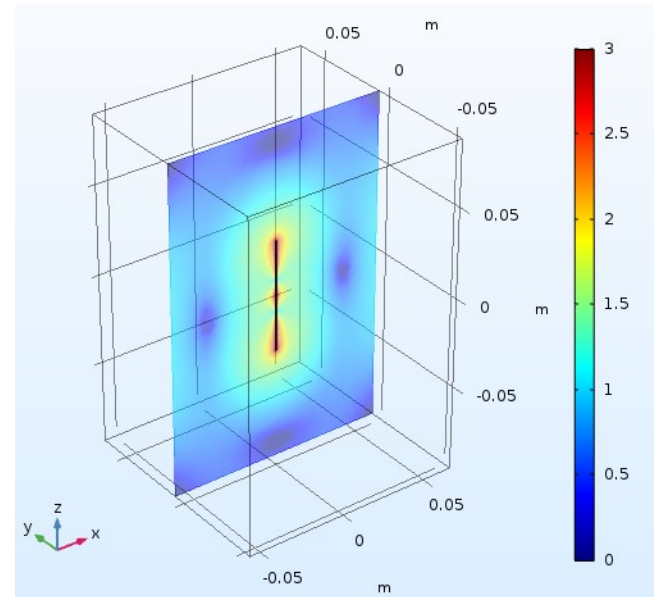
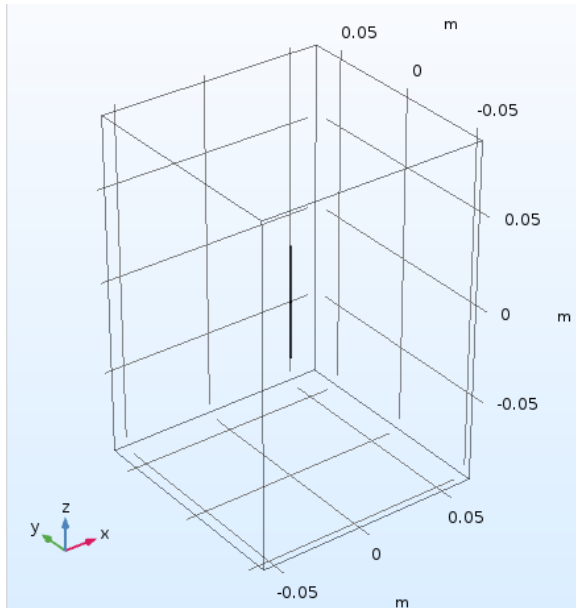
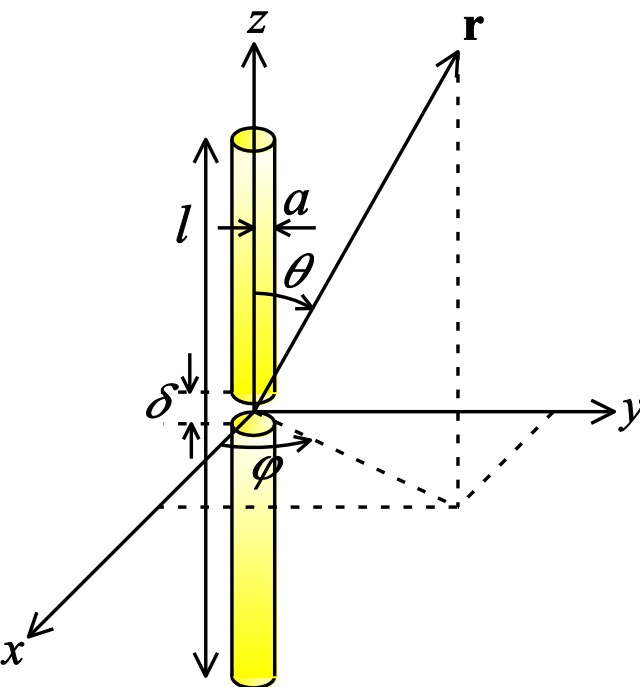


# COMSOLによるダイポールアンテナの解析

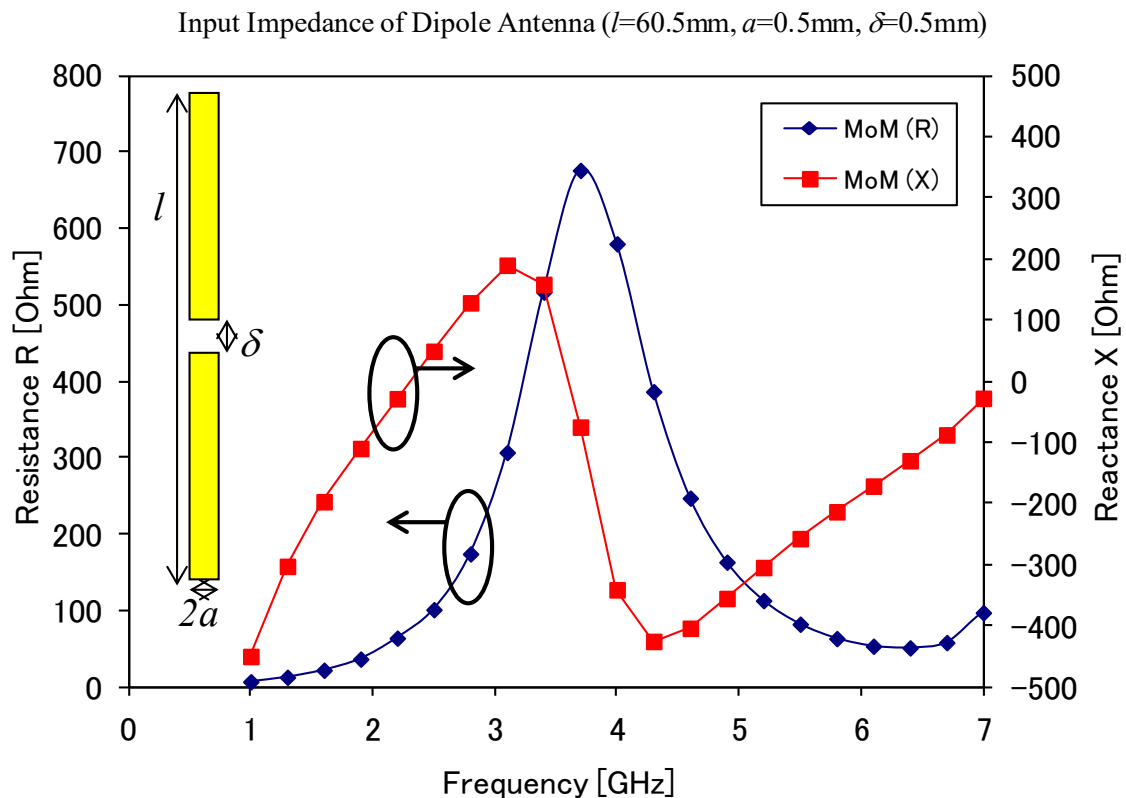
COMSOL 5.3a



平野 拓一



$l=60.5 \text{ mm}$   
 $a=0.5 \text{ mm}$   
 $\delta=0.5 \text{ mm}$



# パラメータ

dipole\_antenn

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Model Builder

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
  - P<sub>i</sub> Parameters**
  - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Far-Field Domain 1
      - Scattering Boundary Condition 1
      - Lumped Port 1

Settings Properties

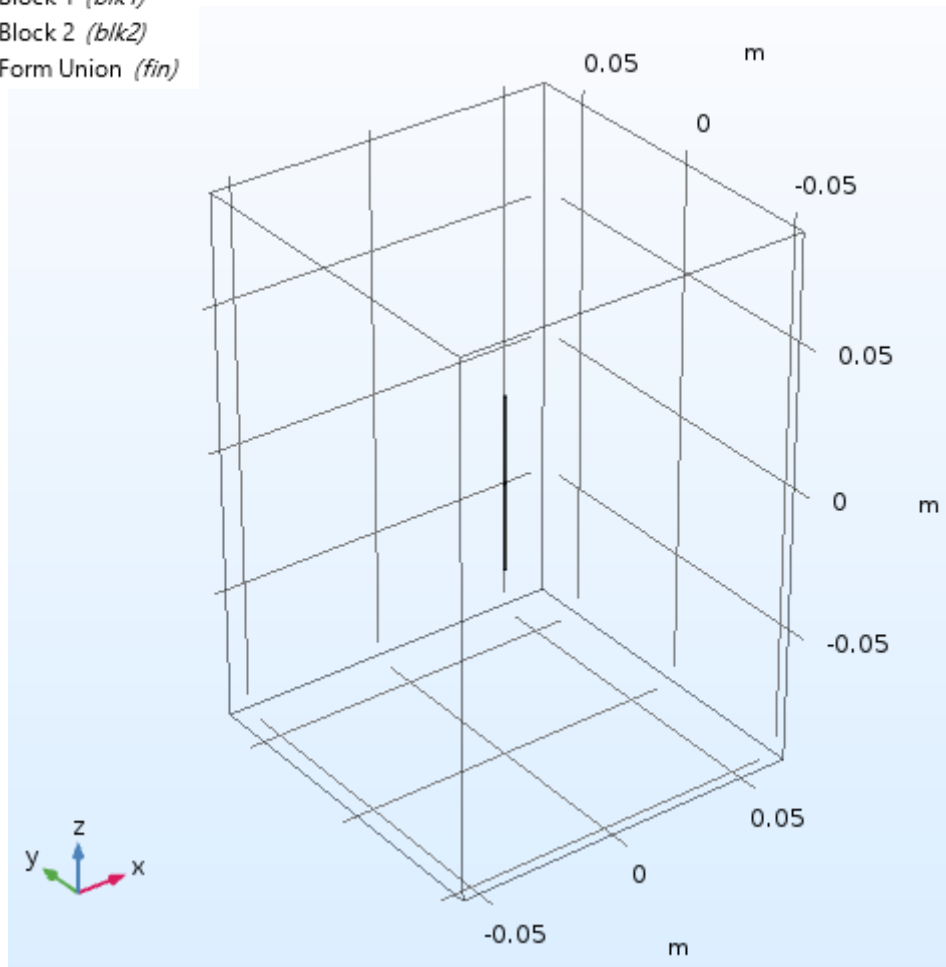
Parameters

Parameters

Name	Expression	Value	Description
l	60.5 [mm]	0.0605 m	Length of dipole
a	0.5 [mm]	5E-4 m	Radius of dipole
d	0.5 [mm]	5E-4 m	Length of gap
wl	122 [mm]	0.122 m	
aw_x	wl	0.122 m	
aw_y	wl	0.122 m	
aw_z	l+w	0.1825 m	

## モデル

- ▶ Definitions
- ▶ Geometry 1
  - Cylinder 1 (*cyl1*)
  - Cylinder 2 (*cyl2*)
  - Block 1 (*blk1*)
  - Block 2 (*blk2*)
  - Form Union (*fin*)



## Cylinder

Build Selected  Build All Objects

Label:

## Object Type

Type:

## Size and Shape

Radius:  m

Height:  m

## Position

x:  m

y:  m

z:  m

## Axis

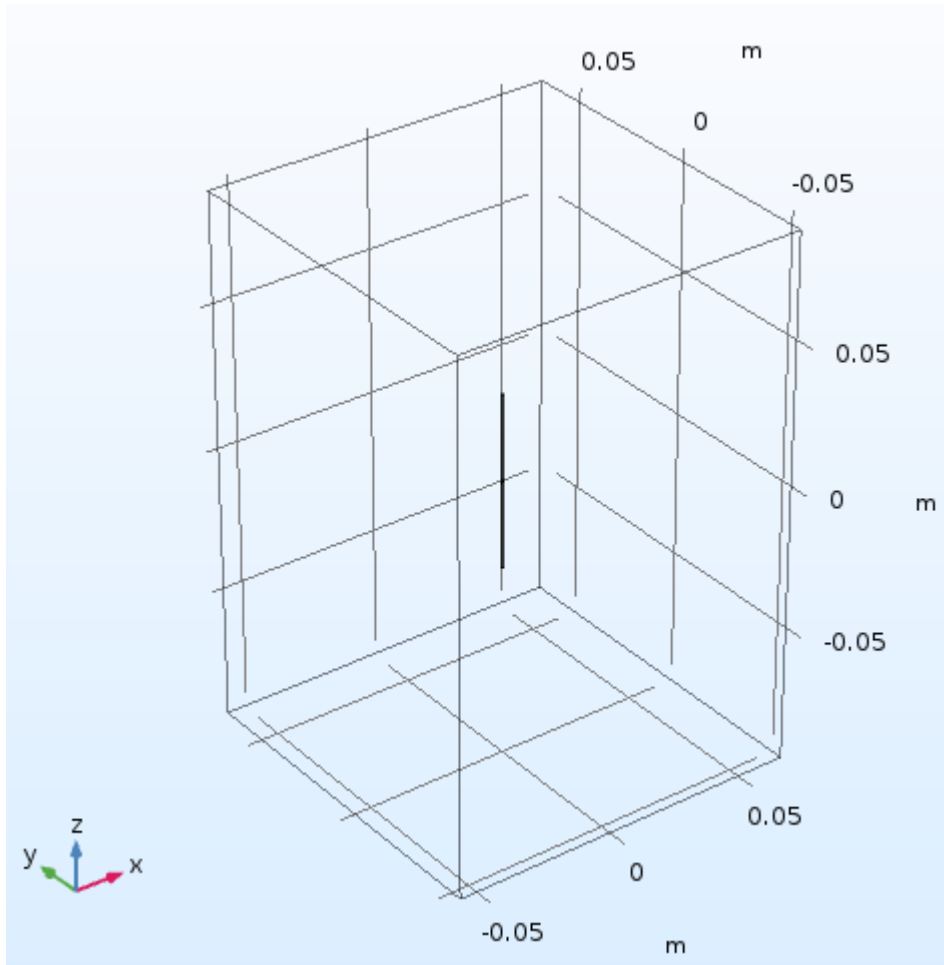
Axis type:

## Rotation Angle

Rotation:  deg

## Coordinate System

Work plane:



## Cylinder

Build Selected Build All Object

Label:

### Object Type

Type:

### Size and Shape

Radius:  m

Height:  m

### Position

x:  m

y:  m

z:  m

### Axis

Axis type:

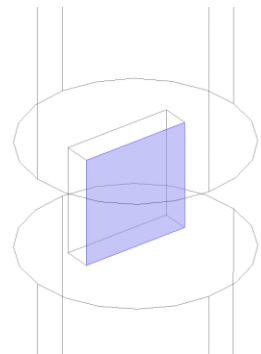
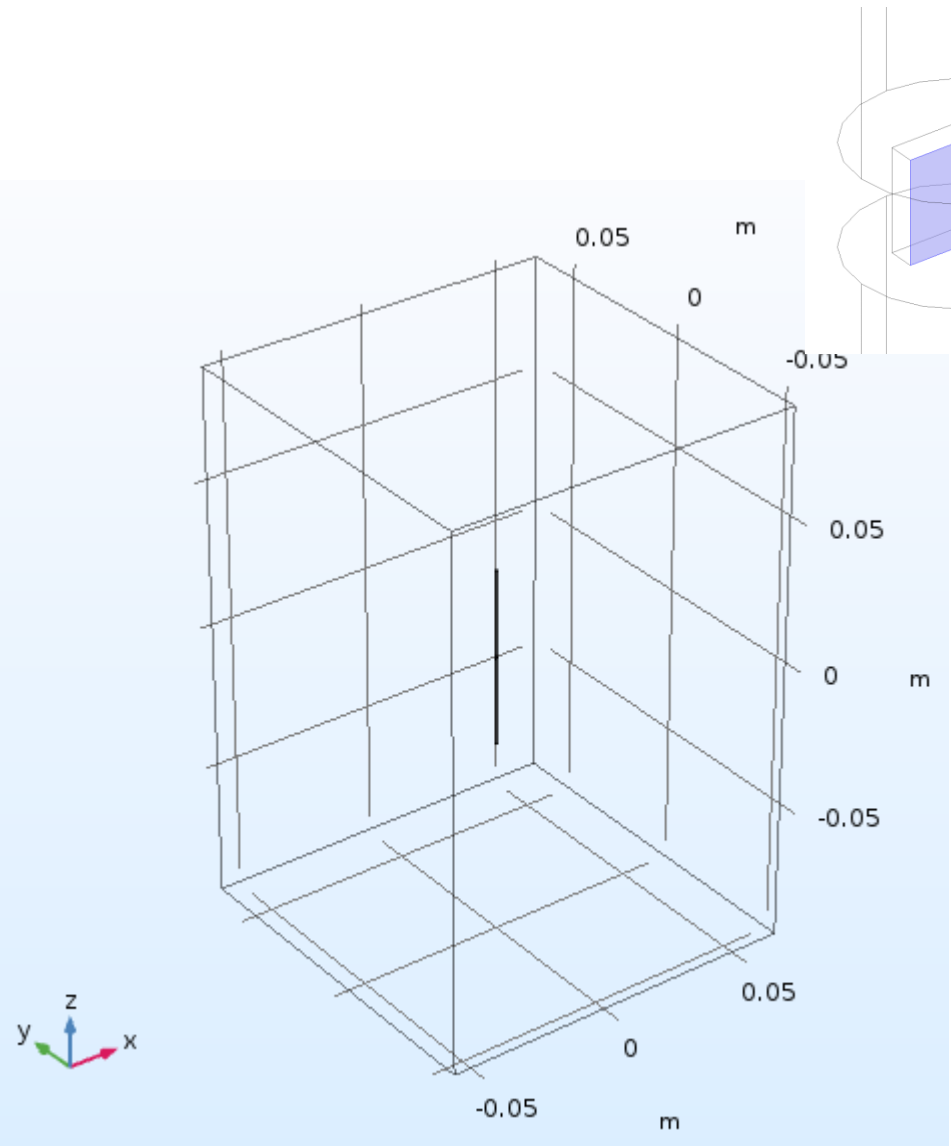
### Rotation Angle

Rotation:  deg

### Coordinate System

Work plane:

## モデル



## Block

Build Selected  Build All Object Label: 

## Object Type

Type: 

## Size and Shape

Width:  mDepth:  mHeight:  m

## Position

Base: x:  my:  mz:  m

## Axis

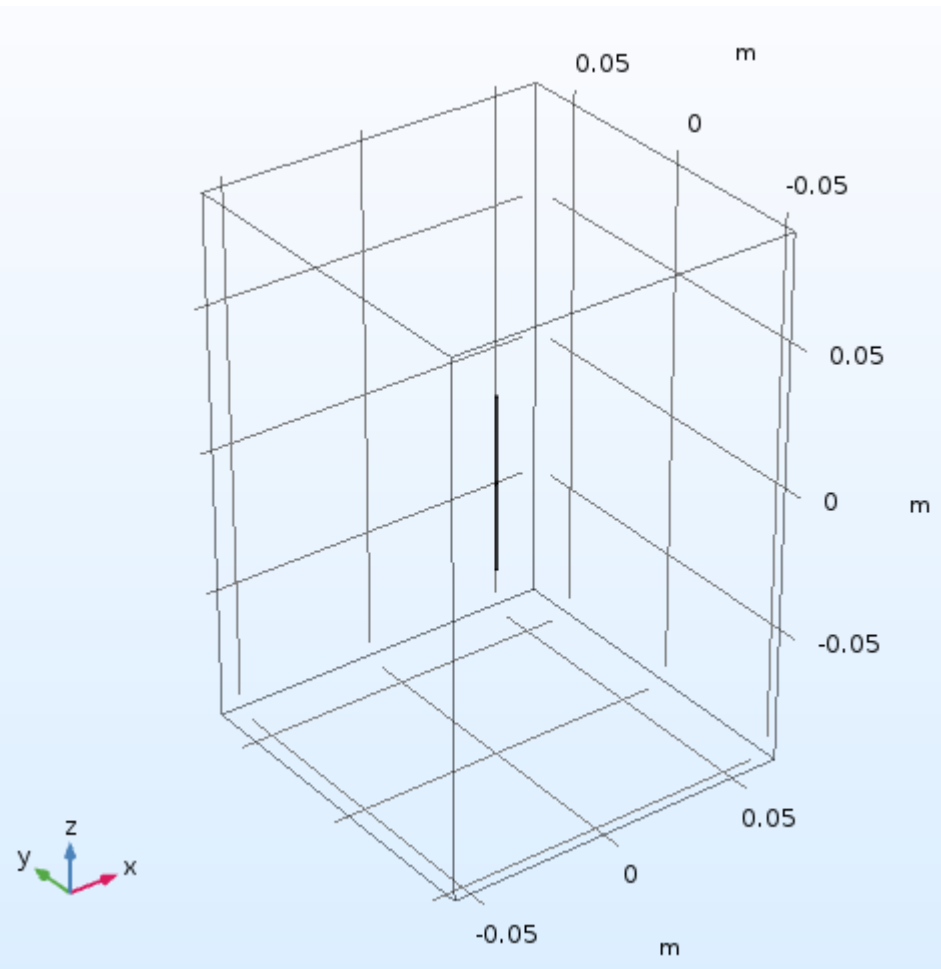
Axis type: 

## Rotation Angle

Rotation:  deg

## Coordinate System

Work plane:



## Block

Build Selected Build All Object

Label:

### Object Type

Type:

### Size and Shape

Width:  m

Depth:  m

Height:  m

### Position

Base:

x:  m

y:  m

z:  m

### Axis

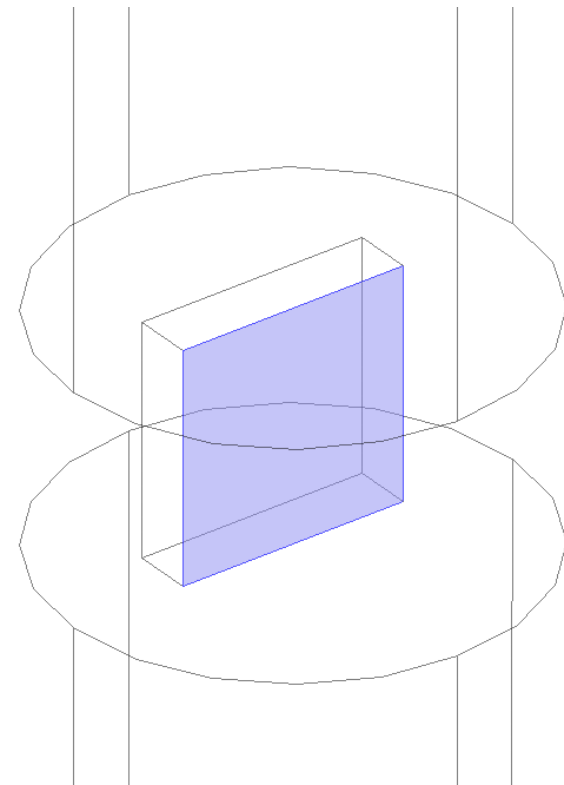
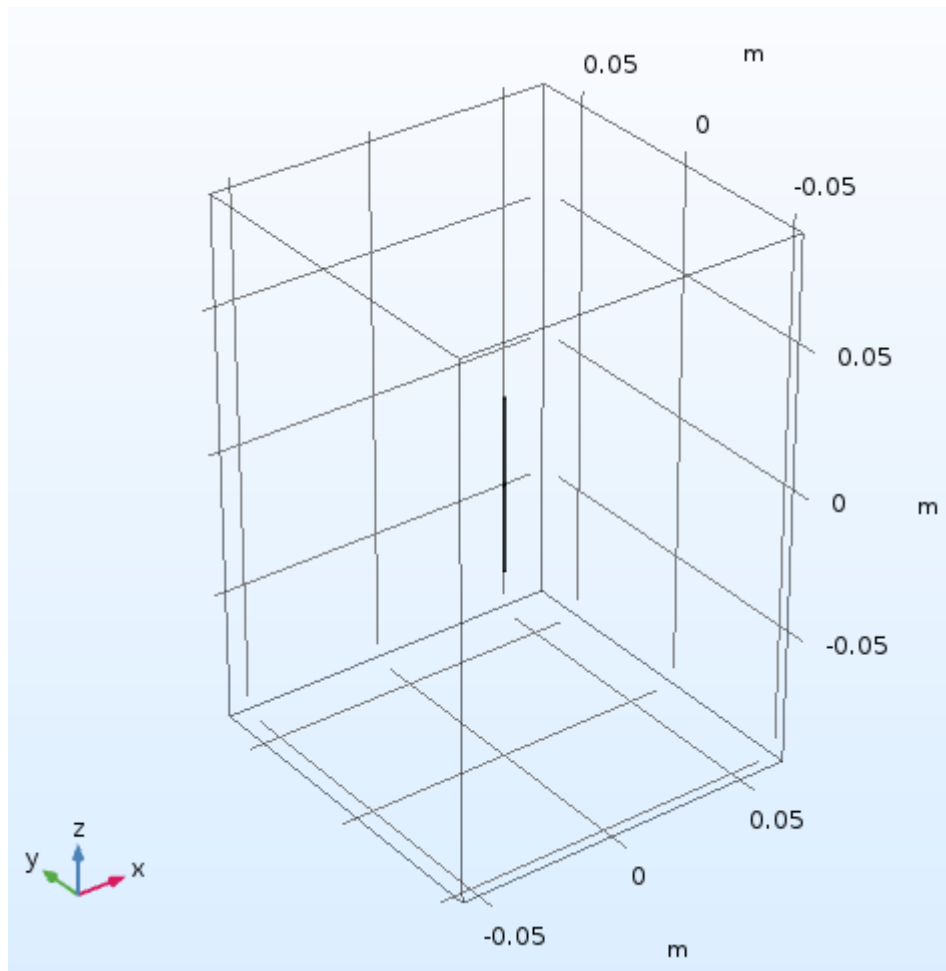
Axis type:

### Rotation Angle

Rotation:  deg

### Coordinate System

Work plane:





The screenshot displays the COMSOL Multiphysics interface for a dipole antenna model. The top menu bar includes File, Home, Definitions, Geometry, Materials, Physics, Mesh, Study, Results, and Developer. The ribbon contains various toolbars for Application, Model, Definitions, Geometry, Materials, Physics, Mesh, Study, Results, and Layout. The left sidebar shows the Model Builder tree with the following structure:

- dipole\_antenna\_app.mph (root)
  - Global Definitions
    - Parameters 1
  - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
      - Cylinder 1 (cyl1)
      - Cylinder 2 (cyl2)
      - Block 1 (blk1)
      - Block 2 (blk2)
      - Cylinder 3 (cyl3) (highlighted)
      - Form Union (fin)
    - Materials
    - Electromagnetic Wave
    - Mesh 1
    - Study 1
    - Study 2
    - Results

The Settings panel for 'Cylinder 3' is open, showing the following parameters:

- Label: Cylinder 3
- Object Type: Solid
- Size and Shape: Radius: a, Height:  $l/2-d/2$
- Position: x: 0, y: 0, z:  $-l/2$
- Axis: z-axis

The Graphics window shows a 3D view of the antenna structure. A pink arrow points to the 'Highlight Result' icon in the Settings panel.

「Highlight Result」を選択しておくと、左のメニューで選んでいるオブジェクトに色がついて見やすい

- Materials
  - Air (*mat1*)
    - Basic (*def*)
  - Cu (*mat2*)
    - Basic (*def*)

— Output properties —

Property	Variable	Expression	Unit
Relative permittivity	epsilon_r...	1	1
Relative permeability	mu_r_iso...	1	1
Electrical conductiv...	sigma_is...	0	S/m

— Output properties —

Property	Variable	Expression	Unit
Relative permittivity	epsilon_r...	1	1
Relative permeability	mu_r_iso...	1	1
Electrical conductiv...	sigma_is...	5.8e7	S/m

dipole\_antenna\_cubic\_abc.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

**Model Builder**

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
      - Air (mat1)
        - Basic (def)
        - Cu (mat2)
          - Basic (def)
        - Electromagnetic Waves, Frequency Domain
        - Mesh 1
      - Study 1
      - Study 2
      - Results

**Settings Properties**

Material

Label: Air

Geometric Entity Selection

Geometric entity level: Domain

Selection: Manual

Active

1
2 (overridden)
3 (overridden)
4

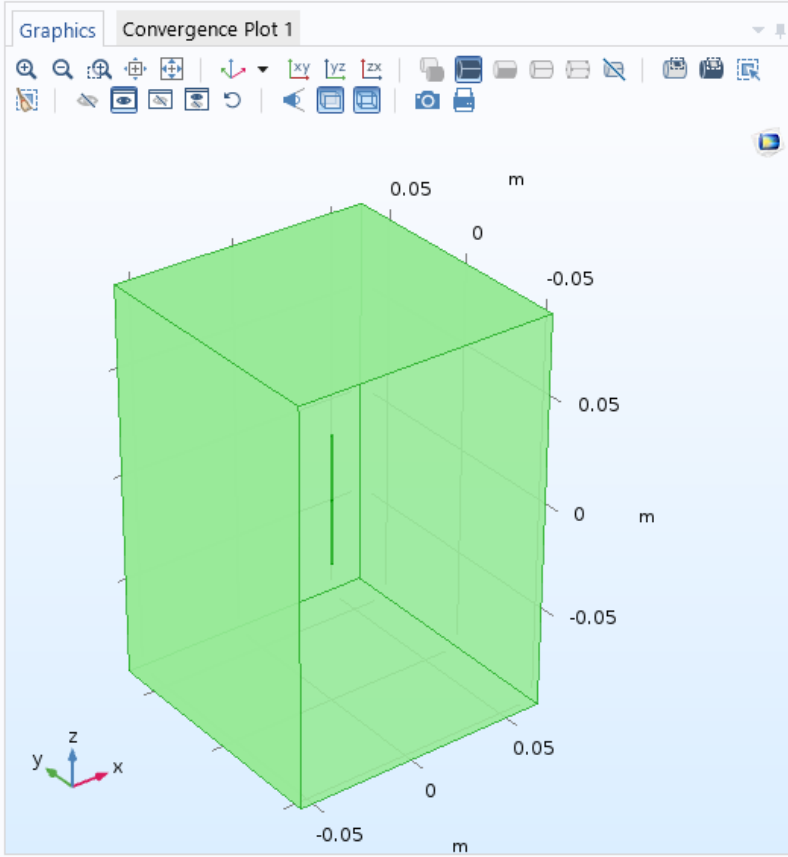
Override

Material Properties

Material Contents

Property	Variable	Value	Unit
<input checked="" type="checkbox"/> Relative permittivity	epsilo...	1	1
<input checked="" type="checkbox"/> Relative permeability	mur_is...	1	1
<input checked="" type="checkbox"/> Electrical conductivity	sigma...	0	S/m

Appearance



**Progress Log**

Progress Log

The screenshot displays the COMSOL Multiphysics interface for a project named 'dipole\_antenna\_cubic\_abc.mph'. The 'Material Builder' window is open, showing the 'Material' tab. The 'Label' is set to 'Cu'. Under 'Geometric Entity Selection', 'Domain' is chosen, and 'Manual' selection is active. A list of domains is shown with '2' and '3' selected. The 'Material Contents' table is expanded, showing the following properties:

Property	Variable	Value	Unit
<input checked="" type="checkbox"/> Relative permittivity	epsilo...	1	1
<input checked="" type="checkbox"/> Relative permeability	mur_is...	1	1
<input checked="" type="checkbox"/> Electrical conductivity	sigma...	5.8e7	S/m

The 'Graphics' window shows a 3D model of a dipole antenna structure. A text box is overlaid on the bottom of the screenshot, providing instructions on how to select the back object.

奥の物体を選ぶときは”Selection”を”All domains”にして全て選択してから不要な領域を”-”で除いてもいい。  
また、集中ポートの設定で説明するように、奥のものを明示的に選択してもよい。

# Object Colorの変更

The screenshot displays the COMSOL Multiphysics interface for a model named 'dipole\_antenna\_app.mph'. The 'Model Builder' tree on the left shows the hierarchy: dipole\_antenna\_app.mph (root) > Global Definitions > Parameters 1 > Materials > Dipole (comp1) > Materials > Conductor (mat2) > Basic (def). The 'Settings' window for the selected material is open, showing the 'Appearance' section. A context menu is open over the color selection area, with 'Show Selection Colors' and 'Show Material Color and Texture' checked. The 'Graphics' window shows a 3D model of a dipole antenna with a coordinate system (x, y, z). The 'Progress' window at the bottom right shows a table of Directivity data.

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
90.000	360.00	1.6764	2.2437

# Object Colorの変更

dipole\_antenna\_app.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Application Dipole Add Component Parameters Variables f(x) Geometry Materials Electromagnetic Waves, Frequency Domain Build Mesh Compute S-Parameter (frequency char.) Add Plot Group Layout

Model Definitions Physics Mesh Study Results

Model Builder

- dipole\_antenna\_app.mph (root)
  - Global Definitions
    - Parameters 1
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
      - Air (mat1)
      - Conductor (mat2)
        - Basic (def)
    - Electromagnetic Waves, Frequency
    - Mesh 1
    - Study 1
    - Study 2
    - Results

Settings

Materials

Material Overview

Material	Selection
Air (mat1)	Domains 1, 3, 5
Conductor (mat2)	Domains 2, 4

Graphics

Progress Log Directivity

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
90.000	360.00	1.6764	2.2437

823 MB | 1008 MB

# 解析種別

dipole\_antenna\_cubic\_abc.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

**Model Builder**

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Far-Field Domain 1
        - Scattering Boundary Condition 1
        - Lumped Port 1
    - Mesh 1
    - Study 1
    - Results

**Settings Properties**

Wave Equation, Electric

Label: Wave Equation, Electric 1

Domain Selection

Selection: All domains

Active

1  
2  
3  
4

Override and Contribution

Equation

Show equation assuming:  
Study 1, Frequency Domain

$$\nabla \times \mu_r^{-1} (\nabla \times \mathbf{E}) - k_0^2 (\epsilon_r - \frac{j\sigma}{\omega\epsilon_0}) \mathbf{E} = 0$$

Model Input

Coordinate System Selection

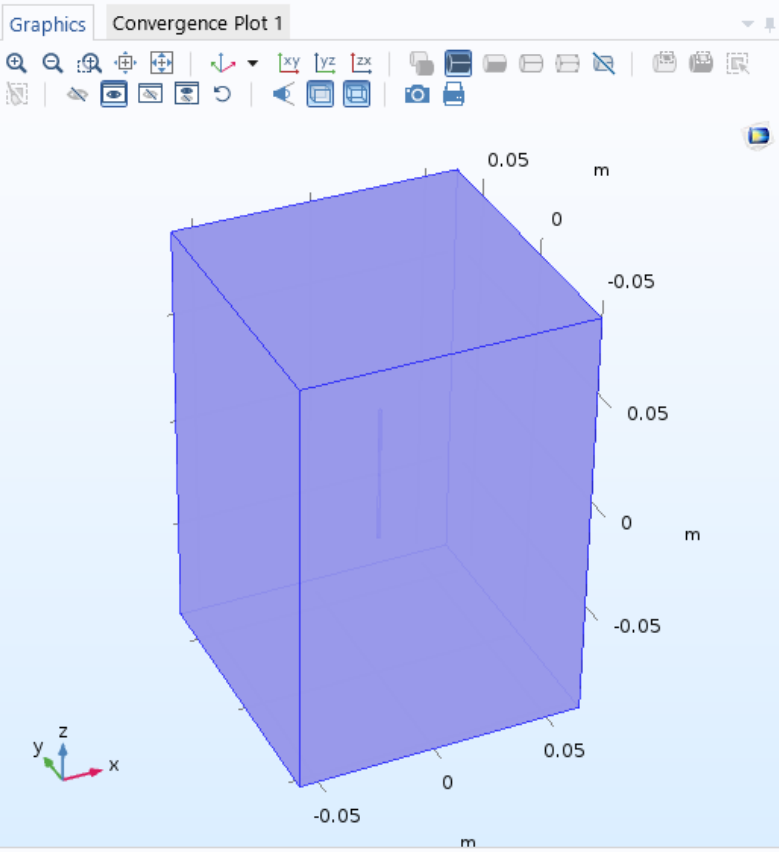
Coordinate system:  
Global coordinate system

Electric Displacement Field

Electric displacement field model:  
Relative permittivity

Relative permittivity:  
 $\epsilon_r$  From material

**Graphics** Convergence Plot 1



Progress Log Table 1

8.85 8.12 AUTO 8.5 850 0.85 e-1 e-3

890 MB | 998 MB

# 遠方界領域の設定(利得・遠方界の計算に必要)<sup>No. 16</sup>

The screenshot displays the COMSOL Multiphysics interface for a simulation titled "dipole\_antenna\_cubic\_abc.mph". The software is running in the "Developer" mode. The "Model Builder" on the left shows the hierarchical structure of the model, with the "Far-Field Domain 1" selected under the "Dipole (comp1)" component. The "Settings" pane for "Far-Field Domain 1" is visible, showing the "Domain Selection" set to "Manual" and a list of active domains containing "1". The "Graphics" window on the right shows a 3D visualization of a green cube representing the far-field domain, centered at the origin of the x-y-z coordinate system. The axes range from -0.05 to 0.05 meters. The "Progress" window at the bottom shows the simulation progress, with a table of values including 8.85, 8.5, 850, and 0.85.

885 MB | 993 MB



# 遠方界領域の設定(利得・遠方界の計算に必要)<sup>No. 17</sup>

The screenshot displays the COMSOL Multiphysics software interface for a model named "dipole\_antenna\_cubic\_abc.mph". The main window is divided into several panels:

- Model Builder:** Shows the hierarchical structure of the model, including Global Definitions, Parameters, Materials, and the Electromagnetic Wave physics interface.
- Settings (Far-Field Calculation):**
  - Label: Far-Field Calculation 1
  - Boundary Selection: Manual
  - Selection: A list of boundaries (1, 2, 3, 4, 5, 24) is shown, with boundary 24 selected.
  - Override and Contribution: Empty.
  - Far-Field Calculation:
    - Far-field variable name: Efar
    - Options for symmetry in the x=0, y=0, and z=0 planes are unchecked.
    - Boundary relative to domain: Outside
    - Reset Far-Field Boundaries button is present.
- Graphics:** A 3D visualization of a green cubic domain with axes labeled x, y, and z. The domain extends from -0.05 to 0.05 meters along each axis.
- Messages:** A log window at the bottom showing system messages, including the file path and a note that some geometric entities are hidden.

765 MB | 860 MB

# 境界条件

The screenshot displays the COMSOL Multiphysics interface for a simulation titled "dipole\_antenna\_cubic\_abc.mph". The left-hand side features the Model Builder tree, which is expanded to show the "Scattering Boundary Condition 1" under the "Electromagnetic Waves, Frequency Domain" section. The central panel shows the "Settings" for this boundary condition, including a "Boundary Selection" table with a list of active boundaries (1, 2, 3, 4, 5, 24) and a "Coordinate System Selection" set to "Global coordinate system". The "Scattering Boundary Condition" section is configured with "No incident field" and "Plane wave" scattered wave type. The right-hand side shows a 3D visualization of a green cube with side lengths of 0.05 m, centered at the origin of the global coordinate system (x, y, z). The bottom status bar indicates a memory usage of 883 MB | 996 MB.

Model Builder

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Far-Field Domain 1
      - Scattering Boundary Condition 1
      - Lumped Port 1
    - Mesh 1
    - Study 1
    - Results

Settings Properties

Scattering Boundary Condition

Label: Scattering Boundary Condition 1

Boundary Selection

Selection: Manual

Active	Selection
<input checked="" type="checkbox"/>	1
<input checked="" type="checkbox"/>	2
<input checked="" type="checkbox"/>	3
<input checked="" type="checkbox"/>	4
<input checked="" type="checkbox"/>	5
<input checked="" type="checkbox"/>	24

Override and Contribution

Equation

Coordinate System Selection

Coordinate system: Global coordinate system

Scattering Boundary Condition

Incident field: No incident field

Scattered wave type: Plane wave

Order: First order

Graphics Convergence Plot 1

Progress Log Table 1

8.85 e-12 AUTO 0.5 e-1 850 e-3 0.85

883 MB | 996 MB

dipole\_antenna\_cubic\_abc.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Model Builder

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Far-Field Domain 1
      - Scattering Boundary Condition 1
      - Lumped Port 1
  - Mesh 1
  - Study 1
  - Results

Settings Properties

Lumped Port

Label: Lumped Port 1

Boundary Selection

Selection: Manual

15

Active

Override and Contribution

Equation

Lumped Port Properties

Lumped port name: 1

Type of lumped port: User defined

Height of lumped port:  $h_{port}$  d m

Width of lumped port:  $w_{port}$  a m

Direction between lumped port terminals:

0	x
0	y
1	z

Terminal type: Cable

Wave excitation at this port:

Graphics Convergence Plot 1

Progress Log Table 1

8.85 e-12 AUTO 8.5 e-1 850 e-3 0.85

878 MB | 991 MB

# 集中ポート: 選択 (奥にある面を選択するとき) No. 20

The screenshot displays the COMSOL Multiphysics interface for a model named "dipole\_antenna\_cubic\_abc.mph". The "Model Builder" tree on the left shows the hierarchy: Global Definitions (Parameters, Materials) > Dipole (comp1) > Electromagnetic Waves, Frequency Domain > Lumped Port 1. The "Settings" pane for "Lumped Port 1" is active, showing the following configuration:

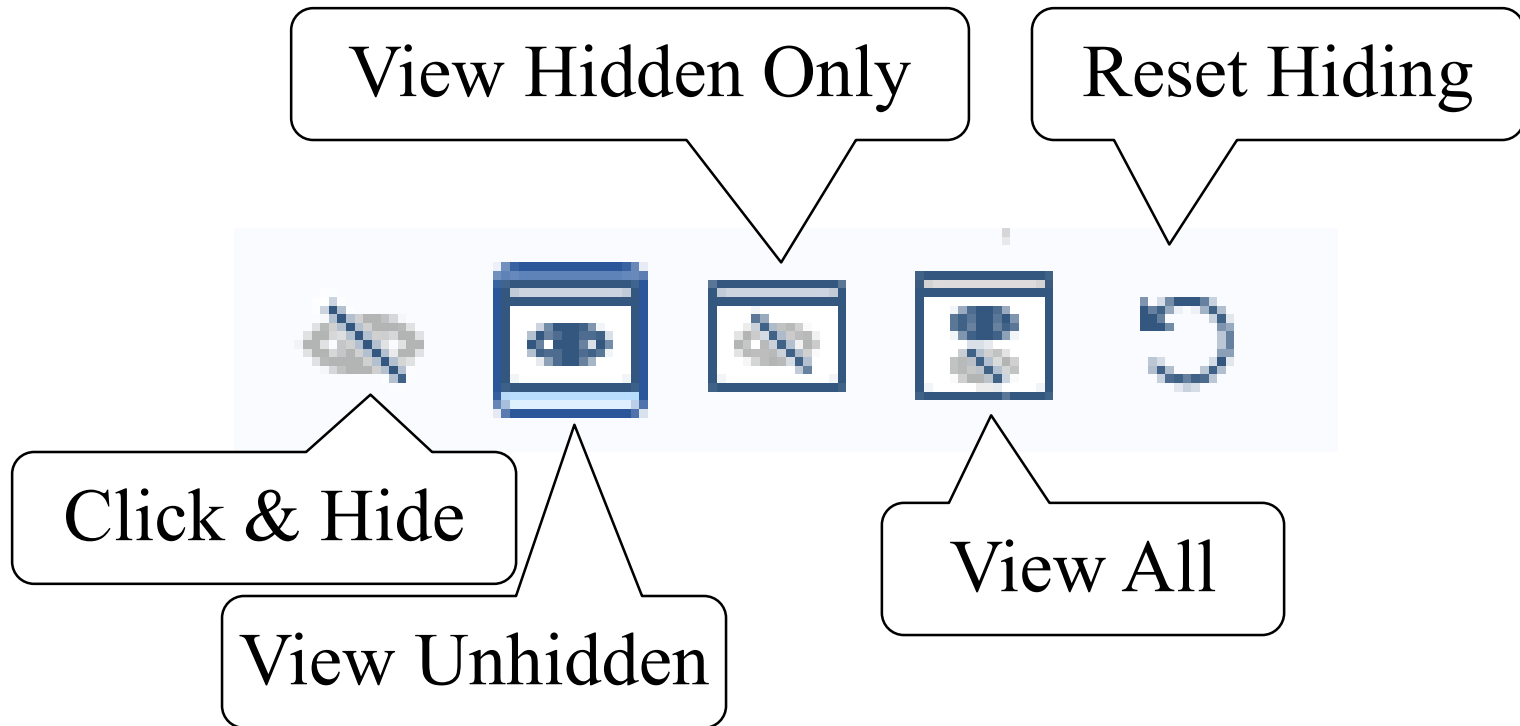
- Selection: Manual
- Active:
- Lumped port name: 1
- Type of lumped port: User defined
- Height of lumped port:  $h_{port}$  d m
- Width of lumped port:  $w_{port}$  a m
- Direction between lumped port terminals: 

0	x
0	y
1	z
- Terminal type: Cable
- Wave excitation at this port: On
- Voltage:  $V_0$  1[V] V

The "Graphics" window shows a 3D view of the dipole antenna structure with a coordinate system (x, y, z) at the bottom left. The "Progress" and "Log" windows are visible at the bottom right.

1.03 GB | 1.21 GB

# 集中ポート: 選択 (奥にある面を選択するとき) <sup>No. 21</sup>



1. “Click & Hide”を押す。
2. すると、次にクリックした物体(面)は選択から除かれる。ここで、選択したくない物体(面)をクリックして除いておく
3. 選択したい物体(面)が選べるようになったら、もう一度“Click & Hide”を押し、選択できるようにする。
4. そして、物体(面)をクリックすると、奥にあった物体(面)を選択できる。

# 集中ポート: 選択 (奥にある面を選択するとき) No. 22

The screenshot displays the COMSOL Multiphysics interface for a model named "dipole\_antenna\_cubic\_abc.mph". The "Model Builder" tree on the left shows the hierarchy: Global Definitions (Parameters, Materials) > Dipole (comp1) > Electromagnetic Waves, Frequency Domain > Wave Equation, Electric 1 > Perfect Electric Conductor 1 > Lumped Port 1. The "Settings" pane for "Lumped Port 1" is active, showing the following configuration:

- Selection: Manual
- Active: 15
- Override and Contribution: (empty)
- Equation: (empty)
- Lumped Port Properties:
  - Lumped port name: 1
  - Type of lumped port: User defined
  - Height of lumped port:  $h_{port}$  d m
  - Width of lumped port:  $w_{port}$  a m
  - Direction between lumped port terminals:

0	x
0	y
1	z
  - Terminal type: Cable
  - Wave excitation at this port: On
  - Voltage:  $V_0$  1[V] V

The "Graphics" window shows a 3D view of the antenna structure with a blue rectangular lumped port highlighted on the back face. A coordinate system (x, y, z) is visible at the bottom left of the graphics window. The "Progress" and "Log" windows are also visible at the bottom right.

1.03 GB | 1.2 GB

# 解析条件

The screenshot displays the COMSOL Multiphysics interface for a model named "dipole\_antenna\_cubic\_abc.mph". The "Model Builder" tree on the left shows the hierarchy: Global Definitions (Parameters, Materials), Dipole (comp1) (Definitions, Geometry 1, Materials, Electromagnetic Waves, Frequency Domain), Mesh 1, and Study 1 (Step 1: Frequency Domain, Solver Configurations, Solution 1 (sol1), Results).

The "Settings" pane for the "Frequency Domain" study is active, showing the following configuration:

- Label: Frequency Domain
- Study Settings:
  - Frequency unit: GHz
  - Frequencies: 2.45 GHz
  - Load parameter values: Browse... Read File
  - Reuse solution from previous step: Auto
- Results While Solving
- Physics and Variables Selection:
  - Modify model configuration for study step:
  - Table with columns: Physics interface, Solve for, Discretization. Row: Electromagnetic Waves, Fre..., , Physics settings
- Values of Dependent Variables
- Mesh Selection
- Adaptation and Error Estimates
- Study Extensions

The "Graphics" window shows a 3D model of a cubic antenna structure within a cylindrical waveguide, with a coordinate system (x, y, z) at the bottom left.

The "Progress" window at the bottom right shows a table with columns for "Progress", "Log", and "Table 1". The table contains numerical values: 8.85, AUTO, 8.5, 850, 0.85.

# S11 (Value)

The screenshot displays the COMSOL Multiphysics interface for a simulation titled "dipole\_antenna\_cubic\_abc.mph". The left sidebar shows the Model Builder tree with the following structure:

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
        - Perfect Electric Conductor 1
        - Initial Values 1
      - Far-Field Domain 1
        - Scattering Boundary Condition 1
        - Lumped Port 1
    - Mesh 1
  - Study 1
    - Step 1: Frequency Domain
      - Solver Configurations
        - Solution 1 (sol1)
    - Results
      - Data Sets
        - Study 1/Solution 1 (sol1)
      - Views
      - Derived Values
        - S-Parameter (emw)
        - Tables
        - Electric Field (emw)
        - 2D Far Field (emw)
        - 3D Far Field (emw)
        - Export
        - Reports

**Settings Properties**

Global Evaluation  
= Evaluate

Label: S-Parameter (emw)

Data  
Data set: Study 1/Solution 1 (sol1)  
Parameter selection (freq): All

Expressions

Expression	Unit	Description
emw.S11dB	1	S11

Expression:  
Description:

Data Series Operation  
Operation: None

**Graphics Convergence Plot 1**

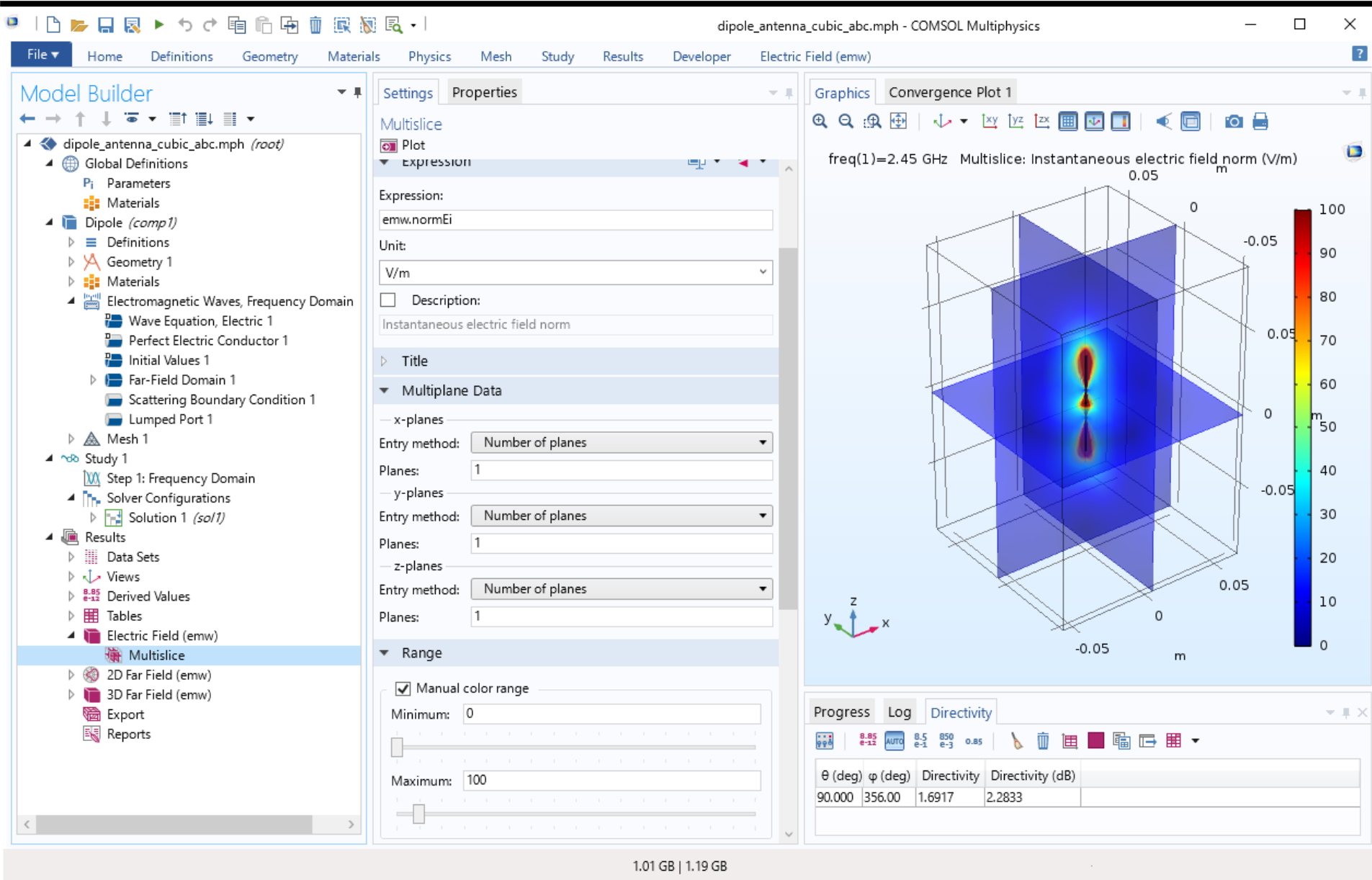
freq(1)=2.45 GHz Multislice: Instantaneous electric field\_norm (V/m)

Progress Log Table 2

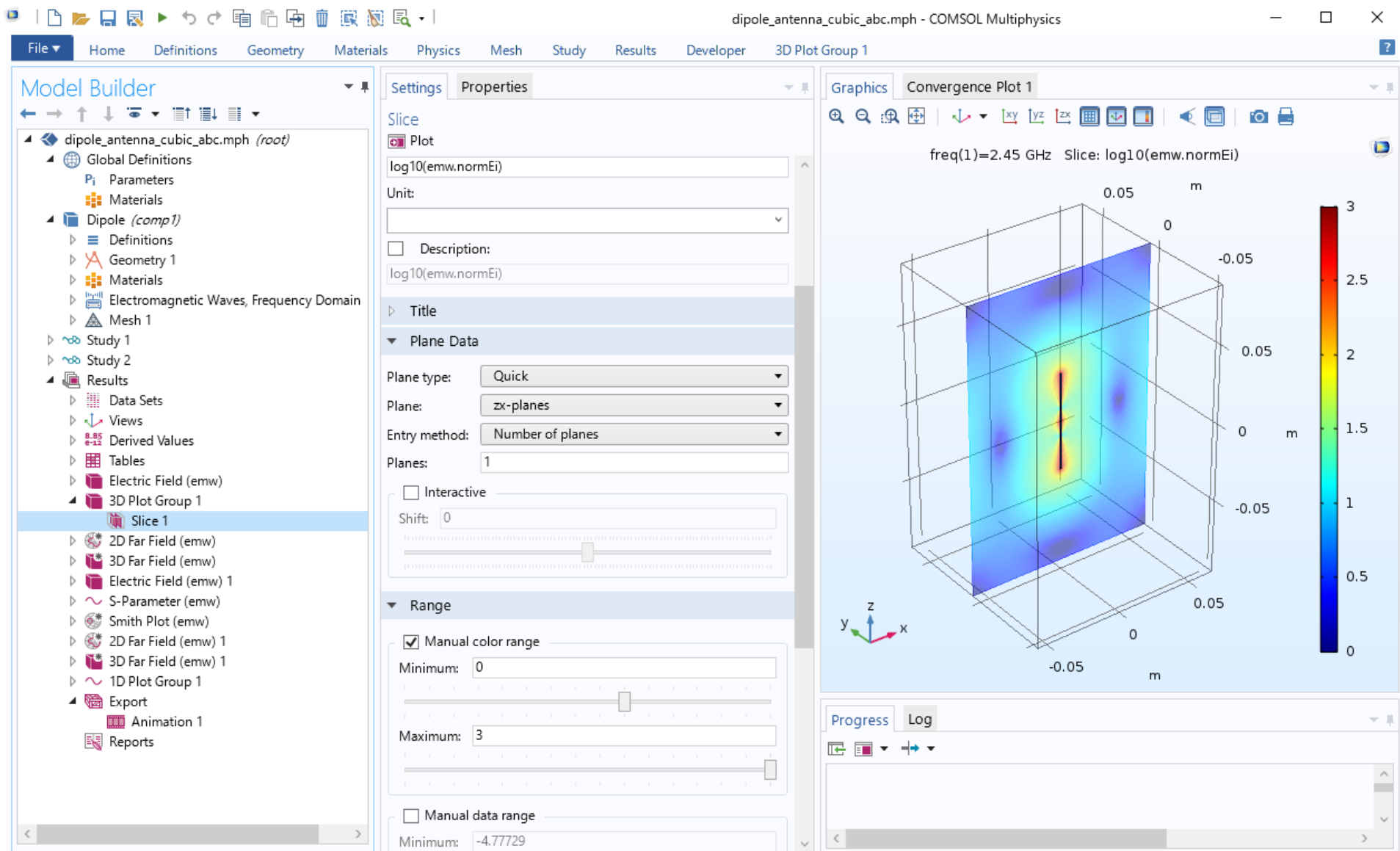
freq (GHz)	S11 (1)
2.4500	-6.9099



# 電界分布



# 電界分布(dB)



# 電界分布アニメーション(dB)

The screenshot displays the COMSOL Multiphysics software interface for a simulation titled "dipole\_antenna\_cubic\_abc.mph".

**Model Builder (Left Panel):** Shows the project hierarchy. The "Results" section is expanded, showing a "3D Plot Group 1" with a "Slice 1" selected. Other results include "Electric Field (emw)", "2D Far Field (emw)", "3D Far Field (emw)", "S-Parameter (emw)", and "Smith Plot (emw)".

**Settings/Properties (Middle Panel):** The "Animation" tab is active. Key settings include:

- Label: Animation 1
- Subject: 3D Plot Group 1
- Target: Player
- Sequence type: Dynamic data extension
- Cycle type: Half harmonic
- Number of frames: 15
- Frame number: 1
- Phase shift: 0
- Display each frame for: 0.1 s
- Repeat:

**Graphics (Right Panel):** Displays a 3D visualization of the electric field distribution. The plot is titled "Convergence Plot 1" and shows a vertical dipole antenna structure. The color scale represents the electric field magnitude in dB, ranging from 0 (blue) to 3 (red). The plot is titled "freq(1)=2.45 GHz Slice: log10(emw.normEi)". The axes are labeled in meters (m) and range from -0.05 to 0.05.

**Progress/Log (Bottom Panel):** Shows the simulation progress and log output.

# 2次元指向性

The screenshot displays the COMSOL Multiphysics interface for a 2D Far Field simulation of a dipole antenna. The Model Builder on the left shows the hierarchy: dipole\_antenna\_cubic\_abc.mph (root) > Global Definitions > Materials > Dipole (comp1) > Electromagnetic Waves, Frequency Domain > Far-Field Domain 1 > 2D Far Field (emw) > Far Field 1. The Settings panel for Far Field 1 shows the expression `emw.gainEfar` and the unit `1`. The Graphics window shows a polar plot titled "Far Field: Far-field gain (1)" with two lobes, one in blue and one in green, plotted against a grid of angles from 0° to 315° in 15° increments. The plot shows a maximum gain of 2 at 0° and 180°.

# 3次元指向性

dipole\_antenna\_cubic\_abc.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer 3D Far Field (emw)

Model Builder

- dipole\_antenna\_cubic\_abc.mph (root)
  - Global Definitions
    - Parameters
    - Materials
  - Dipole (comp1)
    - Definitions
    - Geometry 1
    - Materials
    - Electromagnetic Waves, Frequency Domain
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Far-Field Domain 1
      - Scattering Boundary Condition 1
      - Lumped Port 1
    - Mesh 1
  - Study 1
    - Step 1: Frequency Domain
    - Solver Configurations
    - Solution 1 (sol1)
  - Results
    - Data Sets
    - Views
    - Derived Values
    - Tables
      - Directivity
    - Electric Field (emw)
    - 2D Far Field (emw)
    - 3D Far Field (emw)
      - Far Field 1
    - Export
    - Reports

Settings Properties

Far Field

Plot

Label: Far Field 1

Data

Data set: From parent

Expression

Expression: emw.gainEfar

Unit: 1

Description: Far-field gain

Threshold: 0 1

Use as color expression

Title

Range

Evaluation

Angles

Number of elevation angles: 45

Number of azimuth angles: 90

Restriction: None

Compute directivity: On

Directivity expression: emw.normEfar^2

Coloring and Style

Coloring: Color table

Graphics Convergence Plot 1

freq(1)=2.45 GHz Far Field: Far-field gain (1)

1.69

1.6

1.4

1.2

1

0.8

0.6

0.5

0

-0.5

0.2

7.63 × 10<sup>-7</sup>

Progress Log Directivity

θ (deg)	φ (deg)	Directivity	Directivity (dB)
90.000	356.00	1.6917	2.2833

1 GB | 1.17 GB

# 周波数スイープ

The screenshot displays the COMSOL Multiphysics interface for a simulation titled "dipole\_antenna\_cubic\_abc.mph". The software is running in the "Frequency Domain" study settings.

**Model Builder (Left Panel):** Shows the project hierarchy. The "Step 1: Frequency Domain" is selected. Under "Electromagnetic Waves, Frequency Domain", the "Wave Equation, Electric 1" is active. The "Far-Field Domain 1" is also visible.

**Settings (Middle Panel):** The "Frequency Domain" settings are shown. The "Label" is "Frequency Domain". Under "Study Settings", the "Frequency unit" is set to "GHz" and the "Frequencies" are defined as a "range(1,0.4,9) GHz". The "Load parameter values" section includes "Browse..." and "Read File" buttons. The "Reuse solution from previous step" is set to "Auto".

**Physics and Variables Selection (Middle Panel):** The "Modify model configuration for study step" checkbox is unchecked. The "Physics interface" is "Electromagnetic Waves, Fre..." and the "Solve for" option is checked. The "Discretization" is set to "Physics settings".

**Graphics (Right Panel):** A 3D wireframe plot of a cubic domain is shown. The axes are labeled x, y, and z, with values ranging from -0.05 to 0.05 meters. A vertical dipole antenna is positioned in the center of the cube.

**Progress (Bottom Panel):** The "Log" and "Directivity" tabs are visible. The log shows the following information:  
Virtual memory: 1.52 GB  
Ended at 23-7-2020 01:31:32.  
----- Stationary Solver 1 in Study 2/Solution 2 (sol2) -----

1.04 GB | 1.23 GB

# Frequency-S11

dipole\_antenna\_cubic\_abc.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer S-Parameter (emw)

### Model Builder

- Parameters
- Materials
- Dipole (comp1)
  - Definitions
  - Geometry 1
  - Materials
  - Electromagnetic Waves, Frequency Domain
    - Wave Equation, Electric 1
    - Perfect Electric Conductor 1
    - Initial Values 1
    - Far-Field Domain 1
    - Scattering Boundary Condition 1
    - Lumped Port 1
  - Mesh 1
- Study 1
- Study 2
  - Step 1: Frequency Domain
    - Solver Configurations
  - Results
    - Data Sets
    - Views
    - Derived Values
    - Tables
    - Electric Field (emw)
    - 2D Far Field (emw)
    - 3D Far Field (emw)
    - Electric Field (emw) 1
    - S-Parameter (emw)
    - Global 1
      - Smith Plot (emw)
      - 2D Far Field (emw) 1
      - 3D Far Field (emw) 1
      - Export
      - Reports

### Settings Properties

Global

Plot

Label: Global 1

Data

Data set: From parent

y-Axis Data

Expression	Unit	Description
emw.S11dB	1	S11

Expression:

Description:

Title

x-Axis Data

Parameter: Expression

Expression: freq

### Graphics Convergence Plot 1

S-parameter (dB)

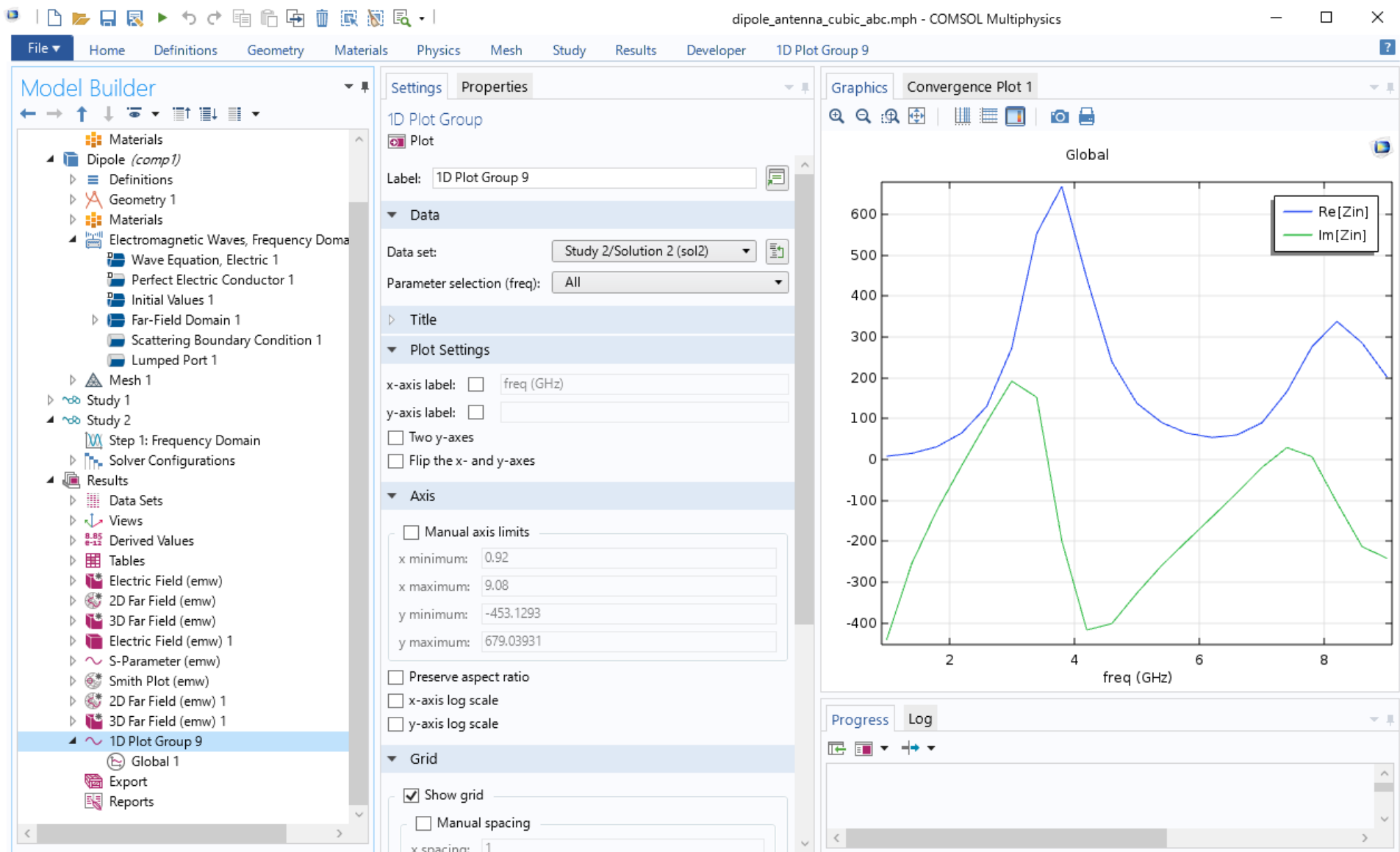
Frequency (GHz)

S11

### Progress Log

1.04 GB | 1.21 GB

# Frequency-Zin



dipole\_antenna\_cubic\_abc.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer 1D Plot Group 9

Model Builder

Settings Properties

1D Plot Group

Plot

Label: 1D Plot Group 9

Data

Data set: Study 2/Solution 2 (sol2)

Parameter selection (freq): All

Title

Plot Settings

x-axis label:  freq (GHz)

y-axis label:

Two y-axes

Flip the x- and y-axes

Axis

Manual axis limits

x minimum: 0.92

x maximum: 9.08

y minimum: -453.1293

y maximum: 679.03931

Preserve aspect ratio

x-axis log scale

y-axis log scale

Grid

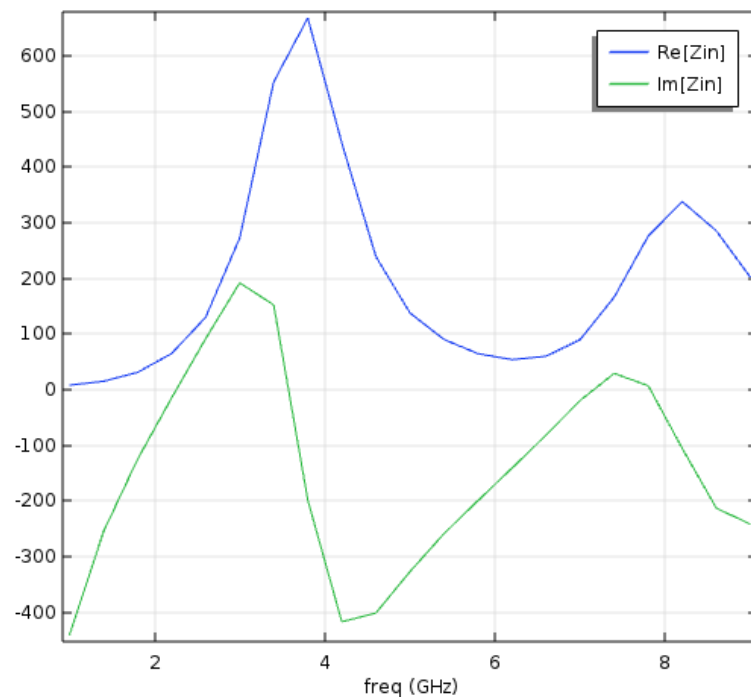
Show grid

Manual spacing

x spacing: 1

Graphics Convergence Plot 1

Global

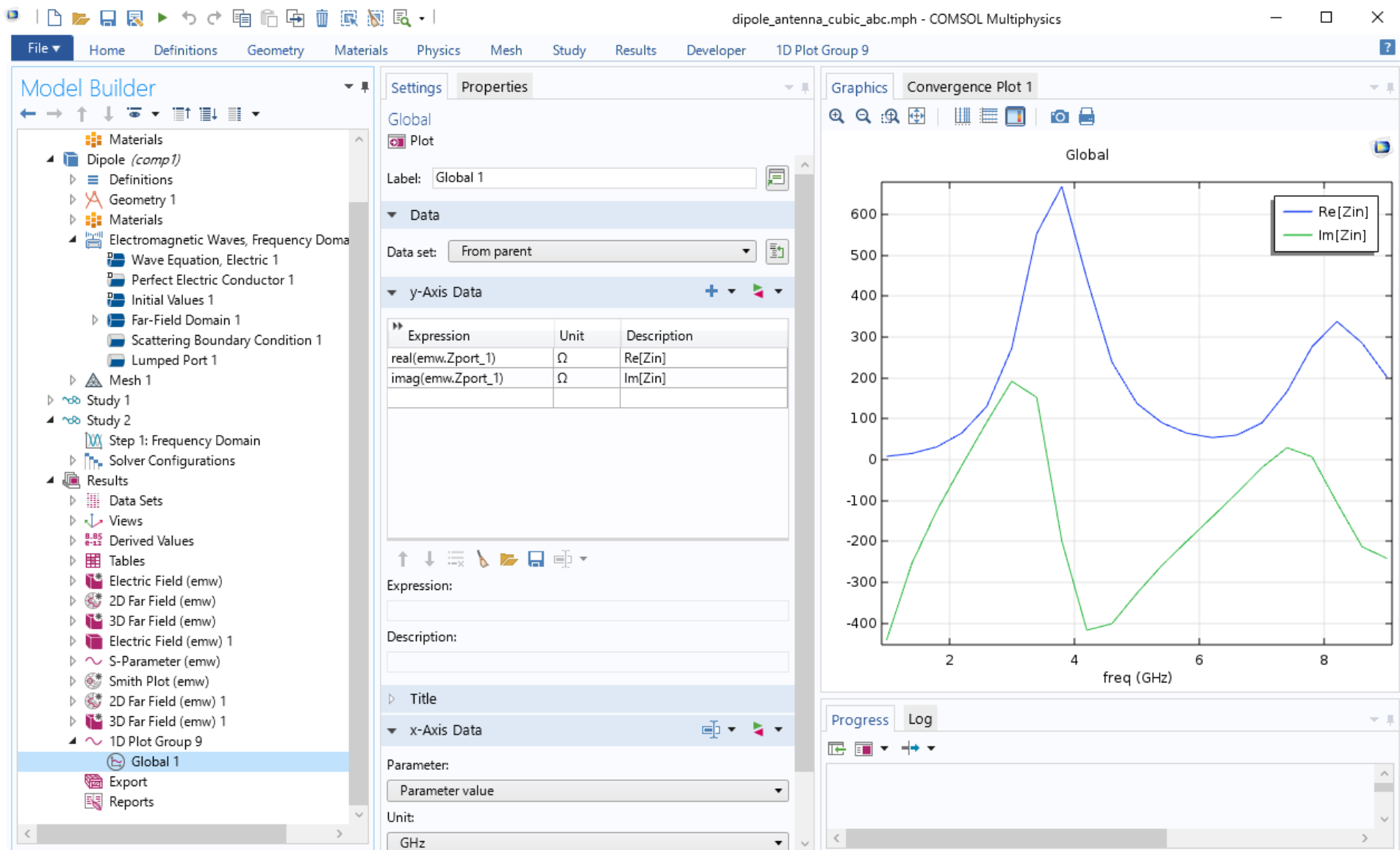


Progress Log

1.03 GB | 1.19 GB



# Frequency-Zin



1.03 GB | 1.19 GB

The screenshot shows the COMSOL Multiphysics interface for a dipole antenna simulation. The 'Derived Values' menu is open, and the path 'Integration' > 'Surface Integration' is selected. The main window displays a 3D model of a dipole antenna in a coordinate system with axes x, y, and z. The axes range from -0.05 to 0.05 meters. The software title is 'dipole\_antenna\_app.mph - COMSOL Multiphysics'.

751 MB | 939 MB

dipole\_antenna\_app.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results Developer

Application Dipole Add Component Parameters Variables f(x) Geometry Materials Electromagnetic Waves, Frequency Domain Build Mesh Compute S-Parameter (frequency char.) Add Plot Group Layout

Model Definitions Physics Mesh Study Results

Type filter text

- Electric
- Energy and power
  - emw.W - Energy density - J/m<sup>3</sup>
  - emw.Wav - Energy density time average - J/m<sup>3</sup>
  - emw.Weav - Electric energy density time average - J/m<sup>3</sup>
  - emw.Wmav - Magnetic energy density time average - J/m<sup>3</sup>
  - Power flow, time average - W/m<sup>2</sup>
    - emw.intWe - Total electric energy - J
    - emw.intWm - Total magnetic energy - J
    - emw.nPoav - Power outflow, time average - W/m<sup>2</sup>
- Far field
- Geometry and mesh
- Global
- Heating and losses
- Magnetic
- Material properties
- Mechanical
- Ports
  - emw.freq - Frequency - Hz

Double-click or press Enter to add selected expression.

input Power  
Radiated Power  
Surface Integration 1

- Tables
- Electric Field (emw)
- E-Field(dB)
- E and H vector field
- 2D Far Field (emw)
- 3D Far Field (emw)

Expressions

Expression	Unit	Description

Graphics

Progress Log Directivity

$\theta$ (deg)	$\phi$ (deg)	Directivity	Directivity (dB)
90.000	360.00	1.6764	2.2437

781 MB | 967 MB

The screenshot displays the COMSOL Multiphysics interface for a dipole antenna simulation. The top toolbar includes options for File, Home, Definitions, Geometry, Materials, Physics, Mesh, Study, Results, and Developer. The Physics toolbar is set to 'Electromagnetic Waves, Frequency Domain'. The Model Builder on the left shows a tree view with 'Dipole (comp1)' expanded to 'Results', where 'Surface Integration 1' is selected. The Properties window for 'Surface Integration 1' shows 'Evaluate' as the operation and 'Manual' as the selection method. The Graphics window shows a 3D plot of a rectangular volume with a vertical dipole antenna in the center. The axes are labeled x, y, and z, with values ranging from -0.05 to 0.05 meters. The Progress window at the bottom right shows a table with the following data:

freq (Hz)	Power outflow, time average (W)
2.4500E9	0.0082049

1.1 GB | 1.41 GB

Poynting Vectorを積分する面を選ぶ。Evaluateを押すと放射電力が計算できる。