FDTD Sources

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Abstract

This document describes and formulates the various sources that can be used in FDTD models.

1D Sources

Gaussian Pulse

The Gaussian Pulse is an impulse function that allows us to excite the problem with a broad range of frequencies all at the same time.

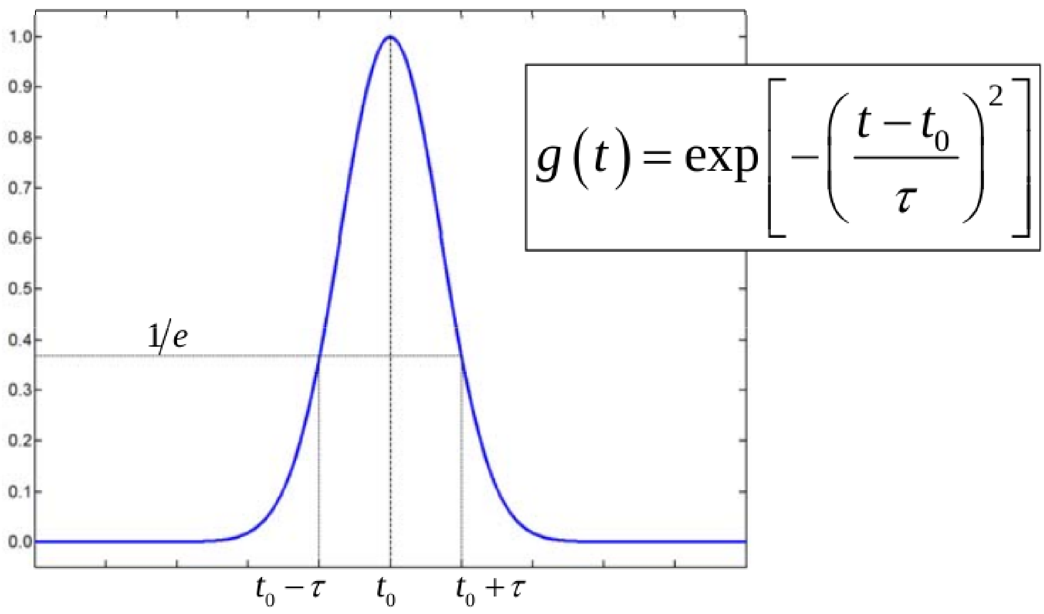

Figure 1: A Gaussian Pulse centered at t_0

To find the frequency content of the Pulse we must perform the Fourier Transform on the pulse.

$$g(t) = \exp\left(-\frac{t^2}{\tau^2}\right) \Longrightarrow G(f) = \frac{1}{\sqrt{\pi}B}\exp\left[-\frac{f^2}{B^2}\right]$$

This shows that the frequency content of the Gaussian Pulse extends from DC up to B where

$$B = \frac{1}{\pi\tau} \tag{1}$$

Pulse Design

To design the pulse for our simulations we must first decide on the maximum frequency we are interested in f_{max} then compute the pulse width with this upper frequency

$$B = f_{max} = \frac{1}{\pi\tau} \Longrightarrow \tau \leq \frac{1}{\pi f_{max}}$$

For simplification we can approximate τ as

$$\tau \cong \frac{0.5}{f_{max}} \tag{2}$$

In order to properly resolve our Guassian pulse, which should be completed by at least 10 to 20 time steps, we need to recalculate Δt. We now need to re-evaluate this value in conjuction with the Courant Stability Condition. We will determine Δt based on the maximum frequency and pick the smallest Δt.

$$\Delta t \leq \frac{\tau}{10} \tag{3}$$

Finally to properly inject our source without any adverse reactions within our model we must include delay 1.1. This will allow the pulse to ease into the problem space without producing large field gradients.

$$t_0 \geq 6\tau \tag{4}$$

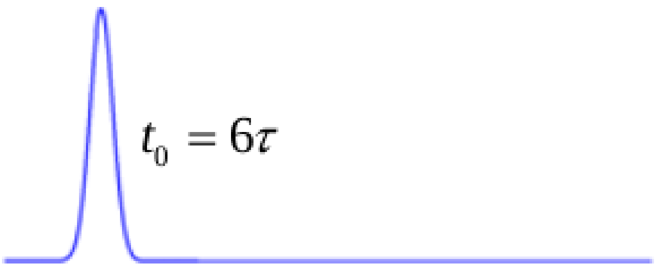

Figure 2: A Gaussian Pulse delayed by $t_0 = 6\tau$

Matlab Example

Program 1 The Gaussian Source Example

```
% Parameters
fmax = 1e9;                              %Max Frequency
dt = 0.5*dz/c0                           %Time Step
tau = 0.5/fmax;                          %Pulse Duration


% Compute Gaussian Source
nzc = round(Nz/2)                        %position of source
dt = 0.6*dz/c0
ta = [0:STEPS-1]*dt;                     %time axis
t0 = 6*tau                               %Pulse Position
s = dz/(2*c0) + dt/2                     %Total delay between E and H
Esrc = exp(-((ta-t0/tau).^2);            %E field source
A = - sqrt(ER(nzc)/UR(nzc));             %amplitude of H field
Hsrc = A * exp(-((ta-t0+s)/tau).^2);     % H field source
```