Time Reversal Using the FDTD Method – Allison Tanner

Formulation for 1D TEz

Hz

$$H_z^{n-\frac{1}{2}}(i) = C_{hzey}\left(E_y^n(i+1) - E_y^n(i)\right) - C_{hzh}H_z^{n+\frac{1}{2}}(i) \quad [1a]$$

Where...

$$C_{hzey} = \frac{-2\Delta t}{(\Delta x)(\Delta t\sigma_z^m(i) - 2\mu_z(i))}, \quad C_{hzh} = \left(\frac{\Delta t\sigma_z^m(i) + 2\mu_z(i)}{\Delta t\sigma_z^m(i) - 2\mu_z(i)}\right) \quad [1b]$$

Ey

$$E_y^n(i) = C_{eyhz}\left(H_y^{n+\frac{1}{2}}(i) - H_y^{n+\frac{1}{2}}(i-1)\right) - C_{eye}\left(E_z^{n+1}(i)\right) \quad [2a]$$

$$C_{eyhz} = \frac{-2\Delta t}{\Delta x(\Delta t\sigma_y^e - 2\varepsilon_y)}, \quad C_{eye} = \left(\frac{\Delta t\sigma_y^e + 2\varepsilon_y}{\Delta t\sigma_y^e - 2\varepsilon_y}\right) \quad [2b]$$

Formulation for 2D TEz

$$E_x^n(i,j) = C_{exhz}(i,j)\left(H_z^{n+\frac{1}{2}}(i,j) - H_z^{n+\frac{1}{2}}(i,j-1)\right) - C_{exe}(i,j)E_x^{n+1}(i,j) \quad [1a]$$

$$C_{exe}(i,j) = \left(\frac{\Delta t\sigma_x^e(i,j) + 2\varepsilon_x(i,j)}{\Delta t\sigma_x^e(i,j) - 2\varepsilon_x(i,j)}\right) \qquad C_{exhz}(i,j) = \frac{2\Delta t}{\Delta y\left(\Delta t\sigma_x^e(i,j) - 2\varepsilon_x(i,j)\right)} \quad [1b]$$

$$E_y^n(i,j) = -C_{eyhz}(i,j)\left(H_z^{n+\frac{1}{2}}(i,j) - H_z^{n+\frac{1}{2}}(i-1,j)\right) - C_{eye}(i,j)E_y^{n+1}(i,j) \quad [2a]$$

$$C_{eye}(i,j) = \left(\frac{\Delta t\sigma_y^e(i,j) + 2\varepsilon_y(i,j)}{\Delta t\sigma_y^e(i,j) - 2\varepsilon_y(i,j)}\right) \qquad C_{eyhz}(i,j) = \frac{2\Delta t}{\Delta x\left(\Delta t\sigma_y^e(i,j) - 2\varepsilon_y(i,j)\right)} \quad [2b]$$

$$H_z^{n-\frac{1}{2}}(i,j) = C_{hzex}(i,j)\left(E_x^n(i,j+1) - E_x^n(i,j)\right) - C_{hzey}(i,j)\left(E_y^n(i+1,j) - E_y^n(i,j)\right) - C_{hzhz}(i,j)H_z^{n+\frac{1}{2}}(i,j) \quad [3a]$$

$$C_{hzex}(i,j) = \frac{2\Delta t}{\Delta y\left(\Delta t\sigma_z^m(i,j) - 2\mu_z(i,j)\right)}, C_{hzey}(i,j) = \frac{2\Delta t}{\Delta x\left(\Delta t\sigma_z^m(i,j) - 2\mu_z(i,j)\right)}, C_{hzh}(i,j) = \left(\frac{\Delta t\sigma_z^m(i,j) + 2\mu_z(i,j)}{\Delta t\sigma_z^m(i,j) - 2\mu_z(i,j)}\right) \quad [3b]$$

Simulation of 1D Time Reversal with FDTD in Matlab