Multimode network equivalence of waveguide discontinuities using full-wave method of moments for spatial power combining

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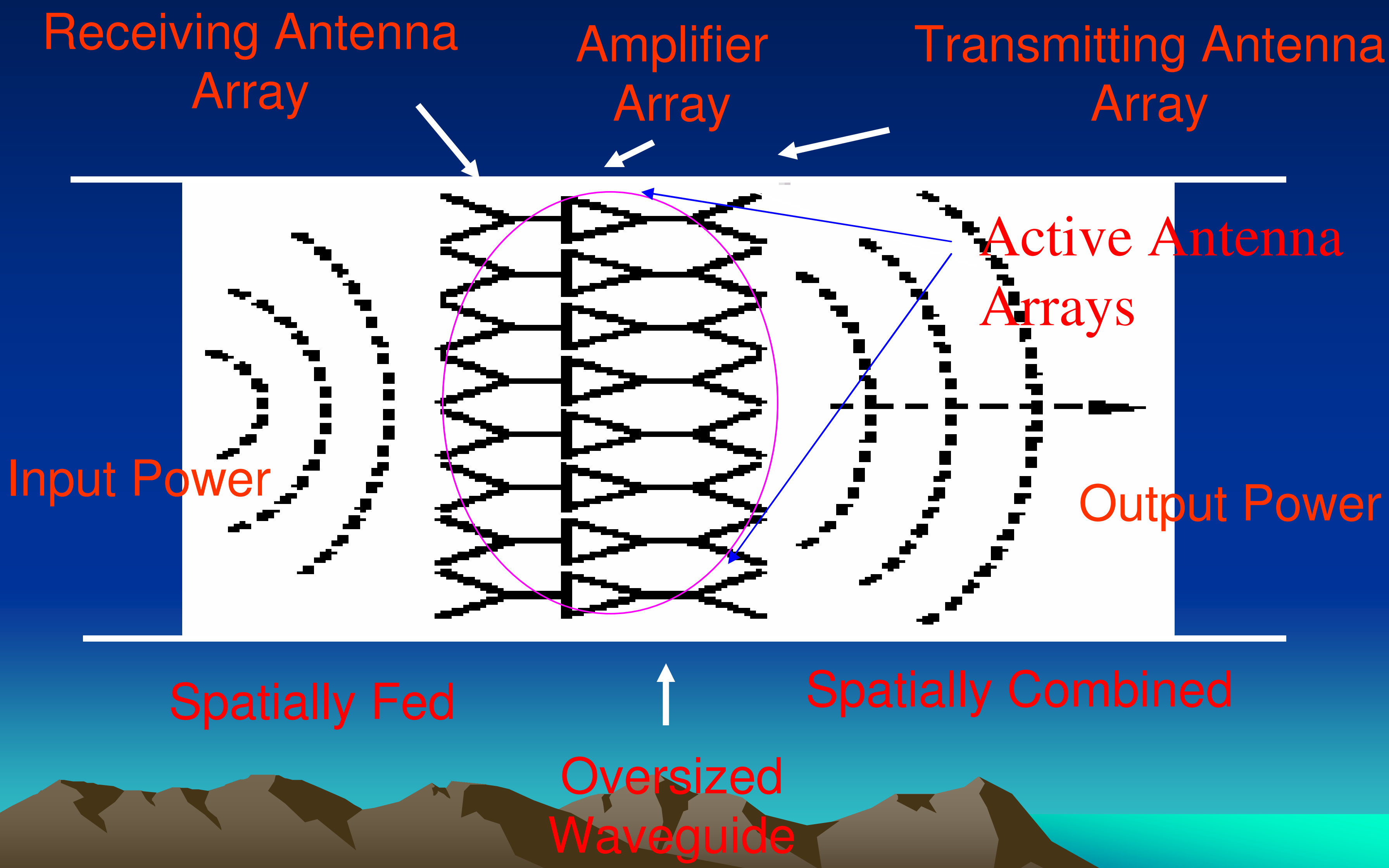
Scope of the presentation

- *Introduction to Spatial Power Combining*
- *Development of full-wave method of moments for electric-type (patch, strip) antenna inside oversized waveguide*
- *Multimode network equivalence of oversized waveguide discontinuities*

Waveguide-based spatial power combining



Modeling Issues

- *Oversized waveguide to accommodate large active antenna arrays*
- *Oversized waveguides: several high-order propagating waveguide modes in addition to the TE10 dominant mode.*
- *But commercial softwares can only model waveguide structures for TE10 mode only.*

Modeling Issues (Contd.)

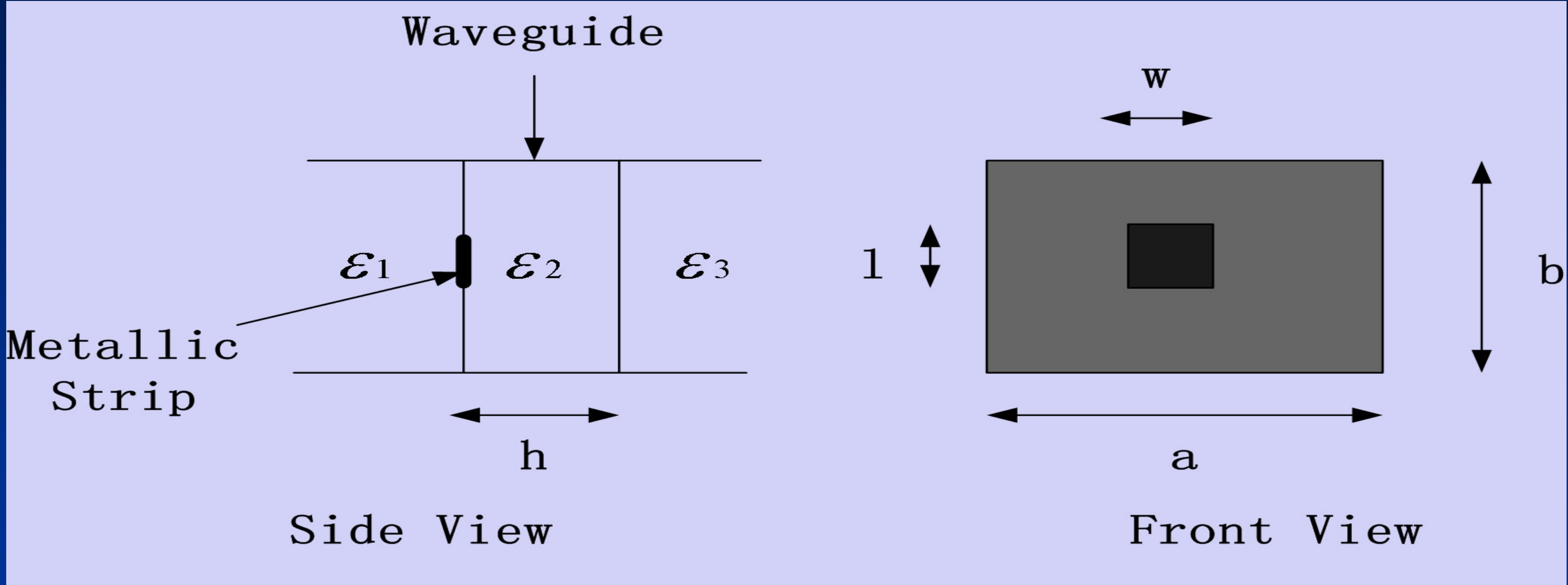


Figure Rectangular metallic strip enclosed inside over-moded waveguide

- *Hence it is necessary to develop a program which can characterize the enclosed metallic strip for multimode case.*

Development of full-wave method of moments

- *S.-G. Pan and I. Wolff,"Scalarization of Dyadic Green's functions and network formalizm for three-dimensional full-wave analysis of planar lines and antennas," in IEEE Trans. MTT, Nov. 1994*

Spectral Dyadic Green's functions

- *The spectral dyadic Green's functions for the layered waveguide is given below.*

$$\hat{\overline{G}}_{EJ}(k_t, z, z') = \frac{jZ_1''Z_2''\tan\gamma_2 h(\hat{k}_t\times z)(\hat{k}_t\times z)}{Z_1'' + jZ_2''\tan\gamma_2 h} + \frac{jZ_1'Z_2'\tan\gamma_2 h(\hat{k})(\hat{k})}{Z_1' + jZ_2'\tan\gamma_2 h}$$

$$Z(z) = \frac{1}{Y(z)} = \begin{cases} Z^e = \dfrac{k_z(z)}{\omega\varepsilon_i(z)} \\ Z^h = \dfrac{\omega\mu_i(z)}{k_z(z)} \end{cases}$$

$$k_z^2(z) = \omega^2\mu_i\varepsilon_i - k_t^2$$

Space domain dyadic Green's functions

The spectral dyadic Green's functions can be transformed into their space domain counterparts:

$$G_{ij}(i,j;i',j') = \sum_{m=0}^{M+1}\sum_{n=0}^{N+1} \tilde{G}_{ij}(k_x,k_y)\phi_{mn}^{i}\phi_{mn}^{j}$$

$$\phi_{mn}^{x} = \sqrt{\frac{\varepsilon_{0m}}{a}}\sqrt{\frac{\varepsilon_{0n}}{b}}\cos(k_x x)\cos(k_y y)$$

$$\phi_{mn}^{y} = \sqrt{\frac{\varepsilon_{0m}}{a}}\sqrt{\frac{\varepsilon_{0n}}{b}}\sin(k_x x)\cos(k_y y)$$

ε_{om} *and* ε_{on} *are Neuman indices where* $\varepsilon_{om}=1$ *for* $m=0$ *and* $\varepsilon_{om}=2$ *for* $m\neq 0$.

Electric Field Integral Equation (EFIE)

$$\hat{z}\times E(r) + j\omega\mu\,\hat{z}\times\left(\int_{strip}\hat{\overline{G}}_{EJ}(r,r').J(r')dS'\right) = 0$$

The vector EFIE can be reduced to a coupled set of scalar integral equations as below:

$$E_x(x,y) = j\omega\mu\left(\int\int_{strip} G_{xx}(x,y;x',y').J_x(x',y')dx'dy' + \int\int_{strip} G_{xy}(x,y;x',y').J_y(x',y')dx'dy'\right)$$

$$E_y(x,y) = j\omega\mu\left(\int\int_{strip} G_{yx}(x,y;x',y').J_x(x',y')dx'dy' + \int\int_{strip} G_{yy}(x,y;x',y').J_y(x',y')dx'dy'\right)$$

Galerkin's Method

- *Galerkin's method is applied to the EFIE to transform the integral equations into matrix systems of linear equations*
- *Piece-wise sinusoidal and pulse functions are used as basis and testing functions*
- *[Z][I]=[V]*

where

$$[\,Z\,] = \begin{bmatrix} Z_{xx} & Z_{xy} \\ Z_{yx} & Z_{yy} \end{bmatrix} \qquad [\,I\,] = \begin{bmatrix} I_x \\ I_y \end{bmatrix} \qquad [\,V\,] = \begin{bmatrix} V_x \\ V_y \end{bmatrix}$$

Matrix systems of linear equations

where the matrix components are given by

$$Z_{ij} = j\omega\mu \sum_{m=0}^{M+1}\sum_{n=0}^{N+1} \tilde{j}_i(k_x, k_y)\tilde{G}_{ij}(k_x, k_y)\tilde{j}_j(k_x, k_y)$$

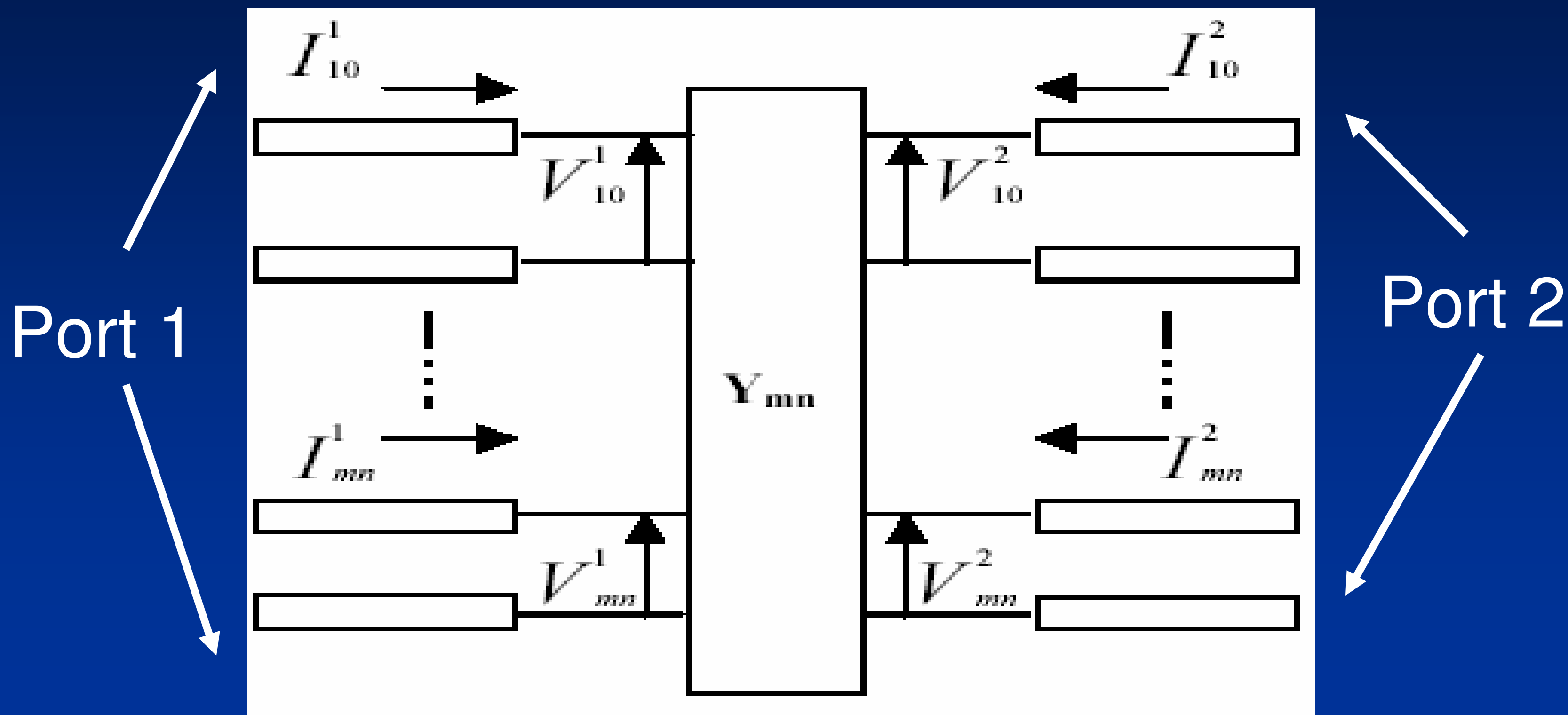
$$V_x = -\int\int_{strip} J_x(x, y)E_x(x, y)dxdy$$

Ix and Iy are the unknown current coefficients

Electromagnetic program

- *An EM program is developed to characterize enclosed metallic strips*
- *Initial results obtained for waveguide dimension a=0.02286, b=0.01016, strip dimension w=0.009271, l=0.007112.*
- *Strip is placed at the centre of the over-moded waveguide. substrate of* $\varepsilon_2=2.33$*, layer thickness h=0.00136.* $\varepsilon_1=1.0$ $\varepsilon_3=1.0$.

Multimode Network Equivalent



Multimode Network Equivalence for metallic strip enclosed inside oversized waveguide

Thank you

Have a Nice Day!