#### **EMPIRE XPU Tutorial**

#### Patch Antenna design



#### **Overview:** Topics





- Template wizard •
- Simulation •
- Nearfield •
- Farfield •
- Array Creation with Template ٠
- Simulation ٠
- Phased array investigations ٠
  - Scan angle •
  - Coupling •
  - Active impedance ٠



#### **Step 1: Template Wizard**





- Start Empire XPU
- Select Templates
- Open Antennas → Microstrip antenna
- Set the "Resonance Frequency" to 2.45 GHz
- Keep "Sweep Parameter: Width"
- Click "OK"
- Select File → Save As, optionally create new folder and name

#### Comments:

Using the template "Microstrip antenna…" • Automatic generation of patch dimensions, substrate, lumped port, near and far field definitions

Automatic generation of mesh



### **Step 2: Structure Check**



- 3D Results Tab: Geometry verification
- Groups: Objects and properties
- Simulation Setup: Settings -
- Open Variables
- Open "width"
- Move slider
- Set Step to "100"

(Stop-Start)/Step= 200 possibilities





### **Step 3: Optimization**





#### **Step 4: Results**

- Switch to 2D Results tab → right click in List, click "Show all"
- Right click on Plot, select "Configure Plot"
- Set Range "2.3" "2.5" GHz, OK –
- Select curve with peak nearest to 2.45 GHz and note Opt Number (here 0008)

#### E Plot Configuration

General / Axis	Legend
X-Axis	
Label:	
> Range:	2.3 🔻 - 2.5 💌 GHz 💌
Log. x-axis	



#### **Step 5: Near Field Display**







#### **Step 6: Far field Display**



#### **Part 2: Array Creation**



- Template wizard
- Simulation
- Postprocessing
- Nearfield
- Farfield
- Phased array investigations
  - Scan angle
  - Coupling
  - Active impedance





### **Step 7: Template Wizard**

EMPIRE XPU

- Start Empire XPU
- Select Templates → Antennas → Patch Array
- Drawing unit: "mm"
- Stop Frequency: 5 GHz
- Target Frequency: 2.45 GHz
- Substrate Material: epsr=2.2
- Resonance Frequency: 2.45 GHz
- Substrate Height: 1.524 mm
- Number of elements in x: 6
- Beam Angle Theta: 35
- Click "OK"
- Open Variables
- Right click on length Edit
- Set Type:Constant, Value:38.8



	📕 Edit Variabl	le "length"	?	×	
	Comment:				
	Type:	Constant			
38.8	Value:	38.8			
1000					M N
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### **Step 8: Simulation Results**



Switch to '3D Results' tab

- Select File  $\rightarrow$  Save As, create new folder
- Click "Start Simulation", OK
- In Plot Tab switch to 'Voltages'



#### Comment:

- The S-parameter results are not valid if multiple ports with the same number are used





# Step 9: Patch Array - Coupling

- Save EMPIRE project to a new file named 'coupling'
- Create individual port numbers for all patches like in the picture below

- Switch on group "port"
- Click Port Setup Wizard
- Table Style: Array View
- Click on Calculator and enter "ix+iy\*10+1"
- Click OK



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		291.84				4	5		
		230.61	11	12	13	14	15	16	
		169.39	21	22	23	24	25	26	
		108.16	31	32	33	34	35	36	
				된 Port Ca	lculator	?	×		
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				Equation	: ix + 10*	iy+1	<b>•</b>		
				X	X position	in units	ue		
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				dx y	X Size in u Y position	inits 306 in units	.12		
				iy ny	y index sta Number o	arting at 0 f rows 4			
				dy	Y Size in u	inits 183	.68		
				ОК	С	ancel	Apply		



#### EMPIRE XPU

### **Step 10: Simulation**

- Switch to 'Simulation' tab -
- Select "Simulation" on
   the left
- Click "Preprocessing"
- Select only some folders for simulation (e.g. sub-1, sub-12)
- Click "Start Complete
   Simulation"
- After completion change
   to 2D Results Tab





### **Step 11: Simulation Results**

Empire XPU 8.0 - C:\Users\andreas.wien\Desktop\Tut-home\03 Patch Array\sim\coupling.er 3D Results Circui Right click in list Select "Show all" Click "Update" -20 Click "Autoscale" Parameters (dB) -40Scattering -60 -100 1.5 2.0 3.0 3.5 1.0 2.5 Frequency (GHz)

Comment: The s-parameter results show the coupling between the different patches and the individual matching if only one port is excited at a time





## **Step 12: Active Impedance**

- Save EMPIRE project to ٠ a new file named 'active'
- Click "Simulation Setup" -٠
- Change "Simulation ٠ Mode" to **"Simultaneous Excitation** (Active Impedance)"
- Click "Start Simulation"
- OK

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(dielectric)	General				
port (active)	Drawing U	nit 1		mm 💌	
<ul> <li>Coordinate Systems</li> <li>Mesh Info (Cells: 667.6k)</li> </ul>	Solvers	EM			
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# **Step 13: Simulation Results**

- 3D Results Circuit M 2D Results tab R(sub-1\Z1.in) J(sub-1\Z1.in) R(sub-1\Z2.in) S-Parameters: --- 3(sub-1\Z2.in) 250 Mark s11, s22, s33 Right click "Show 200 Scattering Parameters (dB) only" g 150 Impedance Click "Add Result" 100 Impedance: 50 Mark Z1.in, Z2.in -10 **Right click "Show** -12 dB(sub-1\s1\_1) only" --- dB(sub-1\s4 4) dB(sub-1\s2\_2) dB(sub-1\s3 3) Autoscale -50 1.0 1.5 2.0 2.5 3.0 3.5 4.0 2.0 2.5 3.0 3.5 Frequency (GHz) Frequency (GHz) howing 4 of 24 curves
- Optionally "Toggle View Mode", Tile Sub Windows

Comment: The s-parameter results show the individual matching if all ports are excited at a time. The active input impedance at all ports can be investigated

