

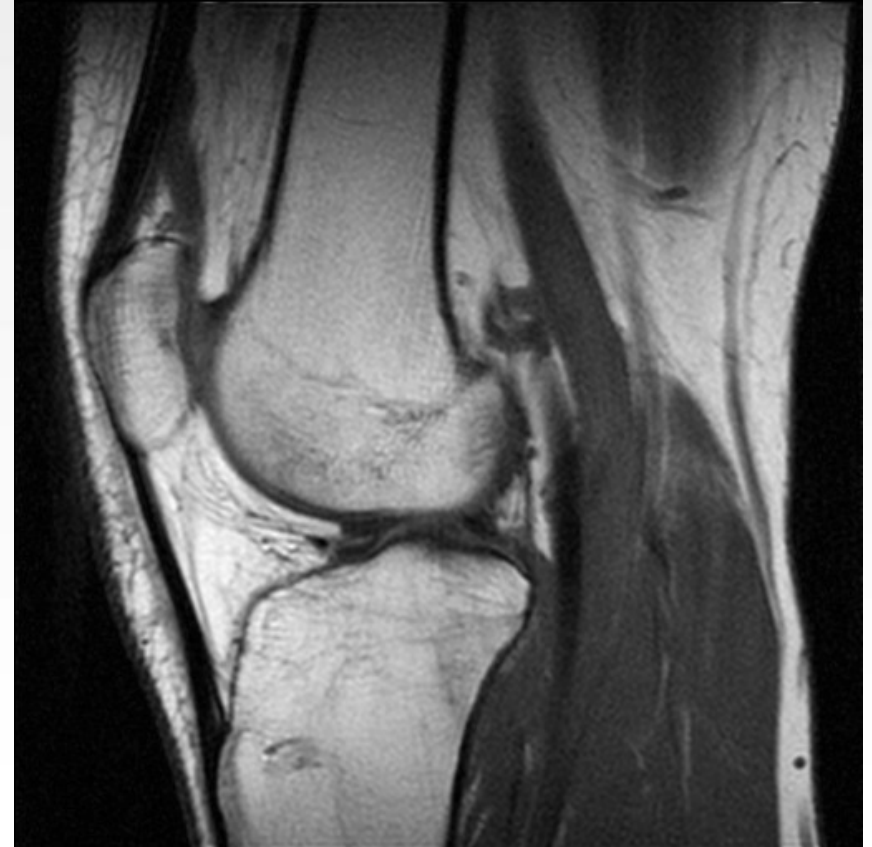
Transmit/Receive Switch for Quadrature Coils in a 7-Tesla Magnetic Resonance Imaging System(MRI)

Project Task for Yipeng LIU and Yan CHENG

1.introduction

- Concept of the MRI

Magnetic resonance imaging (MRI), also called nuclear magnetic resonance imaging (NMRI)

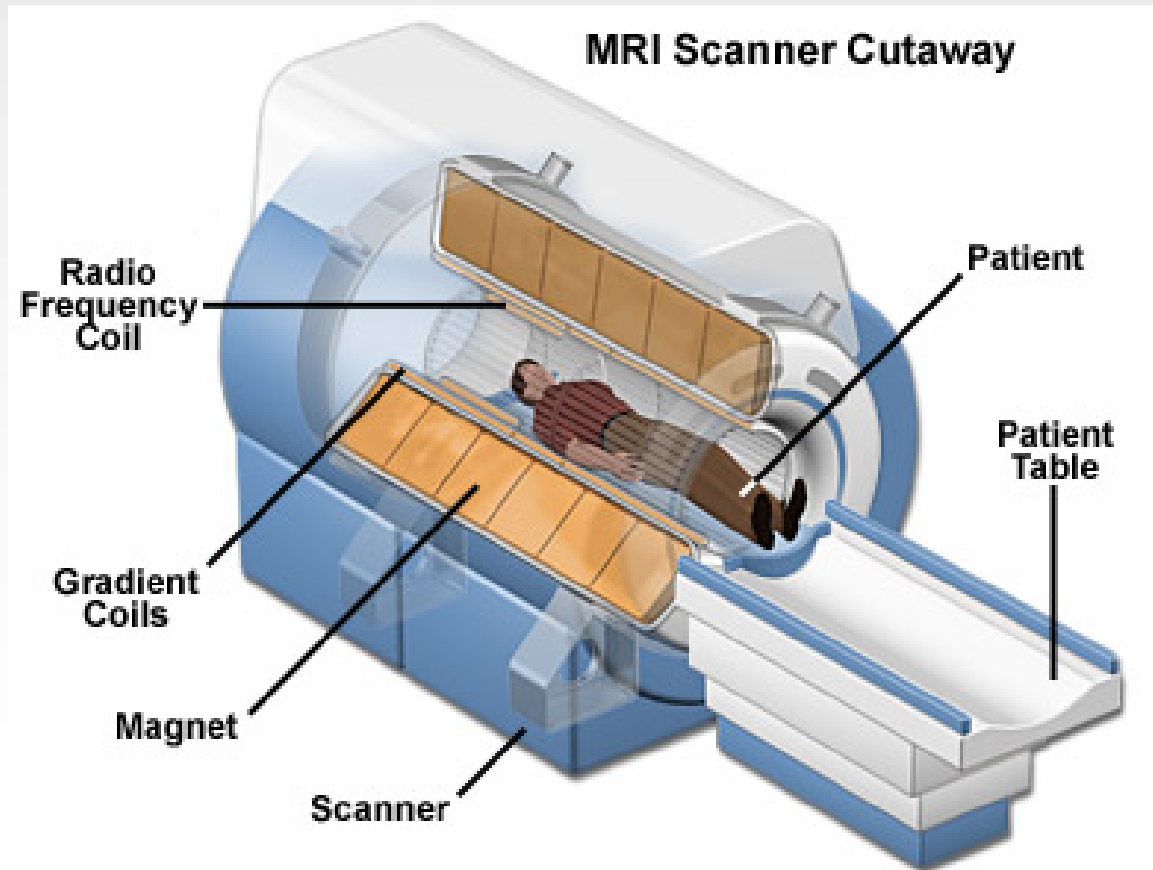


MR image of the knee

1.introduction

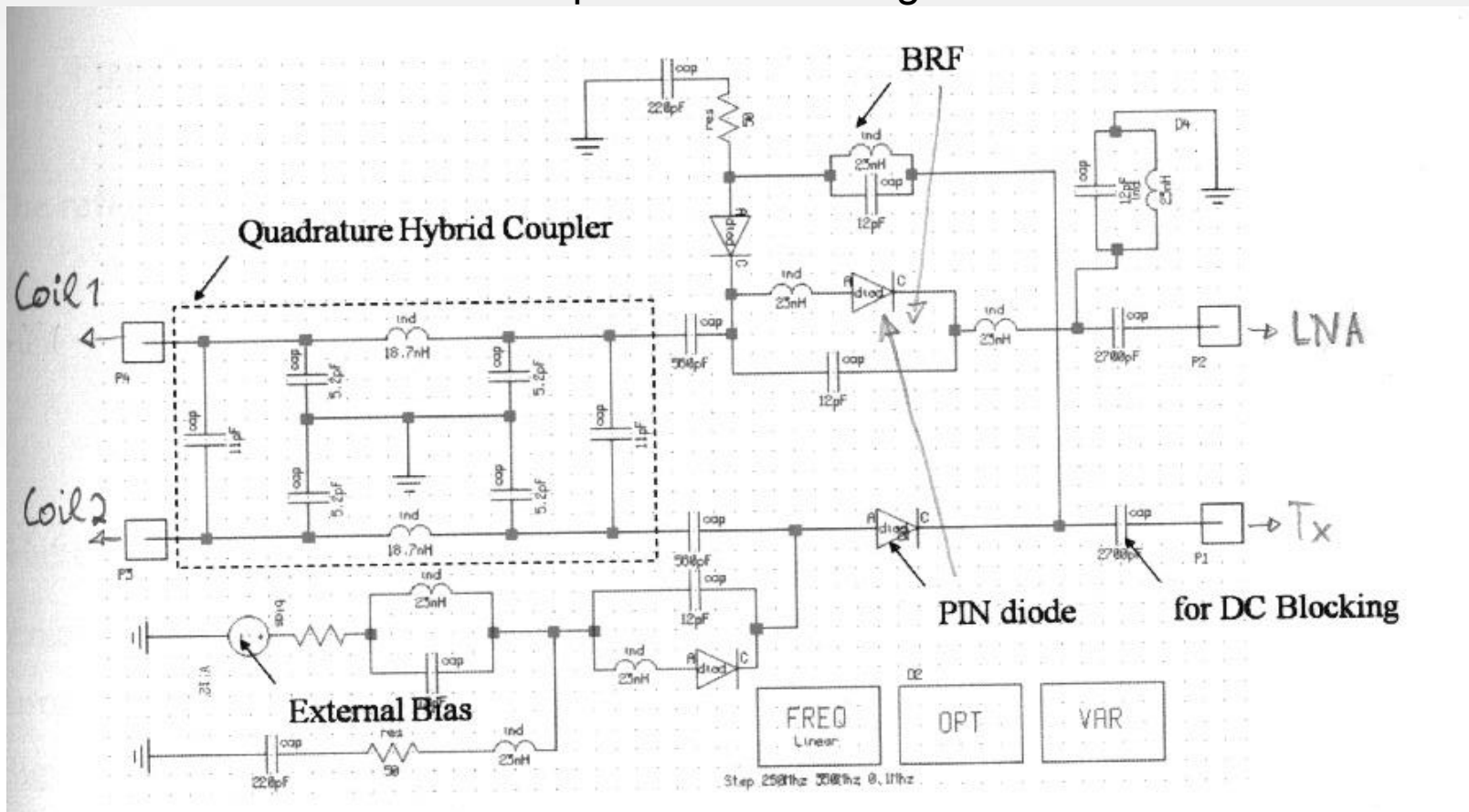
■ Theory

- 1.Body in a large, powerful magnet field.
- 2.Systematically alter the alignment of this magnetization.
- 3.According the Nuclear Magnetic Resonance theory,the nuclei produces a rotating magnetic field detectable by the scanner



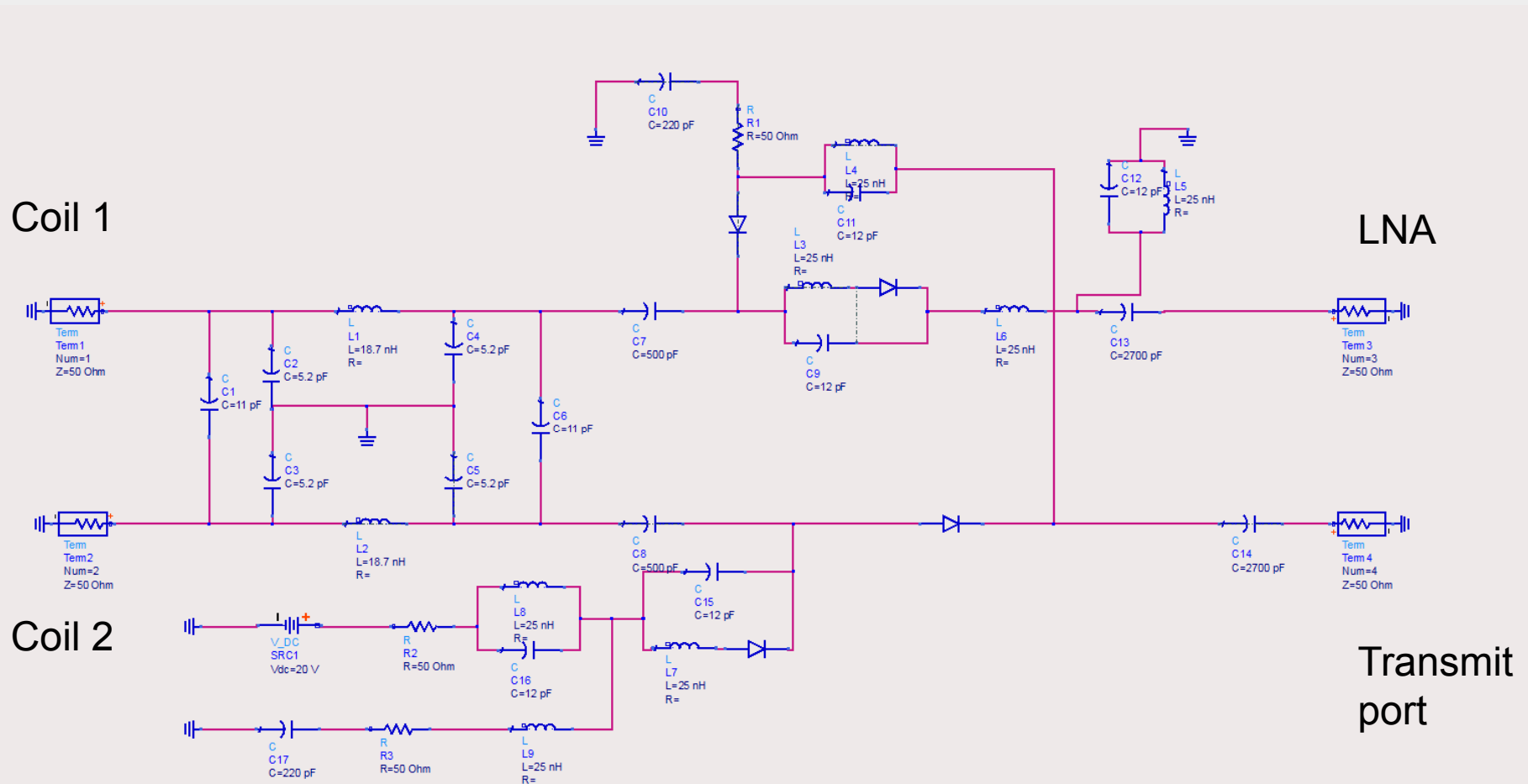
1.introduction

- T/R switch is a circuit which allows the use of the coils in transmit also in receive.
- A recent doctoral thesis has presented a design of such a T/R switch.



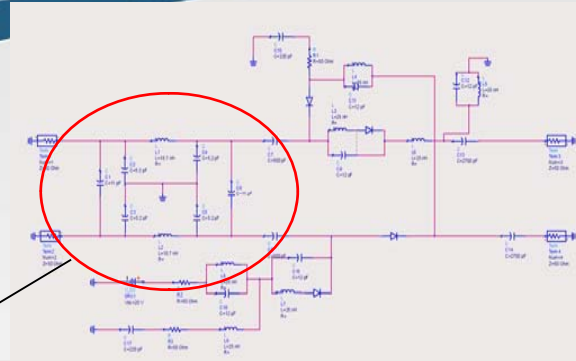
1.introduction

- To make it more clear ,we show it in the ADS Schmatic view



2.Circuit analysis

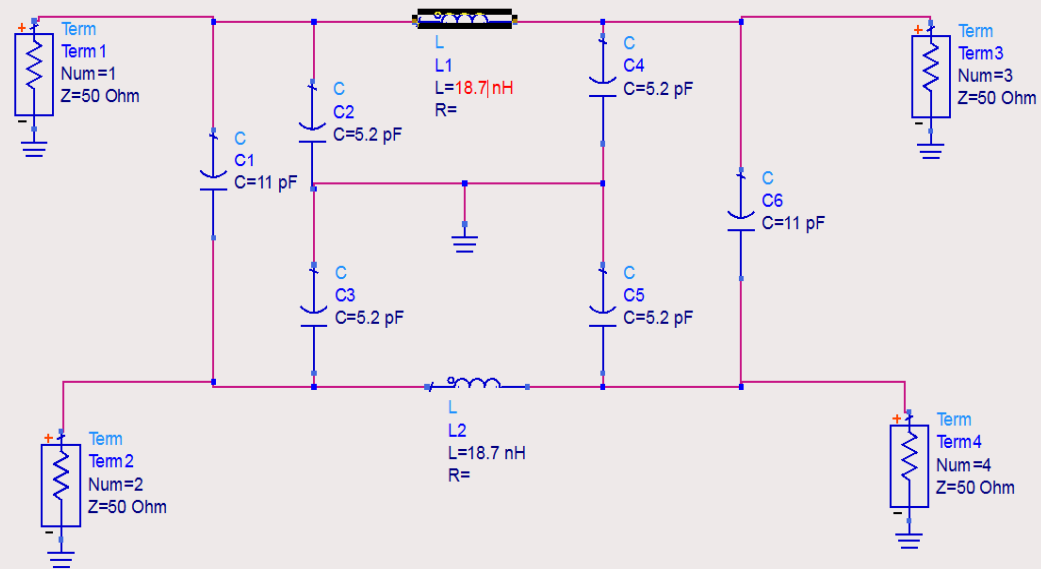
■ Quadrature Hybrid Coupler



Funktion:
•divider
•combiner

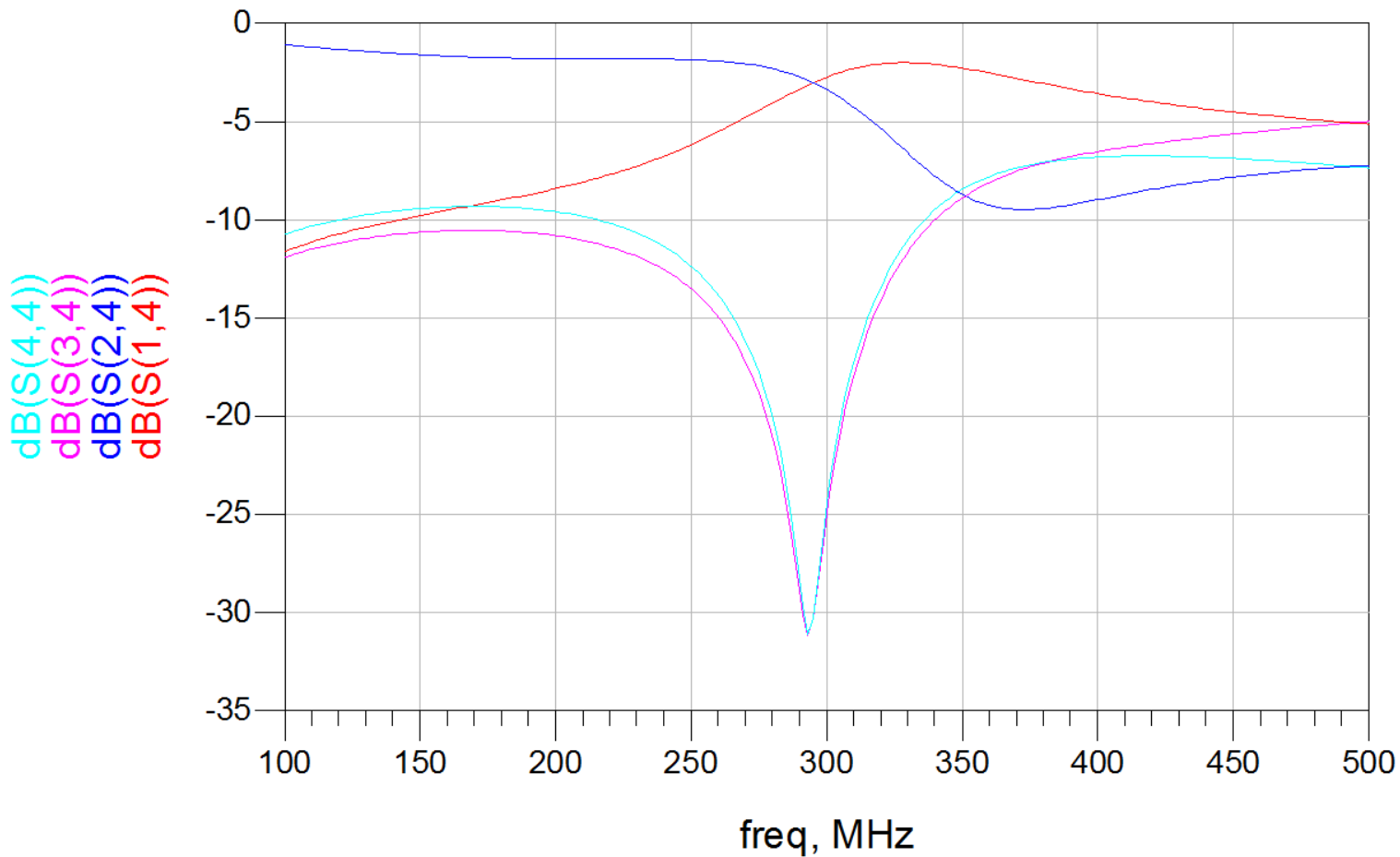
S-PARAMETERS

S_Param
SP1
Start=100 MHz
Stop=500 MHz
Step=



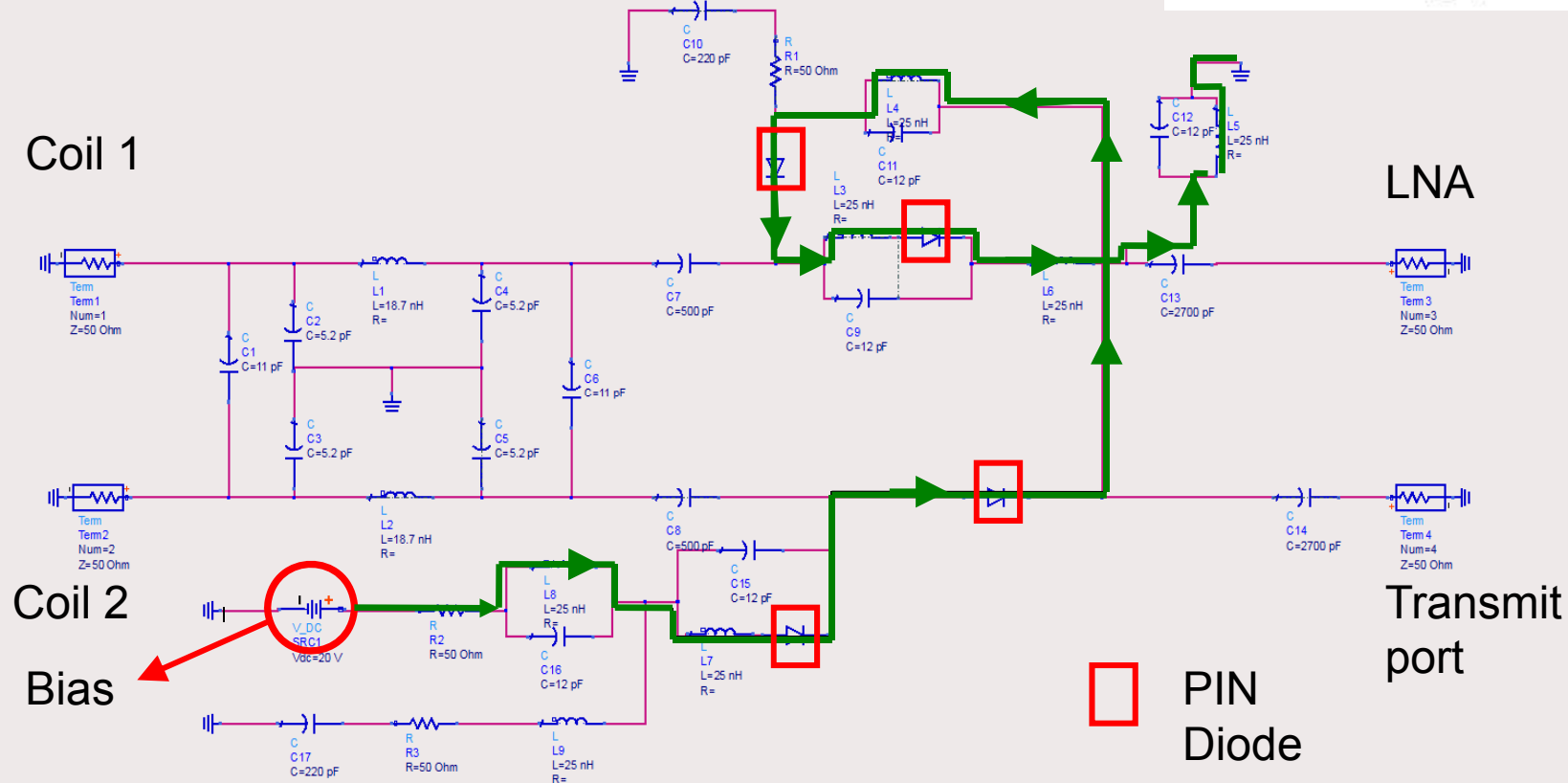
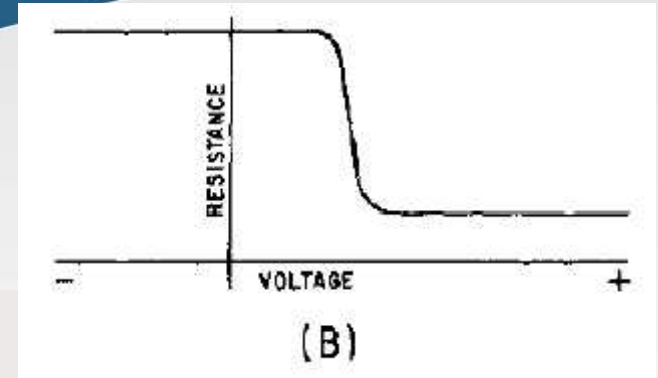
2.Circuit analysis

- Quadrature Hybrid Coupler



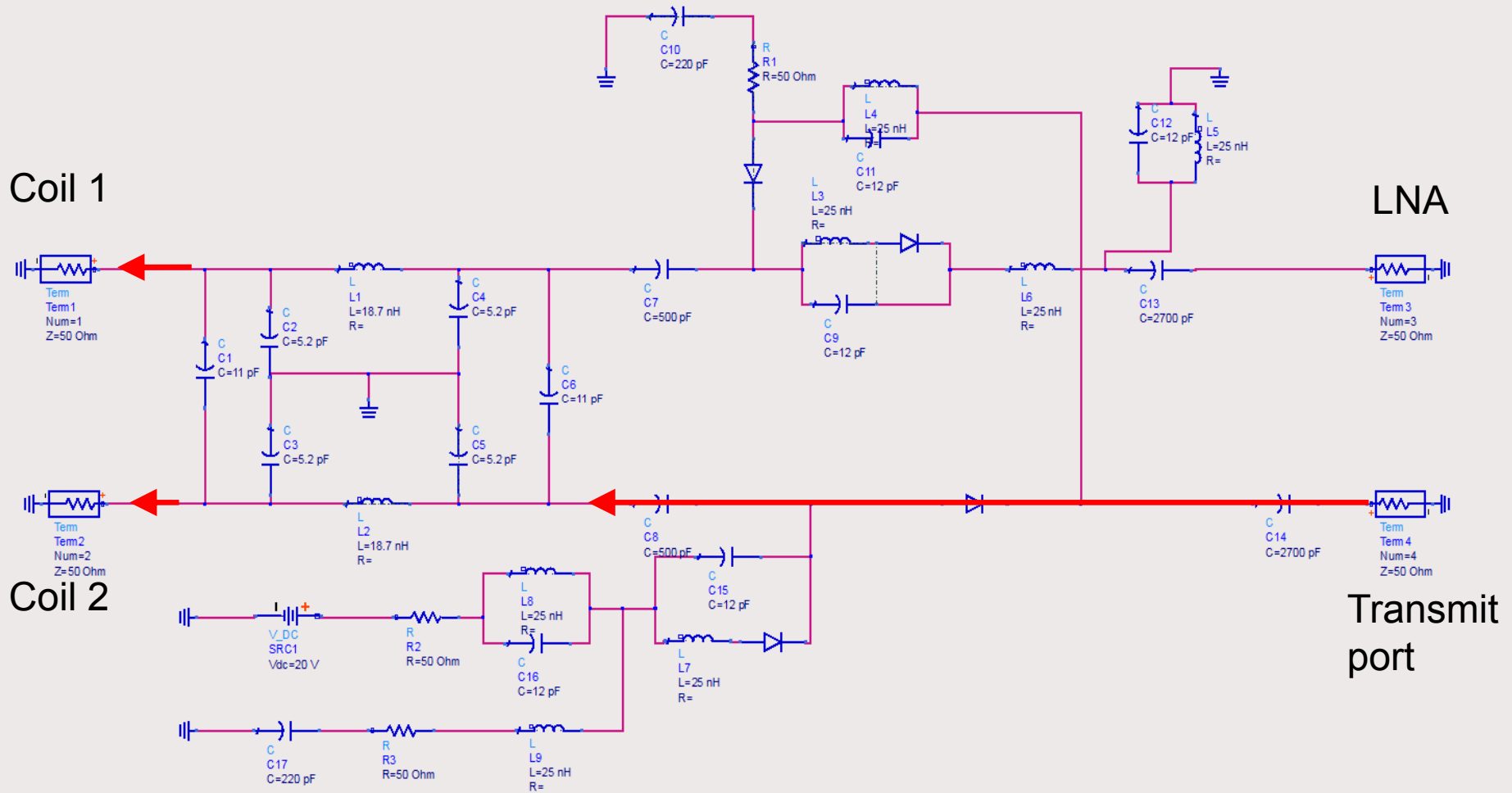
2.Circuit analysis

■ Bias and PIN diode



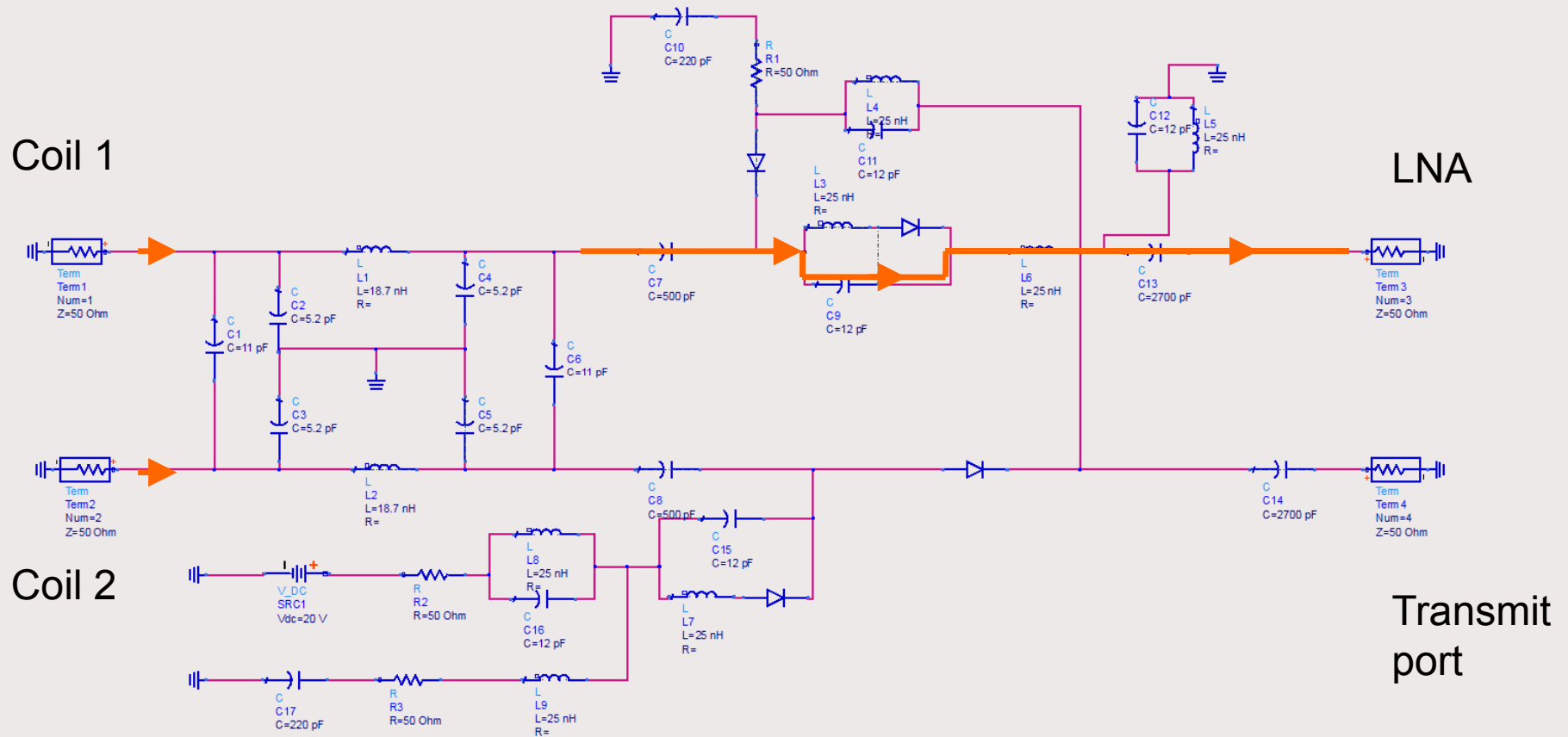
2.Circuit analysis

Switch on Transmit



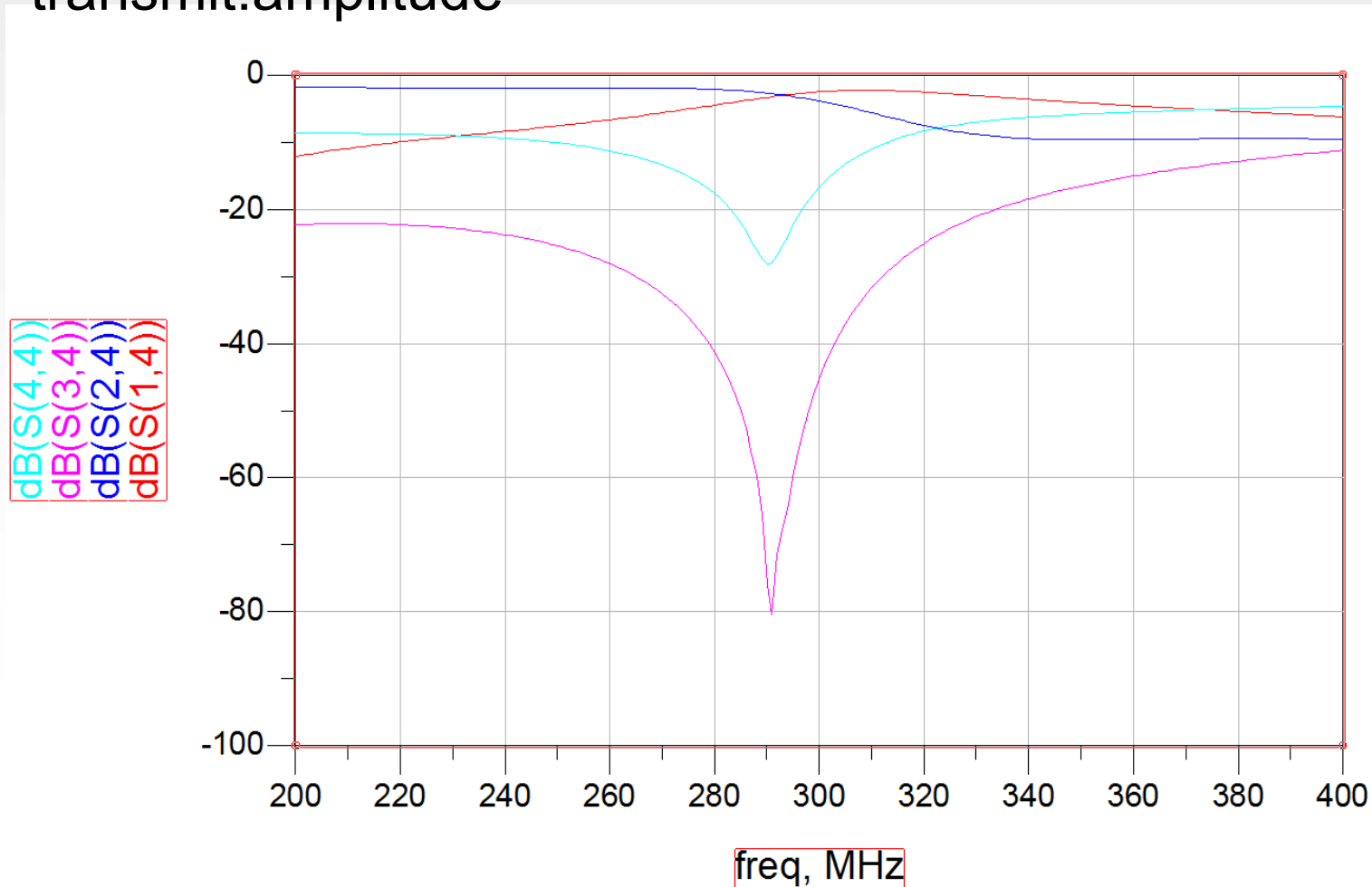
2.Circuit analysis

Switch on receive



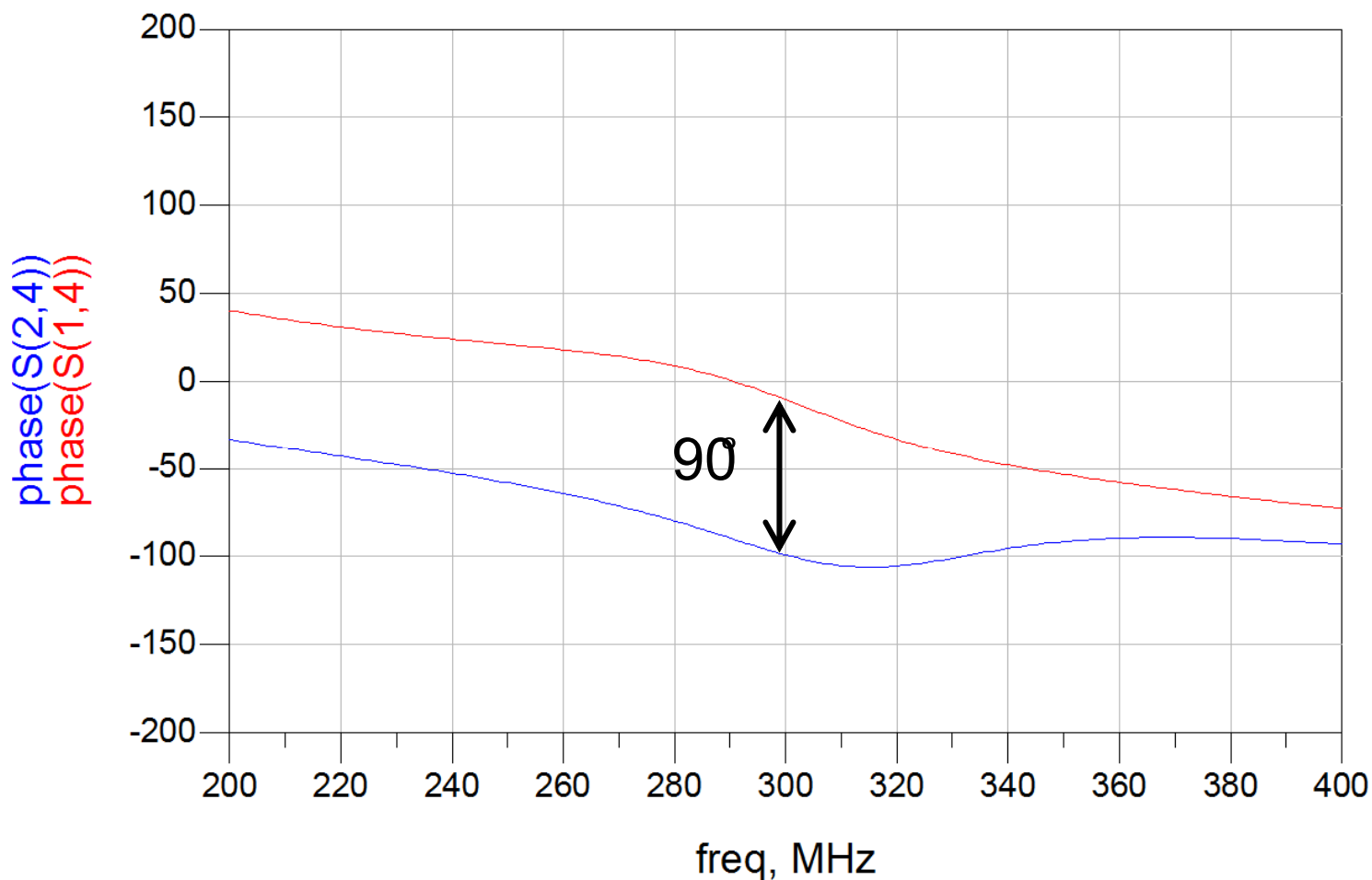
3. Ideal circuit simulation with ADS

- transmit:amplitude



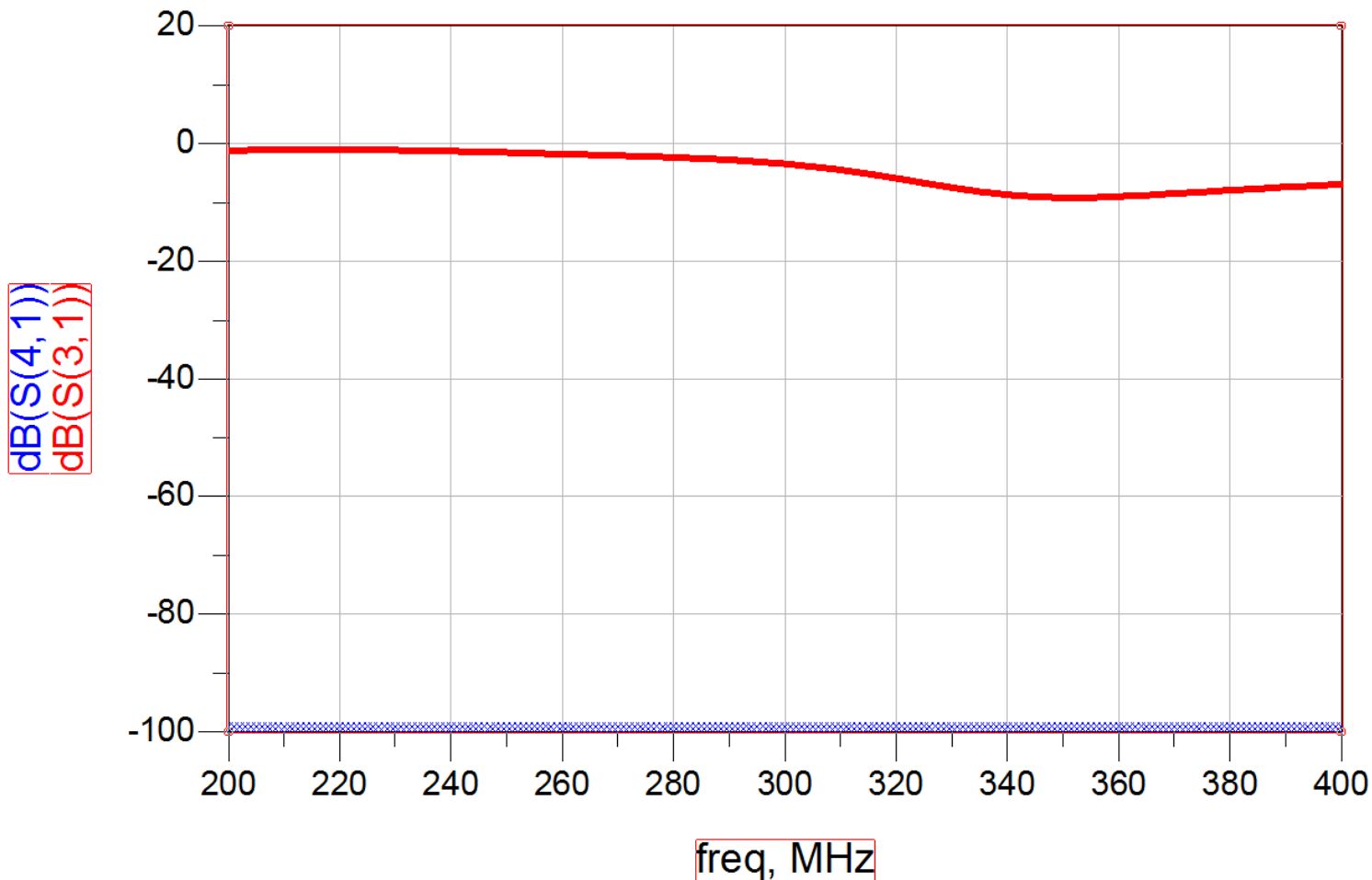
3. Ideal circuit simulation with ADS

- transmit:phase



3. Ideal circuit simulation with ADS

- receive



4. Layout & EM/Circuit Co-simulation

■ Condition:

1. Working Frequency on 300MHz, wave length is about 1m. The influence of TL on signal could be neglected.
2. Component size: see the table.
3. Substrate Ro4003

Component	Type	Size (mm)
Diode	MA4P4006	3.81*3.81*5.08
Capacitor	ATC 100B	2.79*2.79*2.59
Inductor	Hand made with coils	about 10mm long
Resistor	-	about 5 mm long
Connector	-	5*5

4. Layout & EM/Circuit Co-simulation

- EM/Circuit Co-simulation: Simulation in EM environment
- In
ADS: Layout → Simulation → optimize → Layout → Simulation
- Takes several weeks
- More than 10 Visions, which could be divided to 4 stages

4. Layout & EM/Circuit Co-simulation

■ Stage 1

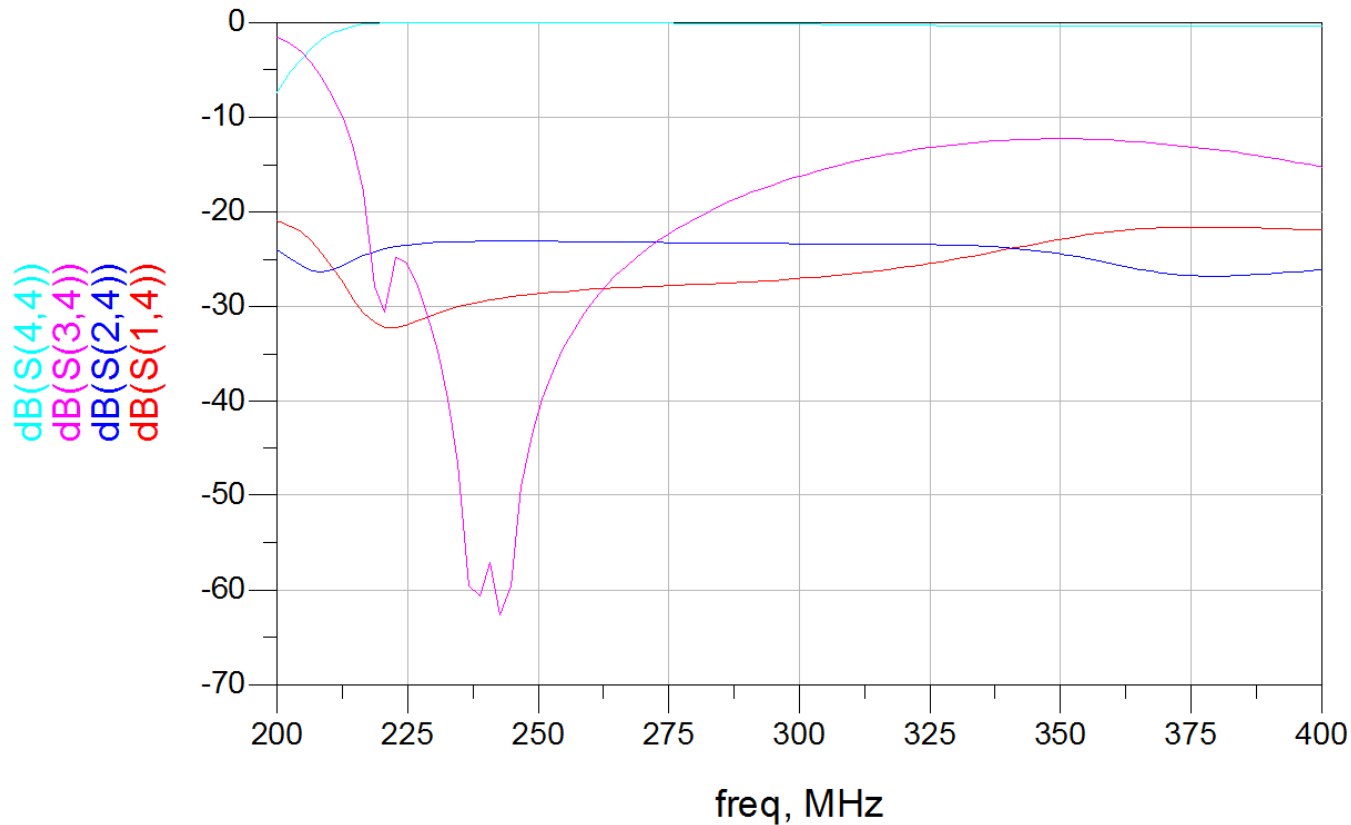


Disadvantage:

1. Almost just replace wires with TL from the Schematic view, not considering the practical condition.
2. Too compact, rather not notice the the distance between 2 TL is too close. The width of TL is too small.
3. The via ground

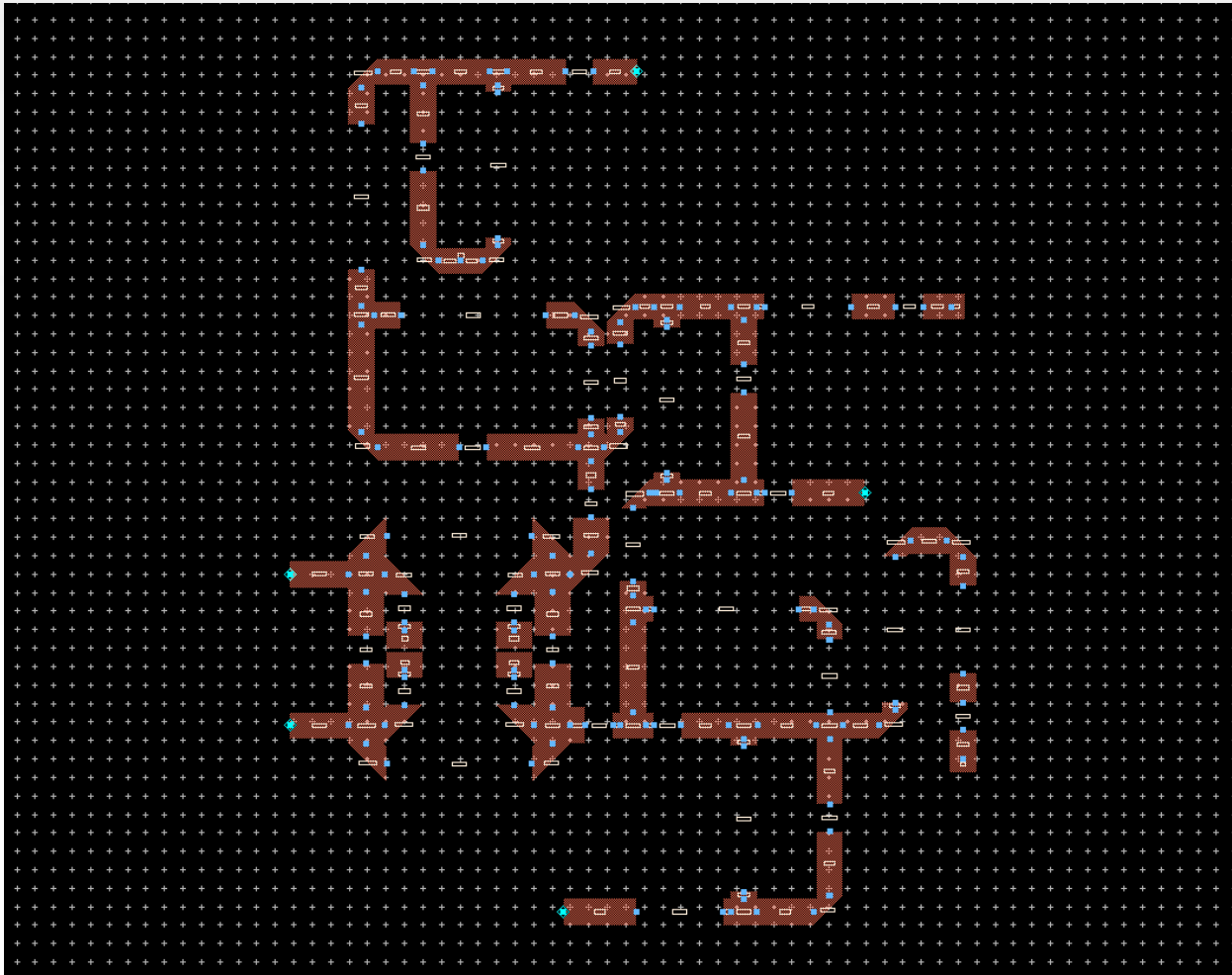
4. Layout & EM/Circuit Co-simulation

- stage 1 simulation result



4. Layout & EM/Circuit Co-simulation

- Stage 2

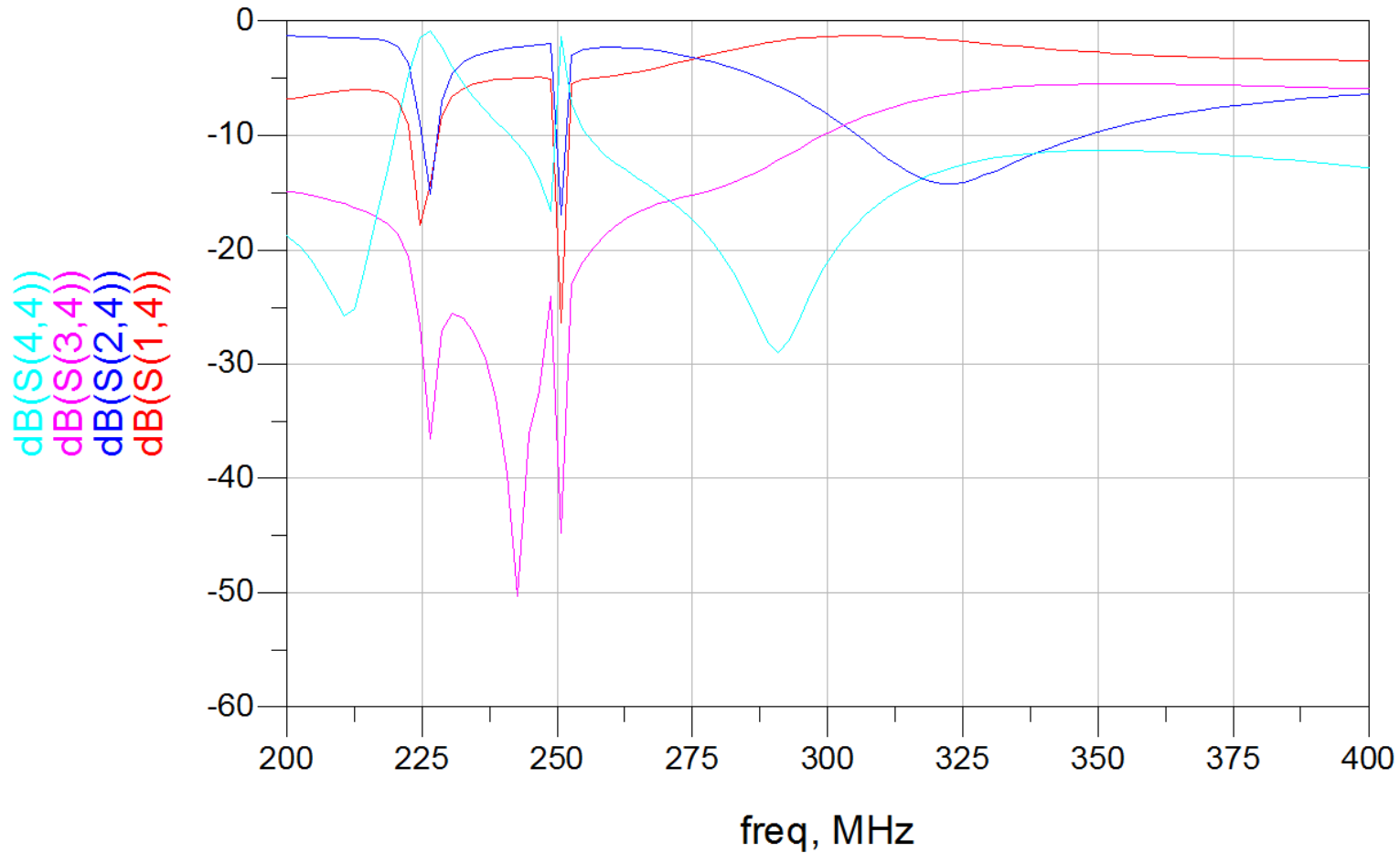


Disadvantage:

1. The size is little large.
2. Transmit port and Receive port are close

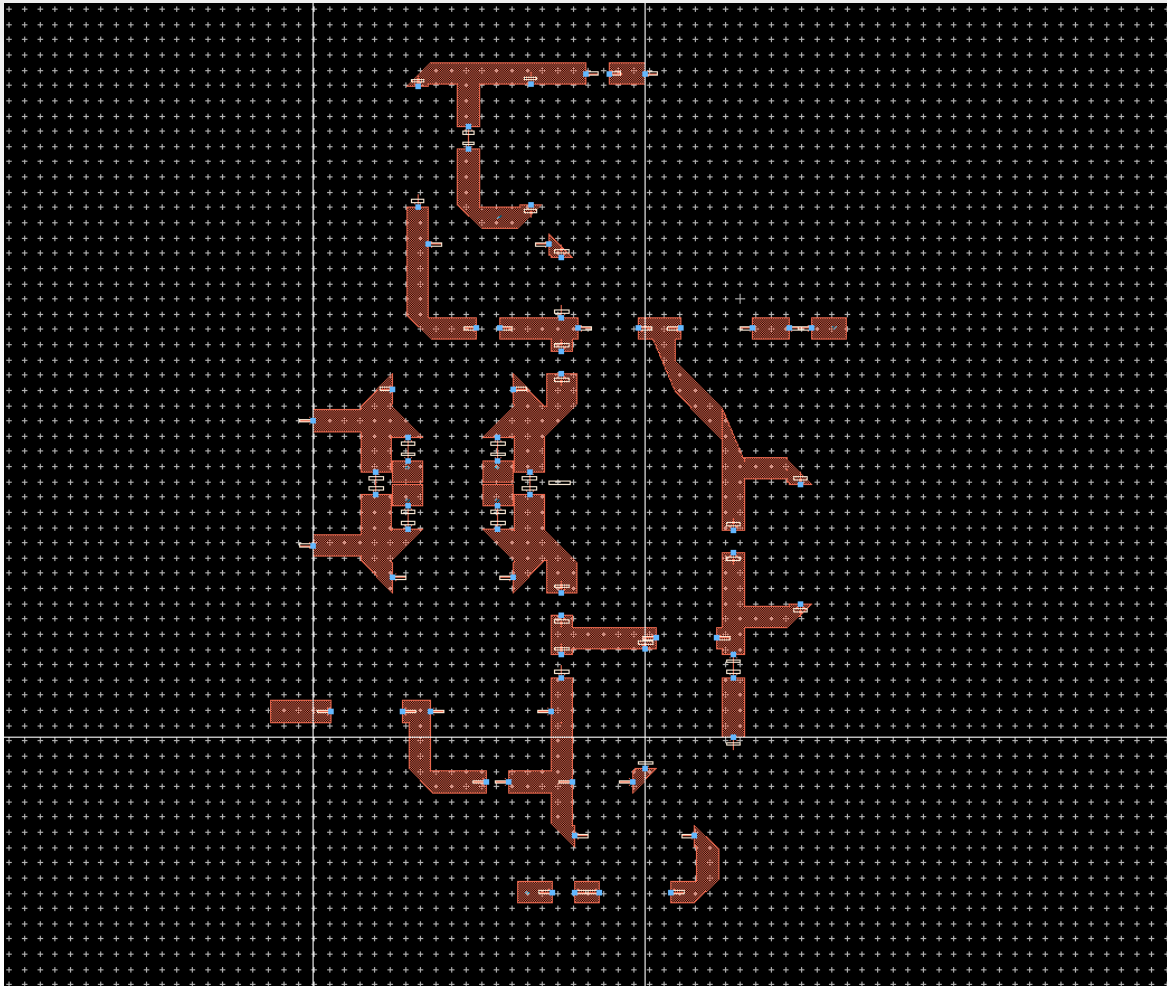
4. Layout & EM/Circuit Co-simulation

- stage 2 simulation result



4. Layout & EM/Circuit Co-simulation

■ Stage 3

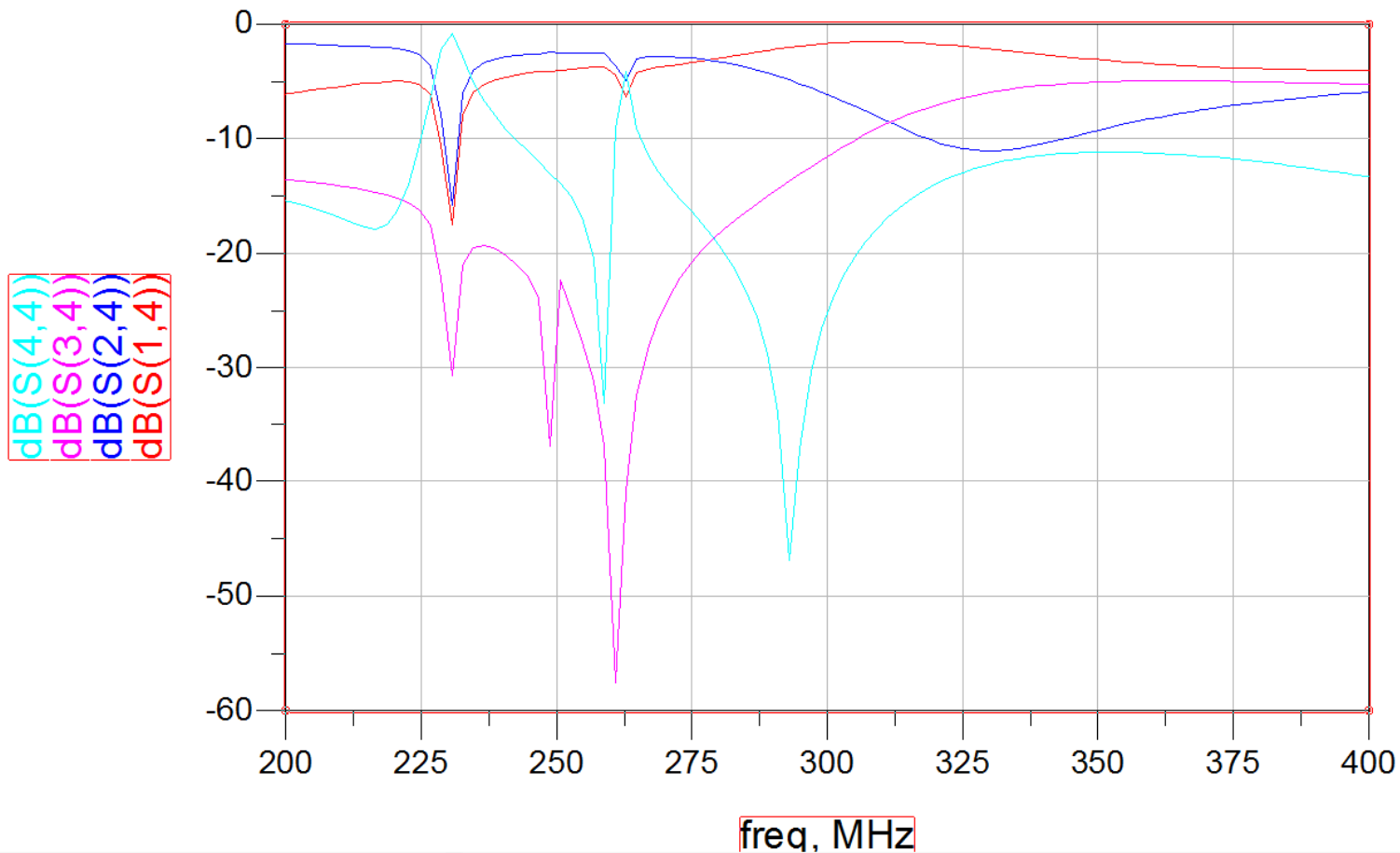


Disadvantage:

1. Still many parallel TL.
2. not making full use of the space

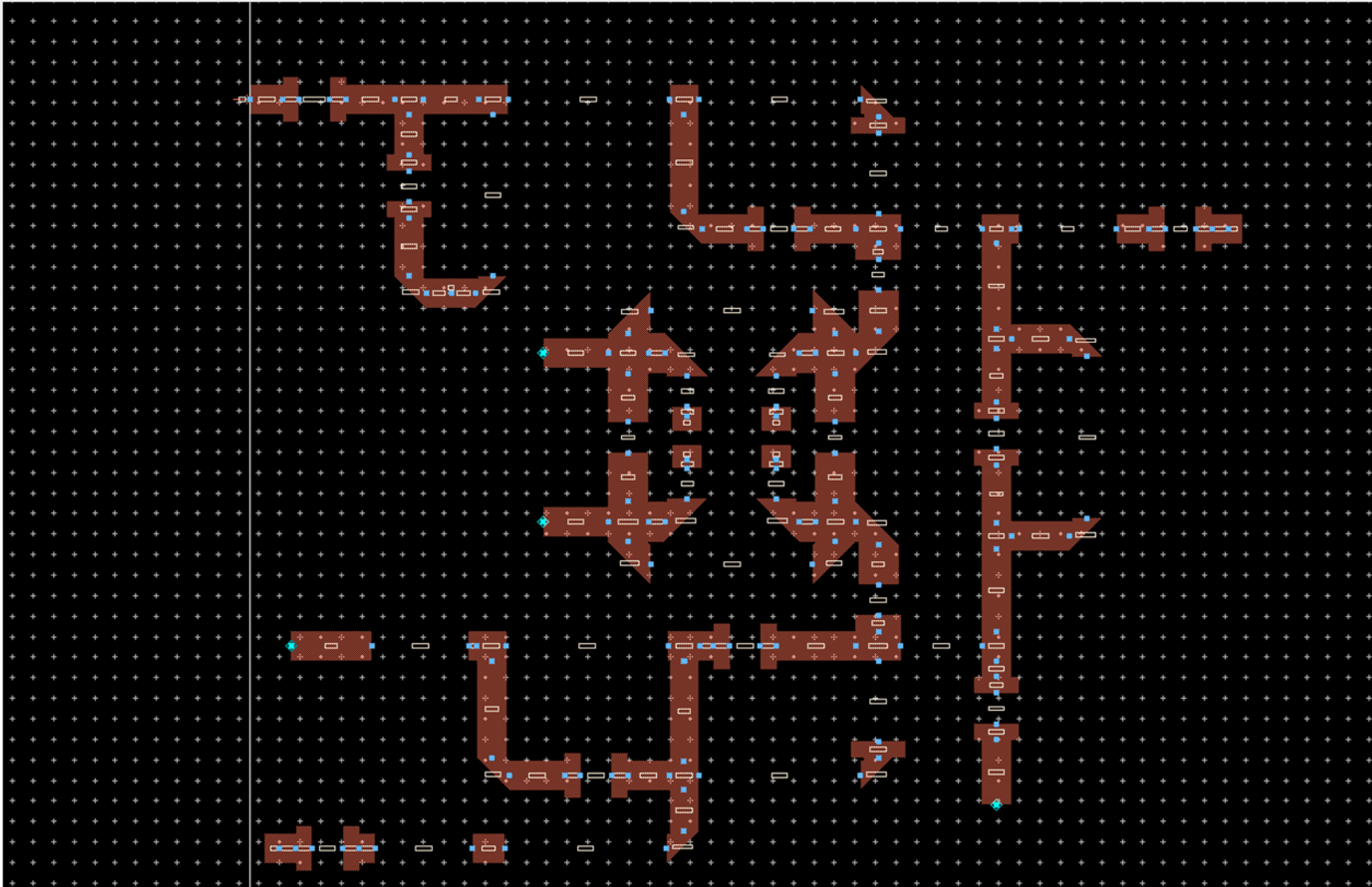
4. Layout & EM/Circuit Co-simulation

- stage 3 simulation result



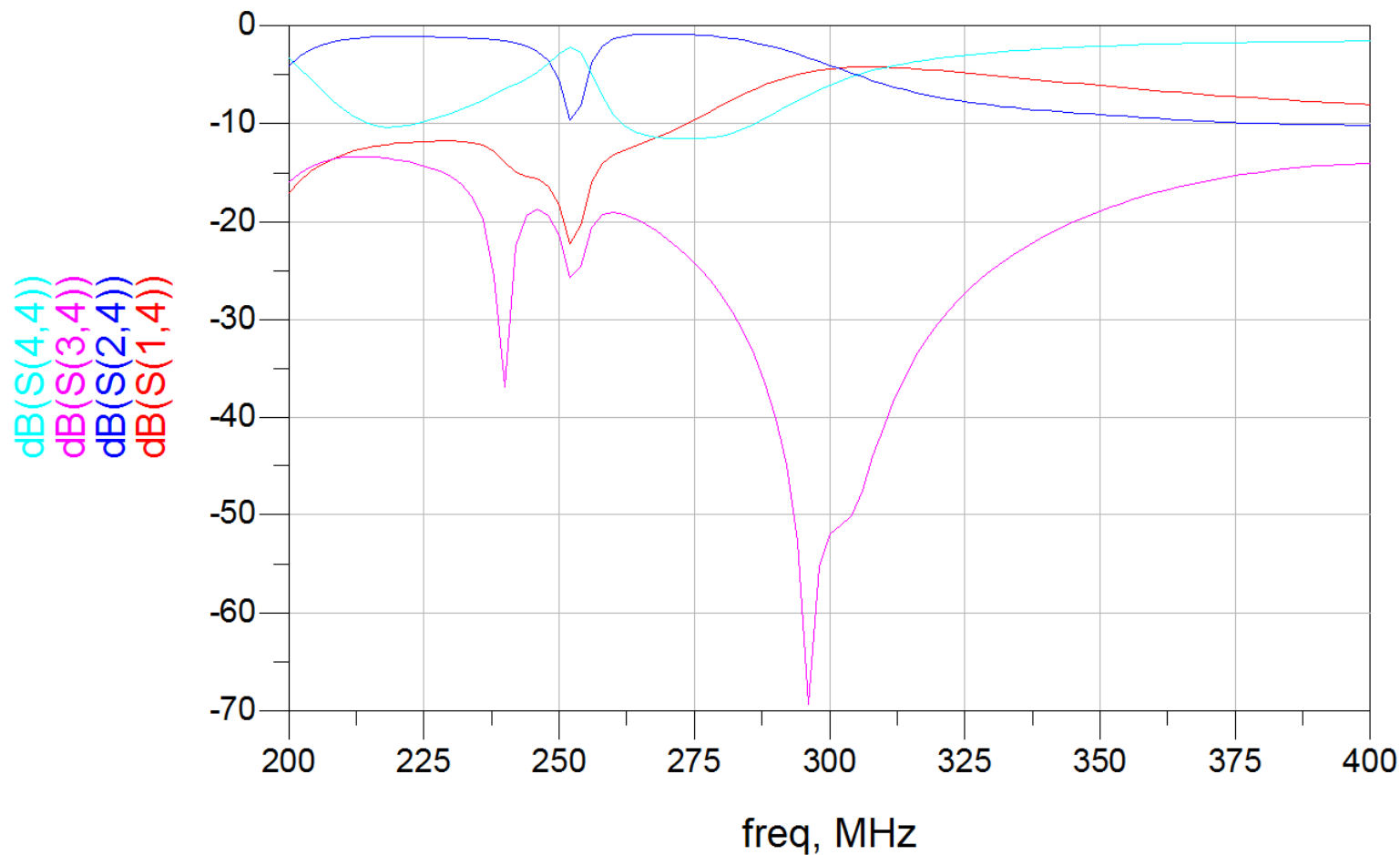
4. Layout & EM/Circuit Co-simulation

- Stage 4 (final vision)



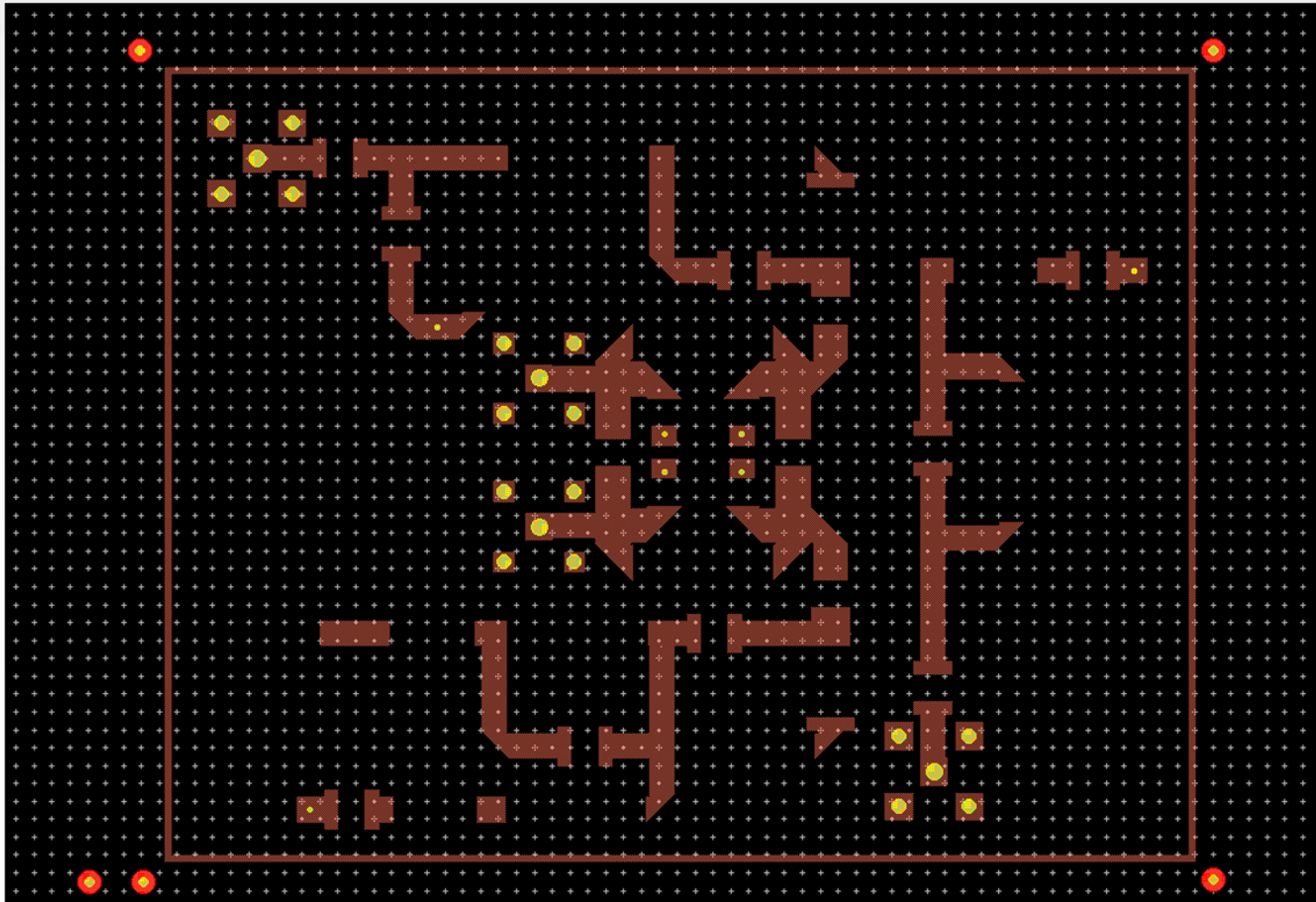
4. Layout & EM/Circuit Co-simulation

Simulation result



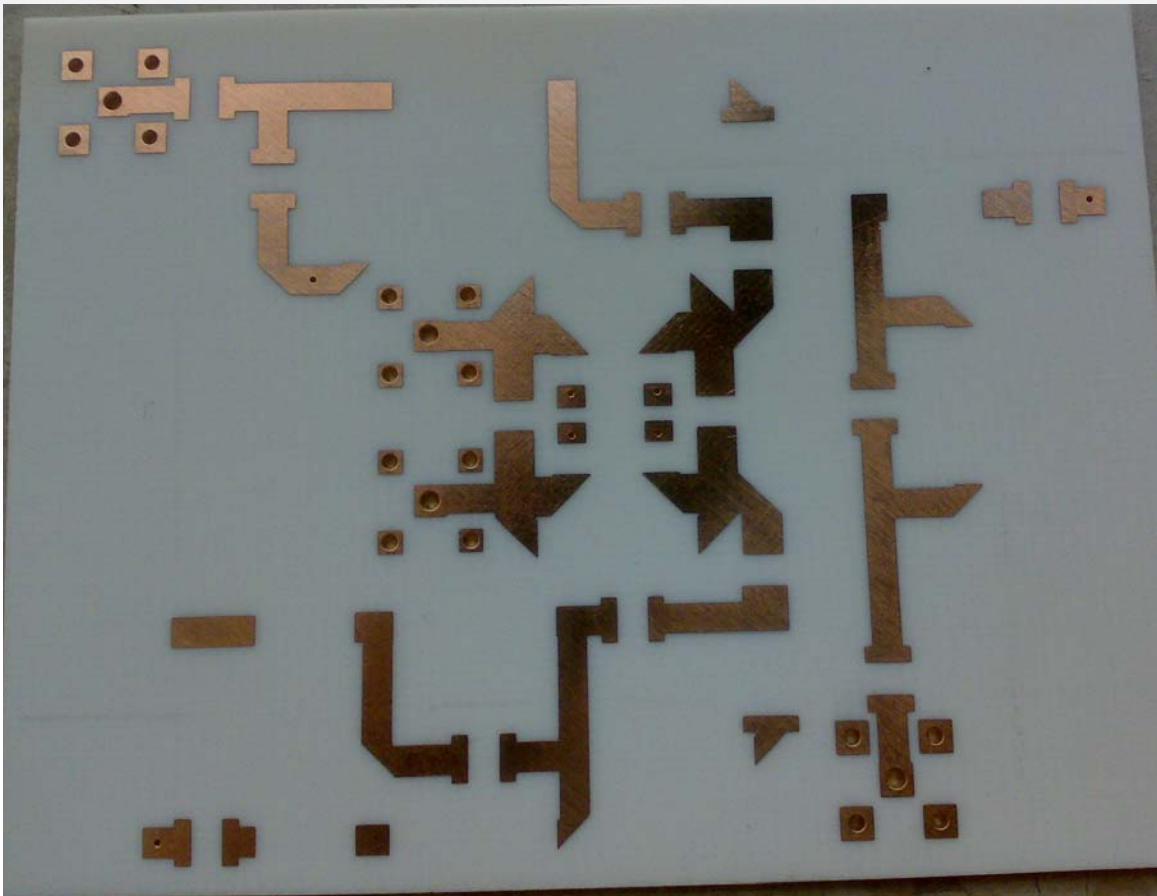
4. Layout & EM/Circuit Co-simulation

- Give the data files(Geber) to the workshop



4. Layout & EM/Circuit Co-simulation

- Get the PCB



5.Soldering

- No experience
- Before soldering , we did a soldering workshop course.



5.Soldering

- build Inductor by hand and use the inductor meter to correct the value of the inductor



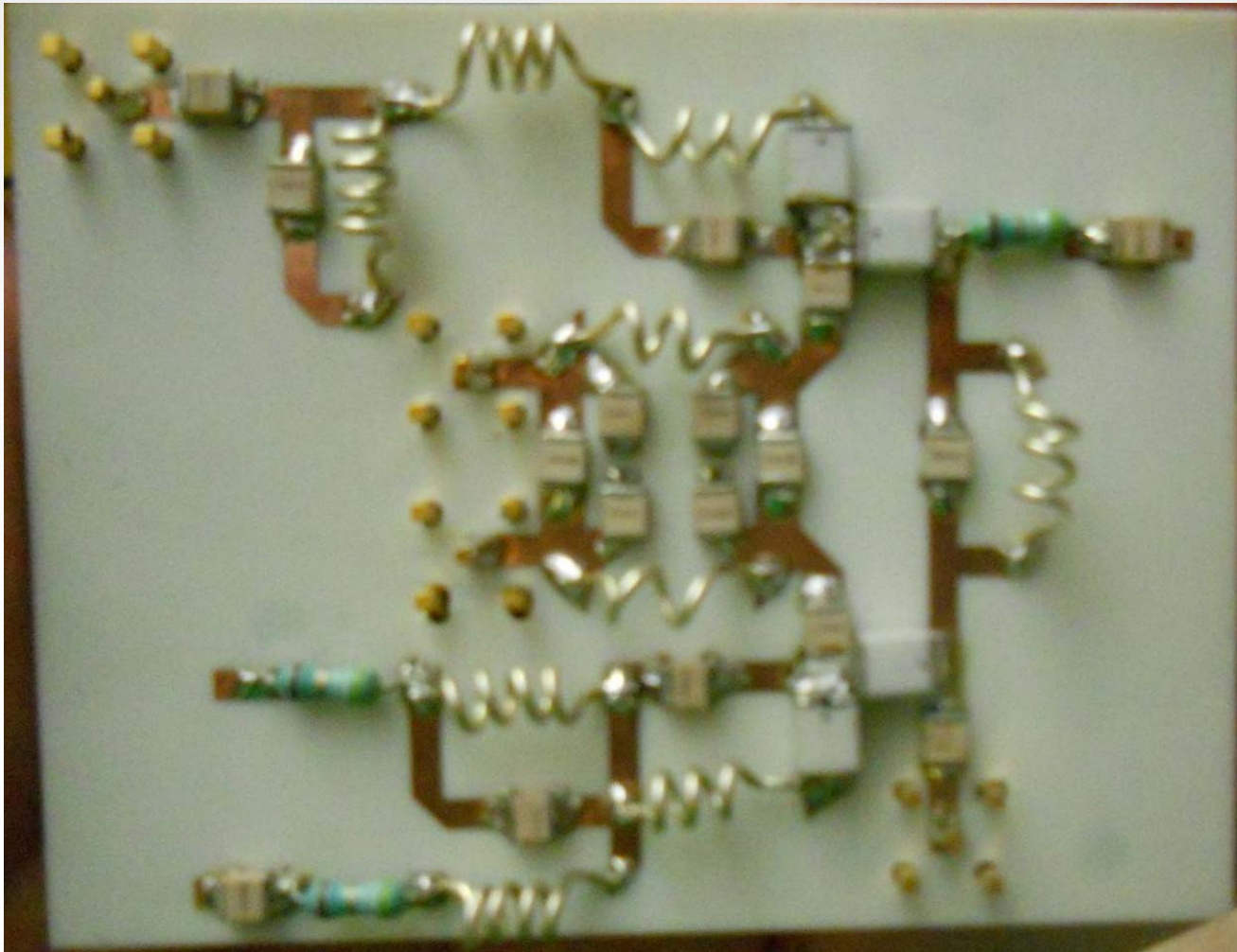
5.Soldering

- hard working



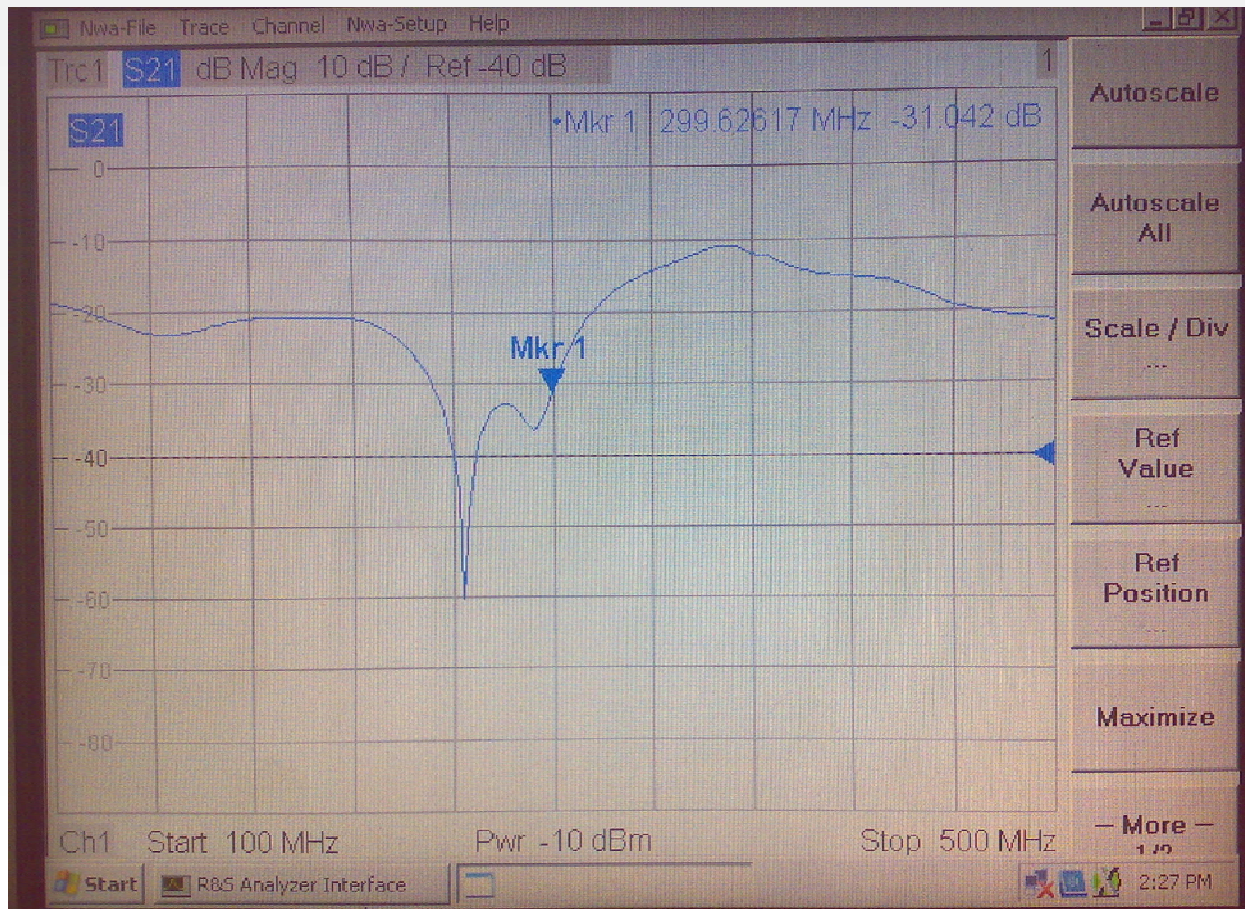
5.Soldering

PCB after soldering



6. Testing with Network Analyzer & Tuning

- Test with Network Analyzer
- 60MHz frequency shift

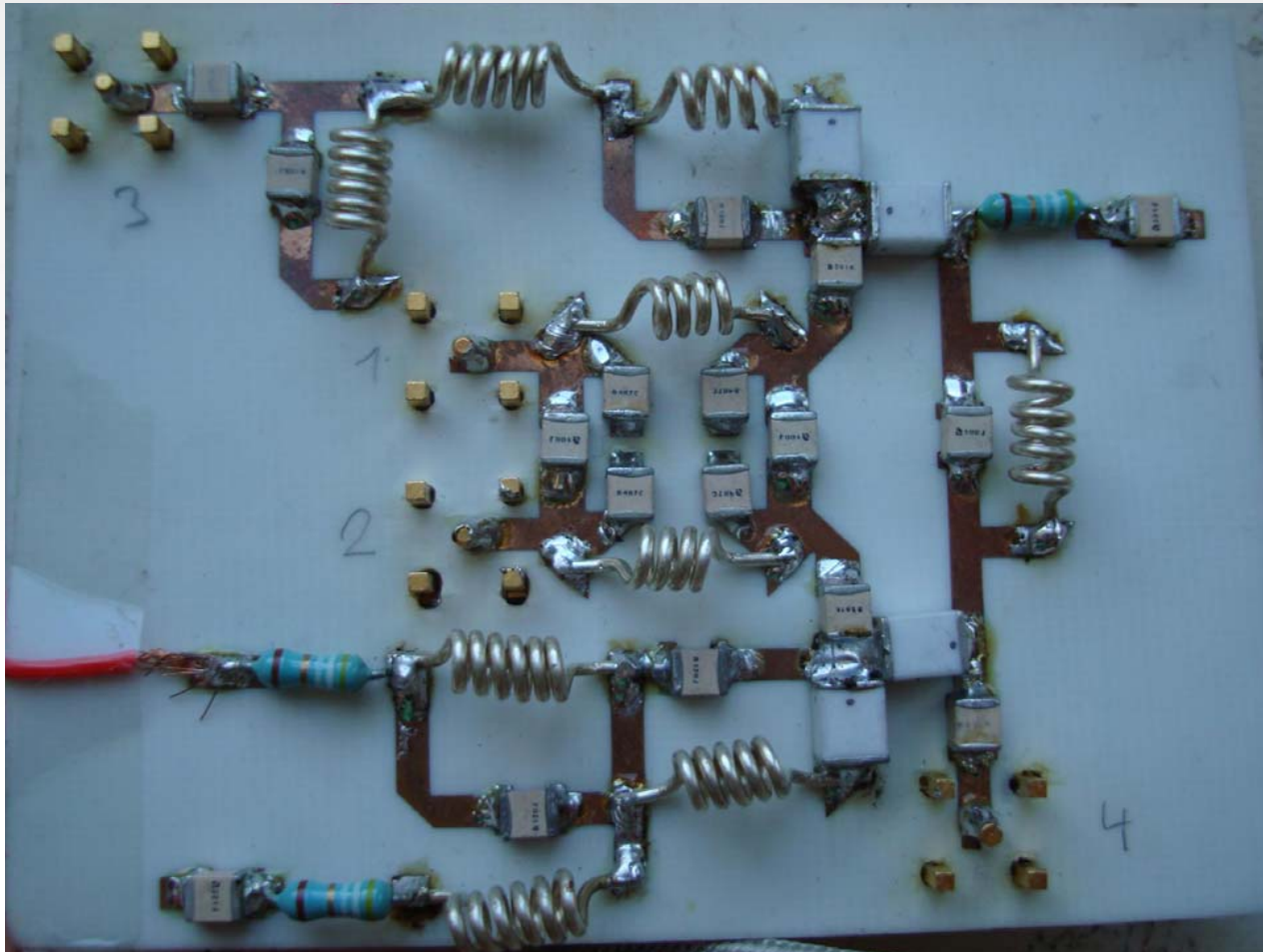


6. Testing with Network Analyzer & Tuning

- Do a EM/circuit co-simulation in ADS again.
- all the inductors are smaller than what we need.
- Rebuild the inductor.
- Desolder the old inductors and solder the new inductors.

6. Testing with Network Analyzer & Tuning

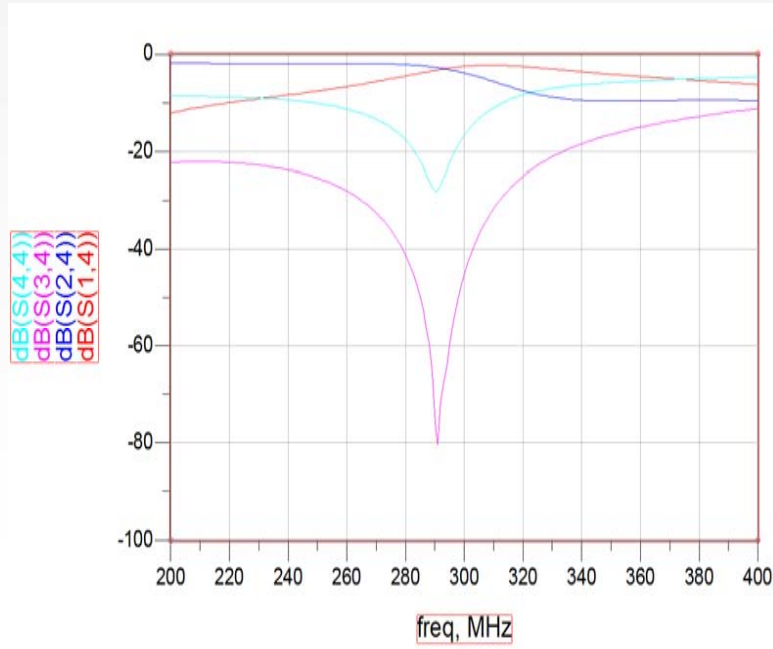
- Finally finished PCB is following



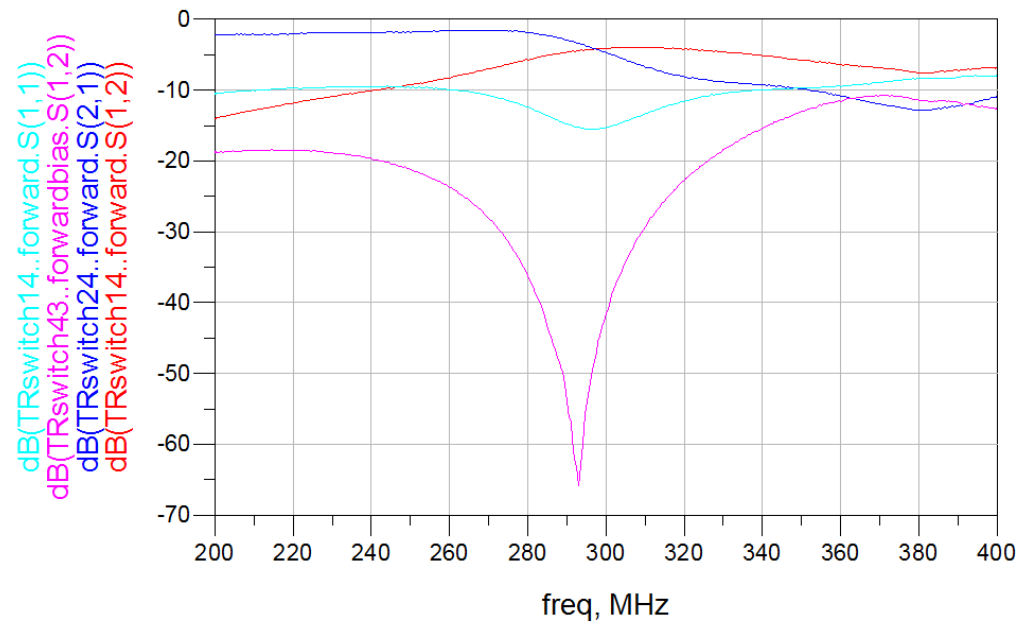
6. Testing with Network Analyzer & Tuning

- transmit:amplitude

ideal circuit simulation

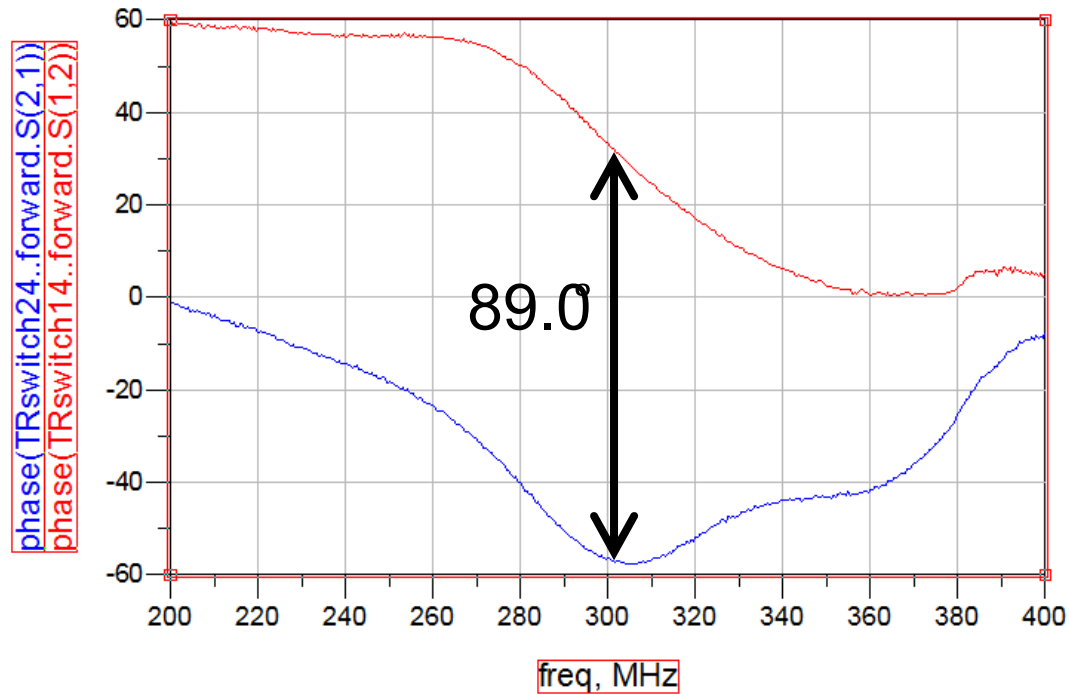


test result



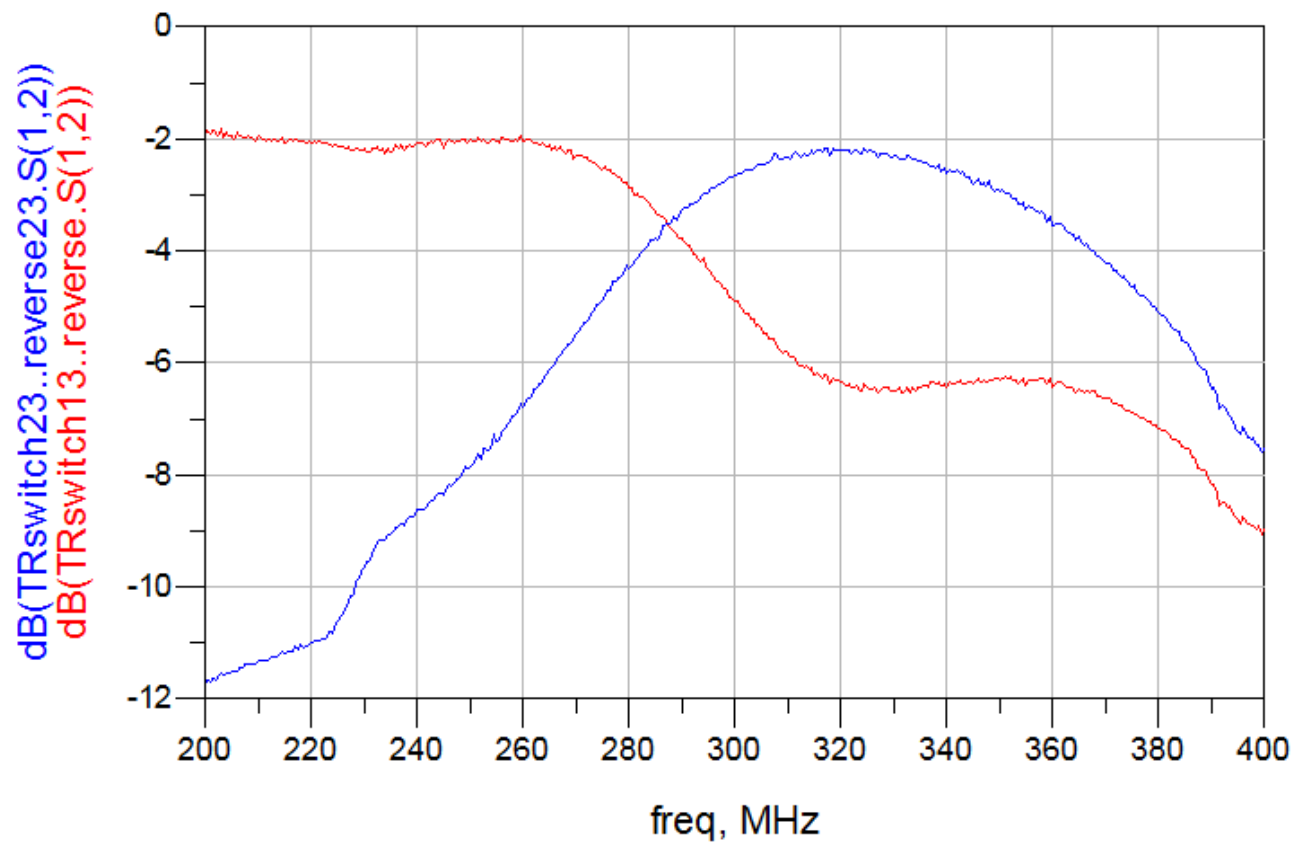
6. Testing with Network Analyzer & Tuning

- transmit:phase



6. Testing with Network Analyzer & Tuning

- receive



Thank you very much!

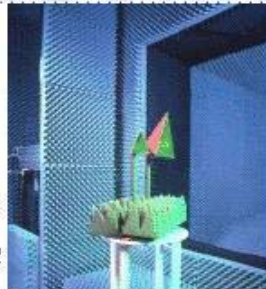
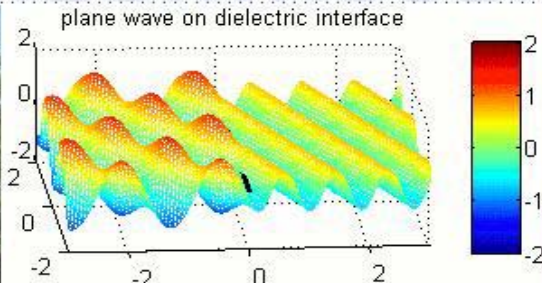
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M.Sc. Saeed Arafat

Dipl.-Ing. Adam Buck

Herr Rolf Küppers

HOCHFREQUENZTECHNIK



Thanks for your watching!

Yipeng LIU

Yan CHENG