Branch-Line Coupler Design Validation in AWR AXIEM EM Solver

Microwave Circuits

(B2M17MIO)

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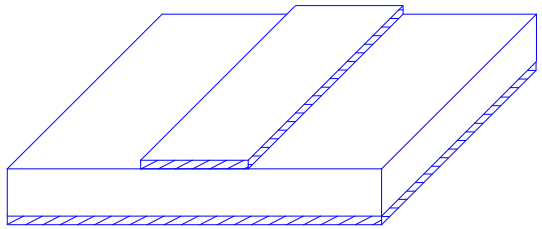
Global Definitions

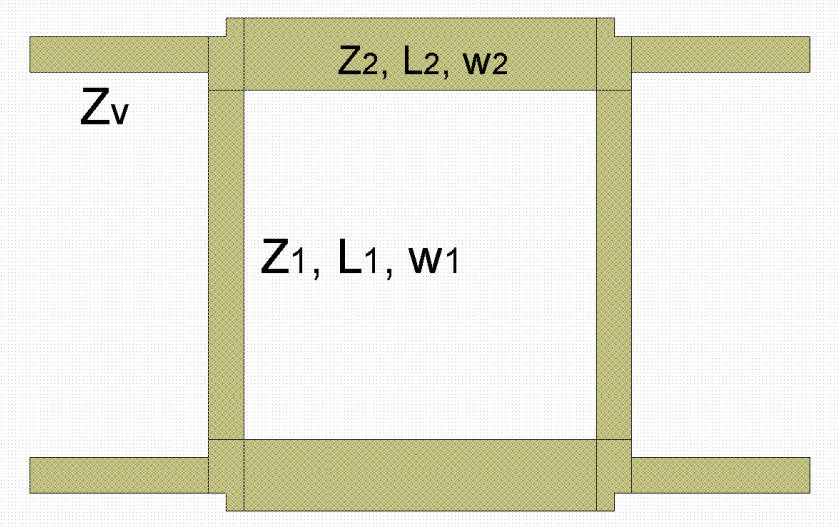
- substrate Duroid 5880
  - $\varepsilon_r = 2.2$
  - $h = 0.127\ \text{mm}$
  - $\text{tg}\delta = 0.0009\ @\ 10\ \text{GHz}$
  - $t = 17\ \mu\text{m}$
  - $\sigma_{\text{Cu}} = 5.88\text{x}10^7\ \text{S/m} \rightarrow \text{Rho} = 0.7$

MSUB
Er=2.2
H=0.127 mm
T=0.017 mm
Rho=0.7
Tand=0.0009
ErNom=2.2
Name=SUB1



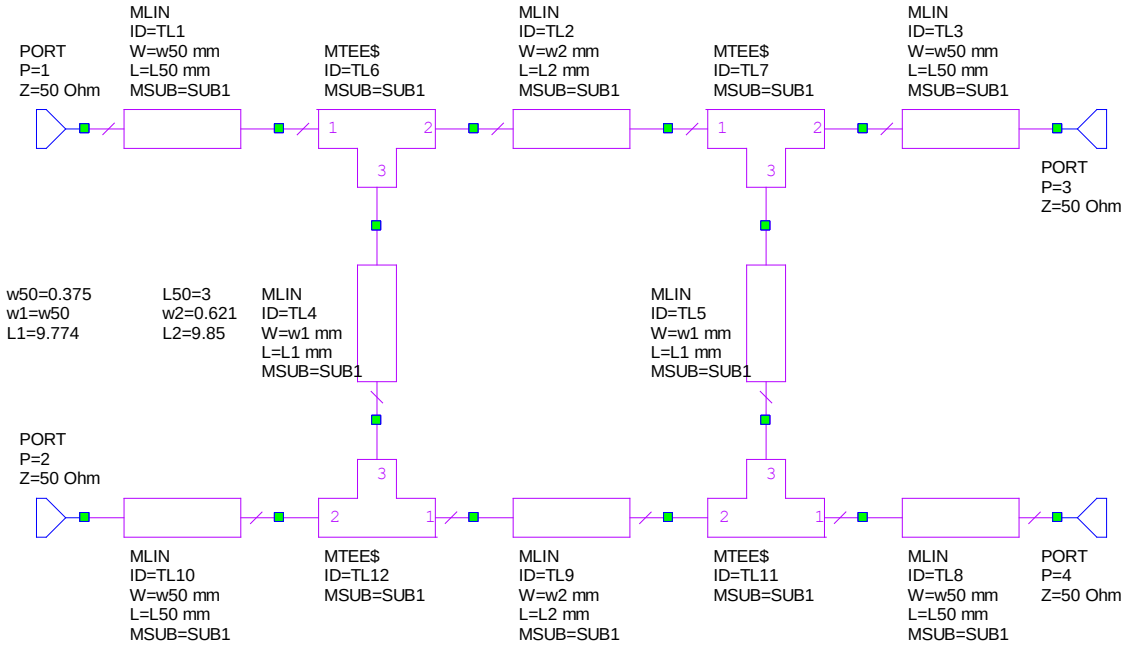
Branch-Line Coupler Design

- 3 dB coupler at 5.4 GHz
  - $Z_v = 50\ \Omega \rightarrow w_1 = 0.375\ \text{mm}$
  - $Z_1 = Z_v \rightarrow w_1 = 0.375\ \text{mm}, L_1 = 10.155\ \text{mm}$
  - $Z_2 = \frac{Z_v}{\sqrt{2}} \rightarrow w_2 = 0.621\ \text{mm}, L_1 = 9.984\ \text{mm}$

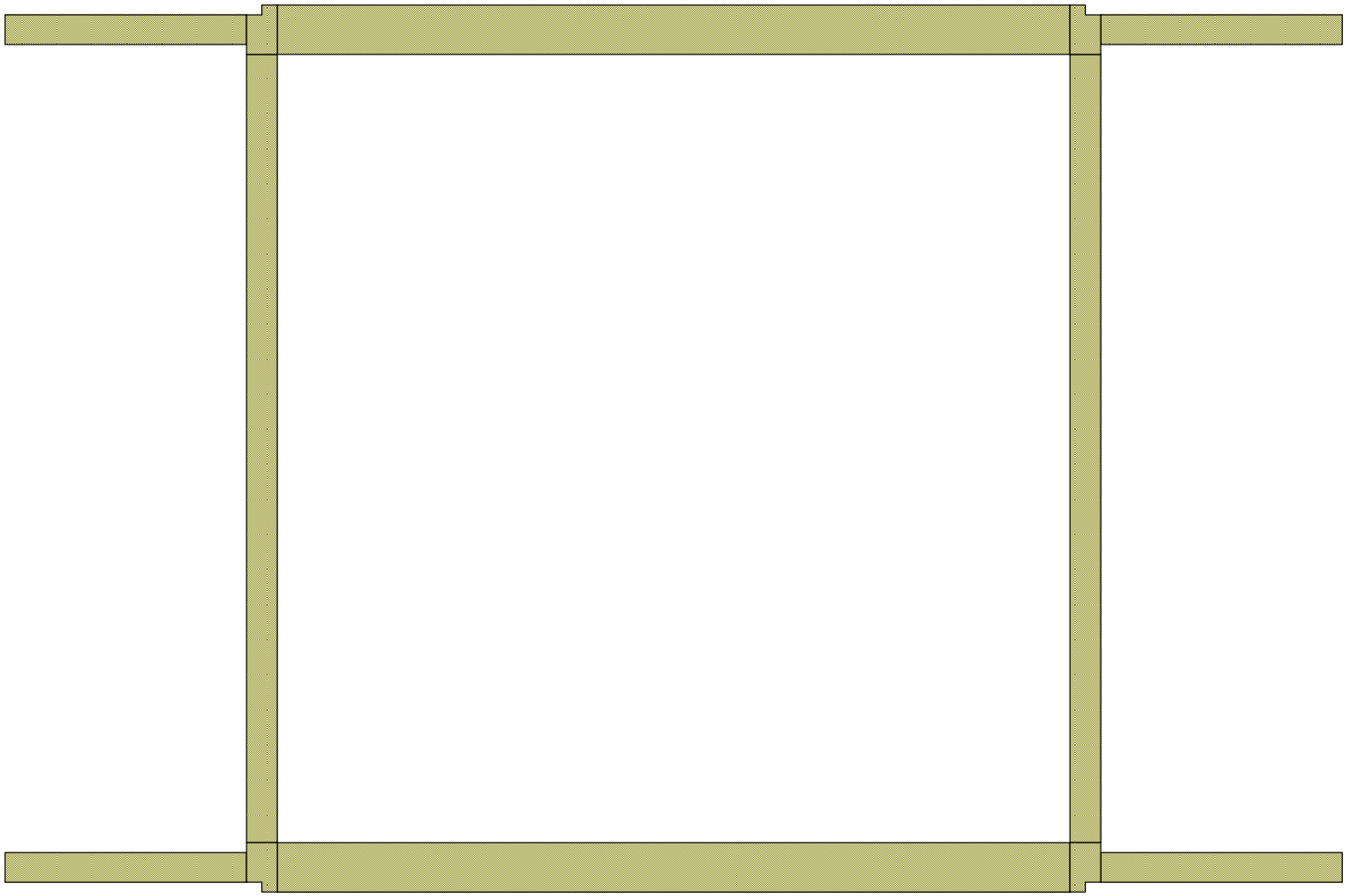


Straight Branch-Line Coupler - Schematic

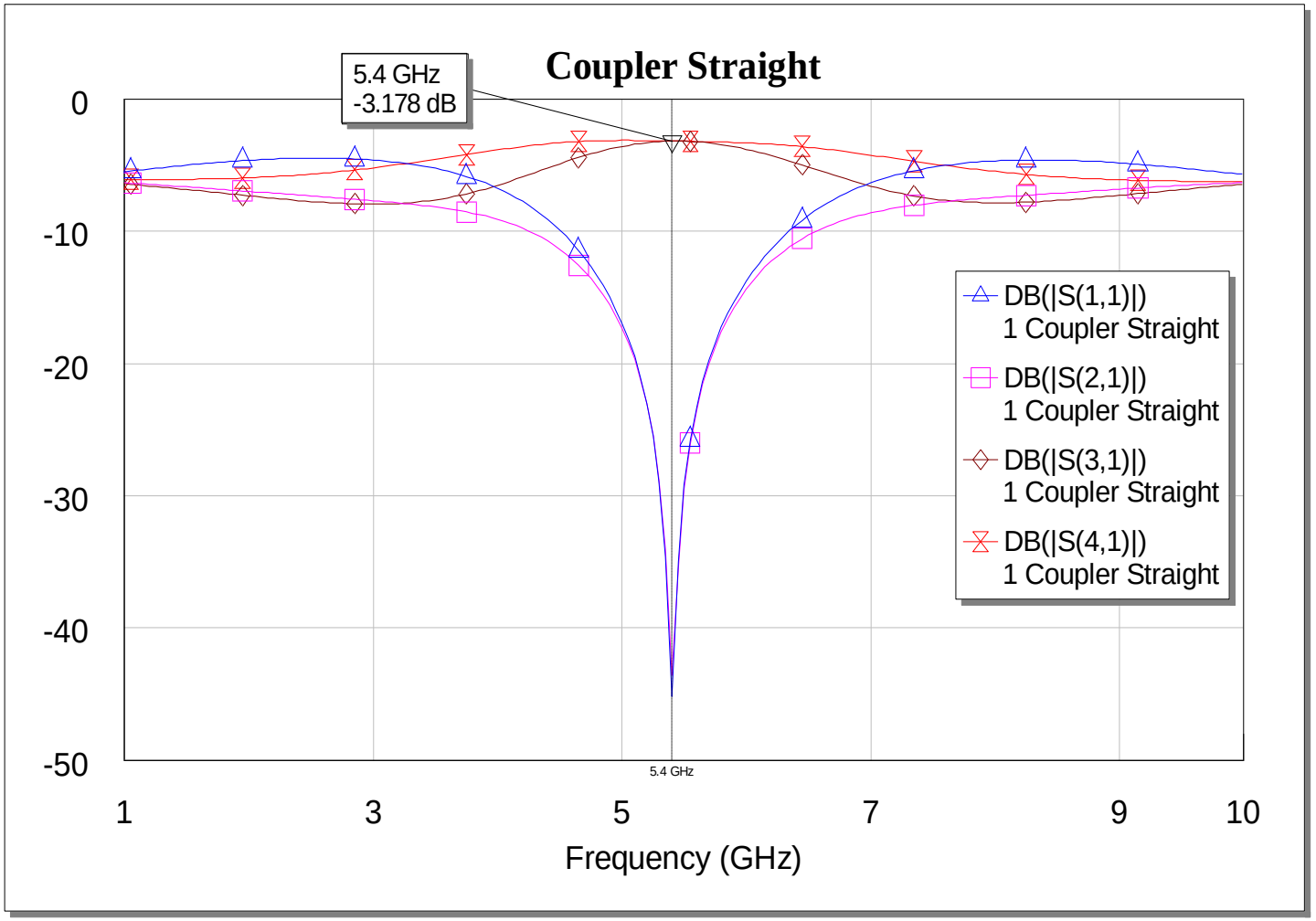
- discontinuities included
- straight lines used
- L_1 and L_2 tuned



Straight Branch-Line Coupler - Layout



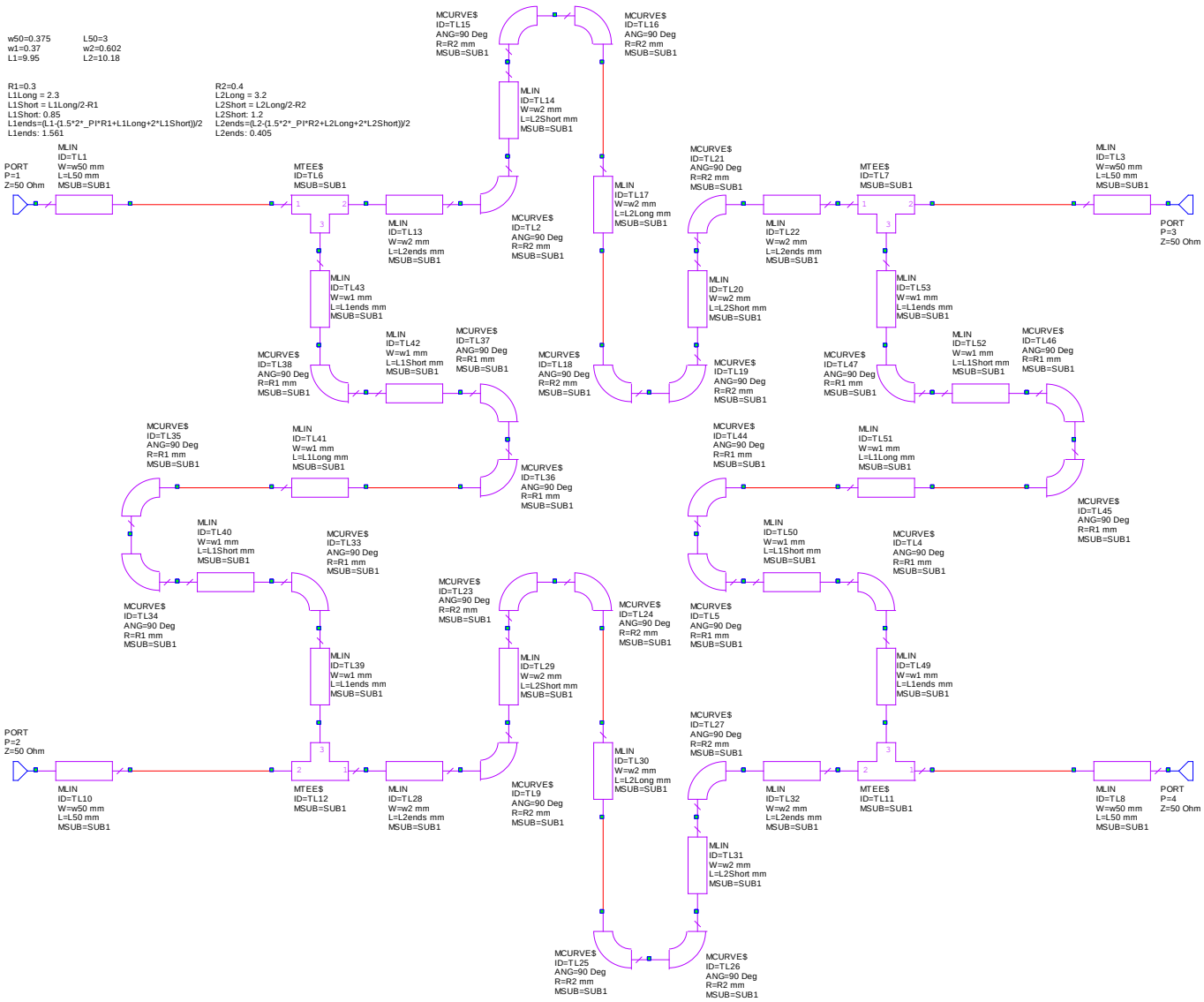
Straight Branch-Line Coupler - Results



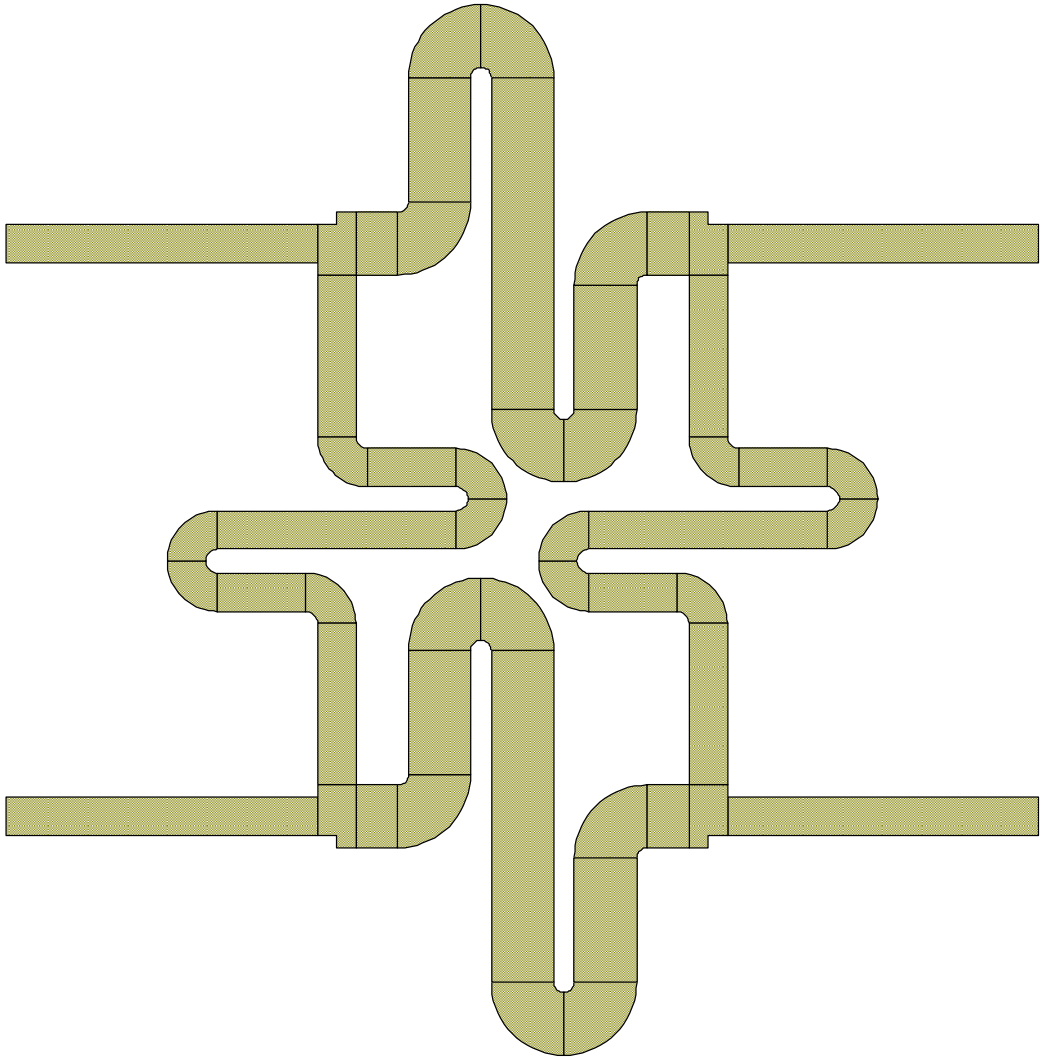
Reduction of Size - Meander Lines

- possible reduction of size - meandered lines
- crosstalks between elements
  - not considered by linear simulator
- verification by EM simulator is needed

Meander Branch-Line Coupler - Schematic

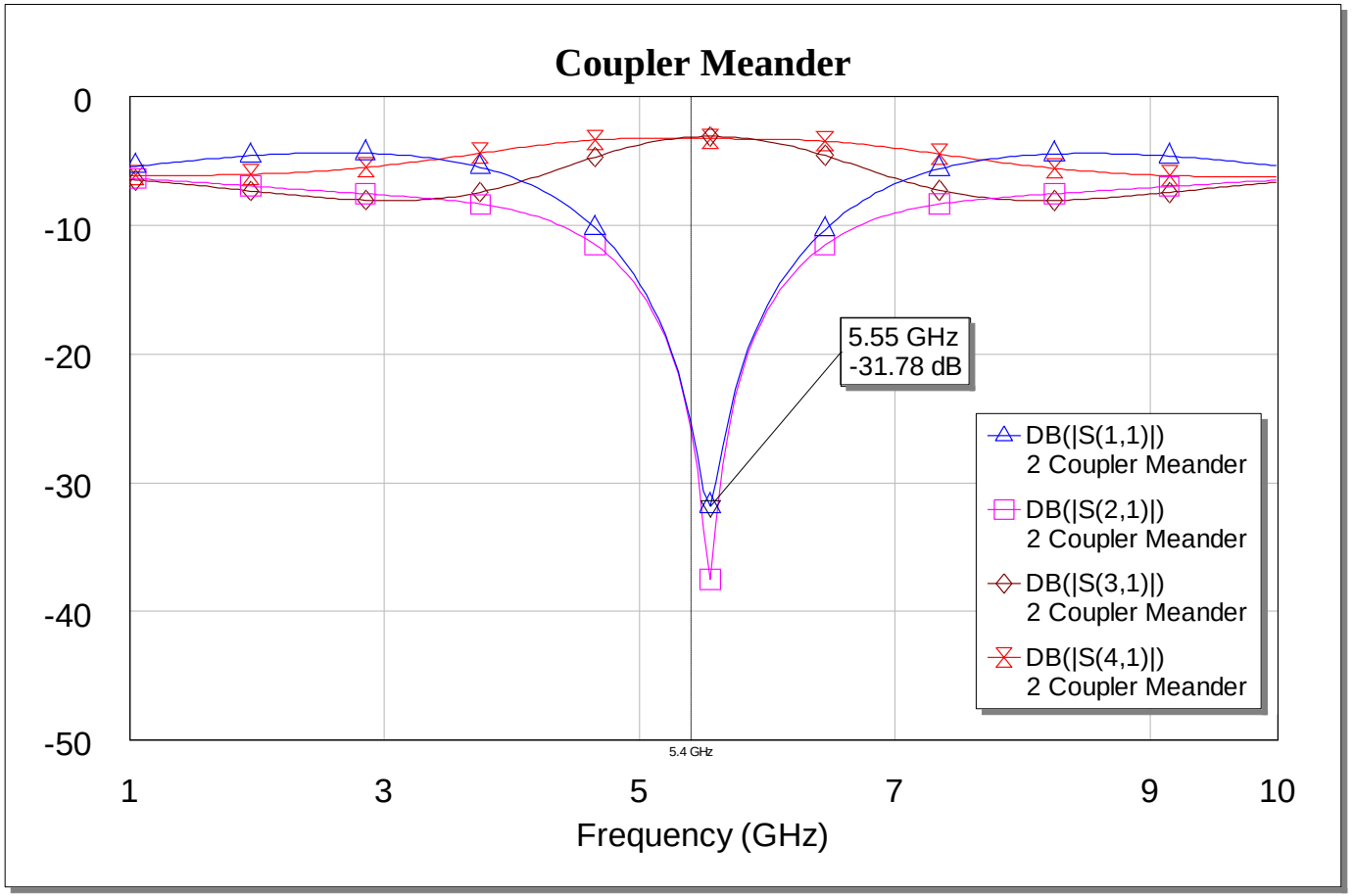


Meander Branch-Line Coupler - Layout



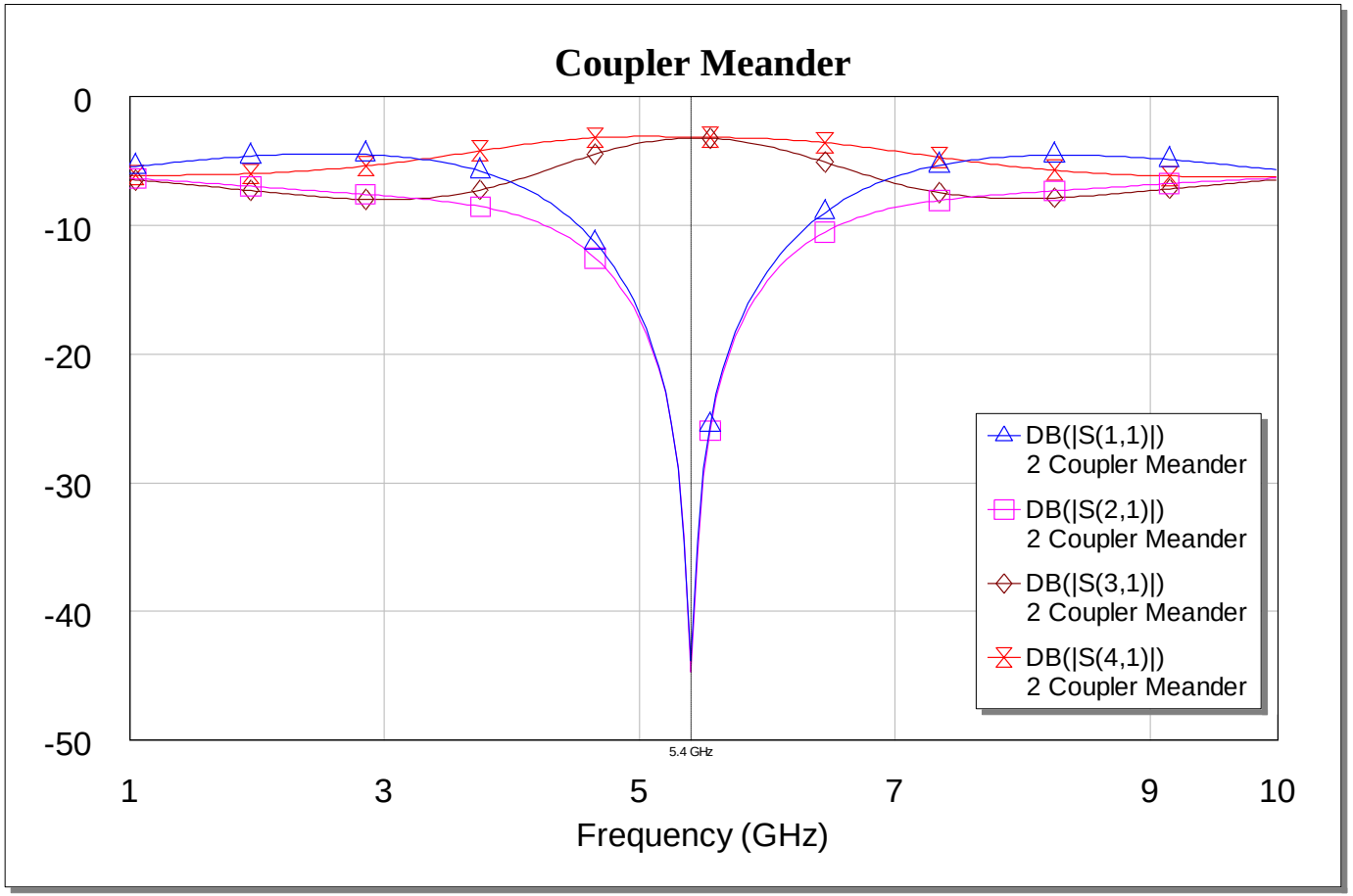
Meander Branch-Line Coupler - Results

- linear simulation results



Meander Branch-Line Coupler - Results

- after slight tunning of L_1, L_2, w_1 and w_2

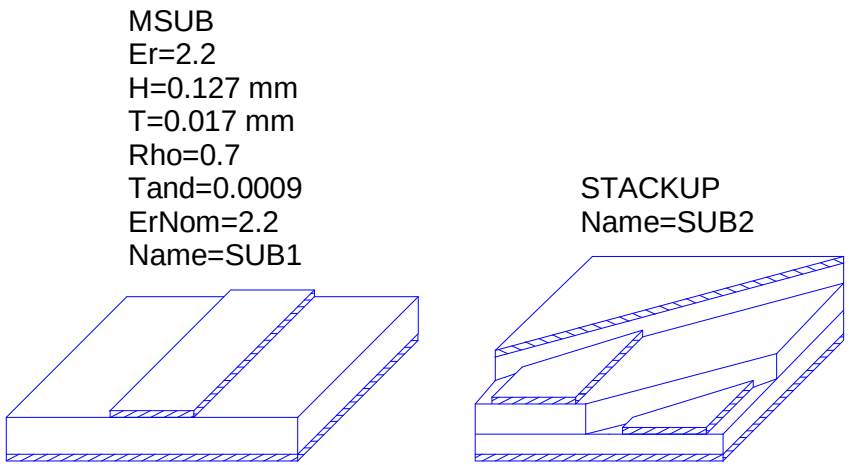


AXIEM - Planar EM Simulator

- methods of moments
  - conducting parts between dielectric layers (2.5D)
  - only conducting parts meshed
  - no side boundaries
- direct extraction of layout to EM simulator
- discrete 2D ports

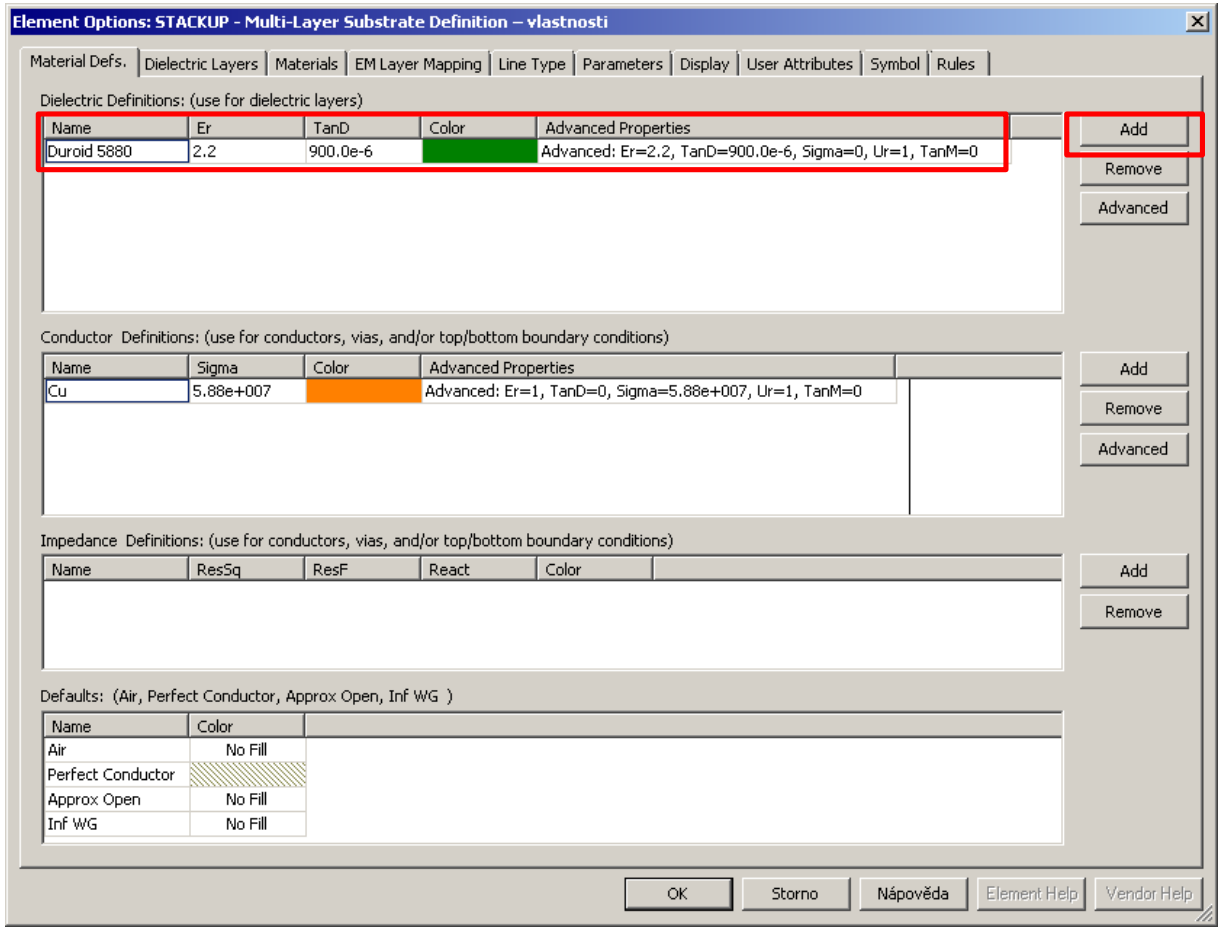
STACKUP Definition

- define materials in EM simulation
- find Elements→Substrates→STACKUP
- place it to Global Definitions as SUB2
- double click - properties are shown



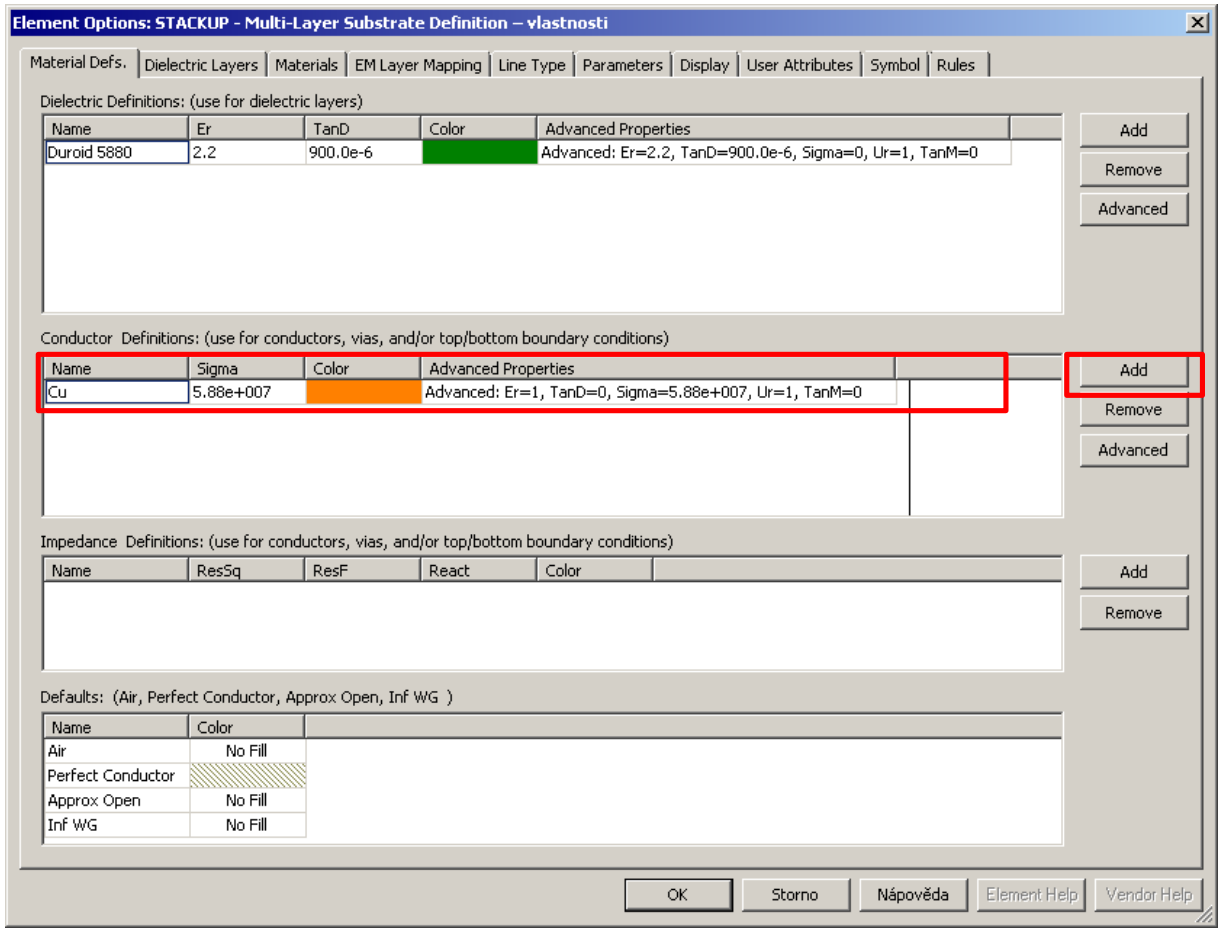
STACKUP Definition - Material Defs.

- add dielectric substrate Duroid 5880



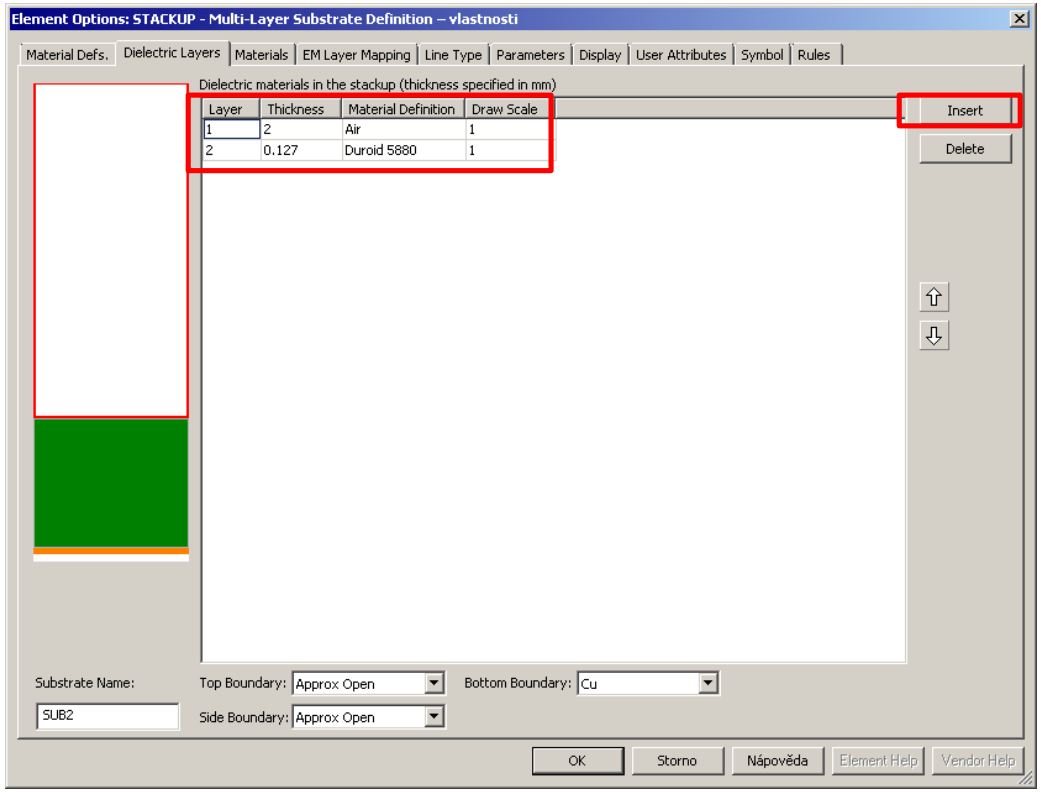
STACKUP Definition - Material Defs.

- add conductor Cu (predefined)



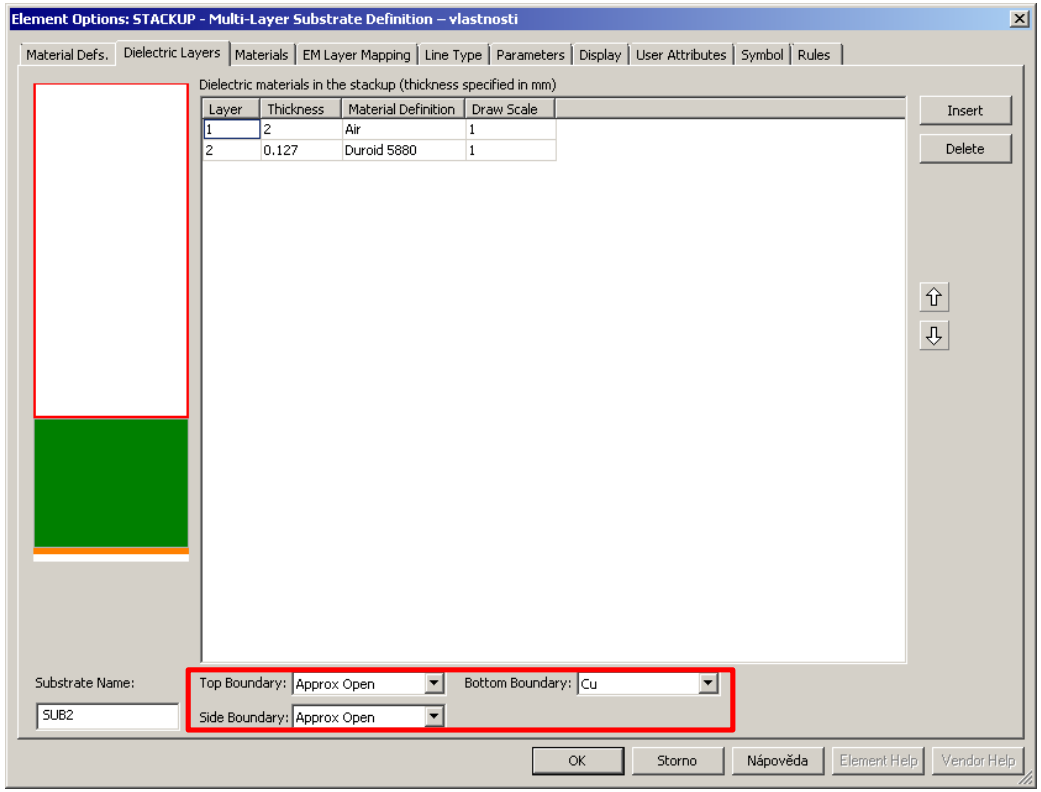
STACKUP Definition - Dielectric Layers

- add layer with substrate Duroid 5880
- thickness of Air above circuit is 2 mm



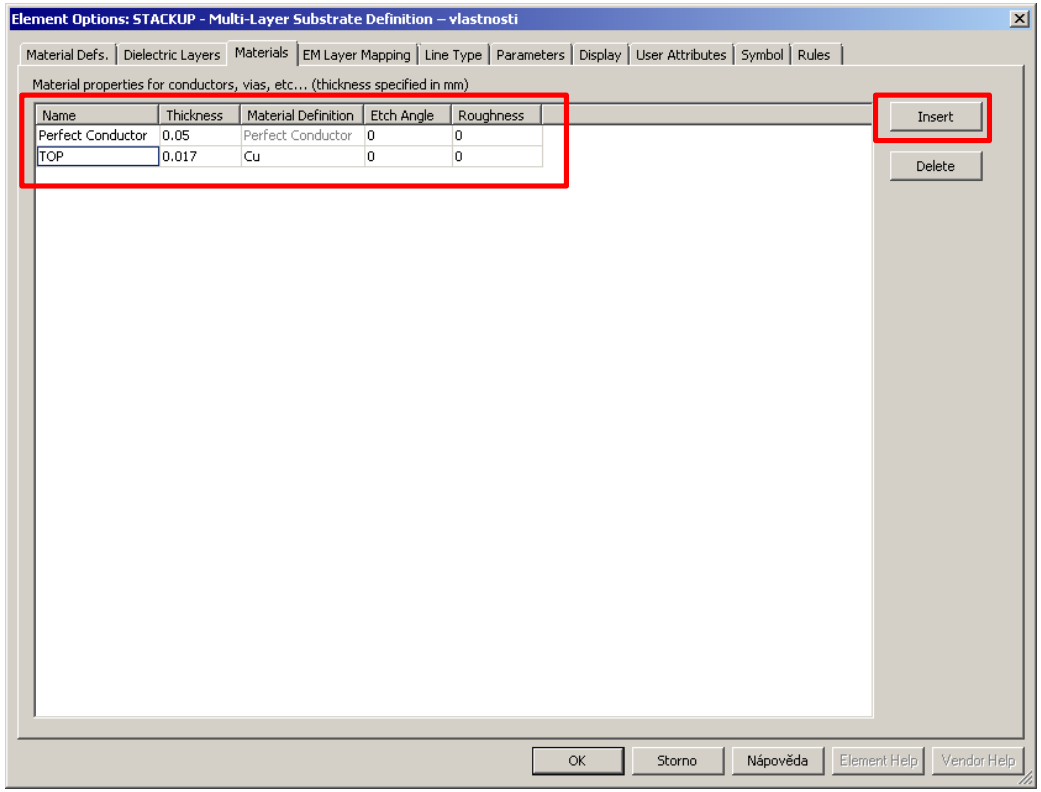
STACKUP Definition - Dielectric Layers

- define boundaries as Open and Cu



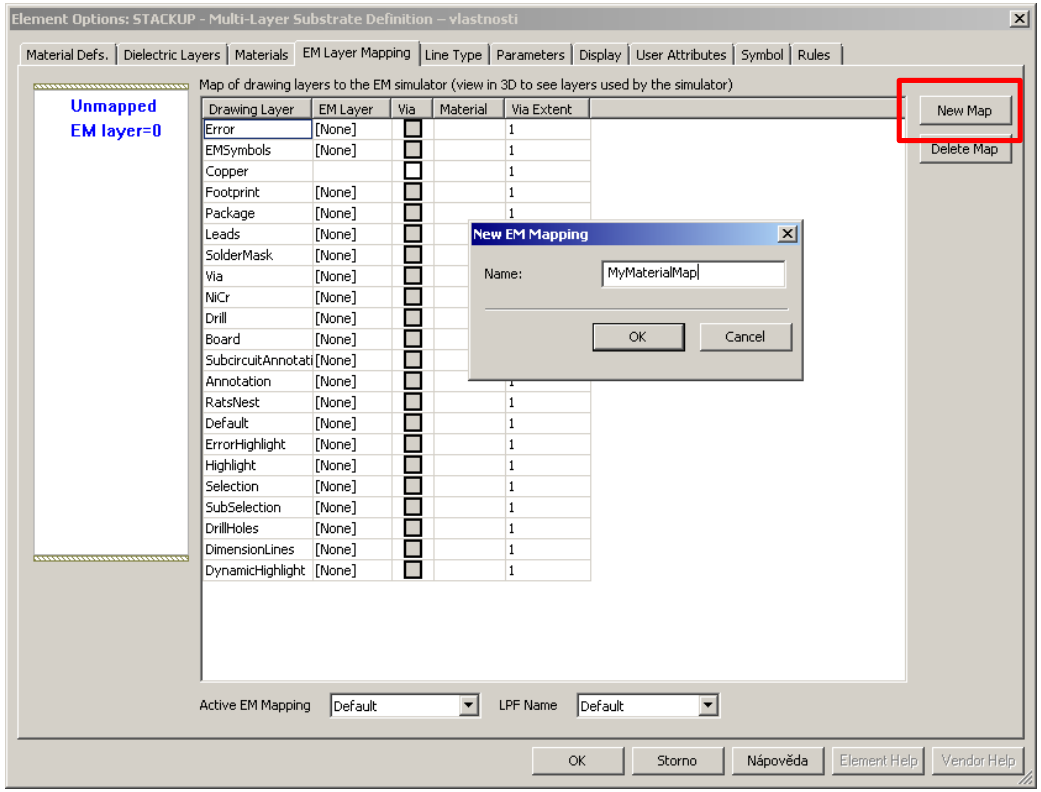
STACKUP Definition - Materials

- add material TOP for mapping from layout



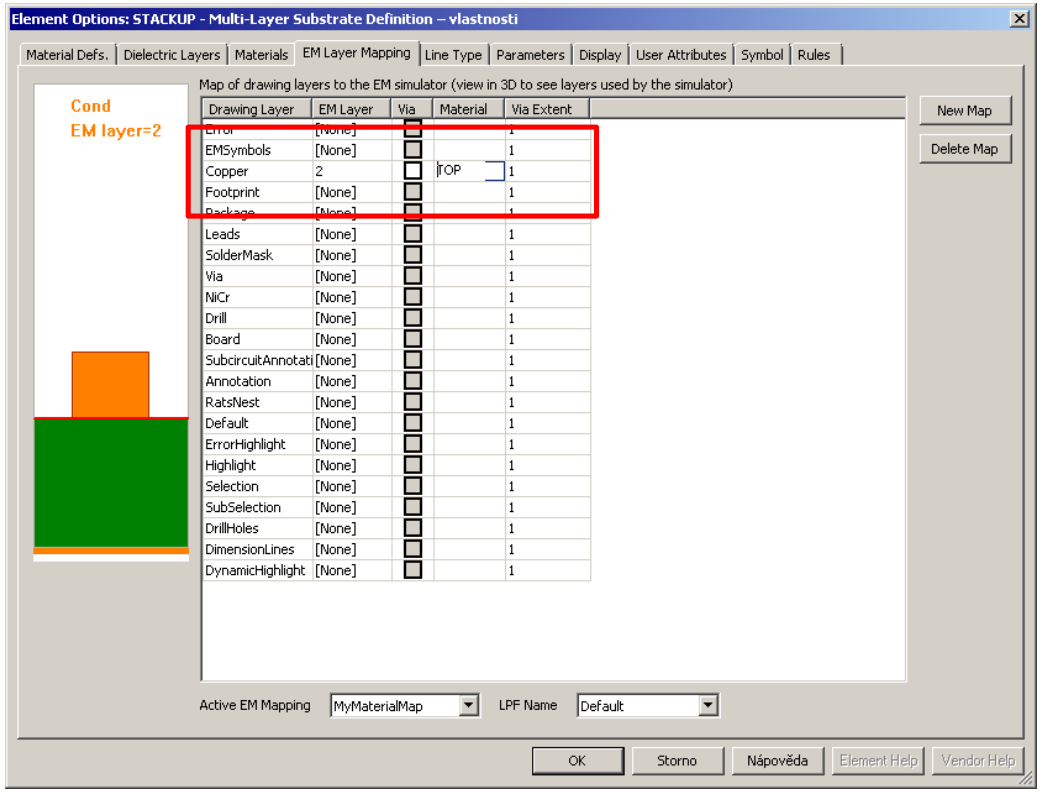
STACKUP Definition - EM Layer Mapping

- define new material map MyMaterialMap



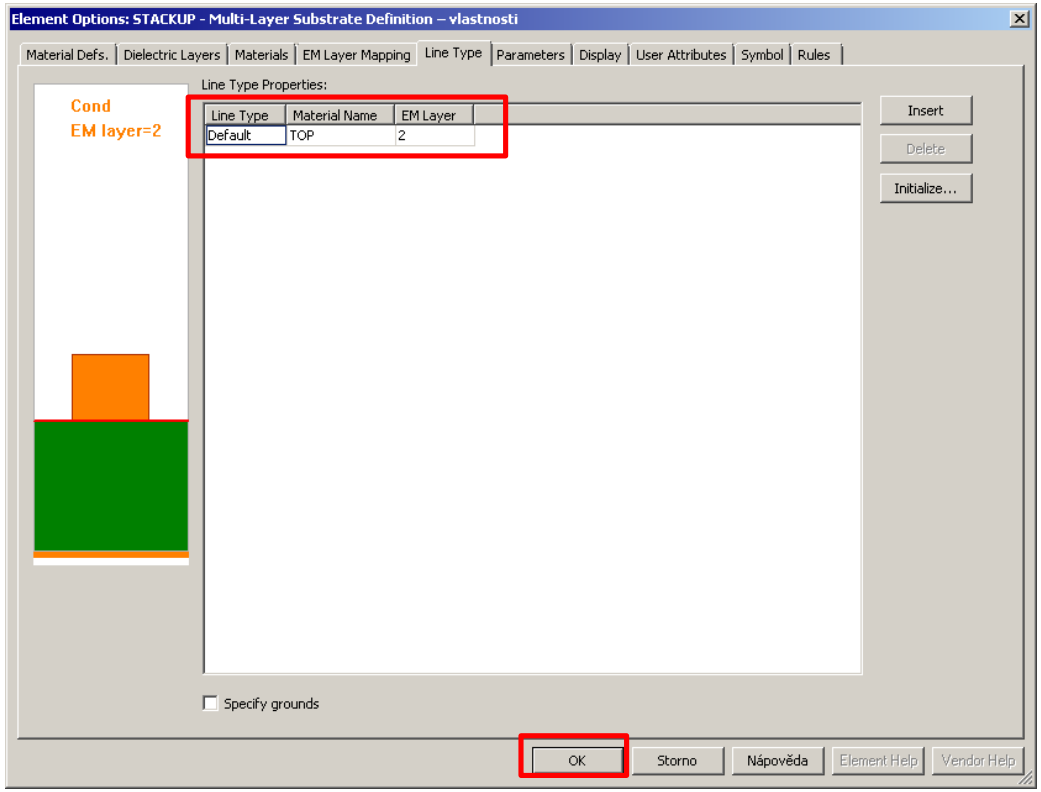
STACKUP Definition - EM Layer Mapping

- set material TOP and layer 2 to drawing layer Copper



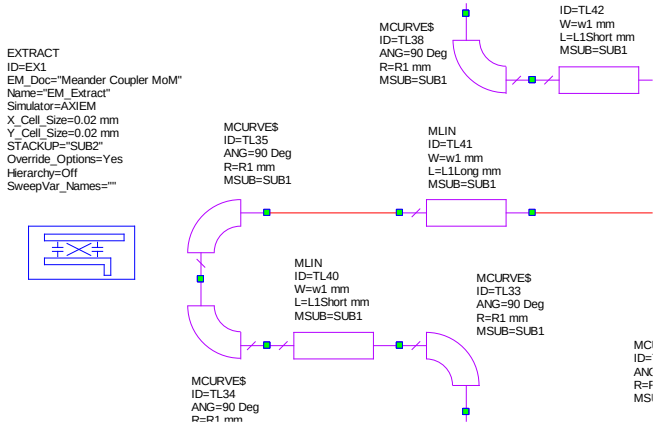
STACKUP Definition - Line Type

- change Material Name to TOP
- push OK



EXTRACT Definition

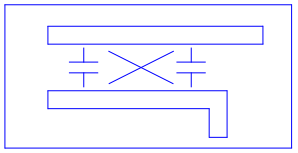
- define export from layout to EM simulator and simulation properties
- find Elements→Simulation Control→EXTRACT
- place it to schematic with coupler
  - it is convenient to have separate schematics for linear simulation and for EM extraction



EXTRACT Definition

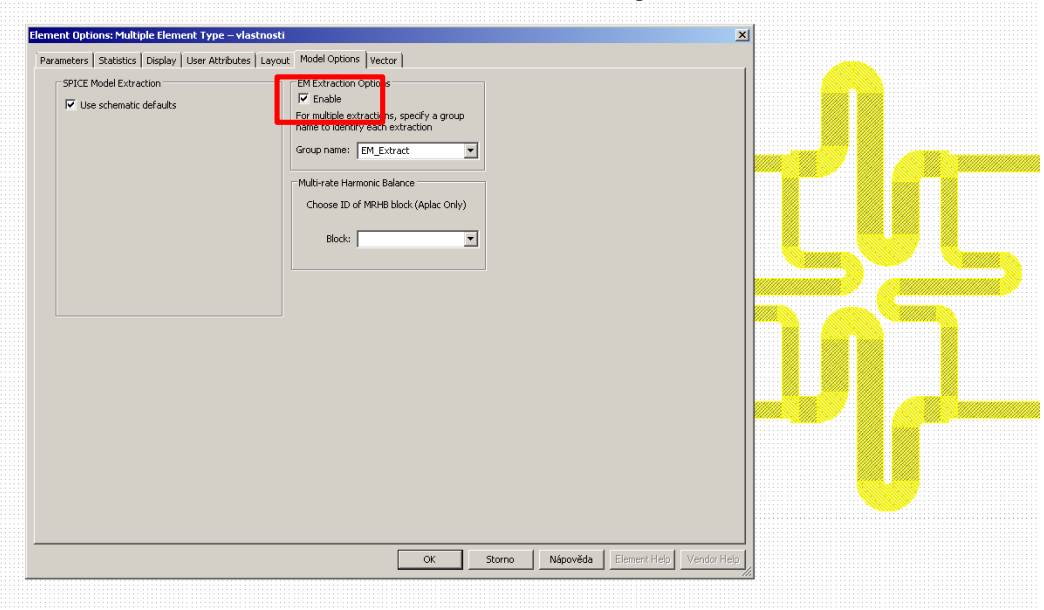
- EM_Doc - name of future EM Structure
- Simulator - choose AXIEM
- X and Y_CellSize - size of grid for mesh - 0.02mm is good choice
- STACKUP - SUB2
- double click on EXTRACT - lot of advanced properties can be setted
  - we use default

```
EXTRACT
ID=EX1
EM_Doc="Meander Coupler MoM"
Name="EM_Extract"
Simulator=AXIEM
X_Cell_Size=0.02 mm
Y_Cell_Size=0.02 mm
STACKUP="SUB2"
Override_Options=Yes
Hierarchy=Off
SweepVar_Names=""
```



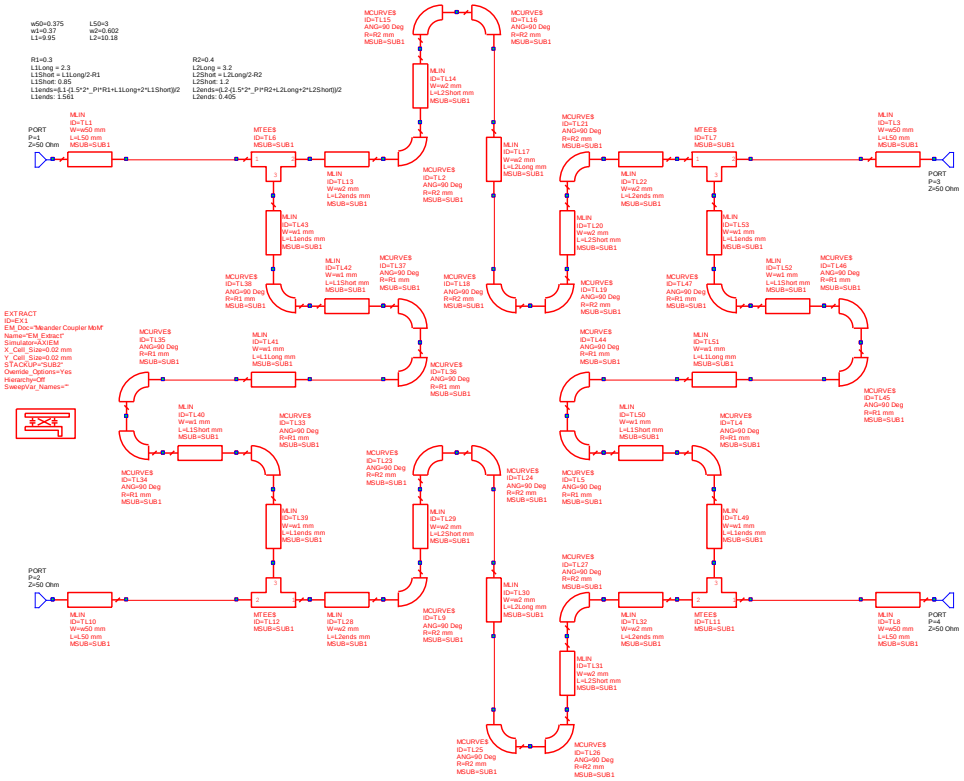
EXTRACT Definition

- show layout of meandered coupler
- select all - Ctrl+A
- right click→Element Properties→Model Options→EM Extraction Options - Enable



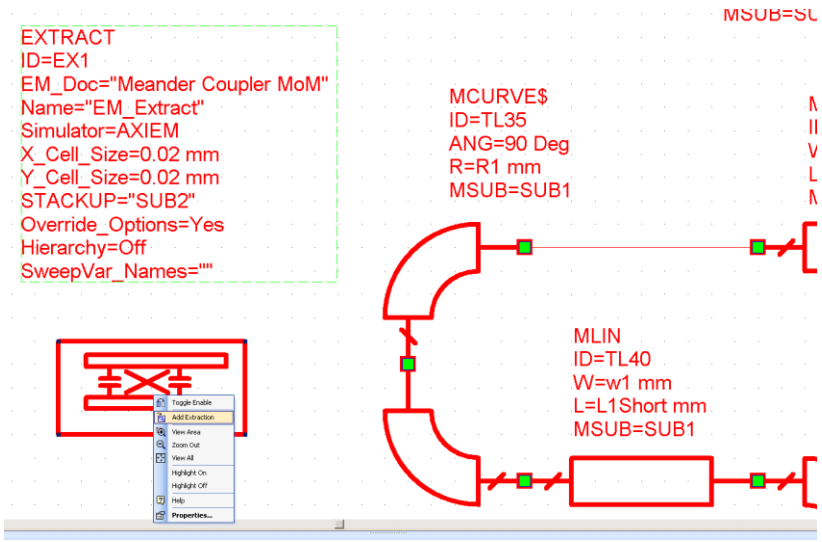
EXTRACT Definition - Check

- click on EXTRACT element in schematic
  - associated elements for extraction should be red

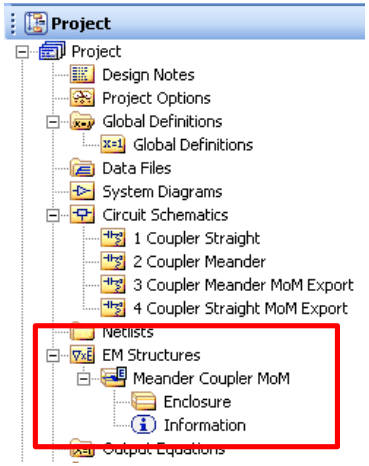


Extraction of Layout to EM Structure

- right click on EXTRACT→Add Extraction

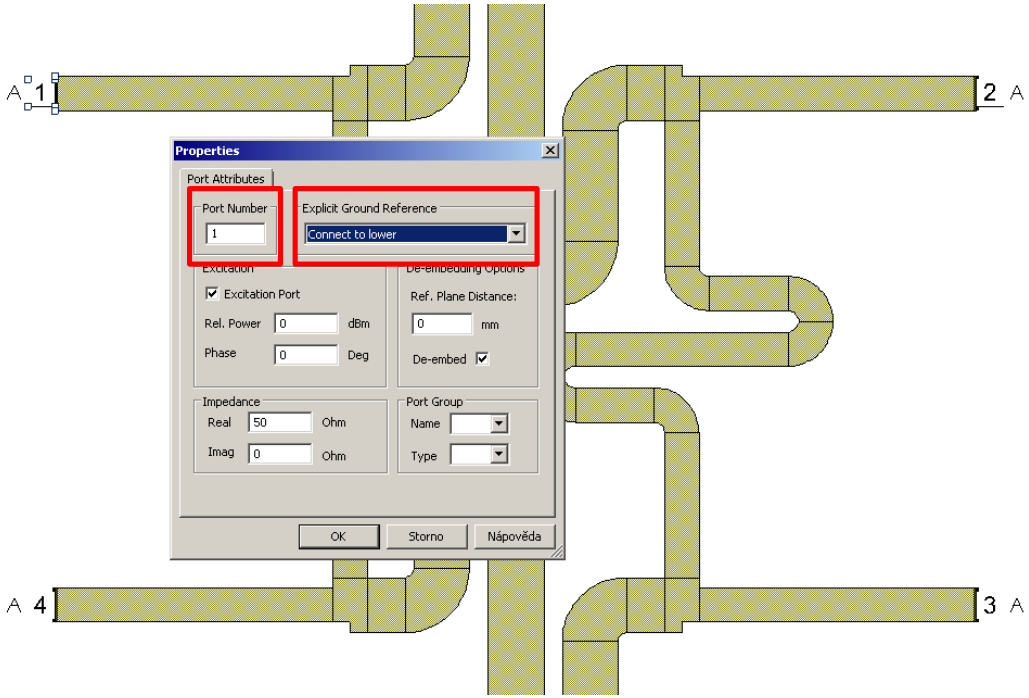


- new EM Structure is created



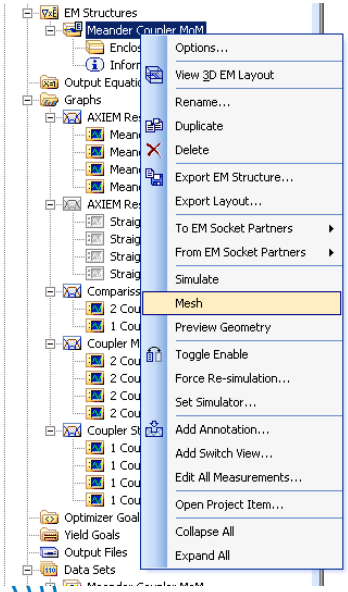
EM Structure - Ports Definition

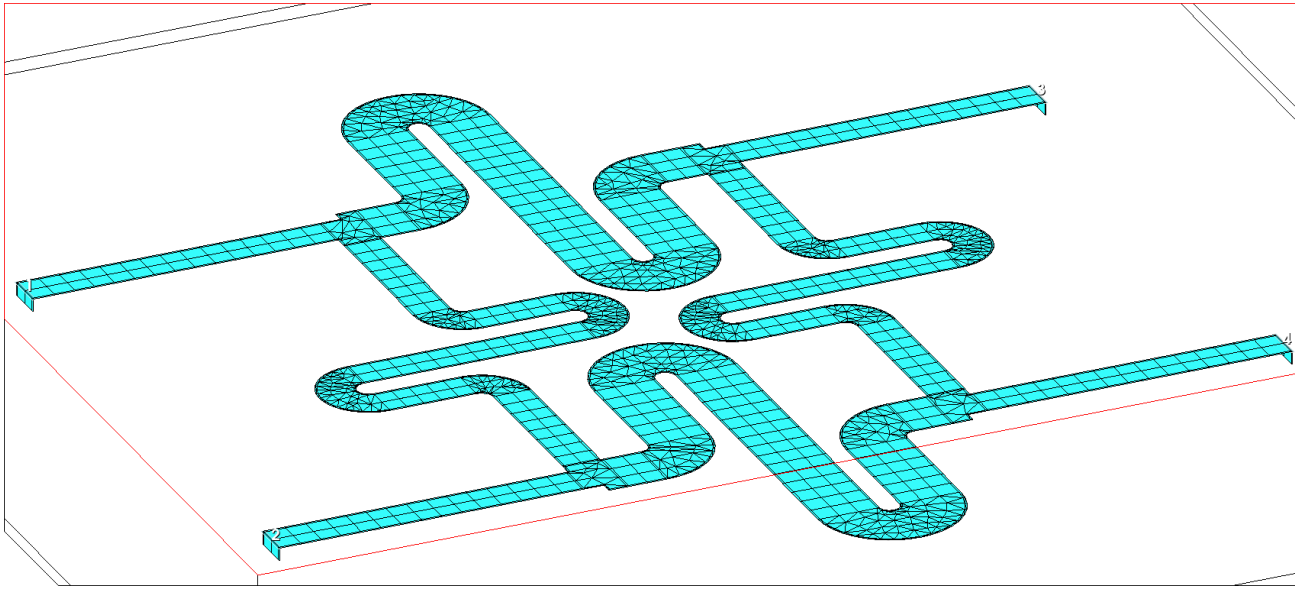
- imported ports do not keep original numbers
- for all ports: double click→change Port Number and set Ground Reference to lower



EM Structure - Meshing

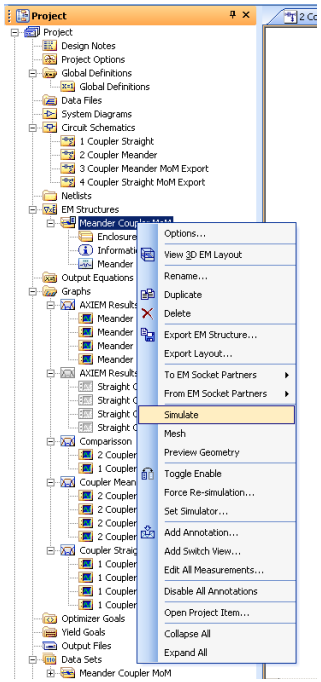
- to mesh structure: right click on Meander Coupler MoM→Mesh
- mesh was computed for highest frequency in project (10 GHz)

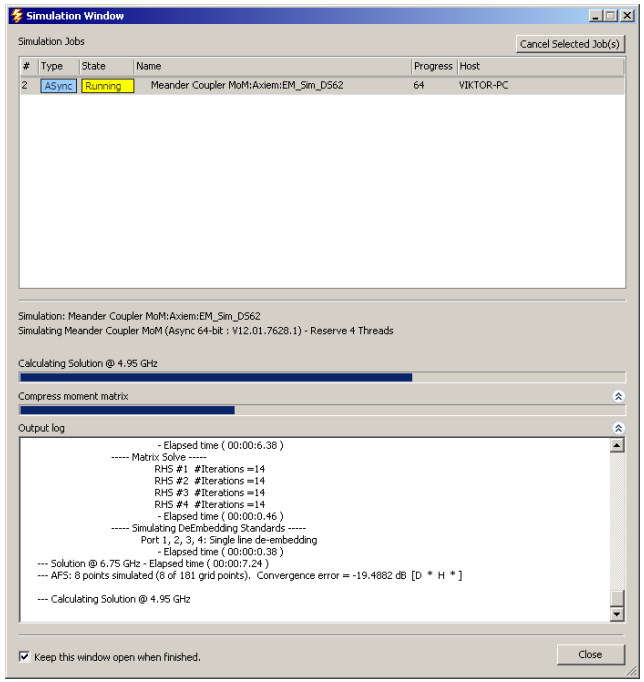




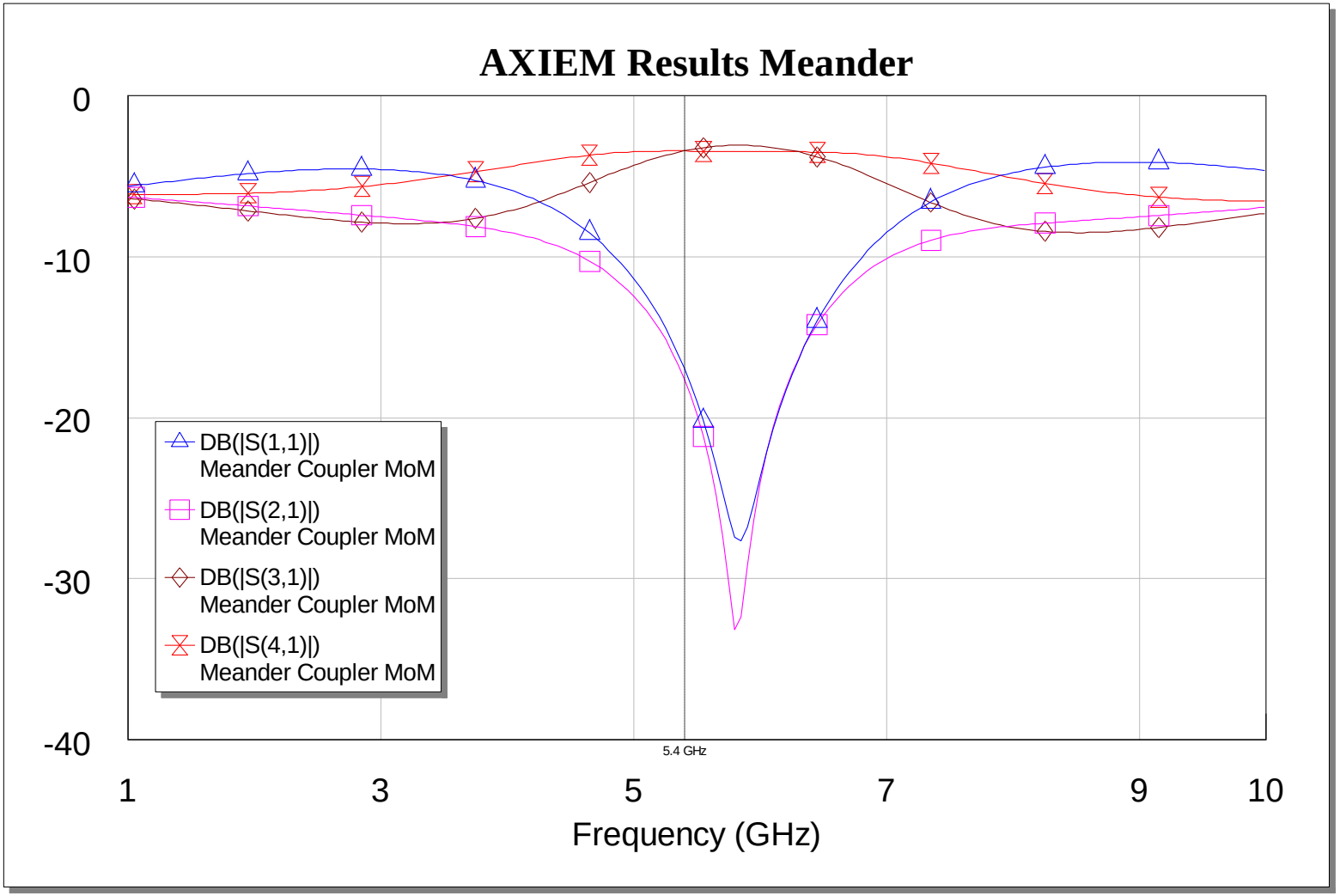
EM Structure - Simulation

- to simulate structure: right click on Meander Coupler MoM→Simulate





EM Structure - Results



EM Structure - Results

- coupler is retuned because of crosstalks between lines
- mesh and simulation was performed with default settings
  - but value of X and Y_Cell_Size is very important
- always check sensitivity of simulation task on mesh density

Thank you for your attention!