ECE 414
RF Circuit Design
PROJECT

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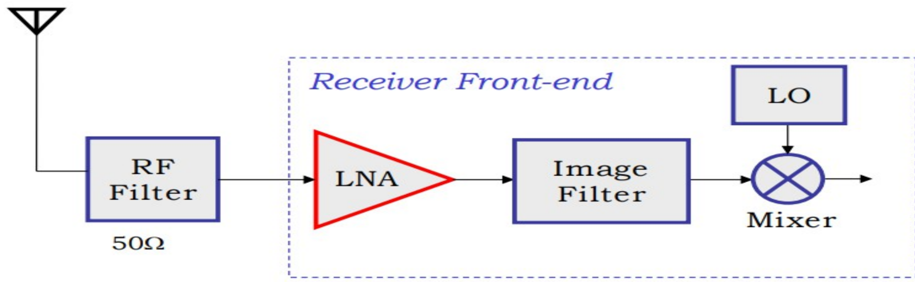
DESIGN PROBLEM:



This project focuses on designing and simulating a complete **RF receiver front-end**, which includes **a Low Noise Amplifier (LNA)** followed by **a double-balanced active mixer**. The system is designed to operate at the **2.4 GHz** ISM band, a common frequency range for wireless communication standards such as Wi-Fi and Bluetooth.

The LNA is responsible for amplifying weak RF signals with minimal added noise. It is designed to achieve a **voltage gain greater than 15 dB**, **a noise figure below 2 dB**, and **input matching with S11 better than −10 dB**.

The mixer performs frequency down conversion, translating the RF signal to an intermediate frequency (IF). It targets **a conversion gain above 12 dB**, **a noise figure below 5 dB**, and **high linearity, measured by IIP3 and IP1dB**, to handle strong interfering signals without distortion.

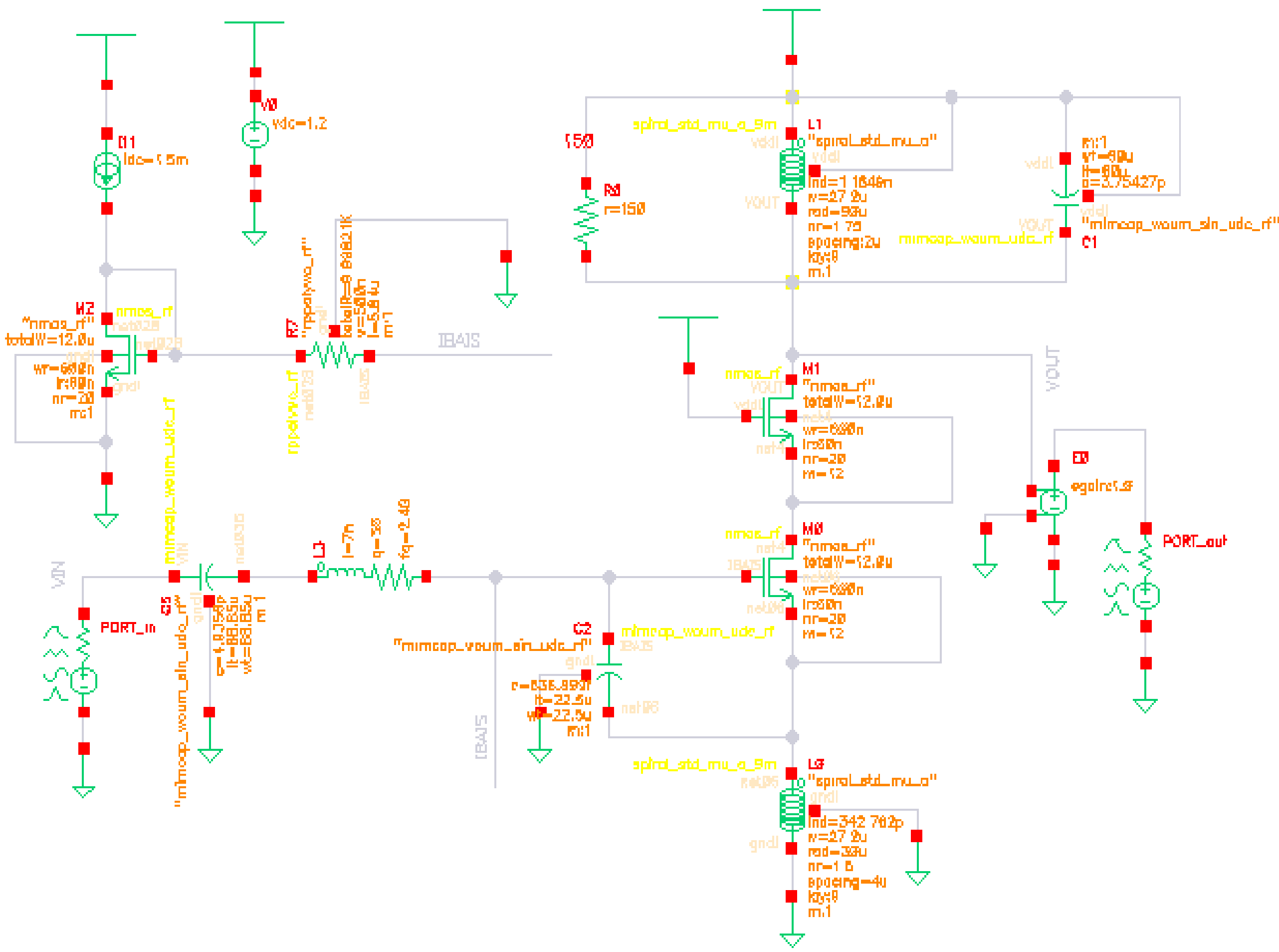
The entire system is implemented using **tsmc60nm** RF CMOS technology within the Cadence Virtuoso design environment. All active and passive components are selected from the tsmc PDK to ensure compatibility with real-world fabrication constraints.

The final goal is to integrate the LNA and mixer into a complete receiver chain and verify the combined performance. This includes total gain, overall noise figure, and system linearity to ensure the design meets all specified requirements.

PART 1 (LNA DESIGN):

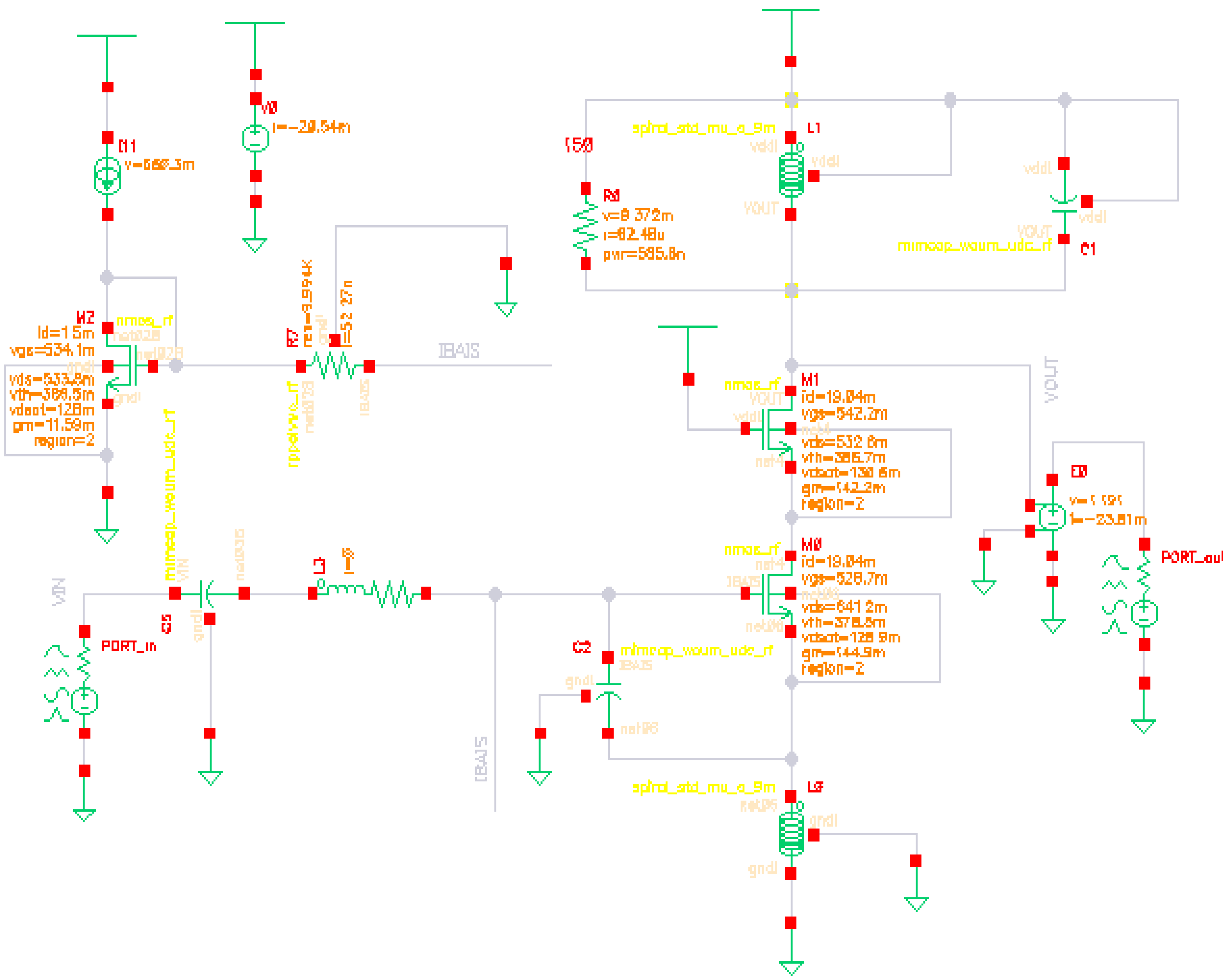
"inductive-degenerated LNA"

SCHEMATIC :

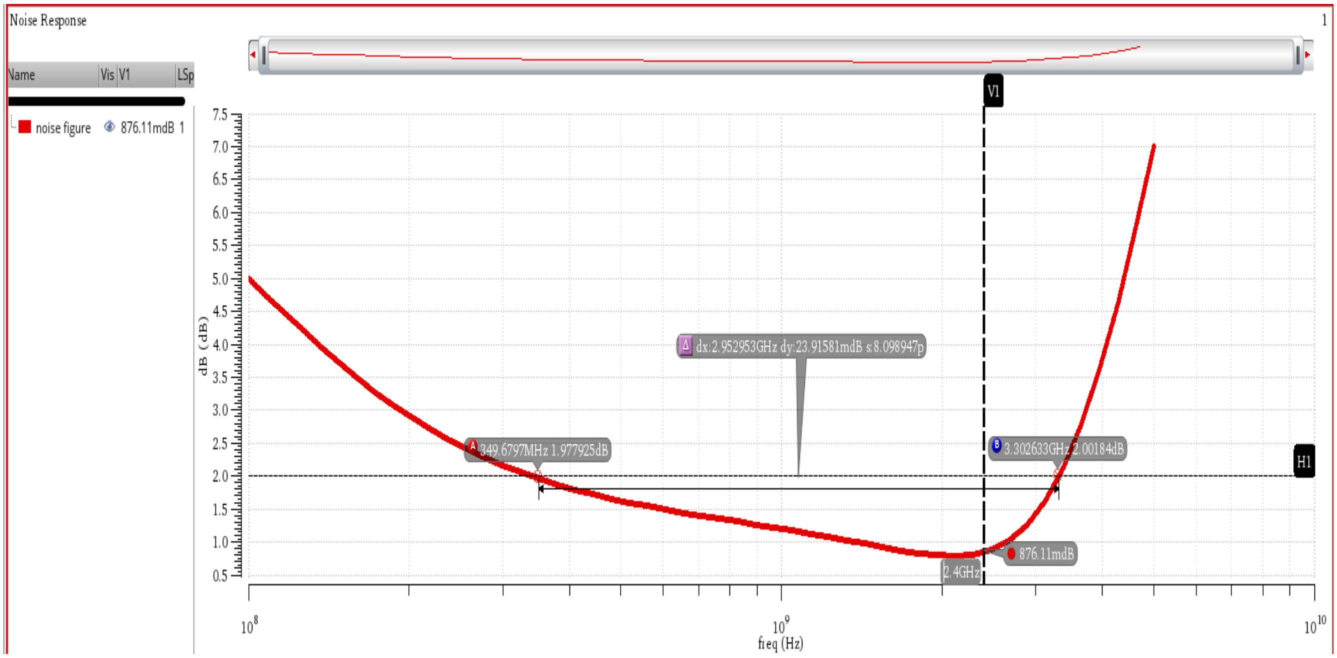


Transistors sizing	144u / 60 n
Current mirror sizing	600n / 60n
ID	1.5 mA
VDD	1.2 V

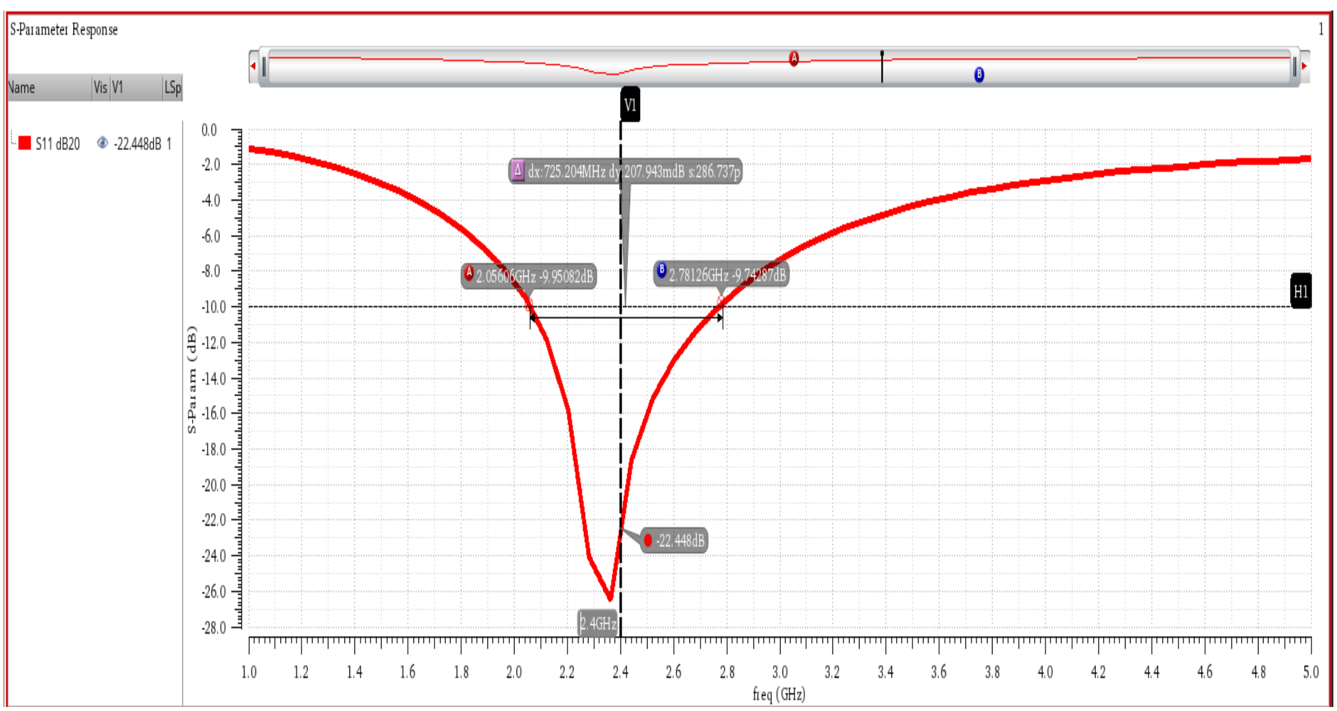
DC OPERATING PIONT :



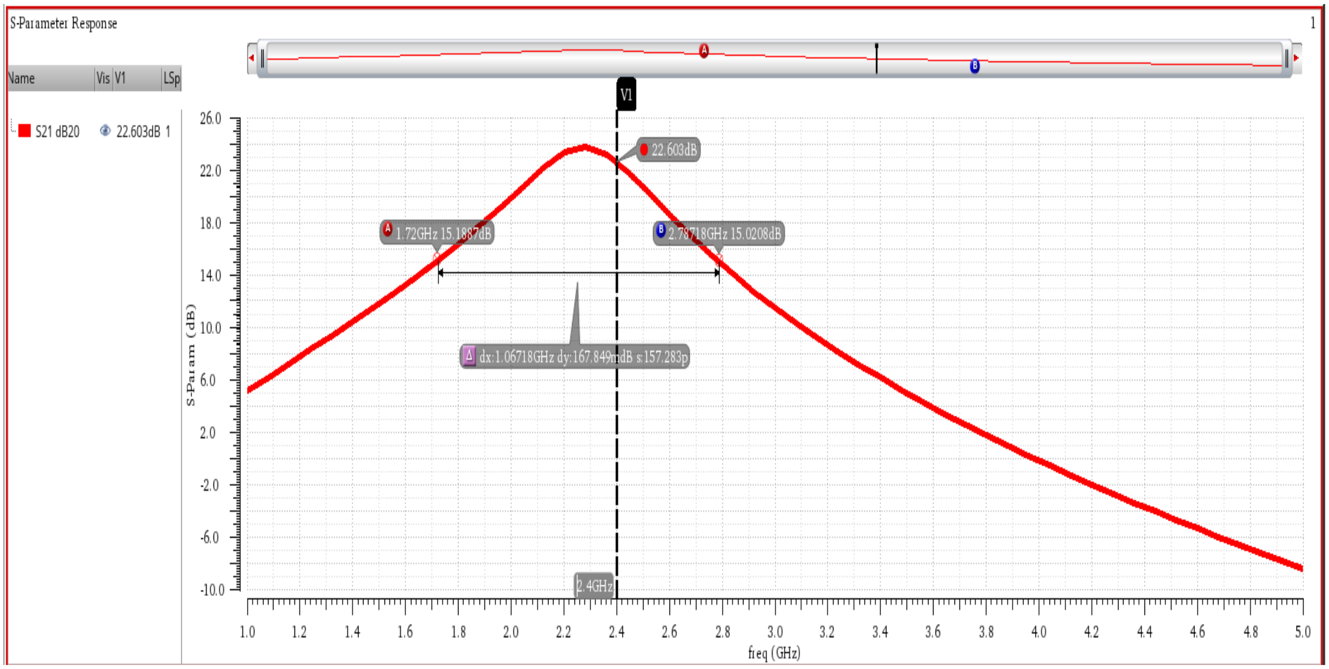
NOISE FIGURE :



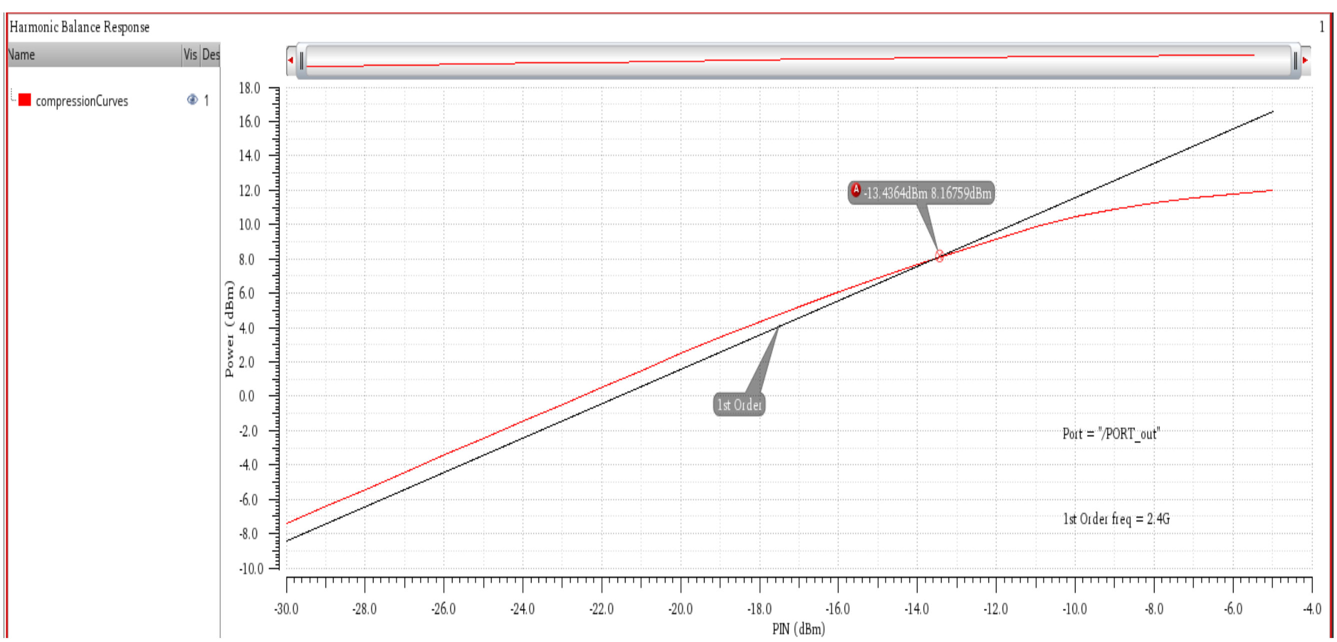
S11:



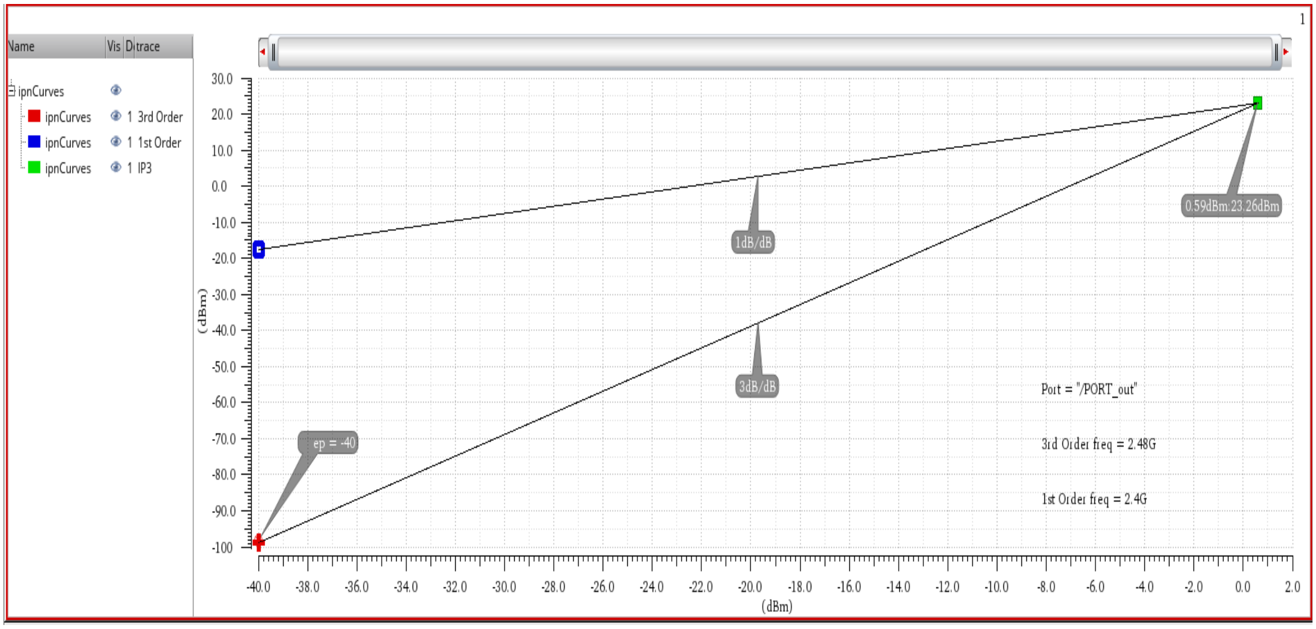
GAIN (S21) :



IP1dB :



IM3 and IIP3 :

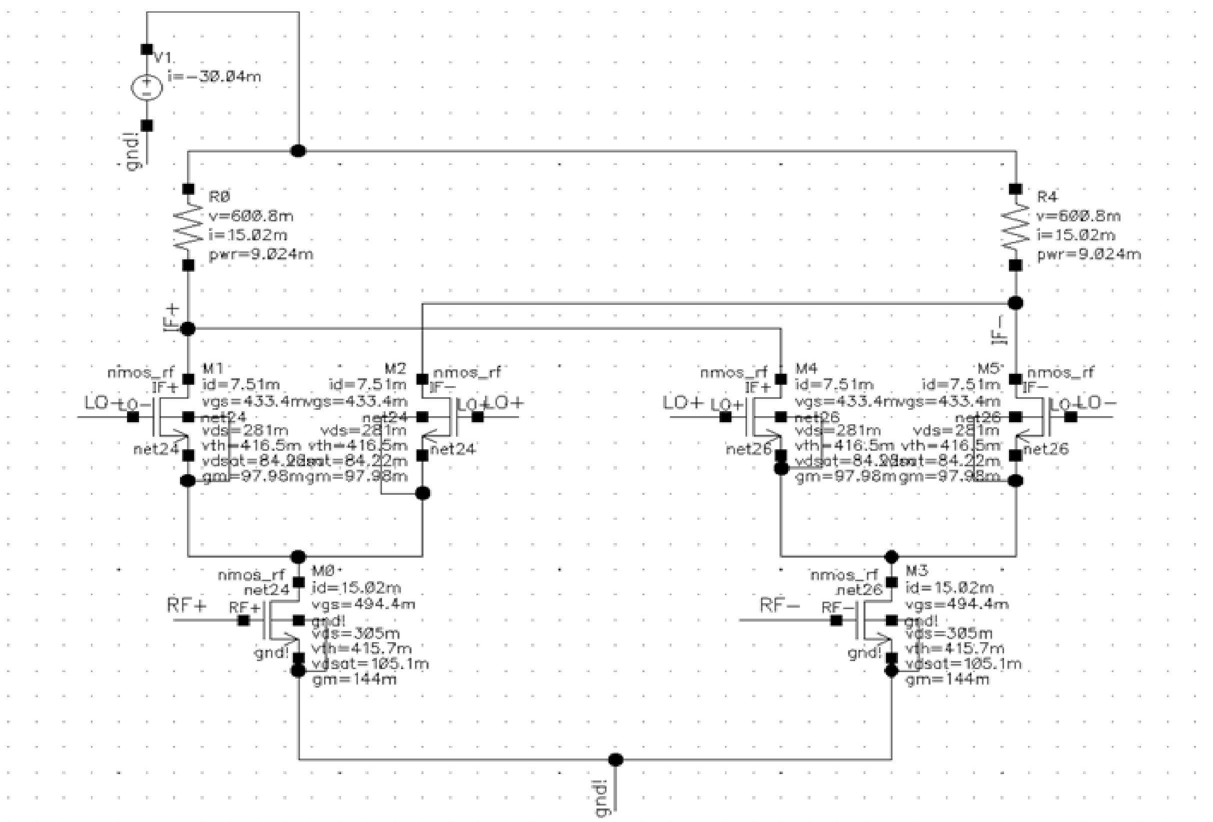


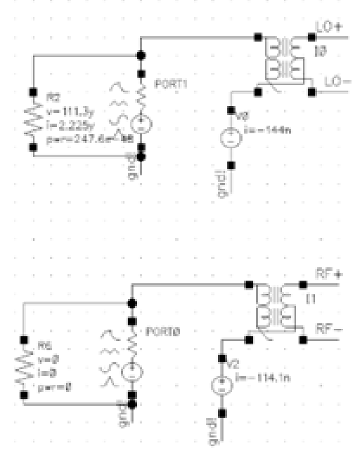
Name
Vis
D
trace
ipnCurves
ipnCurves
1 3rd Order
ipnCurves
1 1st Order
ipnCurves
1 IP3
1dB/dB
3dB/dB
0.59dBm:23.26dBm
ep = -40
Port = "/PORT_out"
3rd Order freq = 2.48G
1st Order freq = 2.4G
(dBm)
(dBm)

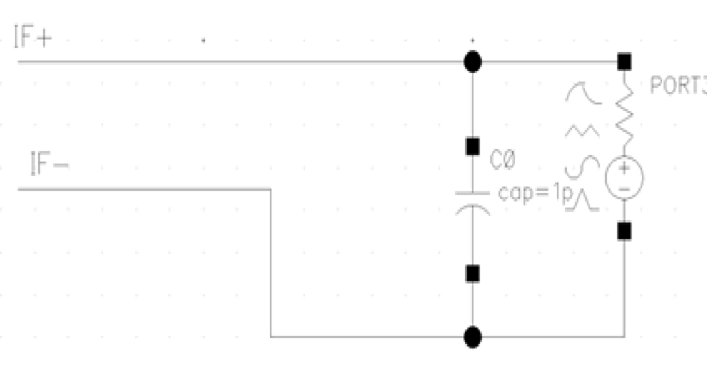
PART 2 (MIXER DESIGN) :

“down-conversion double balanced active mixer”

SCHEMATIC :



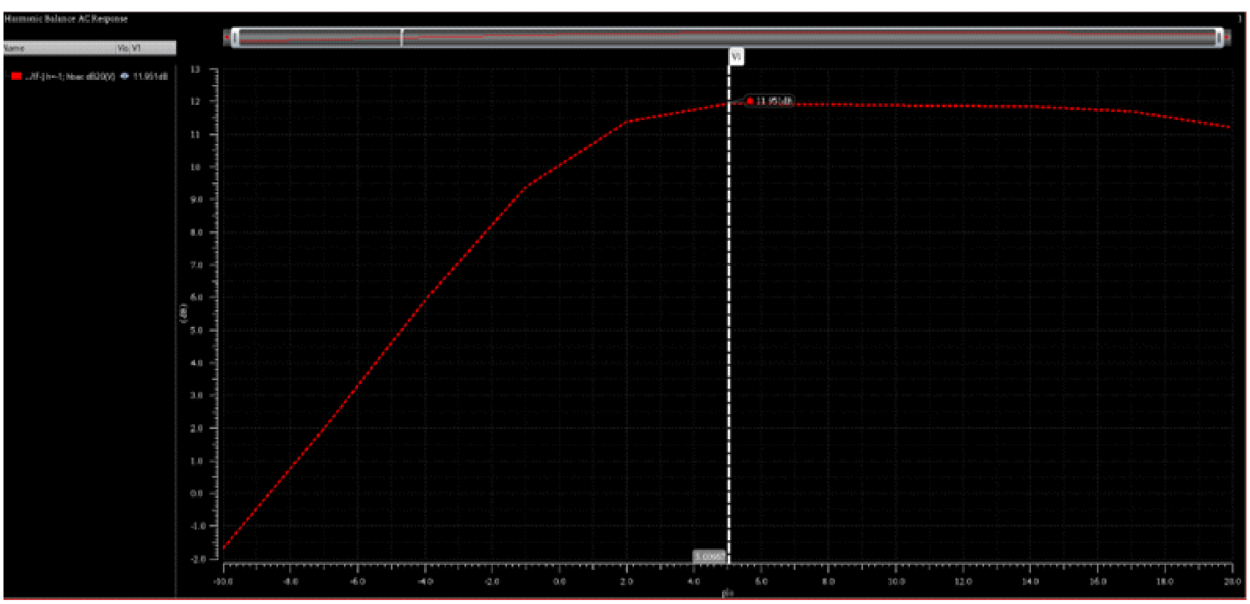




DC OPERATING PIONT AND SIZING :

W/L of input pair	192u/60n
W/L of LO devices	192u/60n
gm of input pair	144m
RL	40 ohm
Full steering current	15mA
IF operating point (output voltage)	600mV

Conversion gain versus the LO amplitude at the RF center frequency :

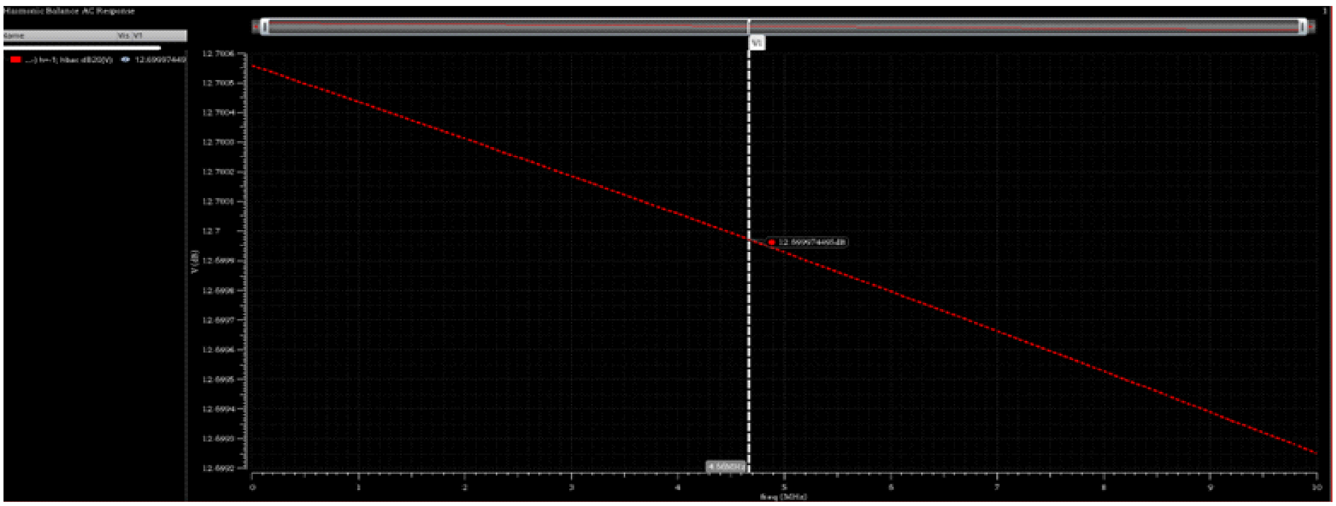


Selecting LO amplitude :

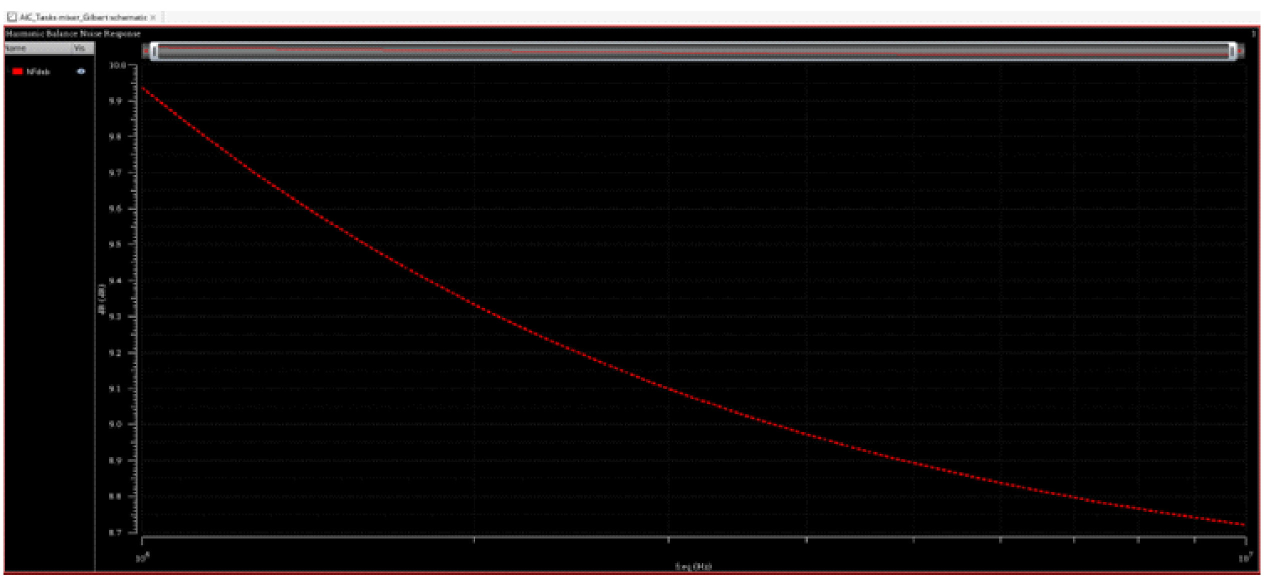
By sweeping output power vs LO amplitude we can choose the value with best gain which is Plo = 5 dBm

This the minimum value as less than that will cause the gain to drop below 12dB

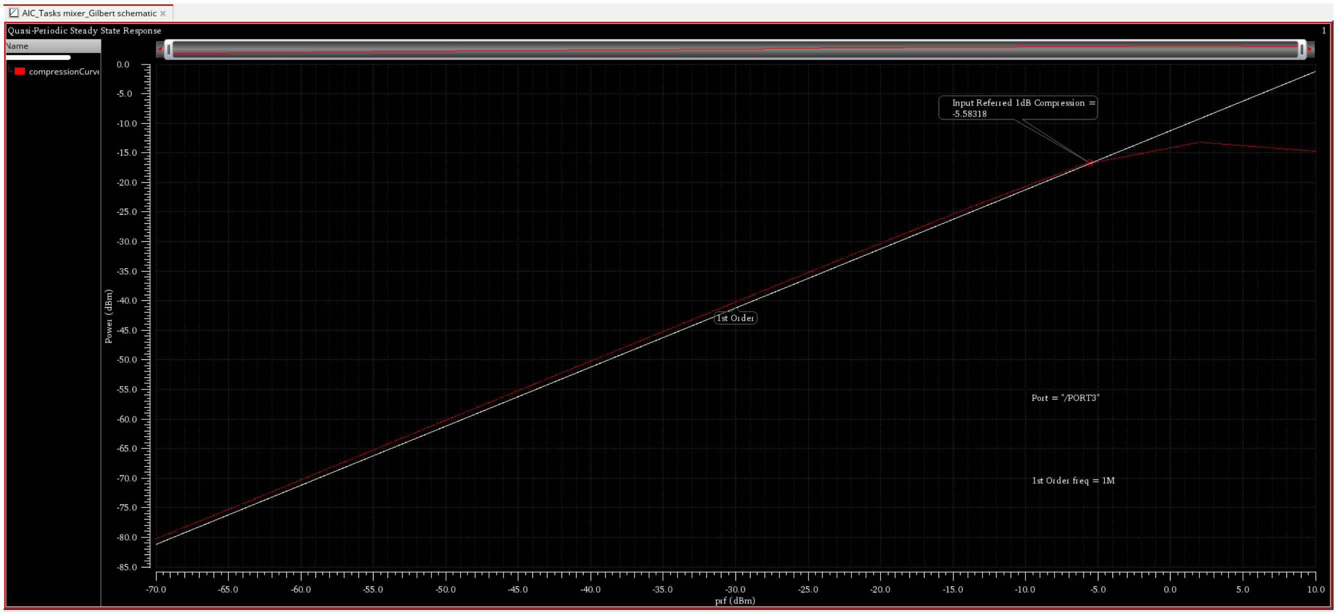
Conversion gain versus RF frequency :



Noise Figure vs RF frequency :

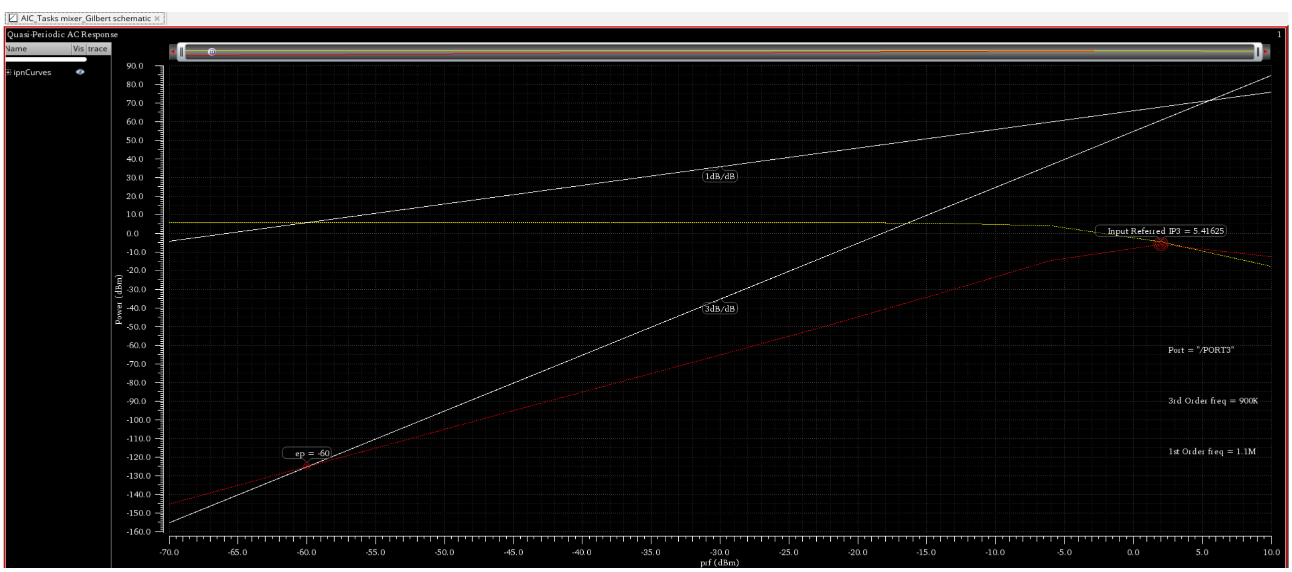


Conversion gain versus the RF amplitude & 1dB compression point:



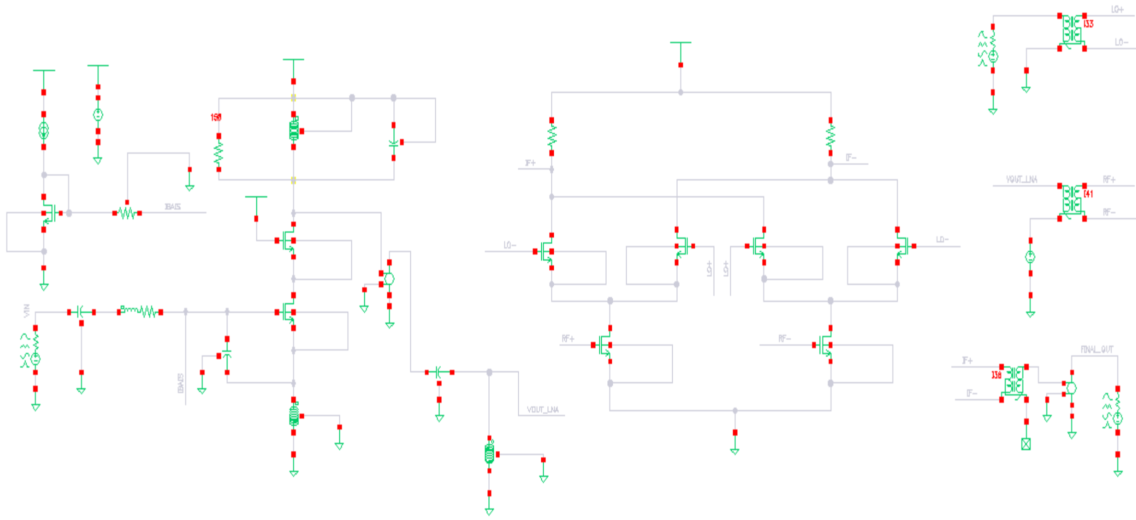
1dB at (-5.1dBm , -16.1dBm)

IM3 and IIP3:

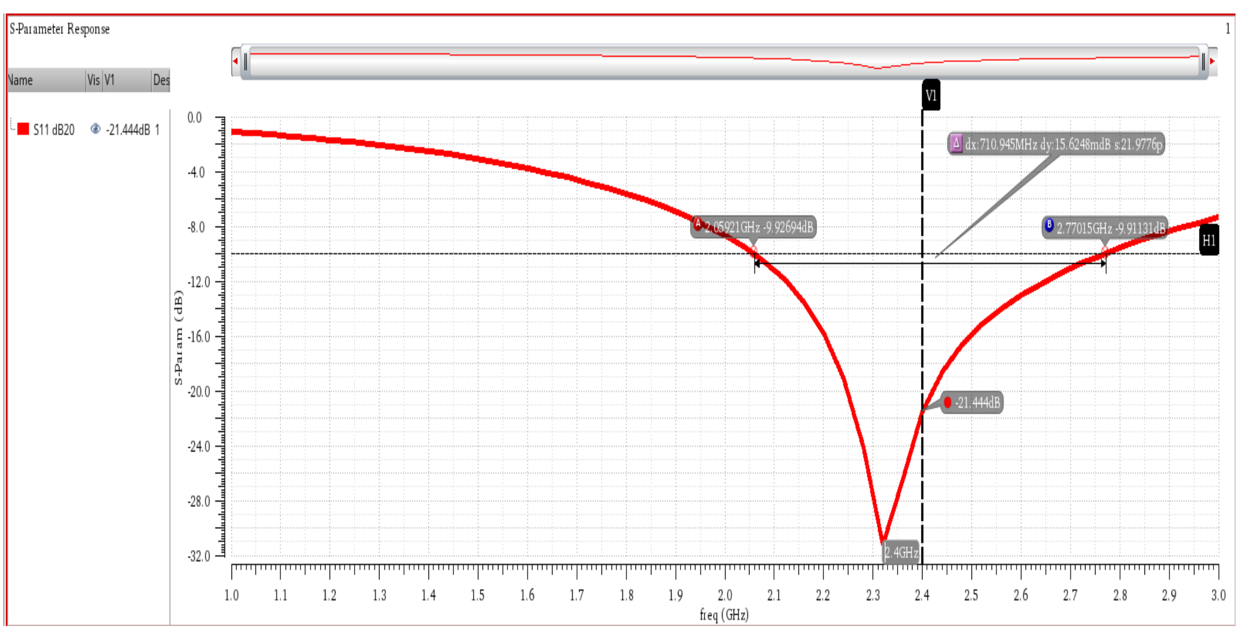


PART 3 (RF SYSTEM INTEGRATION):

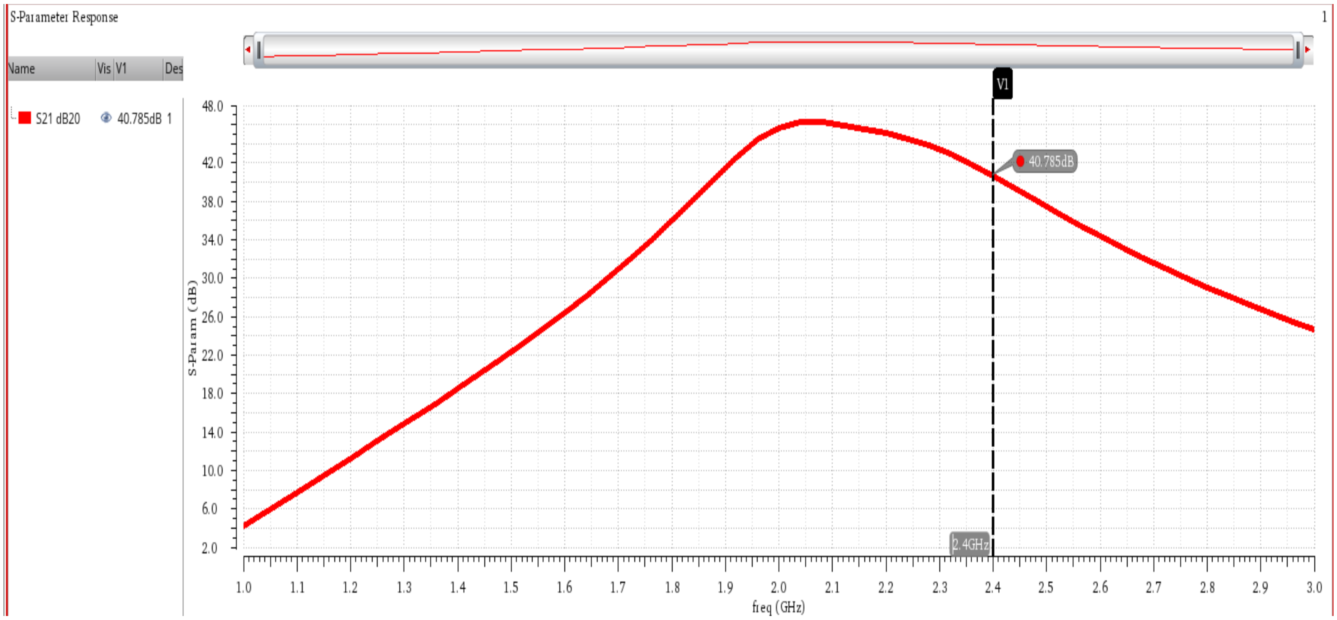
SCHEMATIC:



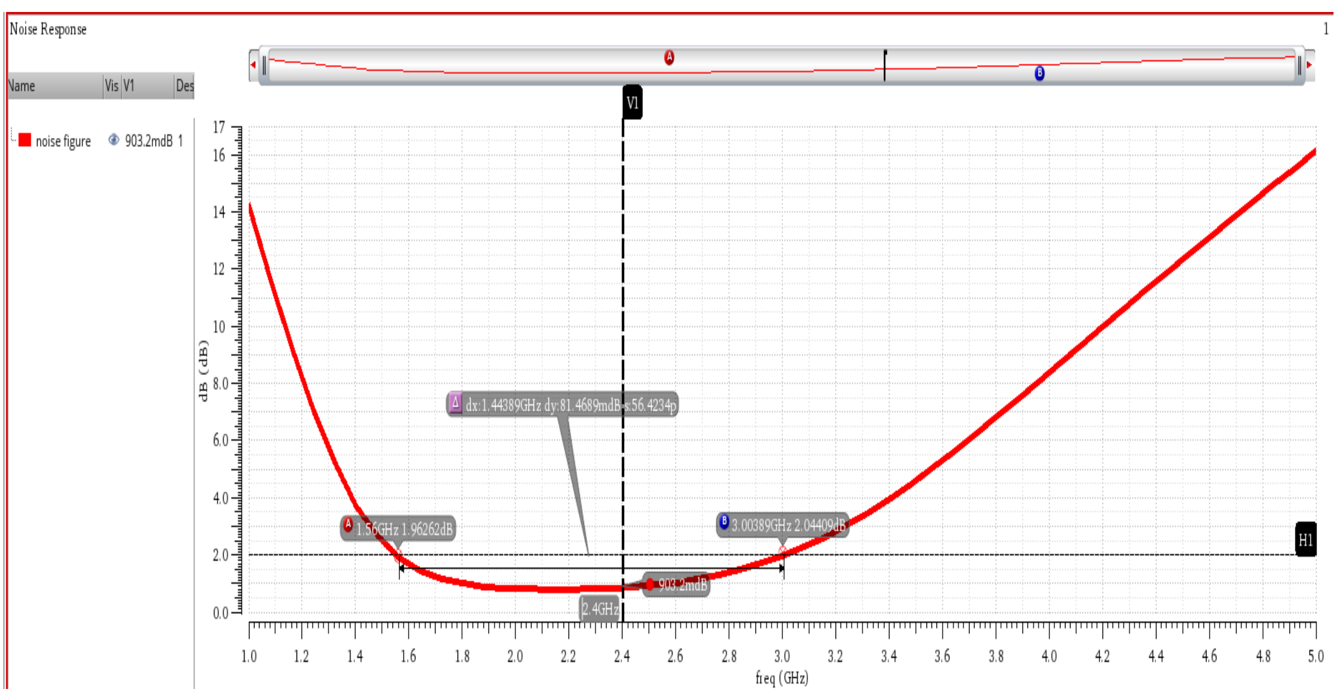
S11:



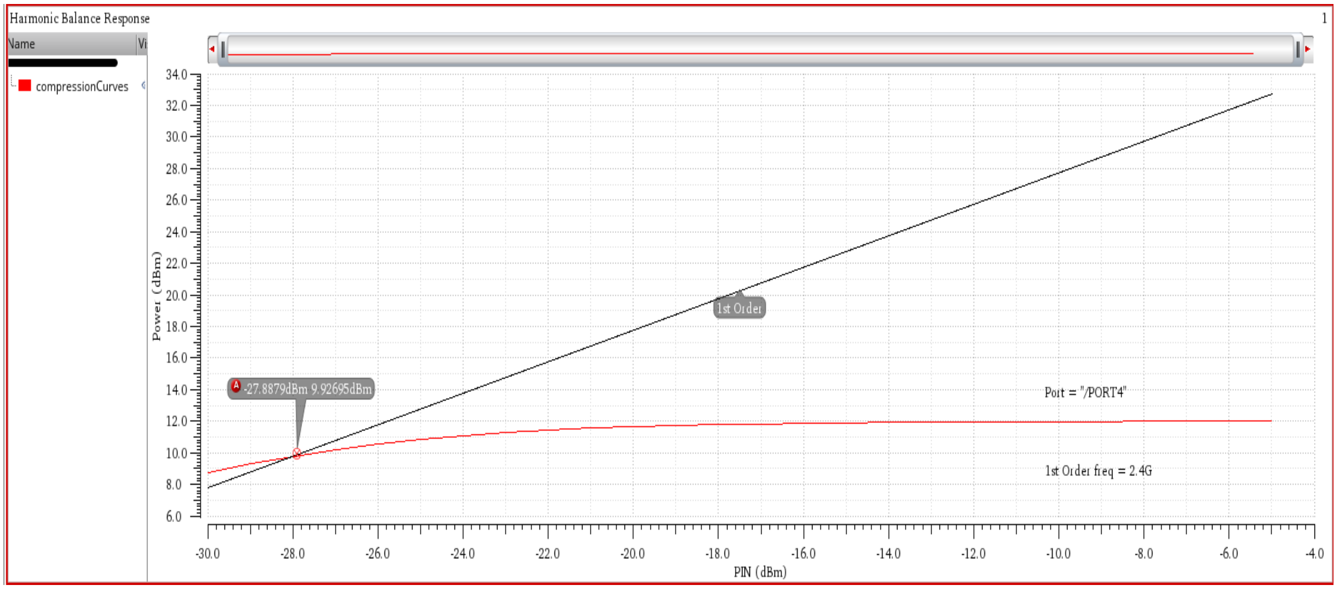
CONVERSION GAIN :



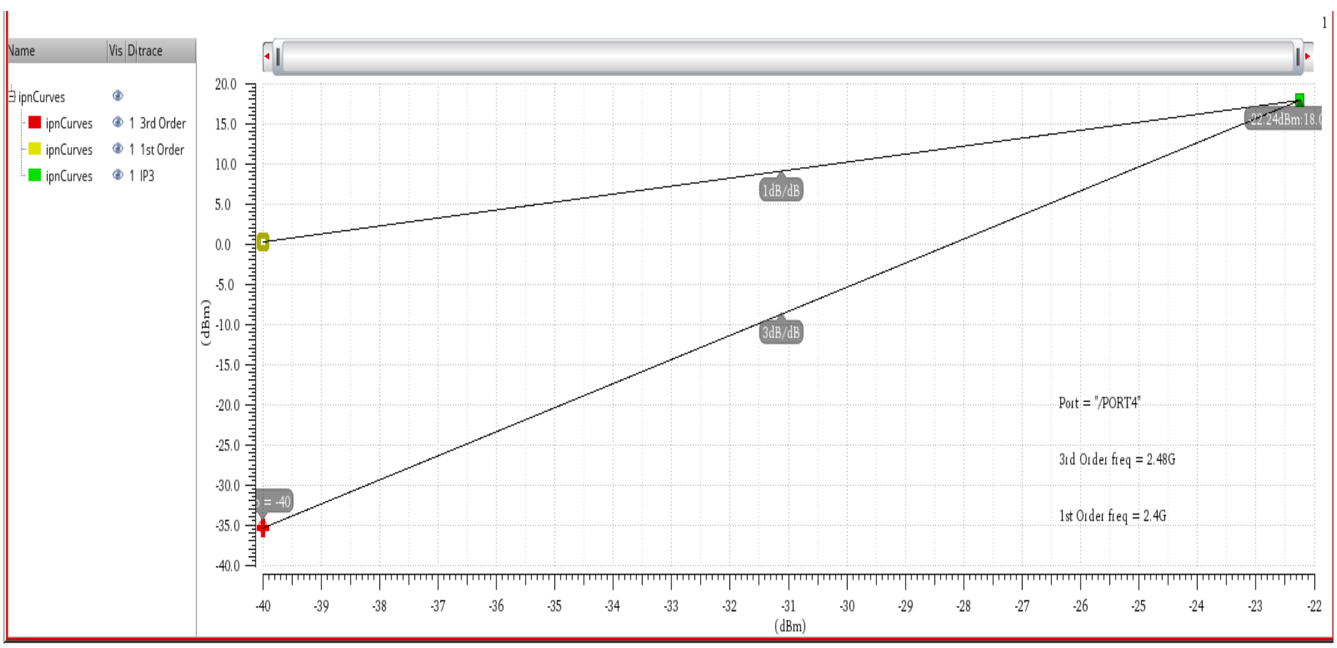
NOISE FIGURE:



IP1dB:


Harmonic Balance Response
Name
compressionCurves
-27.8879dBm 9.92695dBm
1st Order
Port = "/PORT4"
1st Order freq = 2.4G
Power (dBm)
PIN (dBm)

IIP3:


Name
Vis
ipnCurves
ipnCurves 1 3rd Order
ipnCurves 1 1st Order
ipnCurves 1 IP3
1dB/dB
3dB/dB
Port = "/PORT4"
3rd Order freq = 2.48G
1st Order freq = 2.4G
(dBm)