

Cryogenic Performance of NGC 35nm InP Low Noise Amplifiers

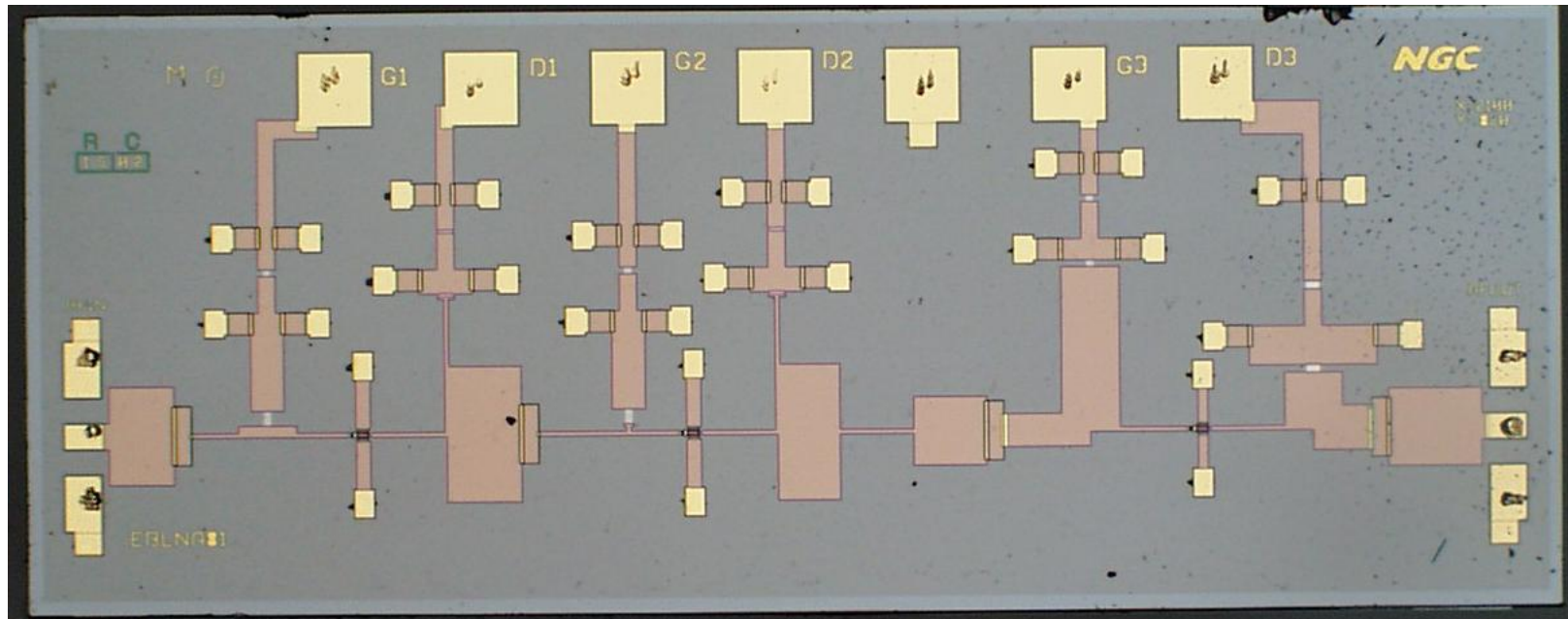


Eric W. Bryerton

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array



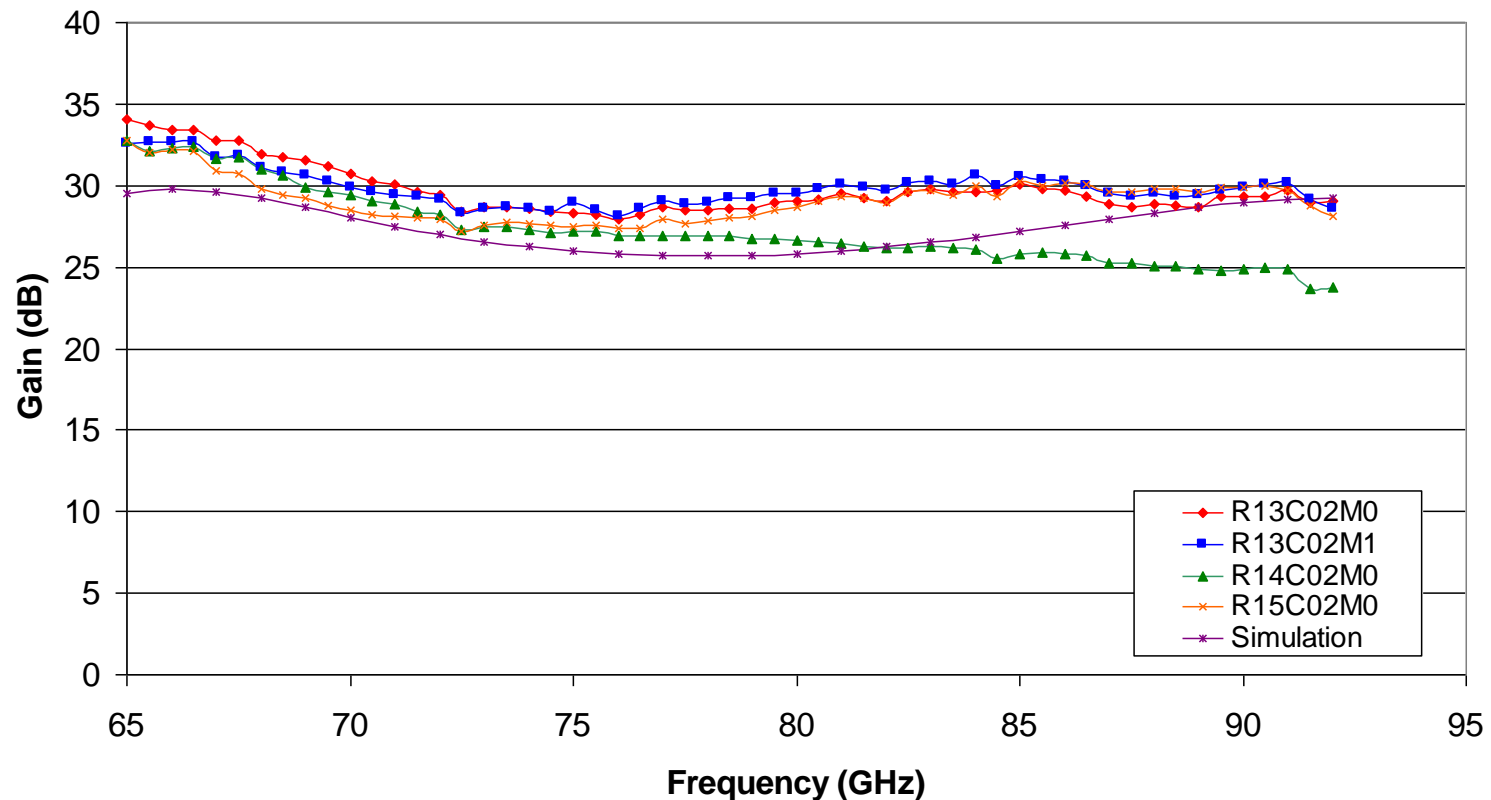
EBLNA8 I



- Wafer run complete 1/15/2008
- Chip Dimension: 2.1mm x 0.8mm

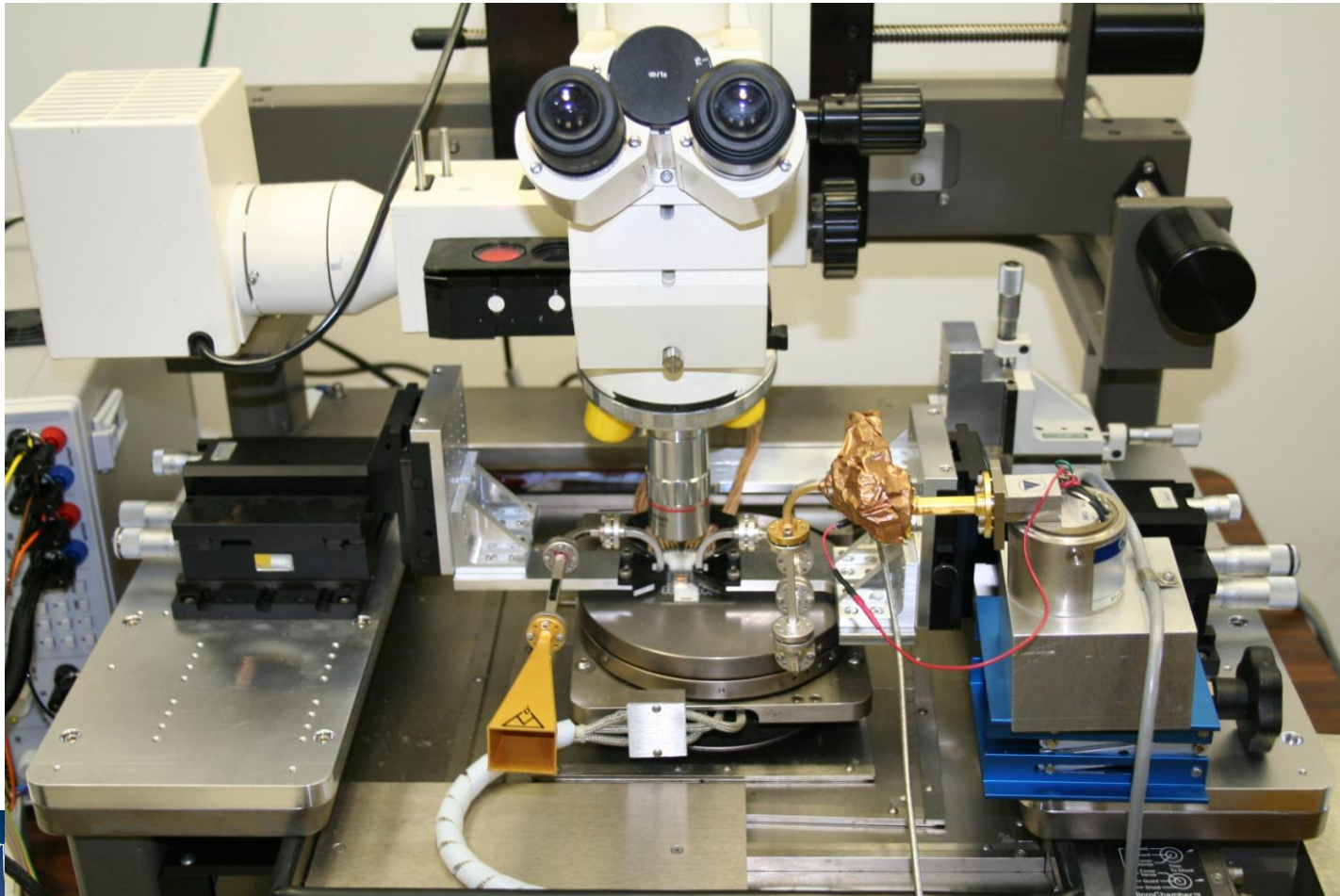
On-chip Measurements

EBLNA81 ($V_G=+0.3V$, $V_D=1.2V$)
On-wafer, $T=297K$

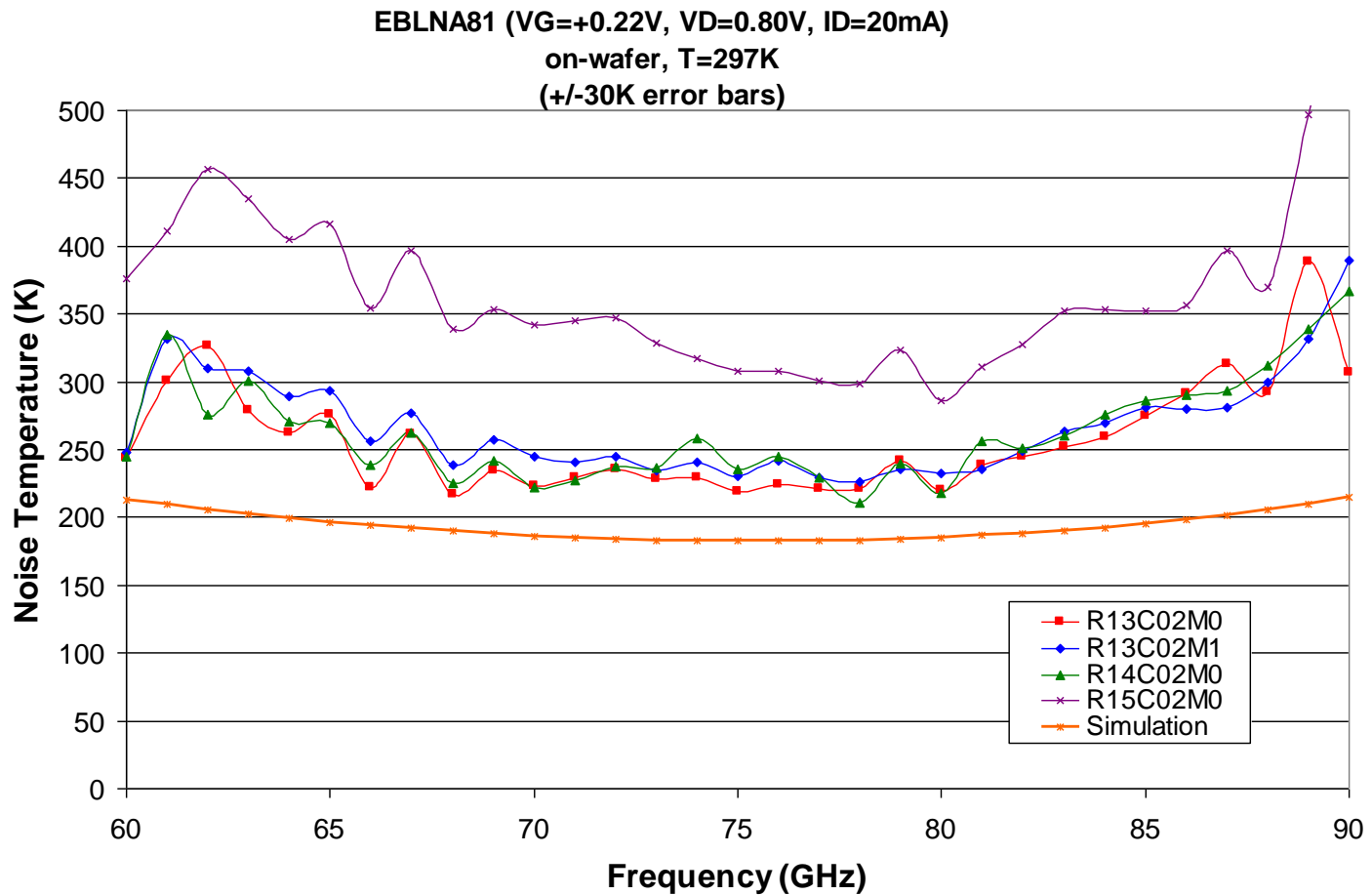


- G_m increased in simulation (from 1950 to 2500 mS/mm) to match measured performance

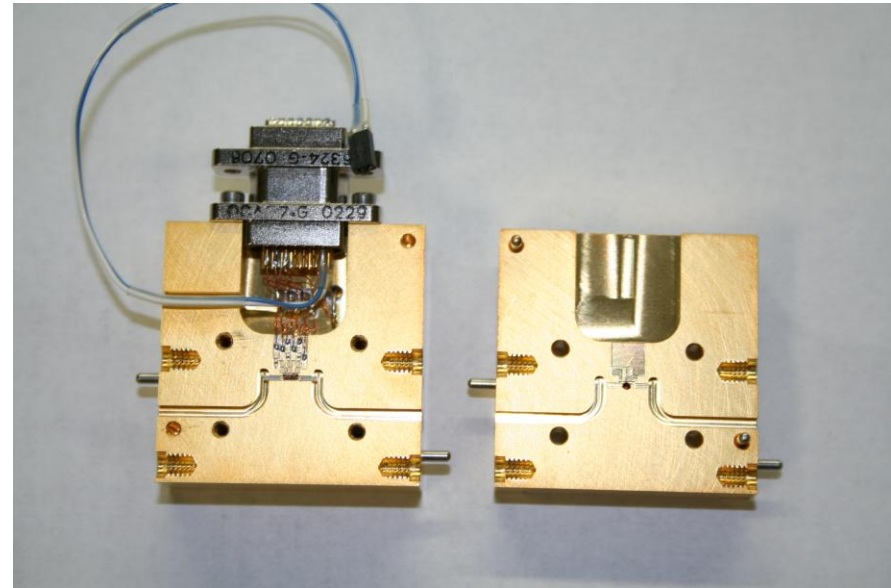
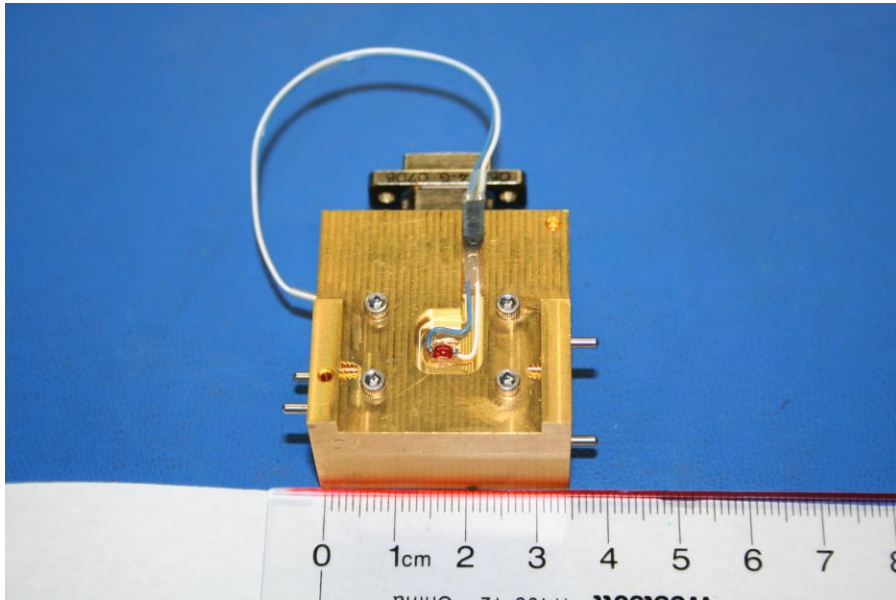
On-Chip Noise Measurement



On-chip Noise Measurement

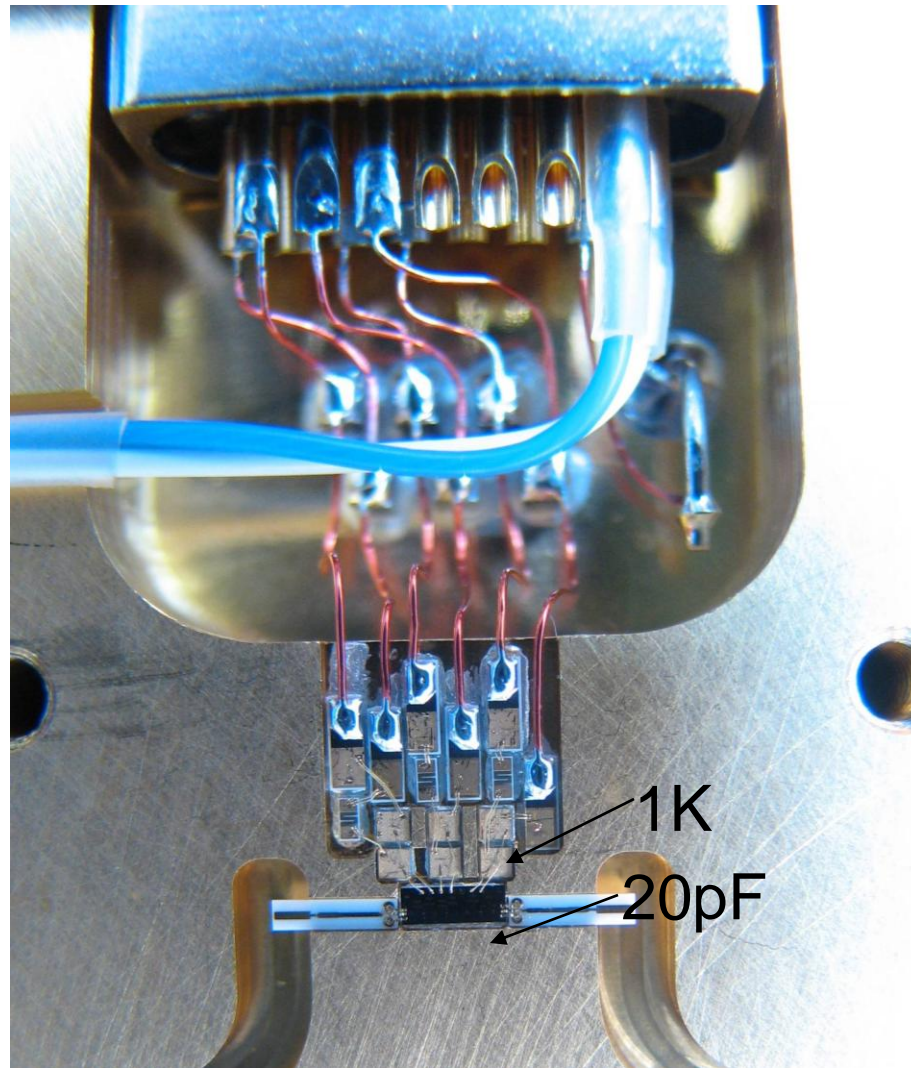


WR-12 LNA Module

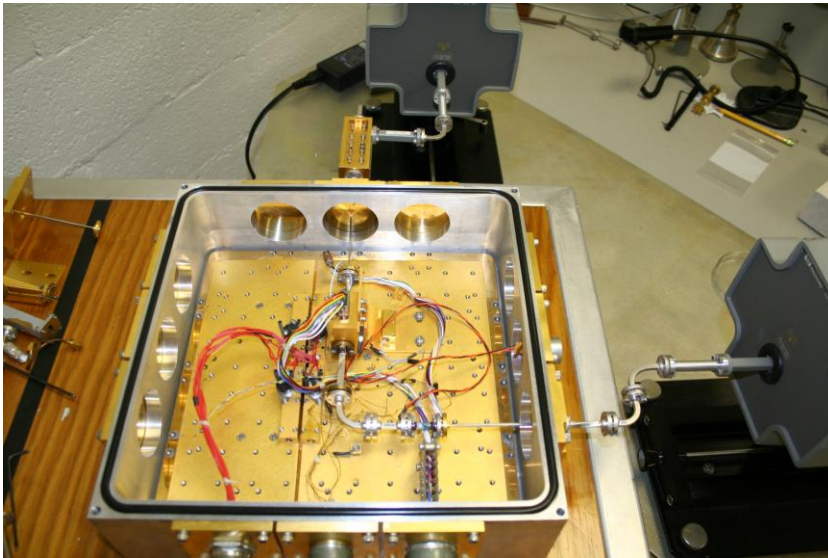


- Same MDM-15 pinout as CDL LNAs

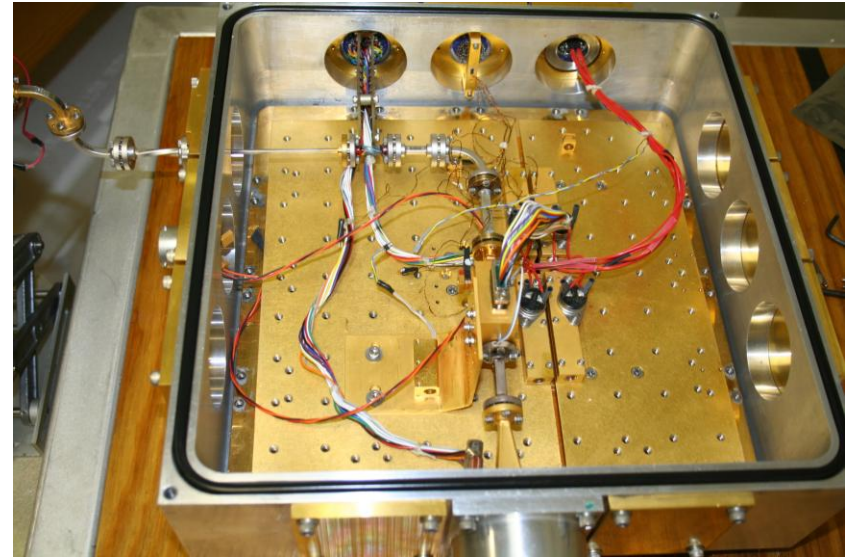
WR-12 LNA Module



LNA Module Measurements

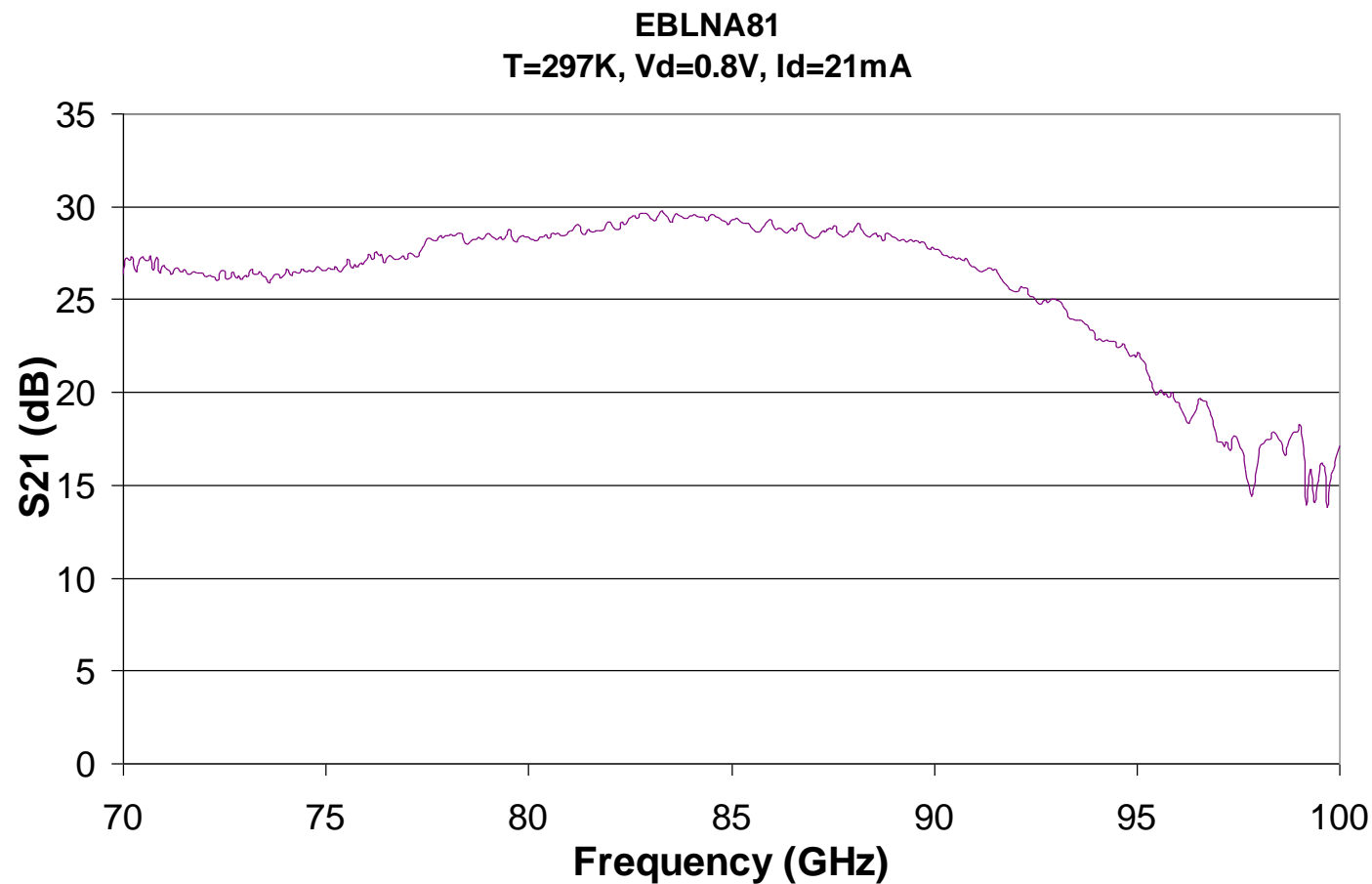


S21

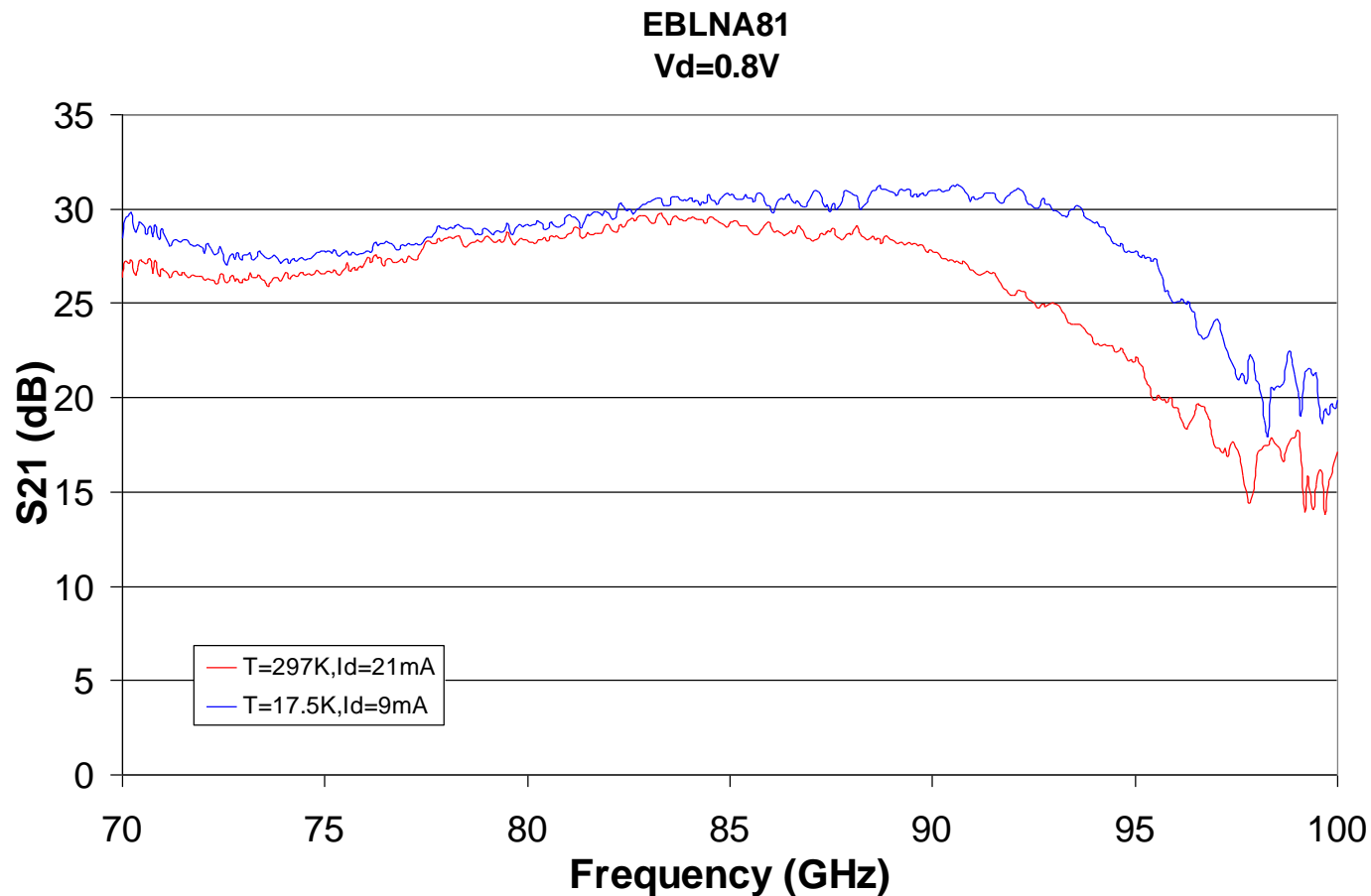


Noise

LNA Module Measurements



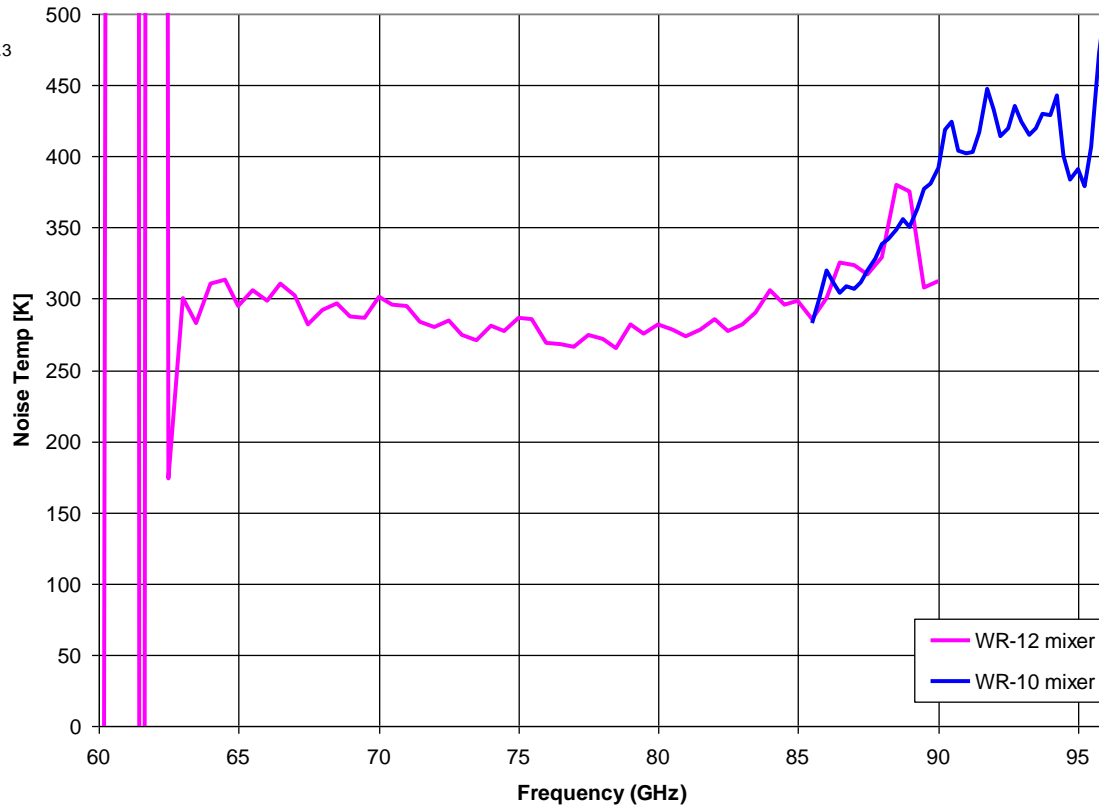
LNA Module Measurements



LNA Module Measurements

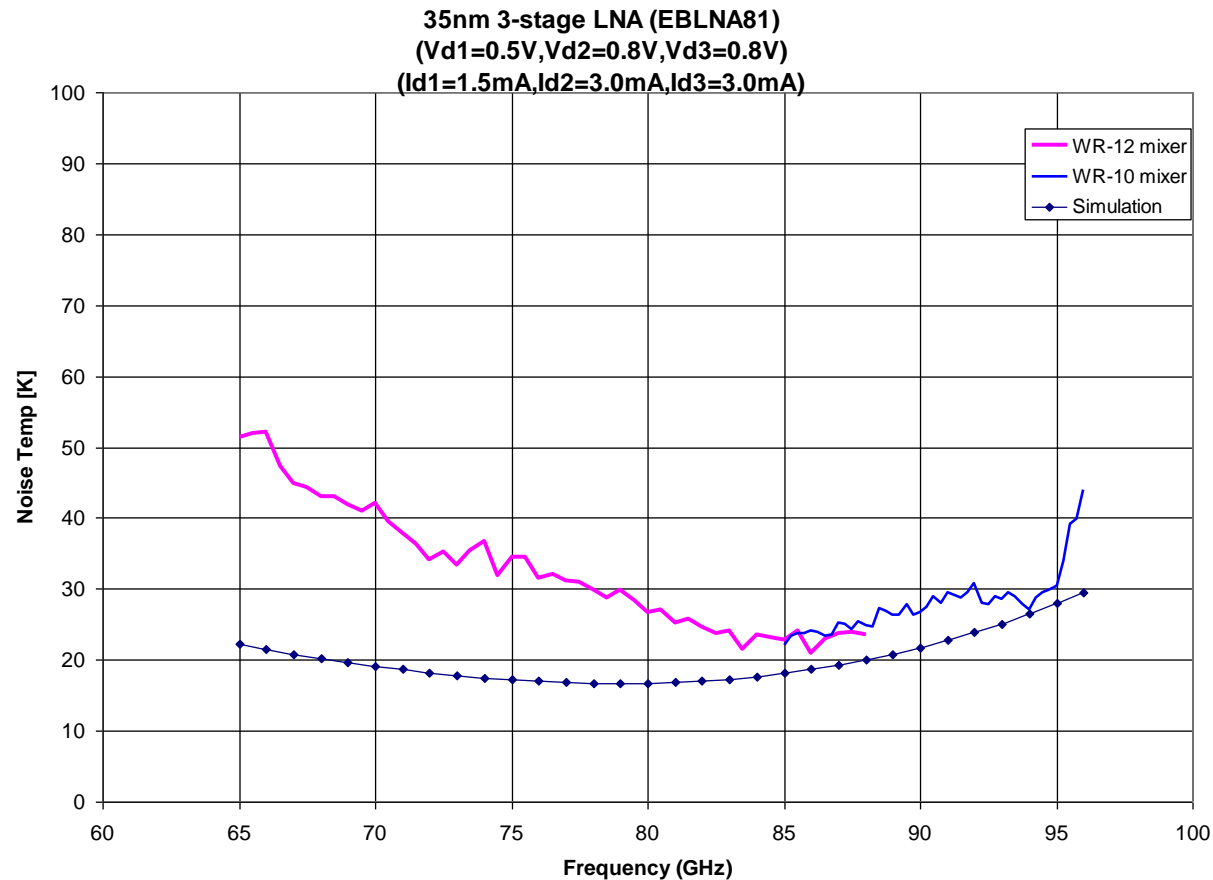
Amplifier ID: eblna81
Timestamp: 7/9/2008 11:12 AM
Measured by:
Dewar Temp: 327
Ambient Temp: 327
Noise Diode: 11833
Software Version: 1.3

Amplifier Noise Temperature



$V_d=0.8V$, $I_d=7mA/stage$

LNA Module Measurements

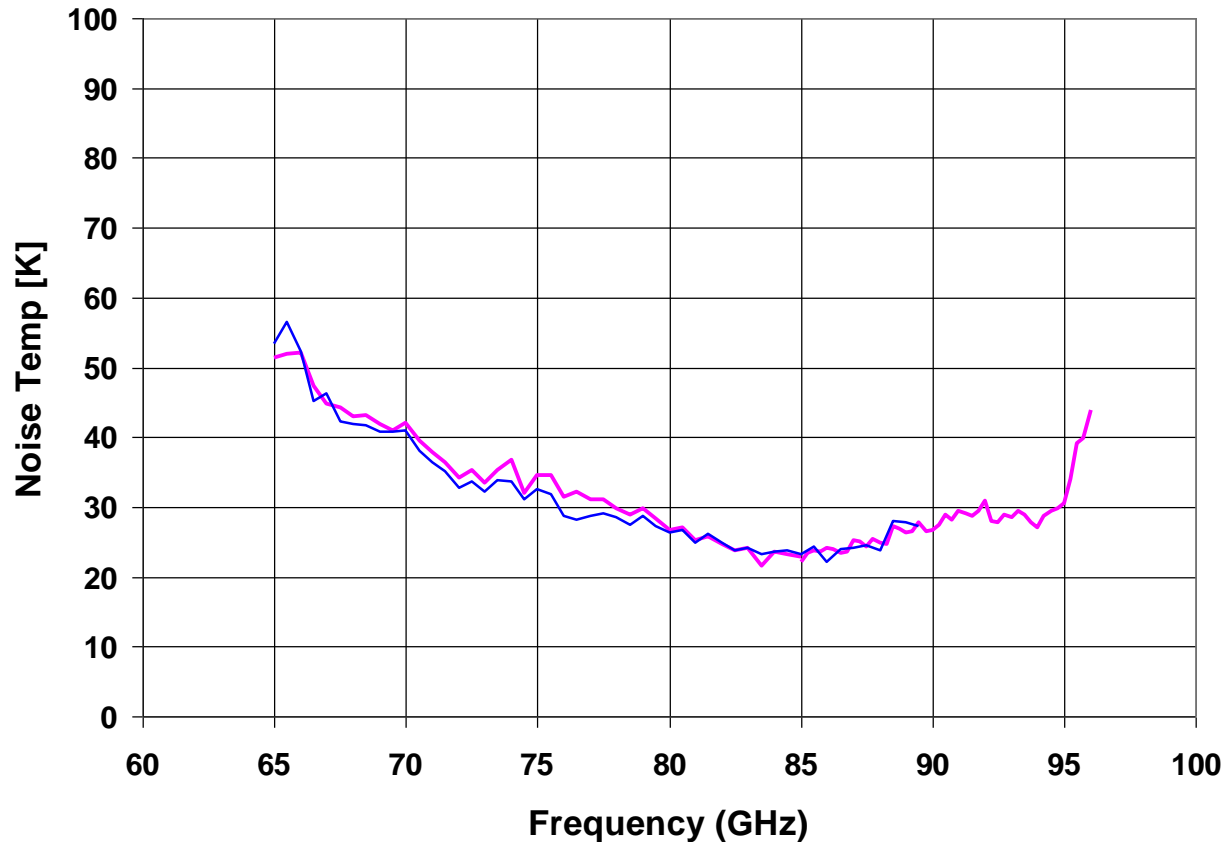


- Simulation: $G_m=2500\text{mS/mm}$, $I_{gs}=0$, $T_{\text{drain}}=1400$
- $P_{\text{diss}} = 5.55\text{mW}$



LNA Module Measurements

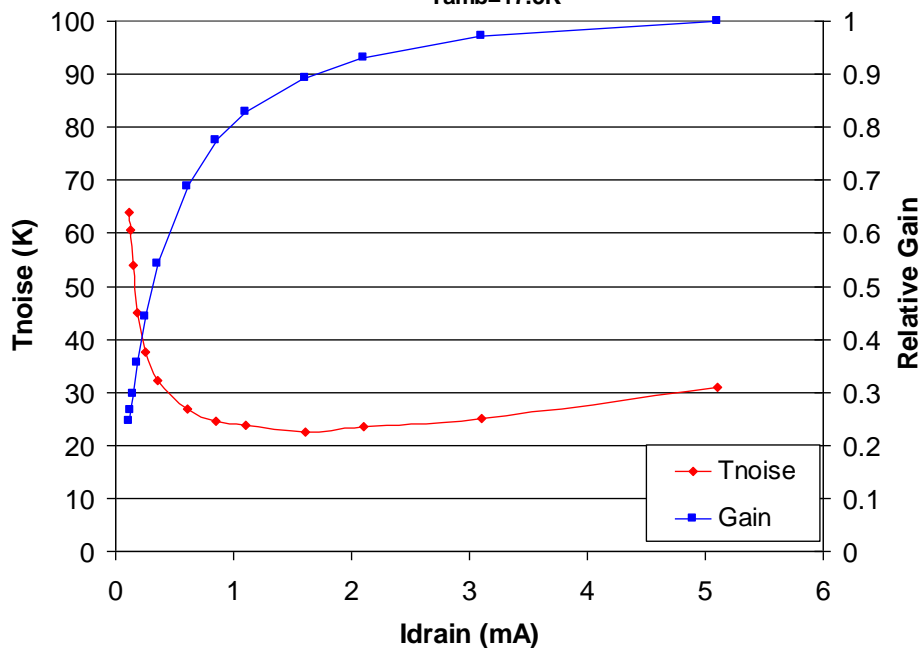
35nm 3-stage LNA (EBLNA81)



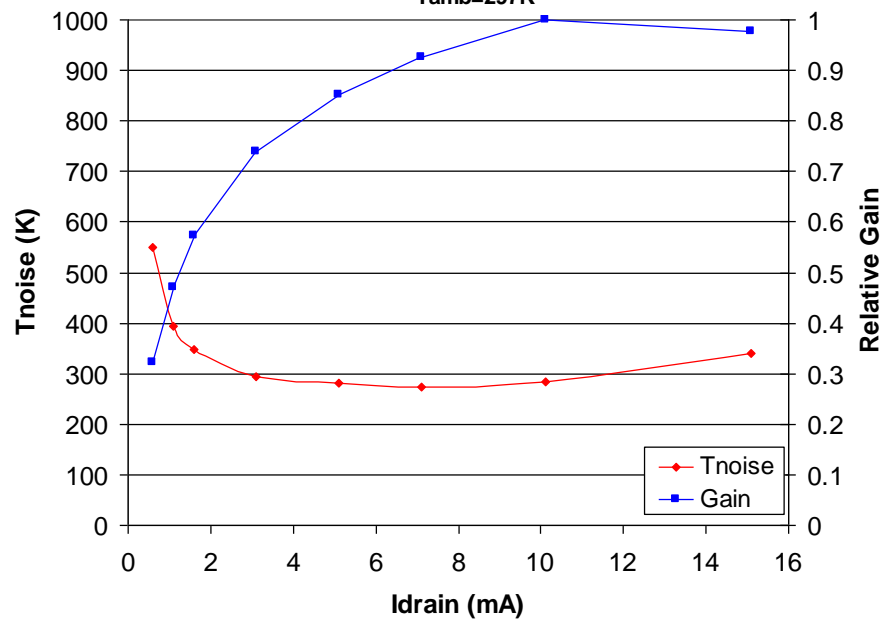
- Blue trace shows noise for minimum power dissipation: $V_{d1}=0.35V$, $V_{d23}=0.5V$, $I_d=4.5mA$ -> $P_{diss} = 2.06mW$

Pinchoff Characteristics

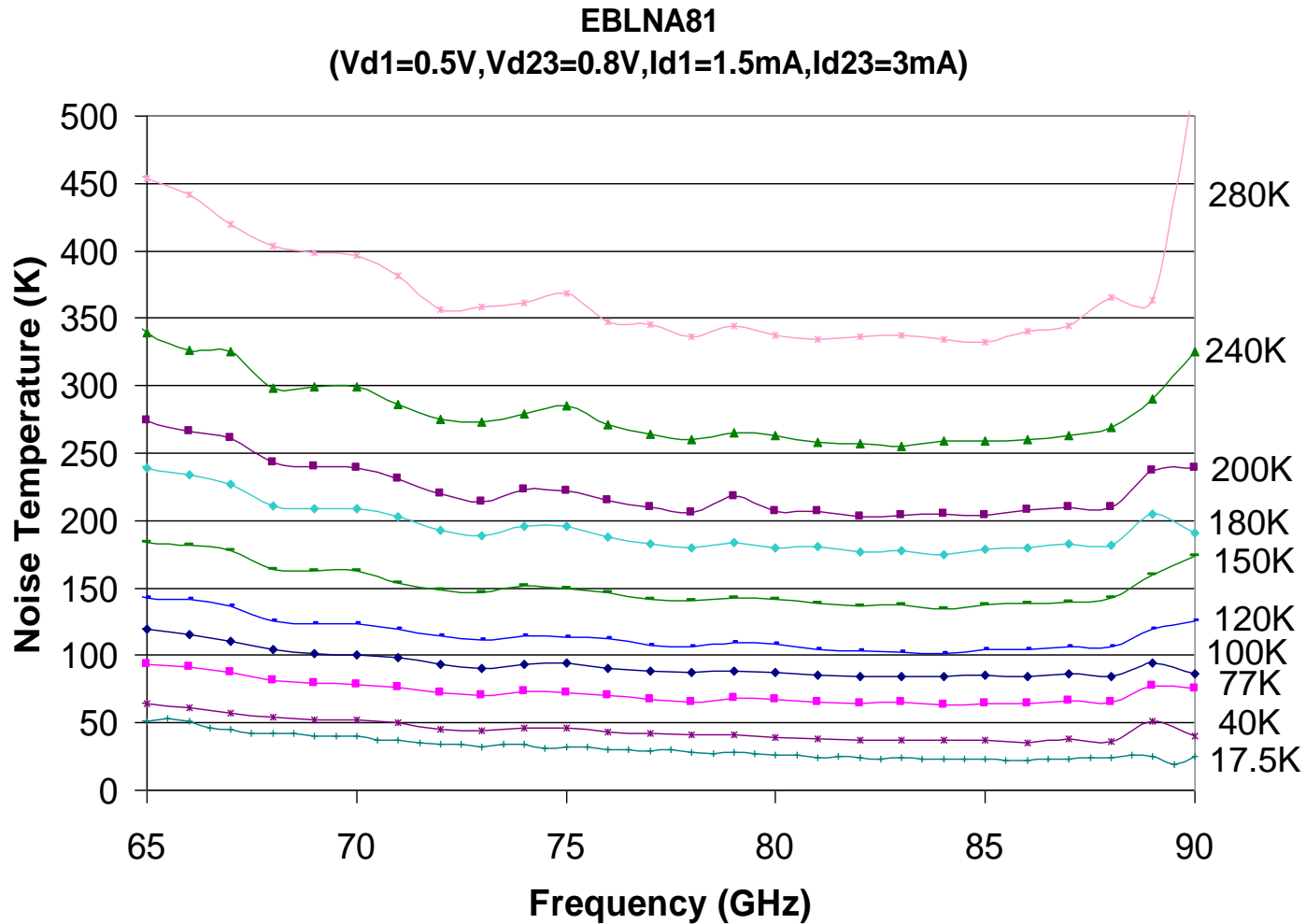
Average Tnoise from 83-87 GHz
Relative Gain at 85 GHz
Tamb=17.5K



Average Tnoise over min 4GHz
Relative Gain at 81 GHz
Tamb=297K

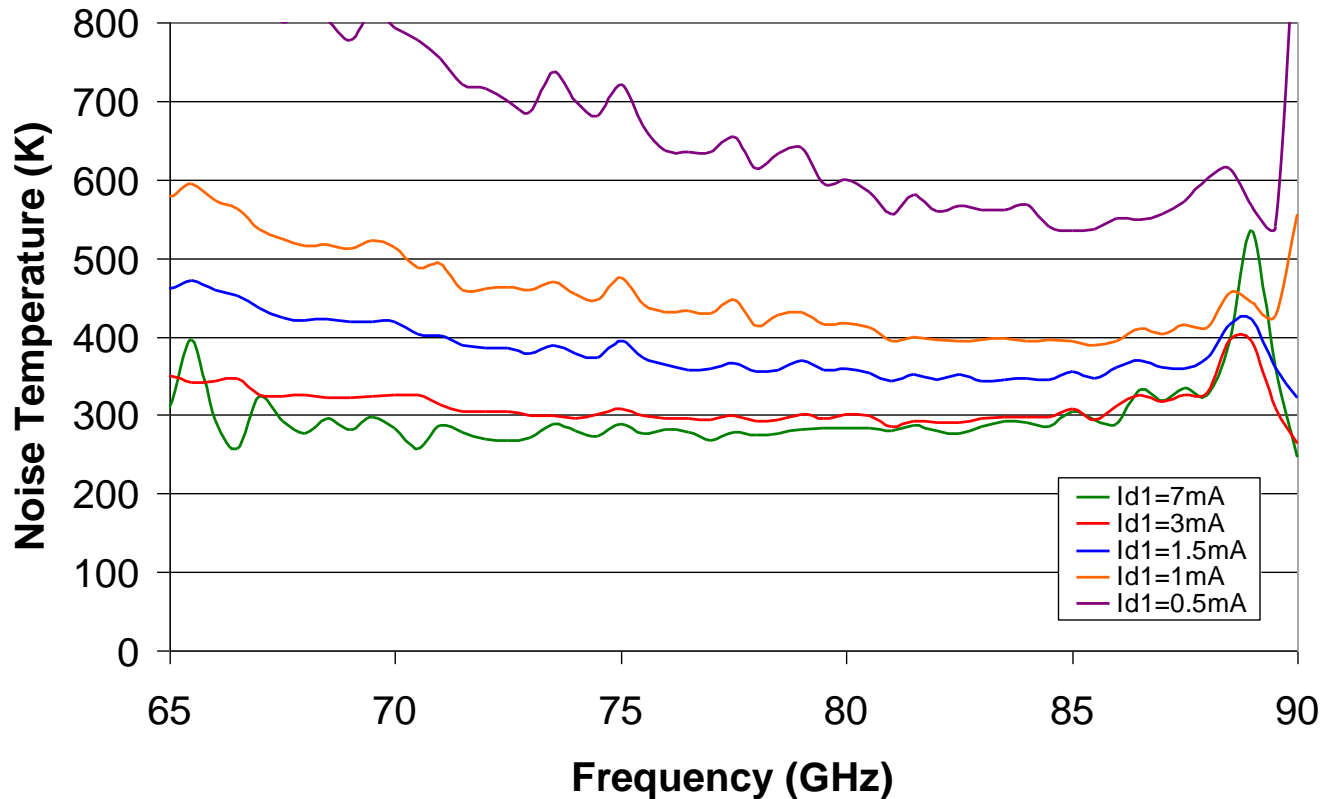


Why the frequency shift cold?



Why the frequency shift cold?

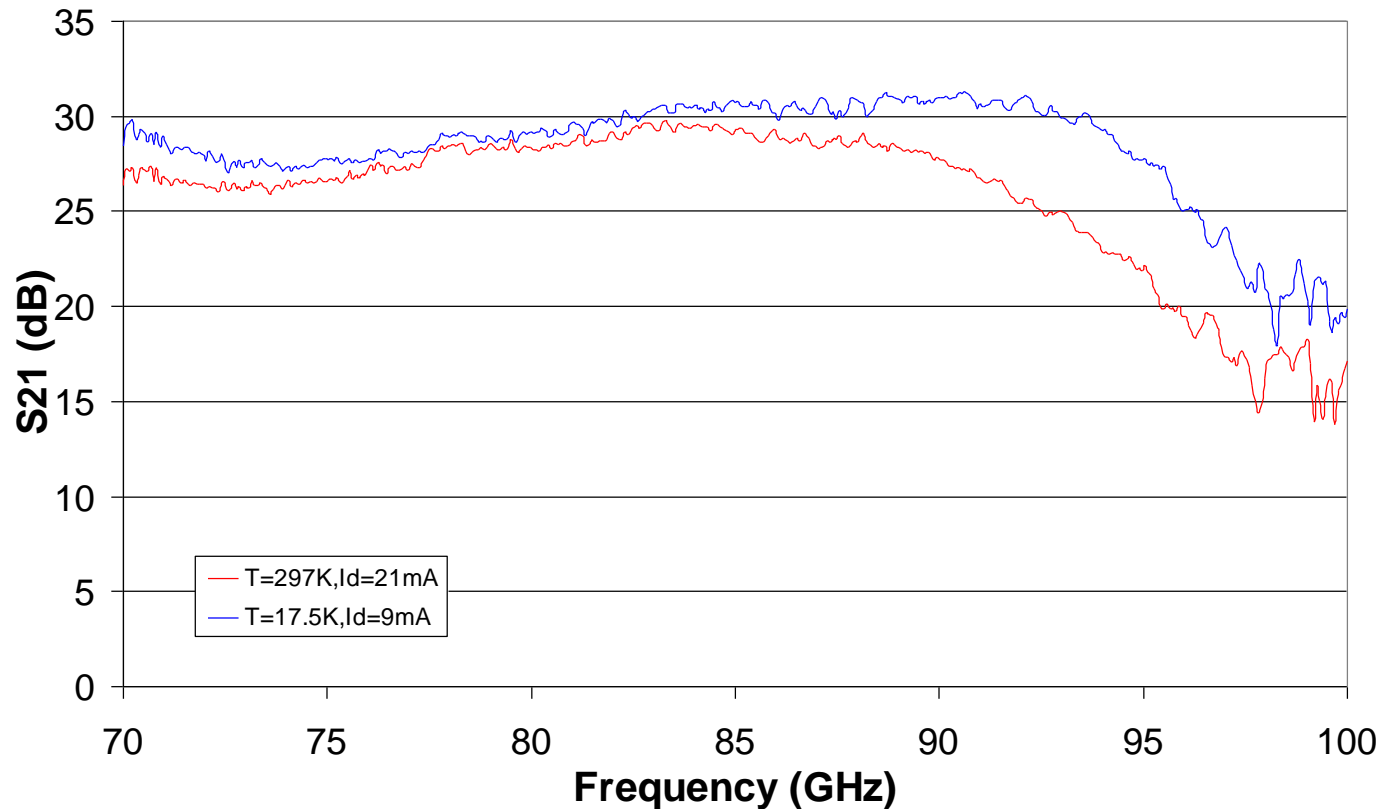
EBLNA81
($T=297\text{K}$, $V_d=0.8\text{V}$, $I_{d23}=7\text{mA}$)



- Hypothesis: $C_{gs}(V_{gs})$ is causing frequency shift

Revised cryogenic model for parasitics

EBLNA81
Vd=0.8V

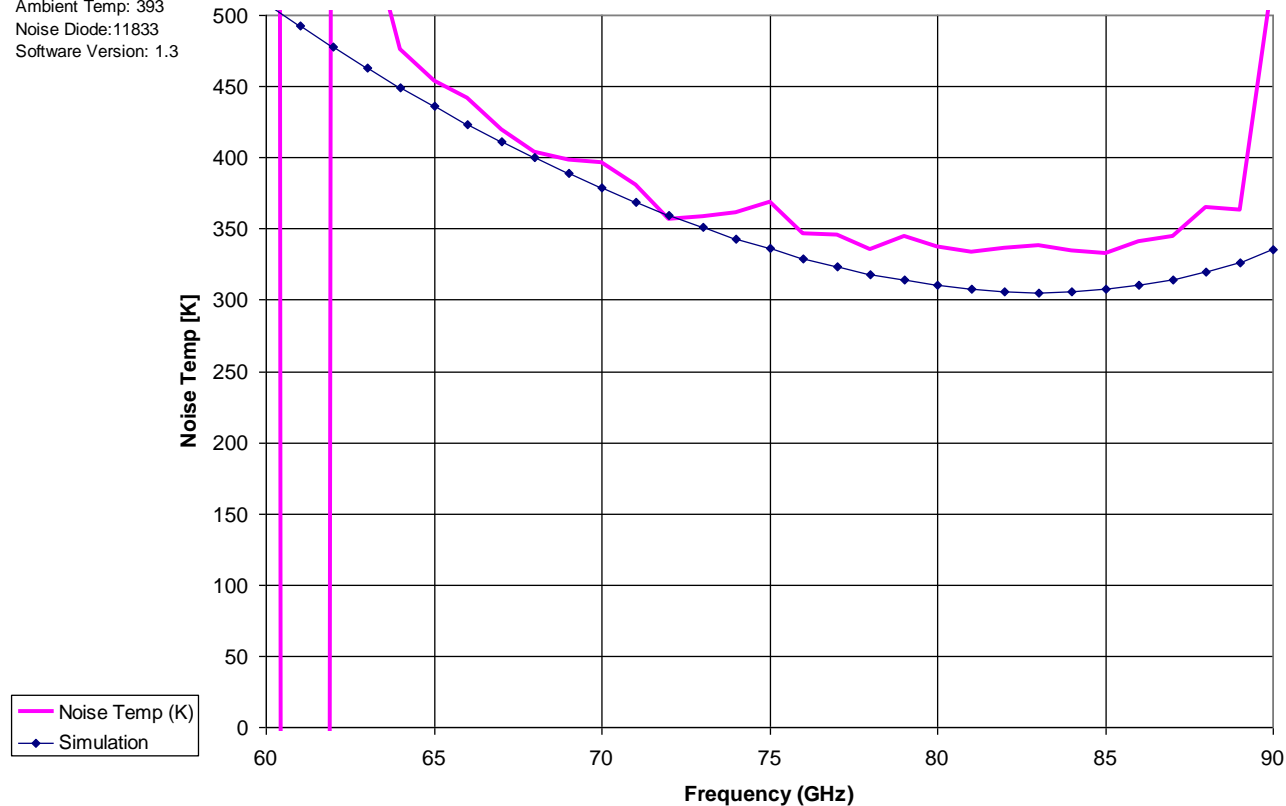


- Change in S₂₁ also modeled well by decrease in C_{gs}

Revised cryogenic model for parasitics

Amplifier ID: eb1na1
Timestamp: 7/11/2008 4:59 PM
Measured by:
Dewar Temp: 393
Ambient Temp: 393
Noise Diode: 11833
Software Version: 1.3

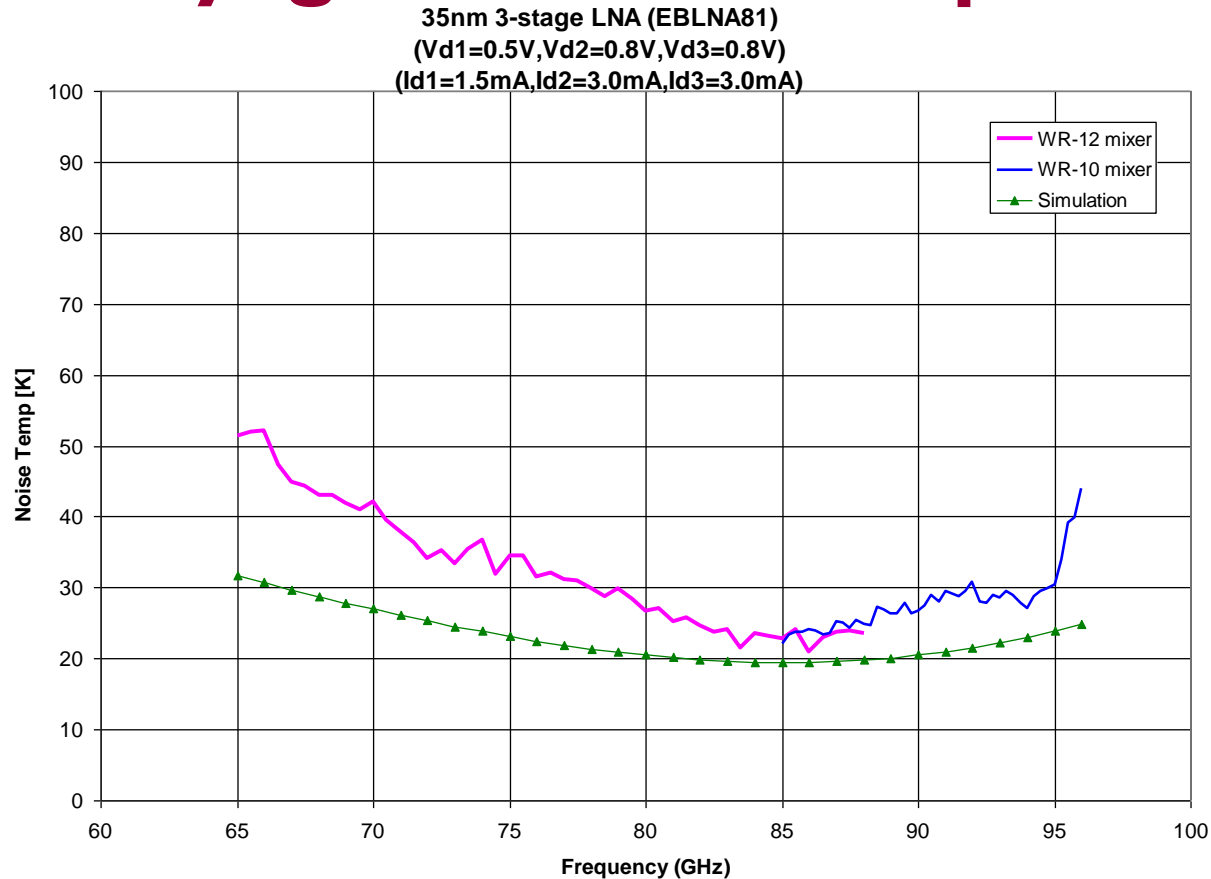
Amplifier Noise Temperature



- $I_{d1}=1.5\text{mA}$
- Simulation: $g_{m1}=33.6\text{mS}$, $g_{m23}=66.6\text{mS}$, $C_{gs1}=12.6\text{fF}$
(versus 17.5fF in original model)

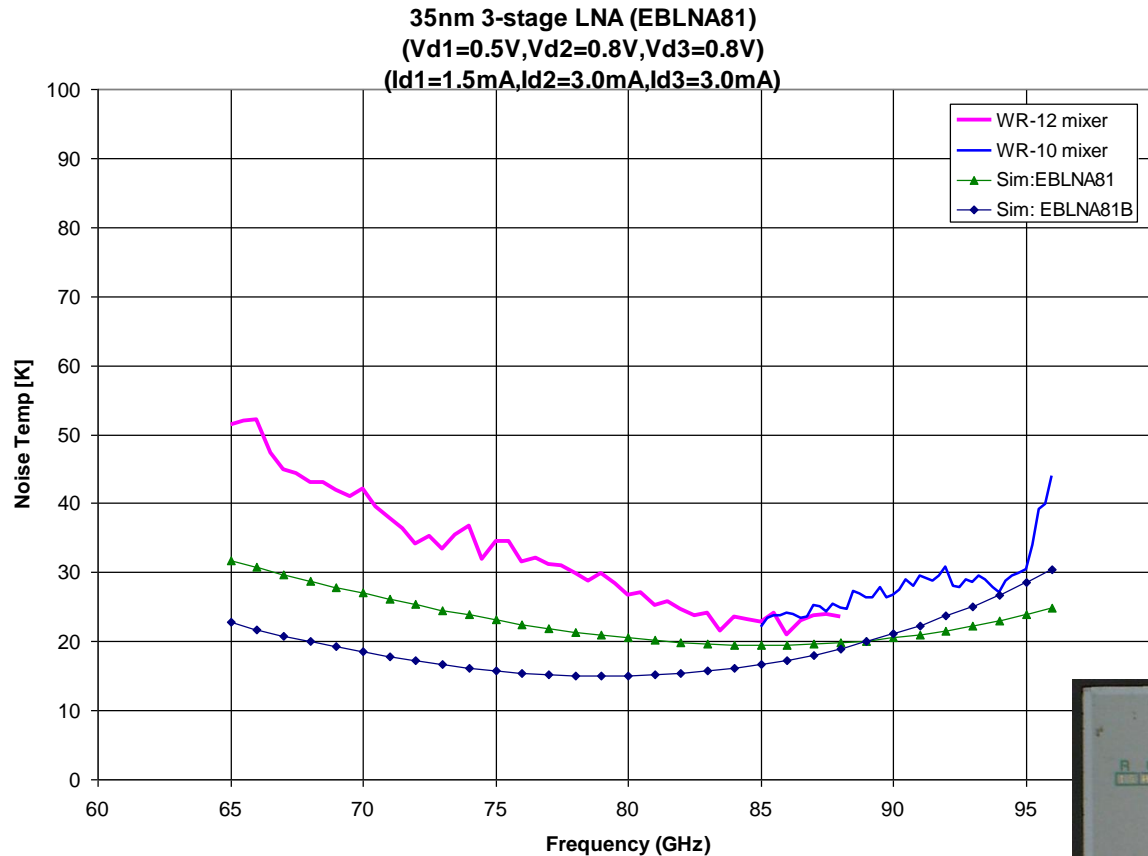


Revised cryogenic model for parasitics

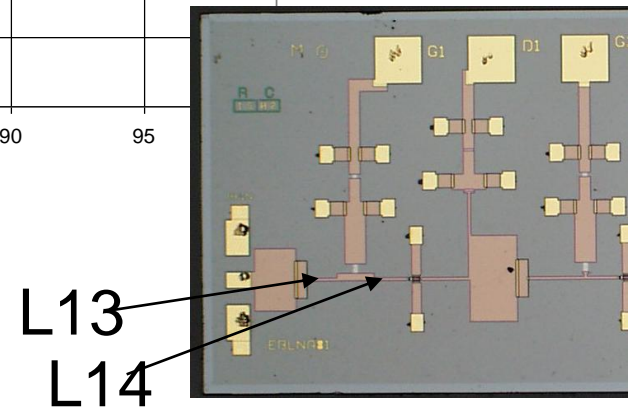


- Simulation: $G_{m1}=64\text{mS}$, $G_{m23}=90\text{mS}$, $T_{d1}=1400\text{K}$, $T_{d23}=2800\text{K}$, $C_{gs1}=12.6\text{fF}$ (compared to 17.5fF original)

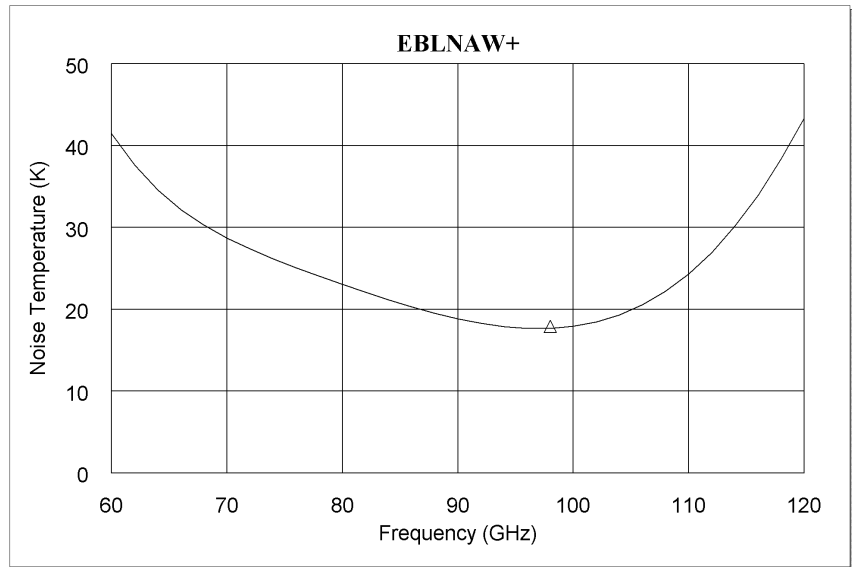
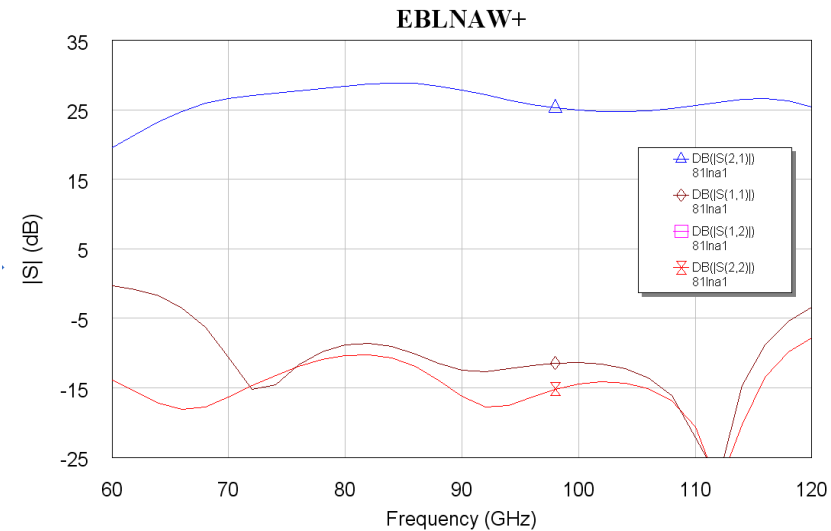
EBLNA81B: Retuned for 67-90 GHz



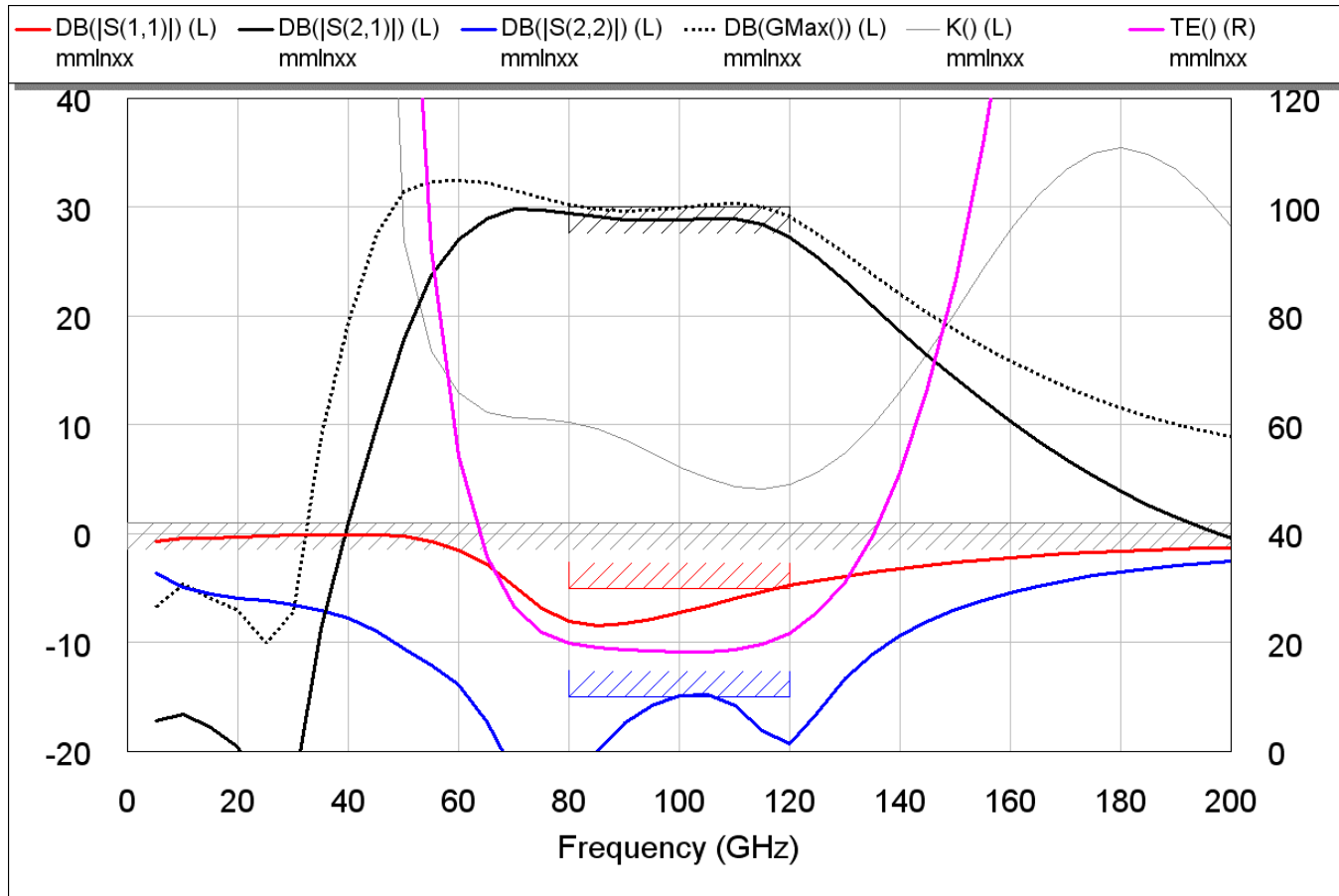
L13: 65 to 34 μ m
L14: 78 to 144 μ m



EBLNAW+: Cover full 68-116 GHz band

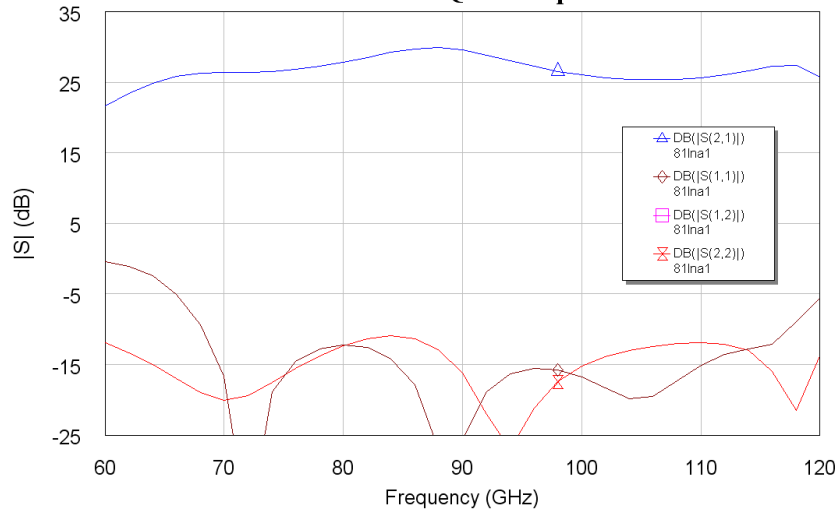


MMLN100: Cover full 68-116 GHz band

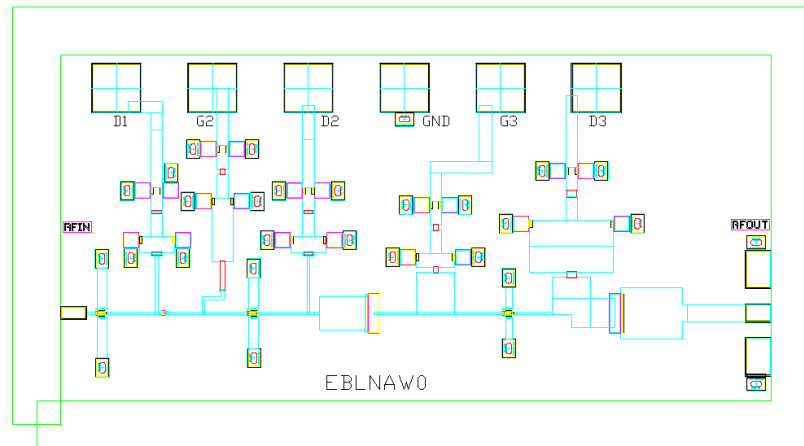
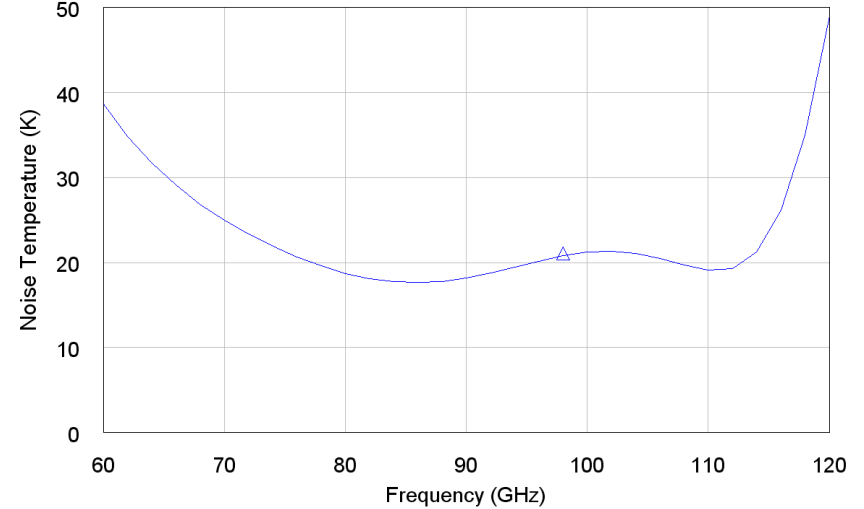


EBLNAW0: A “Tunable” MMIC LNA

EBLNAW0 with Quartz Input Match



EBLNAW0 with Quartz Input Match



Questions / Discussion Points

- Is the process repeatable?
- These results are with 70% channel, what do they look like with 100% channel (higher gm)?
- Operation at 4K
- Ultimate limit for W-band LNA noise temperature
- Comparison to SIS development