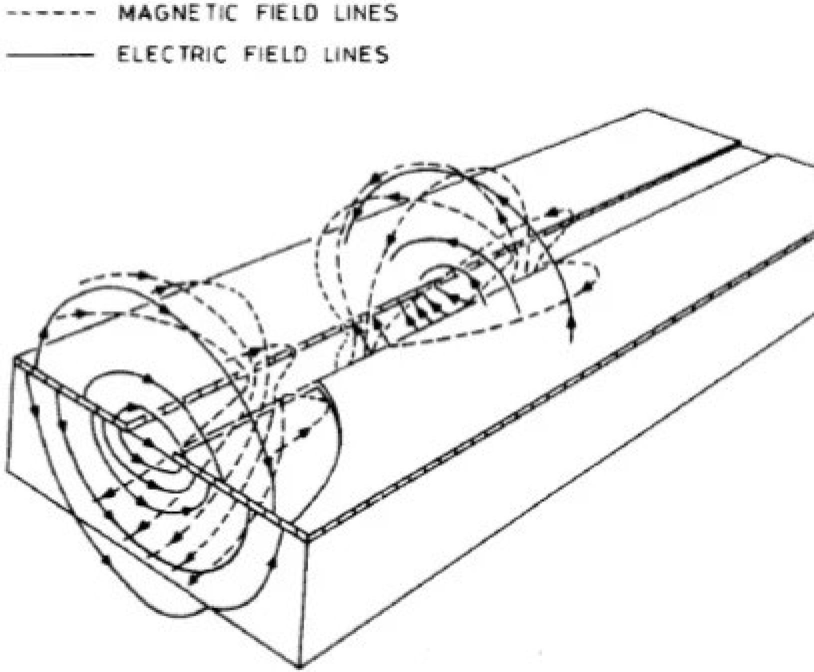
JGEC,ECE,8th Sem2022
Microwave Integrated Circuits
Basics of Slot Lines

Introduction

- Slot line is a planar transmission structure proposed for use in MICs by Cohn in 1968.
- It consists of a thin slot in the ground plane on one side of dielectric substrate.
- Slot line can be employed as a resonance and non-resonance antenna.
- As like in microstrip line, the two conductors of slot line lead to a quasi-TEM type of mode. The mode of propagation is non TEM and almost transverse electric in nature.
- The width of the slot controls the characteristic impedance of the line.

Slot line configuration





Slot line Analysis

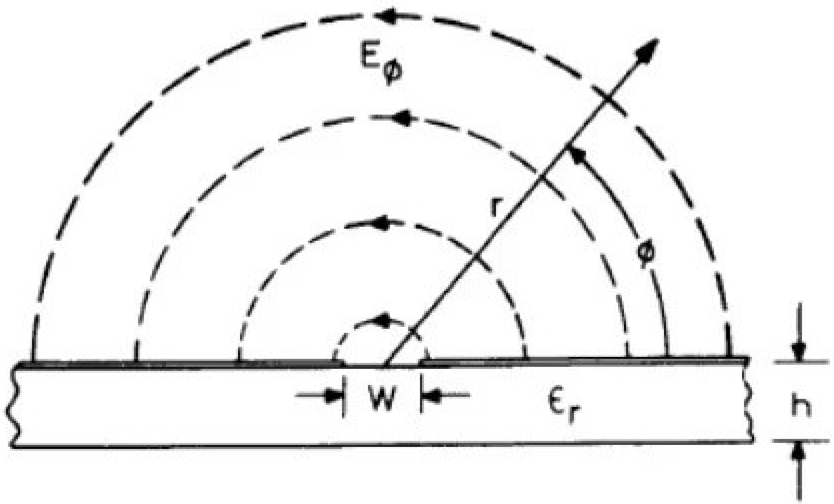
- The slot line is first analysed by Cohn.
- There are numbers of analytical techniques available for slot line:

1. Approximate Analysis
2. Transverse resonance approach
3. Galerkin’s method in Fourier transform domain
4. Finite difference time domain (FDTD) Technique

Approximate Analysis

- This technique has an advantage of mathematical simplicity, and provides better qualitative picture.
- An approximate analysis for the field distribution, polarization for magnetic field and expression for slot wavelength can be done.
- Slot line field contains three electric field and three magnetic field components. The longitudinal component of electric field is very weak since the energy propagates between the two conductors.

Approximate Analysis



$$H_x = AH_0^{(1)}(k_c r)$$

$$H_r = -\frac{\gamma_x}{k_c^2}\frac{\partial H_x}{\partial r} = \frac{A}{\sqrt{1-(\lambda_s/\lambda_0)^2}}H_1^{(1)}(k_c r)$$

$$E_\phi = \frac{j\omega\mu}{k_c^2}\frac{\partial H_x}{\partial r} = -\eta H_r \lambda_s/\lambda_0$$

$$k_c = j\frac{2\pi}{\lambda_0}\sqrt{\left(\frac{\lambda_0}{\lambda_s}\right)^2 - 1}$$

Approximate Analysis

- *Polarization of magnetic field:*

Polarization of magnetic field in a slot line can be obtained by the ratio

|Hx/Hr|

$$\left|\frac{H_x}{H_r}\right| = \left|\frac{H_0^{(1)}(k_c r)}{H_1^{(1)}(k_c r)}\right| \sqrt{1 - (\lambda_S/\lambda_0)^2}$$

Approximate Analysis

- *Slot wavelength:*

Slot line field components are not confined to the substrate alone. They extend to the air regions above the slotand below the substrate also. So, the energy is distributed between substrate and the air region.

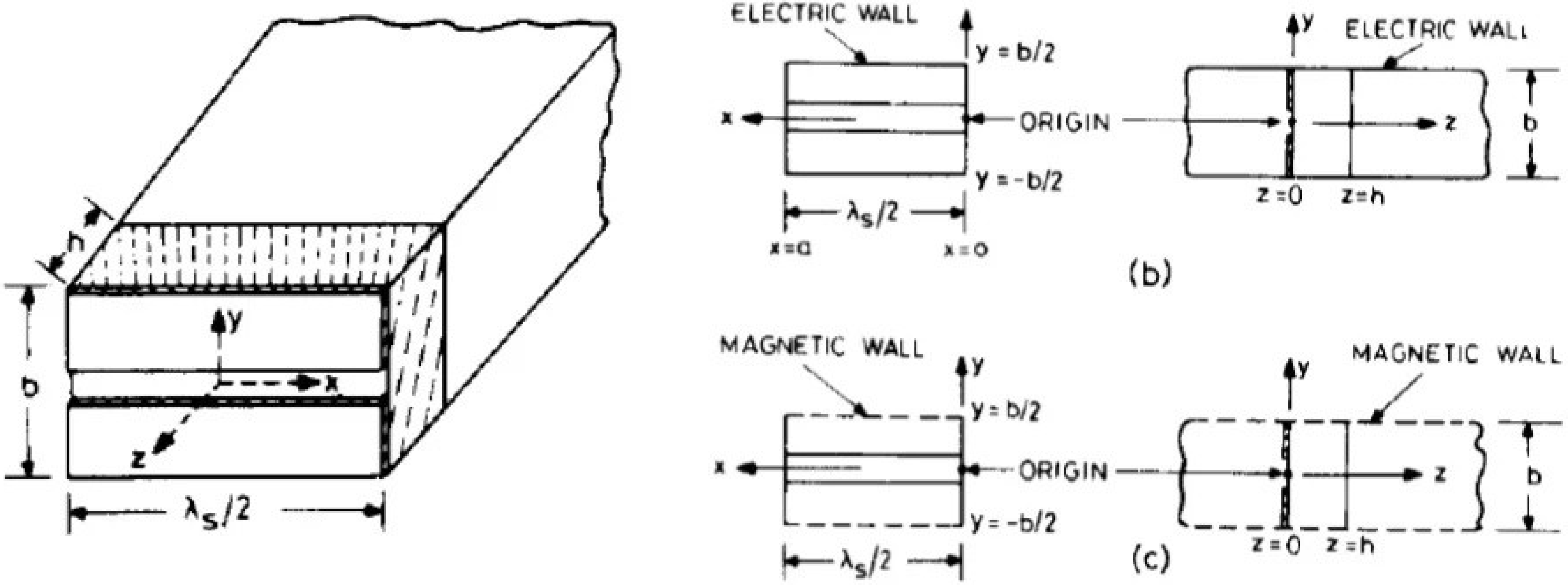
Effective dielectric constant of slot line can be given by -

$$\epsilon_{re} = \frac{\epsilon_r + 1}{2} \qquad \frac{\lambda_s}{\lambda_0} = \sqrt{\frac{2}{\epsilon_r + 1}}$$

Transverse resonance approach

- In this method, slot line is analysed as rectangular waveguide configuration.
- The key feature of this analysis is the introduction of boundary conditions of rectangular waveguide.
- It is then analysed in terms of waveguide modes propagating perpendicular to the slot line plane.

Transverse resonance approach



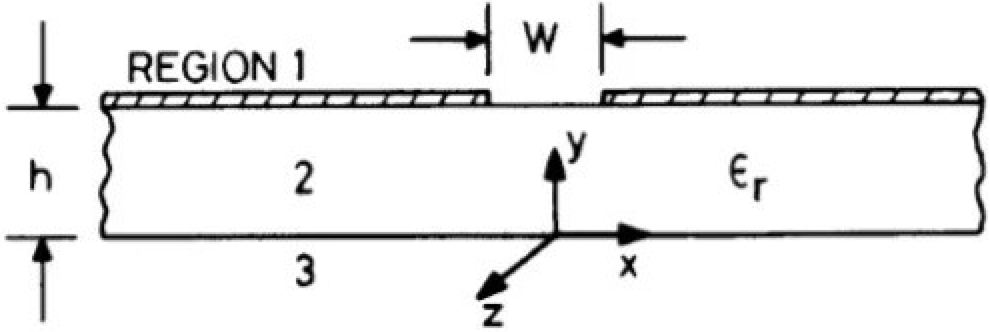
Galerkin's method in Fourier transform domain

- An accurate analysis of slotline is based on the use of Galerkin's method, in the fourier transform domain.
- This method is very popular and similar to those used for full wave analysis of microstrip lines and for analysis of microstrip discontinuities. Field components are:

$$E_z = k_c^2 \psi^e (x, y) \exp(\pm j\beta z)$$

$$H_z = k_c^2 \psi^h (x, y) \exp(\pm j\beta z)$$

Galerkin's method in Fourier transform domain



$$\psi_1^e(\alpha, y) = A^e(\alpha)\exp[-\gamma_1(y-h)]$$

$$\psi_2^e(\alpha, y) = B^e(\alpha)\sinh\gamma_2 y + C^e(\alpha)\cosh\gamma_2 y$$

$$\psi_3^e(\alpha, y) = D^e(\alpha)\exp(\gamma_1 y)$$