Fields & Waves II

Project IV - Finite Difference Time Domain - CW Sources

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Fields & Waves II - ECEN-3623

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Contents

1 Introduction

This assignment is an extension of Fields & Waves II - Project III. In this assignment students we instructed to complete Problem Sets 1.5.1, 1.5.2, and 1.6.1 from the Sullivan PDF. The lab furthered understanding of wave forms through dielectric, C code, and MATLAB Code.

2 Problem Set 1.5

2.1 1.5.1

Modify your program $fd1d_1.3.c$ to simulate the sinusoidal source (see $fd1d_1.4.c$).
The modified program is located in the Appendix.

2.2 1.5.2

Keep increasing your incident frequency from 700MHz upward at intervals of 300MHz. What happens?

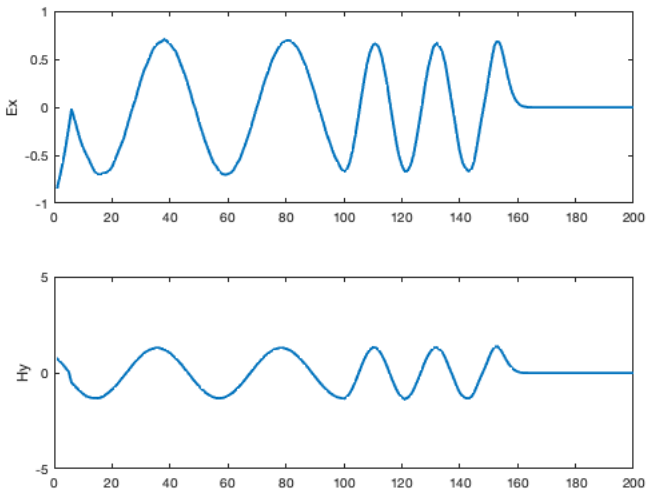

Figure 1: Sinusoidal Gaussian Pulse with frequency of 700MHz

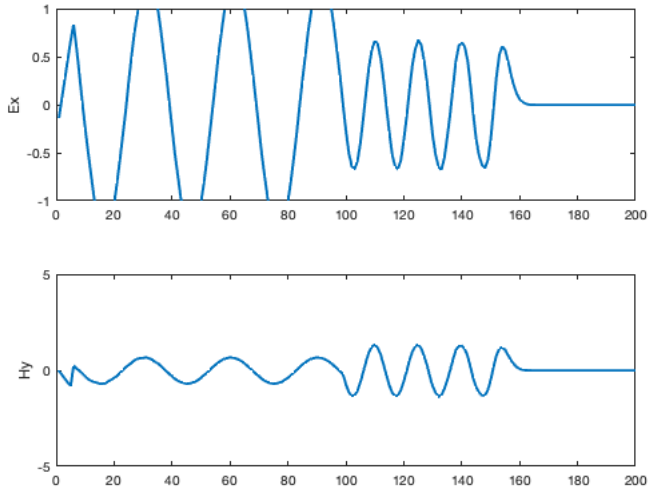

Figure 2: Sinusoidal Gaussian Pulse with frequency of 1GHz

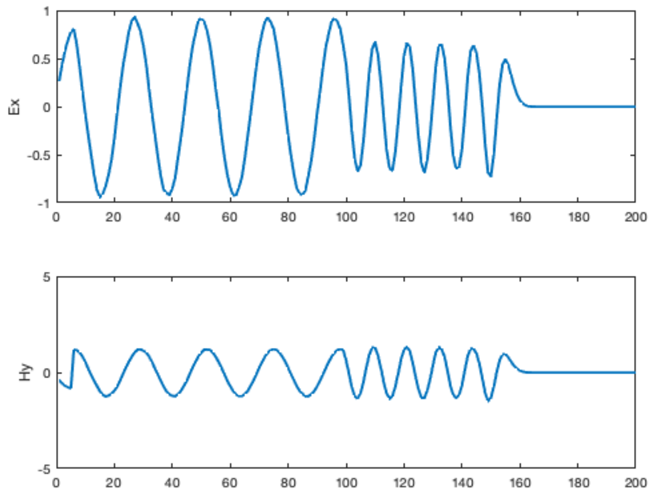

Figure 3: Sinusoidal Gaussian Pulse with frequency of 1.3GHz

These graphs show sinusoidal Gaussian pulses with changing frequencies from 700MHz to 1.3GHz. Some key details we can see from these graphs is the change in reflection amount. We can see the increase in the 1GHz reflection amplitude demonstrating high-pass filter qualities. The 1.3GHz also has an increasing amplitude after the reflection supporting this. The transmission also decreases, which as expected since more energy is reflected back rather than transmitting through the medium. The wave speed for all three waves seems to reduce by the same rate due to a common permittivity value. The first peak of the sinusoidal wave seems to be slightly smaller for all of the wave-forms (including the next section), I am not sure if this is an attribute of the code or intended. I also should've commented out the magnetic field graphs, but I wanted to see them.

3 1.6

3.1 1.6.1

Simulate a 3-GHz sine wave impinging on a material with a dielectric constant of $\epsilon_r = 20$

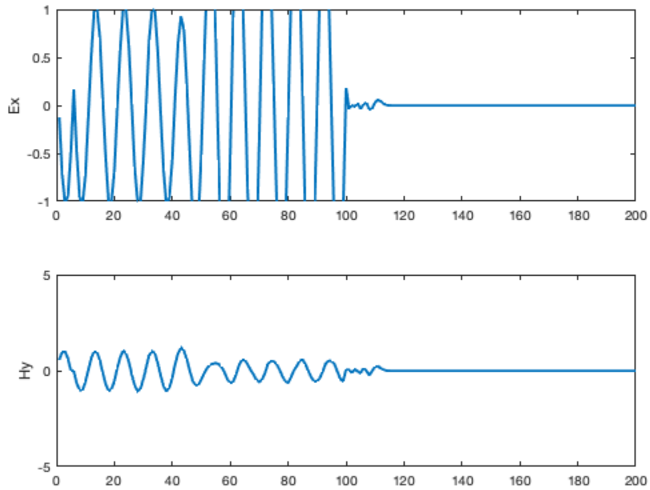

Figure 4: Sinusoidal Gaussian Pulse with frequency of 3GHz

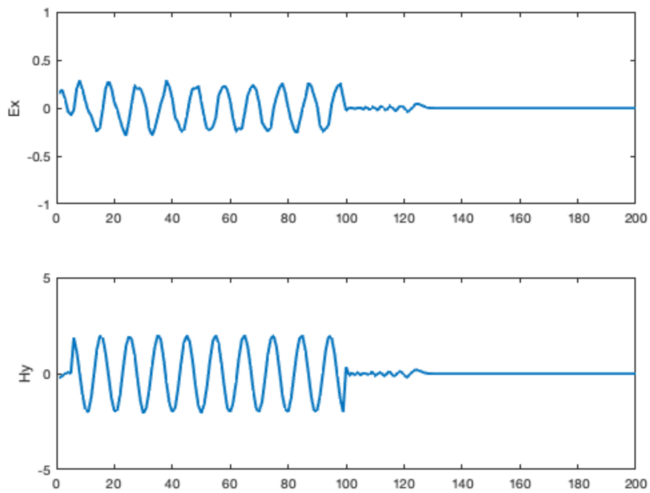

Figure 5: Secondary Image of Sinusoidal Gaussian Pulse with frequency of 3GHz

The graphs (Figure 4 & Figure 5) demonstrate a 300GHz wave travelling from air to a medium with permittivity of 20. Firstly, the wave decreases in speed by a much greater magnitude than the previous medium with permittivity of 4. The transmission is also reduced greatly compared to the previous section. This reduction is due to the larger permittivity, meaning a stronger dielectric. $\epsilon_r >>> \epsilon_o - -- > 20 >>> 8.854 * 10^{-12}$ Lastly, in accordance with the small transmission amount, the reflection amplitude is increased vastly. Nearly all of the energy is reflected.

4 Appendix

```
%Aaron Rosen - Fields & Waves II - Project 4 - FD1D_13.c to MATLAB

%Modify your program fd1d_1.3.c to simulate the sinusoidal source (see
%fd1d_1.4.c)

%Keep increasing your incident frequency from 700MHz upward at intervals of
%300MHz. What happens?

%A type of propagating wave function that is of great interest in areas
%such as optics is the "wave packet," which is a sinusoidal function in a
%Gaussian envelope. Modify your program to simulate a wave packet.

KE = 200;
Ex = zeros(KE, 1);
Hy = zeros (KE, 1);
CB = zeros(KE, 1);

ex_low_m1 = 0;
ex_low_m2 = 0;
ex_high_m1 = 0;
ex_high_m2 = 0;

spread = 12;
t0 = 40.0;
T = 0;
NSTEPS = 1;
kc = KE/2;
ddx =0.01;
dt = ddx/(2*3e8);


for k = 2:KE
    CB(k) = 0.5;
end

dielectric = "Dielectric starts @ --> ";
kstart = input(dielectric);
disp(kstart);
```

```
eps = "Input Epsilon --> ";
epsilon = input(eps);
disp(epsilon);
frequency = "Input frequency (MHz) --> ";
freq = input(frequency)*1e6;

for k =kstart:KE
    CB(k) = 0.5/epsilon;
end


while (NSTEPS > 0)
    n = 0;
    prompt = "NSTEPS --> ";
    NSTEPS = input(prompt);
    disp(NSTEPS);

    for n=1:NSTEPS
        T = T+1;

        %Calculuate E-field
        for k =2:KE
            Ex(k) = Ex(k) + CB(k)*(Hy(k-1) - Hy(k));
        end

                %Define Boundary Conditions
        Ex(1) = ex_low_m2;
        ex_low_m2 = ex_low_m1;
        ex_low_m1 = Ex(2);
        Ex(KE-1) = ex_high_m2;
        ex_high_m2 = ex_high_m1;
        ex_high_m1 = Ex(KE-2);


        %Add Sinusoidal Gaussian Pulse @ low end
        pulse = sin(2*pi*freq*dt*T);
        Ex(6) = Ex(6) + pulse;
        disp(t0-T);
        disp(Ex(6));
```

```
    for k = 1:KE-1
        Hy(k) = Hy(k) + 0.5* (Ex(k) - Ex(k+1));
    end

    figure(1);
    subplot(2,1,1)
    plot(Ex, 'LineWidth', 2)
    ylabel('Ex')
    ylim([-1 1])

    subplot(2,1,2)
    plot(Hy, LineWidth=2);
    ylabel('Hy')
    ylim([-5 5])
    for k = 1:KE
        disp(Ex(k));
    end

    end
    cont = "Would you like to continue?";
    if (input(cont) == 0)
        clear all; close all; clc;
    else if (input(cont) == 1)
            continue;
    end
    end


end
```