EMPIRE XPU Tutorial

28GHz Antenna for Mobile Phone Application





Overview

- 3D STL import ٠
- **Material Definition** •
- Antenna Design ٠
- Port Definition •
- Mesh Hints / Creation ٠
- Simulation •
- S-Parameter •
- **Power Density** ٠
- Simultaneous Excitation •



1.802 W/(m*m) (-40.00 dB)





Step 1: General Settings

- Start EMPIRE XPU
- Click "New Project"
- Frequency:
 - Stop Frequency: 35 GHz
 - Target Frequency: 28 GHz
- Loss Calculation:
 - Dielectrics: narrow band
 - Conductors: narrow band lossy
- OK
- File Save As
 - Create new project folder
 - Choose file name

Project Wizard					? ×
New Project	Open Project	Examples	Templates	Tutorials	
General					Getting Started
Structure Type:	Standard				
Solvers:	EM				Copen the Getting Started Manual
Drawing Unit:	1	µm 💌			
Frequency					EMPIRE Open the Full Manual
Stop Frequency:	35	GHz 👻			KPU
Target Frequency:	28	GHz 👻			
Loss Calculation					You
Dielectrics:	narrow band (targ	iet-freq) 🔻			→ EMPIRE XPU
Conductors:	narrow band lossy				
					► N 40 0.01/7.45 C



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Step 2: CAD Data Import

Click File – Import – 3D Solids – Import STL ٠ Select all 6 STL files in "data"** directory Set Simplify Objects* to 30 ٠ I STL Import ? X Name Orig. Name New Physical Property Туре Stylus.stl conductor PCB.stl PCB conductor Ground.stl conductor Case.stl STL conductor Battery.stl conductor ✓ Battery ✓ Backcover Backcover.stl conductor #001 conductor Options Un Vown Object Unit: Simplify Objects: Wire Radius (m):



Hint:

- * Simplification reduces the complexity of the data: All edges which adjacent faces have an angle difference smaller then 30° will be removed
- ** Usually located at
- C:\EMPIRE XPU 8.00\Tutorials\3D Design\10 5G Mobile





Step 3: Materials

- Edit Property for Groups:
 - Double Click on "conductor"
- Stylus, Case ,Backcover : set Dielectric, Geo. Priority: 150 rel. Permittivity: 3 Conductivity: 0.01 OK
- Battery, Ground: keep Conductor
 - keep Cor
- PCB:

OK

set Dielectric, Database Rogers – RO4003 OK

🚦 STL Import		? ×
Name Name Ne	w Type P	Physical Property
 ✓ Groups ✓ Stylus Stylus.stl ✓ PCB PCB.stl ✓ Ground Ground.stl ✓ Case Case.stl ✓ Battery Battery.stl ✓ Backcover Backcover.stl ✓ #001 	STL d STL c STL c STL d STL c STL c STL d	dielectric name Dielectric prio 150 epsr 3.0 tand 0.0 sigma 0.1 dielectric name Rogers-RO4003 prio 100 epsr 3.55 tand 0.00 conductor dielectric name Dielectric prio 150 epsr 3.0 tand 0.0 sigma 0.1 conductor dielectric name Dielectric prio 150 epsr 3.0 tand 0.0 sigma 0.1 conductor
🚺 Property Editor - Dielectric		? ×
 Material Property Dielectric Conductor Absorber Advanced Advanced Material Drude/Plasma Material Gabriel Material Gabriel Material Conformal Dielectric Material Script Drude/Plasma Script Circuit Property Thermal Property Mesh Property Mesh Property User Defined 	General Database Info General Parameters Name Geometric Priority (10250) Electric Parameters Rel. Permittivity Electric Loss Tangent Conductivity in 1/(Ohm*m) Thermal Parameters Conductivity in W/K/m Surface Heatsink Coefficient (W/m*2/K) Surface Relation Emmission Coefficient (rel.)	Dielectric Image: Constraint of the second seco



Step 4: Adjust Construction Grid

- Hide all groups except Ground & PCB (click on lamp)
- Right click while pointing the mouse on the PCB
 - Open Grid menu
- Select z=813

•

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• Checkmark 'Stay on Grid'





Stay on Current Face

Get LCS from Face ✓ Stay on Grid

Enable Stay on Face

✓ Show Grid

✓ Tripod

z=813

Show Mesh

✓ Cursor Projection

Grid to Current Position New LCS From Current Position Next Grid <Space>

Outline View

O Hide Group PCB

Create

Select

Mesh

Advanced

Show Only Group PCB



Step 5: Antenna Design

Groups (*active*)

(conductor)

Height: z=0...20

conductor

- Right click on group #001
 - Set active
 - Edit Name: set to "met0"
 - Enable visibility
 - Set color
- Double Click Height, Set group height z=0...20
- Zoom to PCB area
- Click Create Box
- Click first Point: **x= -16200, y=58000**
- Click second point: x= -16000, y=62000

• Long left click (assign group height)

🚦 Box Editor			?	×	
General					
Name:	BOX 3				
Group:	met0 (cond	met0 (conductor)			
Assign Heigh	t 🔍 Custom 🔿	From Group 🔿 Fro	m Group (relative))	
		у			
Point 1	-16200.0	58000.0	813.0		
Point 2	-16000.0	62000.0	833.0		







Step 6: Antenna Design





Step 7: Port

√²,

Switch to Iso-z-View, zoom in, keep "Stay on Grid"

Click Create Source

- Select Lumped In-Plane Port
- Select Start Point (center, yellow dot) and End Point (edge, orange dot)
- Long left click for group height
- Click on corner of antenna for port witdth (corner , blue dot)
- OK











Step 8: Copy Antenna

- \sqrt{z}
 - Zoom out
 - Hold CTRL key & drag left mouse button over the complete antenna (right to left)*, release
 - Click Multiple Copy
 - Enter Values as shown
 - Press Ok
 - Zoom out



Hint*:

• Select all structures which have points inside a region: with Ctrl-Key pressed, drag with left click from right to left

📳 Multiple Copy Setup						?	×
Multiple Copy Type:	Rectangular Array						
Distance	Number		Port Nr. Inc	rement	Mapping F	unction	
X: 10800	4	٦	1	•			
Y: 100.0	0	٢	0	-			
Z:		-	0				
					ОК	Canc	el
						~	-

Step 9: Mesh

- Disable automesh for groups **Battery**, **Case, Stylus**
- Set to "Edges Only" for **Backcover** and **Ground**
- Set "Edges and Interior" for **met0** and **PCB**
- Click Simulation Setup, Select "Mesh" tab
- Change Mesh Resolution to **Coarse**, OK

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Setup







Step 10: Meshhint



- Right click on "conductor" in group met0
- Select "Add Property"
- Select "Mesh Property" "Mesh Hint"
- Enter Max. Interval X,Y,Z: 250
- Press OK

Hint:

• With meshhint we specify the maximum cell size for the group objects area (Max. Interval)

🚦 Property Editor - Mesh Hint

▼ Material Property	General	
	General Paran	neters
← Absorber ▼ Advanced	Strictness	hint
- Advanced Material Debye Material	Edge Use	off
— Drude/Plasma Material — Meta Material	Edge Max. Int	terval
Gabriel Material	x	auto
✓ Material Scripts		auto
Drude/Plasma Script	Z	auto
Thermal Property	Refinement	
Mesh Property	x	1
│		1
Discretize Solid Interior only	z	1
▶ Advanced Property └─ User Defined	Max. Interval	
	x	250
	Y	250
	Z	250
	Min. Interval	





Step 11: Boundary Setup

Click on Simulation Setup

🚦 Simulation Setup

Setup

- Switch to Boundary tab
- Set Distances as shown
- OK
- Click Create Mesh



General	EM Setup	Mesia Boundary	/		
Boundary	Conditions		Boundary	Distance	
xmin	Absorbing 6 (> 40 dB)	•	xmin	50 percent	•
xmax	Absorbing 6 (> 40 dB)	•	xmax	50 percent	-
ymin	Absorbing 6 (> 40 dB)	-	ymin	20 percent	-
ymax	Absorbing 6 (> 40 dB)	-	ymax	50 percent	-
zmin	Absorbing 6 (> 40 dB)	-	zmin	200 percent	-
zmax	Absorbing 6 (> 40 dB)	•	zmax	500 percent	•

Hint:

- The Boundary Distance allows to add mesh cells at the sides of the structure when using the automesh mode
- Values can be in percent of the model size or absolute



Step 12: Field Monitor







Step 13: Port Setup







Step 14: Simulation







Step 15: S-Parameter

- Go to 2D Results
- Click Update
- Sort Curves by Port Number (click on Port)
- Mark all S22 Curves
- Right Click, select Show only & Autocolor
- Right Click on plot Configure Axis

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Set frequency axis to
x-axis: 25 GHz - 35 GHz
y-axis: -40 dB - 0

Empire XPU 8.0 - C:\Users\; File Edit Utilities Help	andreas.wien\Desktop\Tut-home\105G Mobile\sim\phone.emx		- Ö EMPIRE XPU 8.0 (buld 11	× 8285)
2D Design Project Gener	3D Design Simulation Circuit 리 Parizon Maker · X 클 腔 Q, 것 것 슈子 <u>무 가 규</u>	2D Results :		
Plot Type: Sattering Para Plot Format: Log. Magnitude Reduct Mark Mark 10 d million 10 d million 2 10 d million 2 10 d million 2 10 d million 2	Image: second condition Image: second			-
Plot Configuration				-
X-Axis	sgend	Title	28 30 32 34 Frequency (GHz)	
Label:		Label:		
Range:	25 💌 - 35 💌 GHz 💌	Fontsize:		
Log. x-axis		Location:		
Unit Prefix:	Automatic 🔹	Markor	Parameter with best fit	
Ticks (major):	Automatic 🔹	Marker	for 5G 28GHz band	
Ticks (minor):	Automatic 🔹	Fontsize:		
Y-Axis		Digit Count:	length = 300	
Label:		Grid		V
Range:	-40 - 0 -	Grid Fontsize:		
Ticks (major):	Automatic 🚽	Grid Style (Major	MI S	
		Crid Chule (Miner		



I M S

Step 16: Field Monitor Settings

-		🚺 Near Field Monitor Settings				
•	GO IO 3D Results	Storage Options Plot Option	15			
•	Open Field Menitors	Data Source				
•	Dight click on EIELDMON 1 Edit	Source Type	Manual	-		
•		File	v-opt-00004-len 🔻 Brows	se		
•	Source Type: Manual	Frequency (Hz)	28 • GH:	z 🔻		
•	Source Type. Manual	Field Options				
•	File. (last entry). v -opt-00004-	Field	Power Flow (real)			
	Pharmuchum a 1 albur	Fiend Components	хуz			
	2\emvolume_1.dbx	Plane Interpolation	Cell	•		
		Normalization (Frequency Doma	in Only)			
•	Field: S Power Flow (real)	Туре	Power	•		
		Port	2			
•	Normalization: Power	Weight	1.0	-		
		Scaling				
٠	Scaling: Range: 40	Туре	Logarithmic	•		
•	OK	Max. Value	Auto			
		Range (dB)	40	•		

Switch off Field Monitor
 → FIELDMON 2 (EM Farfield)



Step 17: Power Density

Optional: Change visibility of phone objects







Step 18: Simulation (Simultaneous Excitation)



ŁMPIRE **Step 19: Power Density (Simultaneous Excitation)** Near Field Monitor Settings Storage Options Go back to 3D Results Data Source Manual Right click on FIELDMON 1 - Edit Source Type mvolume_1.dbx Browse File: sub-1\emvolume_1.dbx (select Frequency (Hz) 28 GHz 1 item from drop down list) Field Options OK Field Power Flow (real) 🛐 Empire XPU 8.0 - C:\Users\andreas.wien\Desktop\Tut-home\10 5G Mobile\sim\all\phone.emx σ \times Components xyz 2D Result Cell e Interpolation СССАТА Ф 9 9 9 0 °С Ф 📾 🖬 🖬 🗊 🗩 🖬 🖬 🏧 0 lization (Frequency Domain Only) Power 2 Plane: xy, Height: 6152.2135949 Plane: xz, Height: 79577.723224 Logarithmic



Auto

40

Value

ge (dB)