W8\_THz simulation

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Using the following parameters:

## Plotting THz transmission line using the following parameter:

### The input is a sinewave with frequency of 0.1 THz.

A graph with a line

AI-generated content may be incorrect.

Figure 1 : shows the response using the exact solution.

clear

clc

R = 1200; % Resistance per unit length (Ω/m)

L = 250e-9; % Inductance per unit length (H/m)

C = 1e-10; % Capacitance per unit length (F/m)

Rs = 10;

G = 0;

l = 150e-6; % Length of the transmission line

f\_max = 100e9; % Maximum frequency (100 GHz)

w = 2\*pi\*f\_max;

s = 1i\*w;

vs\_sine = @(s) w./(s.^2 + w^2);% Laplace transform of sin(wt)

% Transfer function (exact solution)

vo = @(s) 1 ./ (cosh(l .\* sqrt((R + L.\*s) .\* (G + C.\*s))));

vo\_sine = @(s) vs\_sine(s).\*vo(s);

time =10e-12;

[y\_sine,t] = niltcv(vo\_sine,time);

% Plot the frequency response

plot(t, y\_sine)

xlabel('time (s)');

ylabel('Vo');

grid on;

## RLC,

Unit step response.

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Figure 2 illustrates the output of the transmission line (TL) using the RLC ladder method with a unit step input.

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Figure 3 :shows the output of the transmission line (TL) using the RLC ladder method with a unit step input and R\_s = 10.

## The response due to sinewave with frequency of 0.1 THz.

A graph with a line

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Figure 4 :presents the output of the transmission line (TL) using the RLC ladder method with a sinusoidal input at a frequency of 0.1 THz.

A graph with a blue line

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Figure 5:shows the response of the transmission line (TL) using the RLC ladder method with a sinusoidal input at a frequency of 0.1 THz and R\_s = 10.

### The input is a pulse with a rise time from 0 to 1V of 1ps and the same fall time and it stays at 1V for 5ps using trapezoidal pulse.

A trapezoidal pulse that:

* Rises linearly from 0 V to 1 V over 1 ps,
* Stays at 1 V for 5 ps,
* Falls back to 0 V over 1 ps,  
  can be built from ramps and exponentials in the Laplace domain.

Time‐Domain Definition

Total duration: 7 ps = 1 ps (rise) + 5 ps (high) + 1 ps (fall).

a function is coded in MATLAB below to implement this pulse.

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Figure 6: illustrates the output of the transmission line (TL) using the RLC ladder method with a trapezoidal pulse input.

A graph with blue lines

AI-generated content may be incorrect.

Figure 7: illustrates the output of the transmission line (TL) using the RLC ladder method with a trapezoidal pulse input and R\_s=10.

function v = trapezoidalPulse(t)

% Define pulse parameters

T\_r = 1e-12; % Rise time (1 ps)

T\_p = 5e-12; % High-level duration (5 ps)

T\_total = 2\*T\_r + T\_p; % Total pulse duration (7 ps)

% Piecewise definition of the pulse

if t < 0

v = 0;

elseif t < T\_r

% Linear rise: from 0 to 1 V over T\_r

v = t / T\_r;

elseif t < T\_r + T\_p

% Constant high level at 1 V

v = 1;

elseif t < T\_total

% Linear fall: from 1 V back to 0 over T\_r

v = (T\_total - t) / T\_r;

else

v = 0;

end

end

%RLC input as pulse

clear

clc

len=150e-6;

N = 200; % Number of sections in the transmission line

dz=len/N;

L = 250e-9\*dz; % Inductance

C = 1e-10\*dz; % Capacitance

R = 1200\*dz; % Resistance per section

Rs = 0; % Source resistance

vs\_pulse = @(t) trapezoidalPulse(t);

y0 = zeros(2 \* N, 1);

tspan = linspace(0,10e-12,10e4);

% Solve using ode45

[t, y\_pulse] = ode45(@(t, y) fline\_noR(t, y, N, L, C, R, Rs, vs\_pulse), tspan, y0);

% Plot voltage at the end of the transmission line (VN)

figure(1);

plot(t, y\_pulse(:,N\*2));

xlabel('Time (s)');

ylabel('Voltage (V)');

title('RLC with Trapezoidal Pulse input');

grid on

## FDTD improvised with 100 sections.

Unit step response

A graph of blue lines

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Figure 8 : shows the unit step response using FDTD and 1000000-time steps.

With 10000000 time steps and 100 sections

A graph of a graph showing a number of blue lines

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Figure 9: shows the unit step response with 10^7-time steps and 100 sections

## The response due to sinewave with frequency of 0.1 THz.

A graph showing a line

AI-generated content may be incorrect.

Figure 10: the response due to sinewave at 0.1 THz and 100 segments .

clear

clc

L\_total = 150e-6; % Total length of the line (m)

R = 1200;

l = 250e-9;

c = 1e-10;

Zc = sqrt((R+l)/(c)); % Characteristic impedance (Ohms)

v = 2e8; % Speed of propagation (m/s)

% Compute inductance and capacitance

C = 1 / (v \* Zc);

L = Zc/v;

NDZ = 100; % Number of spatial steps

dz = L\_total / NDZ; % Spatial step delta z

dt = 1e-17; % Time step delta t

t\_max = 10e-12;

t\_steps = round(t\_max / dt); % Number of time steps

% allocate voltage and current arrays

V = zeros(NDZ+1, t\_steps);

time = (0:t\_steps-1)\*dt;

Vs = sin(2\*pi\*100e9.\*time);

V(1,:)=Vs.\*ones(1,t\_steps);

I = zeros(NDZ, t\_steps);

% FDTD Loop for Time Stepping

for n = 1:t\_steps-1

%V(1,n+1) = V(1,n);

V(1, n+1) = sin(2\*pi\*100e9 \* time(n+1));

for k = 1:NDZ

if k>1

V(k,n+1) = V(k,n) + dt/(dz \*C)\* (I(k-1,n) - I(k,n)); % Update voltag

dV\_k = V(k-1,n) - V(k,n); % Voltage difference between points

I(k-1,n+1) = I(k-1,n) + dt/(dz \*L) \* dV\_k;

end

end

V(NDZ,n+1) =V(NDZ,n)+dt\*(I(NDZ-1,n)/(C\*dz));

end

y\_FDTD = V(NDZ,:);

% Plot the results for the voltage at the load

figure(1)

plot((0:t\_steps-1)\*dt/1e-12, V(NDZ,:));

xlabel('Time (ps)');

ylabel('V Load (Volts)');

%title('FDTD Simulation of Transmission Line with unit step input');

title('FDTD Simulation of Transmission Line with 100 GHz Sine Wave Input');

grid on;

## The input is a pulse with a rise time from 0 to 1V of 1ps and the same fall time and it stays at 1V for 5ps using trapezoidal pulse

A graph of a graph

AI-generated content may be incorrect.

Figure 11: illustrates FDTD simulation of a TL with a pulse input using 100 sections and 10^6 time steps.

clear

clc

L\_total = 150e-6; % Total length of the line (m)

R = 1200;

l = 250e-9;

c = 1e-10;

Zc = sqrt((R+l)/(c)); % Characteristic impedance (Ohms)

v = 2e8; % Speed of propagation (m/s)

% Compute inductance and capacitance

C = 1 / (v \* Zc);

L = Zc/v;

NDZ = 100; % Number of spatial steps

dz = L\_total / NDZ; % Spatial step delta z

dt = 1e-17; % Time step delta t

t\_max = 10e-12;

t\_steps = round(t\_max / dt); % Number of time steps

% allocate voltage and current arrays

V = zeros(NDZ+1, t\_steps);

time = (0:t\_steps-1)\*dt;

%Vs = sin(2\*pi\*100e9.\*time);

%Vs = 1;

%V(1,:)=Vs.\*ones(1,t\_steps);

V(1,1) = trapezoidalPulse(time(1));

I = zeros(NDZ, t\_steps);

% FDTD Loop for Time Stepping

for n = 1:t\_steps-1

%V(1,n+1) = V(1,n);

%V(1, n+1) = sin(2\*pi\*100e9 \* time(n+1));

V(1,n+1) = trapezoidalPulse(time(n+1));

for k = 1:NDZ

if k>1

V(k,n+1) = V(k,n) + dt/(dz \*C)\* (I(k-1,n) - I(k,n)); % Update voltag

dV\_k = V(k-1,n) - V(k,n); % Voltage difference between points

I(k-1,n+1) = I(k-1,n) + dt/(dz \*L) \* dV\_k;

end

end

V(NDZ,n+1) =V(NDZ,n)+dt\*(I(NDZ-1,n)/(C\*dz));

end

y\_FDTD = V(NDZ,:);

% Plot the results for the voltage at the load

figure(1)

plot((0:t\_steps-1)\*dt/1e-12, V(NDZ,:));

xlabel('Time (ps)');

ylabel('V Load (Volts)');

%title('FDTD Simulation of Transmission Line with unit step input');

%title('FDTD Simulation of Transmission Line with 100 GHz Sine Wave Input');

title('FDTD Simulation of Transmission Line with Trapezoidal Pulse Input');

grid on;