

Triangle Geometry

To duplicate the results of this benchmarking document exactly, build your triangle unit cell using the following code:

```
% INITIALIZE MATLAB
close all;
clc;
clear all;

% UNITS
meters = 1;
centimeters = 1e-2 * meters;
degrees = pi/180;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% STEP 1: INITIALIZE PARAMETERS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% SOURCE PARAMETERS
lam0 = 2 * centimeters;           %free space wavelength
theta = 0 * degrees;
phi = 0 * degrees;
pte = 1;
ptm = 0;

% DEVICE PARAMETERS
ur1 = 1.0;                        %permeability in reflection region
er1 = 2.0;                        %permittivity in reflection region
ur2 = 1.0;                        %permeability in transmission region
er2 = 9.0;                        %permittivity in transmission region
urd = 1.0;                        %permeability of device
erd = 6.0;                        %permittivity of device
Lx = 1.75 * centimeters;         %period along x
Ly = 1.5 * centimeters;         %period along y
d1 = 0.5 * centimeters;         %thickness of layer 1
d2 = 0.3 * centimeters;         %thickness of layer 2
w = 0.8*Ly;

% RCWA PARAMETERS
Nx = 512;                         %number of point along x in real-space grid
Ny = round(Nx*Ly/Lx);            %number of point along y in real-space grid
PQ = 1 * [1 1];                 %number of spatial harmonics along x and y

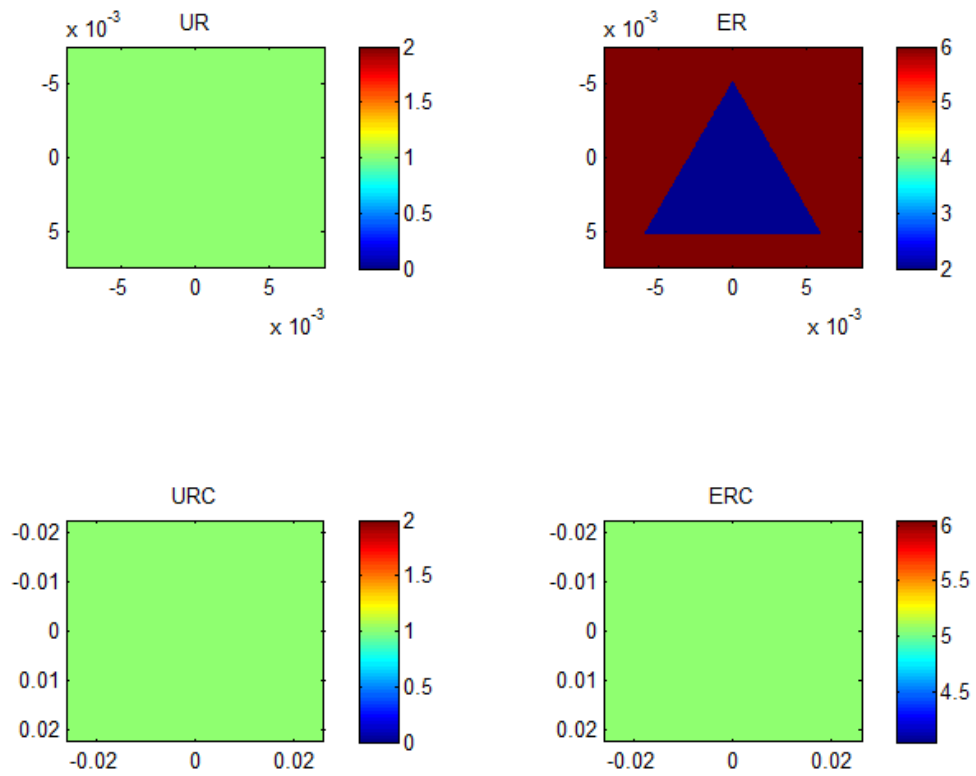
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% STEP 2: BUILD DEVICE LAYERS ON HIGH RESOLUTION GRID
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% CROSS SECTIONAL GRID
dx = Lx/Nx;                       %grid resolution along x
dy = Ly/Ny;                       %grid resolution along y
xa = [0:Nx-1]*dx;                 %x axis array
xa = xa - mean(xa);               %center x axis at zero
ya = [0:Ny-1]*dy;                 %y axis vector
ya = ya - mean(ya);               %center y axis at zero

% INITIALIZE LAYERS TO er AND ur
UR = urd * ones(Nx,Ny,2);
ER = erd * ones(Nx,Ny,2);
L = [ d1 d2 ];

% BUILD LAYER 1 (TRIANGLE)
h = 0.5*sqrt(3)*w;
ny = round(h/dy);
ny1 = round((Ny - ny)/2);
ny2 = ny1 + ny - 1;
for ny = ny1 : ny2
    f = (ny - ny1)/(ny2 - ny1);
    nx = round(f*w/Lx*Nx);
    nx1 = 1 + floor((Nx - nx)/2);
    nx2 = nx1 + nx;
    ER(nx1:nx2,ny,1) = er1;
end
```

Data Visualization



The Data

```
*****  
***** RCWA BENCHMARKING DOCUMENT *****  
***** 1x1 Spatial Harmonics *****  
*****  
*****
```

===== UNITS

meters = 1

===== STEP 1: DASHBOARD

lam0 = 0.02
theta = 0 deg.
phi = 0 deg.
pte = 1
ptm = 0

ur1 = 1
er1 = 2
ur2 = 1
er2 = 9

urd = 1
erd = 6
Lx = 0.0175
Ly = 0.015
d1 = 0.005
d2 = 0.003
w = 0.012

Nx = 512
Ny = 439
P = 1
Q = 1

===== STEP 2: BUILD DEVICE

dx = 3.418e-05
dy = 3.4169e-05

===== STEP 3: CONVOLUTION MATRICES

NH = 1
NLAY = 2

LAYER 1...

URC =
1

ERC =
5.0449

LAYER 2...

URC =
1

ERC =
6

===== STEP 4: WAVE VECTOR EXPANSION

I =
1

Z =
0

n1 = 1.4142
n2 = 3
k0 = 314.1593
kinc = [0;0;1.4142]

p = [0]
q = [0]

Kx =
0

Ky =
0

Kzref =
-1.4142

Kztrn =
3

RCWA Benchmark Data
1x1 Spatial Harmonics



===== STEP 5: FREE SPACE

Kz =
1

Q =
0 1
-1 0

W0 =
1 0
0 1

LAM =
0.0000 + 1.0000i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.0000 + 1.0000i

V0 =
0.0000 + 0.0000i 0.0000 - 1.0000i
0.0000 + 1.0000i 0.0000 + 0.0000i

===== STEP 6: INITIALIZE GLOBAL S

SG.S11 =
0 0
0 0

SG.S12 =
1 0
0 1

SG.S21 =
1 0
0 1

SG.S22 =
0 0
0 0

===== STEP 7: MAIN LOOP

LAYER 1...

P =
0 1
-1 0

Q =
0 5.0449
-5.0449 0

OMEGA_SQ =
-5.0449 0
0 -5.0449

W =
1 0
0 1

LAM =
0.0000 + 2.2461i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.0000 + 2.2461i

V =
0.0000 + 0.0000i 0.0000 - 2.2461i
0.0000 + 2.2461i 0.0000 + 0.0000i

A =
1.4452 0
0 1.4452

B =
0.5548 0
0 0.5548

X =
-0.9262 + 0.3770i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.9262 + 0.3770i

S.S11 =
-0.1544 - 0.2819i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.1544 - 0.2819i

S.S12 =
-0.8305 + 0.4549i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.8305 + 0.4549i

S.S21 =
-0.8305 + 0.4549i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.8305 + 0.4549i

S.S22 =
-0.1544 - 0.2819i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.1544 - 0.2819i

SG.S11 =
-0.1544 - 0.2819i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.1544 - 0.2819i

RCWA Benchmark Data
1x1 Spatial Harmonics

SG.S12 =
-0.8305 + 0.4549i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.8305 + 0.4549i

SG.S21 =
-0.8305 + 0.4549i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.8305 + 0.4549i

SG.S22 =
-0.1544 - 0.2819i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.1544 - 0.2819i

LAYER 2...

P =
0 1
-1 0

Q =
0 6
-6 0

OMEGA_SQ =
-6 0
0 -6

W =
1 0
0 1

LAM =
0.0000 + 2.4495i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.0000 + 2.4495i

V =
0.0000 + 0.0000i 0.0000 - 2.4495i
0.0000 + 2.4495i 0.0000 + 0.0000i

A =
1.4082 0
0 1.4082

B =
0.5918 0
0 0.5918

X =
-0.6727 - 0.7400i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.6727 - 0.7400i

S.S11 =
-0.5085 + 0.3235i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.5085 + 0.3235i

S.S12 =
-0.4283 - 0.6733i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.4283 - 0.6733i

S.S21 =
-0.4283 - 0.6733i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.4283 - 0.6733i

S.S22 =
-0.5085 + 0.3235i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.5085 + 0.3235i

SG.S11 =
-0.2280 + 0.3606i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.2280 + 0.3606i

SG.S12 =
0.7386 + 0.5219i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.7386 + 0.5219i

SG.S21 =
0.7386 + 0.5219i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.7386 + 0.5219i

SG.S22 =
-0.2638 + 0.3354i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.2638 + 0.3354i

===== STEP 8: REFLECTION SIDE

Q =
0 2
-2 0

LAM =
0.0000 + 1.4142i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.0000 + 1.4142i

Wref =
1 0
0 1

Vref =
0.0000 + 0.0000i 0.0000 - 1.4142i
0.0000 + 1.4142i 0.0000 + 0.0000i

RCWA Benchmark Data
1x1 Spatial Harmonics

A =
2.4142 0
0 2.4142

B =
-0.4142 0
0 -0.4142

SR.S11 =
0.1716 0
0 0.1716

SR.S12 =
0.8284 0
0 0.8284

SR.S21 =
1.1716 0
0 1.1716

SR.S22 =
-0.1716 0
0 -0.1716

===== STEP 9: TRANSMISSION SIDE

Q =
0 9
-9 0

LAM =
0.0000 + 3.0000i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.0000 + 3.0000i

Wtrn =
1 0
0 1

Vtrn =
0.0000 + 0.0000i 0.0000 - 3.0000i
0.0000 + 3.0000i 0.0000 + 0.0000i

A =
4 0
0 4

B =
-2 0
0 -2

ST.S11 =
-0.5000 0
0 -0.5000

ST.S12 =
1.5000 0
0 1.5000

ST.S21 =
0.5000 0
0 0.5000

ST.S22 =
0.5000 0
0 0.5000

===== STEP 10: CONNECT

SG.S11 =
-0.3156 - 0.0437i 0.0000 + 0.0000i
0.0000 + 0.0000i -0.3156 - 0.0437i

SG.S12 =
1.2541 + 0.5773i 0.0000 + 0.0000i
0.0000 + 0.0000i 1.2541 + 0.5773i

SG.S21 =
0.5912 + 0.2721i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.5912 + 0.2721i

SG.S22 =
0.2384 + 0.2113i 0.0000 + 0.0000i
0.0000 + 0.0000i 0.2384 + 0.2113i

===== STEP 11: FIELDS

delta =
1

ate = [0;1;0]
atm = [1;0;0]
EP = [0;1;0]

esrc =
0
1

csrc =
0
1

RCWA Benchmark Data
1x1 Spatial Harmonics

```
cref =  
  0.0000 + 0.0000i  
 -0.3156 - 0.0437i  
  
ctrn =  
  0.0000 + 0.0000i  
  0.5912 + 0.2721i  
  
eref =  
  0.0000 + 0.0000i  
 -0.3156 - 0.0437i  
  
etrn =  
  0.0000 + 0.0000i  
  0.5912 + 0.2721i  
  
rx =  
  0  
  
ry =  
 -0.3156 - 0.0437i  
  
rz =  
  0  
  
tx =  
  0  
  
ty =  
  0.5912 + 0.2721i  
  
tz =  
  0
```

===== STEP 12: DIFFRACTION EFFICIENCIES

```
R =  
  0.1015  
  
T =  
  0.8985  
  
REF = 0.10149  
TRN = 0.89851
```

===== STEP 13: CONSERVATION

```
REF = 10.149%  
TRN = 89.851%  
-----  
CON = 100%
```