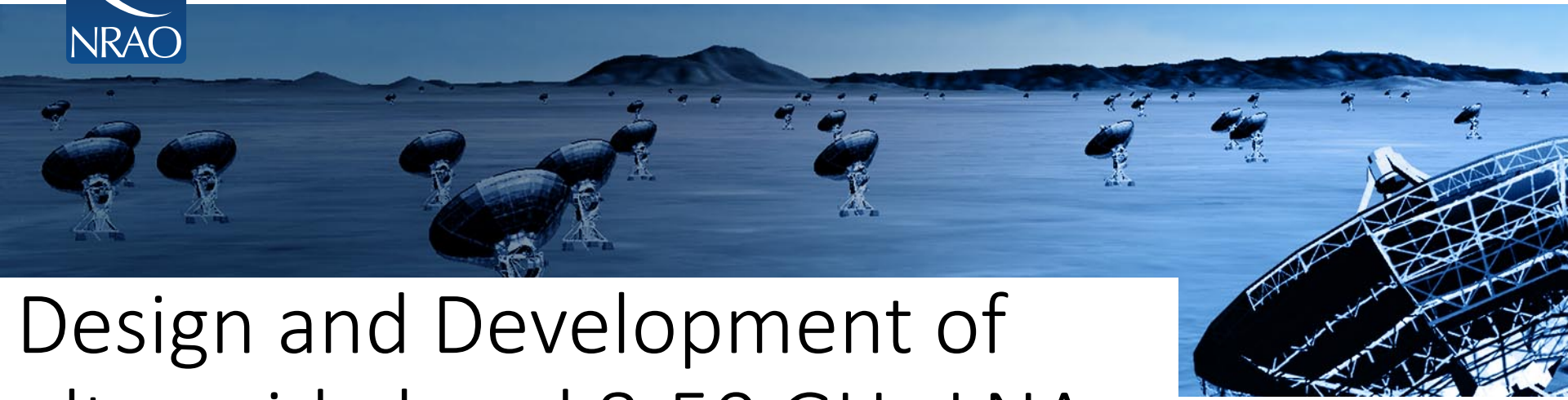
NATIONAL RADIO ASTRONOMY OBSERVATORY



Design and Development of ultra wide band 8-50 GHz LNA

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Associated Universities, Inc.

Jet Propulsion Laboratory
California Institute of Technology

ngVLA
The Next Generation Very Large Array

Outline

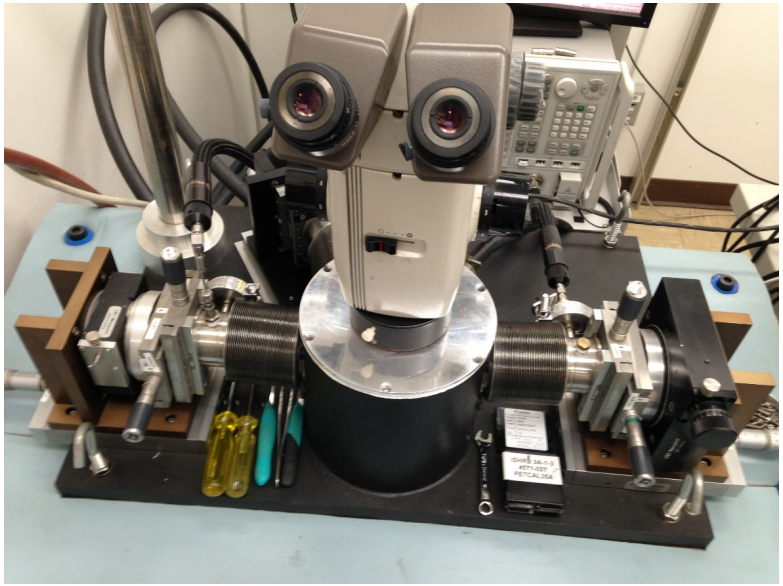
- Motivation
- Modeling
- MMIC measurements
- LNA measurement results
- MMIC design iteration

Motivation

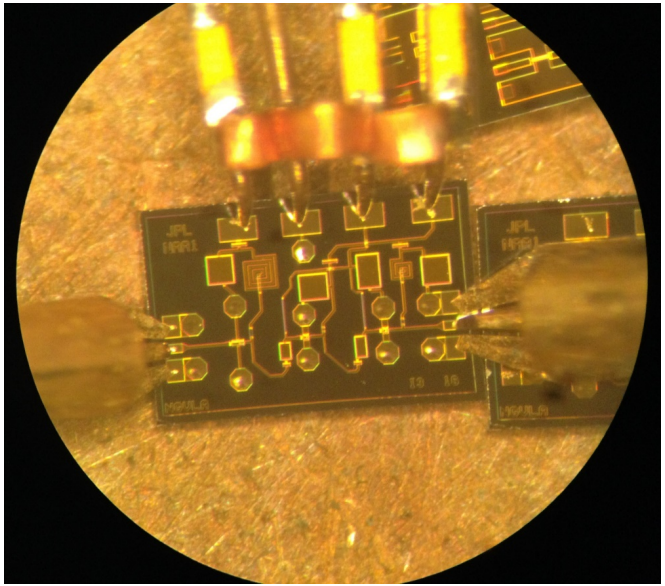
- Increase DSN downlink data rate by 10x at X and KA bands
- Decrease system cost of NGVLA
- Open doors for wideband science
- Challenge old design assumptions

DC – 50 GHz Probe station

Probe station

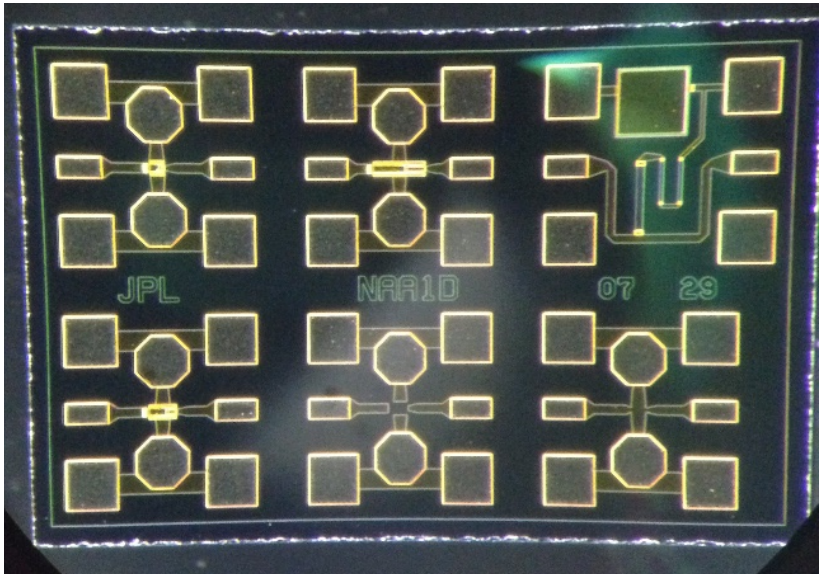


MMIC under microscope

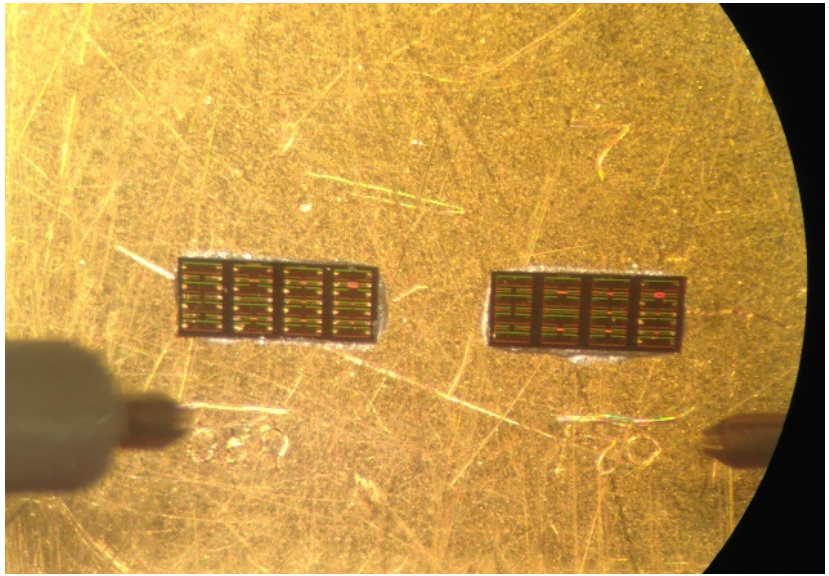


Transistors under Test

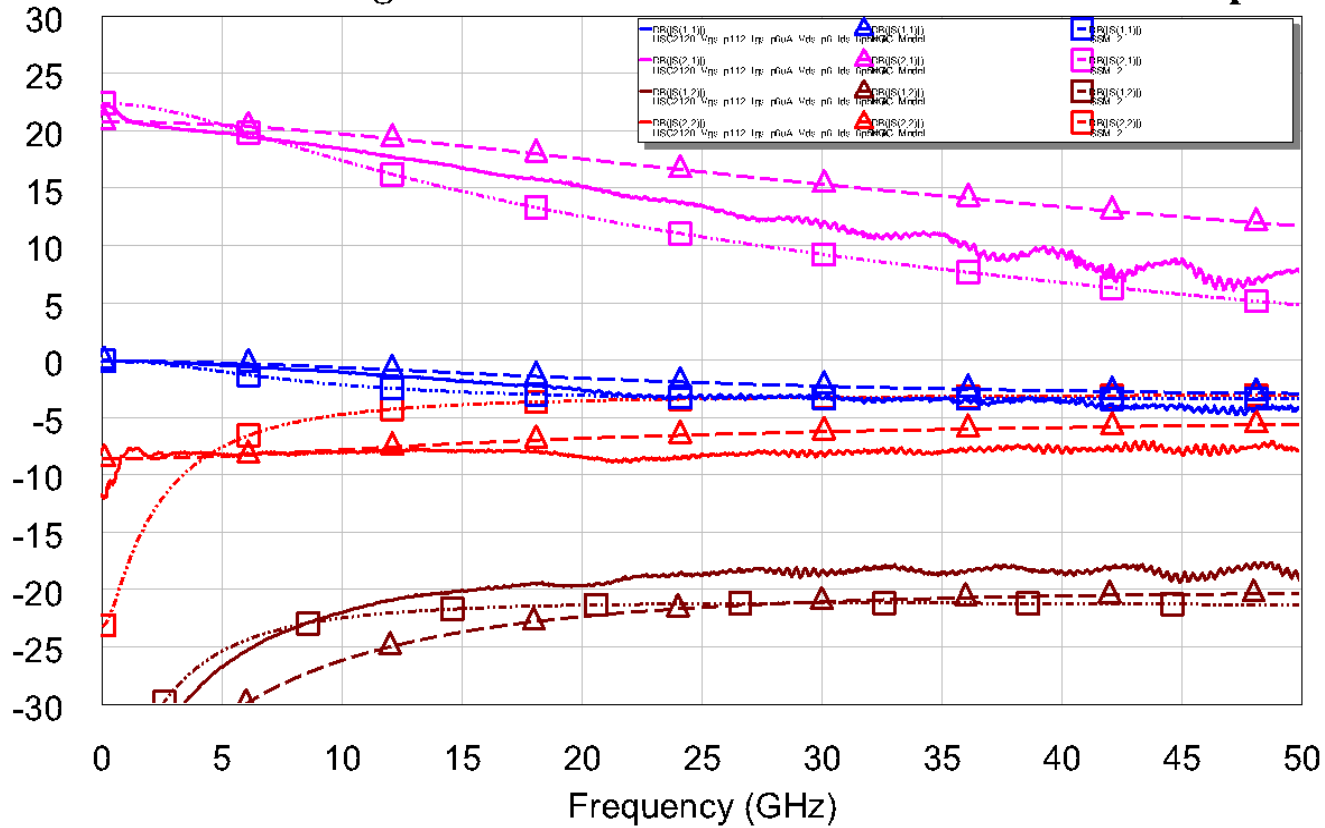
OMMIC Transistors

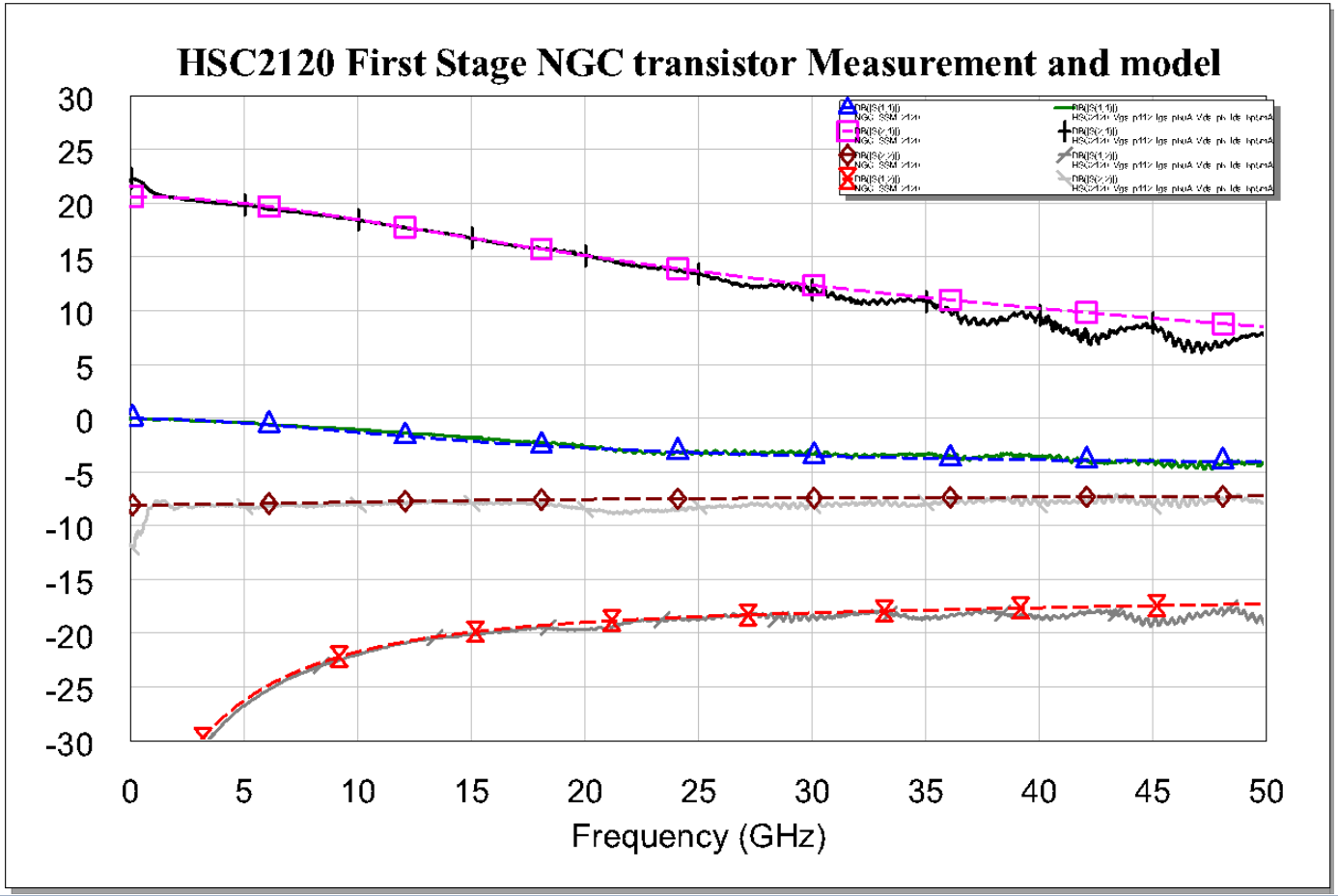


NGC Transistors

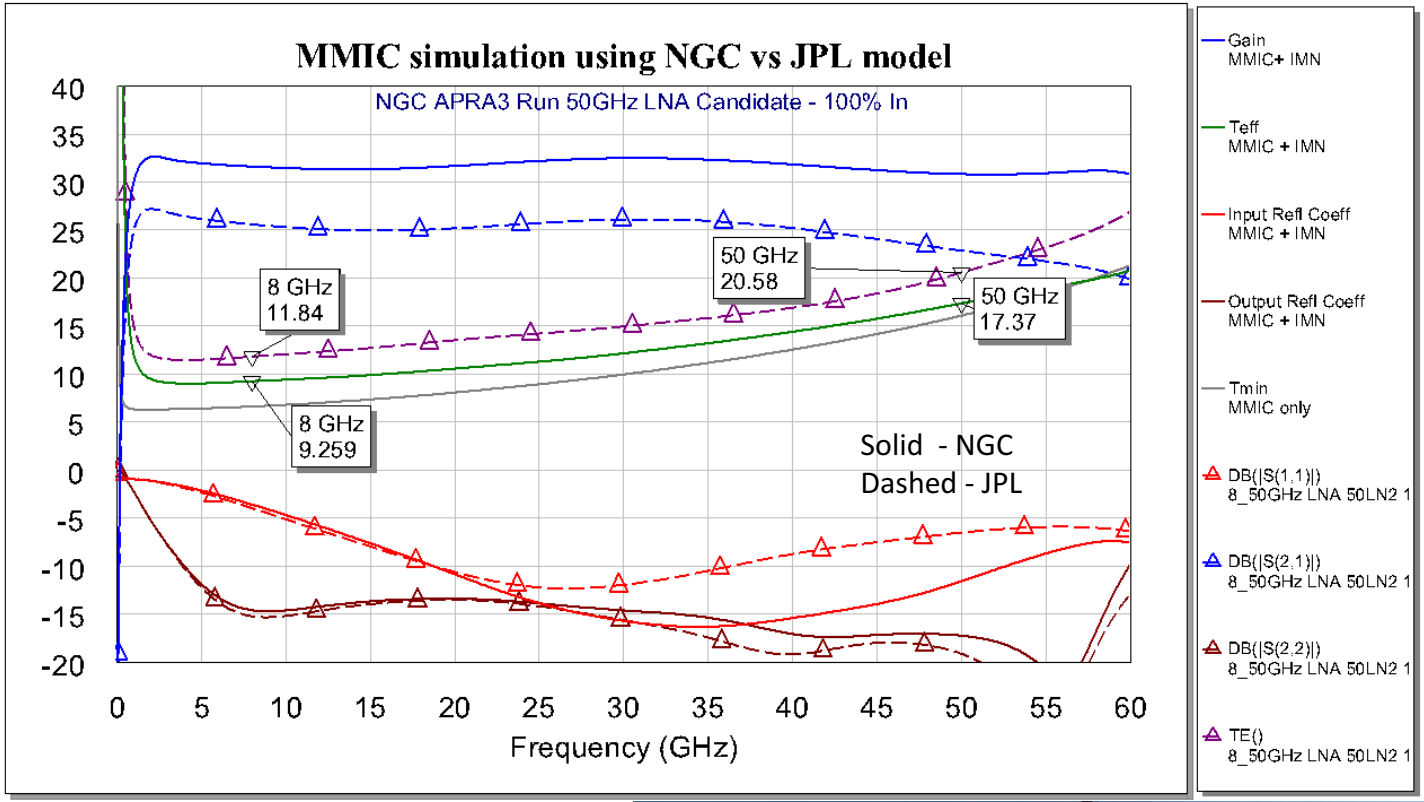


HSC2120 First Stage NGC transistor Measurement and model comparison

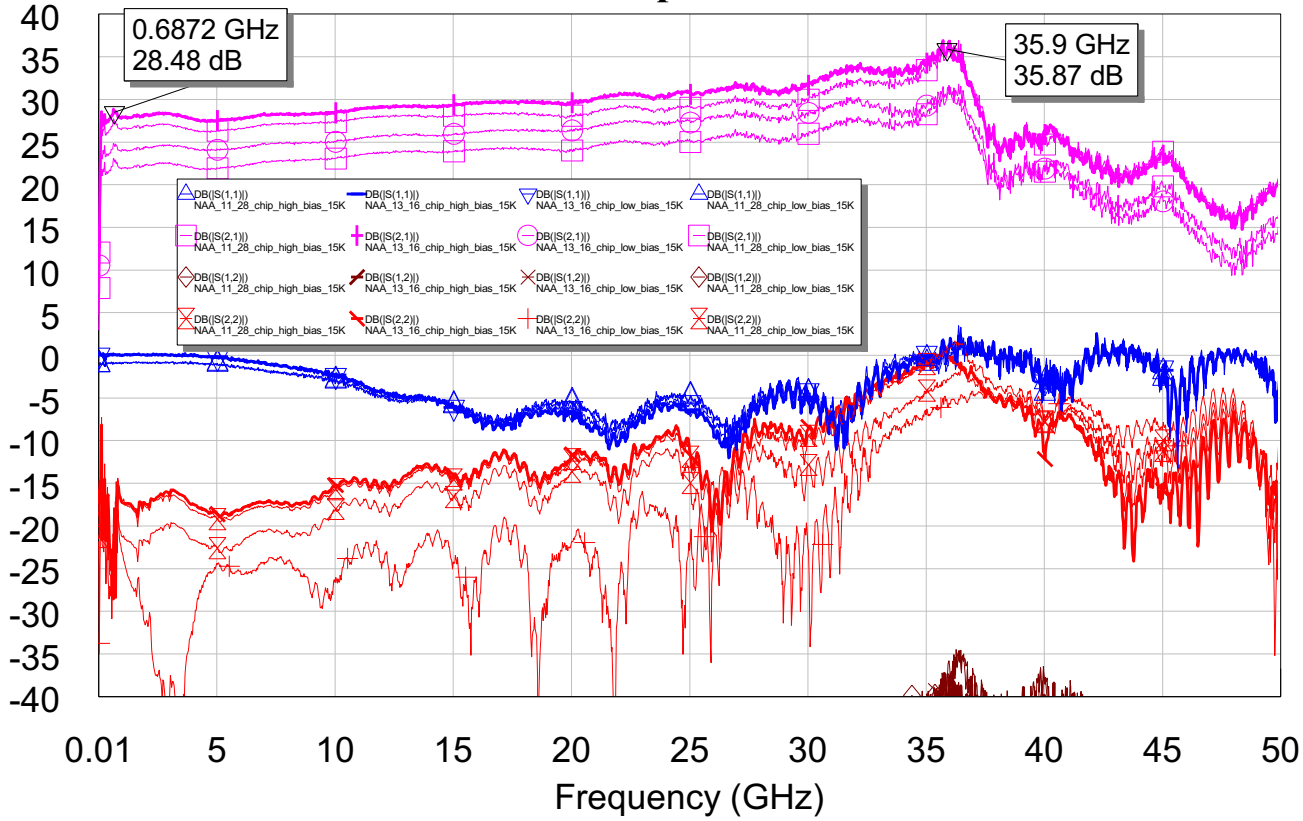



HSC2120 First Stage NGC transistor Measurement and model
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
5
10
15
20
25
30
35
40
45
50
Frequency (GHz)

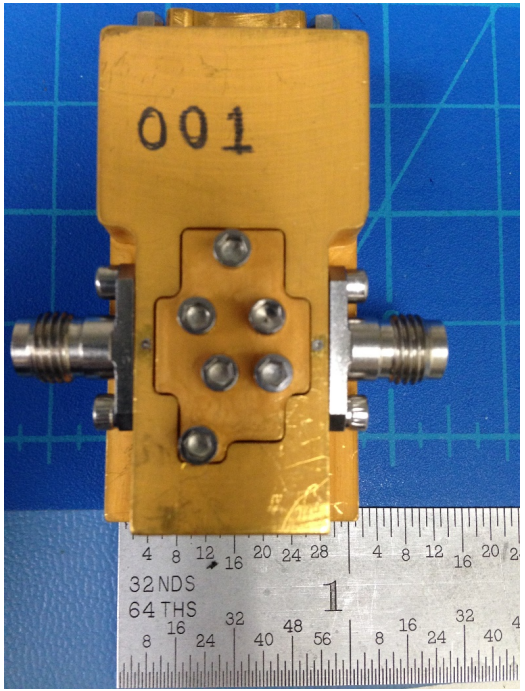
How better models effect LNA predictions

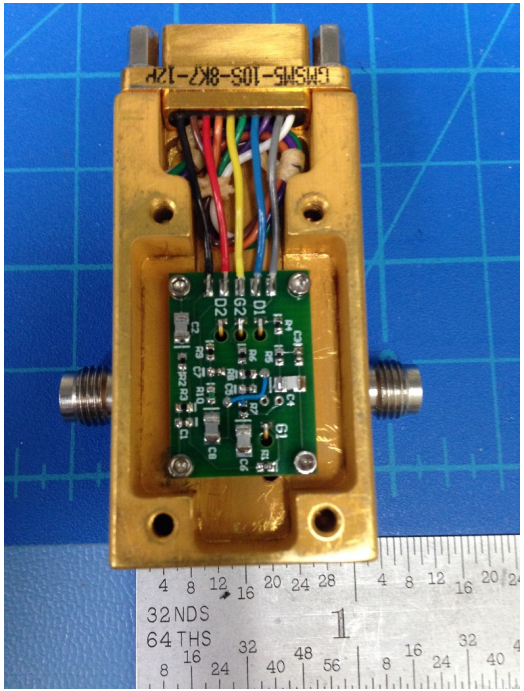


OMMIC MMIC probe measurements



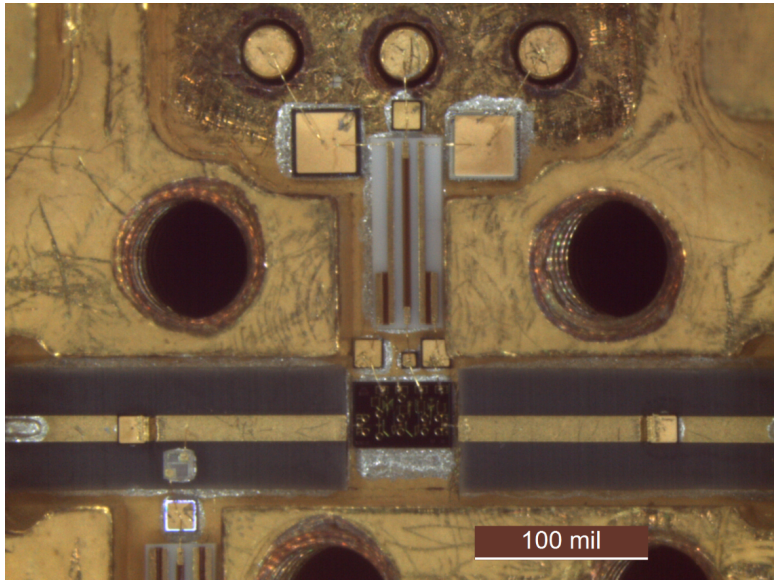
50 GHz LNA Module Development



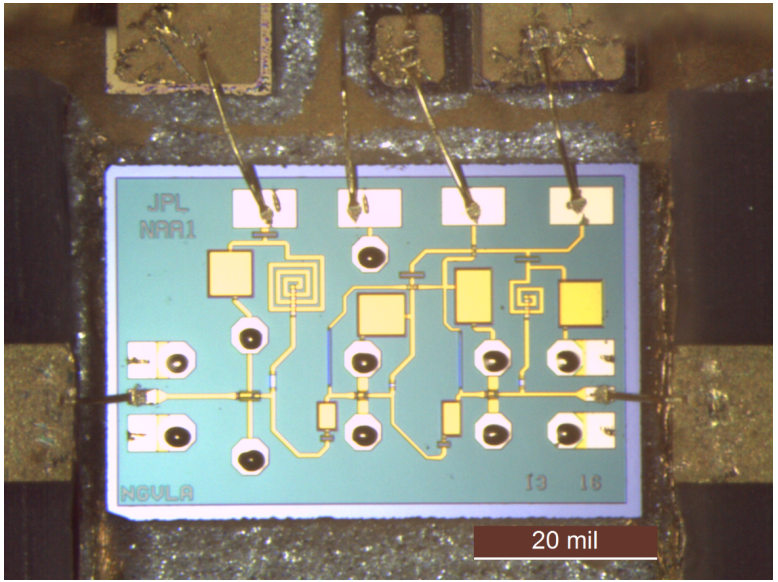


LNA assembly - OMMIC

LNA layout

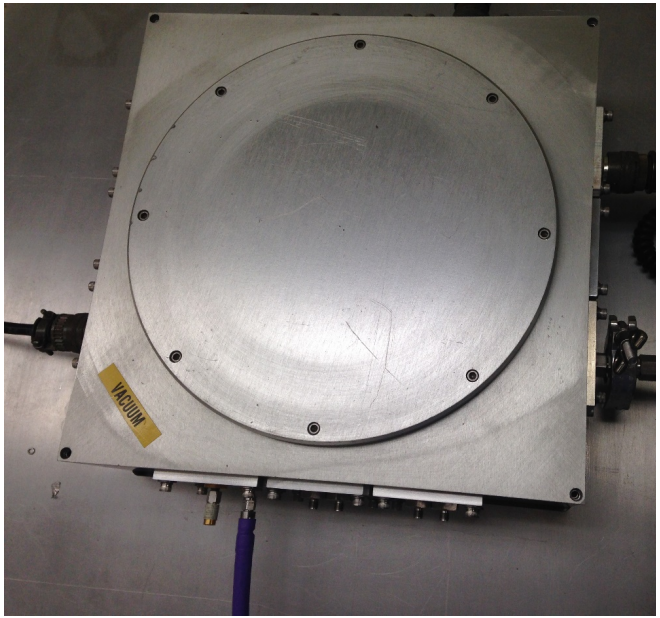


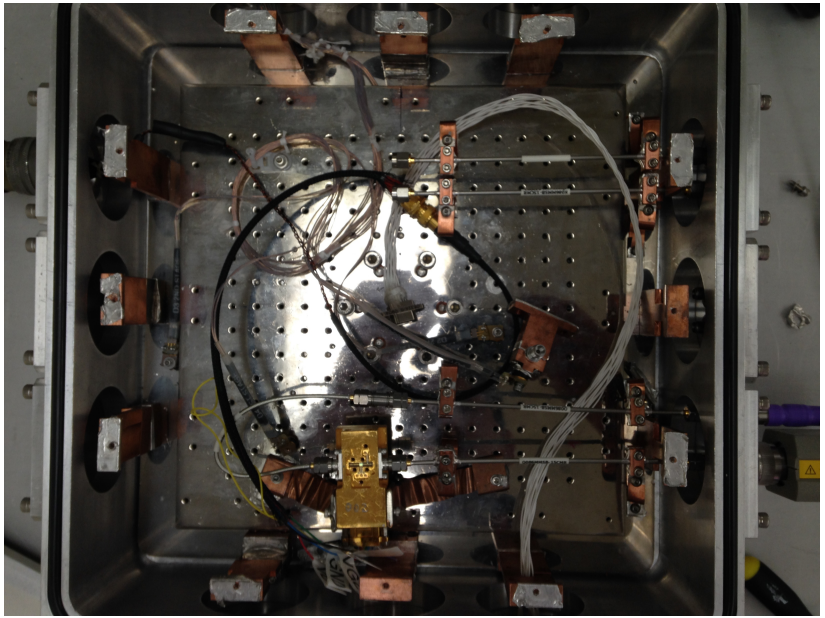
Zoom in on MMIC

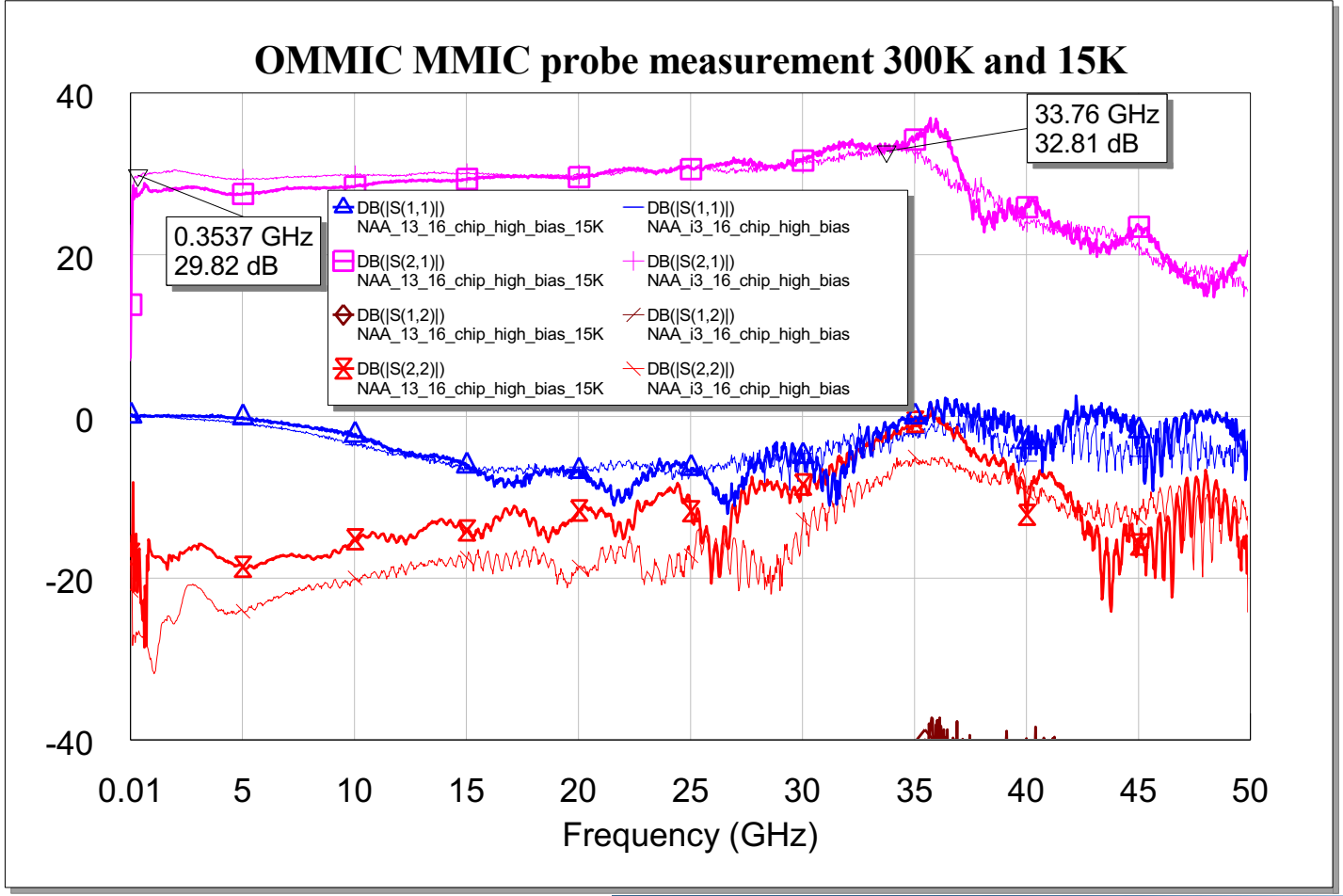


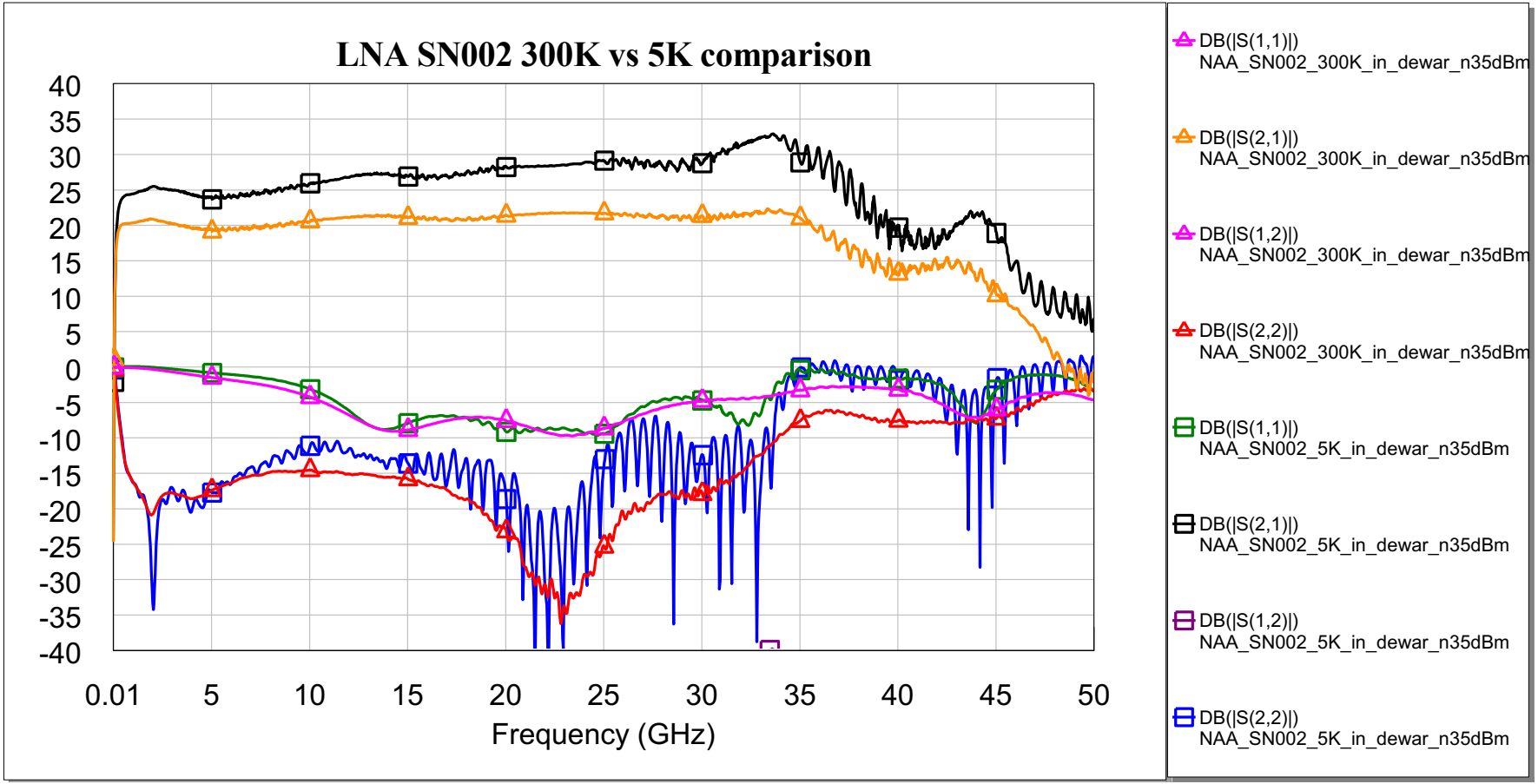
50 GHz Test bed

Enables Hot/cold, noise source, S parameters to 50 GHz

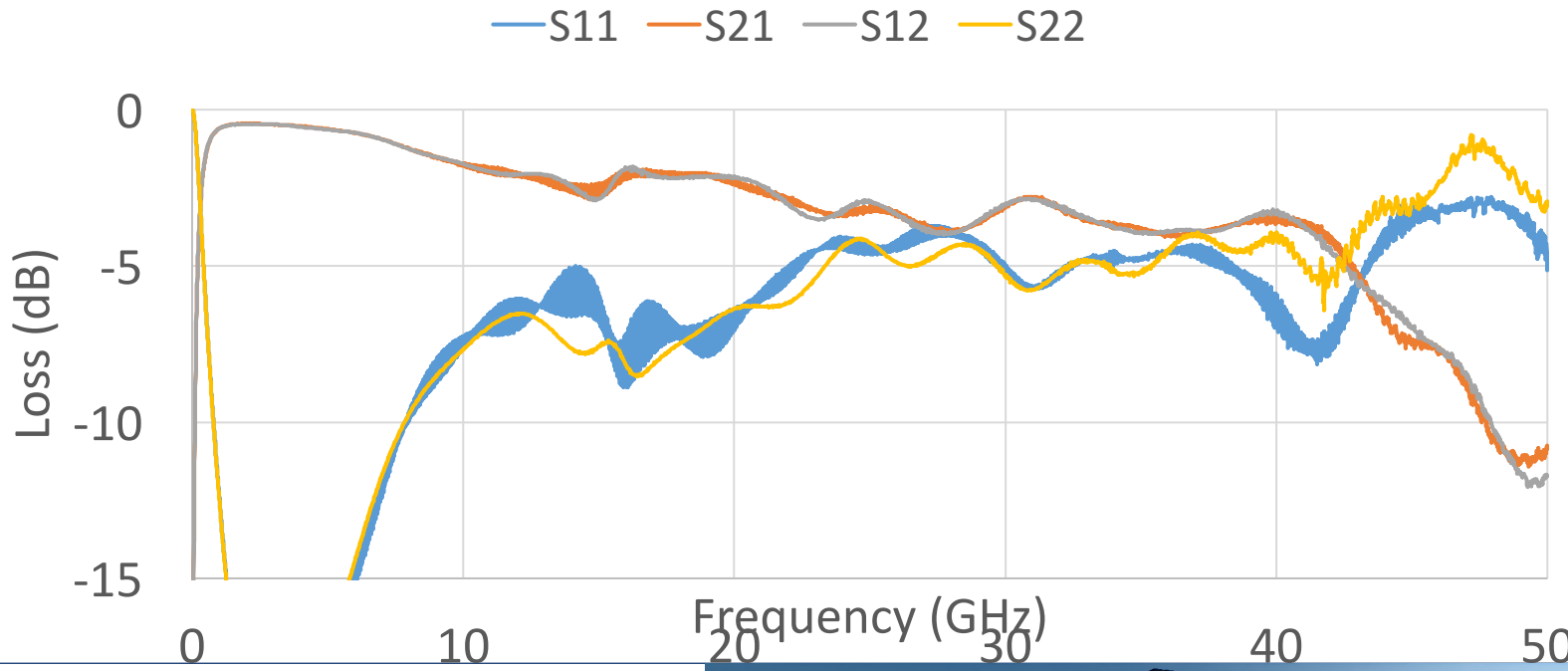





OMMIC MMIC probe measurement 300K and 15K
40
20
0
-20
-40
0.01
5
10
15
20
25
30
35
40
45
50
Frequency (GHz)
33.76 GHz
32.81 dB
0.3537 GHz
29.82 dB
DB(|S(1,1)|)
NAA_13_16_chip_high_bias_15K
DB(|S(1,1)|)
NAA_i3_16_chip_high_bias
DB(|S(2,1)|)
NAA_13_16_chip_high_bias_15K
DB(|S(2,1)|)
NAA_i3_16_chip_high_bias
DB(|S(1,2)|)
NAA_13_16_chip_high_bias_15K
DB(|S(1,2)|)
NAA_i3_16_chip_high_bias
DB(|S(2,2)|)
NAA_13_16_chip_high_bias_15K
DB(|S(2,2)|)
NAA_i3_16_chip_high_bias


LNA SN002 300K vs 5K comparison
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
0.01
5
10
15
20
25
30
35
40
45
50
Frequency (GHz)
DB(|S(1,1)|)
NAA_SN002_300K_in_dewar_n35dBm
DB(|S(2,1)|)
NAA_SN002_300K_in_dewar_n35dBm
DB(|S(1,2)|)
NAA_SN002_300K_in_dewar_n35dBm
DB(|S(2,2)|)
NAA_SN002_300K_in_dewar_n35dBm
DB(|S(1,1)|)
NAA_SN002_5K_in_dewar_n35dBm
DB(|S(2,1)|)
NAA_SN002_5K_in_dewar_n35dBm
DB(|S(1,2)|)
NAA_SN002_5K_in_dewar_n35dBm
DB(|S(2,2)|)
NAA_SN002_5K_in_dewar_n35dBm

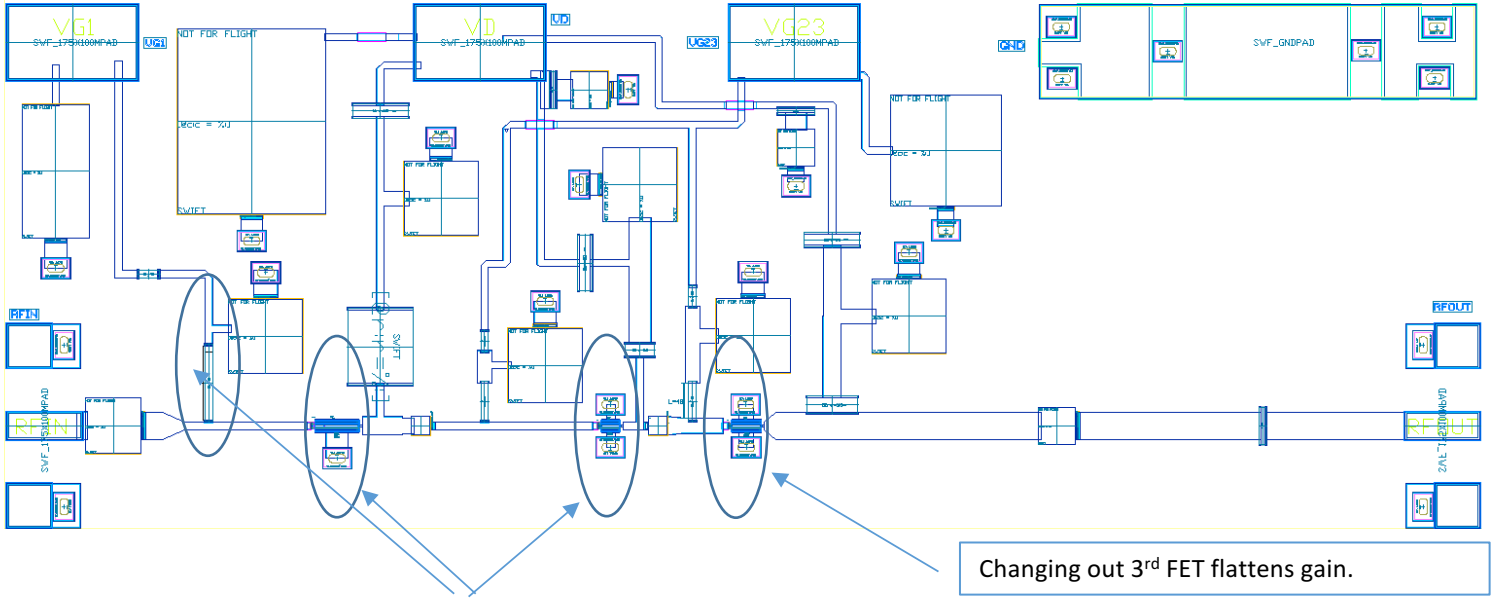
Ommic Wideband LNA Housing #002 Thru Measurement with inductor and bias network



Design iteration

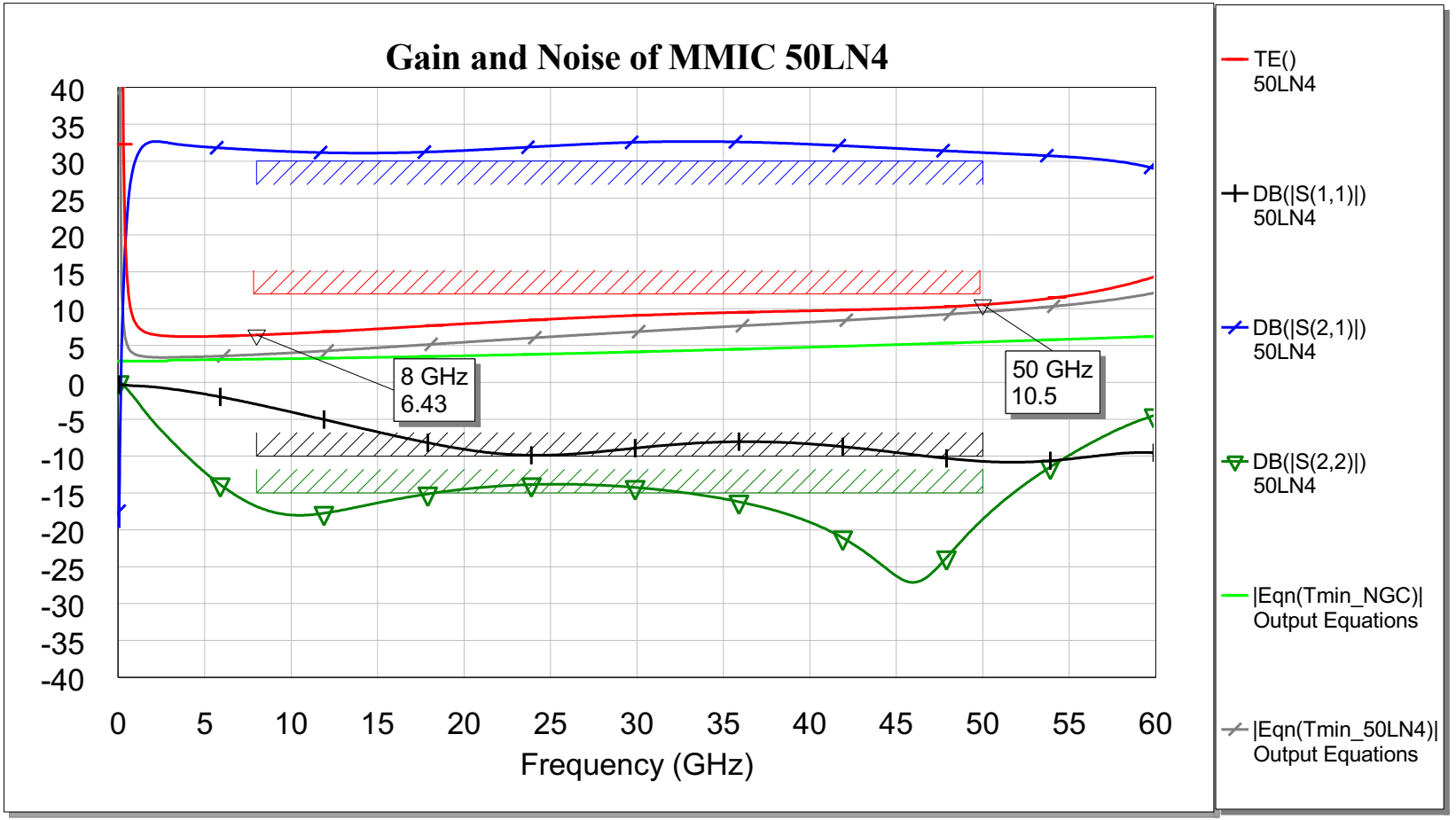
- NGC MMIC redesign
- Used four finger device on first stage
- Changed device sizes
- Decoupled first stage bias network from subsequent stages
- Removed input bias network on first stage

50LN2N2 - Ahmed Akgiray Original Design of 2011



Changing out 3rd FET flattens gain.

Changes to the input transistor, 2nd transistor, and input gate bias resistor


Gain and Noise of MMIC 50LN4
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
0
5
10
15
20
25
30
35
40
45
50
55
60
Frequency (GHz)
8 GHz
6.43
50 GHz
10.5
TE()
50LN4
DB(|S(1,1)|)
50LN4
DB(|S(2,1)|)
50LN4
DB(|S(2,2)|)
50LN4
|Eqn(Tmin_NGC)|
Output Equations
|Eqn(Tmin_50LN4)|
Output Equations

Confusions, Confessions, Conclusions

- Development complete on a set of testbeds to 50 GHz
- Improved models to 50 GHz achieved for NGC
- Improved MMIC design nearly complete for NGC
- Current testing in progress of OMMIC prototype LNA
- Current work progressing on improved module design