A Planar RF/LO Coupler Design for Heterodyne Receiver at 220 GHz

Reporter: Yan-Jun, Wang (王彥竣) ASIAA[1]&NTU[2]

Teddy Huang[1], Chun-Lun Wang [1], Tse-Jun Chen [1], Chao-Te Li [1], Chuang-Ping Chiu [1], Chao-Ching Wang [1], Fang-Yu Hsu [1], Jia-Ruei Nian [1] and Ming-Jye Wang [1]

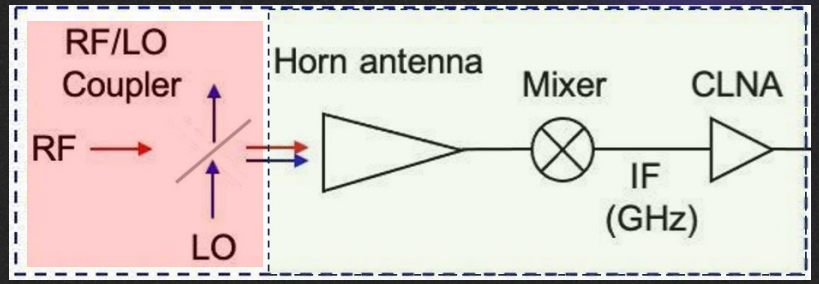
Nov. 20-23, 2023, Taipei

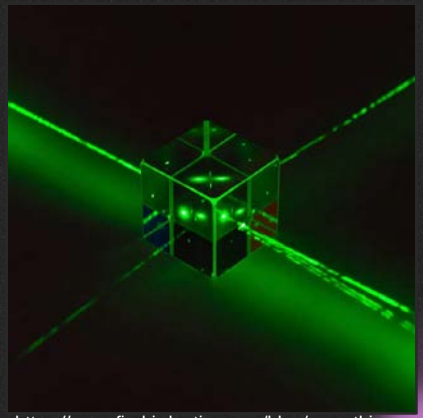
2023 Advanced Telescope and Instrument Technology Conference

What is RF/LO coupler?

The component used to combine the RF and LO signal before the mixer in heterdyne receiver

Current receivers typically employ two main types: Lense and Waveguide





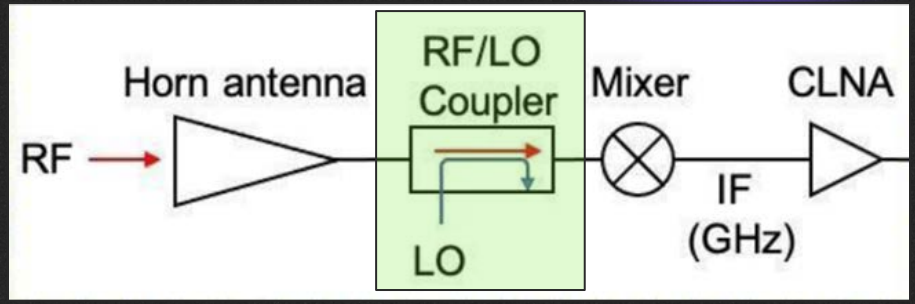
https://www.firebirdoptics.com/blog/everything-you-need-to-know-about-beamsplitters

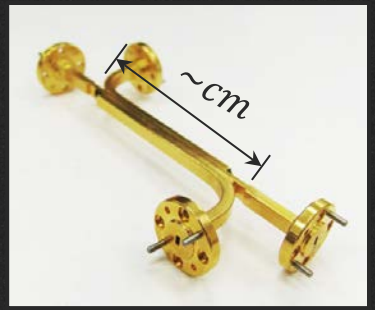
What is planar RF/LO coupler?

The properties of RF/LO coupler we pursued for constructing the multipixel module :

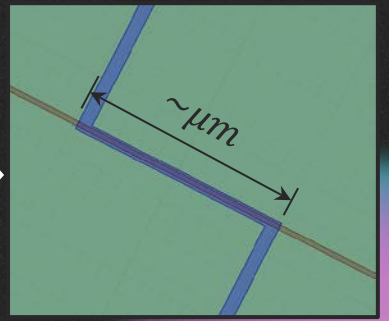
- Small size
- Can be easily integrated into the chip circuit

The points above can be achieved by “Planarizing” it





https://www.miwv.com/waveguide-type-dual-directional-couplers/



Outline

01 The Design Concept

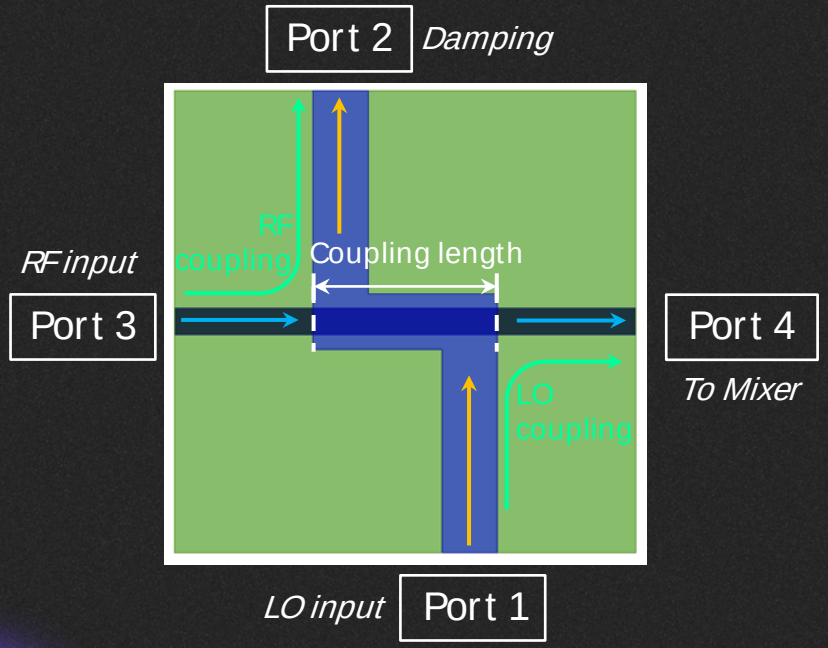
02 Verification with HFSS Simulation

03 Th Plan of Proving Concept: Scale down model

04 Fabrication Process

05 Summary

The Design Concept

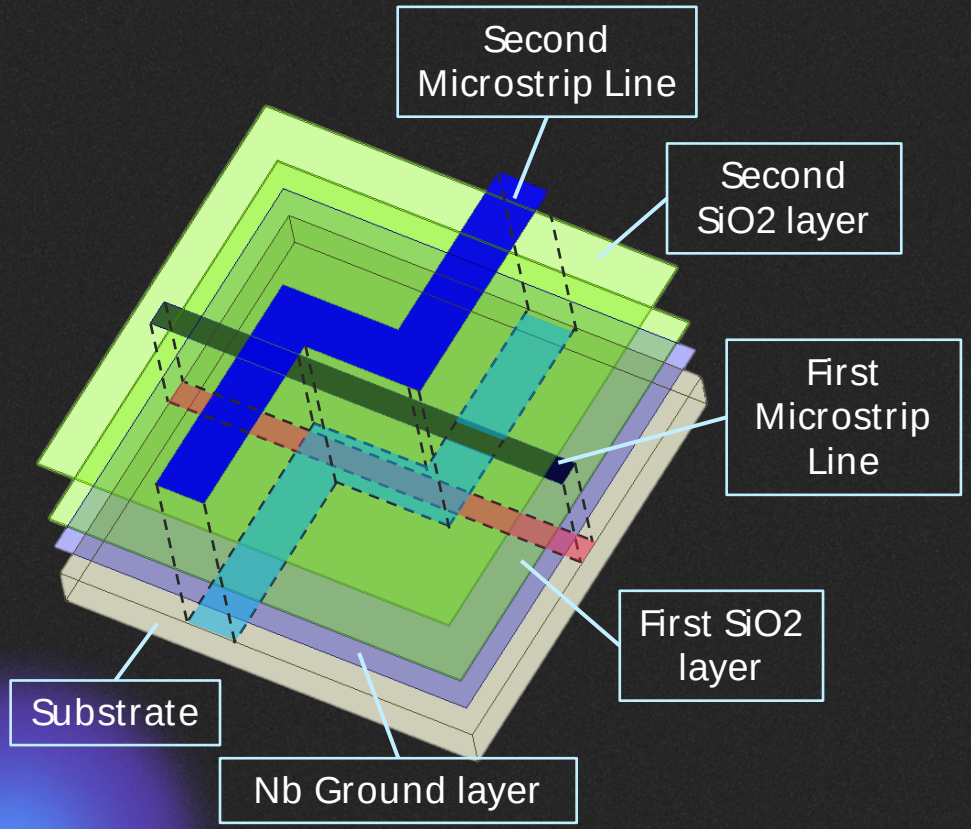


Stacking the source line of two microstrips will let their EM field overlap with each other and allow the power coupling

- Planar!
- Small Size!
- Coupling efficiency can be modified through the overlapping length!

Operation frequency: 200-240 GHz

The Design Concept

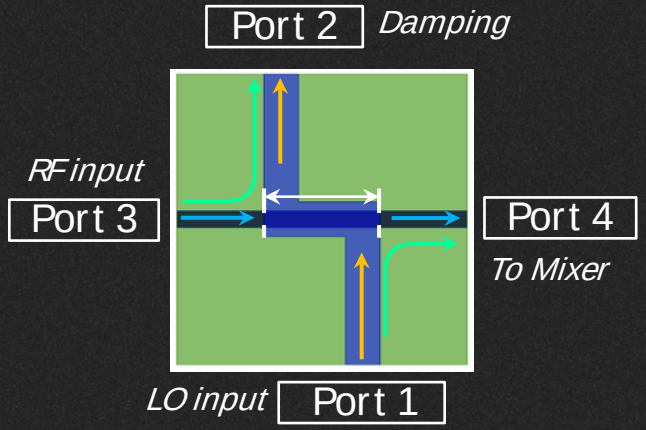


Six layers of this structure are included in our designD

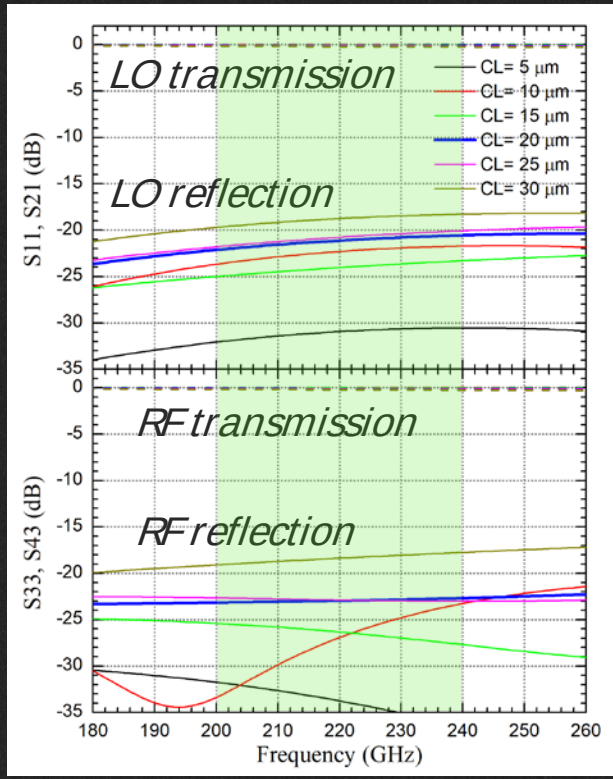
- 300 um SiO2 for substrate
- 0.3 um SiO2 for two dielectric layers
- 0.3 um Nb for two microstrip lines. The widths of them separately are 3 & 6 um

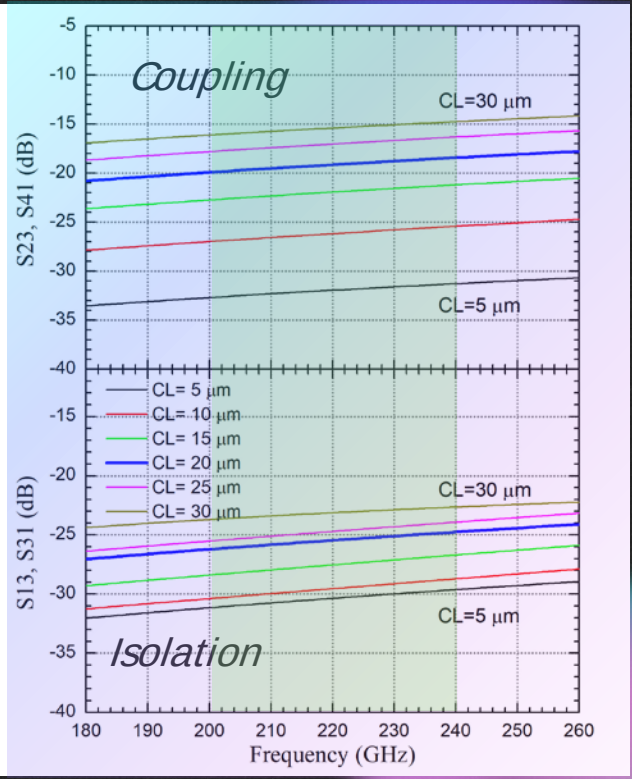
Both impedance of the two microstrips are 16 Ohm

Verification with HFSS simulation

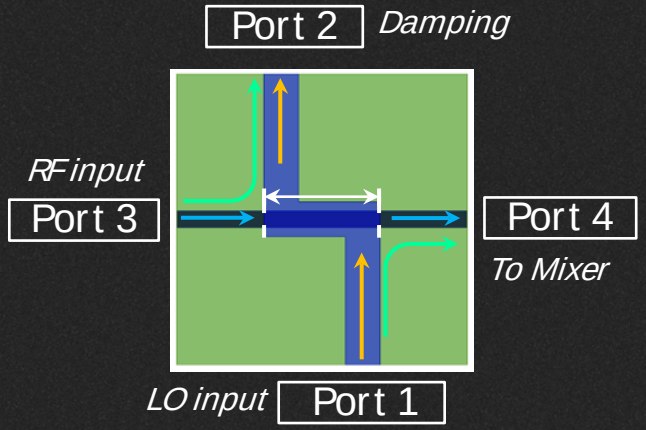


The circuit can keep the good transmission (return loss > -15 dB) during the coupling

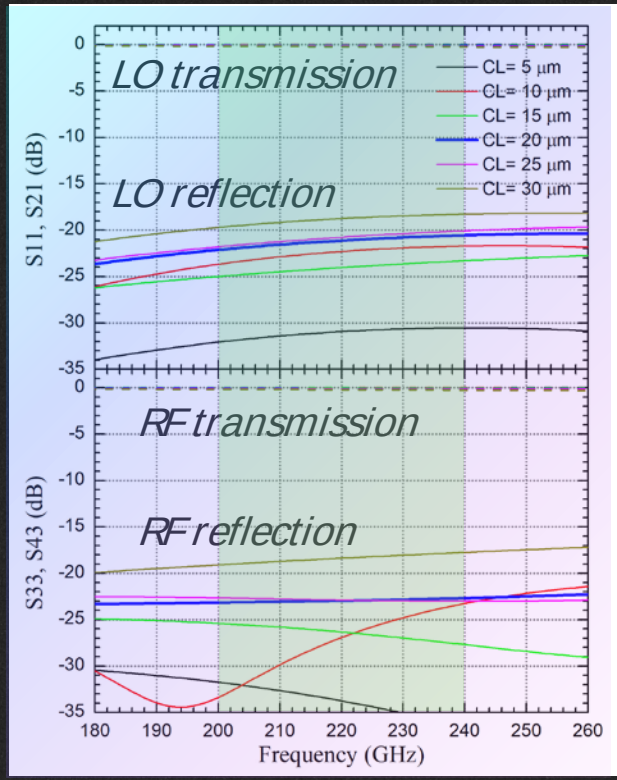


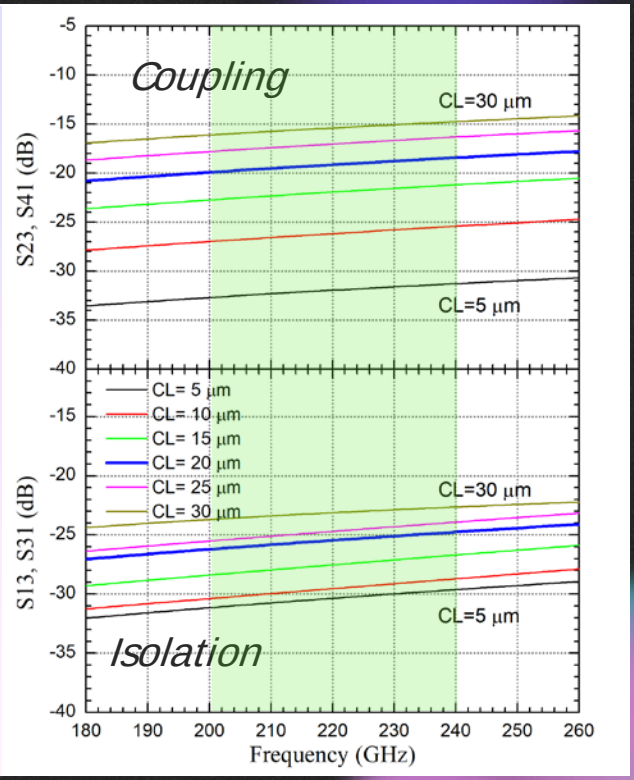


Verification with HFSS simulation



The coupling efficiency can reach -15 dB in the model of 30 um coupling length



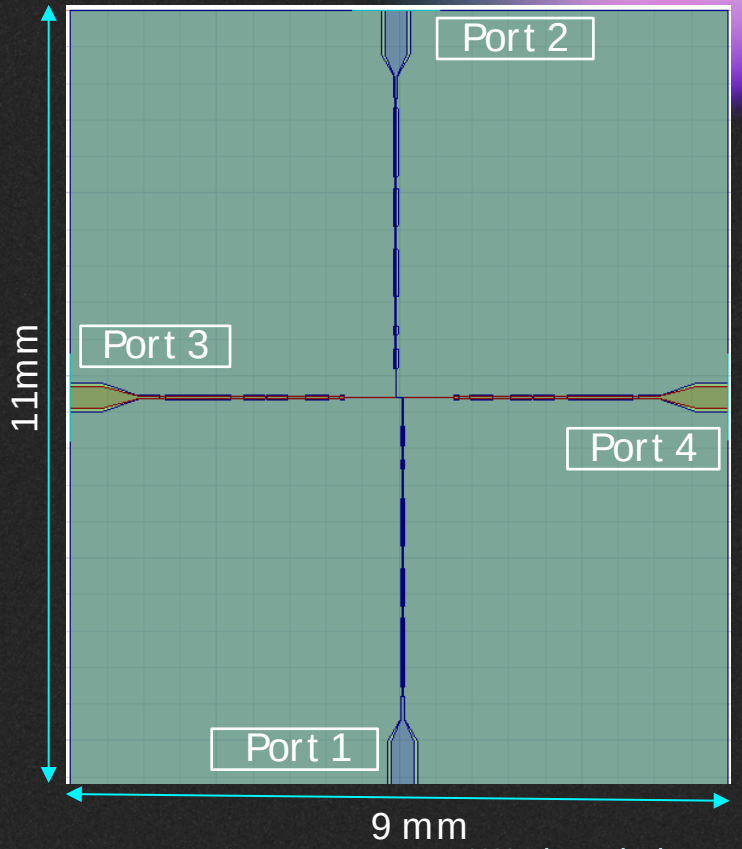


Concept proving with the scaled model

Scale the central frequency from 220 GHz to 10 GHz to do the measurement

Design a chip for this scaling model

The transmission line needs to be CPW for wire-bonding to output PCB (CPW)

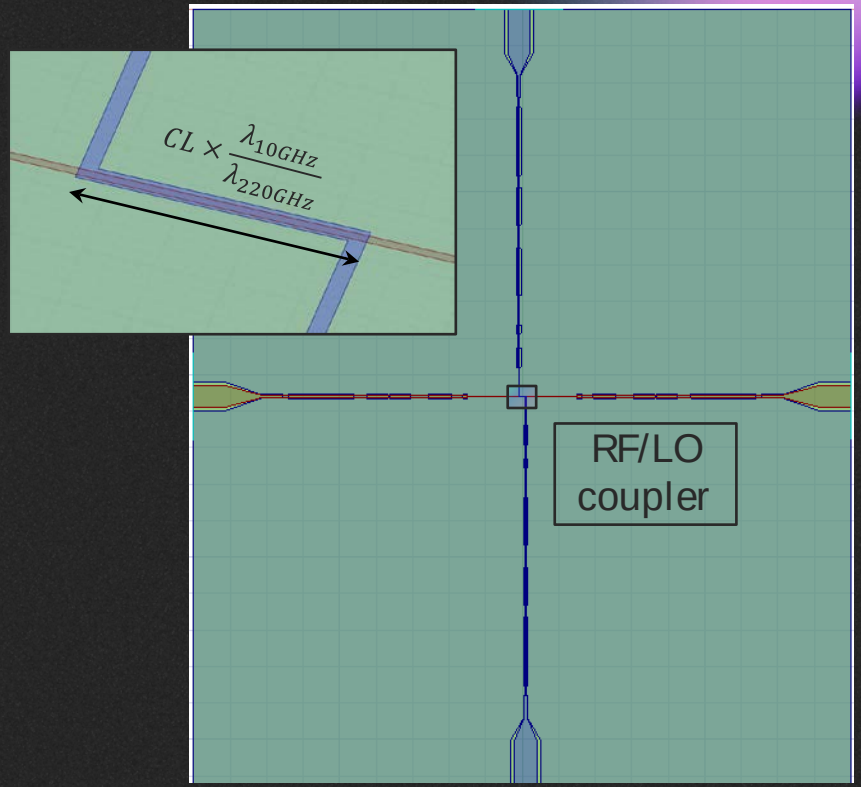


The Chip of scaled model

Extending the coupling length with the ratio (22) of frequency change

Our target coupling length (CL=20) becomes 440 um in this design

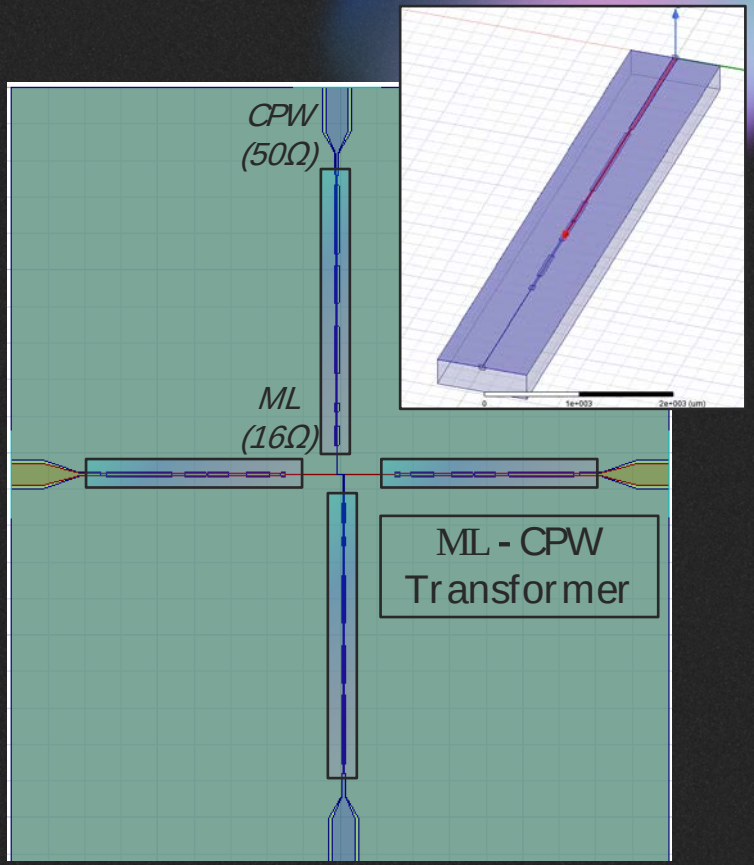
The configuration of two microstrips keep the same as the 220GHz version



The Chip of scaled model

The transmission line on the boundary needs to be 50 Ω CPW for bonding to the SMA

A transformer for the transition between 50 Ω CPW and 16 Ω ML is needed

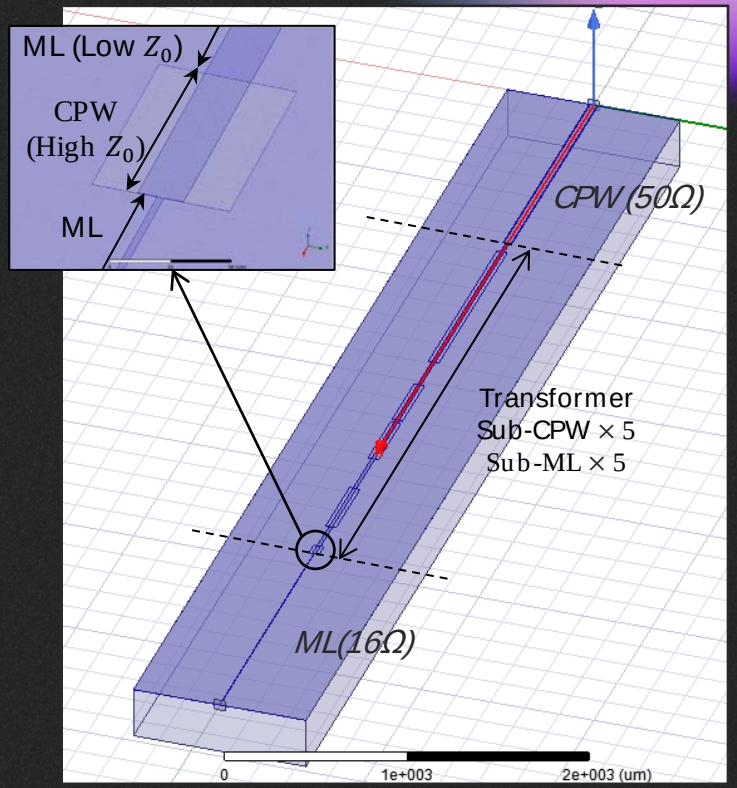


The Chip of scaled model

This transformer is composed of 10 sub-transmission lines which form a series of high-low impedance regions for matching

The best length of each sub-element is found with HFSS optimization

The simulation shows the positive result



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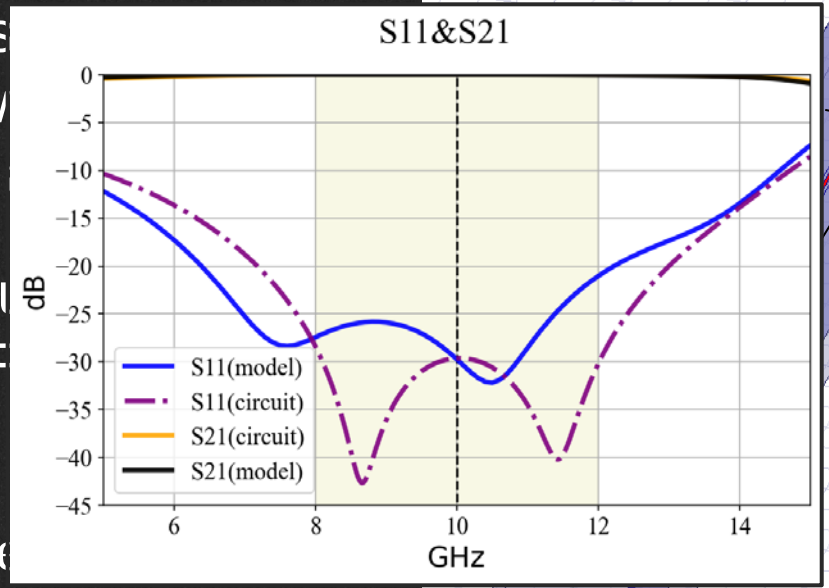
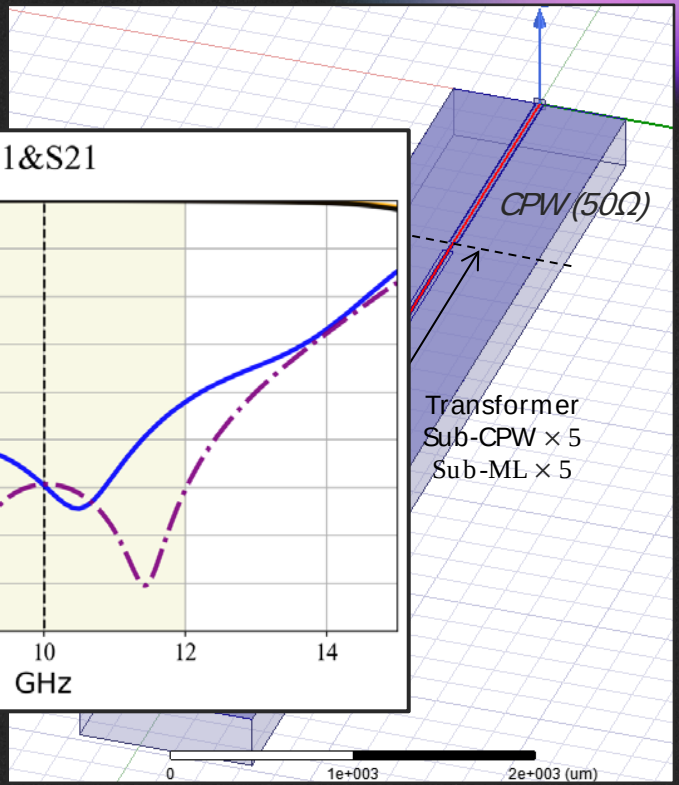
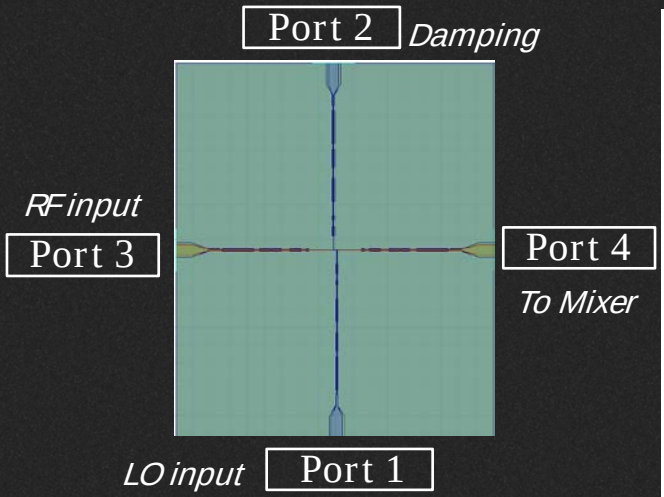
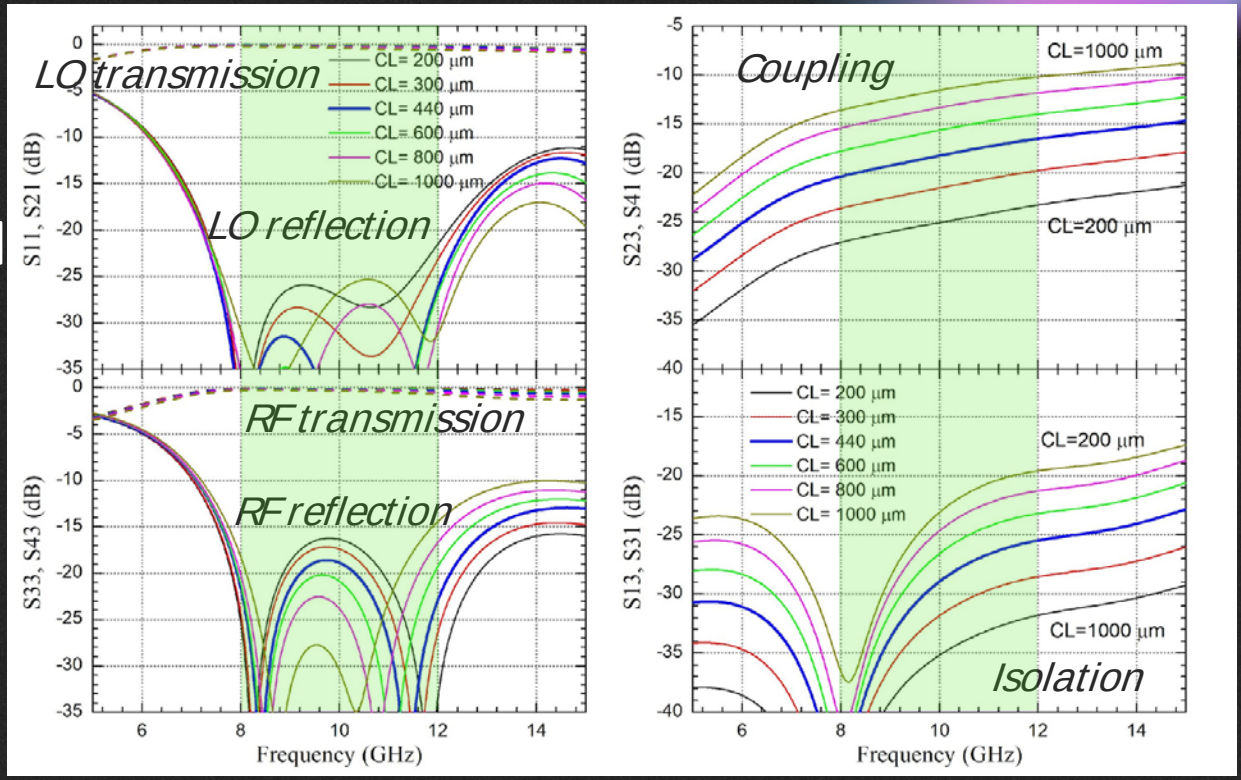




The Chip of scaled model



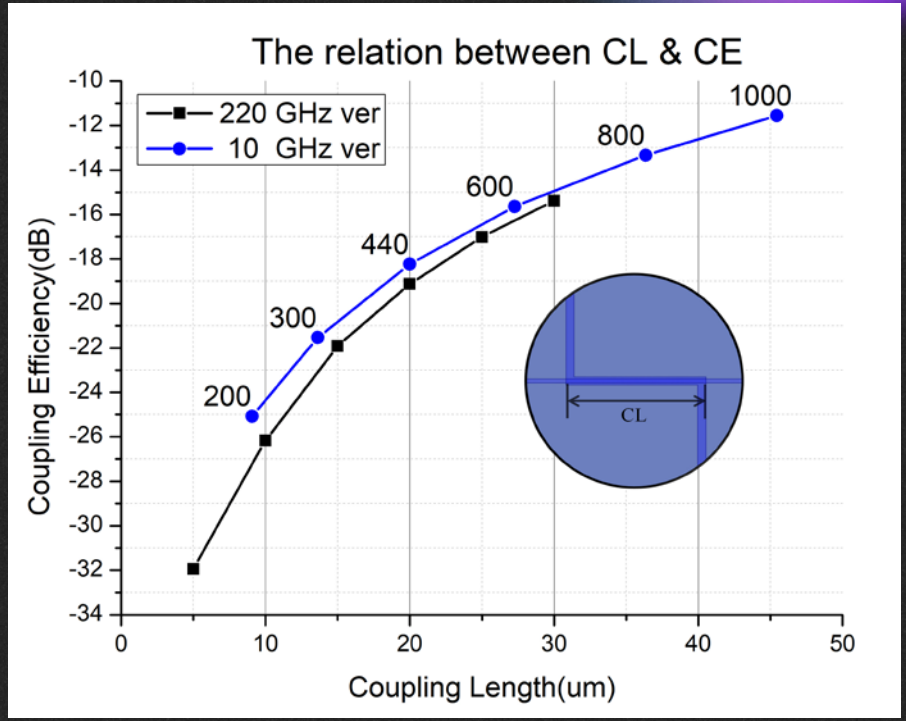
The simulation also shows the positive result in the whole chip model.



The Chip of scaled model

We also compare this simulation result with the 220 GHz model

The coupling efficiency of two versions are close (~1dB difference)

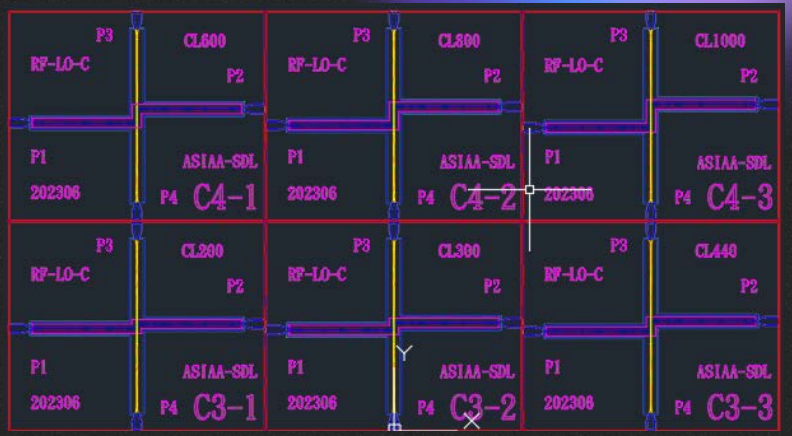


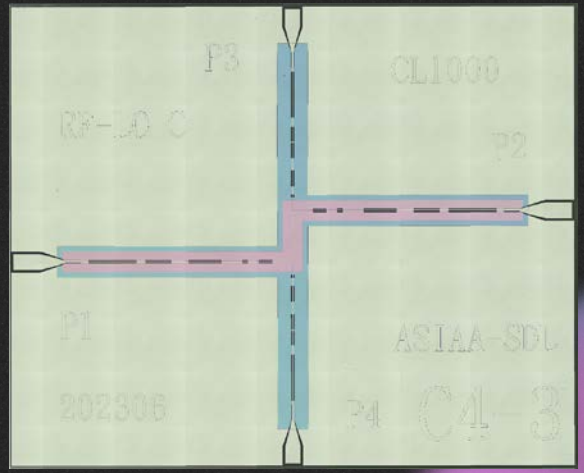
Fabrication Process

Six chip with different coupling length (200, 300, 440,600, 1000 um) are arranged in the design

Using the photolithography for patterning

This fabrication has successfully finished the Run 1



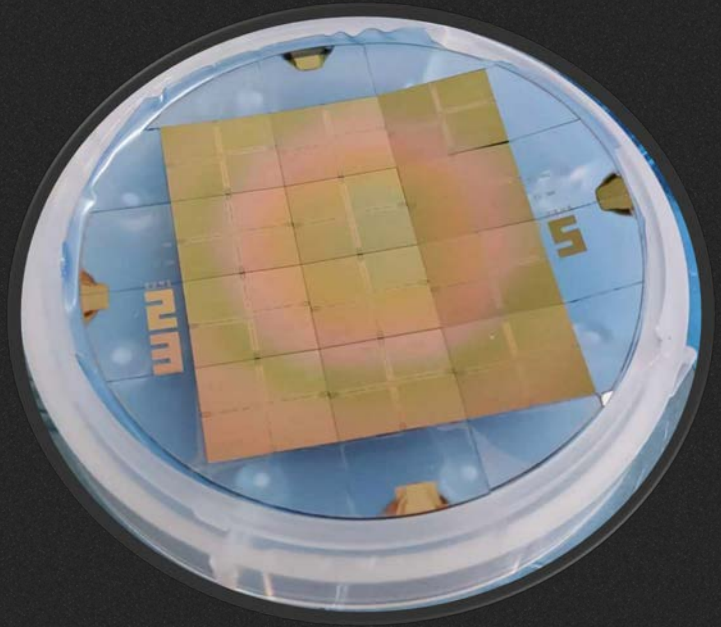


Summary

Planarizing the circuit is necessary for constructing the sub-THz heterodyne receiver with a large pixel number

This report provides a structure to couple the LO and RF signals at 200-240 GHz. And its possibility has been verified by the simulation and fabrication

The performance measurement will be established soon.

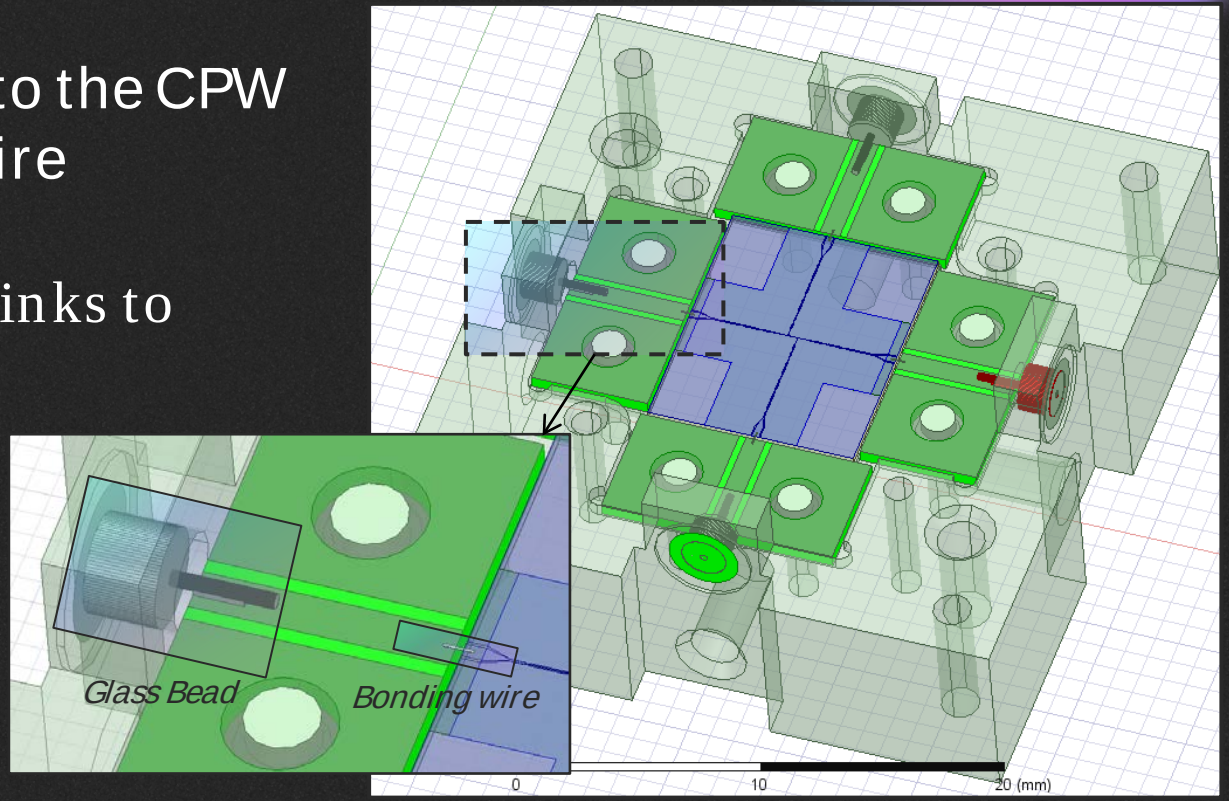


The end

About the Housing Block

The CPW on chip links to the CPW on PCB with bonding wire

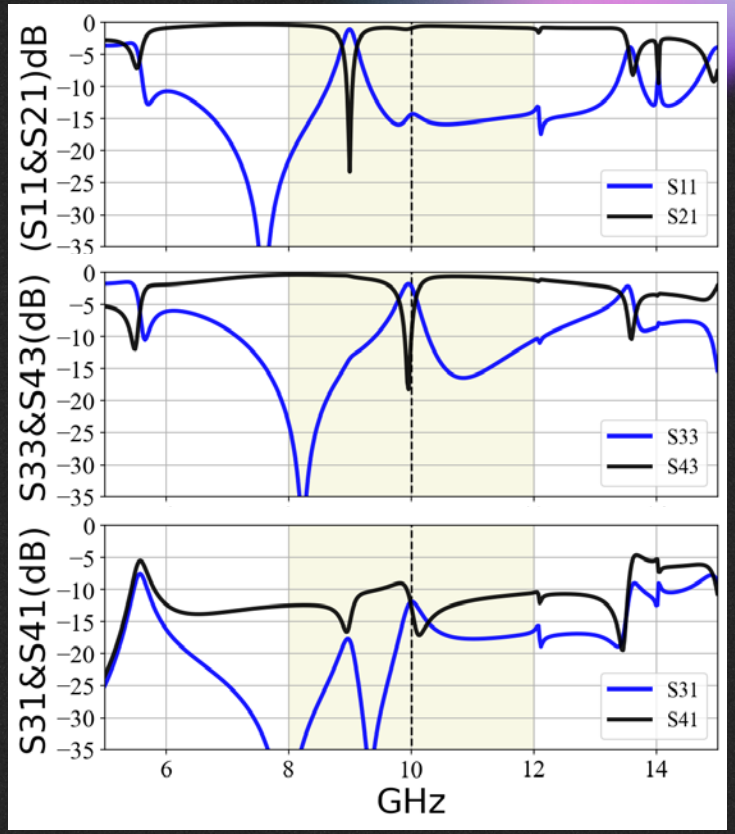
Then the CPW on PCB links to SMA with Glass bead



About the Housing Block

Some resonate peak appear after chip connecting to the CPW on PCB

The reason is still under investigation.



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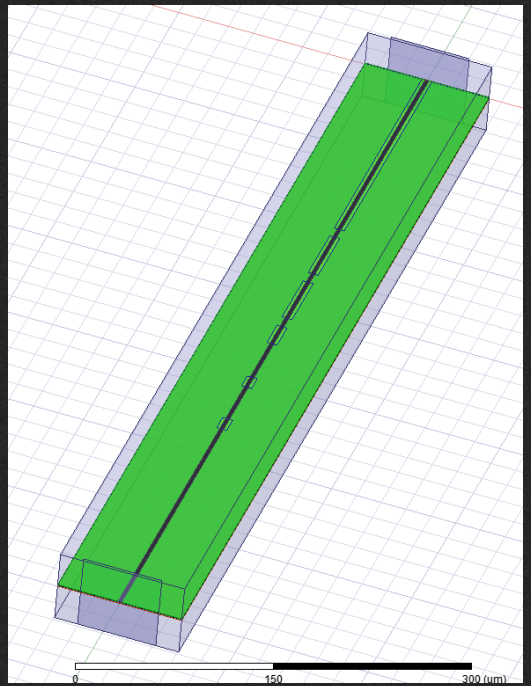
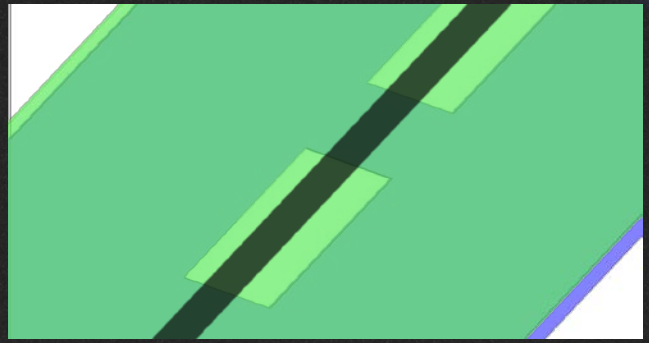

0
150
300 (um)



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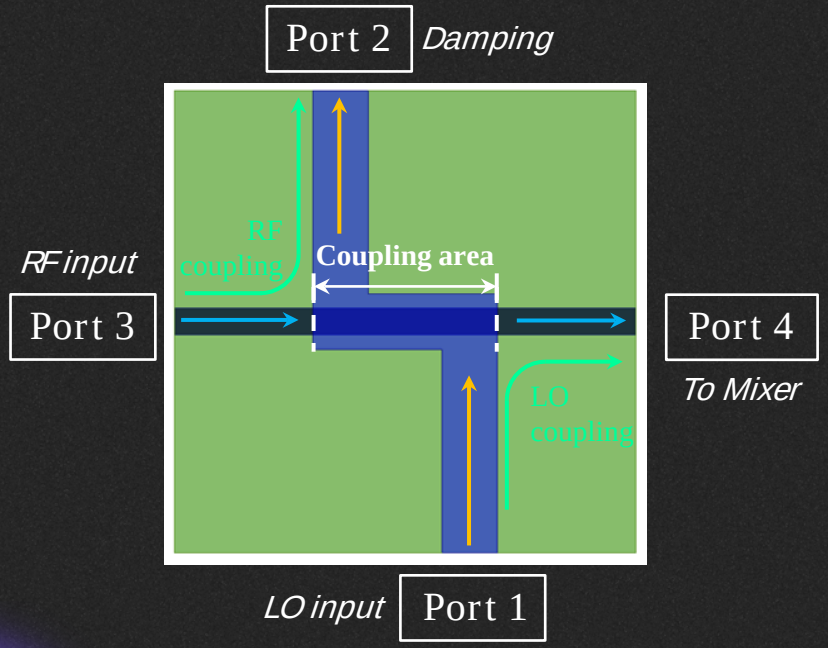
The Design Concept



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