RF Microelectronics

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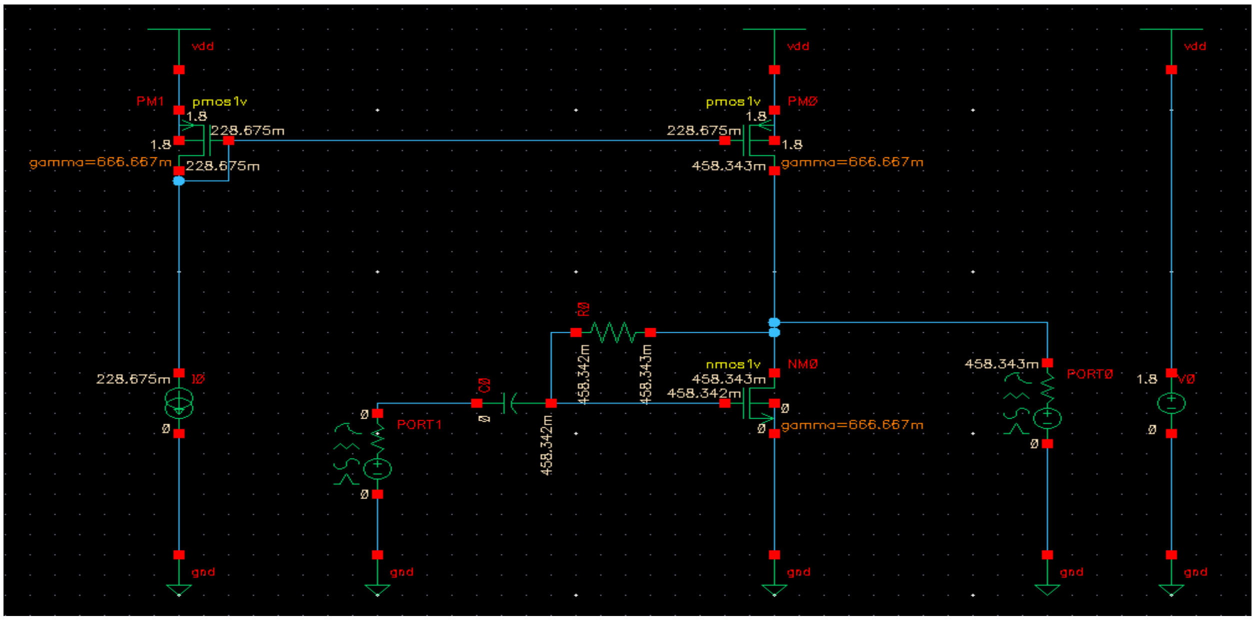
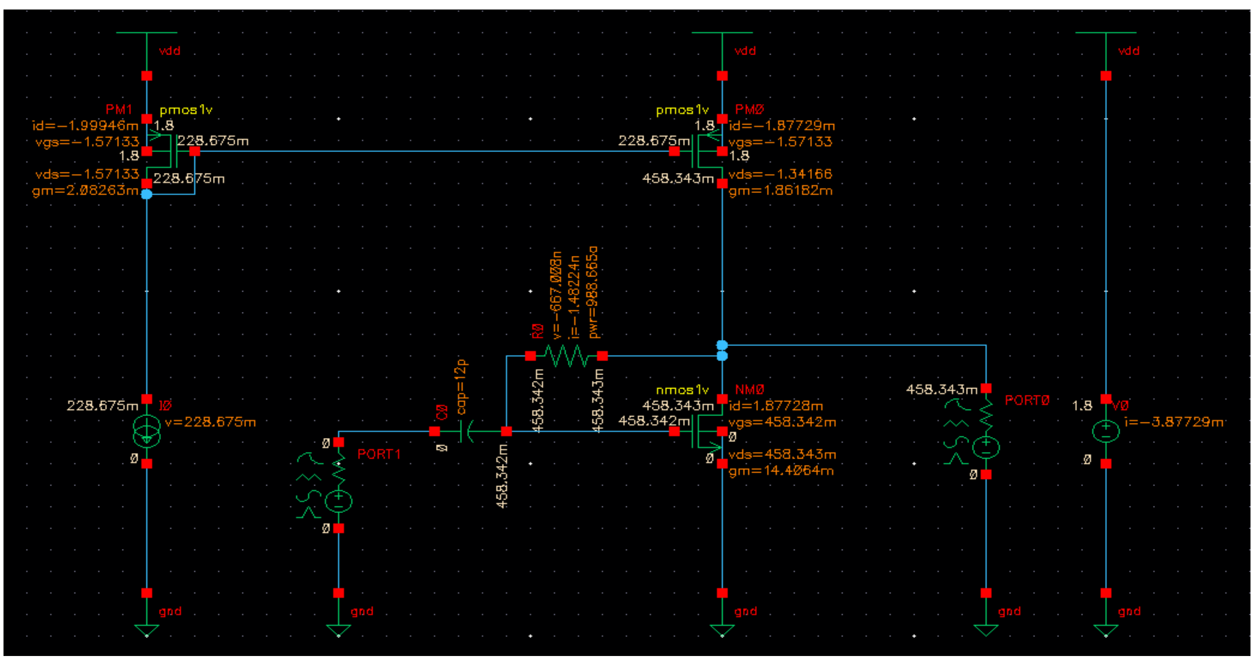
LNA

Schematic



Part (A)

DC Analysis



****
DC Analysis `dcOp'
****

Opening the PSF file ../psf/dcOp.dc ...
Important parameter values:
    reltol = 1e-03
    abstol(V) = 1 uV
    abstol(I) = 1 pA
    temp = 27 C
    tnom = 27 C
    tempeffects = all
    gmindc = 1 pS
Convergence achieved in 6 iterations.
Total time required for dc analysis `dcOp': CPU = 1.999 ms, elapsed = 2.61998 ms.
Time accumulated: CPU = 140.977 ms, elapsed = 679.158 ms.
Peak resident memory used = 53.6 Mbytes.

dcOpInfo: writing operating point information to rawfile.

Opening the PSF file ../psf/dcOpInfo.info ...
modelParameter: writing model parameter values to rawfile.

Opening the PSF file ../psf/modelParameter.info ...
element: writing instance parameter values to rawfile.

Opening the PSF file ../psf/element.info ...
outputParameter: writing output parameter values to rawfile.

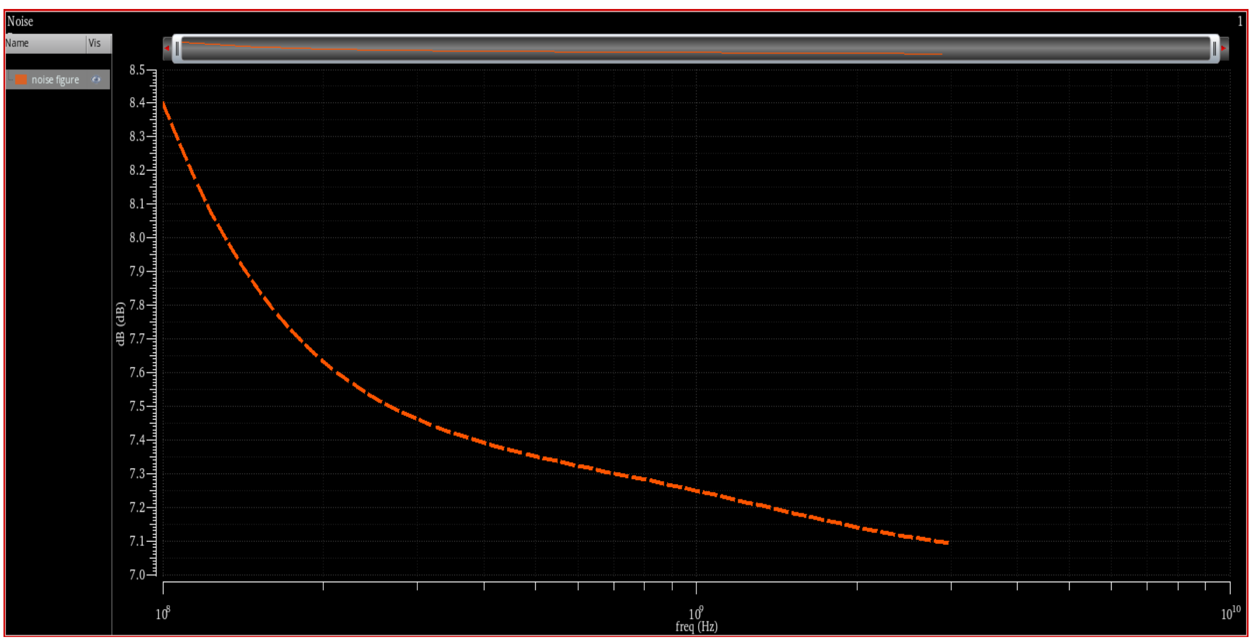
Opening the PSF file ../psf/outputParameter.info ...
designParamVals: writing netlist parameters to rawfile.

Opening the PSFASCII file ../psf/designParamVals.info ...
primitives: writing primitives to rawfile.

Opening the PSFASCII file ../psf/primitives.info.primitives ...
subckts: writing subcircuits to rawfile.

Opening the PSFASCII file ../psf/subckts.info.subckts ...

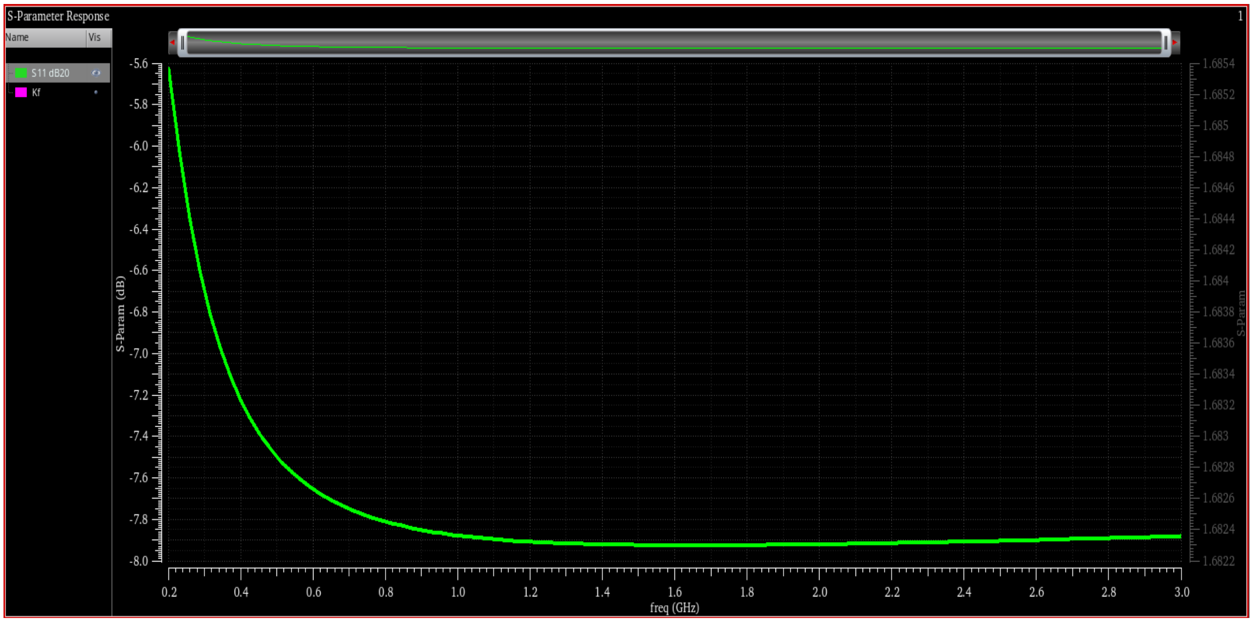
NF



Noise Figure

- The Noise Figure (NF) starts at around 8.4 dB at low frequencies (100 MHz) and gradually decreases, reaching just above 7.0 dB at higher frequencies (~10 GHz).
- This NF value is relatively high for an LNA. A good LNA typically has NF < 3 dB.
- The high NF suggests non-ideal matching, possibly excessive noise contribution from the resistive feedback or poor transistor sizing.
- Since NF improves with frequency, this LNA might perform better at higher GHz ranges, but optimization is still needed.
- As frequency increases,The matching network starts to better match the source impedance to the input of the transistor.
- Good matching = less signal reflection = less added noise, hence lower NF,This often happens around the frequency where the matching was optimized (likely mid to high frequencies in your case

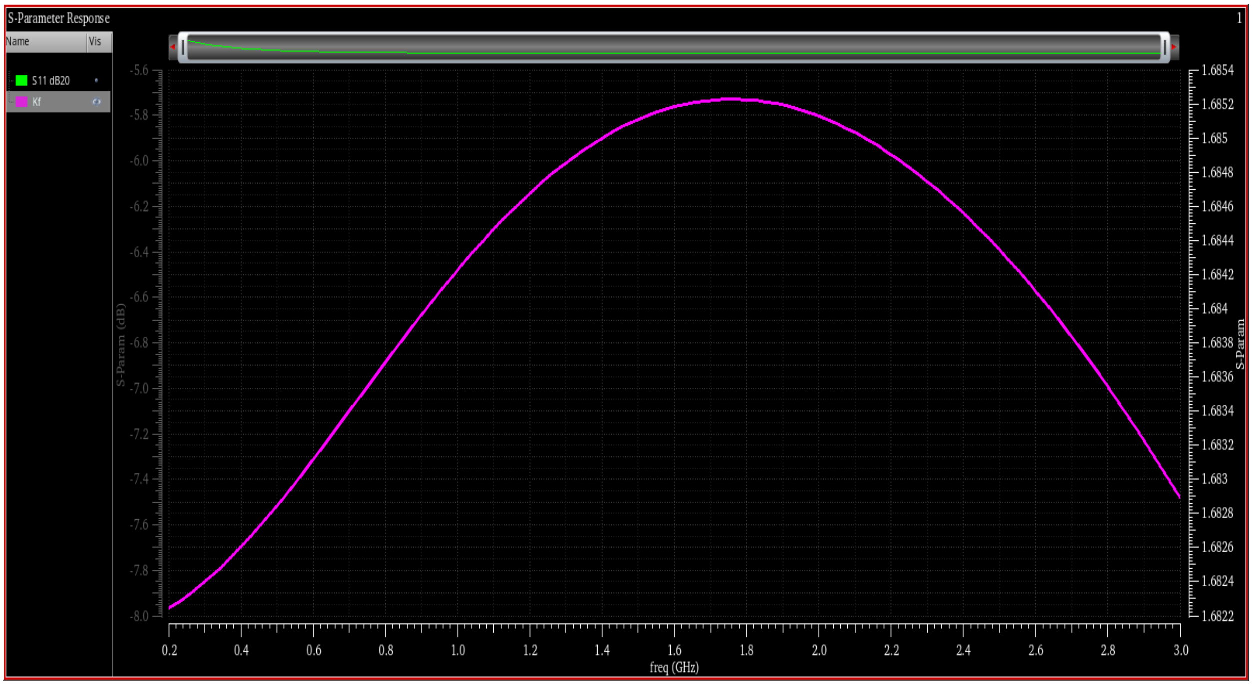
S11



S11 (Return Loss):

- The curve labeled S11 dB20 shows how much of the input signal is reflected back.
- S11 ranges roughly between -8 dB to -5.6 dB, which indicates a moderate impedance match at the input.
- A good match usually means S11 < -10 dB, so we can improve more for matching

Kf



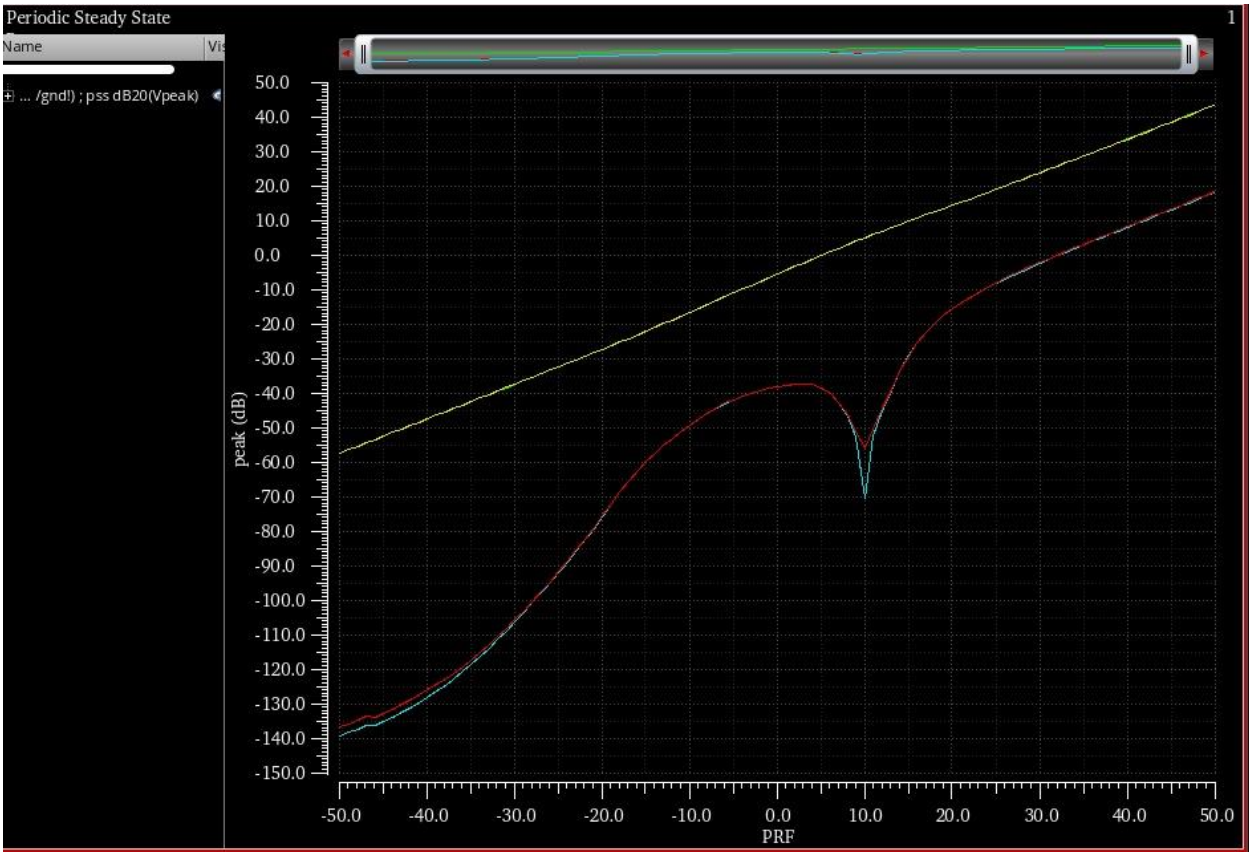
- **Kf (Stability Factor):**

The stability factor (Kf) is greater than 1 across the entire frequency range (100 MHz to 3 GHz), indicating that the LNA is unconditionally stable.This is a good result and expected with resistive feedback.

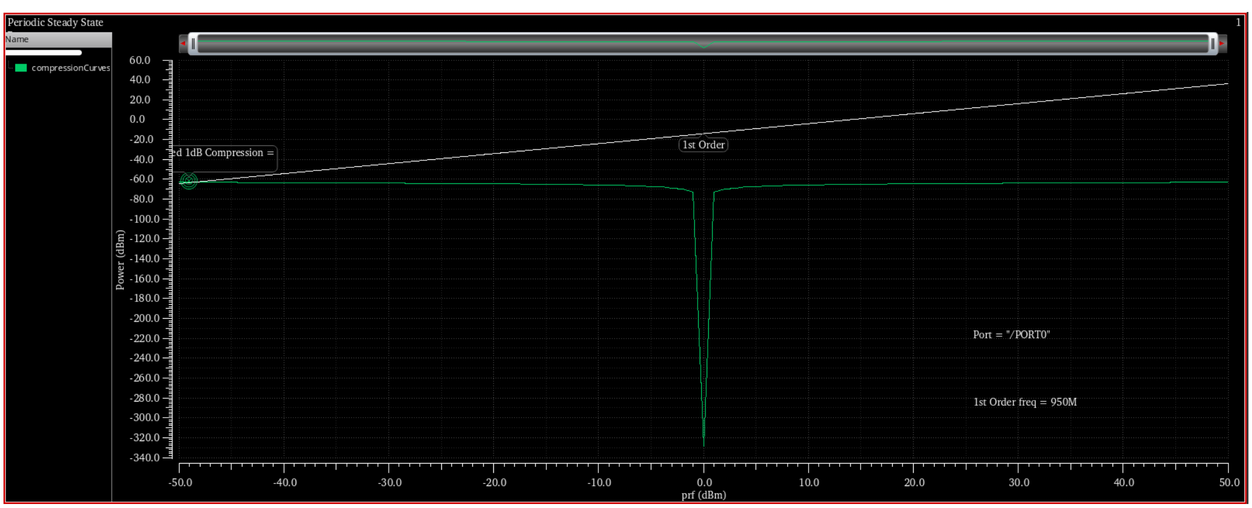
- We are using **resistive feedback**, which **improves stability** This feedback becomes **more effective** at mid frequencies, where reactive (capacitive/inductive) effects are not dominating yet.As a result, **Kf increases** significantly in that region

Part (B):

IIP3 for the LNA graphically

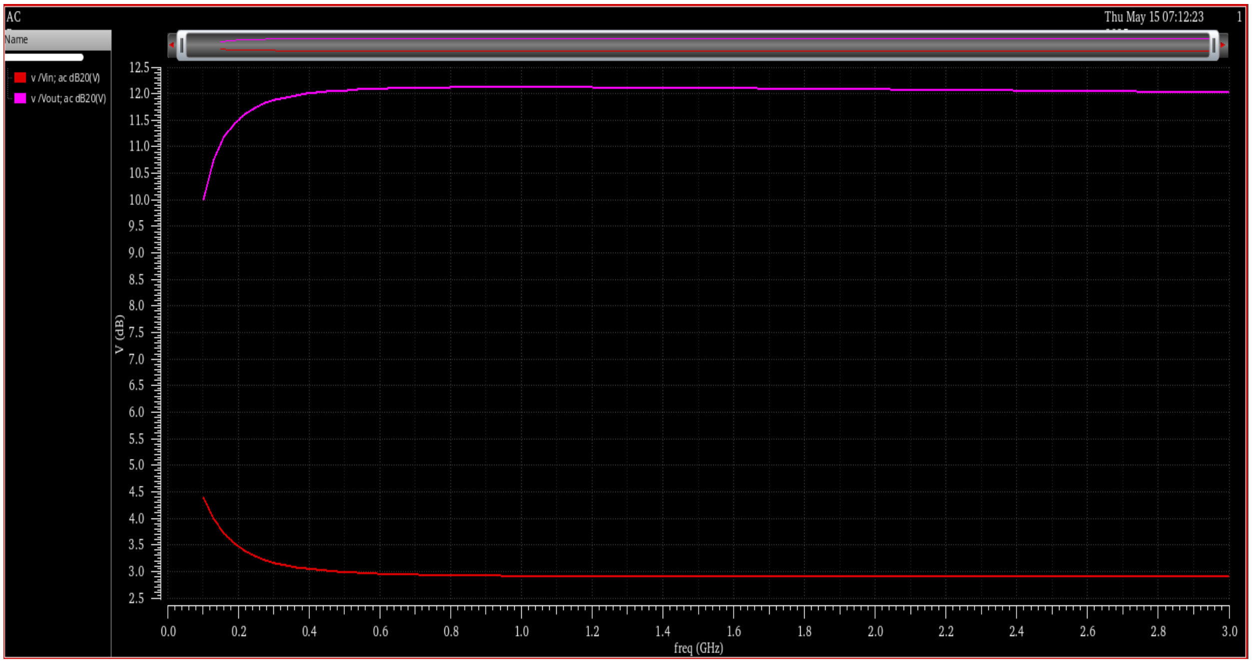


A1dB point

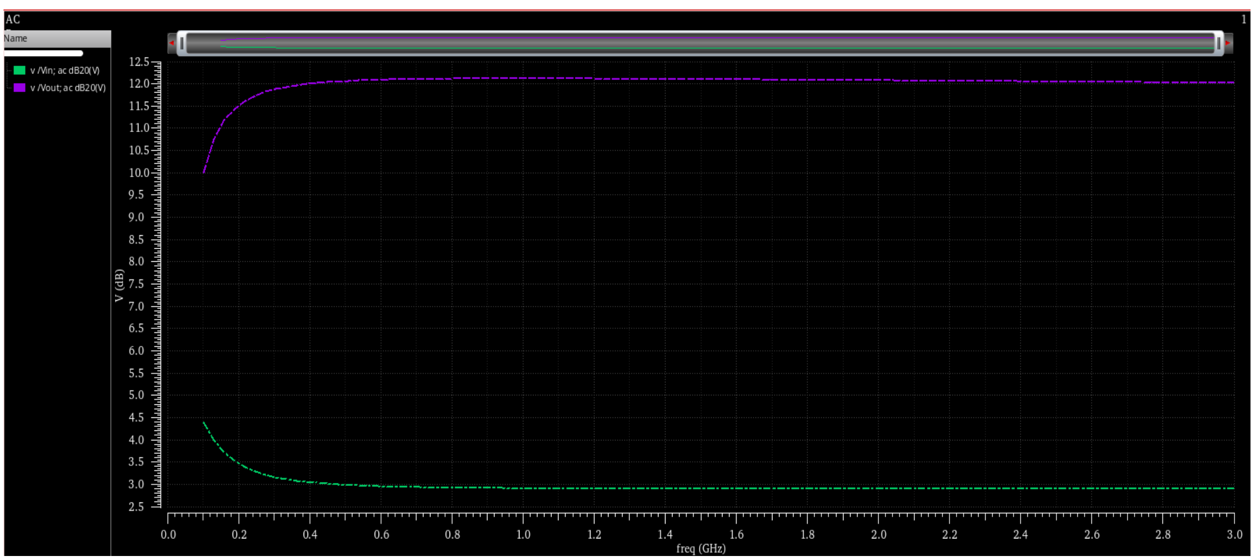


For gain simulation:

With cap



Without cap

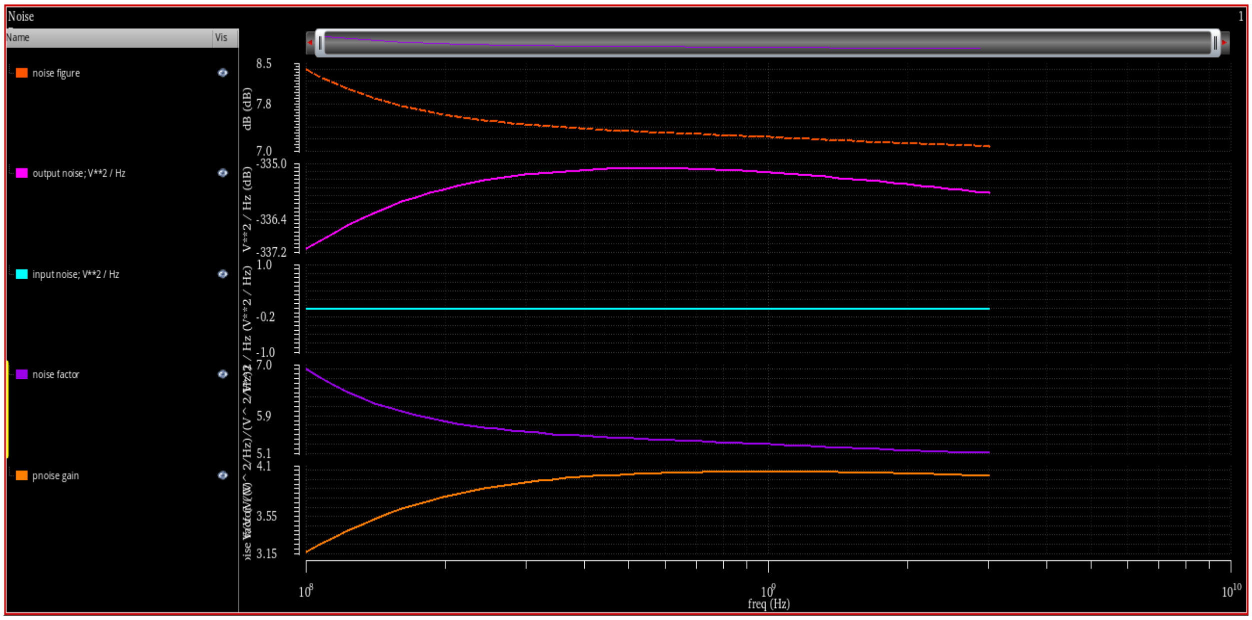


Q. Comment on your results. Comment on the results after adding a capacitor

The gain shows a flat midband region, indicating good amplifier performance over a wide frequency range. The gain rolls off at high frequencies due to parasitic capacitances and intrinsic limitations of the active device.

After adding a 100 fF capacitor at the output, the gain bandwidth product decreases. The gain starts to drop earlier due to increased output loading, forming a low-pass filter with the output impedance. This shows the trade-off between load capacitance and frequency response in amplifier design.

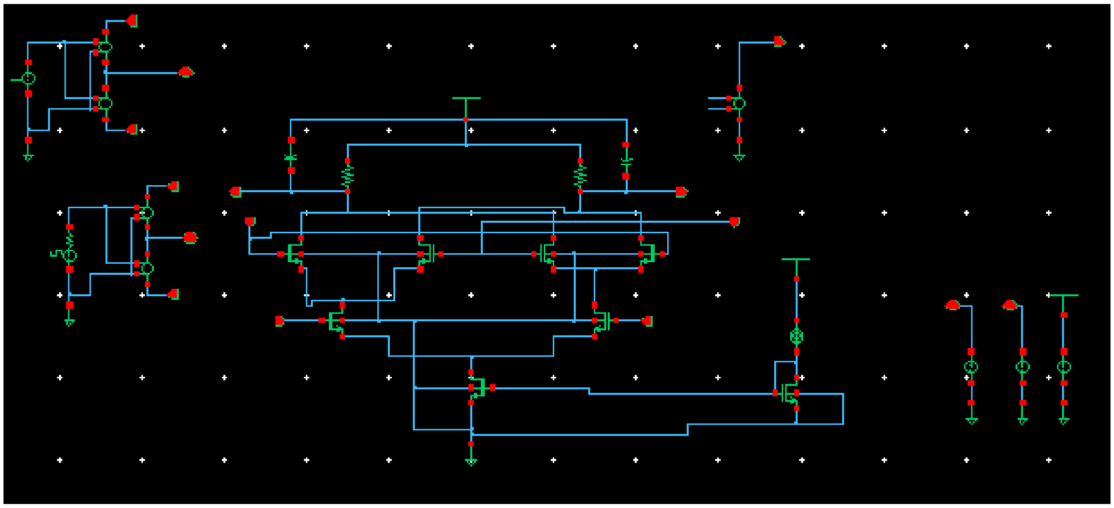
Noise analysis :-



Lab 5

Mixer

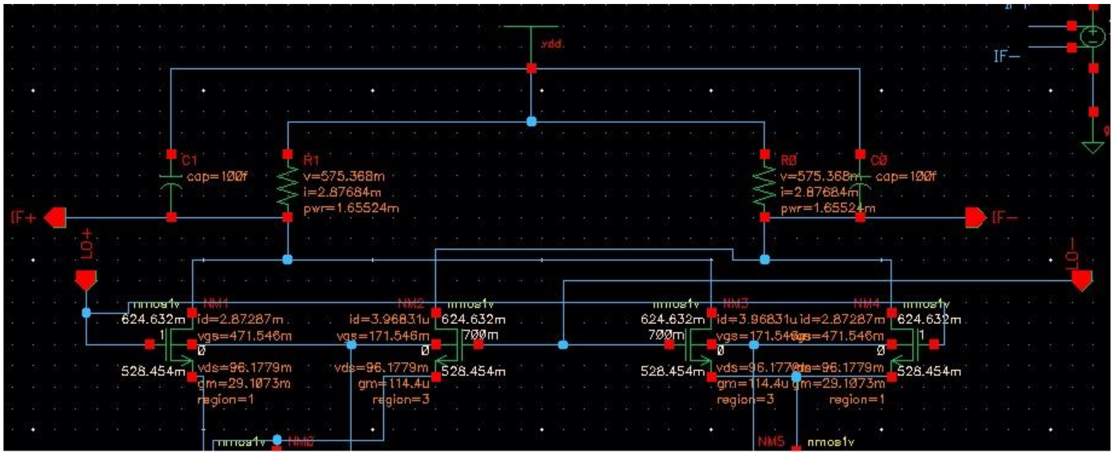
Circuit:

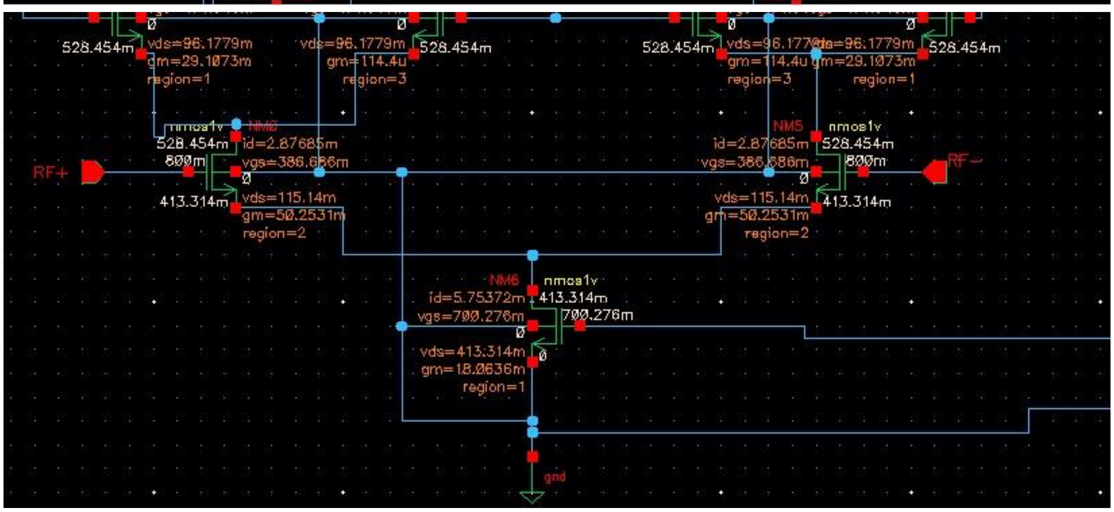


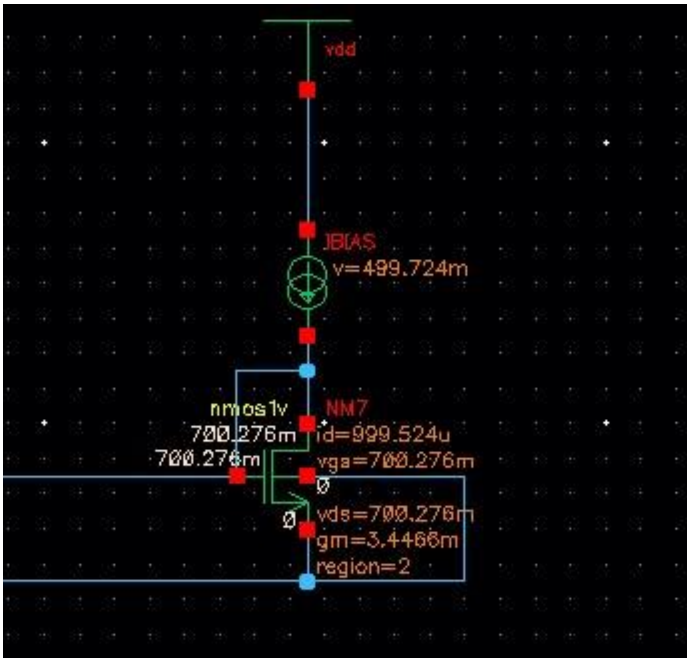
Q1) Describe the operation of the Gilbert cell as a down-conversion mixer.

The Gilbert cell, used as a down-conversion mixer, multiplies a differential RF input signal with a local oscillator (LO) signal through a cross-coupled transistor switching stage. The RF signal is converted to a differential current, modulated by the LO, producing an intermediate frequency (IF) output at |f_RF - f_LO|. The differential structure ensures good linearity, LO-to-RF isolation, and conversion gain. A filter selects the desired IF signal while suppressing unwanted frequencies.

1-DC Analysis

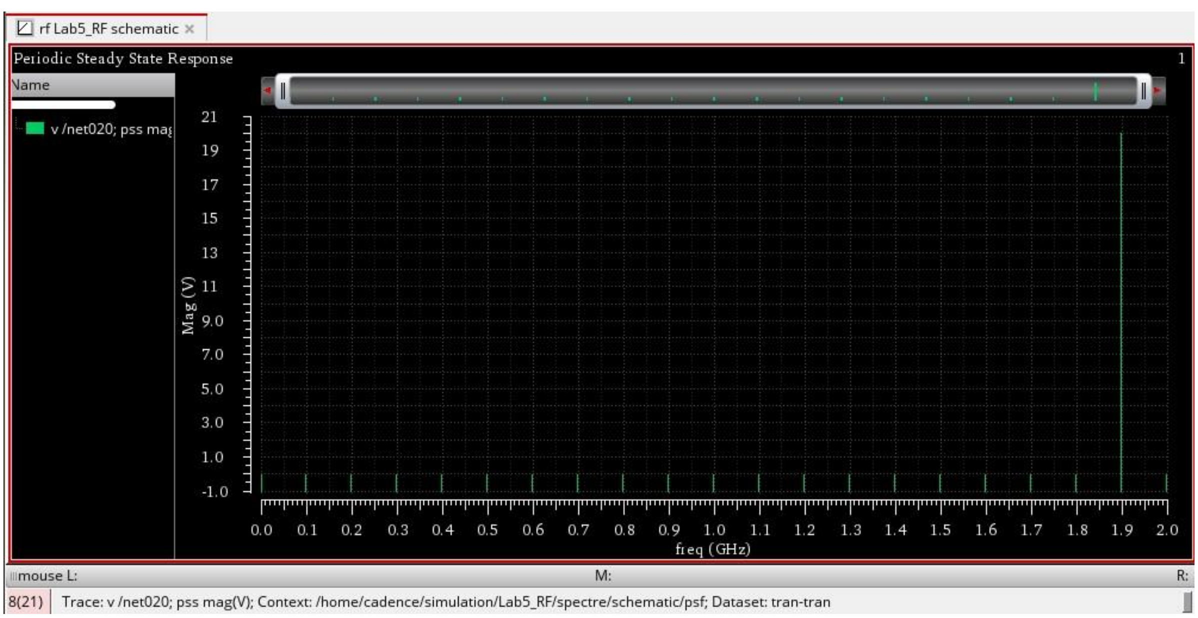




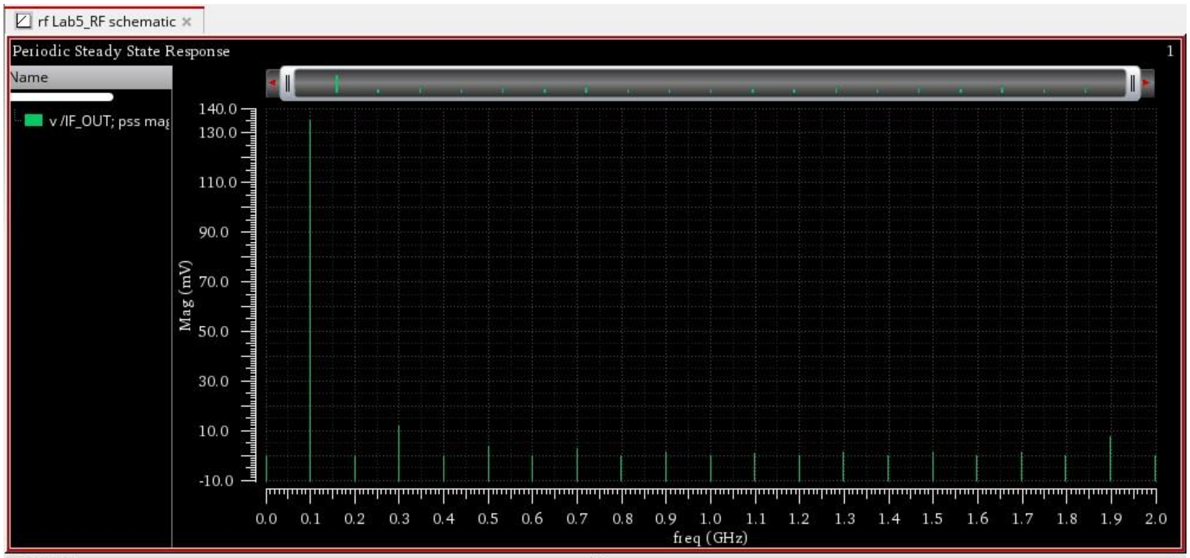


<u>4-pss_sim_magnitude_curves:</u>

-port0



-IF_OUT



Q2) Explain the result.

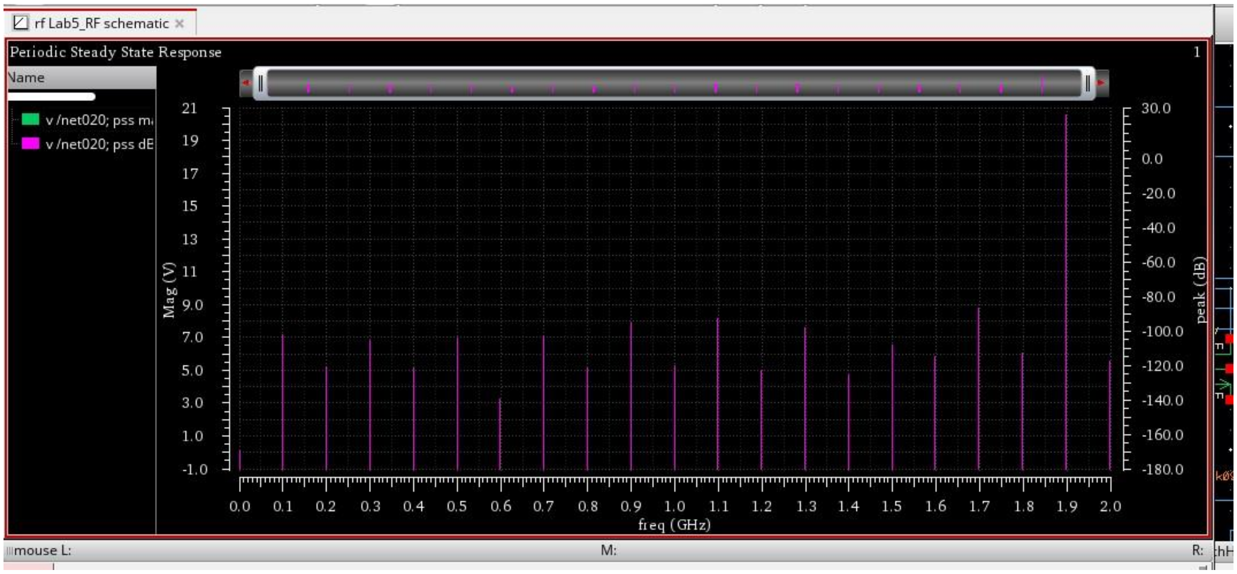
For first graph we can see the main component at frequency 1.9GHz which is the frequency we set for the port

For second graph we see a main component at frequency 100MHz which we used to be the IF frequency in the simulation and it represents the mixer output after mixing the port with the pulse source .

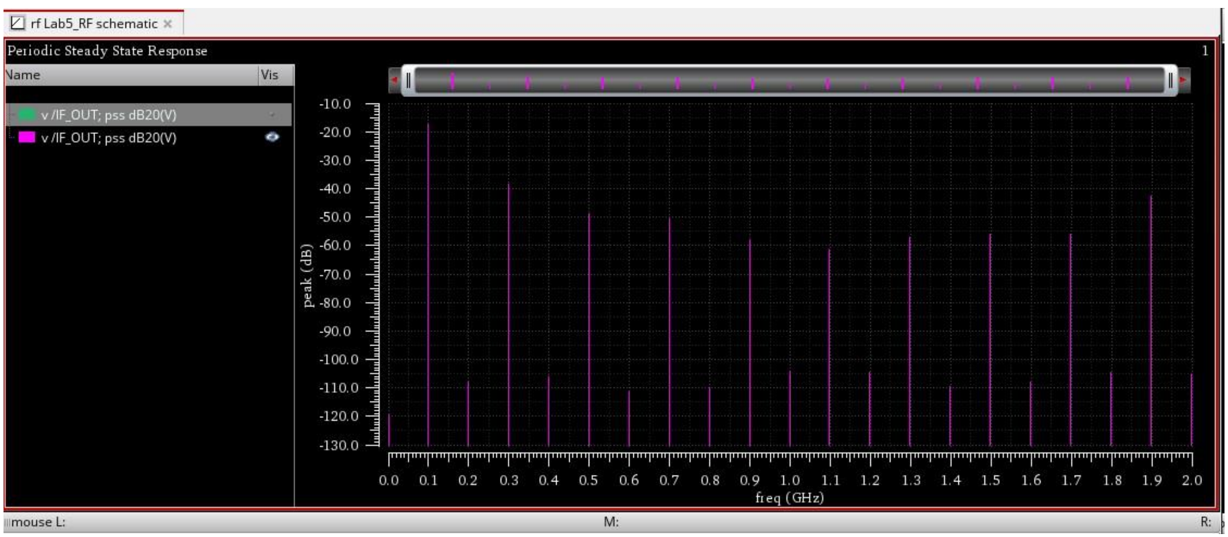
We can notice that the output signal is attenuated so we will have negative conversion gain.

<u>5-pss_sim_dB_curves:</u>

-port0

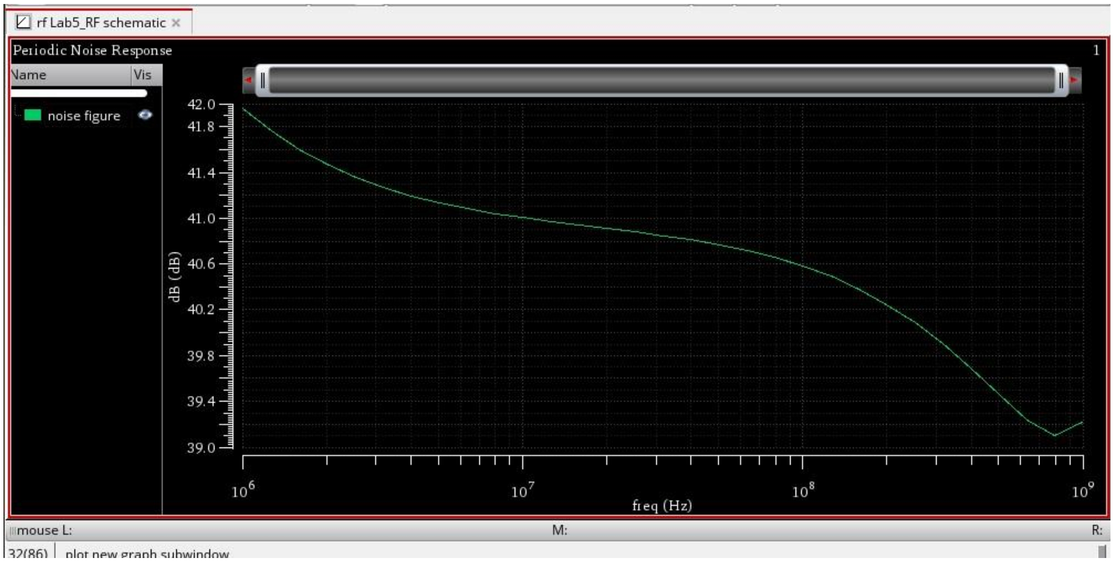


-IF_OUT



Conversion gain = -16 dB – 30 dB = -46 dB

6- noise figure :



Q4) Is the shape of the NF Vs. frequency plot what you expect? What is missing in the noise analysis?

(a) Yes, the general shape of the noise figure vs. frequency plot is expected for a CMOS Gilbert-cell mixer.

At low frequencies (around 1 MHz), the NF is high (~42 dB), which is common due to flicker noise that dominates at low frequencies.

As the frequency increases the flicker noise's effect decrease and thermal noise becomes more dominant .

(b) What is missing in the noise analysis?

1-LO Noise Contribution

2-Parasitic Effects and Layout-Dependent Noise

3-Mismatch and Process Variations

4-Non-Idealities in Biasing