EFIE-based MoM (Part V)

- Volumetric Dielectric Formulation

E8-202 Class 11

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Module 2: Method of Moments

- 2D vs 2.5D vs. 3D Formulations
- Electrostatic Formulation: Capacitance matrix extraction
- Magnetostatic Formulation: Inductance matrix extraction
- Electric Field Integral Equation (EFIE): S-parameter extraction
- Partial Element Equivalent Circuit (PEEC) Method
- Magnetic Field Integral Equation (MFIE) and Combined Field Integral Equation (CFIE)
- PMCHWT Formulation: Dielectric modeling
- Parallelization techniques

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References

- D. H. Schaubert, D. R. Wilton, and A. W. Glisson, “A tetrahedral modeling method for electromagnetic scattering by arbitrarily shaped inhomogeneous dielectric bodies,” IEEE Trans. Antennas Propag., vol. AP-32, pp. 77–85, Jan. 1984.

Volumetric Formulation (Preferred)

- Equation:

$$J = j\omega(\varepsilon_r - \varepsilon_0)E = j\omega\gamma D$$

$$E_s + E_i = E_T = \frac{J}{j\omega(\varepsilon_r - \varepsilon_0)}$$

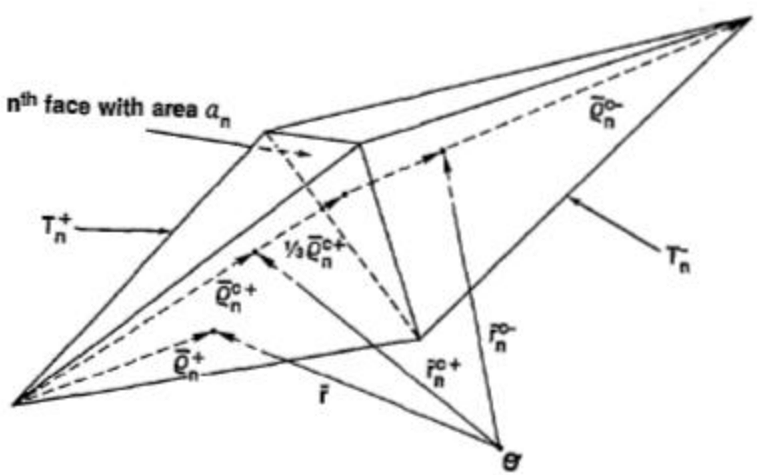
$$E_i = \frac{J}{j\omega(\varepsilon_r - \varepsilon_0)} + j\omega A + \nabla\phi$$

$$E_i = \frac{j\omega\gamma D}{j\omega(\varepsilon_r - \varepsilon_0)} + j\omega A + \nabla\phi$$

Volumetric Formulation

- Basis Function:

$$f_s \to j\omega D$$



$$\mathbf{f}_n(\mathbf{r}) = \begin{cases} \dfrac{a_n}{3V_n^+}\,\rho_n^+, & \mathbf{r} \in T_n^+ \\ \dfrac{a_n}{3V_n^-}\,\rho_n^-, & \mathbf{r} \in T_n^- \\ 0, & \text{otherwise} \end{cases}$$

$$\nabla \cdot \mathbf{f}_n(\mathbf{r}) = \begin{cases} \dfrac{a_n}{V_n^+}, & \mathbf{r} \in T_n^+ \\ \dfrac{-a_n}{V_n^-}, & \mathbf{r} \in T_n^- \\ 0, & \text{otherwise} \end{cases}$$

D. H. Schaubert, D. R. Wilton, and A. W. Glisson, “A tetrahedral modeling method for electromagnetic scattering by arbitrarily shaped inhomogeneous dielectric bodies,” IEEE Trans. Antennas Propag., vol. AP-32, pp. 77–85, Jan. 1984.

Term 1

$$E_i = \frac{j\omega\gamma D}{j\omega(\varepsilon_r - \varepsilon_0)} + j\omega A + \nabla\phi$$

$$\left\langle \frac{j\omega\gamma D}{j\omega(\varepsilon_r - \varepsilon_0)}, f_t \right\rangle$$

$$\left\langle \frac{f_s}{j\omega\varepsilon_r}, f_t \right\rangle$$

$$\frac{1}{j\omega\varepsilon_r}\int_v f_s . f_t dv$$

Term 2

$$\left\langle j\omega A, f_t \right\rangle$$

$$j\omega \int_t f_t \cdot \int_s G J ds$$

$$j\omega \int_t f_t \cdot \int_s G j\omega\gamma D ds$$

$$\frac{j\omega\gamma\mu}{4\pi} \int_t f_t \cdot \int_s \frac{e^{-jk\left|r-r'\right|}}{\left|r-r'\right|} f_s ds$$

Term 3

$$\left\langle \nabla \phi, f_t \right\rangle$$

3b 3a

$$\int_t \phi f_m.\hat{n} dt - \int_t \phi \nabla . f_t dt = \int_t f.\nabla \phi dt$$

$$\rho = \frac{\gamma \nabla . f_s}{-j\omega} + \frac{f_s . \nabla . \gamma}{-j\omega}$$

Surface

$$T_{3a} = \frac{A_t A_s}{V_t V_s} \frac{\gamma}{j\omega 4\pi\varepsilon_0} \int_t \int_s \frac{e^{-jk|r-r'|}}{|r-r'|} dsdt + \frac{A_t}{V_t} \frac{1}{j\omega 4\pi\varepsilon_0} \left(\gamma^+ - \gamma^-\right) \int_t \int_s \frac{e^{-jk|r-r'|}}{|r-r'|} dsdt$$

++ term only mentioned

$$T_{3b} = \frac{A_s}{V_s} \frac{\gamma}{j\omega 4\pi\varepsilon_0} \int_t \int_s \frac{e^{-jk|r-r'|}}{|r-r'|} dsdt + \frac{1}{j\omega 4\pi\varepsilon_0} \left(\gamma^+ - \gamma^-\right) \int_t \int_s \frac{e^{-jk|r-r'|}}{|r-r'|} dsdt$$

Surface