Reflection and Transmission Coefficients

Assume that there is a boundary between free space and a dielectric material which has a relative permittivity of 9.0 (i.e. $\varepsilon_{r2} = 9$, $\mu_{r_2} = 1$). We want to find the transmission coefficient for a wave originating in free space and is incident on this dielectric material.

Since the permittivity and permeability are independent of frequency, the transmission coefficient is also independent of frequency.

Because the FDTD method is not exact, we will not obtain a constant, but the agreement with the exact result should be good, especially at the low frequencies where the discretization is fine.

Write a one-dimensional FDTD program (using Matlab) to advance the first-order governing differential equations. Assume the non-zero fields are Ex and Hy.

Although everything could be left unitless, to make things more concrete use the following parameters (or at least think in terms of the following parameters):

$$\Delta z = 0.002m$$

$$\Delta t = \frac{\Delta z}{2*3X10^8}$$

So, the Courant number in free space is unity and in a dielectric is $\frac{u\Delta t}{\Delta z}$.

For the construction of your program, use the following. (Here node numbers follow the conventional matlab array notation and are assumed to start with 1.)

The computational domain should have 180 electric field points and 179 magnetic field points (the computational domain begins and ends on electric field points).

Assume $E_{k=90}$ is located at z = 0 which corresponds to the boundary between free space and the dielectric. For this electric field node, and only this node, use a relatively permittivity (1+9)/2=5) (i.e., the average premittivity to either side). Assume free space is to the left of the boundary and the dielectric is to the right.

To terminate the grid, use a first-order absorbing boundary condition.

Use a Gaussian pulse as the excitation at k=5.

Record the value of $E_{k=50}$ in a data file Ei for $\varepsilon_{r2} = 1$, this is the incident field.

Record the value $E_{k=170}$ in a data file after you put the second material. This is the transmitted field.

Record $E_{k=50}$ after you put the second material. This is the incident plus the reflected wave.

Observe the wave propagation at different time steps.

Calculation of the transmission coefficient: Use Matlab to find the transmission coefficient. For n use he power of 2.

```
%load c:\et.dat;
%load c:\ei.dat;
%load c:\dt;
v2=fft(et);
v3=fft(ei);
n=length(v3);
f=(1/(dt))*(0:n-1)/n;
xx=1:20;
xlabel('Frequency, Hz')
plot(f(xx),abs(v2(xx)./v3(xx)))
ylabel('Transmission Coefficient')
title(' Frequency response of the transition')
```