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Advanced Computation:

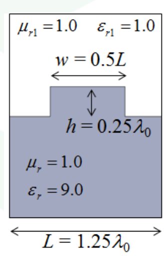
Computational Electromagnetics

Parameter Sweeps

1

What is a Parameter Sweep?

So far, TMM can only simulate a single device at a single frequency, or wavelength.

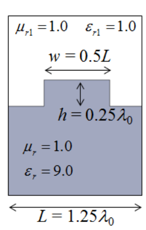


Sim

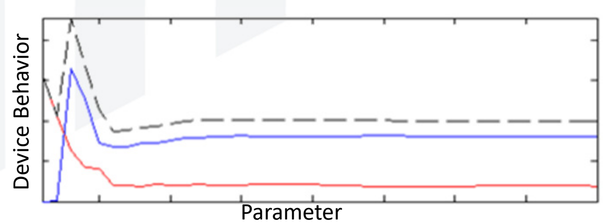
R = 81%
T = 19%

Parameter sweeps are perhaps the most powerful tool in the analysis arsenal.

Suppose this data is calculated as we continuously change one or more parameters? This is called a parameter sweep.



Sim



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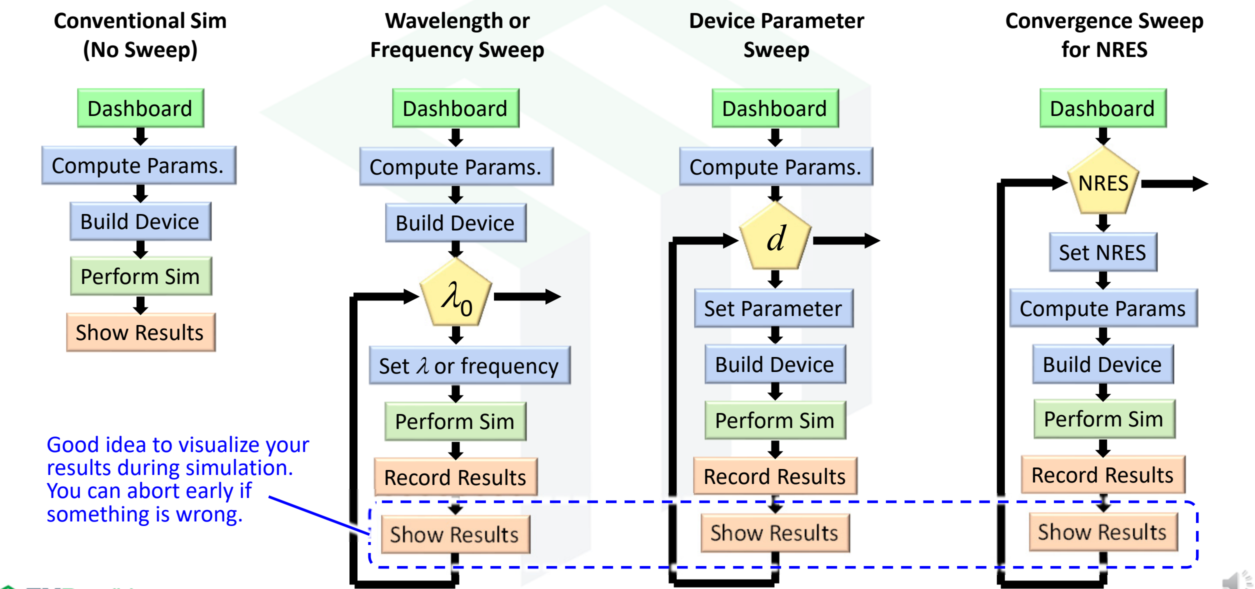
Slide 2

2

Block Diagrams of Common Parameter Sweeps



3

Make a Generic TMM Function

A great way to simplify programming parameter sweeps is to first make a generic function out of the TMM code.

The basic TMM simulation will take as input arguments:

Source: λ_0, θ, ϕ, polarization, etc.
Device: UR, ER, L, etc.

Given these input arguments, a generic TMM function cab simulate the device and calculate reflectance, transmittance, fields, etc.

It may return REF, TRN, or whatever else is desired.

4

Example Header for a Generic TMM Function

These comments are displayed at the command prompt by typing

`>>help tmm1d`

It is always a good idea to include a help section at the start of your codes.

```
function DAT = tmm1d(DEV,SRC)
% TMM1D     One-Dimensional Transfer Matrix Method
%
% DAT = tmm1d(DEV,SRC);
%
% INPUT ARGUMENTS
% ================
% DEV       Device Parameters
%   .er1    relative permittivity in reflection region
%   .ur1    relative permeability in reflection region
%   .er2    relative permittivity in transmission region
%   .ur2    relative permeability in transmission region
%   .ER     array containing permittivity of each layer
%   .UR     array containing permeability of each layer
%   .L      array containing thickness of each layer
%
% SRC       Source Parameters
%   .lam0   free space wavelength
%   .theta  elevation angle of incidence (radians)
%   .phi    azimuthal angle of incidence (radians)
%   .pte    amplitude of TE polarization
%   .ptm    amplitude of TM polarization
%
% OUTPUT ARGUMENTS
% ================
% DAT       Output Data
%   .REF    Reflectance
%   .TRN    Transmittance
```

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Slide 5

5

What Steps are Performed by TMM1D()

- Step 0 – Define problem
- Step 1 – Dashboard
- Step 2 – Describe device layers
- Step 3 – Compute wave vector components
- Step 4 – Compute gap medium parameters
- Step 5 – Initialize global scattering matrix
- Step 6 – Main loop through layers
- Step 7 – Compute reflection side scattering matrix
- Step 8 – Compute transmission side scattering matrix
- Step 9 – Update global scattering matrix
- Step 10 – Compute source
- Step 11 – Compute reflected and transmitted fields
- Step 12 – Compute reflectance and transmittance
- Step 13 – Verify conservation of power

human does this

computer does the rest

Step 6: Iterate through layers

- Compute **P** and **Q**
- Compute eigen-modes
- Compute layer scattering matrix
- Update global scattering matrix

tmm1d()

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Slide 6

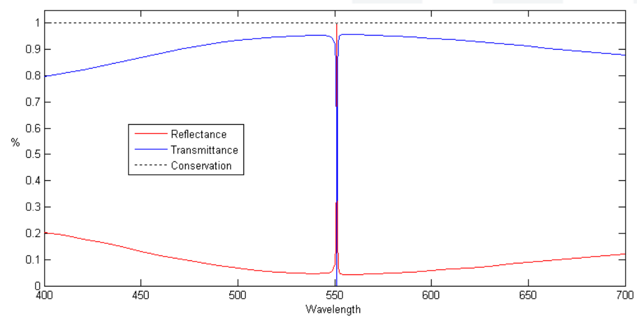
6

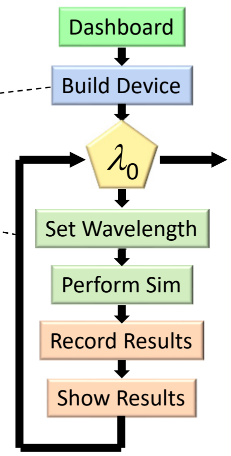
Wavelength or Frequency Parameter Sweep

By far, the most common parameter sweep is calculating the device behavior as a function of frequency or wavelength.

```
for nlam = 1 : NLAM
    SRC.lam0 = LAMBDA(nlam);
    DAT = tmm1d(DEV,SRC);
    REF(nlam) = DAT.REF;
end
```

```
UR = [ 1 1 1 ];
ER = [ 2.5 6.0 2.0 ];
L  = [ 0.5 0.78 0.25 ];
```





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Slide 7

7

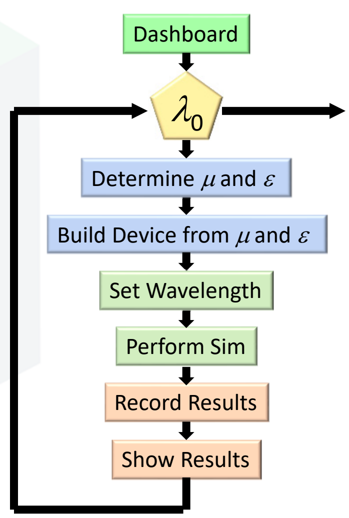
Incorporating Material Dispersion into a Parameter Sweep

Sometimes the material properties change significantly as a function of frequency, or wavelength.

This is called dispersion.

Dispersion can be incorporated into your parameter sweep by:

(1) Calculate the material properties at the given wavelength or frequency.
(2) Rebuild the device each iteration with the material properties that were just calculated.



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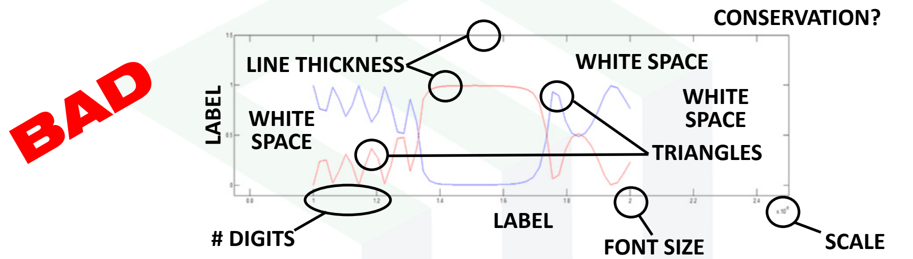
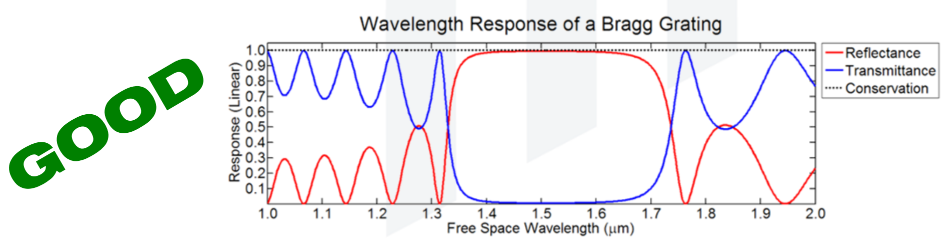
Slide 8

8

Bad Vs. Good Parameter Sweeps





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Slide 9

9