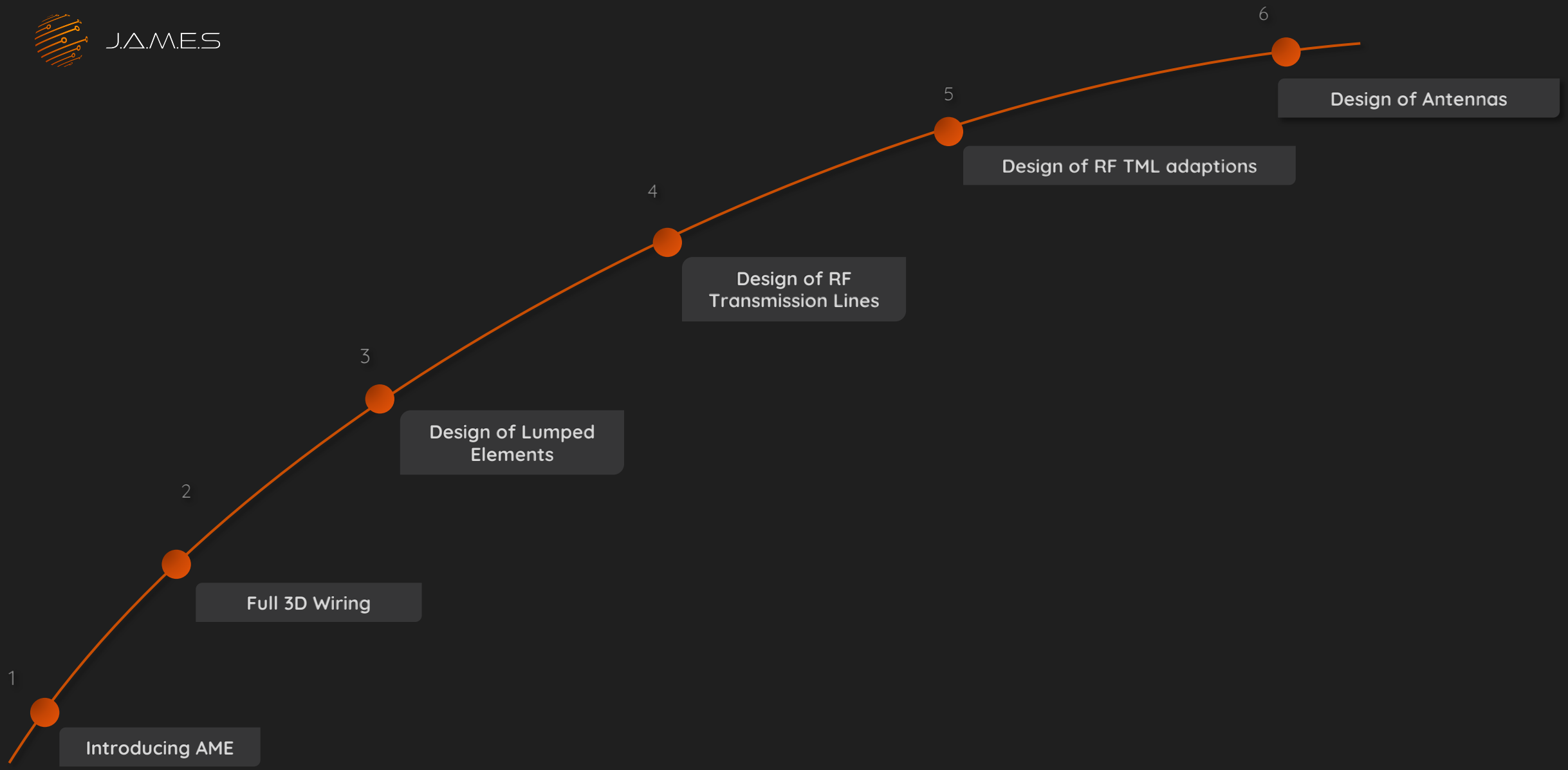
J.A.M.E.S

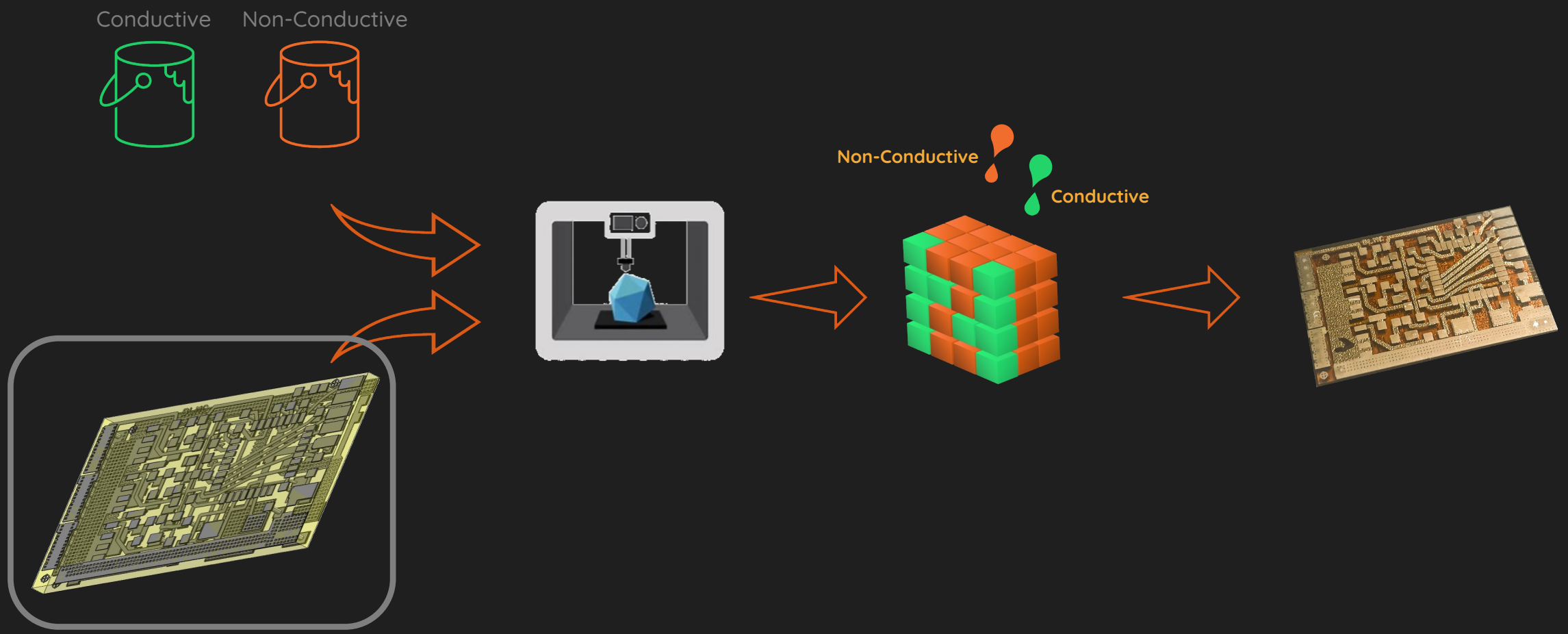
How to Design AME with the CST Studio Suite

Dr.-Ing. Rolf Baltes
Head of Engineering

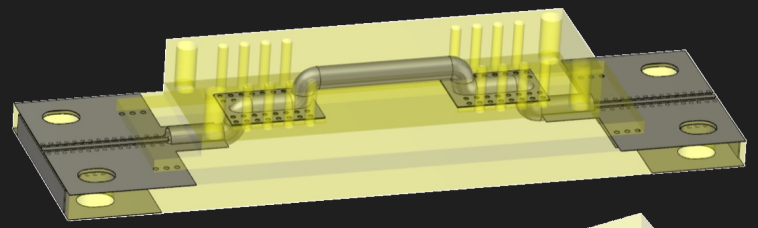


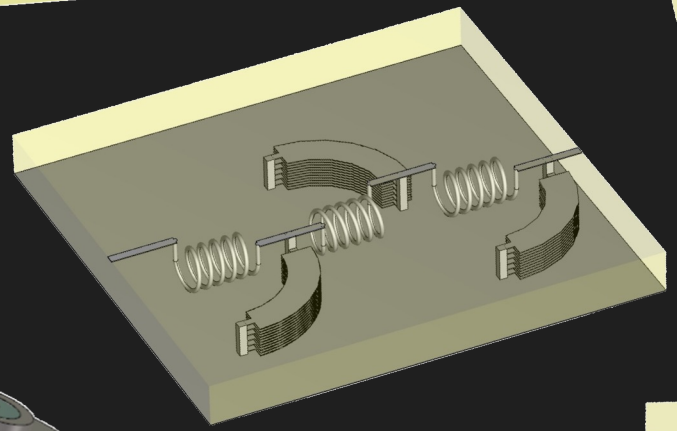
01 Introducing A.M.E

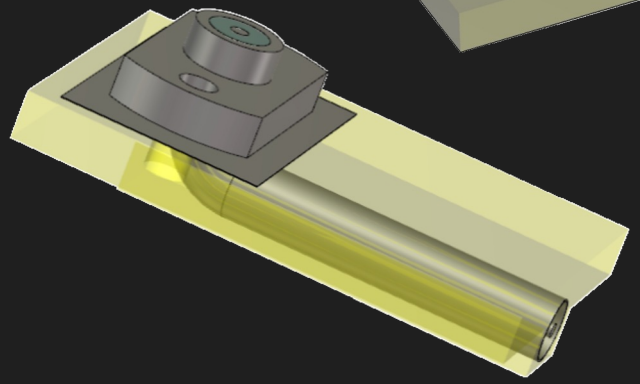
Introducing AME

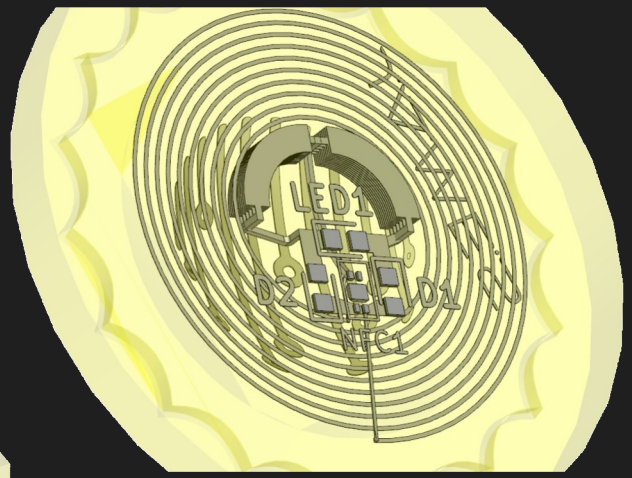


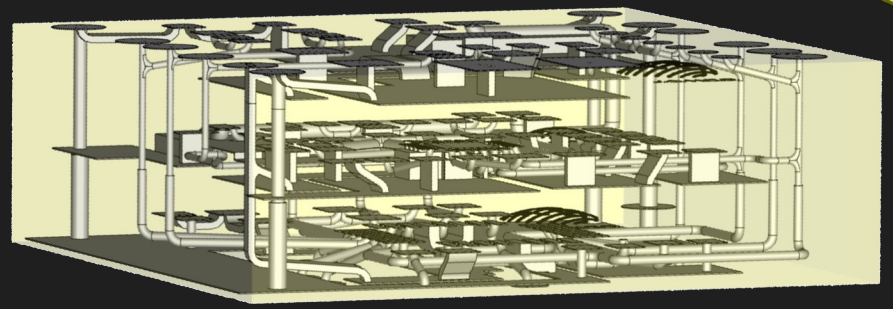
Introducing some AME designs

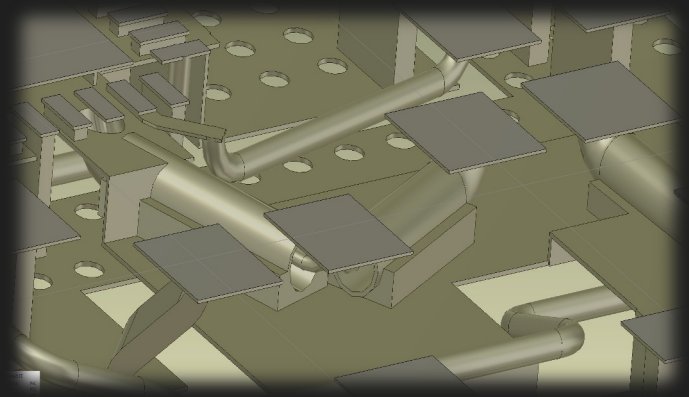


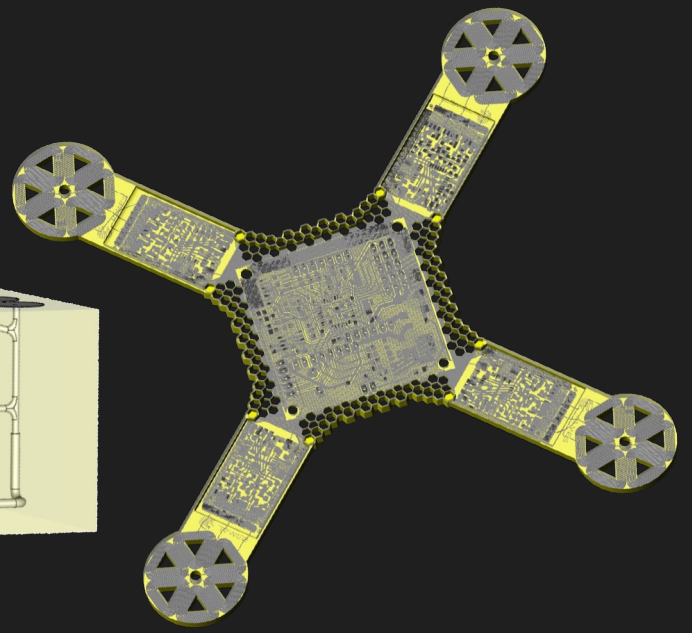












Required design features

(Some) Needs when Designing AMEs

- Schematic of the electronic circuit
- Footprints of used components
- Which Pads to interconnect?
- Outlines of components
- 3D Wiring
- Capacity/inductivity of printed capacitors/ coils
- Impedance of RF lines
- Cross-Talk between the lines
- Antenna efficiency and radiation characteristics
- RF Reflection/transmission on Filters/Couplers…

Why CST Studio Suite?

- Ability to import Footprints
- Ability to import interconnection information
- 3D tool:
    - 3D Wiring
    - Placing and embedding 3D bodies
- Simulation capabilities:
    - Lumped passive elements
    - RF transmission lines
    - Scattering parameters
    - Antenna performance
    - And much more…

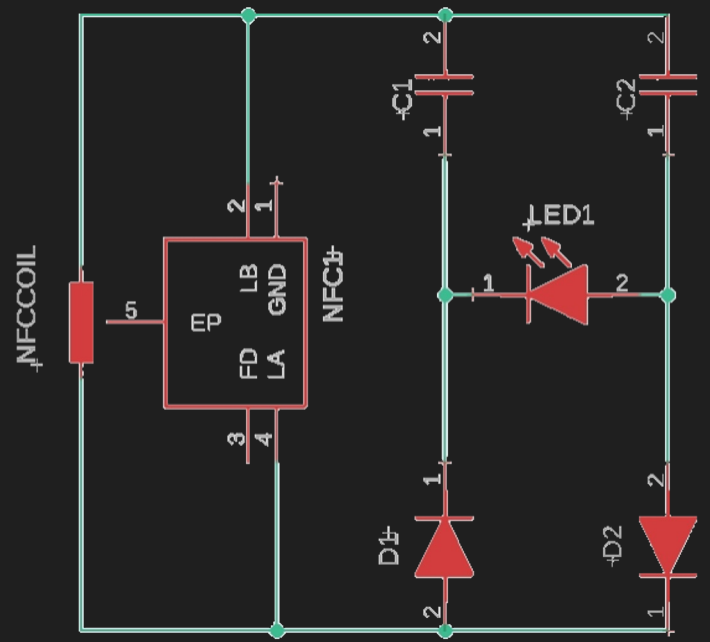
02 Full 3D Wiring

The J.A.M.E.S Coin

Starting in eCAD

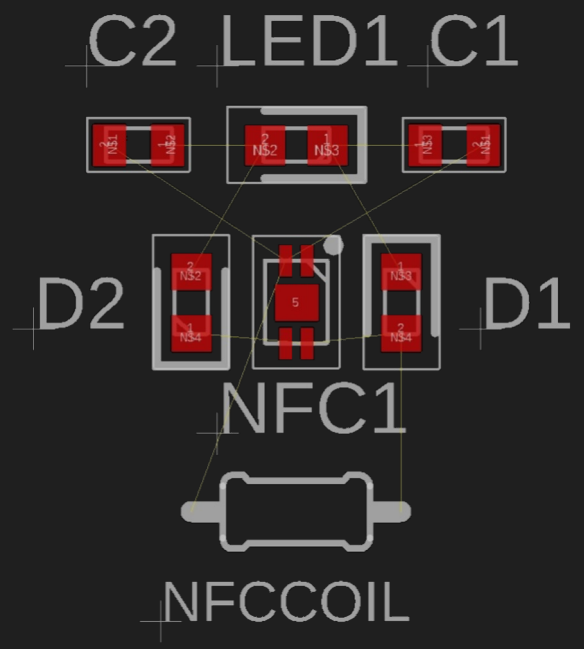
Starting point: schematic in eCAD

- Data for COTS available for eCAD
- Way of circuit design does not change



Next step: Place footprint in PCB design tool

- Footprints required in 3D design tool
- Coil and capacitors will be added in 3D



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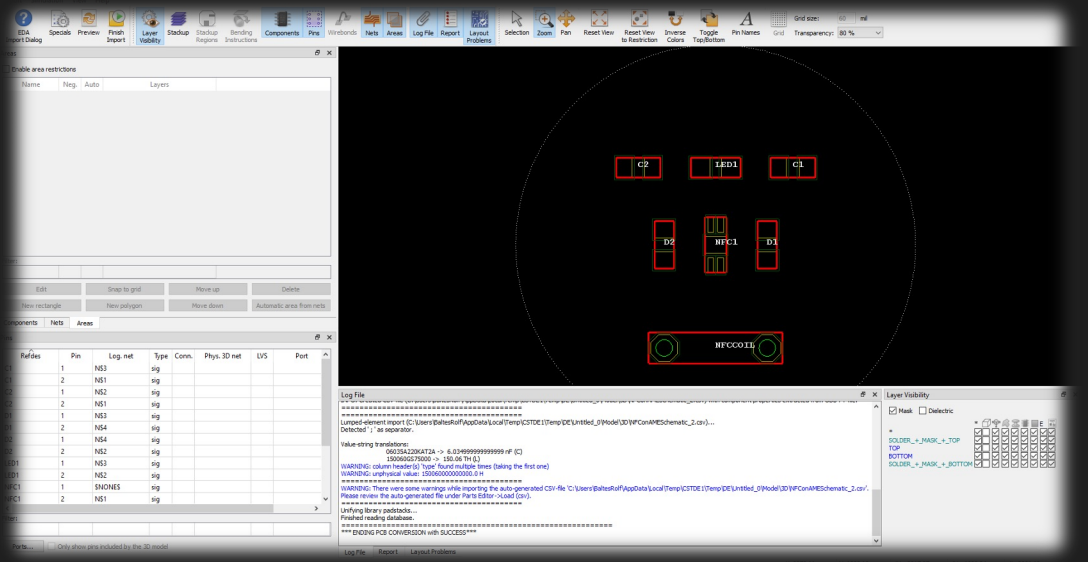
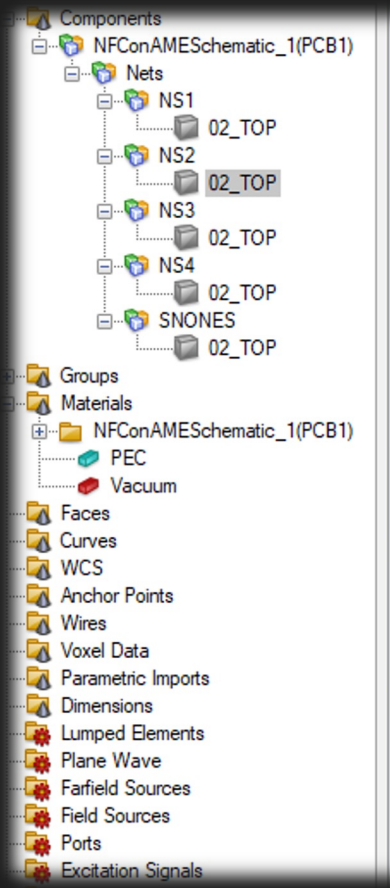
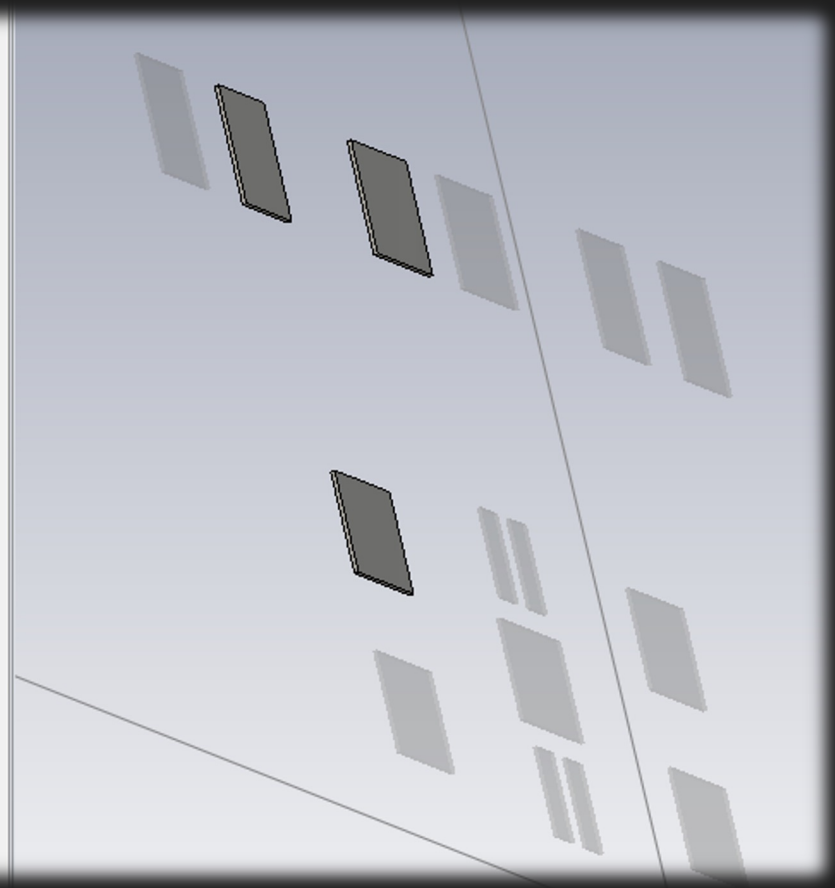
Going 3D in CST Studio Suite

Export as ODB++

- Contains dimension of the pads
- Preserves information of interconnectivity







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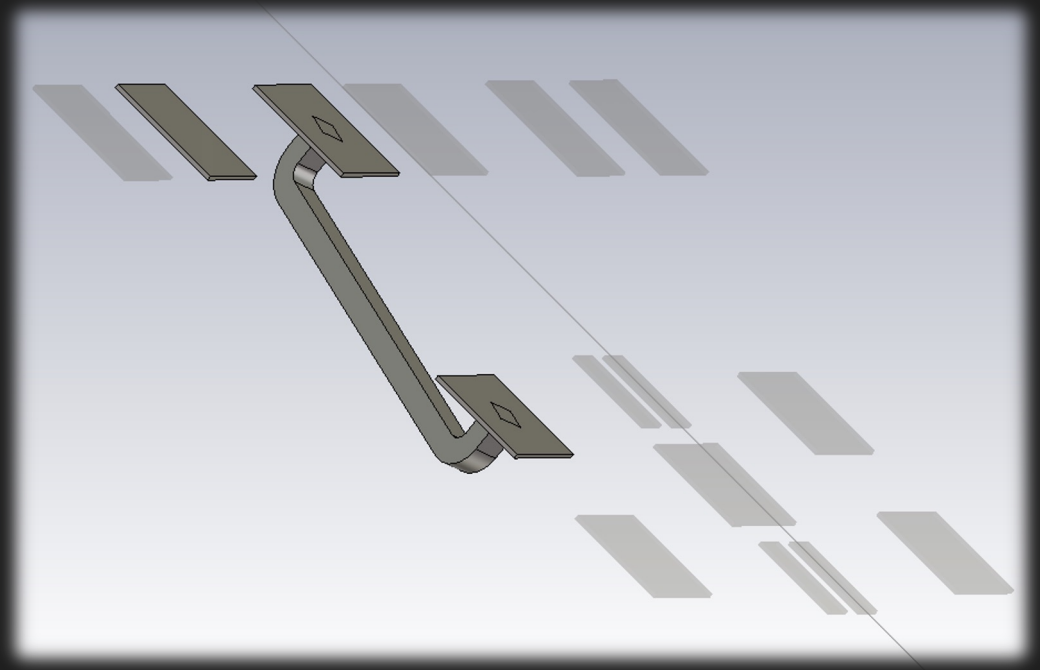
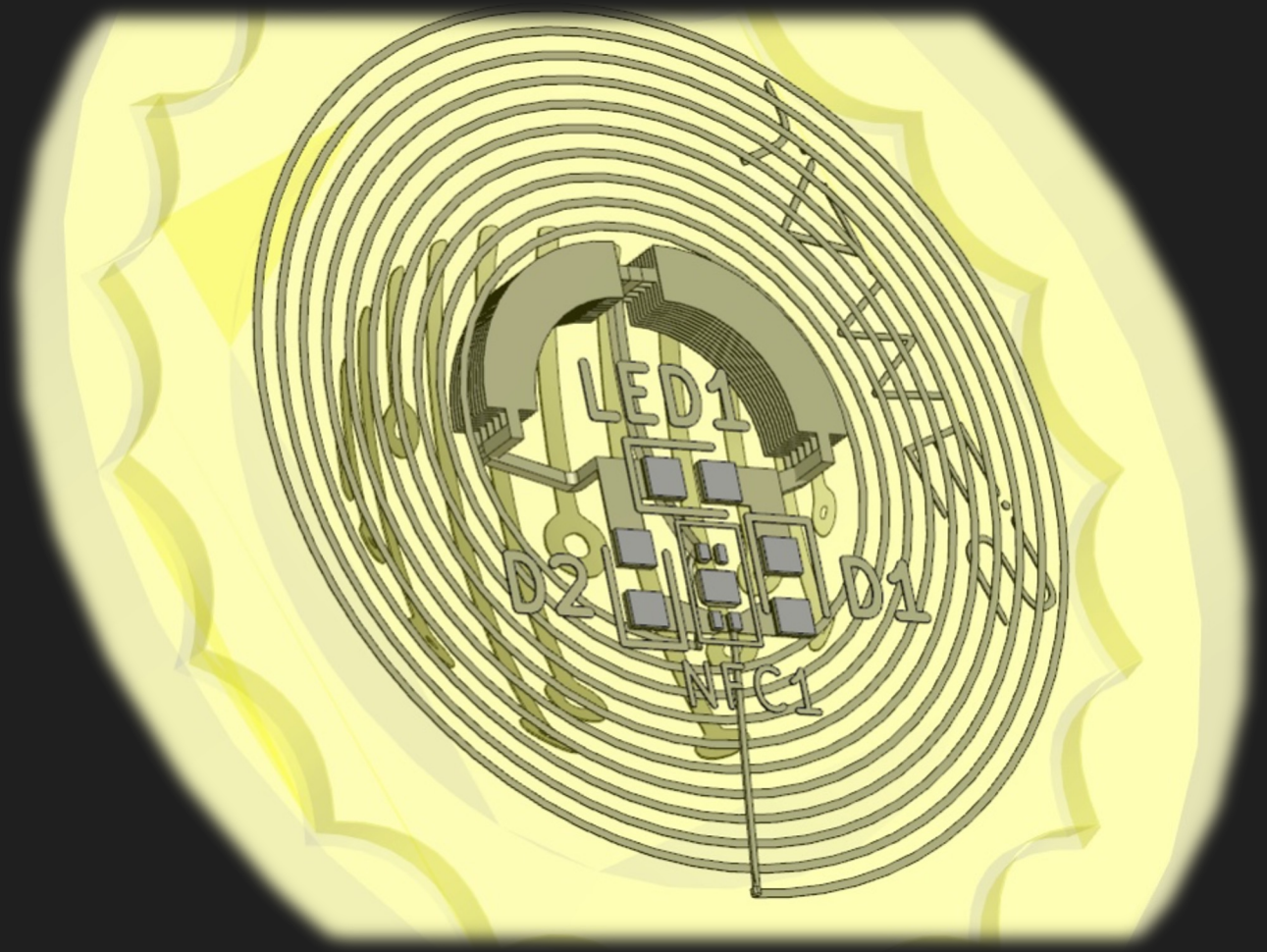
3D Wiring in CST Studio Suite

Interconnecting Lines

- Arbitrary cross section
- Can run through all 3 dimensions





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Becoming Reality

03 Design of Lumped Elements

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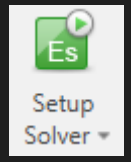
DC Simulation of capacitors

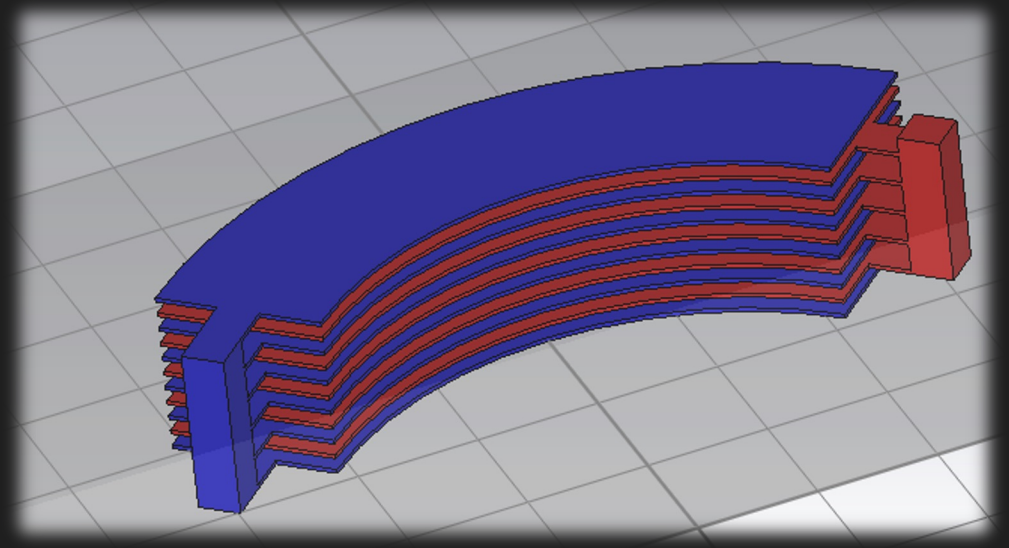
- Use the Electro-Static solver



- Create a 3D model of the capacitor

- Define different electric potential on the plates

- Diagonal entries define the capacity towards the boundary defined as GND

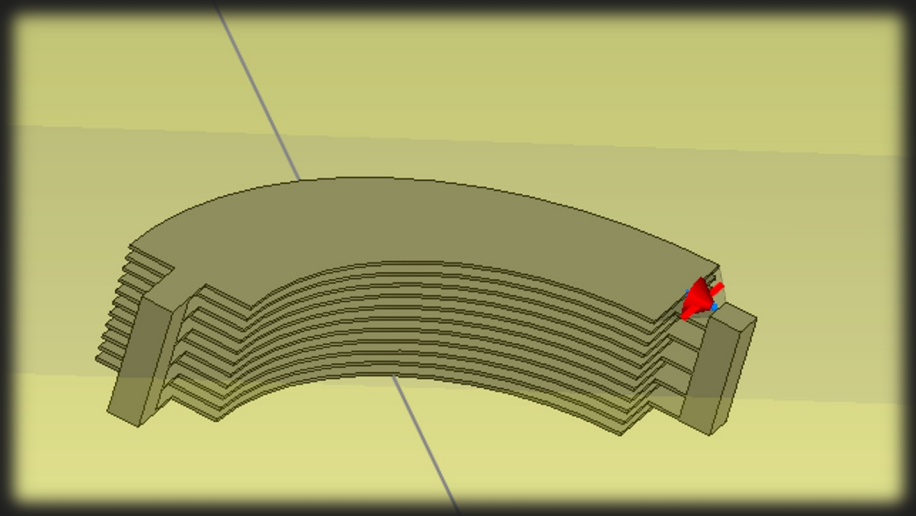


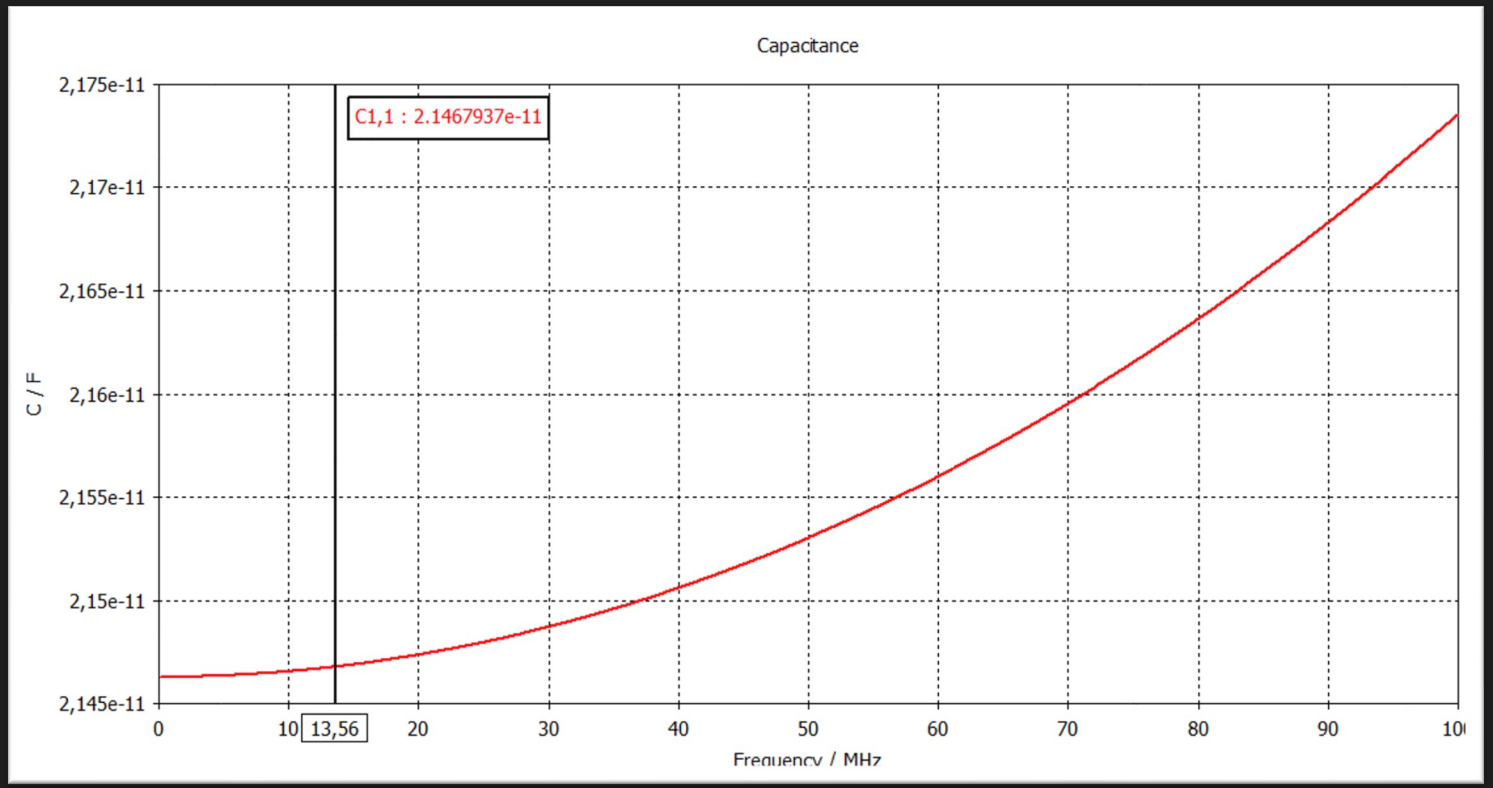
Capacitance Matrix (lumped):

	potential1	potential2
potential1	1.91026e-13 F	2.136648e-11 F
potential2	2.136648e-11 F	9.655935e-14 F

Simulation of capacitors for RF

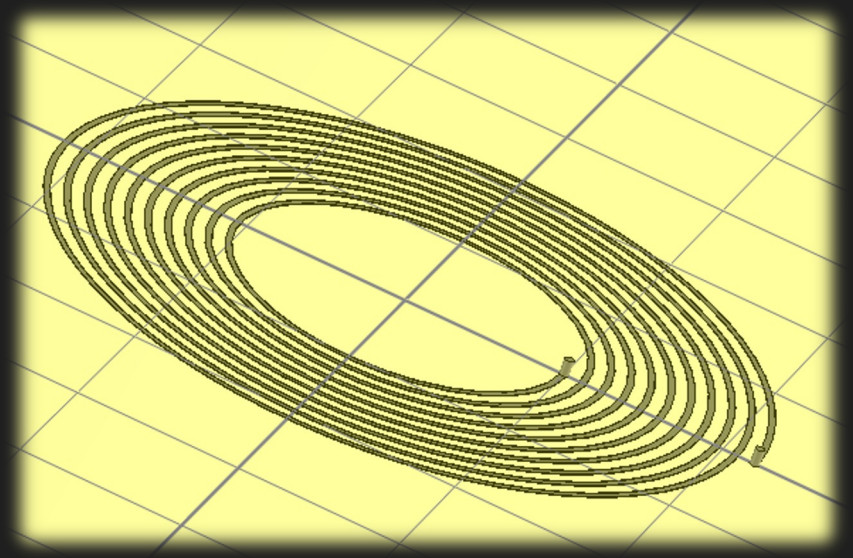
- Use the frequency domain RF solver
- Select the frequency range
- Template to calculate Capacity available

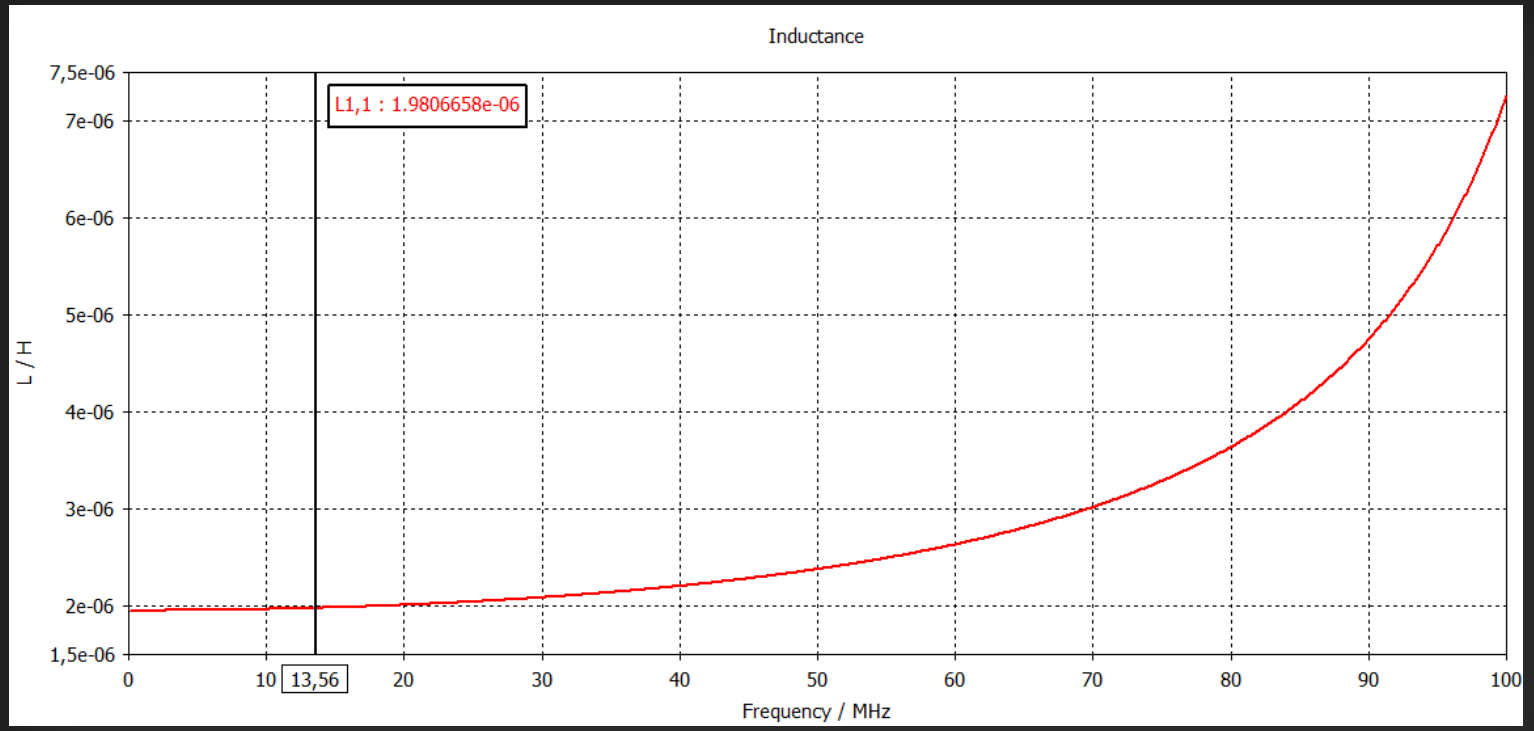




Simulation of coils for RF

- Template to calculate Inductivity also available
- Take care of right boundary settings
- Inductivity changes with frequency





04 Design of RF Transmission Lines

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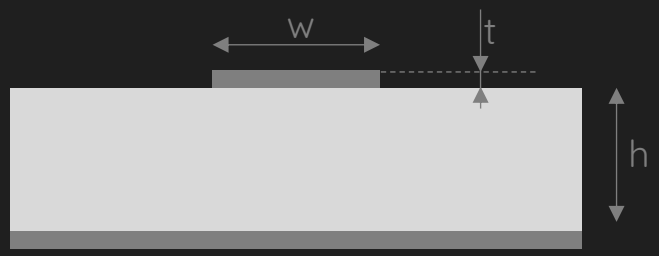
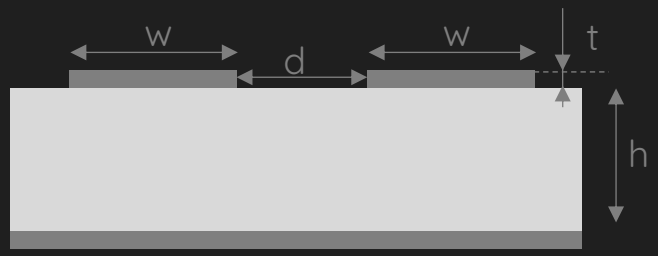
Traditional Transmission Lines

Microstrip

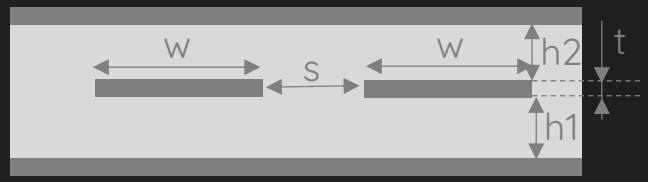


Differential Microstrips

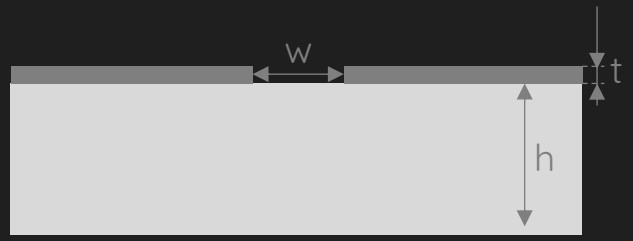


Stripline

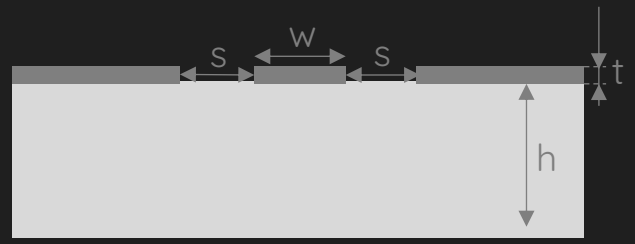
Differential stripline



Slotline

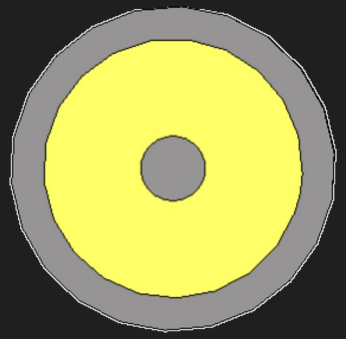


Coplanar Waveguide



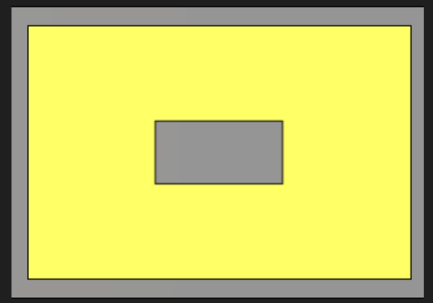
AME Transmission Lines

Possibilities



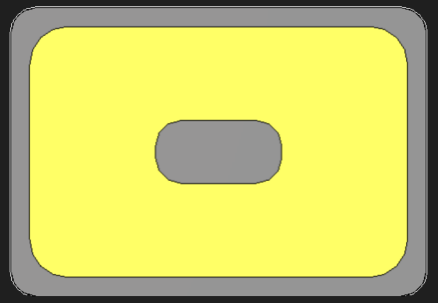
Coaxial line

- TEM-mode
- Impedance constant
- No modal dispersion



Rectangular line

- TEM-mode
- Impedance constant
- No modal dispersion
- Easier to print



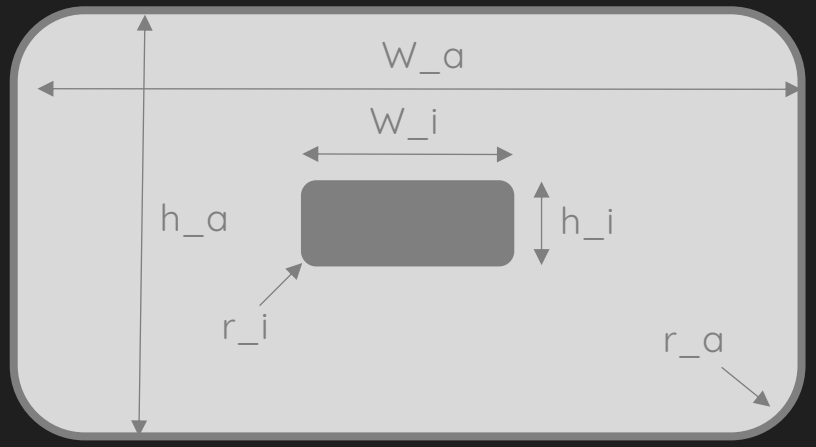
Rounded rectangular line

- TEM-mode
- Impedance constant.
- No modal dispersion
- Easier to print
- No sharp edges/corners

AME Transmission Lines

Design and Simulation

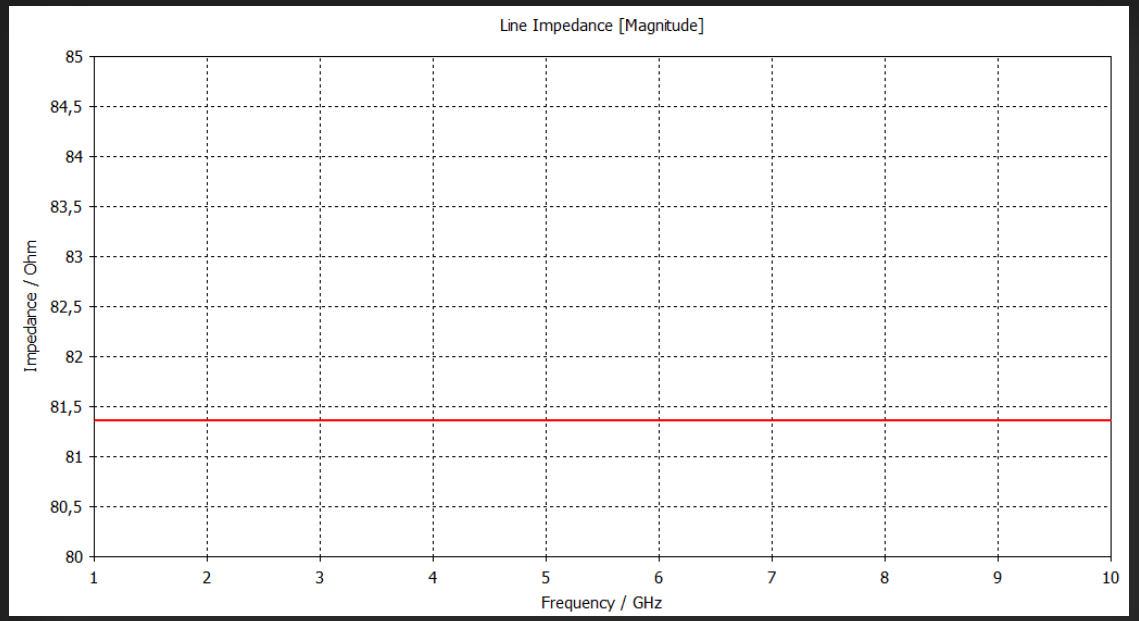
Parametrization of Transmission line



Selected parameters - Goal: 50Ω

w_i	0.5 mm
h_i	0.1 mm
r_i	0.03 mm
w_a	5 mm
h_a	2.5 mm
r_a	0.3 mm

Simulation of initial parameters



How to get to 50Ω without manual fine tuning ?

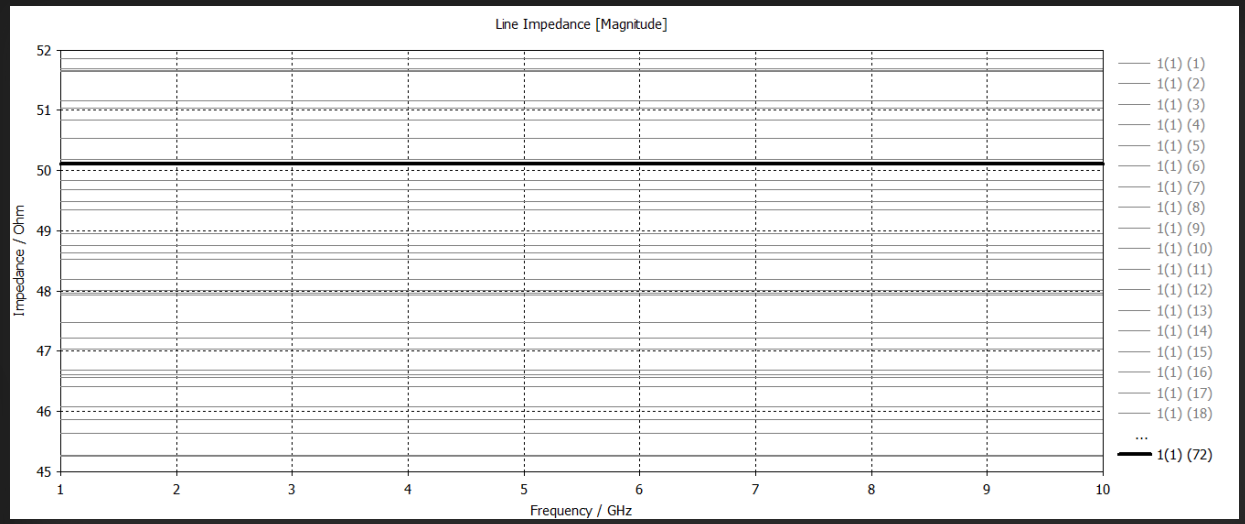
AME Transmission Lines

Parameter Sweep

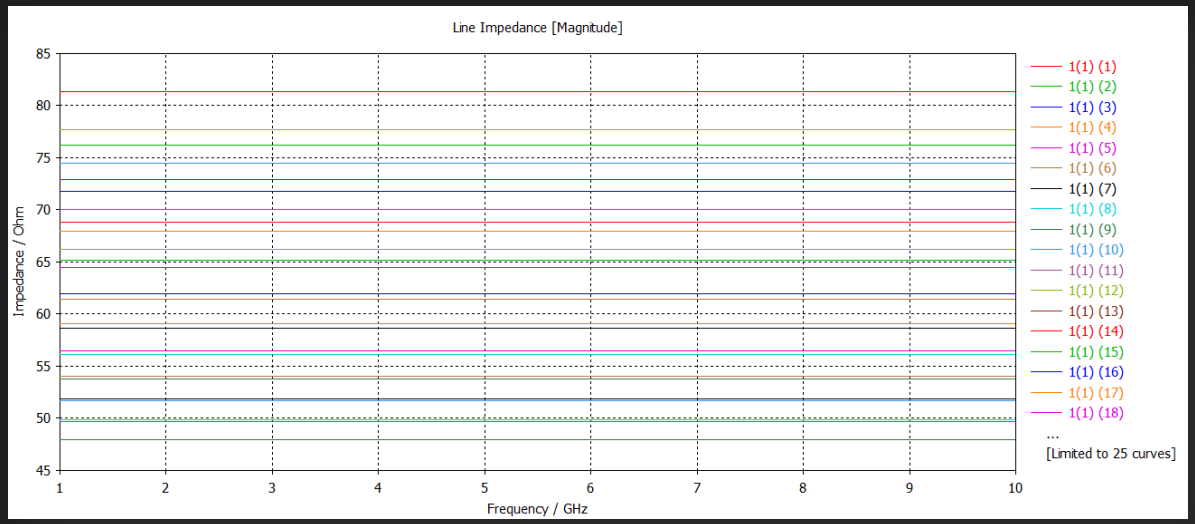
Parameter sweep settings:
121 Evaluations

Sequence 1
- hi = 0.1, 0.15, … , 0.6 (11, Linear)
- wi = 0.5, 0.6, … , 1.5 (11, Linear)

Zoom in to 50Ω



Results of parameter sweep



Best Parameter settings

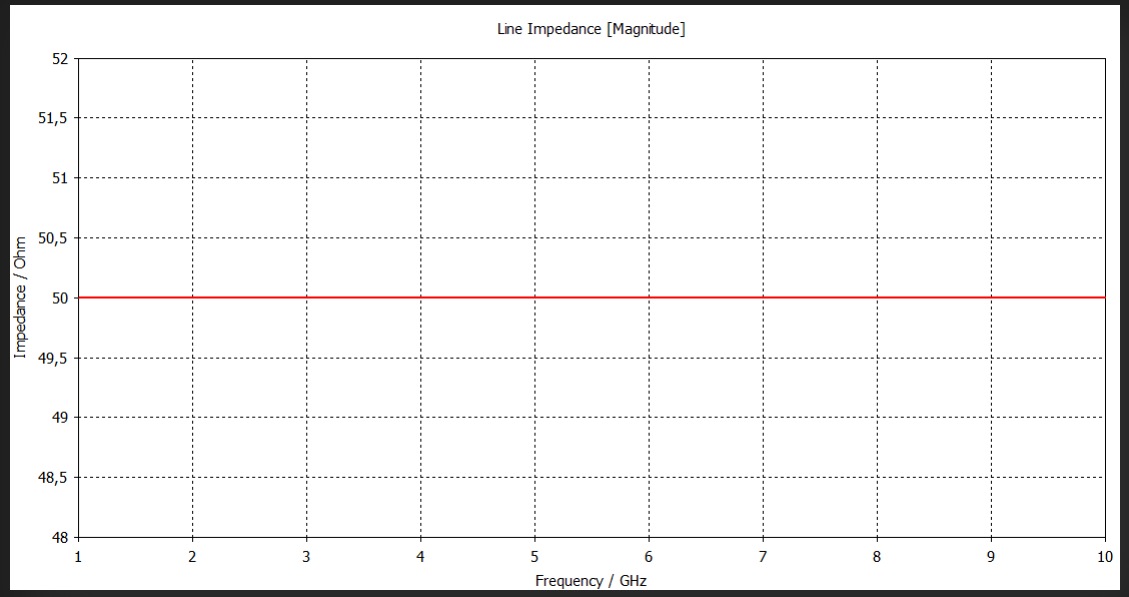
w_i	1 mm
h_i	0.4 mm

AME Transmission Lines

Optimizer

Drawbacks of parameter sweep

- Parameter sweep can be time-consuming
- Rough idea of parameter direction required
- Usually very coarse scanning of parameter space



Alternative: Integrated Optimizer

- Easy way to define cost function
- Geometrical limits of parameters easily implemented
- Very little manual effort/ interference required

Best Parameter settings after 42 evaluations

w_i	0.99707366718717 mm
h_i	0.15313665841374 mm
r_i	0.024693243111302 mm
w_a	4.698797724559 mm
h_a	1.8908158097319 mm
r_a	0.3 mm

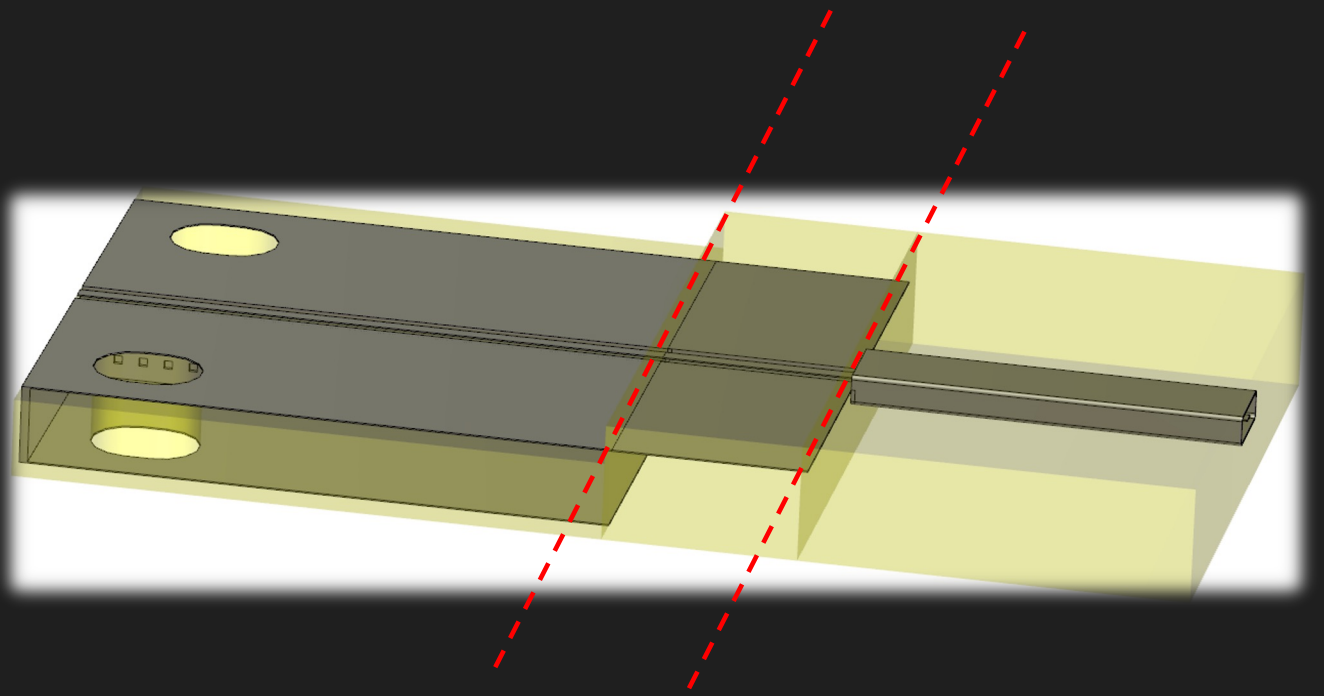
05 Design of RF TML Adaptions

J.A.M.E.S

RF scattering parameters

Connector for rounded rectangular line

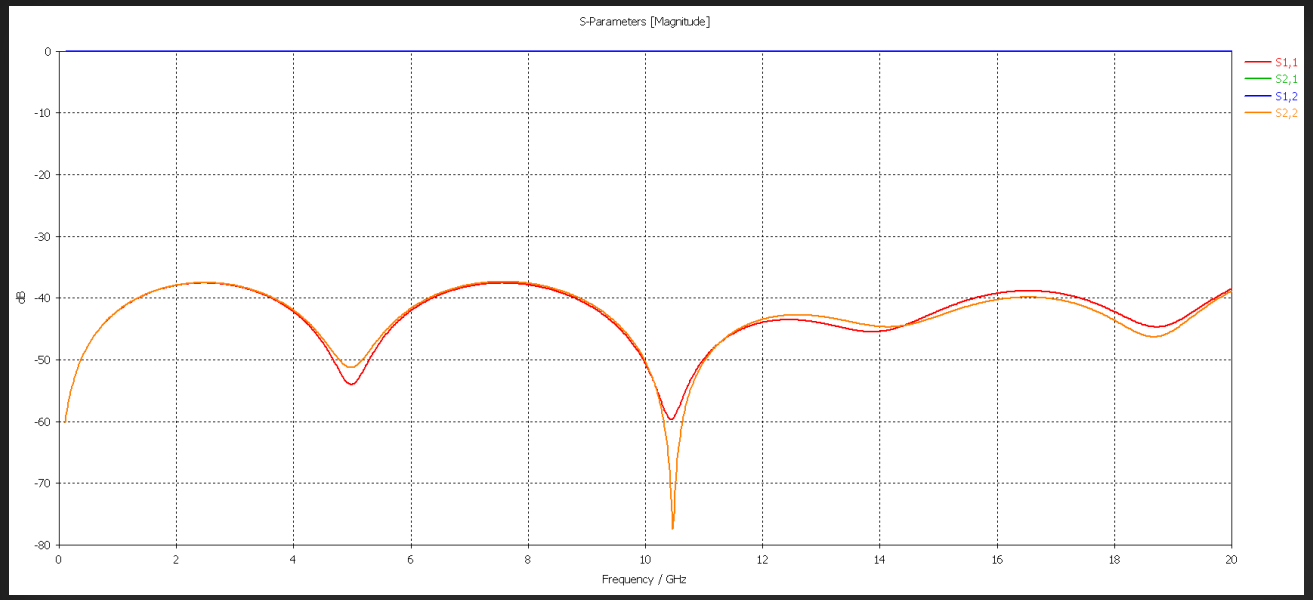
- Goal: provide adaption of RF connectors to TML for measurement setup (< 20Ghz)
- Direct adaption difficult due to material flow at edges
- Considering 3 different parts i.e., 2 transitions

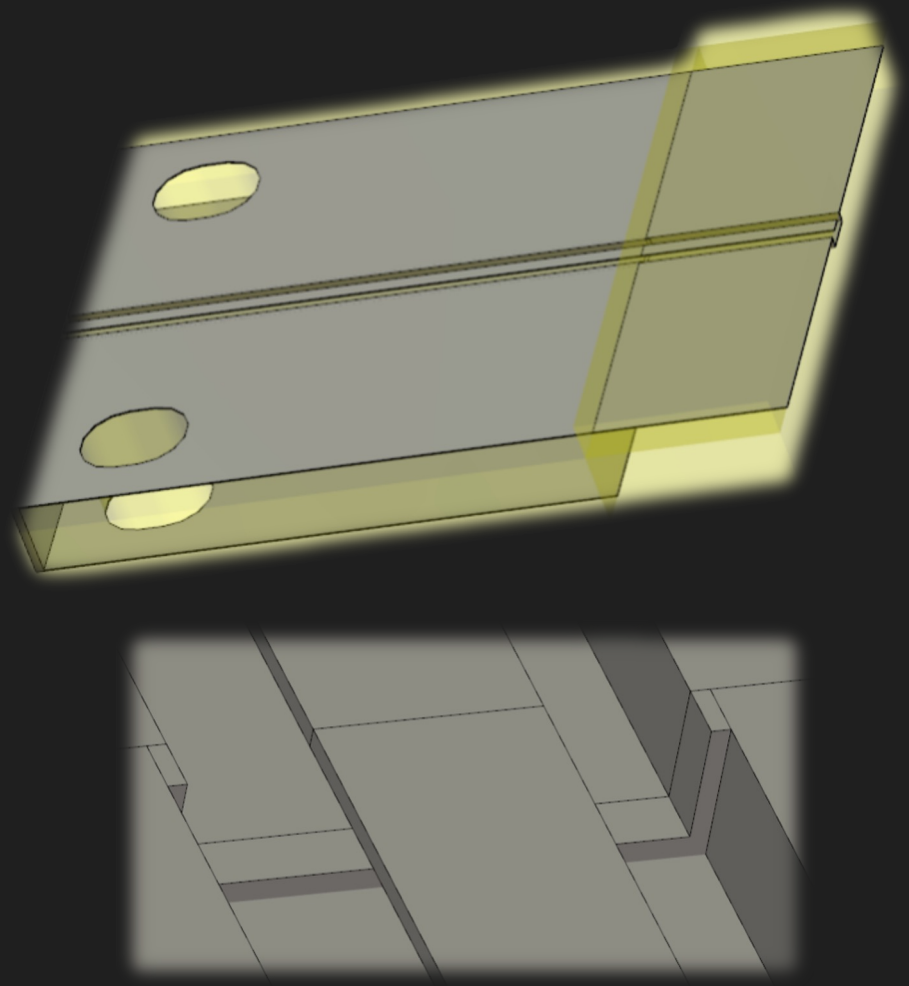


RF scattering parameters

Connector for rounded rectangular line - 1st transition

- Determine geometrical parameters to get 50Ω lines
- Geometrical variations small

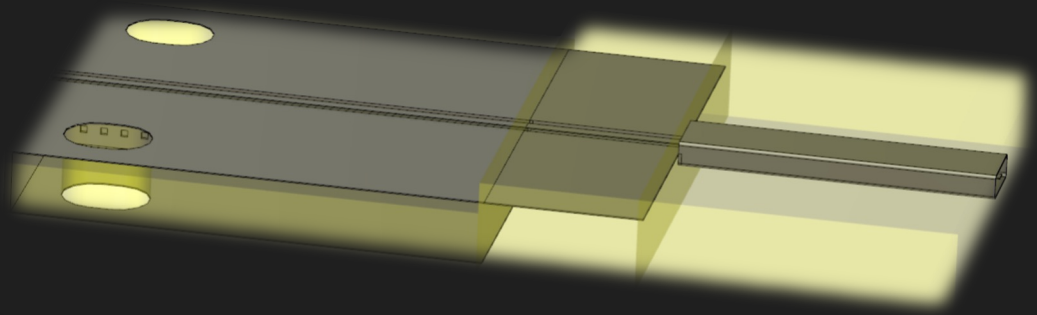


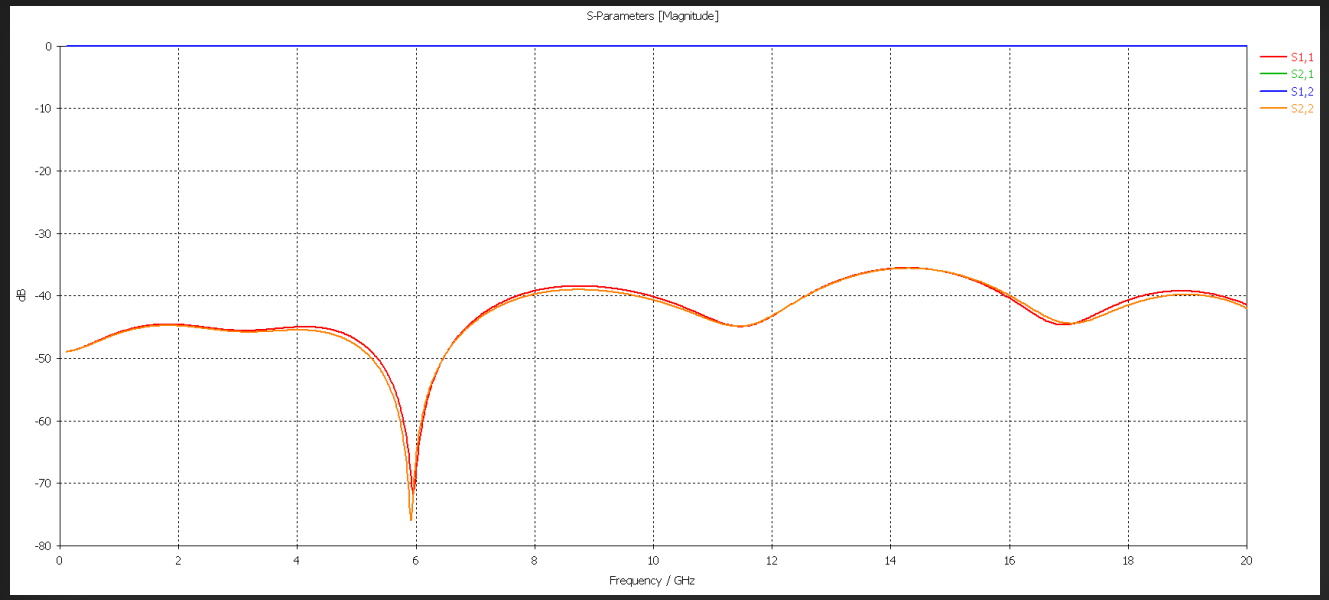


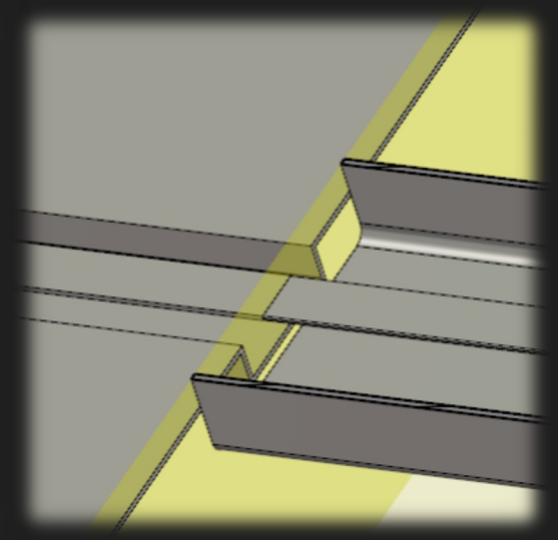
RF scattering parameters

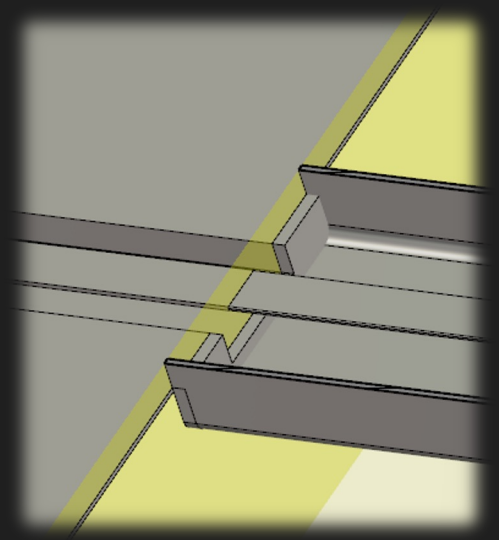
Connector for rounded rectangular line - 2nd transition

- Consideration of whole structure
- Make sure rectangular TML is 50Ω







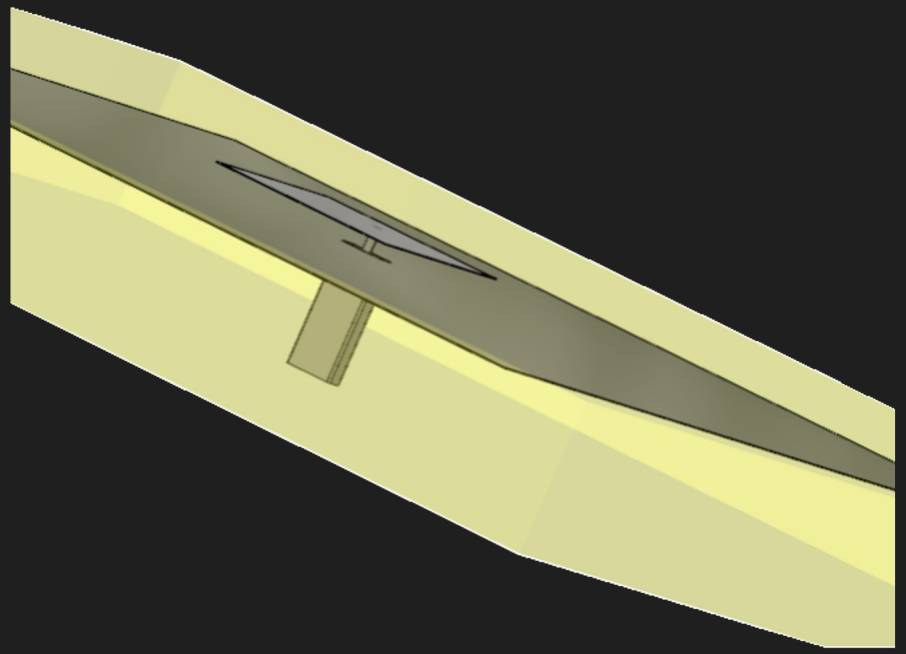


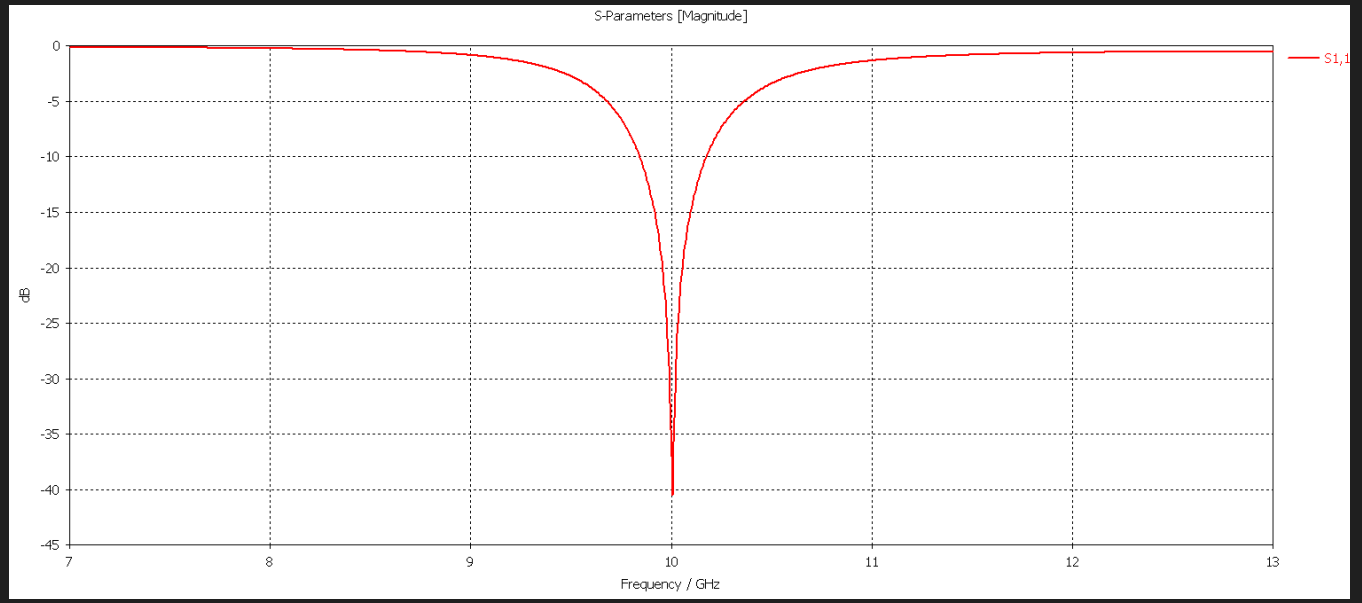
06 Design of Antennas

Antenna performance

Patch antenna

- Feed structure: rectangular TML with rounded corners
- Goal: patch antenna at 10GHz
- Interesting data: reflection, far fields, efficiency
- Optimized for resonance frequency of 10GHz
- Small bandwidth

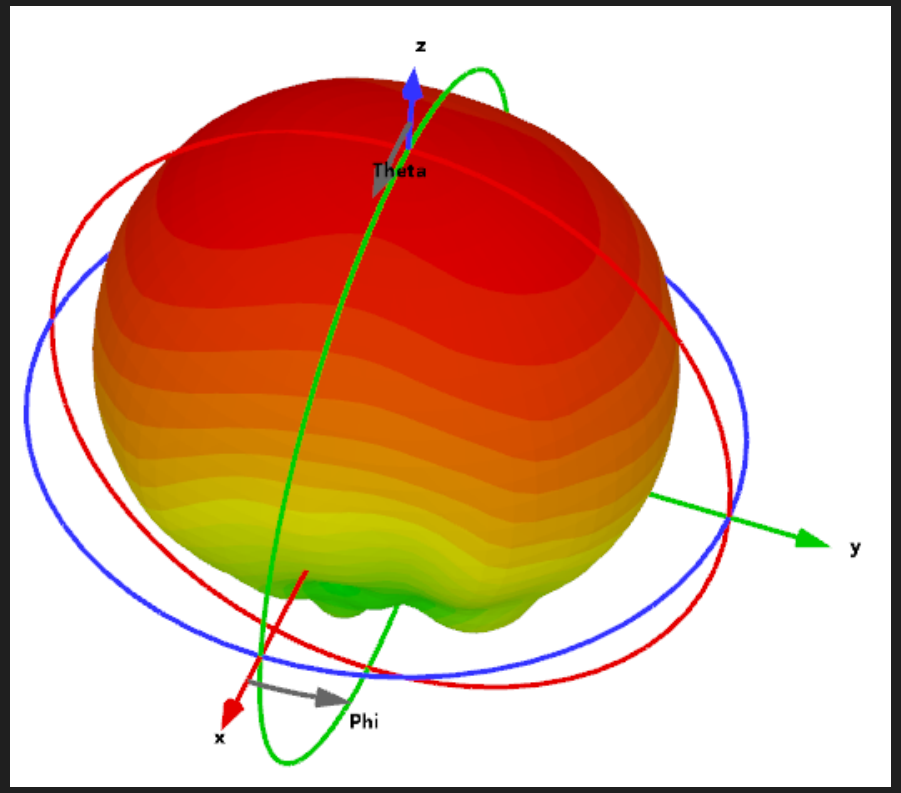




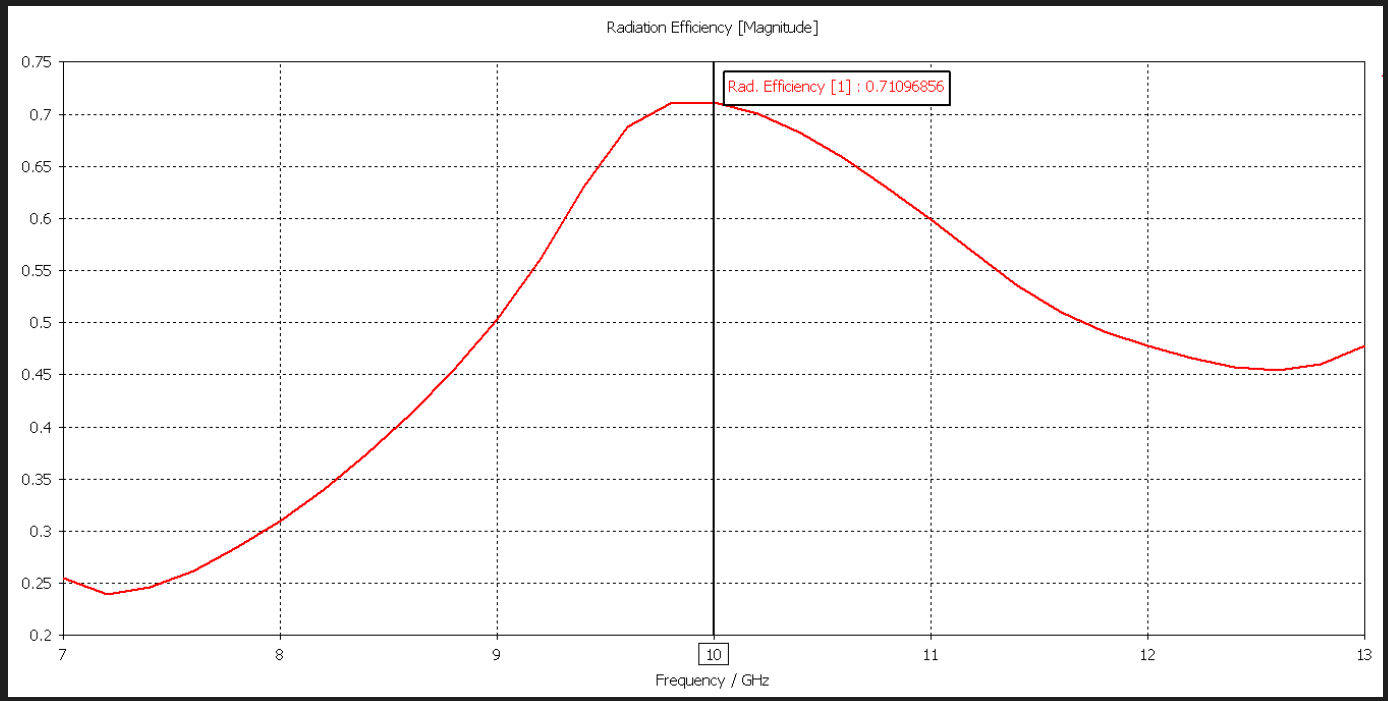
Antenna performance

Patch antenna

- Radiation pattern



- Radiation efficiency
- Loss tangent of 0.02



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