Computational Electromagnetics : Finite Difference Time Domain Methods – Sources

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Topics in this module

1. Current Sources
2. Indirect Sources: Scattering problems
3. Summary of FDTD

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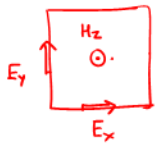
Volume current excitation

$\vec{J}(r,t)$

(2D) TE case $\rightarrow (E_x, E_y, H_z)$

$$\bar{\nabla}\times\bar{H}^{n-1/2} = \varepsilon \dot{\bar{E}}^{n-1/2} + \bar{J}^{n-1/2}$$



We need to know $\vec{J} = (J_x, J_y, J_z)$ as fn (r,t)

at time instances : $n-1/2$

at space instances : E field locations.

Easy to implement.

Set $\Delta x, \Delta t, \alpha$

Relation between current source and Δt, Δx?

$\vec{J}(t) \xleftrightarrow{\mathcal{F}} \tilde{J}(f)$, say band limited.

$\tilde{J}(f) = 0$, $f > f_0$

Nyquist thm: Correctly represent $\vec{J}(t)$

$\Delta t \leq \frac{1}{2 f_0}$

$\Rightarrow$ High BW current source

$\Rightarrow$ space discretization fixed.

At the same time,

Courant factor: $\alpha = \frac{c \Delta t}{\Delta x}$

f_0 fixed $\Rightarrow$ Δt fixed $\Rightarrow$ Δx fixed.

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Other implementation issues

1) Gaussian current source.

$$g(t) = \exp\left(-\left(\frac{t-t_0}{t_w}\right)^2\right) \xleftrightarrow{\mathcal{F}} t_w\sqrt{\pi}\,\exp\left[-(\pi t_w f)^2\right]\exp\left[-j2\pi f t_0\right]$$

What is $f_{bw} = \frac{1}{\pi t_w}$. To be safe $f_0 = 2 f_{bw} \Rightarrow f_0 = f_{max} = \frac{2}{\pi t_w}$

$\Rightarrow$ fixes Δx.

2) At start, $t = 0$, $g(0) = e\left(-\left(\frac{t_0}{t_w}\right)^2\right)$. Minimize high values of $g(0)$

Make to large. eg. $t_0 \approx 4 t_w \Rightarrow$ longer simulation.

3) How long to run the sim? long enough e.g $4t_w \times 2$.

Common mistake eg. $T \approx 2 t_w$.

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No "$J(r,t)$" term in scattering problems

Fix via total/scattered formulation

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Summary of FDTD

Topics that were covered in this module

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3. Summary of FDTD

References:

* Ch 12 of Computational Methods for Electromagnetics - Peterson, Ray, Mitra

* Computational Electrodynamics: The Finite-Difference Time-Domain Method – Allen Taflove (the 'Bible' for FDTD)