

Branch-Line Coupler Design Validation in AWR AXIEM EM Solver

Microwave Circuits (B2M17MIO)

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Global Definitions

- substrate Duroid 5880

- $\epsilon_r = 2.2$

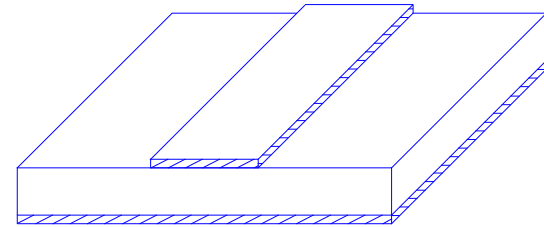
- $h = 0.127 \text{ mm}$

- $\text{tg}\delta = 0.0009 @ 10 \text{ GHz}$

- $t = 17 \mu\text{m}$

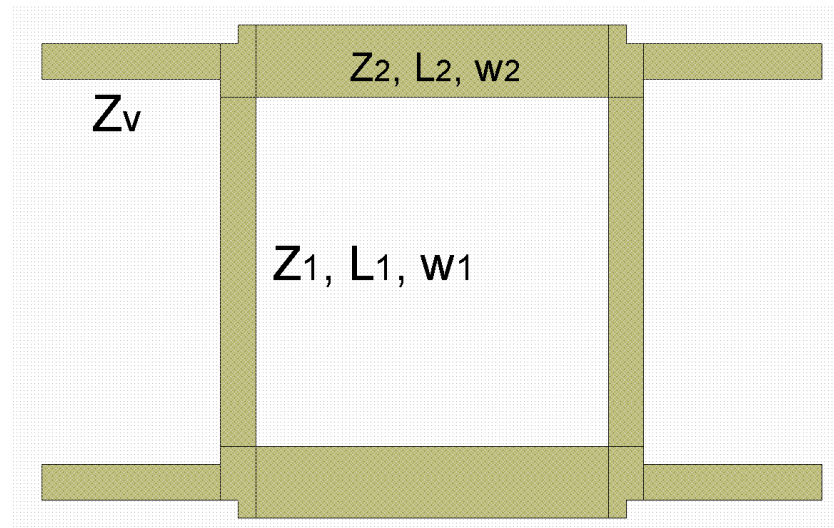
- $\sigma_{\text{Cu}} = 5.88 \times 10^7 \text{ S/m} \rightarrow \text{Rho} = 0.7$

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



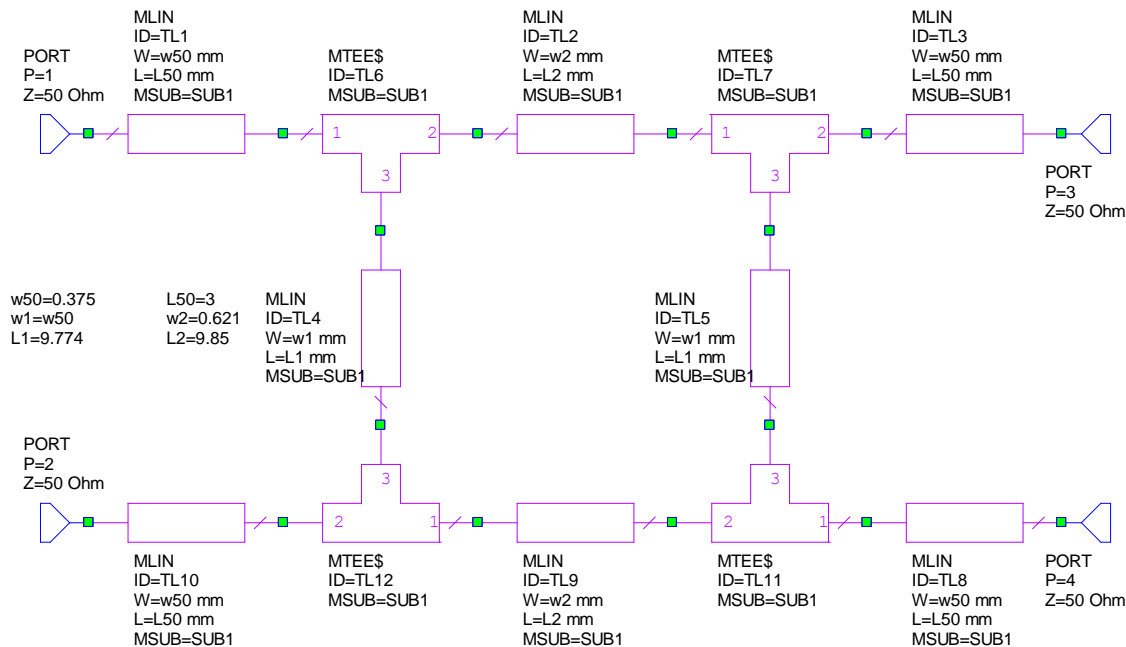
Branch-Line Coupler Design

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

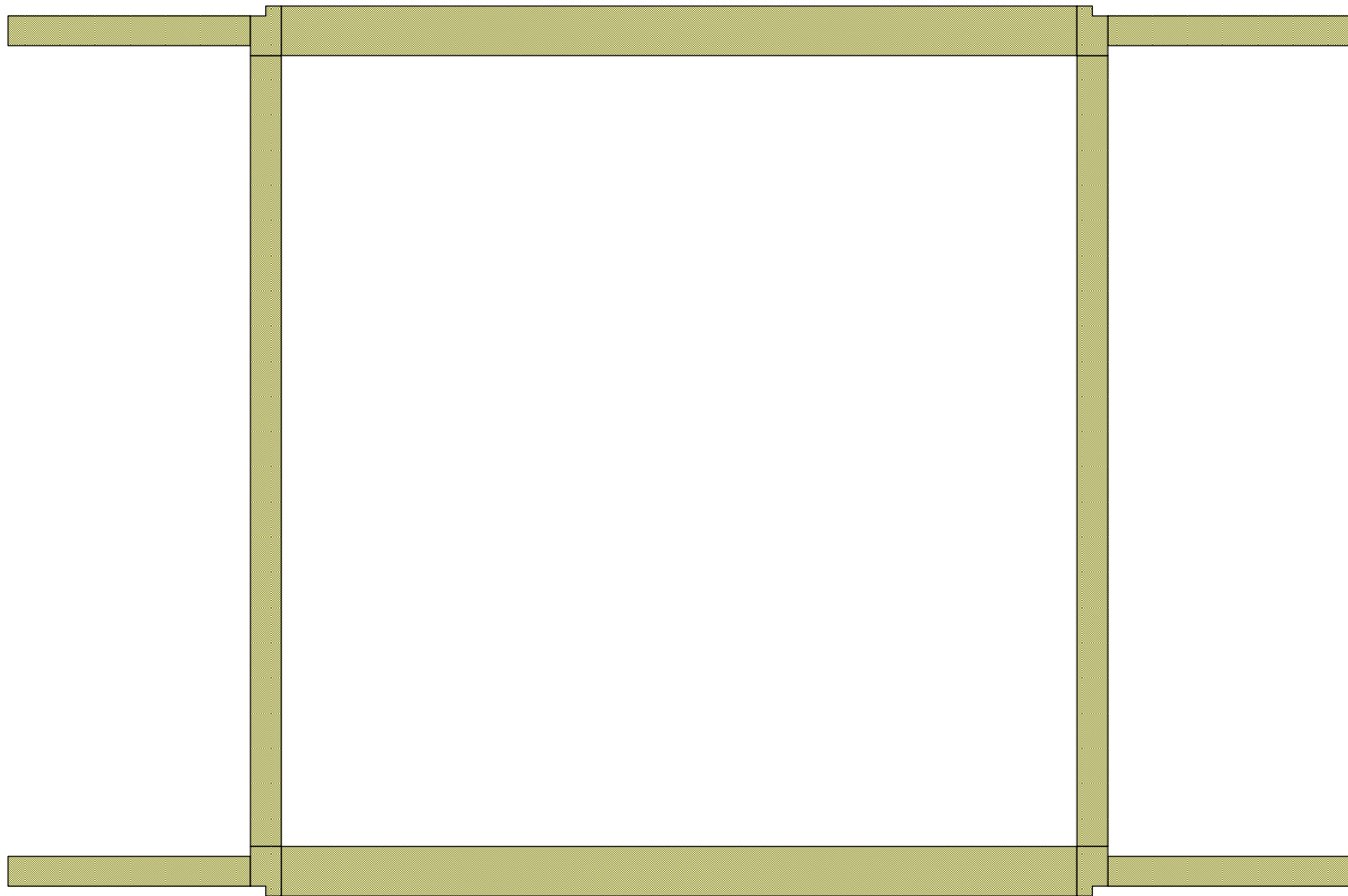


Straight Branch-Line Coupler - Schematic

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

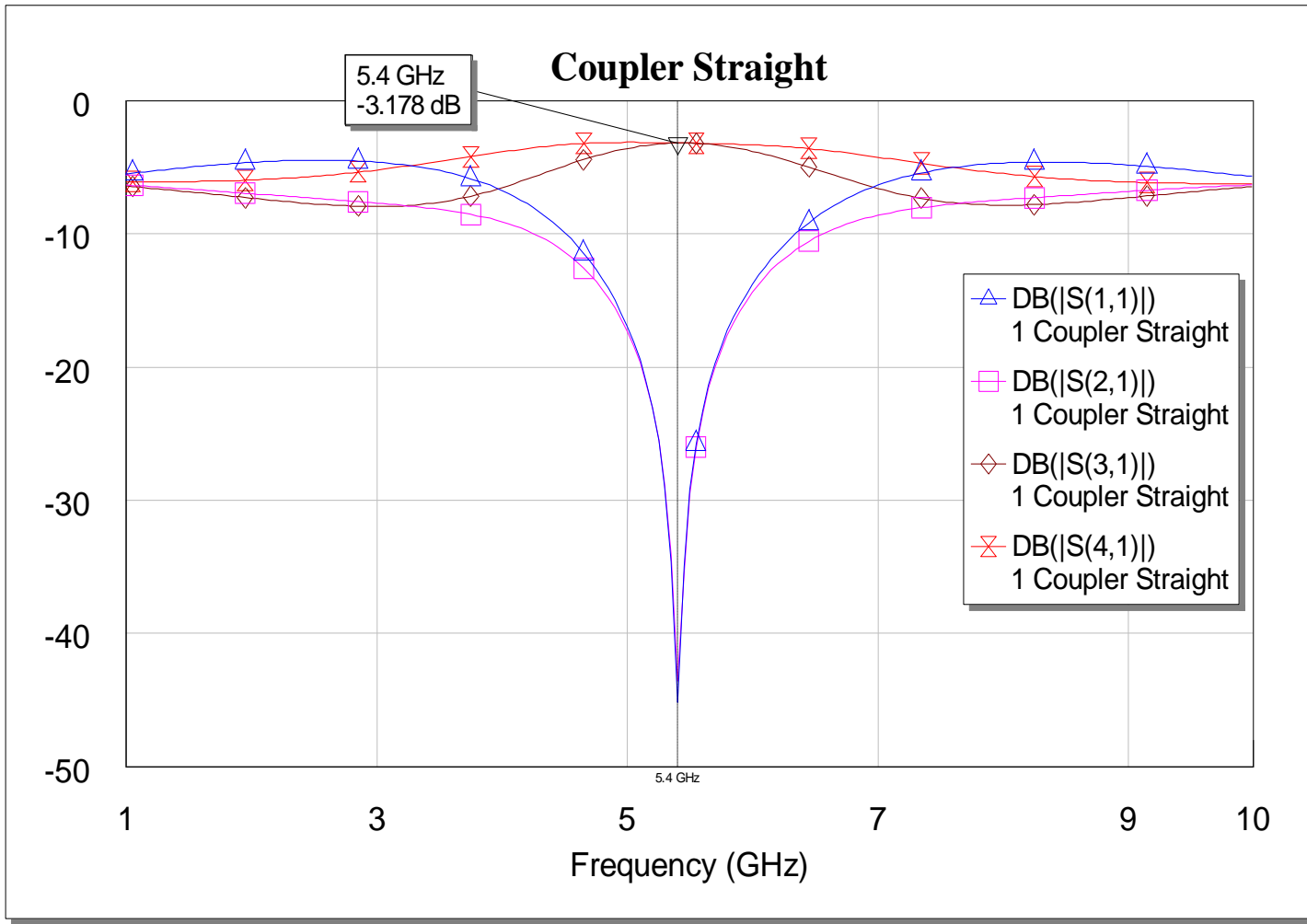


Straight Branch-Line Coupler - Layout





Straight Branch-Line Coupler - Results

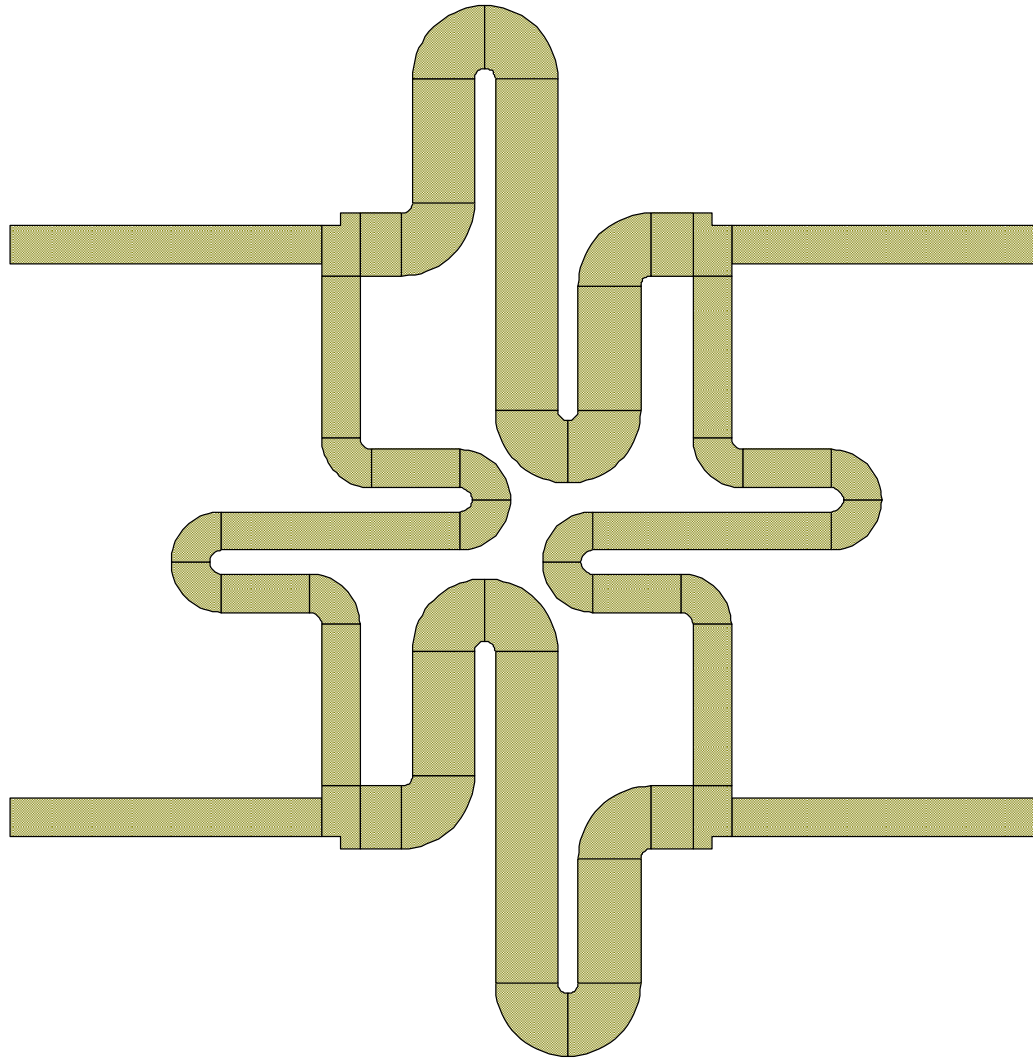


Reduction of Size - Meander Lines

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

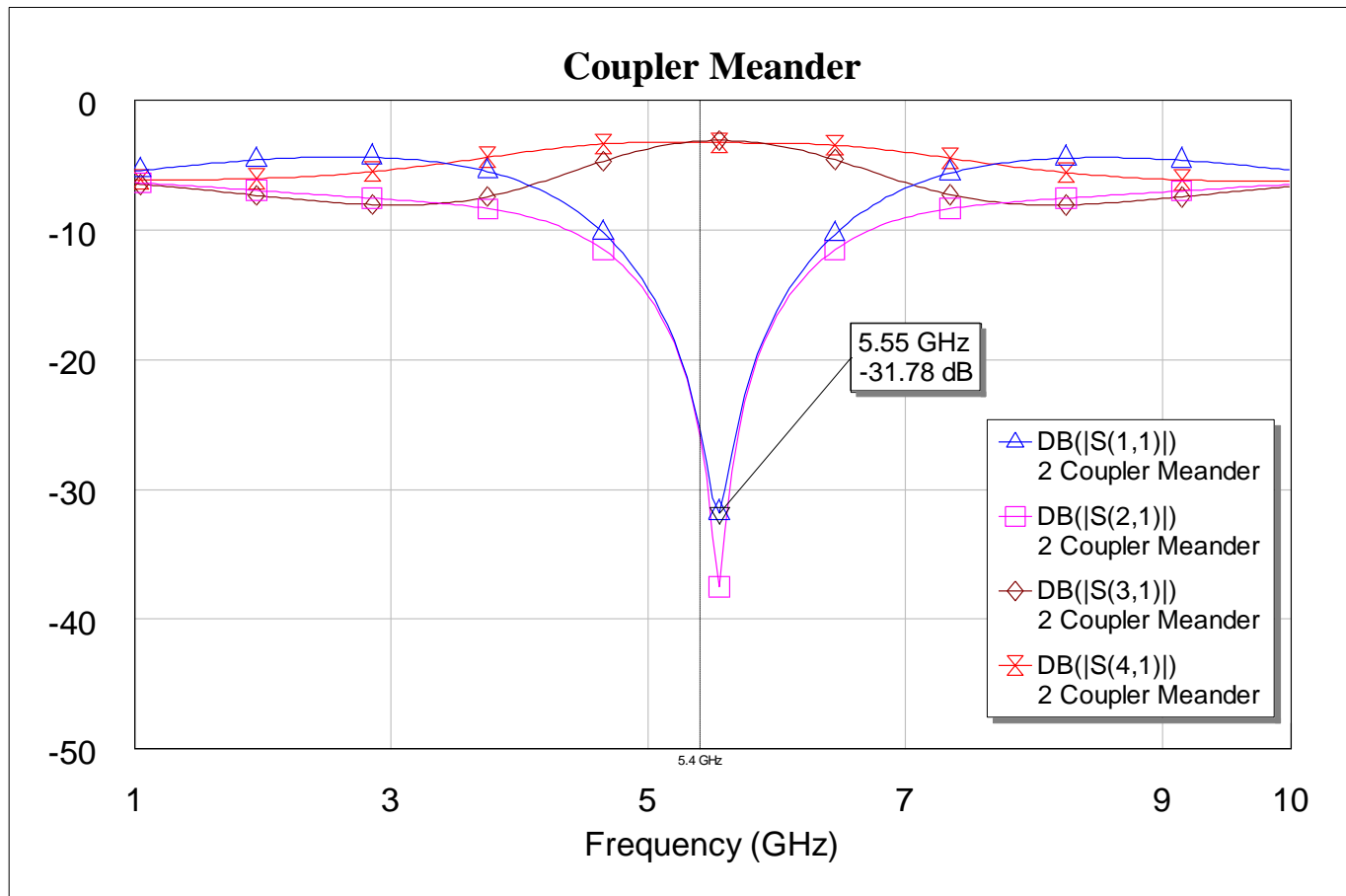


Meander Branch-Line Coupler - Layout



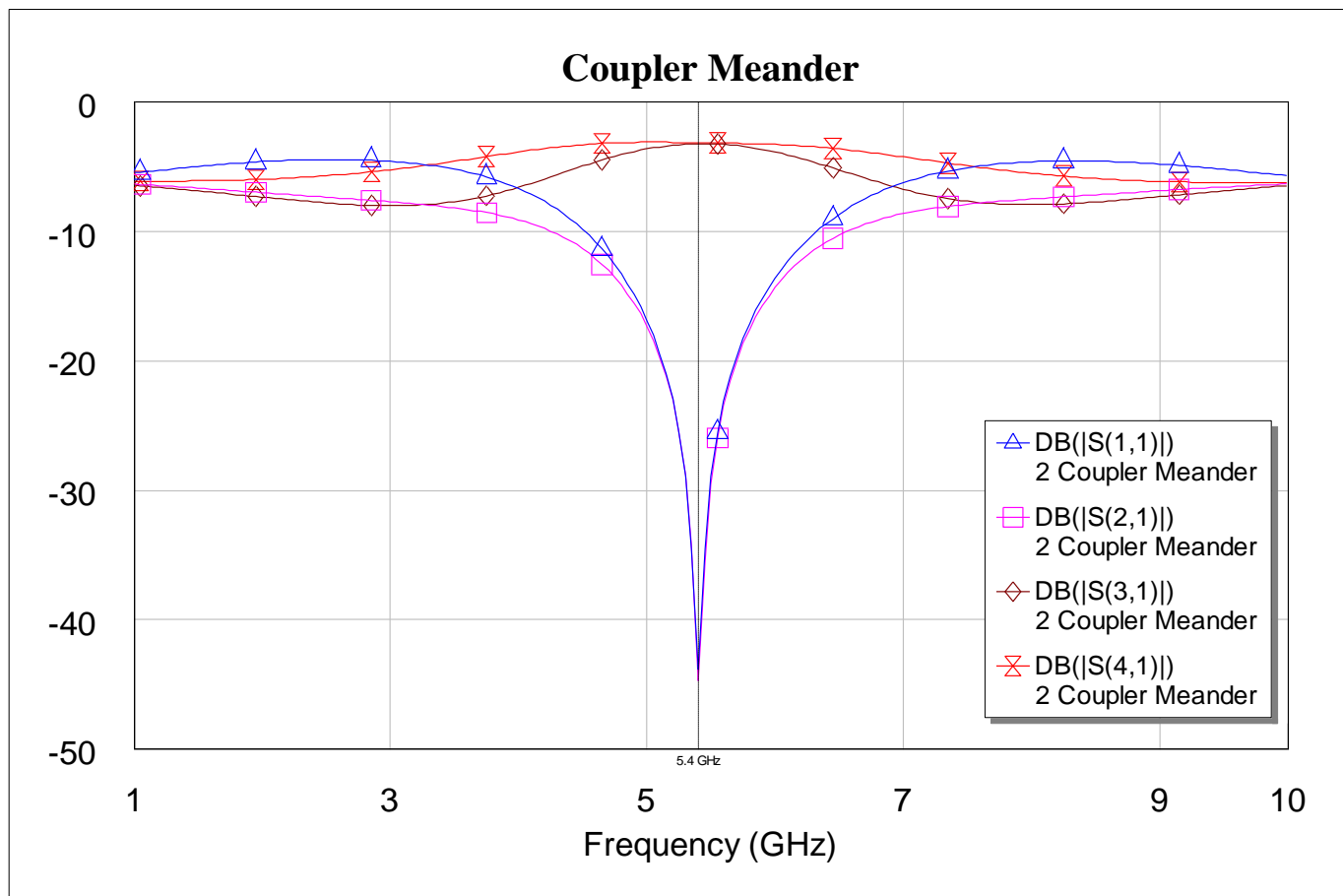
Meander Branch-Line Coupler - Results

- linear simulation results



Meander Branch-Line Coupler - Results

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



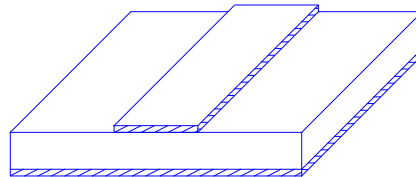
AXIEM - Planar EM Simulator

- 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

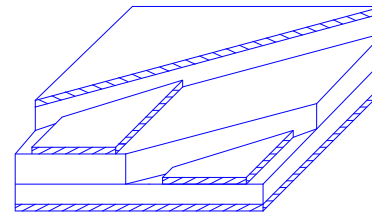
STACKUP Definition

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

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



STACKUP
Name=SUB2



STACKUP Definition - Material Defs.

- add dielectric substrate Duroid 5880

Element Options: STACKUP - Multi-Layer Substrate Definition - vlastnosti

Material Defs. | Dielectric Layers | Materials | EM Layer Mapping | Line Type | Parameters | Display | User Attributes | Symbol | Rules

Dielectric Definitions: (use for dielectric layers)

Name	Er	TanD	Color	Advanced Properties
Duroid 5880	2.2	900.0e-6		Advanced: Er=2.2, TanD=900.0e-6, Sigma=0, Ur=1, TanM=0

Add Remove Advanced

Conductor Definitions: (use for conductors, vias, and/or top/bottom boundary conditions)

Name	Sigma	Color	Advanced Properties
Cu	5.88e+007		Advanced: Er=1, TanD=0, Sigma=5.88e+007, Ur=1, TanM=0

Add Remove Advanced

Impedance Definitions: (use for conductors, vias, and/or top/bottom boundary conditions)

Name	ResSq	ResF	React	Color
------	-------	------	-------	-------

Add Remove

Defaults: (Air, Perfect Conductor, Approx Open, Inf WG)

Name	Color
Air	No Fill
Perfect Conductor	
Approx Open	No Fill
Inf WG	No Fill

OK Storno Nápověda Element Help Vendor Help

STACKUP Definition - Material Defs.

- add conductor Cu (predefined)

Element Options: STACKUP - Multi-Layer Substrate Definition - vlastnosti

Material Defs. | Dielectric Layers | Materials | EM Layer Mapping | Line Type | Parameters | Display | User Attributes | Symbol | Rules

Dielectric Definitions: (use for dielectric layers)

Name	Er	TanD	Color	Advanced Properties
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Conductor Definitions: (use for conductors, vias, and/or top/bottom boundary conditions)

Name	Sigma	Color	Advanced Properties
Cu	5.88e+007		Advanced: Er=1, TanD=0, Sigma=5.88e+007, Ur=1, TanM=0

Impedance Definitions: (use for conductors, vias, and/or top/bottom boundary conditions)

Name	ResSq	ResF	React	Color
------	-------	------	-------	-------

Defaults: (Air, Perfect Conductor, Approx Open, Inf WG)

Name	Color
Air	No Fill
Perfect Conductor	
Approx Open	No Fill
Inf WG	No Fill

Buttons: Add, Remove, Advanced

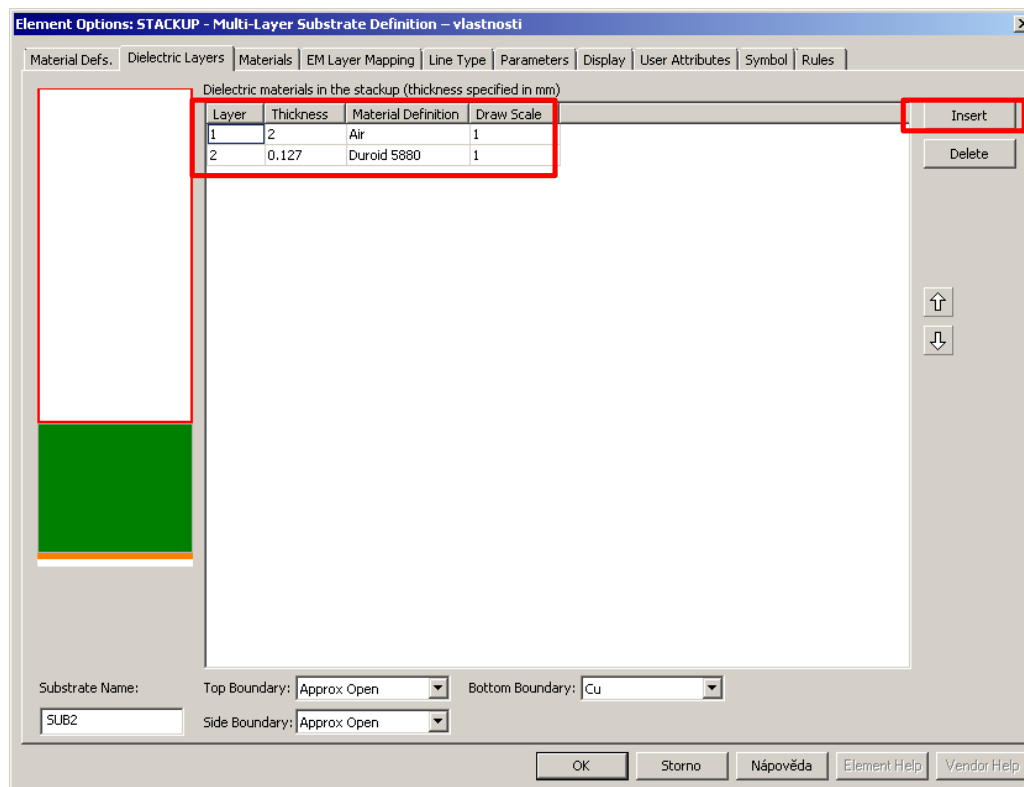
Buttons: Add, Remove, Advanced

Buttons: Add, Remove

Buttons: OK, Storno, Nápořádá, Element Help, Vendor Help

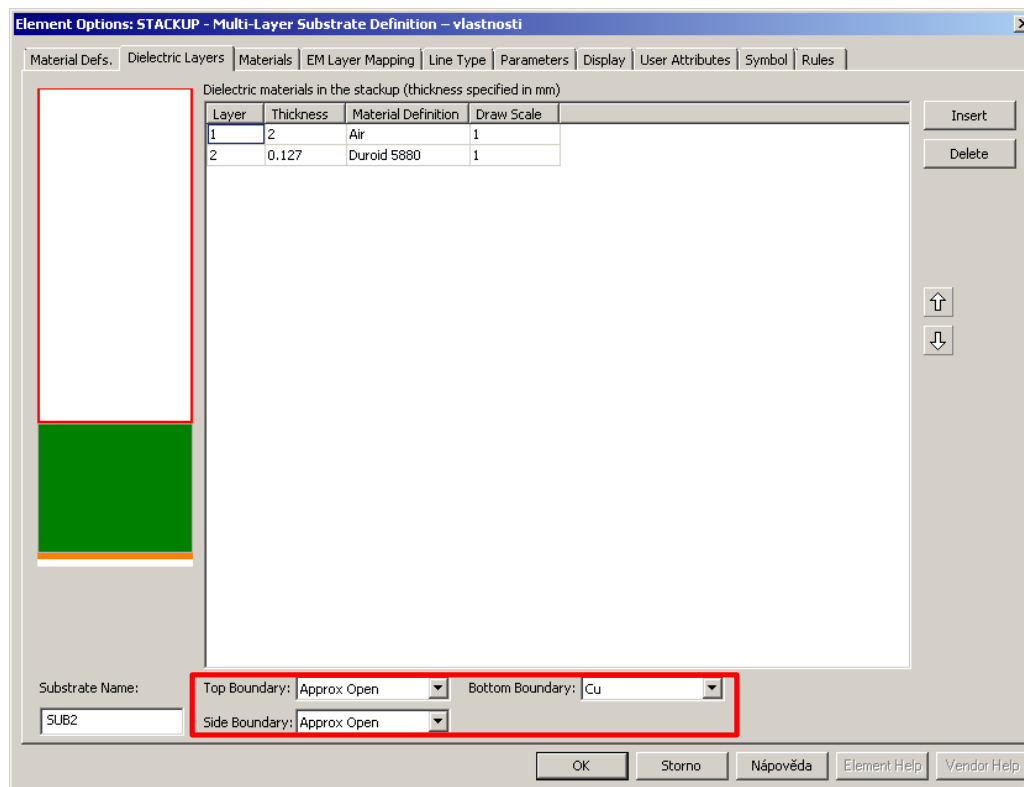
STACKUP Definition - Dielectric Layers

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



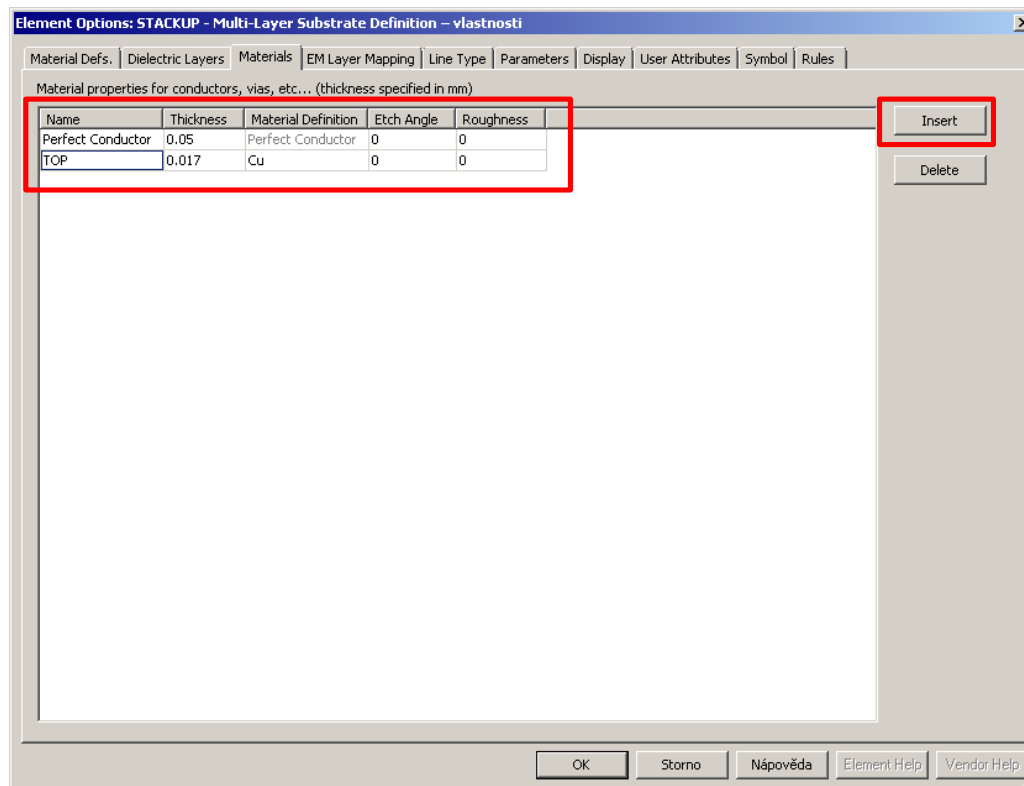
STACKUP Definition - Dielectric Layers

- define boundaries as Open and Cu



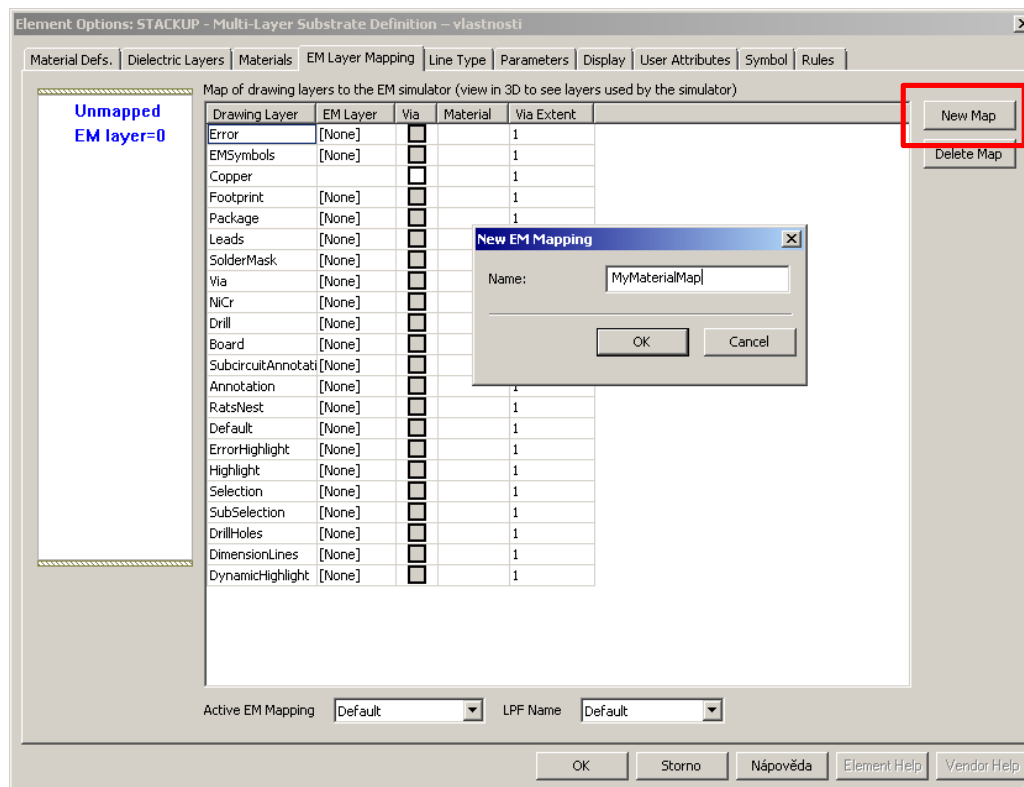
STACKUP Definition - Materials

- add material TOP for mapping from layout



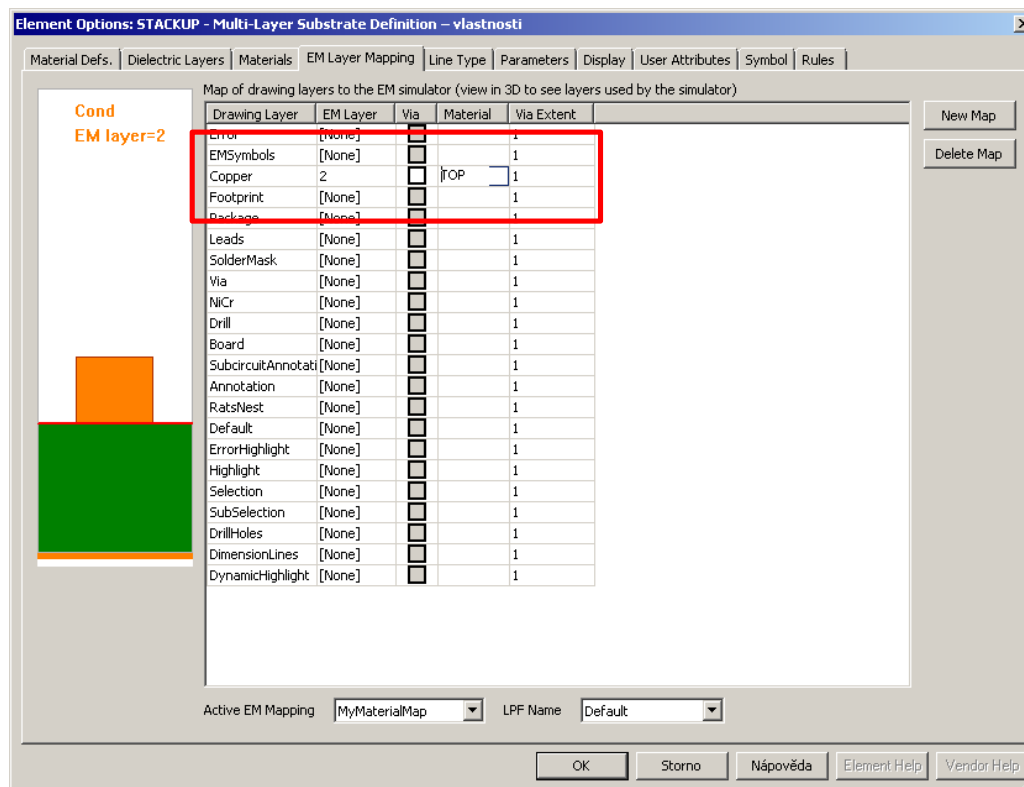
STACKUP Definition - EM Layer Mapping

- define new material map MyMaterialMap



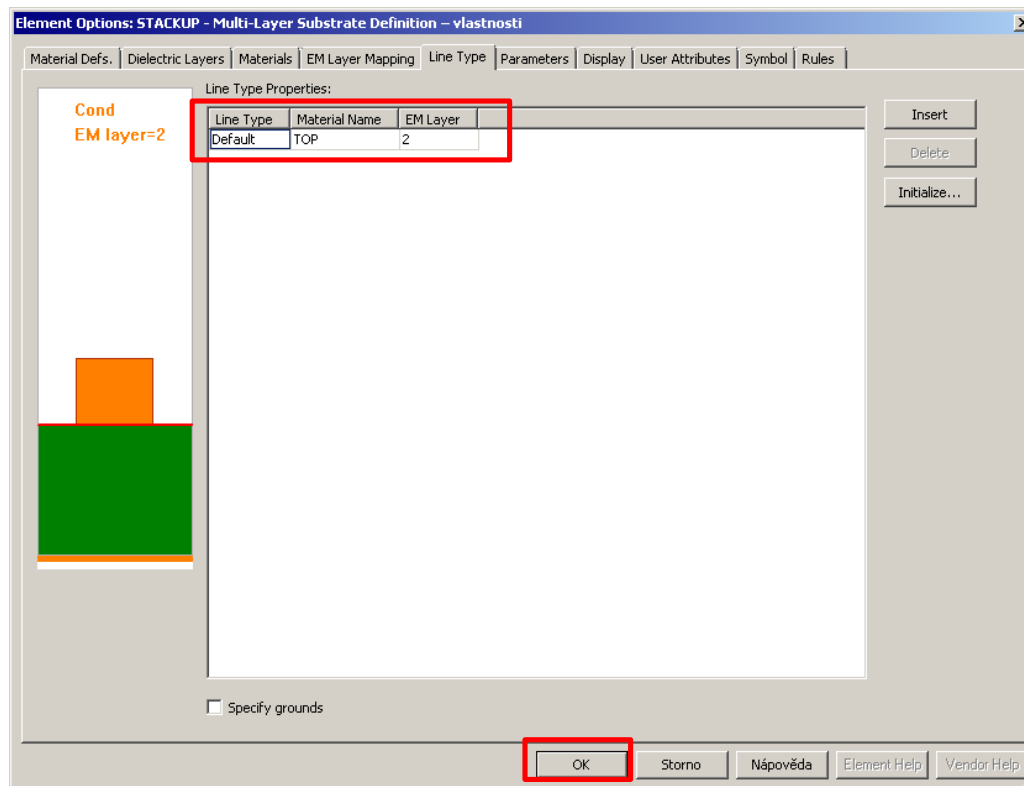
STACKUP Definition - EM Layer Mapping

- set material TOP and layer 2 to drawing layer Copper



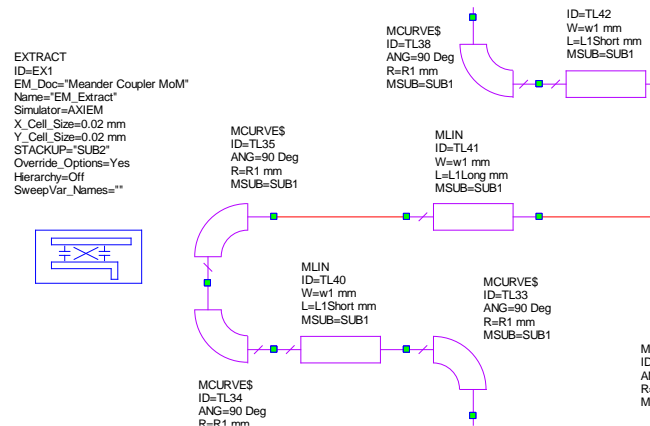
STACKUP Definition - Line Type

- change Material Name to TOP
- push OK



EXTRACT Definition

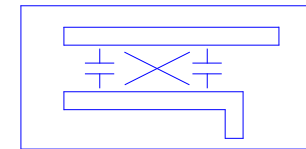
- define export from layout to EM simulator and simulation properties
- find Elements → Simulation Control → EXTRACT
- place it to schematic with coupler
 - it is convenient to have separate schematics for linear simulation and for EM extraction



EXTRACT Definition

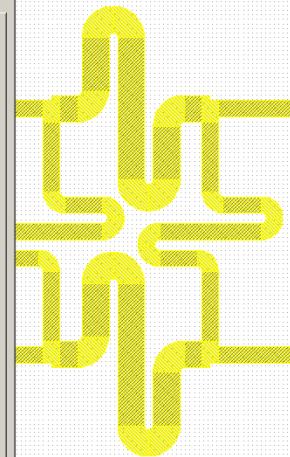
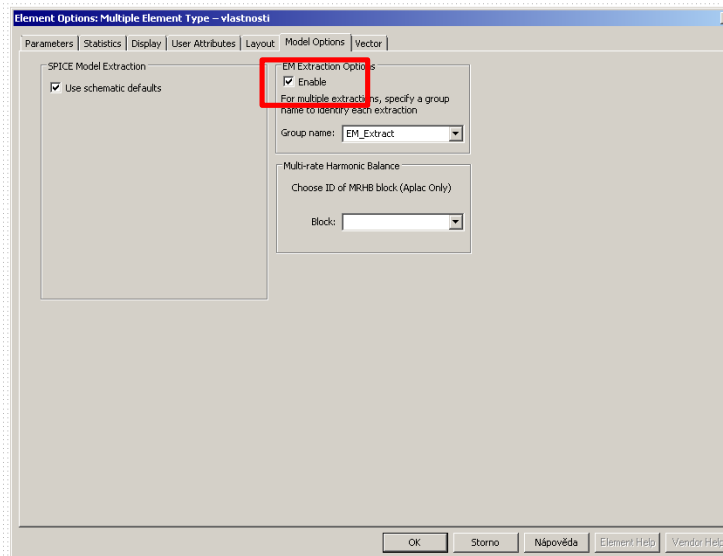
- EM_Doc - name of future EM Structure
- Simulator - choose AXIEM
- X and Y_CellSize - size of grid for mesh - 0.02mm is good choice
- STACKUP - SUB2
- double click on EXTRACT - lot of advanced properties can be setted
 - we use default

```
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



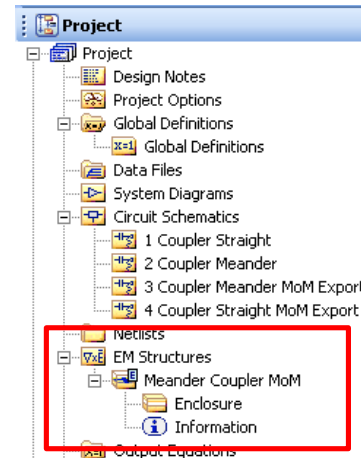
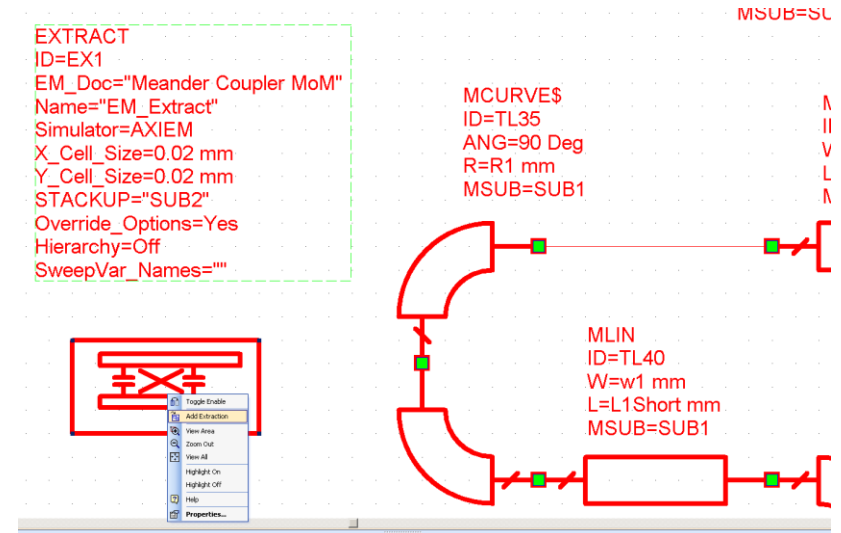


- click on EXTRACT element in schematic
 - associated elements for extraction should be red



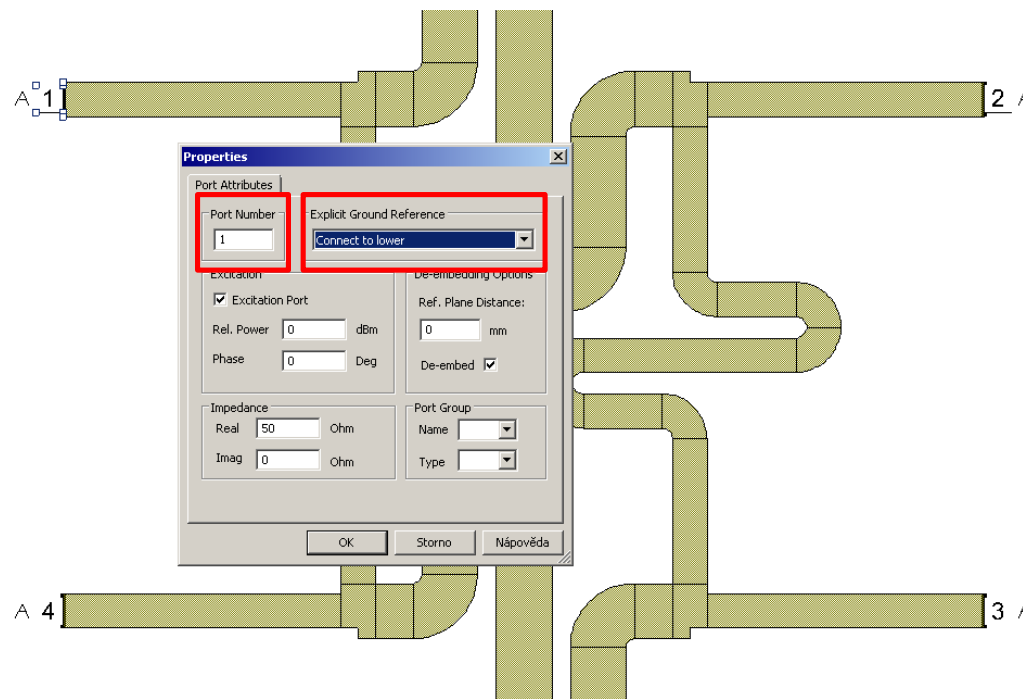
Extraction of Layout to EM Structure

- right click on
EXTRACT→Add
Extraction
- new EM Structure is
created



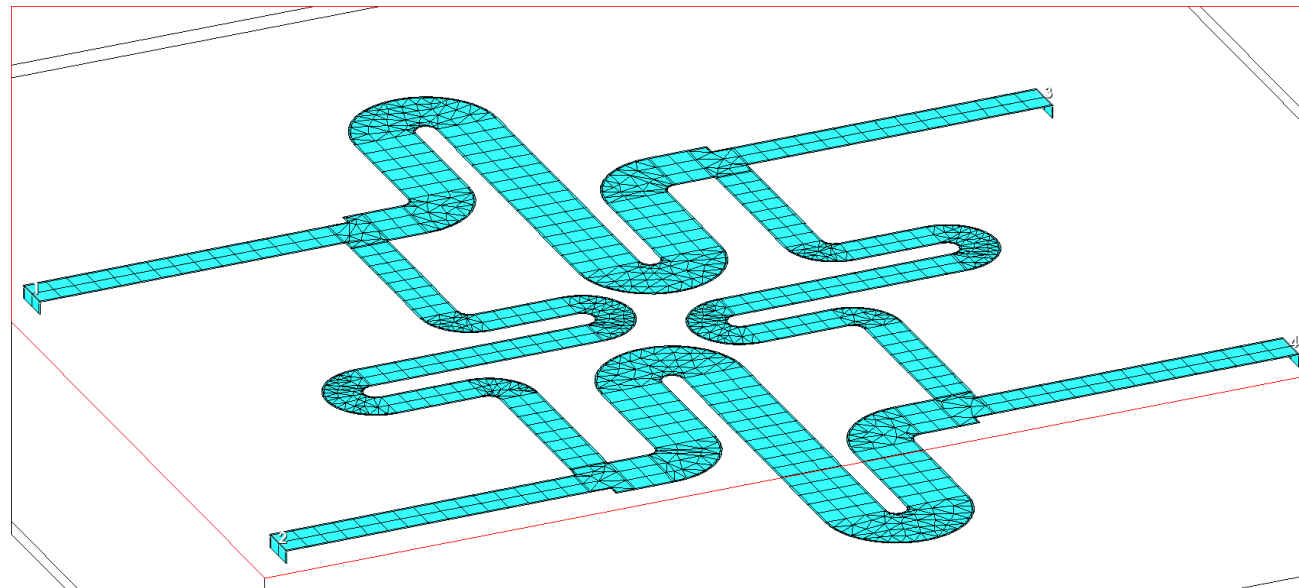
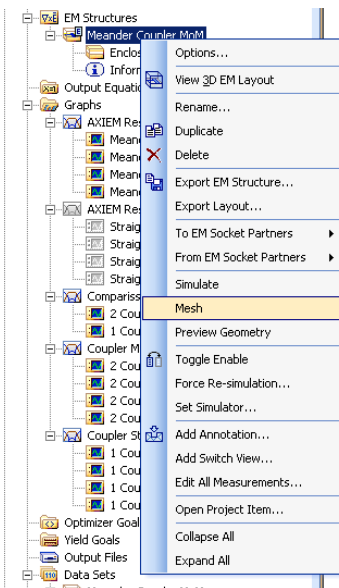
EM Structure - Ports Definition

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



EM Structure - Meshing

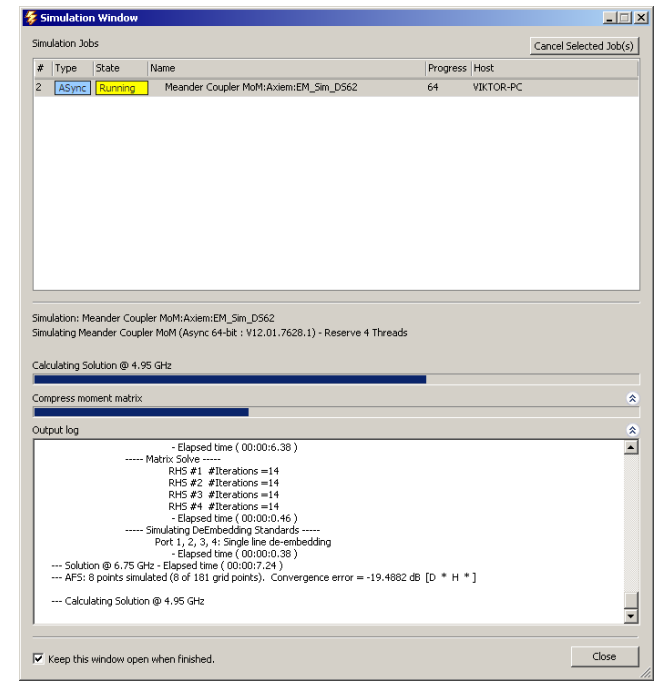
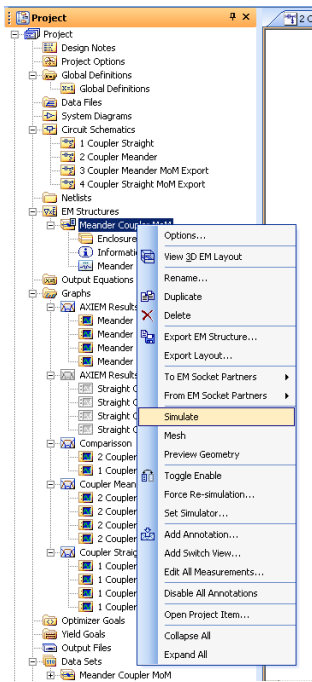
- to mesh structure: right click on Meander Coupler MoM → Mesh
- mesh was computed for highest frequency in project (10 GHz)



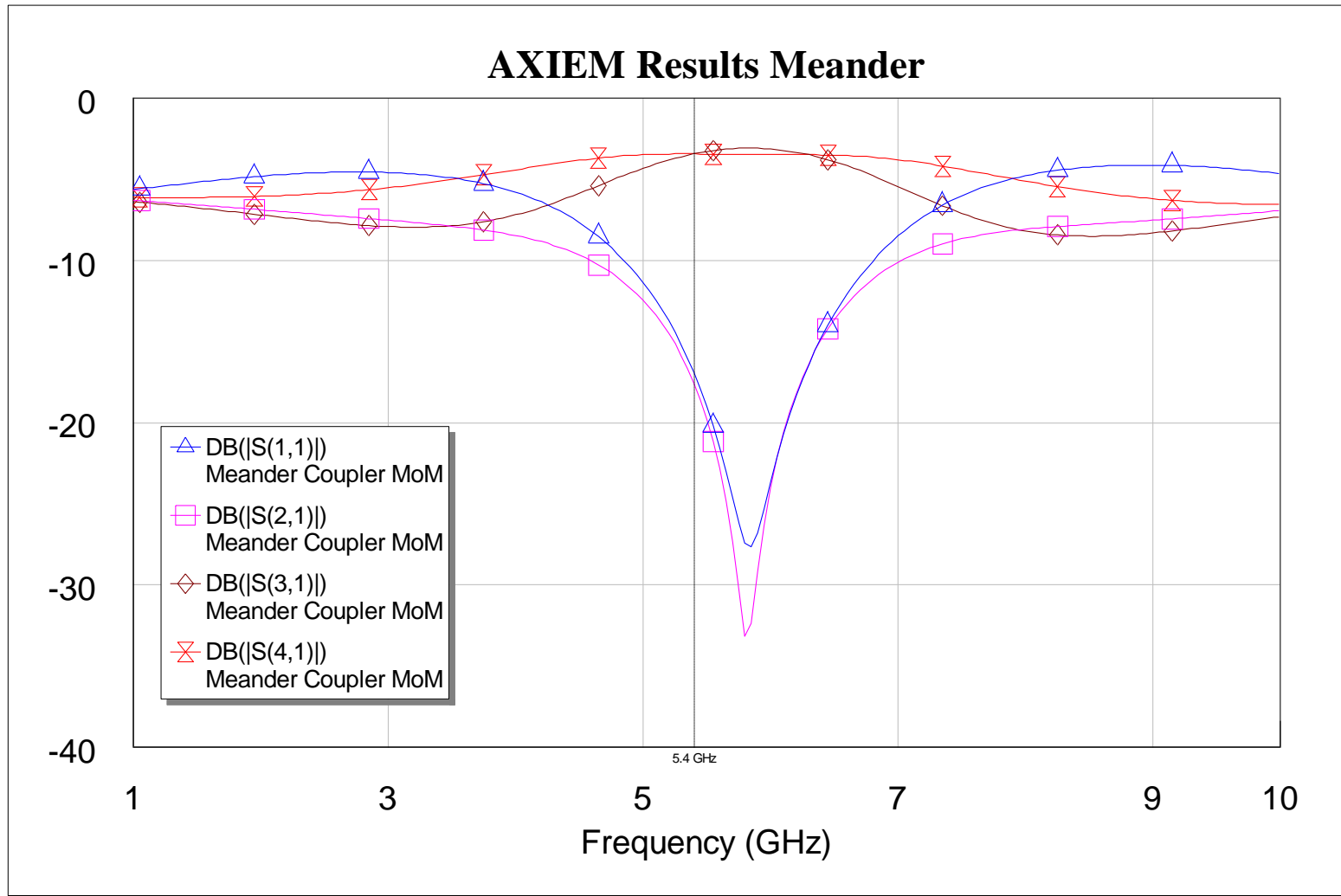


EM Structure - Simulation

- 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!