

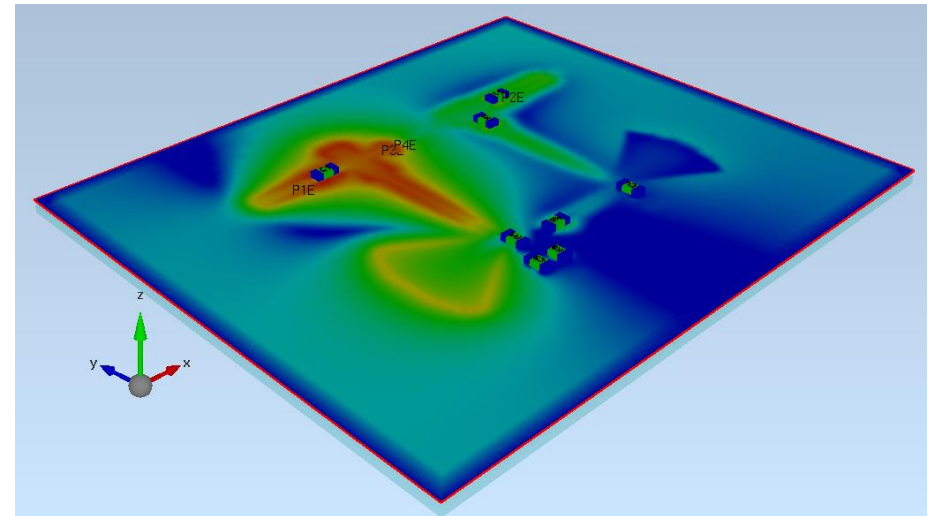
# EMPIRE XPU Tutorial

## Low Noise Amplifier Design using Circuit Processing



# Overview: Topics

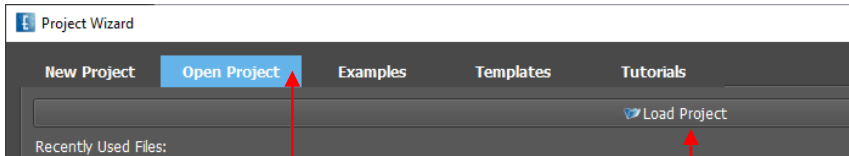
- LNA Design
- Circuit simulation in Empire using touchstone files
- Optimisation of active circuits
- S-parameter postprocessing



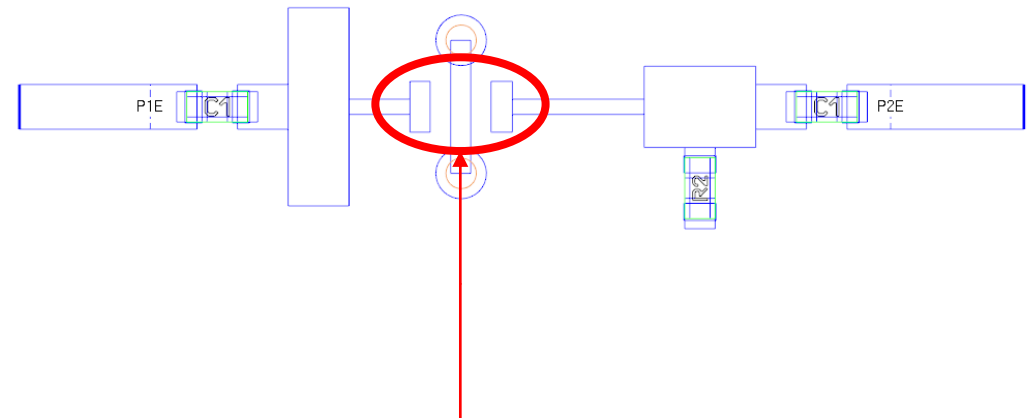
*Comments:*

- *The advantage of such a design in comparison with conventional circuit simulation is that it includes all the EM effects surrounding the active device.*

# Step 1: Modelling



- Start Empire XPU
- Tab Open Project
- Click “Load Project”  
data/lna.gym in Tutorial folder
- Switch to 2D Design tab
- File – “Save as” project in a new folder



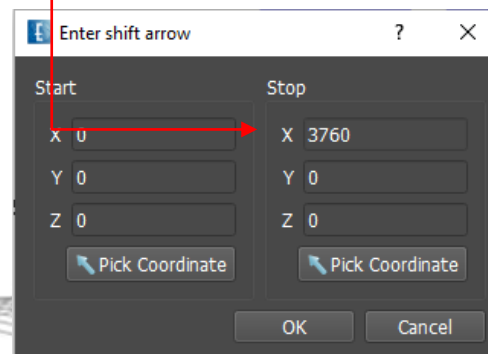
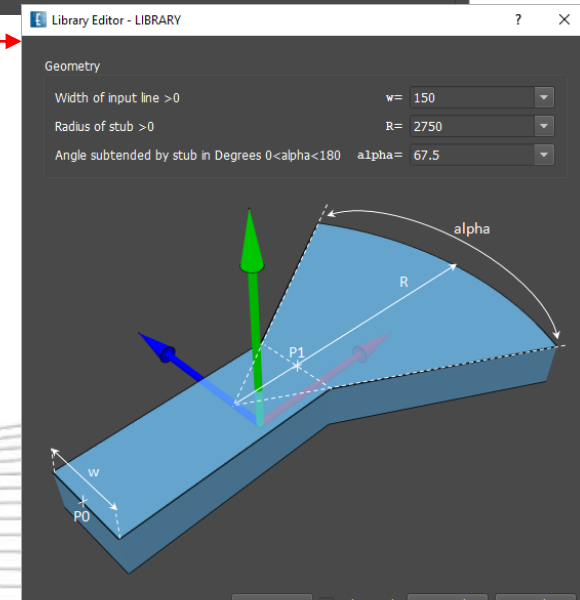
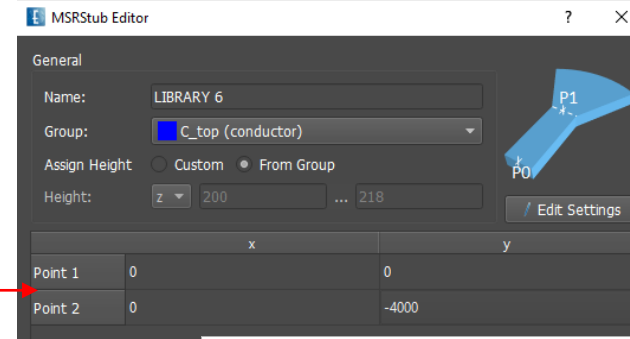
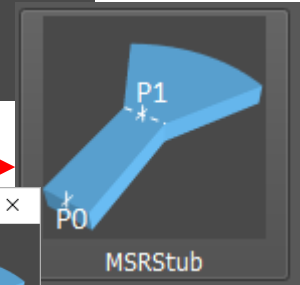
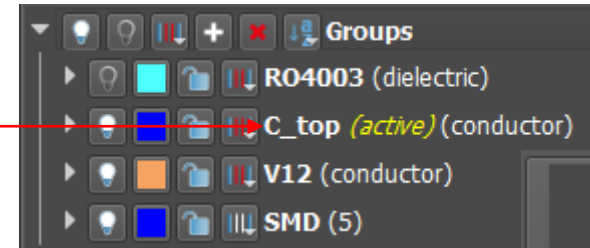
Position of transistor

## Comments:

- The goal is to design a low noise amplifier for 11 GHz
- The input and output matching circuits can also be part of optimization
- The boundaries are set to magnetic to save simulation time

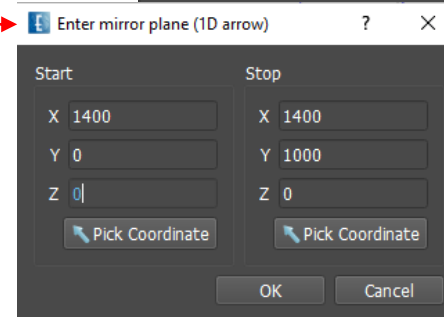
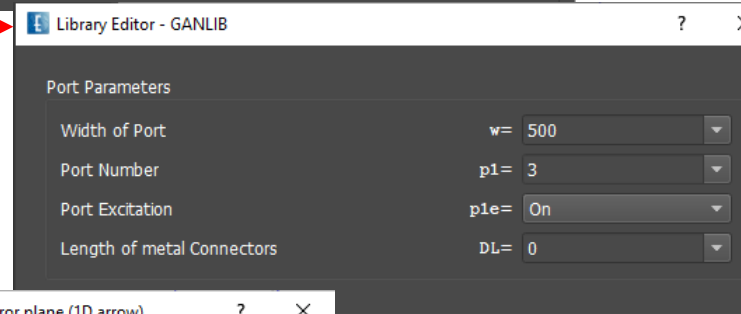
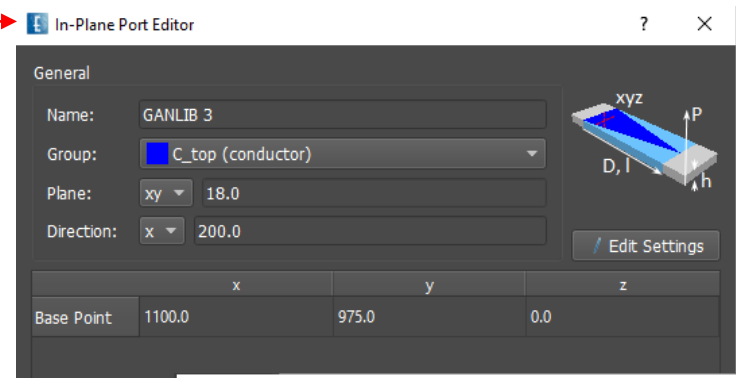
# Step 2: Radial Stubs

- Open “Groups” and Verify ‘C\_top’ as active group
- Click “Create Library Object” → Tab: “MSL Planar” → “MSRStub”
- Enter the following coordinates:  
as Point 0 :  $x = 0$  and  $y = 0$   
Point 1 :  $x = 0$  and  $y = -4000$
- Click on “Edit Settings” and enter:  
 $w = 150 \text{ } \mu\text{m}$   
 $R = 2750 \text{ } \mu\text{m}$   
 $\alpha = 67.5$
- Click “Ok” to close windows
- Click on radial stub to select it
- Press “Copy” and enter X=3760 as Stop value



# Step 3: Ports for Touchstone



- Click “Create Source” →  
→ Tab: “Lumped” → “In-Plane Port”
- Enter  $x=1100$ ,  $y=975$ ,  $z=0$ ,
- Direction  $x=200$
- Click on “Edit Settings” and enter:  $W=500$
- Close with “OK”
- Click on Port 3
- Click “Copy & Mirror”
- Enter Start  $x=1400$
- Enter Stop  $x=1400$   $y=1000$
- Click on created port
- Click “Set port number”
- Enter “4”, “OK”

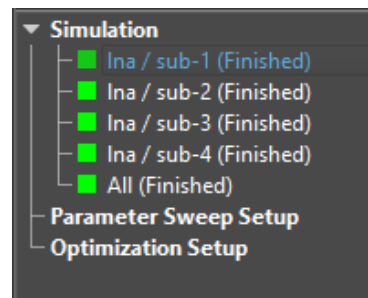
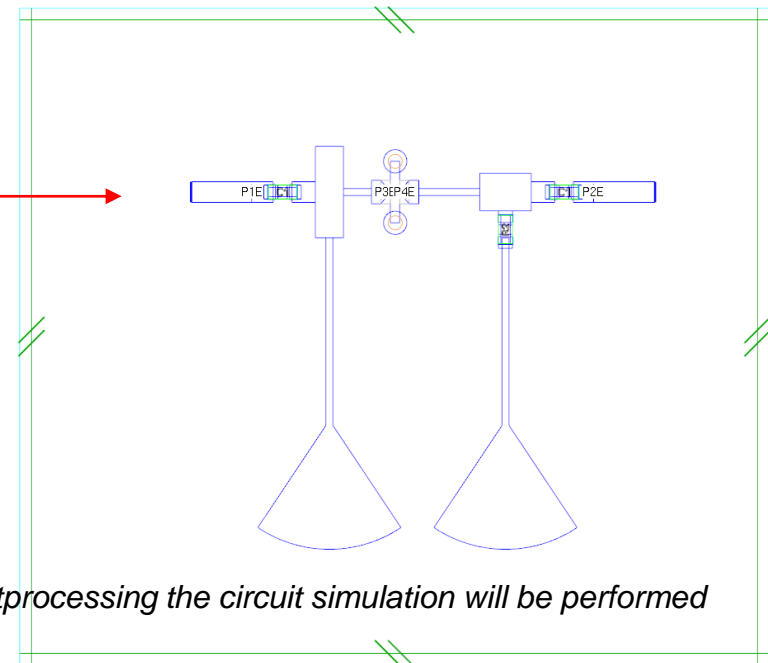
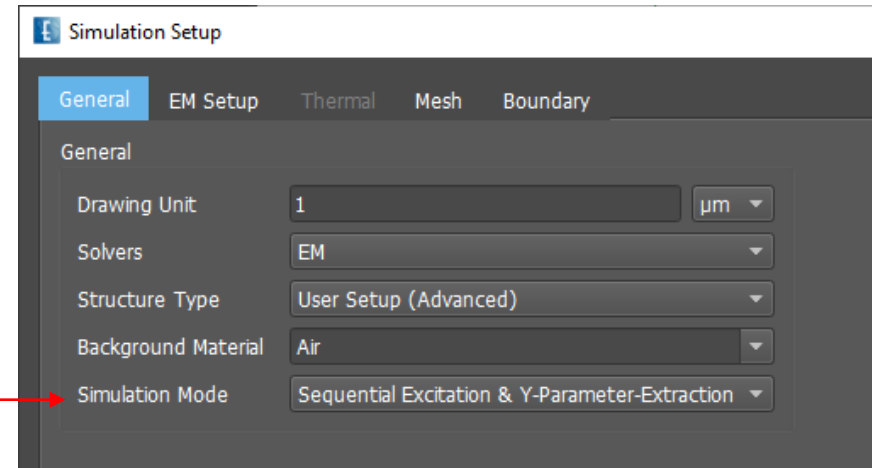


## Comments:

- In order to import touchstone files of the active device, ports are used
- The number of required ports corresponds to the number of ports of the active device
- All kind of ports (microstrip, coplanar, lumped ports, ...) can be used for this purpose
- The touchstone file should be placed in the project folder

# Step 5: Simulation


- Click Simulation Setup 
- Simulation Mode: “Sequential Excitation & Y-Parameter-Extraction”
- Close window
- Switch on group RO4003, check structure and port numbers
- Press “Start Simulation” 
- Confirm Message
- Wait until all 4 simulations are finished

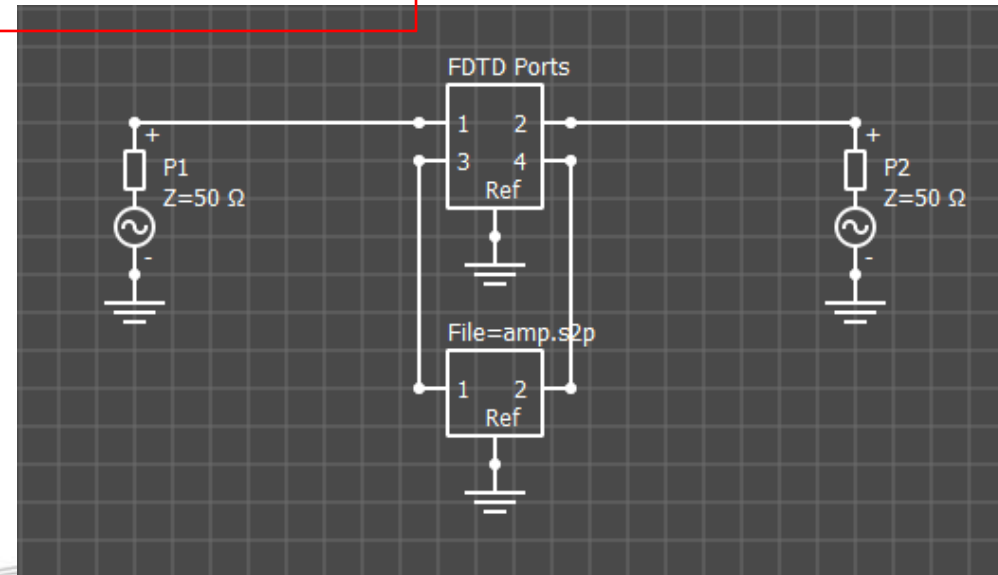


## Comments:

- Four simulations will be performed and at the end in one separate postprocessing the circuit simulation will be performed

# Step 6: Circuit Elements

- Switch to Circuit tab
- Click “Add Schematic” 
- Pick and place “Data Element”
- Press “Esc” to finish, right click “Edit”
- Browse file “amp.s2p”, OK
- Pick and place “Empire Ports”, Esc
- Pick and place 2 “Ports”, Esc
- Pick and place 4 “Grounds”, Esc
- Place 4 “Wire connections”, Esc

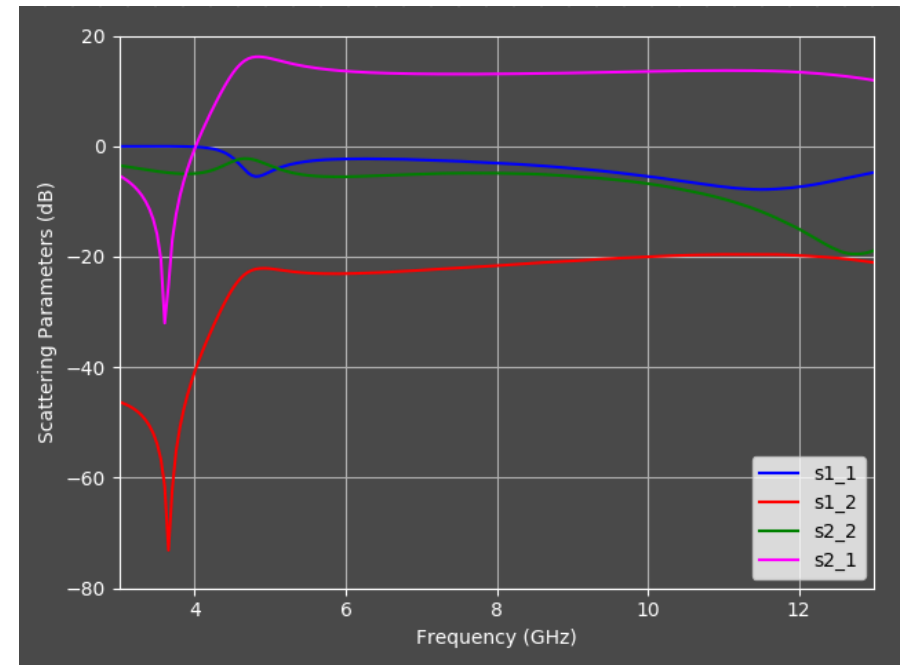
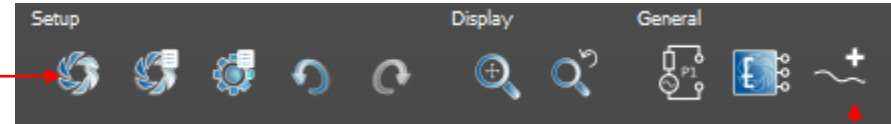


## Comments:

- The “Data Element” will load the touchstone file of the LNA
- “Empire Ports” define the result of the EM simulation
- “Port” defines the external ports of the circuit simulation
- Circuit elements and wires have no effect on the EM simulation

# Step 7: Results

- Click “Run Circuit Simulation”
- Click “Add Result”
- Select S-Parameters, OK



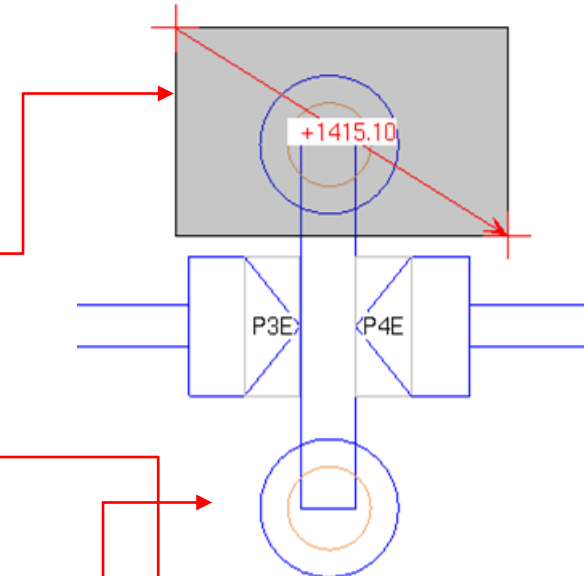
## Comments:

- The result of the 2 port circuit simulation is displayed in the schematic window
- The result of the 4-port simulation can be displayed in the 2D Result Tab



# Step 8: Gain Tuning

- Switch back to the 2D Design mode
- Draw an arrow over the via and the pad
- Click “Select overlapping”
- Click “Stretch”
- Enter Stop Y: dz, OK
- Enter Type=“Stepped” and the parameters: Value=0, Start=0, Stop=1000 and Step=250, OK
- Draw an arrow over the lower via and the pad
- Click “Select overlapping”
- Click “Stretch”
- Enter Stop Y: -dz, OK
- Slide the ‘dz’ bar in “Variables” and check the length variation of the line under transistor



Edit Variable "dz"

Comment:

Type: Stepped

Value: 0.0

Start: 0.0

Stop: 1000.0

Step Value: 250.0

OK Cancel Help

Enter stretch arrow

Start	Stop
X 0	X 0
Y 0	Y -dz
Z 0	Z 0

Pick Coordinate Pick Coordinate

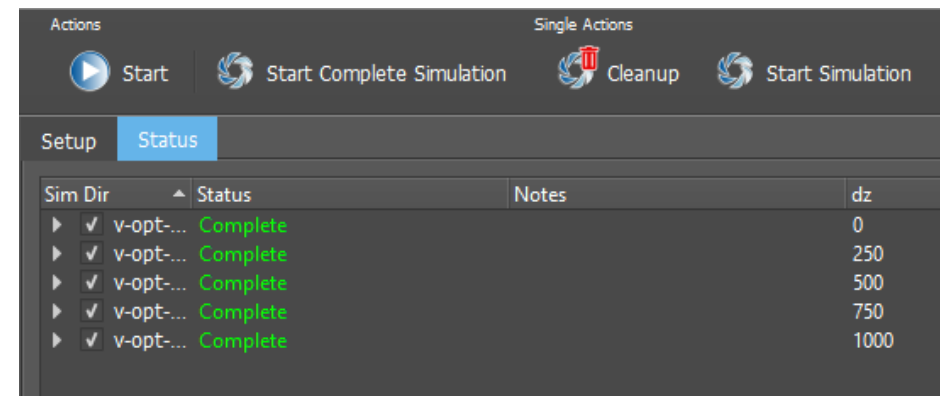
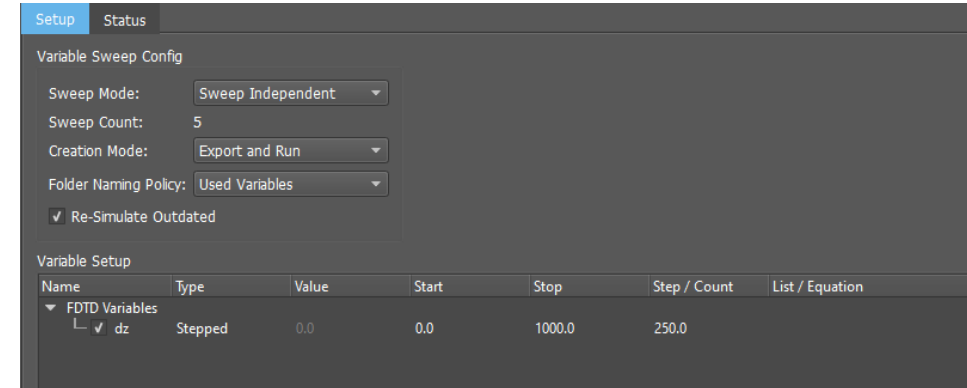
OK Cancel

*Comments:*

- The length of the ground connection is used here to tune the gain of the LNA

# Step 9: Variable Sweep

- Switch to the “Simulation” tab
  - Select “Parameter Sweep Setup”
  - Click “Create Parameter Sweep”
  - Keep default settings
- 
- Click “Start”, Confirm message
  - Wait until all sweeps are finished
  - Switch to “Circuit” tab
  - Open “Variables” and sweep slider to generate circuit results for each value



# Step 10: Results

- Switch to the “2D Results” Tab
- Click on “Circuit” Column to sort files
- Select all “Circuit\_001” results (e.g. drag left mouse button)
- Right click: “Show only & Autocolor”

