# Doubler/Amplifier Building Block for CW-Radar

By:

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# Outline

- Motivation
- Introduction
- Frequency Doubler
- Amplifier 24GHz
- Measurement Results
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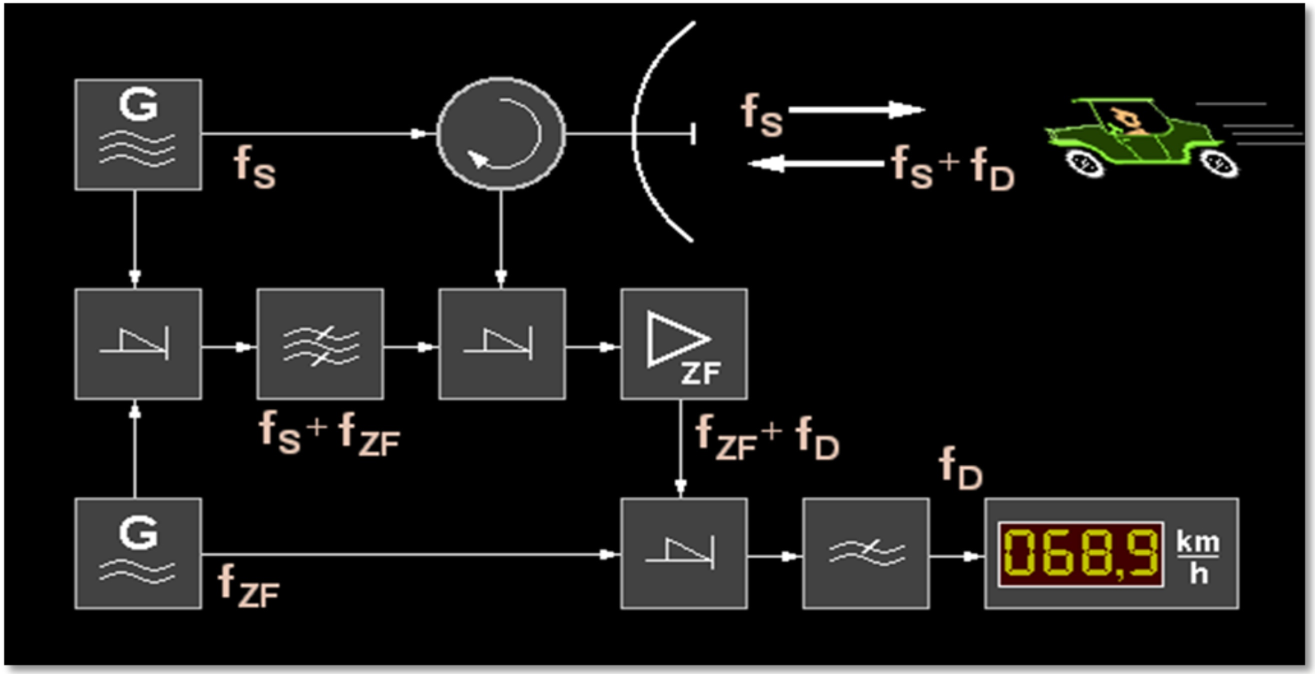
# Motivation

## Continuous-Wave (CW) Radar

- Transmit a high-frequency signal continuously.
- CW-Radar systems are used for the measurement of velocity of ,e.g., cars on the street or objects.
- They have no minimum or maximum range and maximize power on a target because they are always broadcasting.

• CW-Radar measures the Doppler-frequency of the microwave radiation.

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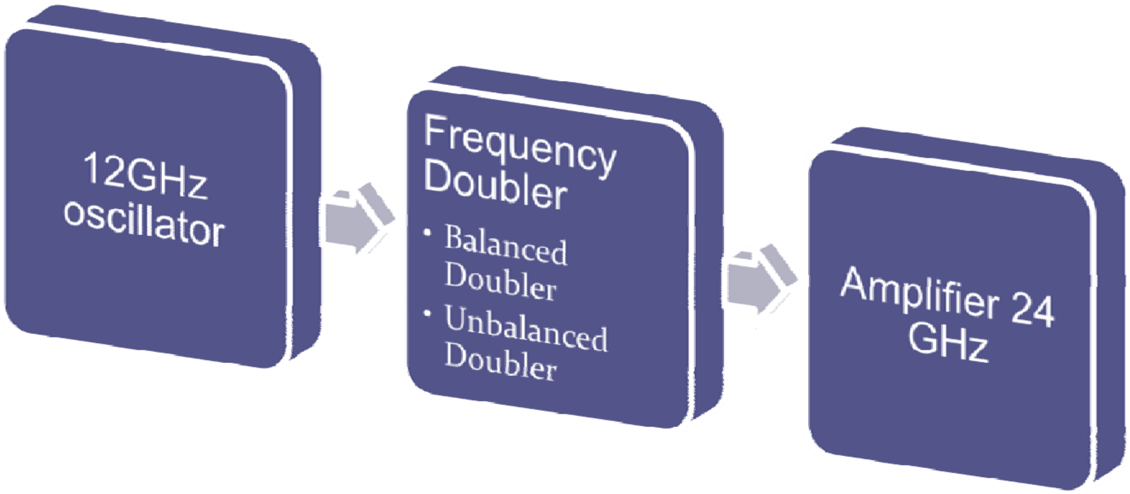
• One part of the radar system



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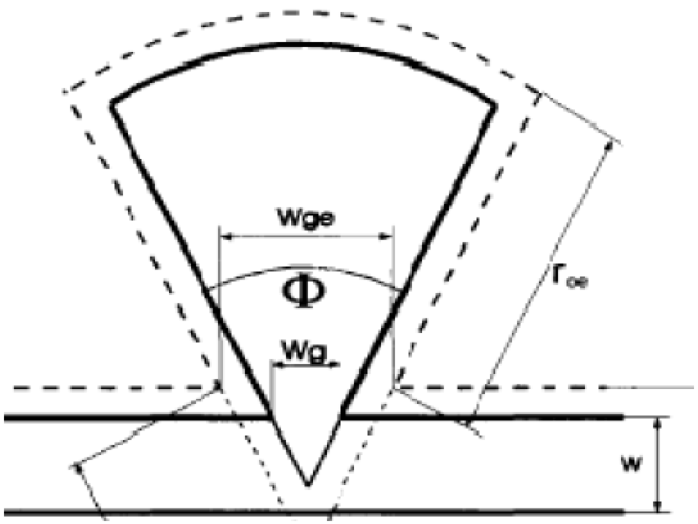
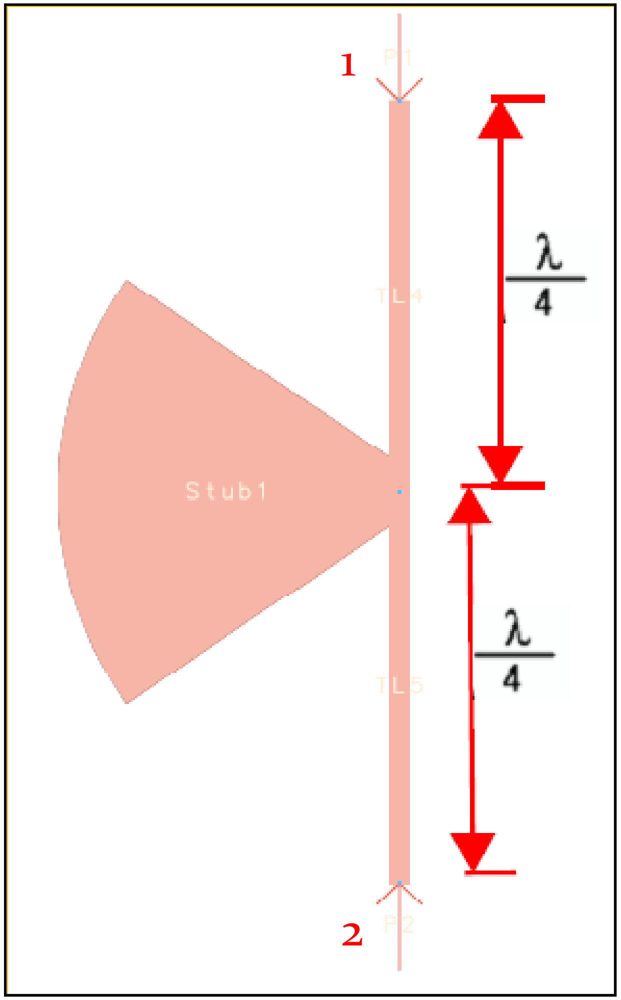
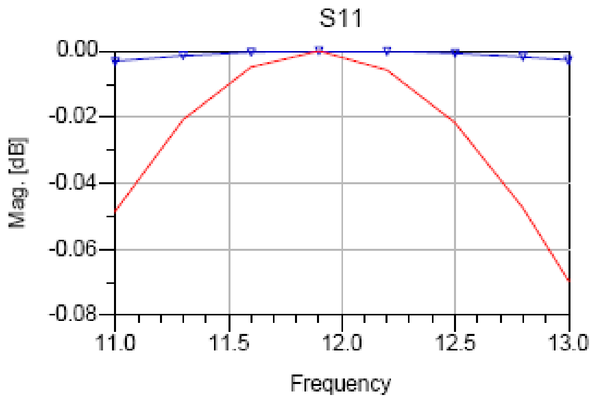
# Microstrip Radial Stub (RS)

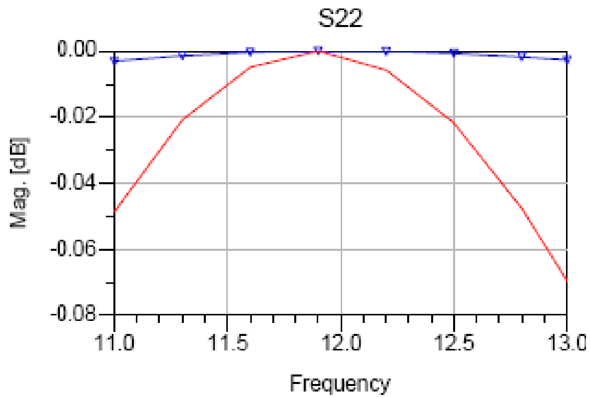
Many microstrip circuits, such as low-pass filters, mixers, etc. often require the use of Radial Stubs.

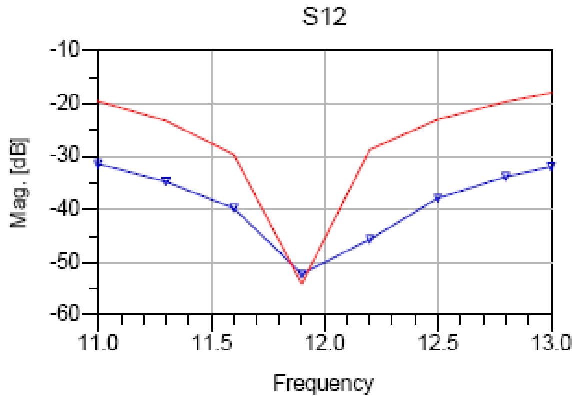


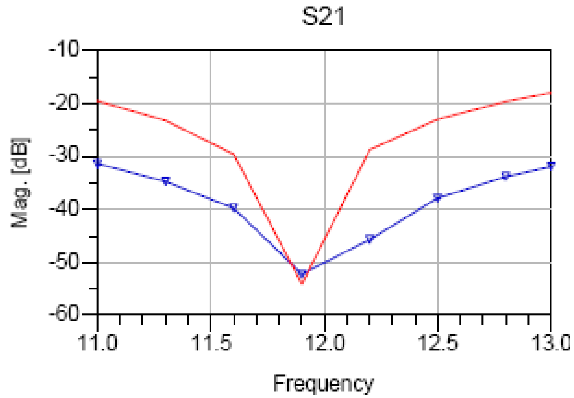



# Radial Stub Simulation by ADS

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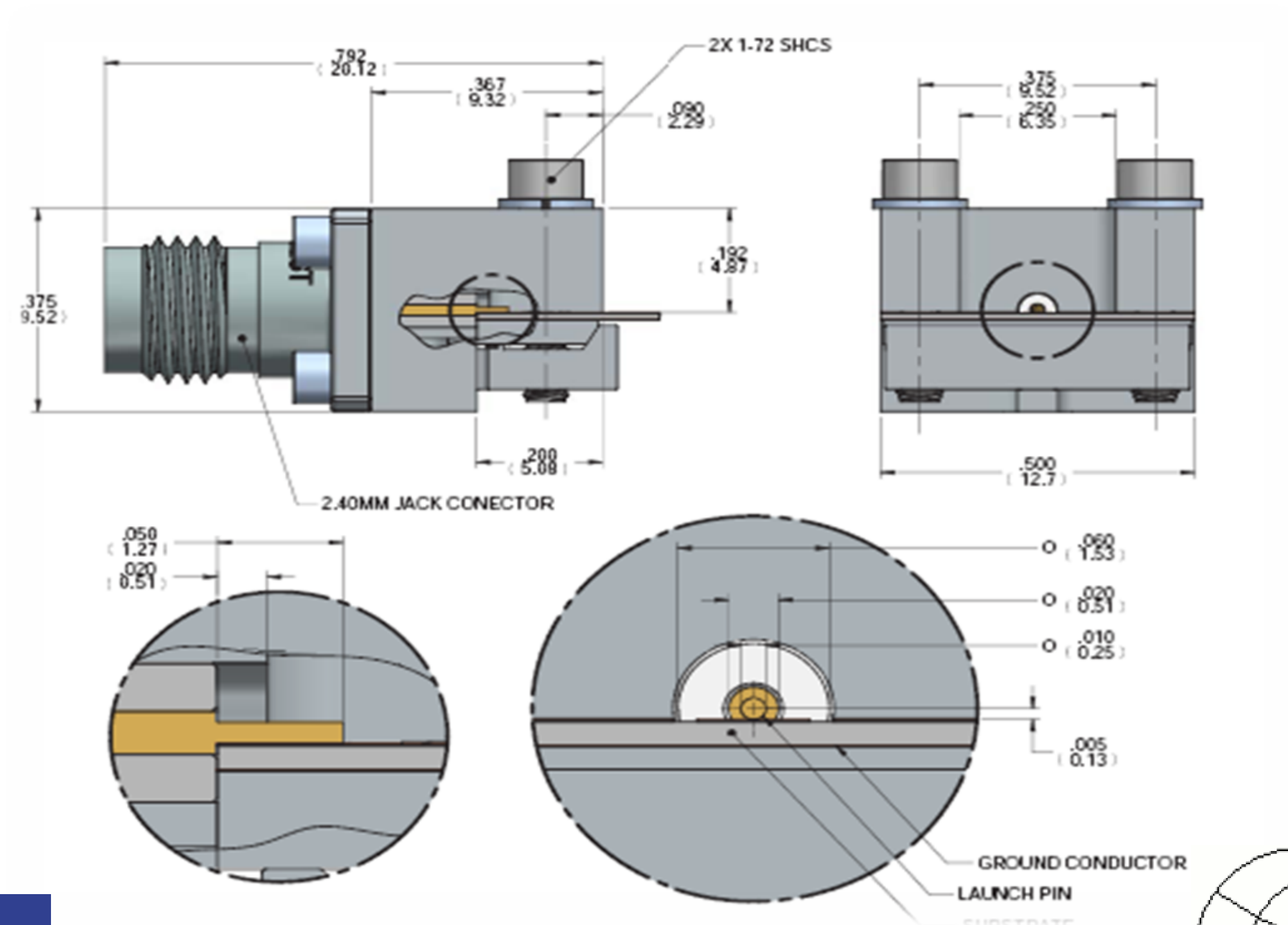
# Connectors

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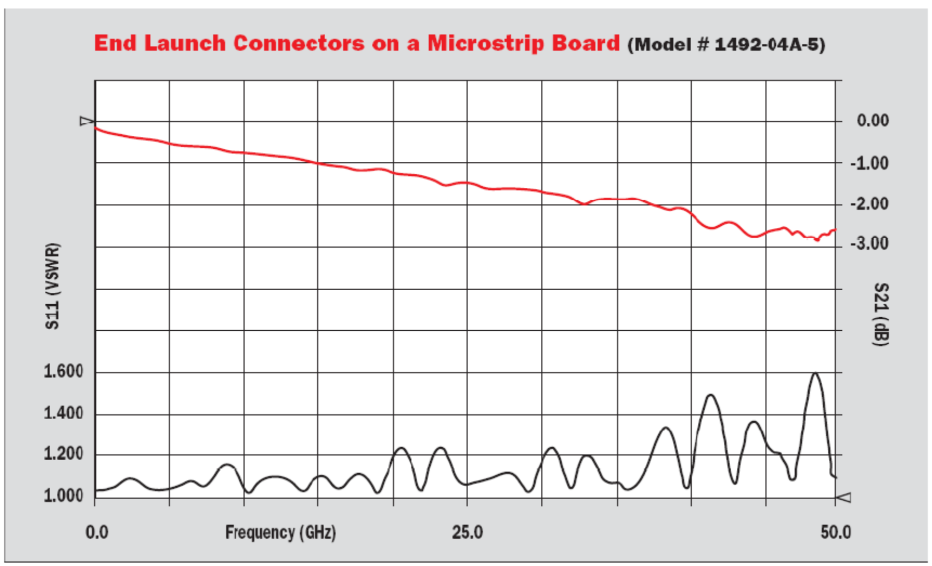
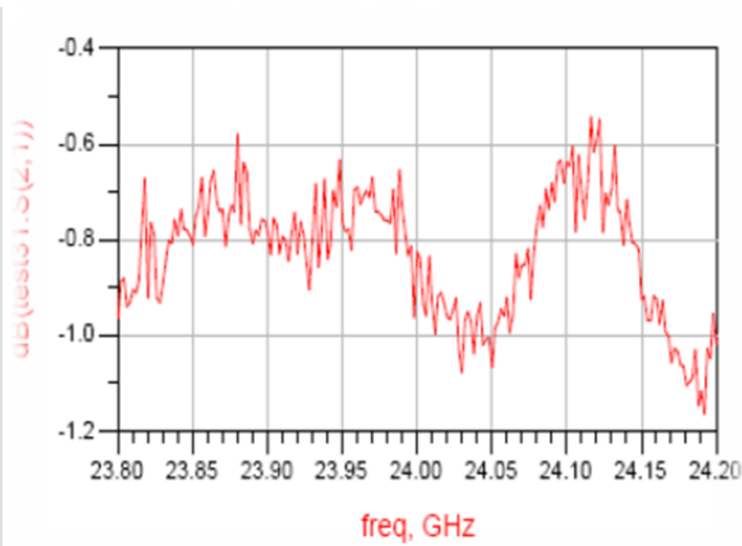
# Testing Super SMA (27GHz)



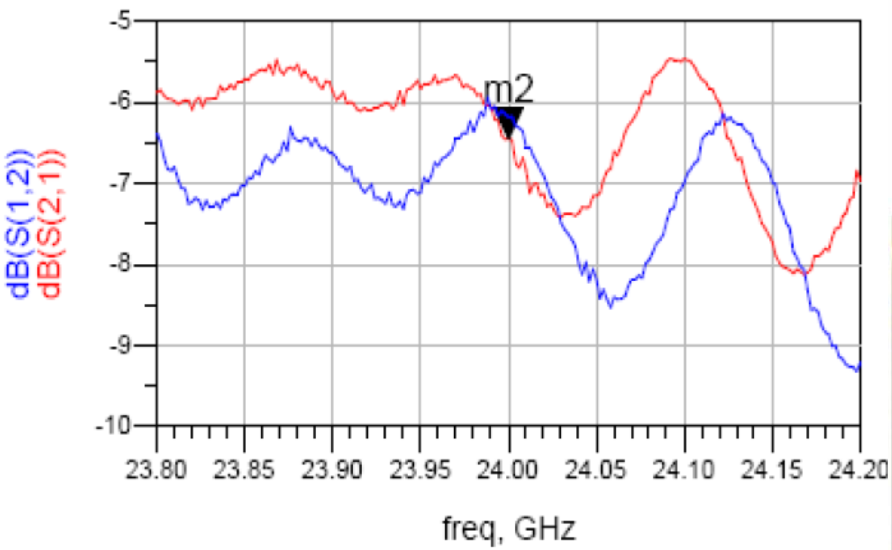

Model 2.4 mm connector (50GHz)

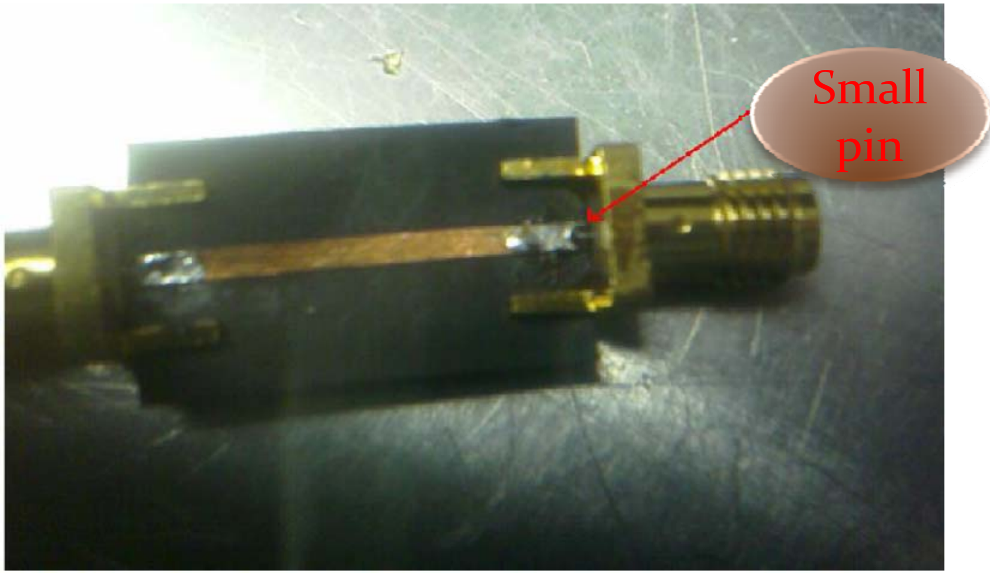



Duroid RT5870 ,H=0.5,ε = 2.33

# Sub-Miniature Version A Connectors(SMA)

- SMA connectors are manufactured to have excellent performance up to 18 GHz, from Stainless Steel Construction.



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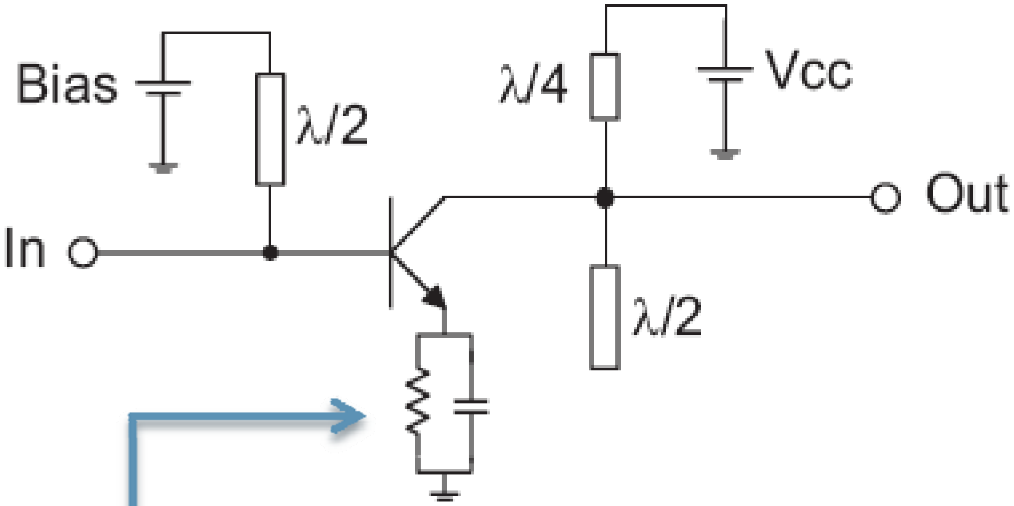
# Frequency Doubler

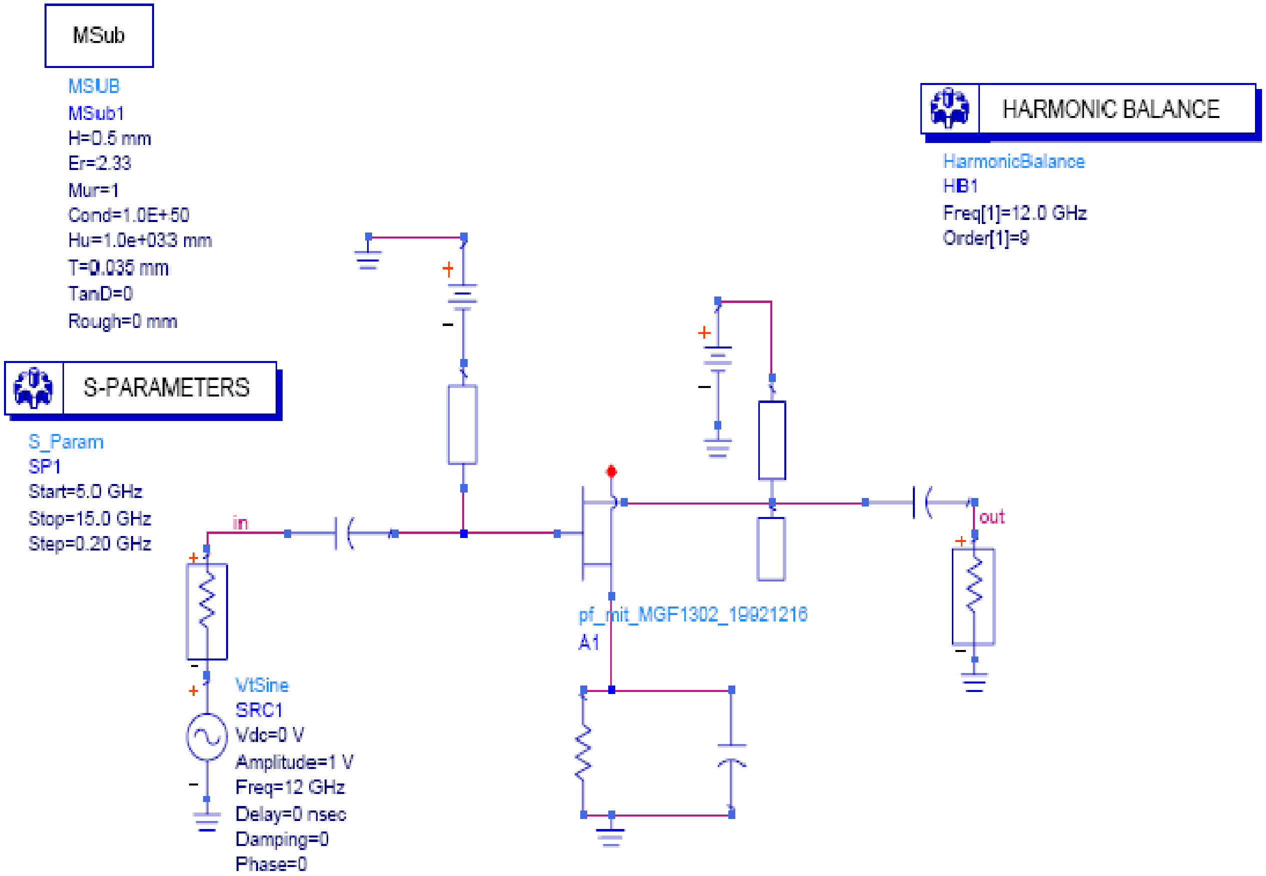
- Unbalanced Doubler



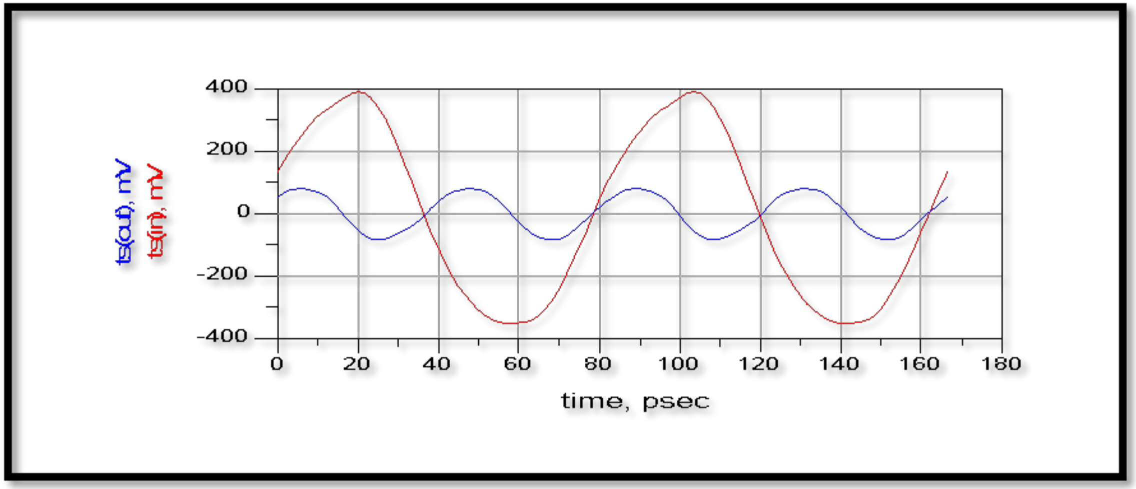

λ for 24 GHz

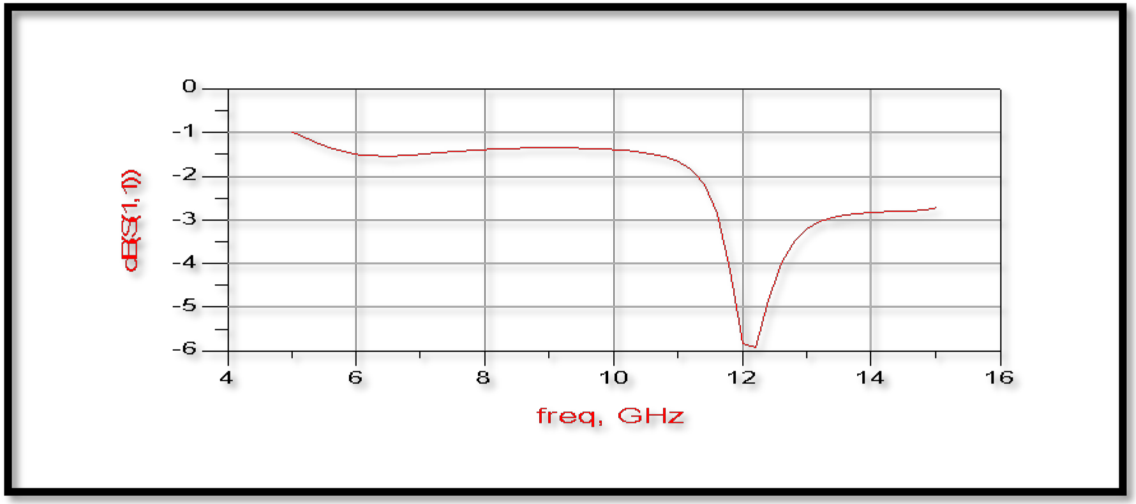
to make the operating point less sensitive to technology variations

# Designing in the ADS



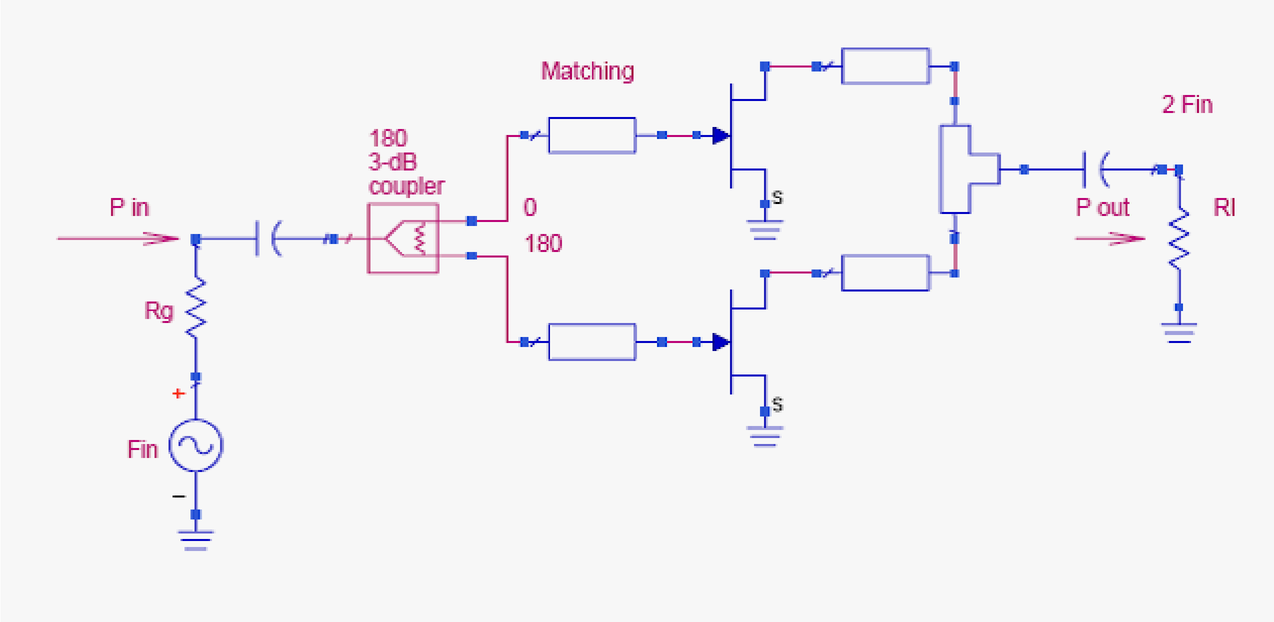
# Input and the Output in the Harmonic Balance



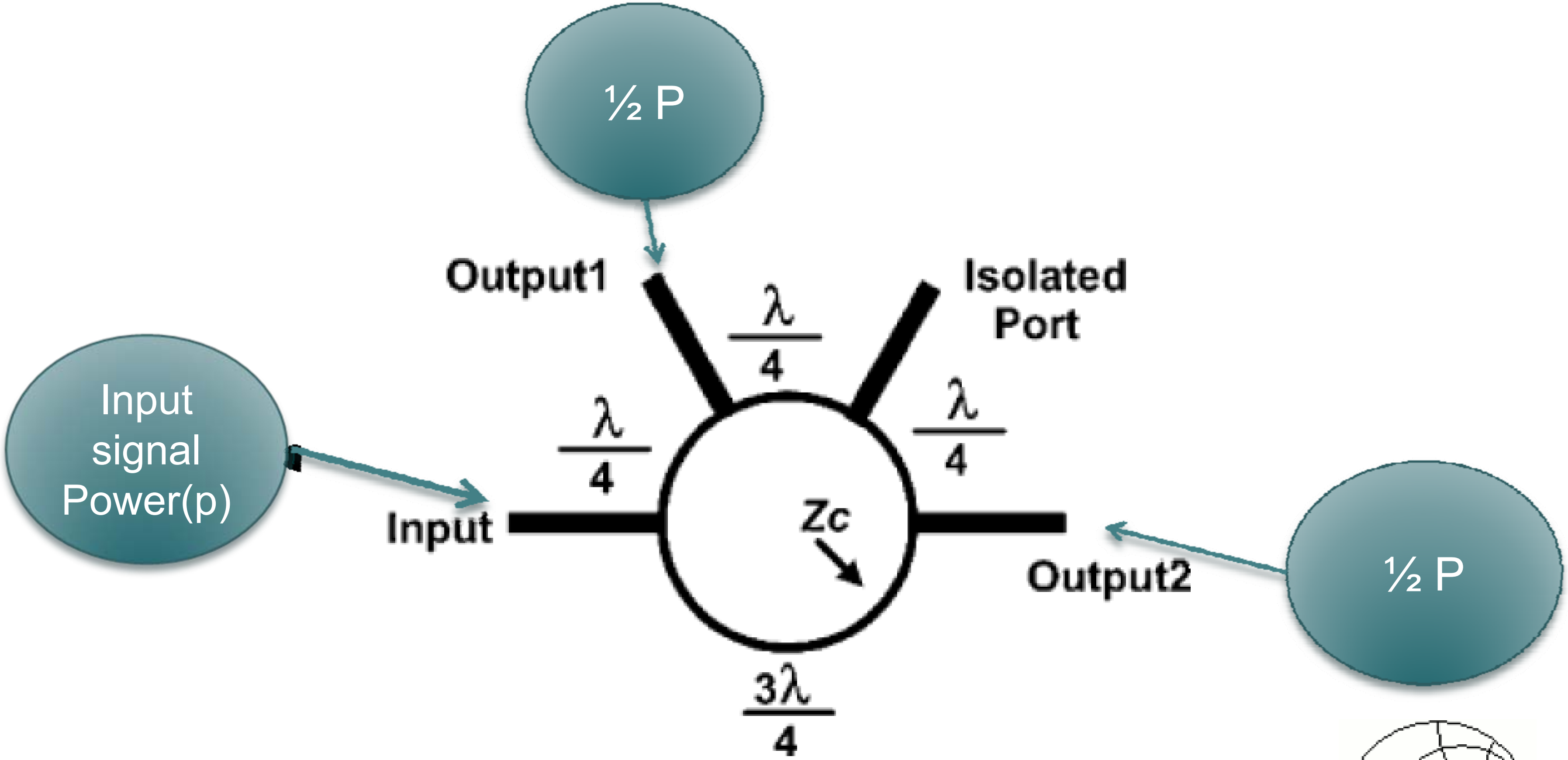



- # Balanced Doubler

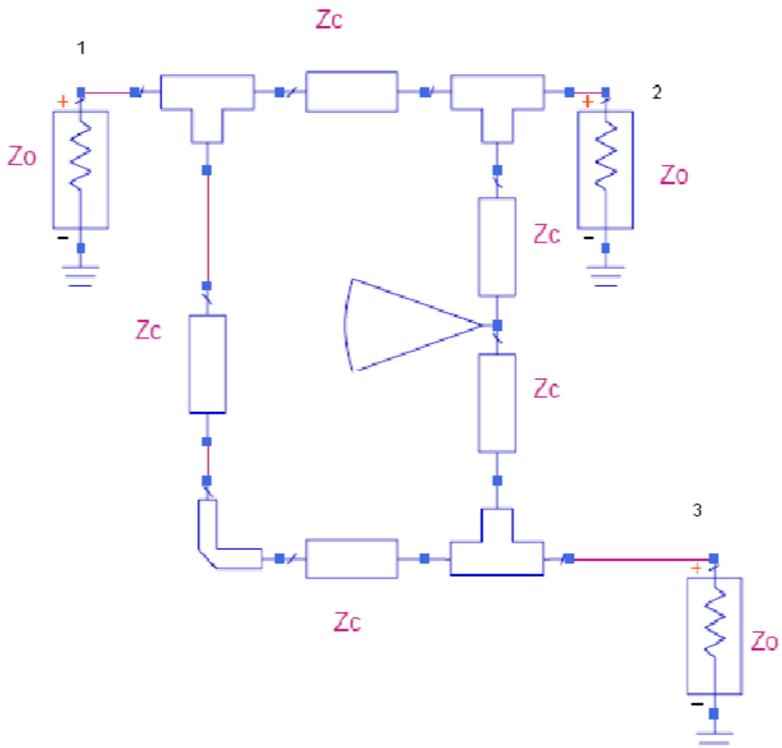
The balanced doubler is especially attractive due to the high conversion efficiency



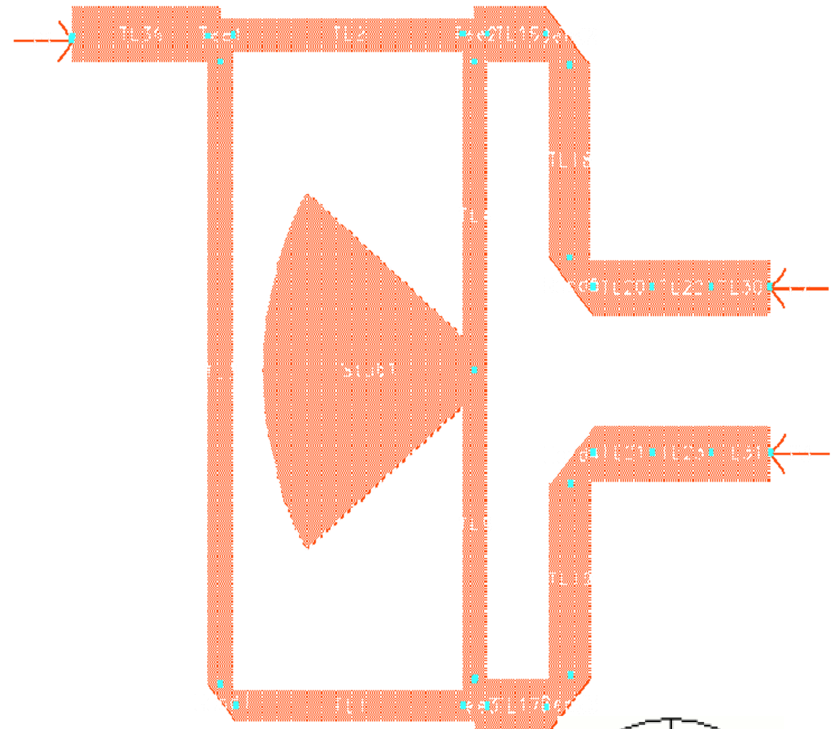
# The 180  3-dB coupler rat-race hybrid ring



# Rat-Race Ring Coupler in ADS




Schematic



Layout

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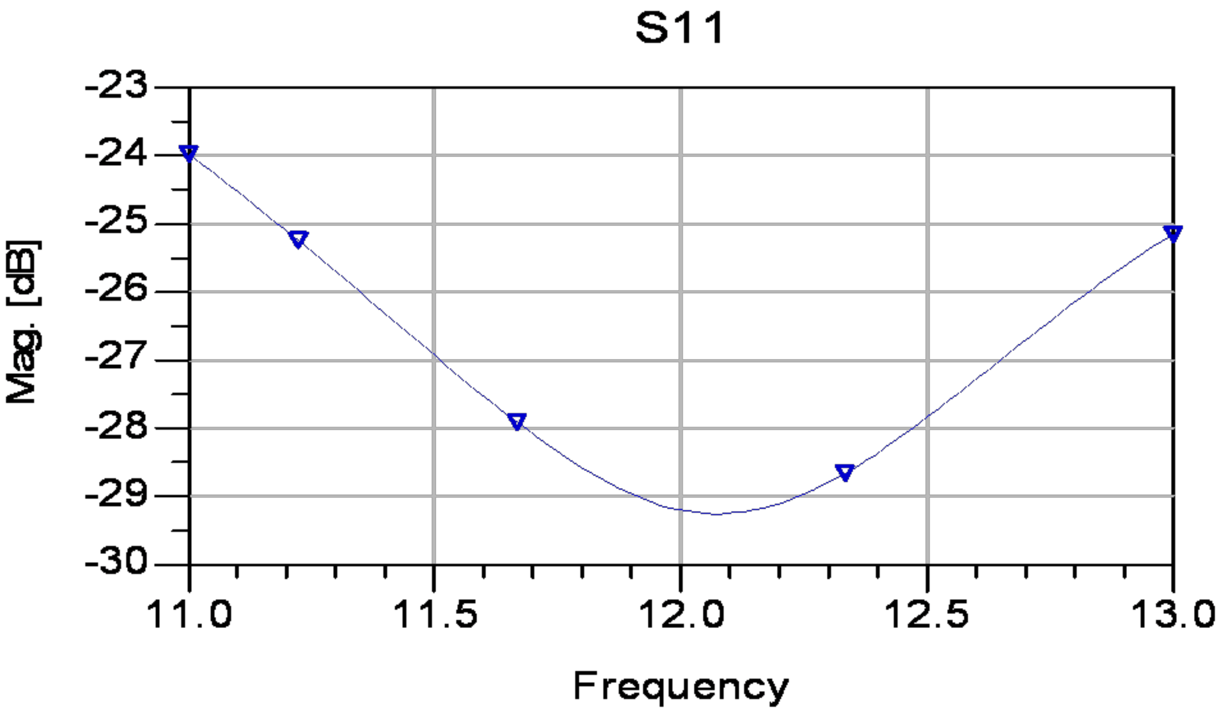
# S-Parameters




Power Divider =-3dB

12GHz


180 Degree between S21&S31

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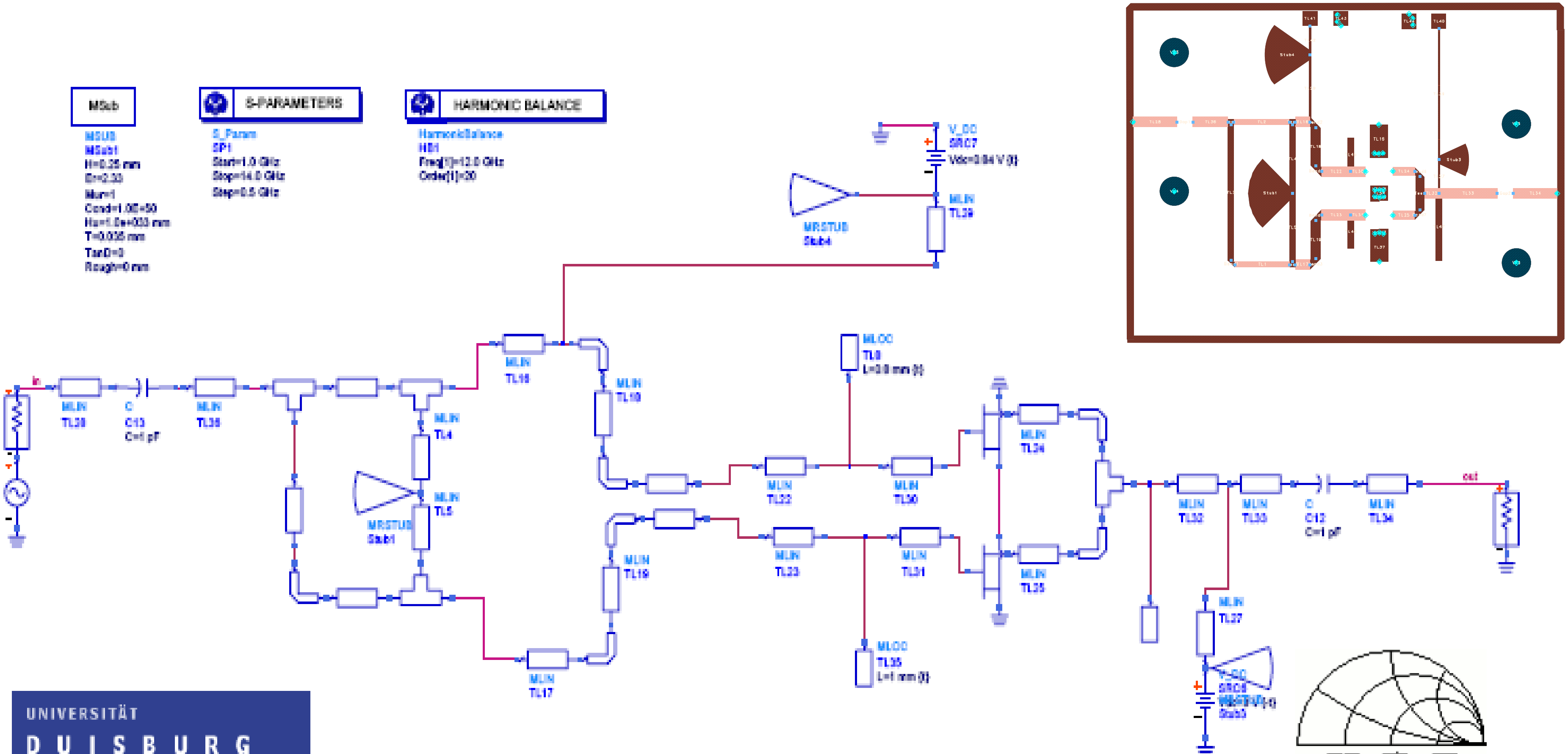
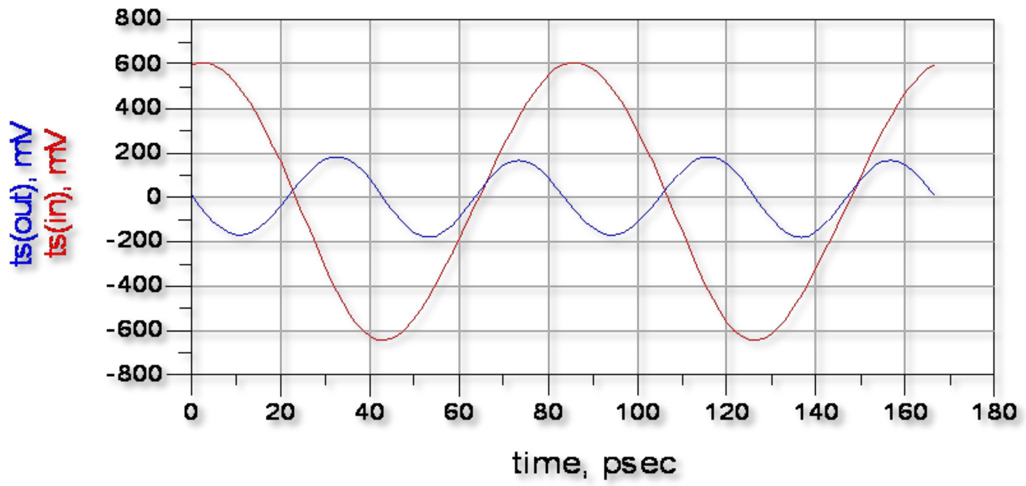
# Design and Simulation By ADS



# Harmonics Balance for Input and Output




Input =12 GHz
5.6 dBm
Output=24 GHz
-5.1 dBm

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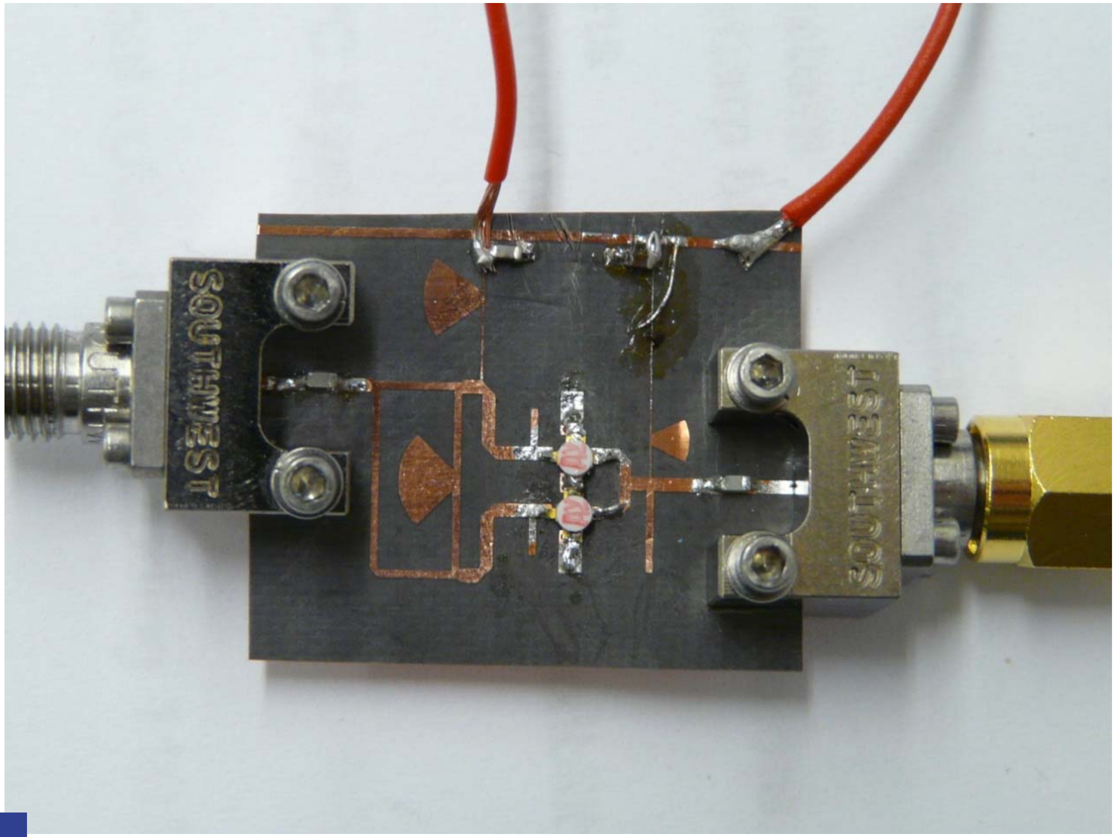
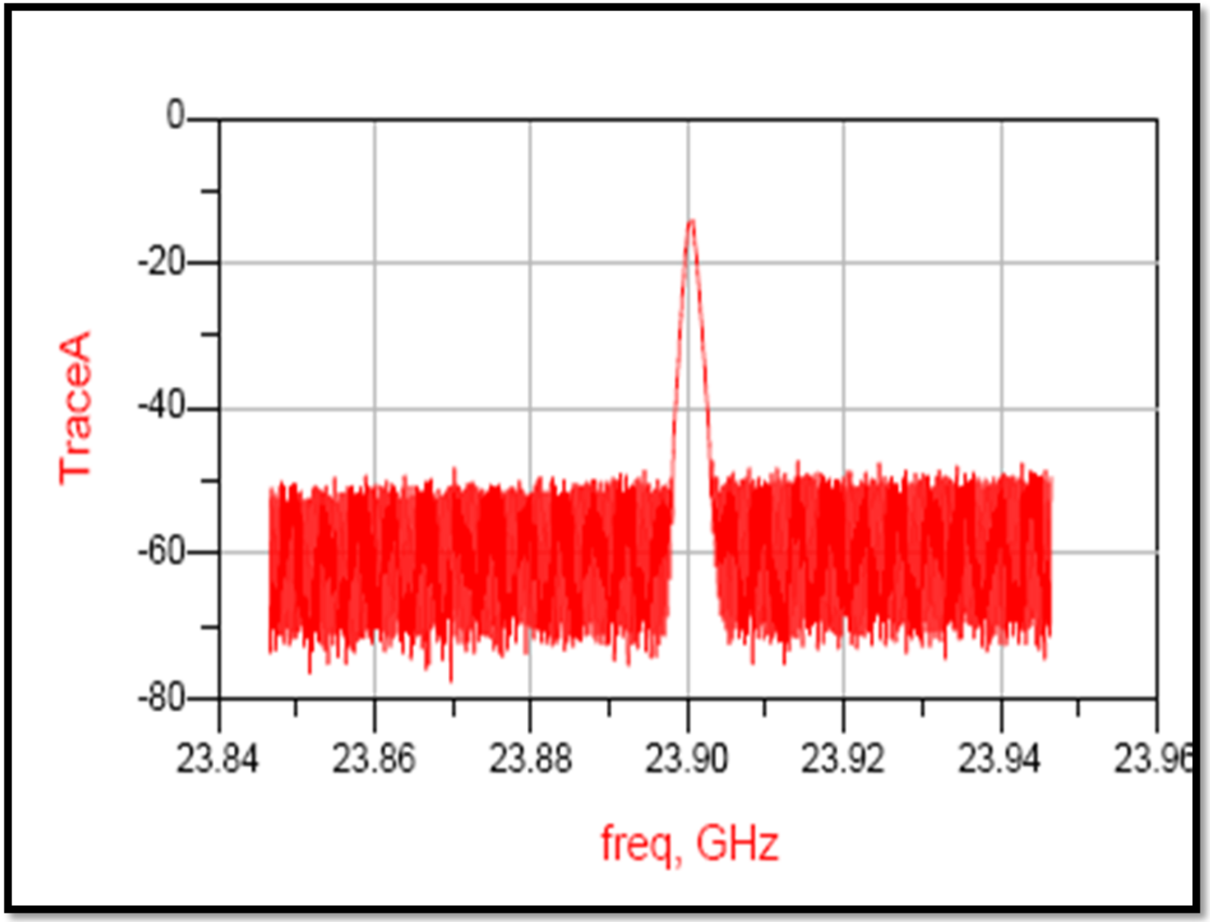
# The Fabrication and Measurement

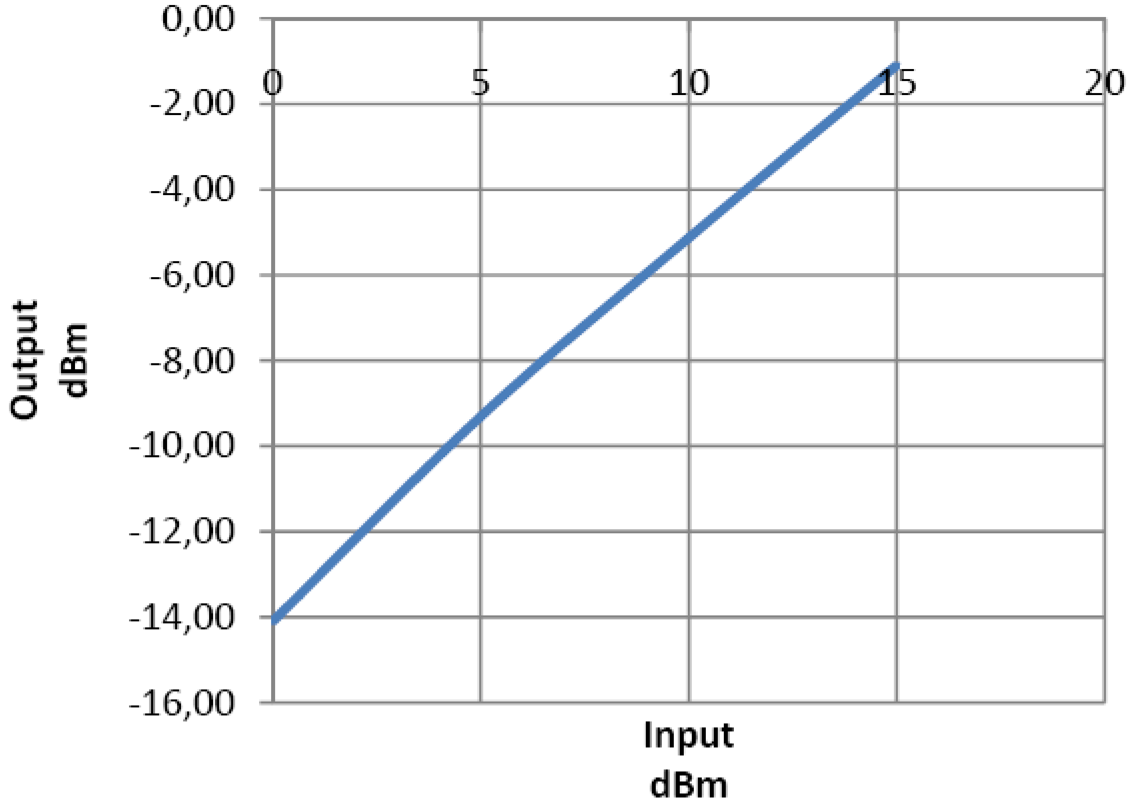


# Spectrum Output for the Frequency Doubler

For
input(12GHz)
0dBm,
the
output(23.9GHz)
-14dBm



# Measured output power versus input power

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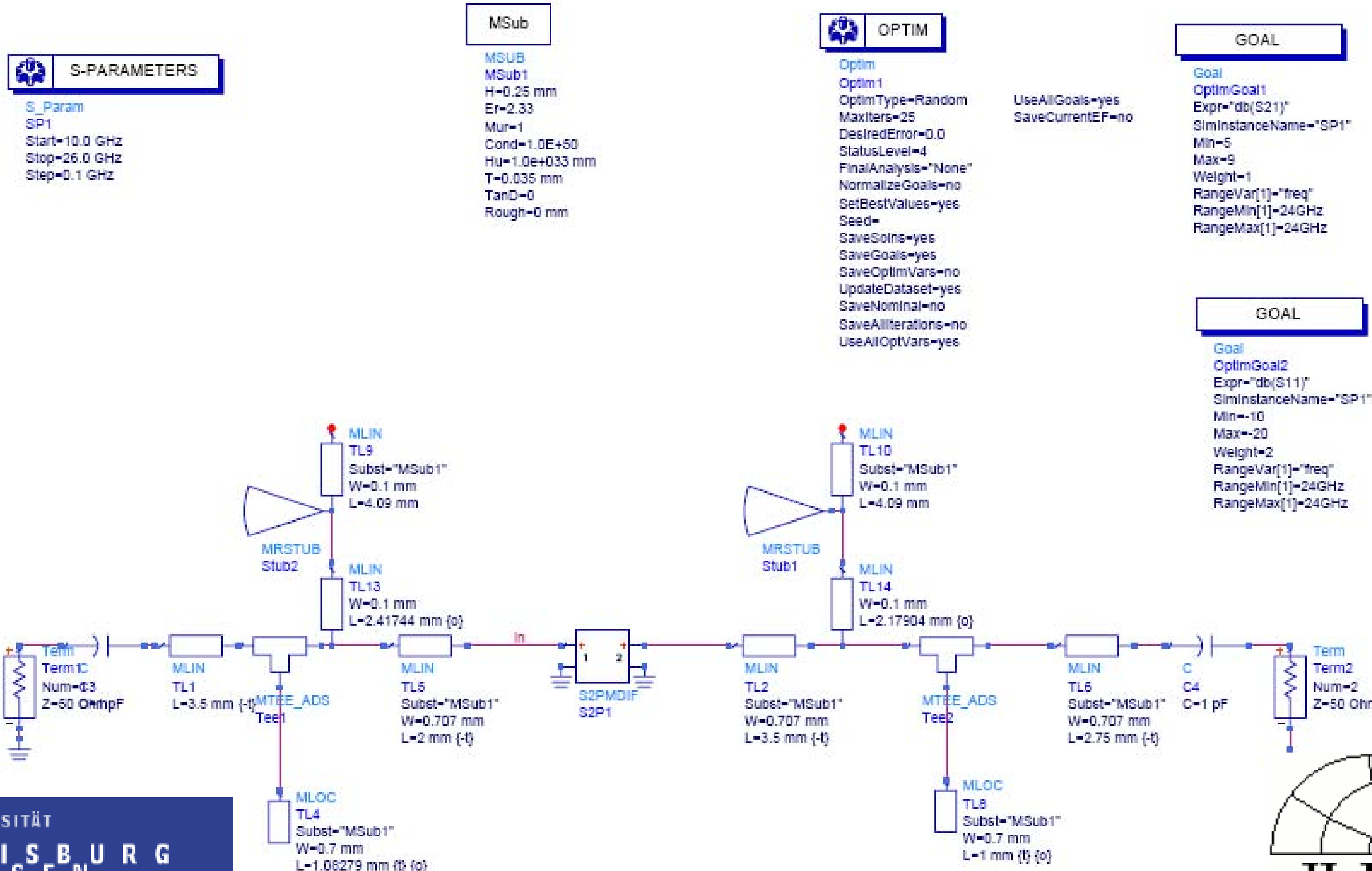
# Amplifier 24 GHz

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# The steps for nominal optimization

- Running a simulation.
- Comparing results with the goals (10dB>S21>5dB), (-10dB>S11>-20dB).
- Changing the circuit parameters to obtain results that are likely to be closer to the goal.
- Running a simulation again with the new parameter values.

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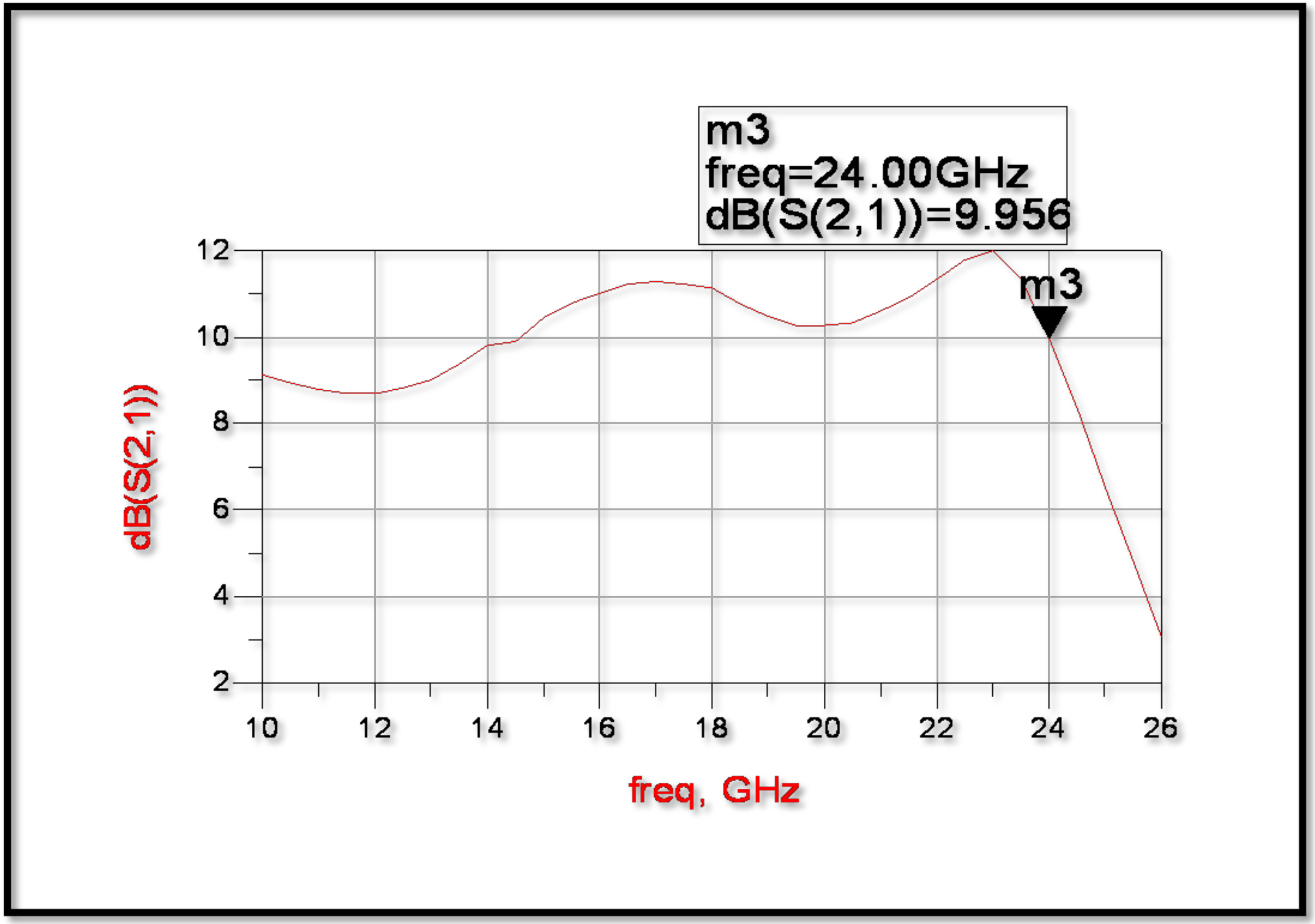
# Simulation By ADS

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# S11,S22


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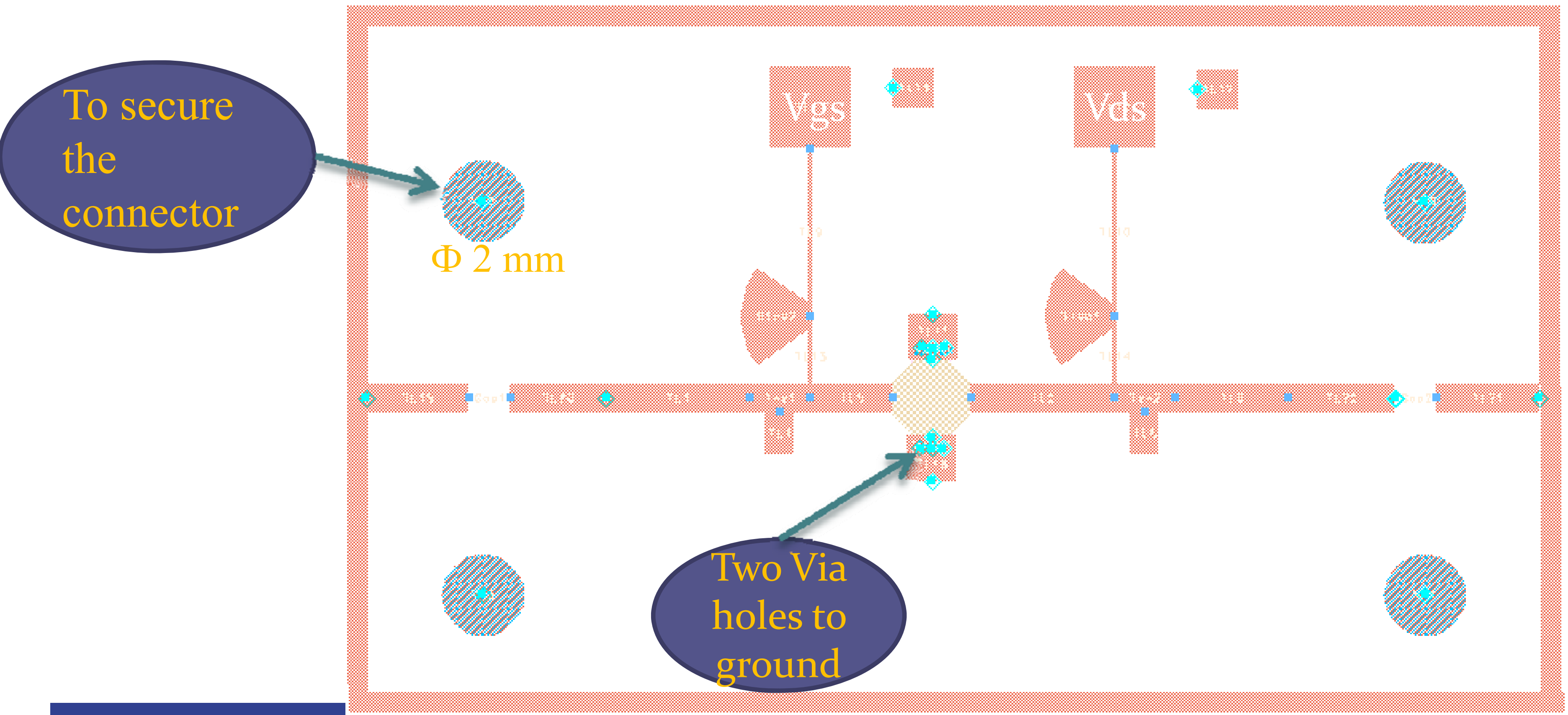
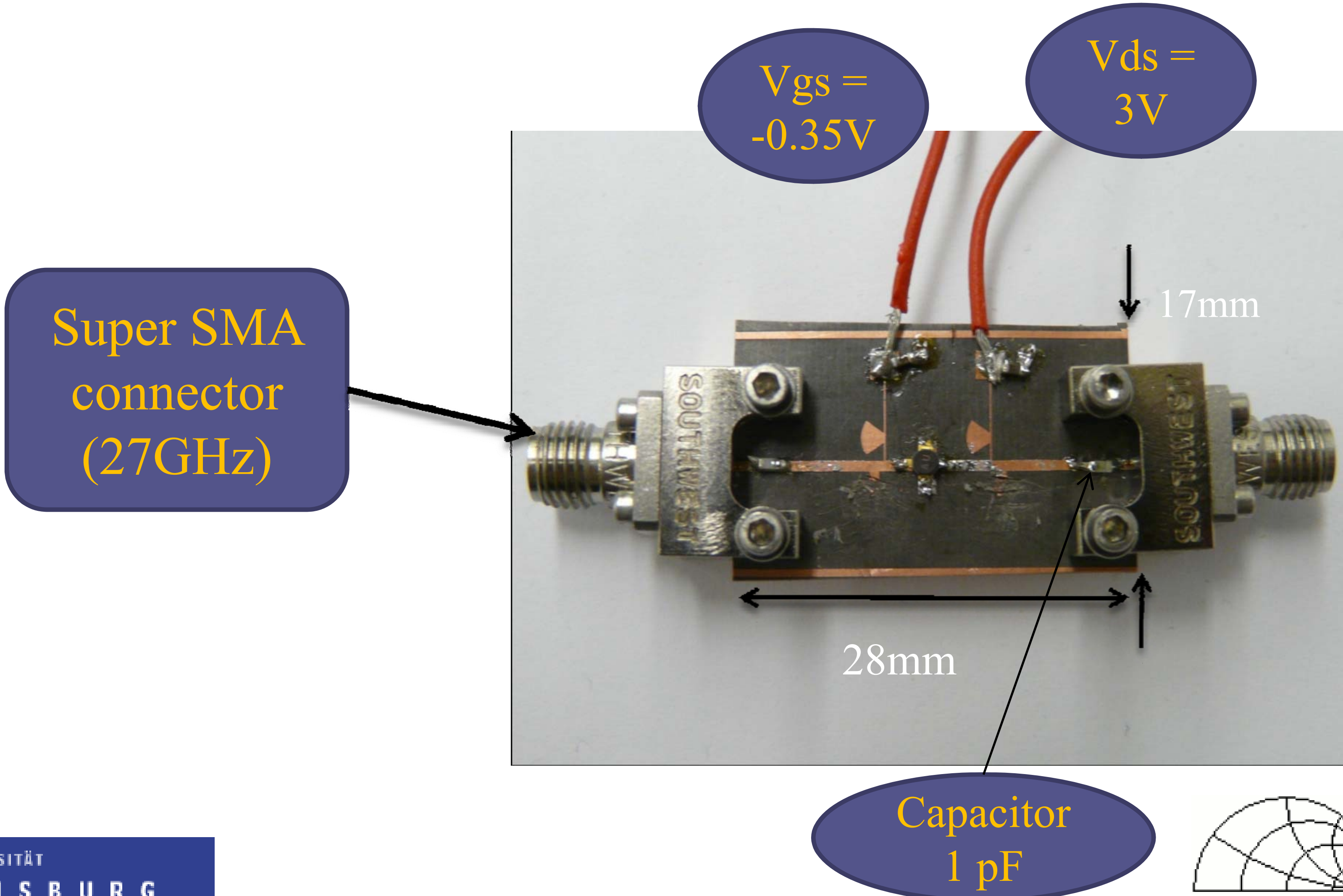
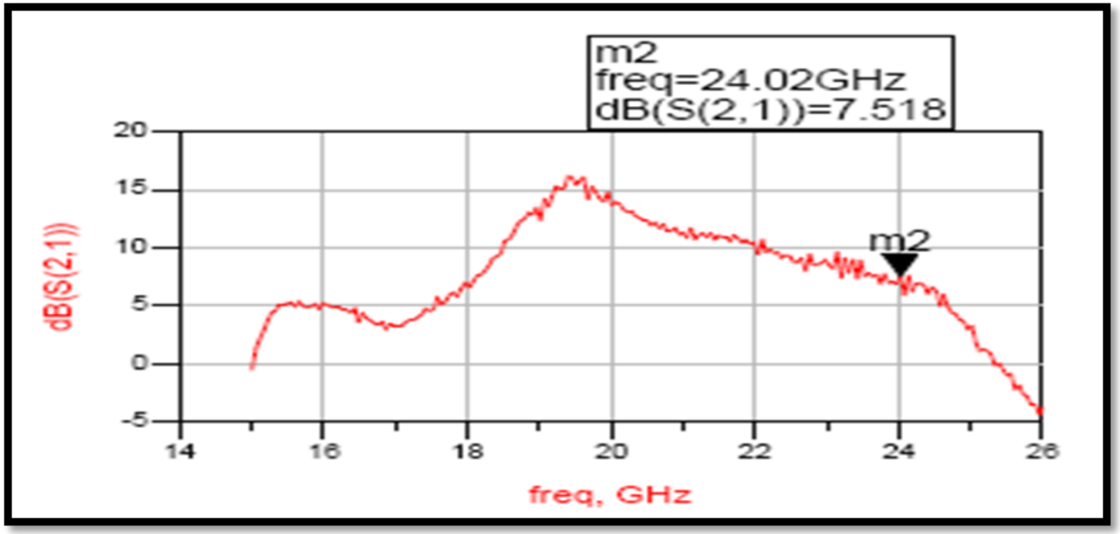
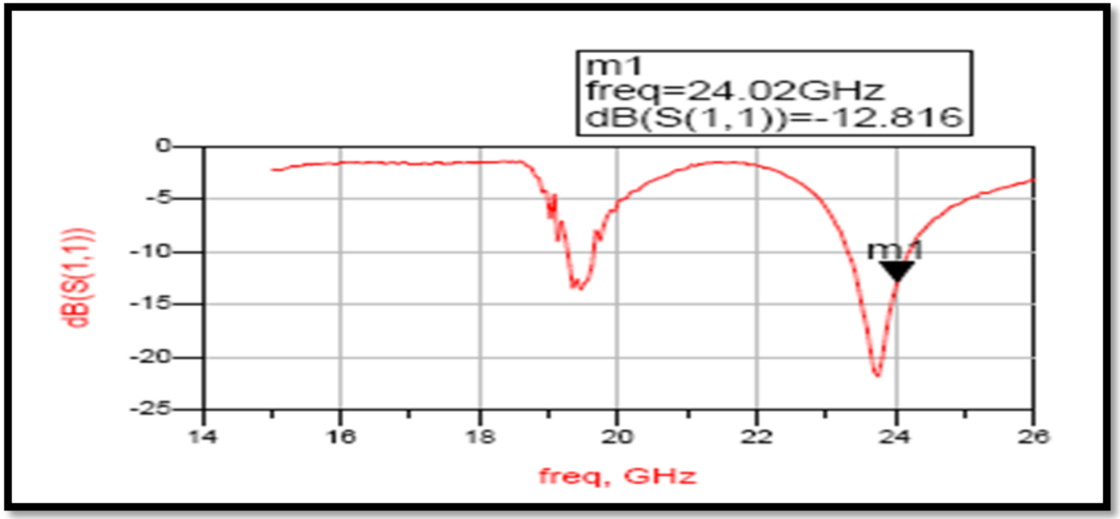
# The Fabrication and Measurement




Super SMA connector (27GHz)
Vgs = -0.35V
Vds = 3V
17mm
28mm
Capacitor 1 pF

# S-Parameters

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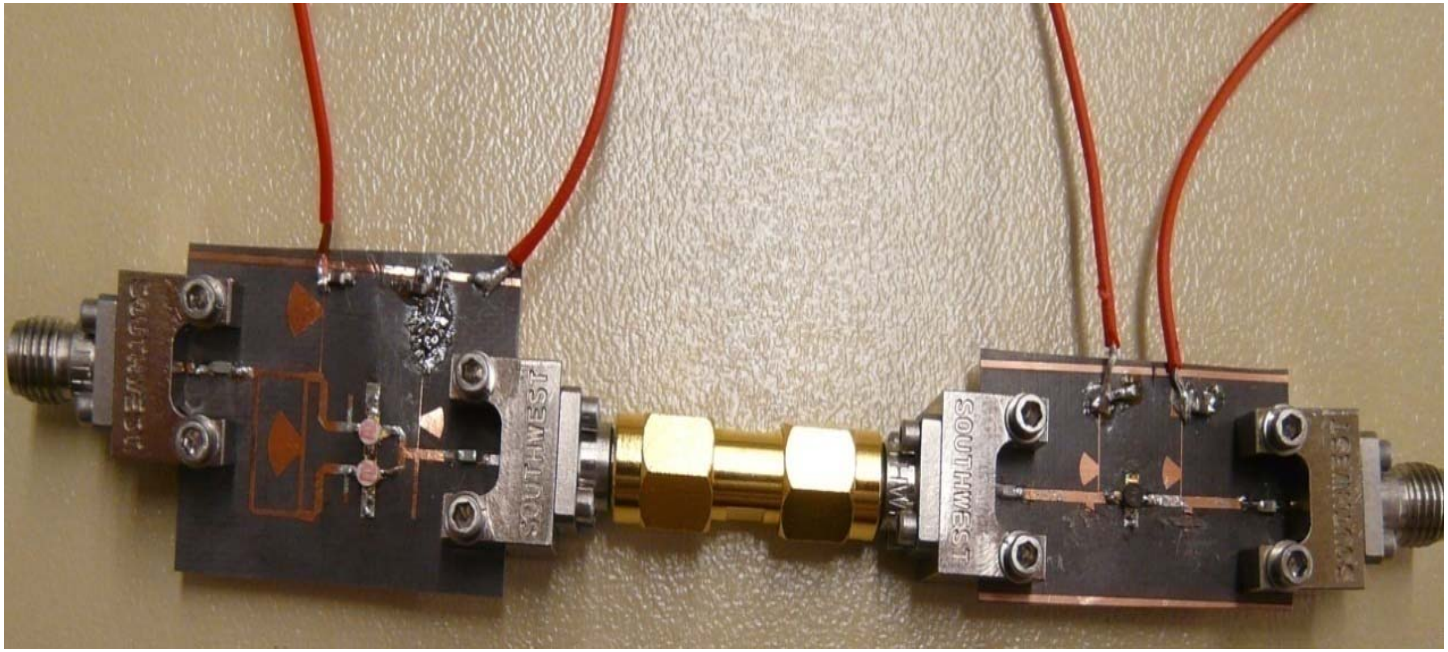
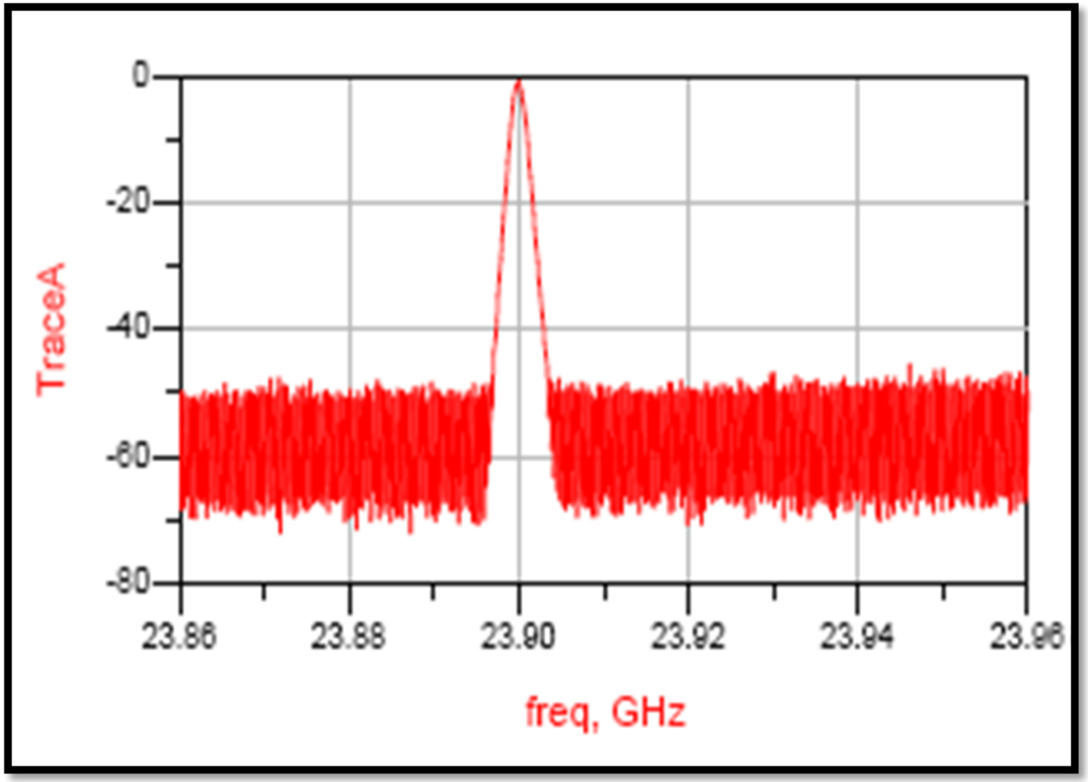
# Measurement Results



# Spectrum of the output

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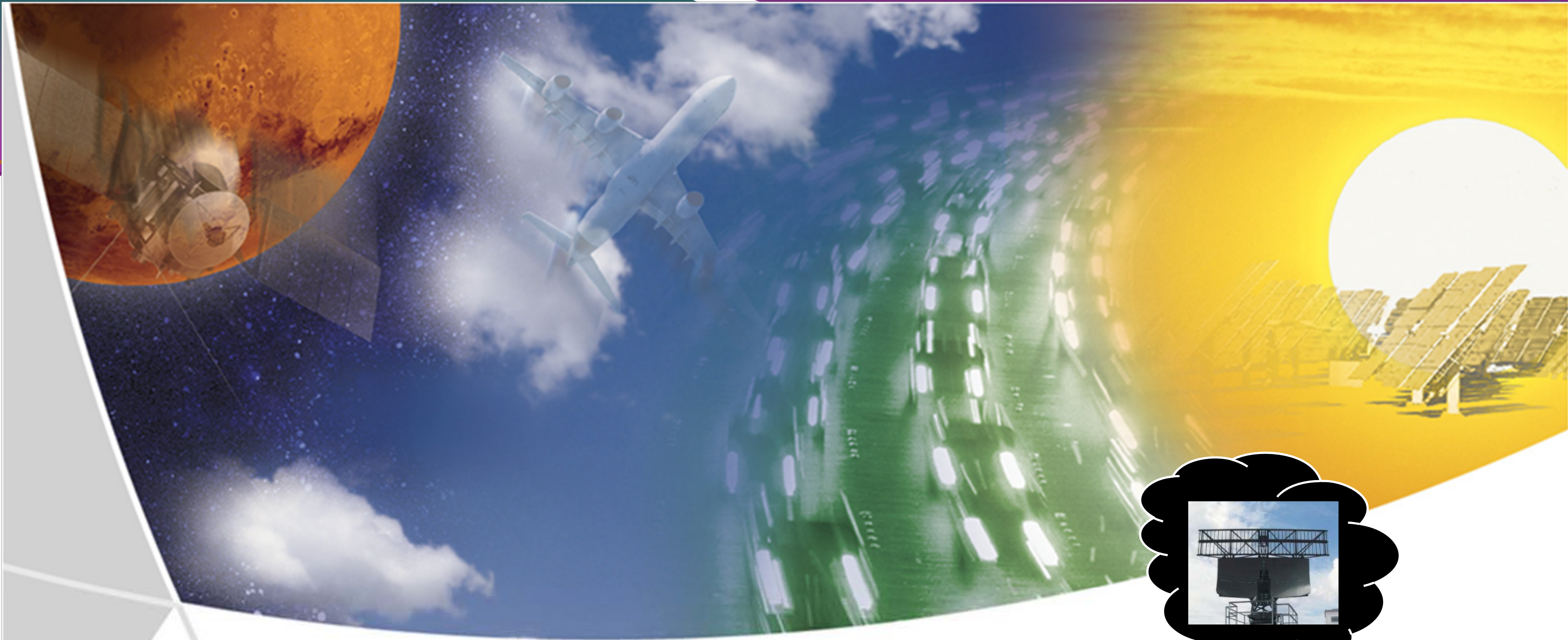
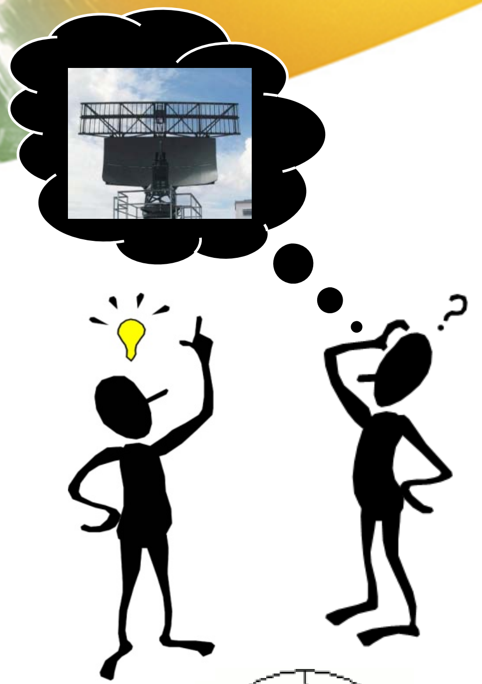
## Conclusion

- In this thesis, a block consists of the frequency doubler and the amplifier at the output is designed for the CW-radar system has been developed.

- The frequency doubler by using the coupler and the HEMT transistor , and the amplifier at 24 GHz with gain 7.5dB are designed.

- The simulation results show that, for high frequency and after the fabrication with RT/Duroid 5870 substrate of 0.25 mm and 0.5 mm, found substrate of 0.25 mm is correspondingly used.





# *Thank you for your attention!*

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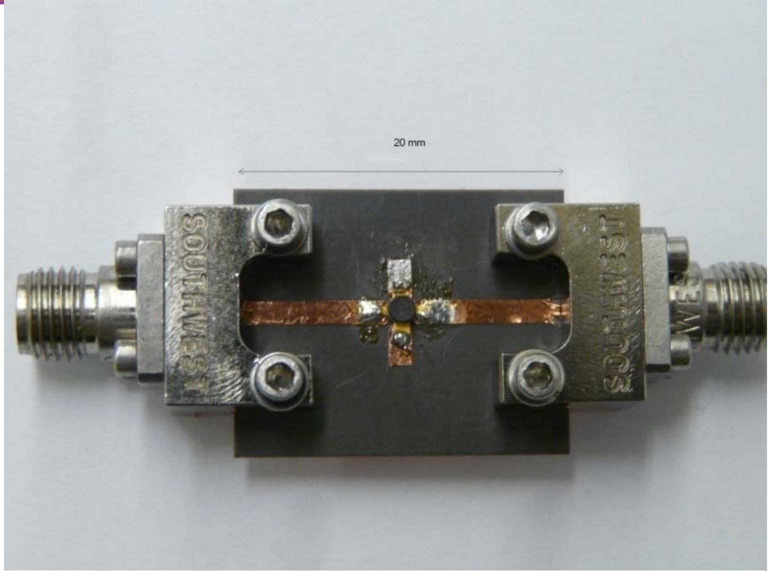
## Appendix A

Transmission Coefficient S-Parameter from the measurement
MGF 4961B
RT/Duroid 5870 ,0.5 mm ,2.33




| ***Frequency*** | $S_{11}$ | $S_{12}$ | $S_{21}$ | $S_{22}$ |
|---|---|---|---|---|
| 15.0 GHz | 0.62 / 38.51 | 0.07 / 126 | 3.06 / 113 | 0.54 / 58.09 |
| 15.5 GHz | 0.57 / -6.35 | 0.07 / 94.68 | 3.33 / 75.30 | 0.52 / 15.44 |
| 16.0 GHz | 0.53 / -63.00 | 0.07 / 60.61 | 3.26 / 29.28 | 0.48 / -32.83 |
| 16.5 GHz | 0.51 / -124 | 0.08 / 18.07 | 3.46 / 3.54 | 0.42 / -87.14 |

| | | | | |
|---|---|---|---|---|
| 17.0 GHz | 0.52 / 180 | 0.08 / -13.86 | 3.80 / -44.78 | 0.37 / -149 |
| 17.5 GHz | 0.56 / 120 | 0.07 / -52.87 | 3.39 / -90.34 | 0.37 / 147 |
| 18.0 GHz | 0.60 / 63.75 | 0.07 / -89.63 | 3.12 / -128 | 0.40 / 89.21 |
| 18.5 GHz | 0.64 / 24.49 | 0.07 / -121 | 2.86 / -166 | 0.45 / 33.84 |
| 19.0 GHz | 0.67 / -17.84 | 0.06 / -159 | 2.91 / 155 | 0.49 / -4.99 |
| 19.5 GHz | 0.68 / -58.83 | 0.05 / 166 | 2.77 / 116 | 0.52 / -47.70 |
| 20.0 GHz | 0.66 / -105 | 0.05 / 129 | 2.74 / 73.20 | 0.55 / -91.48 |
| 20.5 GHz | 0.62 / -146 | 0.05 / 97.35 | 2.45 / 34.03 | 0.57 / -132 |

| | | | | |
|---|---|---|---|---|
| 21 GHz | 0.57 / 174 | 0.06 / 57.40 | 2.40 / -2.60 | 0.58 / -172 |
| 21.5 GHz | 0.53 / 131 | 0.06 / 18.25 | 2.44 / -39.38 | 0.58 / 147 |
| 22 GHz | 0.49 / 85.68 | 0.06 / -34.29 | 2.72 / -82.85 | 0.57 / 103 |
| 22.5 GHz | 0.45 / 33.74 | 0.06 / -83.91 | 2.61 / -125 | 0.54 / 55.49 |
| 23 GHz | 0.42 / -24.95 | 0.06 / -130 | 2.46 / -165 | 0.49 / 2.04 |
| 23.5 GHz | 0.43 / -86.64 | 0.07 / 173 | 2.31 / 152 | 0.44 / -57.03 |
| 24 GHz | 0.51 / -146 | 0.08 / 111 | 1.89 / 115 | 0.44 / -124 |
| 24.5 GHz | 0.64 / 157 | 0.08 / 46.42 | 2.05 / 81.10 | 0.48 / 166 |
| 25 GHz | 0.71 / 97.39 | 0.06 / -12.00 | 1.89 / 24.60 | 0.55 / 98.41 |
| 25.5 GHz | 0.75 / 50.97 | 0.05 / -50.87 | 1.50 / -8.82 | 0.60 / 46.75 |
| 26 GHz | 0.75 / 6.20 | 0.04 / -84.78 | 1.54 / -39.38 | 0.63 / 0.47 |