# IC CAD Project

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# 1 Theoretical Design

There are 3 criteria that determine the design of the amplifier. First is the central frequency, which is the frequency of the LC tank:

$$f = \frac{1}{2\pi\sqrt{LC}} = 8\,\text{GHz} \Rightarrow LC = 3.95 \times 10^{-22}$$

As the inductor values are limited due to the design rules, I first checked to see what values are available and then chose the capacitor accordingly:

$$L = 1.44\,\text{nH} \quad , \quad C = 274\,\text{fF}$$

Then I used the fractional bandwidth to find the quality factor of the LC tank:

$$\frac{f_C}{\Delta f} = Q = 10 = \frac{R_p}{L\omega} \Rightarrow R_p = 10L\omega = 725\,\Omega$$

Then, I find the transconductance of the transistors by ignoring the output resistance of the transistor compared to the parallel resistance of the tank and assuming the capacitor to be ideal:

$$A_v = 25\,\text{dB} = 17.78 = R_p g_m \Rightarrow g_m = 23.4\,\text{mS}$$

Then, using ADS, I plotted the $g_m$ versus the drain current of an NMOS transistor with $W = 50\,\mu m$, as seen in figure 1 and as the current for this width would be too much, I increased the width as well to reach $W = 90\,\mu m$ and a current of 2.16 mA. The size of the tail transistor is chosen to be twice that of the input transistors and the size of the current mirror transistor is one-tenth of the tail transistor.

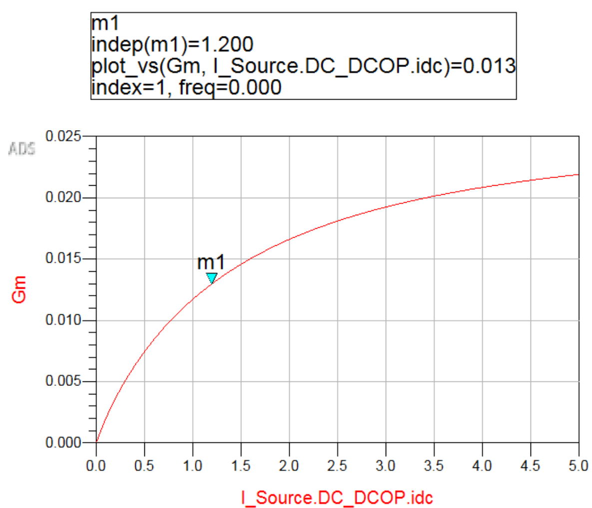



Figure 1: $g_m$ vs. $I_D$

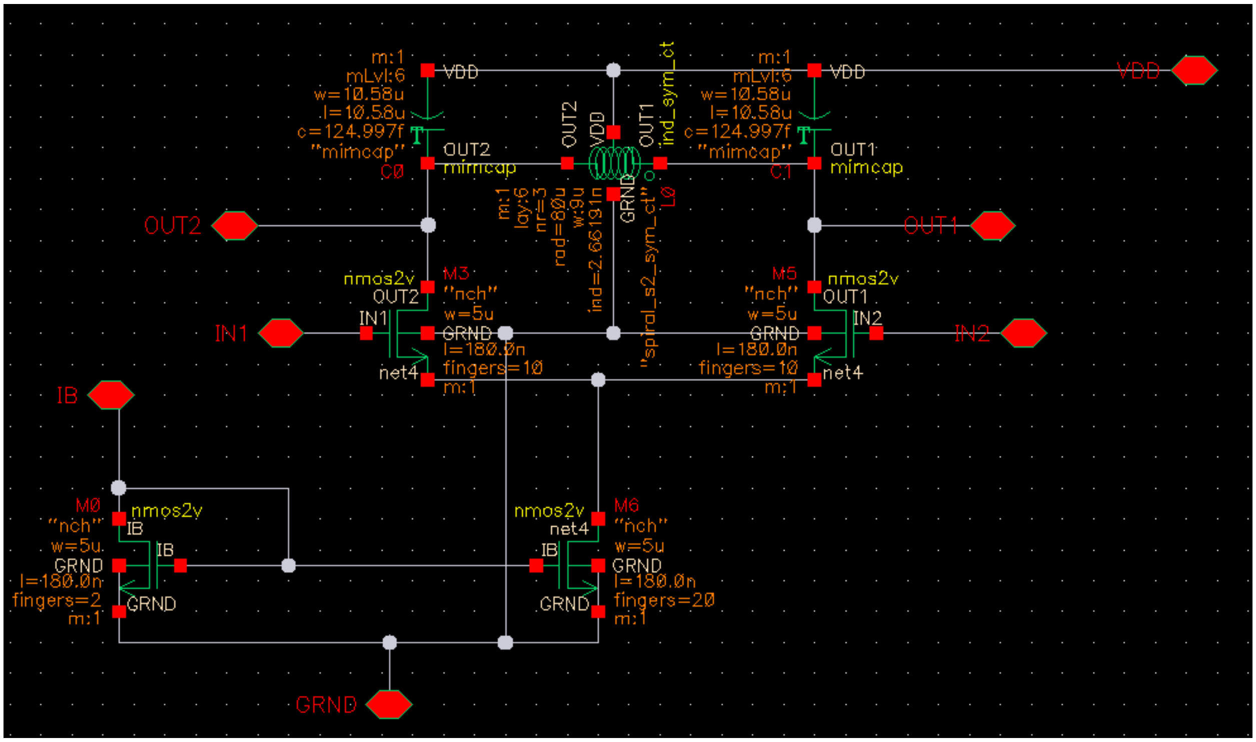



Figure 2: The final schematics

| | Width (um) | Length (nm) | Fingers |
|---|---|---|---|
| Input transistors (M3 & M5) | 5 | 180 | 10 |
| Tail transistor (M6) | 5 | 180 | 20 |
| Current mirror transistor (M0) | 5 | 180 | 2 |

Table 1: The transistor specification

## 2 Schematic

After some trial and error, the circuit in fig. 2 was reached that satisfies all but one of the requirements. I created a symbol from the schematic and used it for further testing.

I used two test benches to test the properties of my design: one for the AC analysis to find the gain and bandwidth, and another for the PSS analysis to show the linearity requirements (fig. 3).

The analysis specifications for the AC analysis (fig. 4), the compression point analysis (fig. 82), the IPn analysis (fig. 6), and the noise analysis (fig. 7) are shown below. The analysis results, including the operating points of the transistors from a DC analysis, are shown in the following figures and in table 4.

| | Radius (um) | Number of turns | Width (um) | Inductnce (nH) |
|---|---|---|---|---|
| Inductor (L0) | 80 | 3 | 9 | 2.661 |

Table 2: Inductor specifications

| | Width (um) | Length (um) | Capacitance (fF) |
|---|---|---|---|
| Capacitors (C0 & C1) | 10.58 | 10.58 | 124.997 |

Table 3: Capacitor specifications

| | |
|---|---|
| Power comsumption (mW) | 8.378 |
| Gain (@ 8GHz, dB) | 25.891 |
| Bandwidth (GHz) | 1.153 |
| 1dB compression point (dBm) | -4.359 |
| 3rd input intercept point (dBm) | 4.668 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 2.071 |

Table 4: The circuit properties at normal temperature

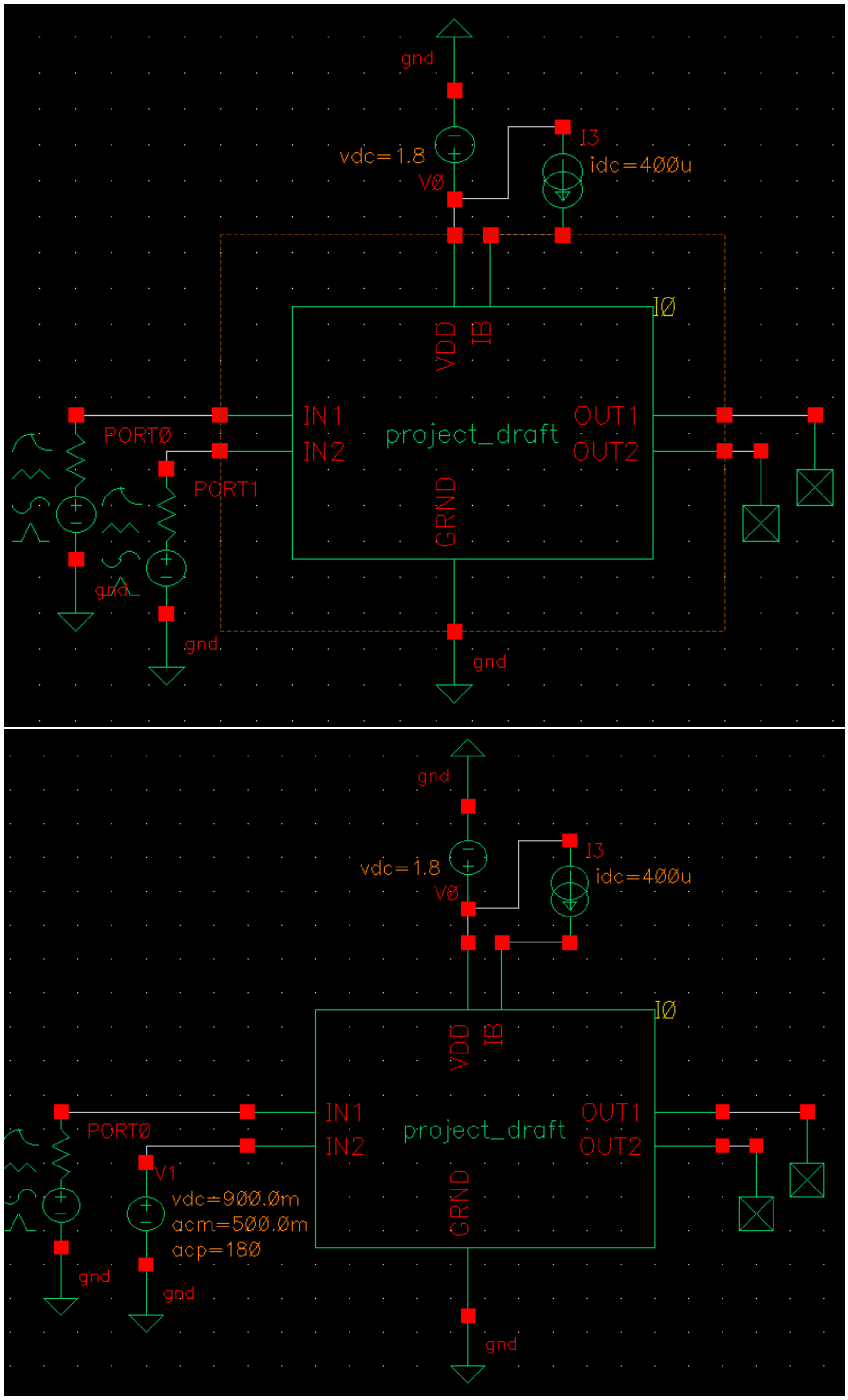



Figure 3: The test benches

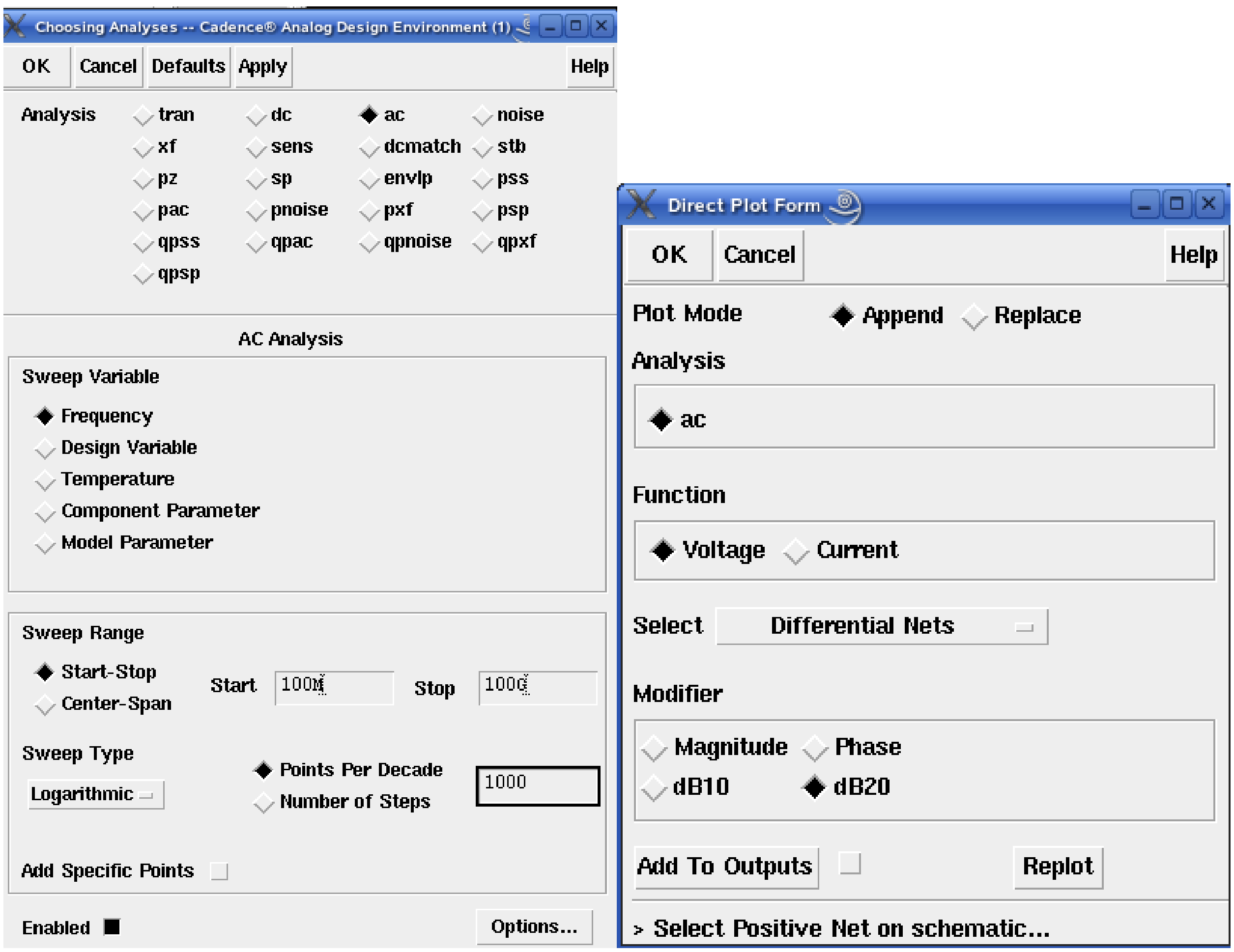



Figure 4: AC analysis setup

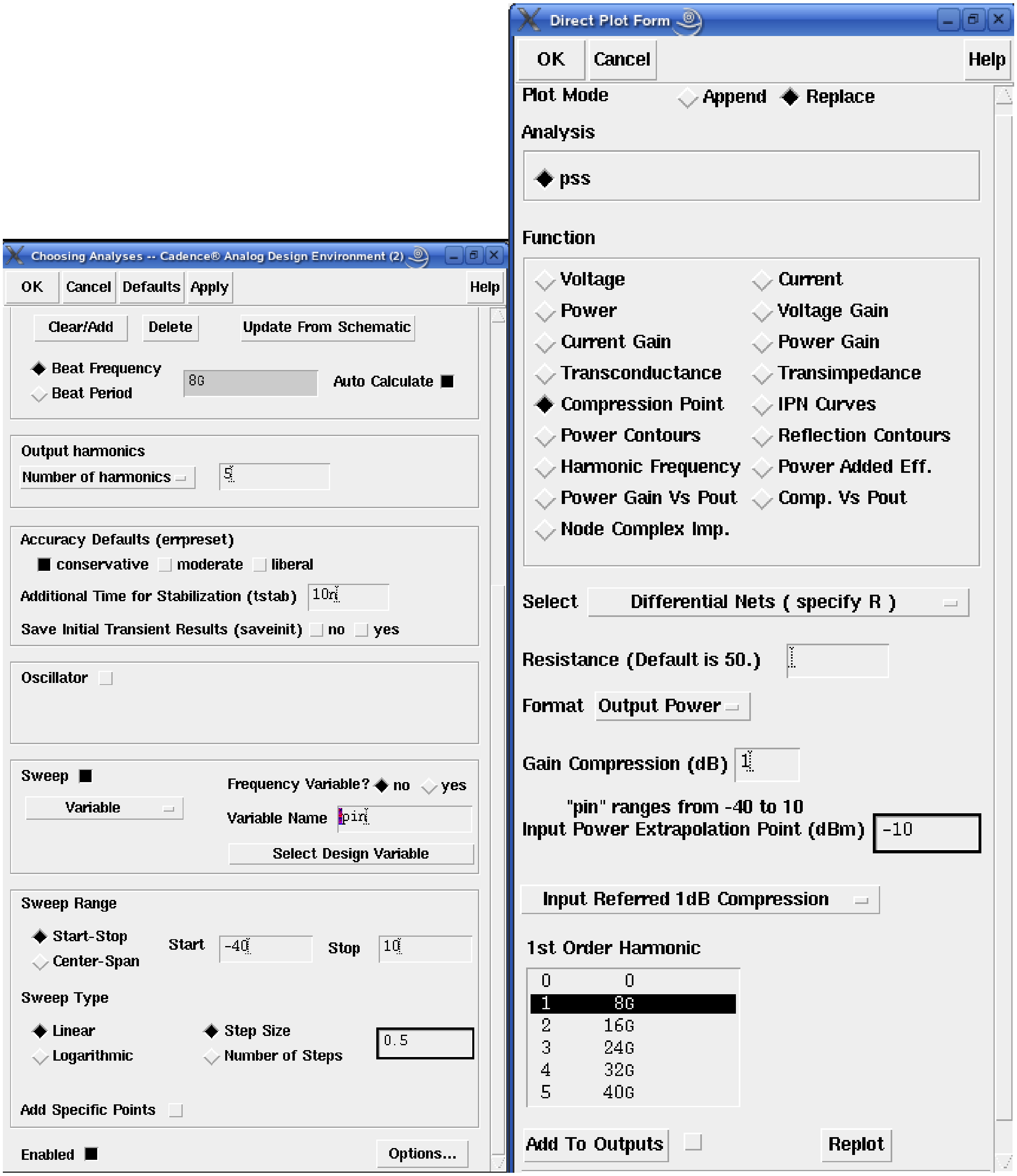



Figure 5: The compression point analysis setup

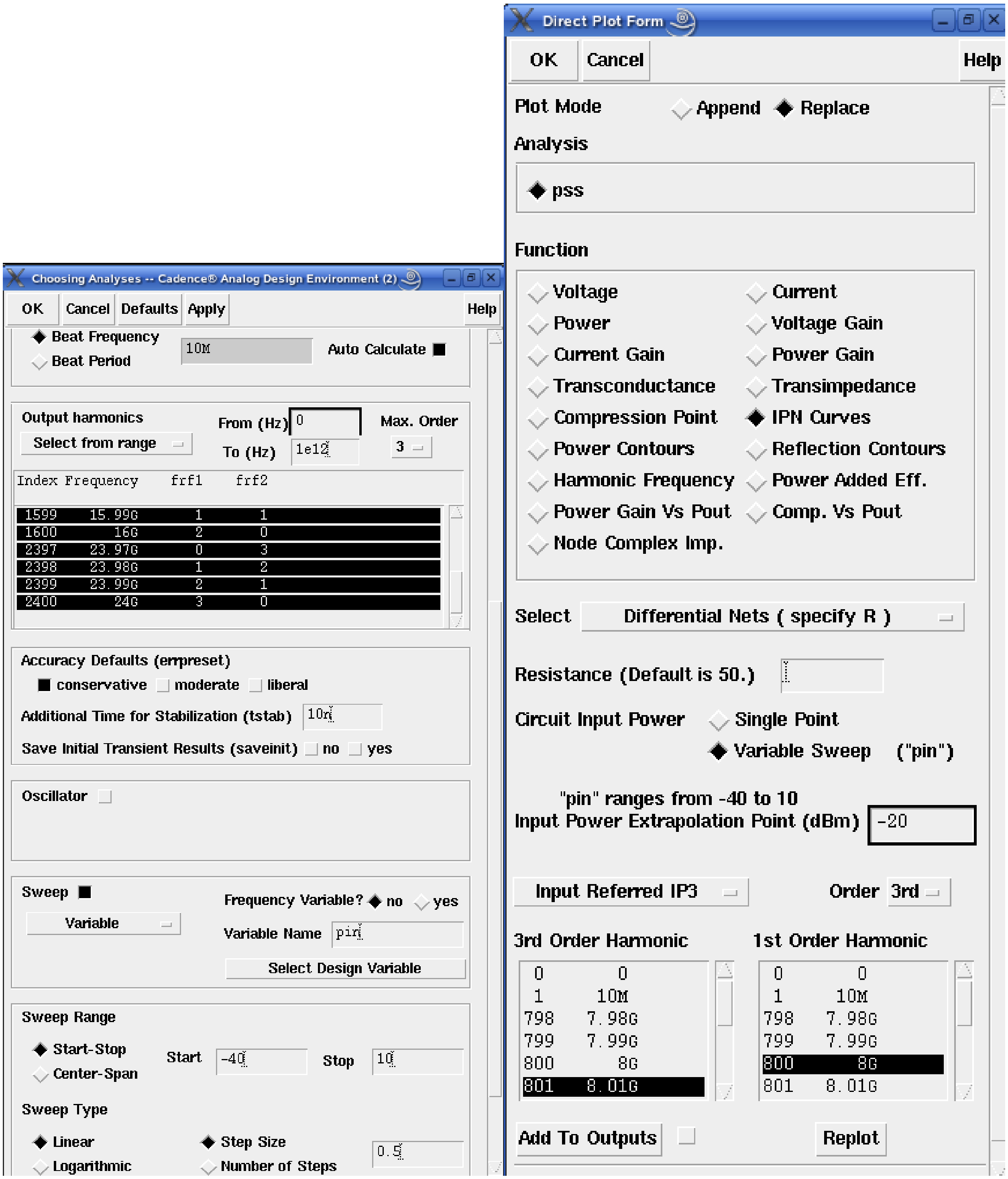



Figure 6: The IP3 analysis setup

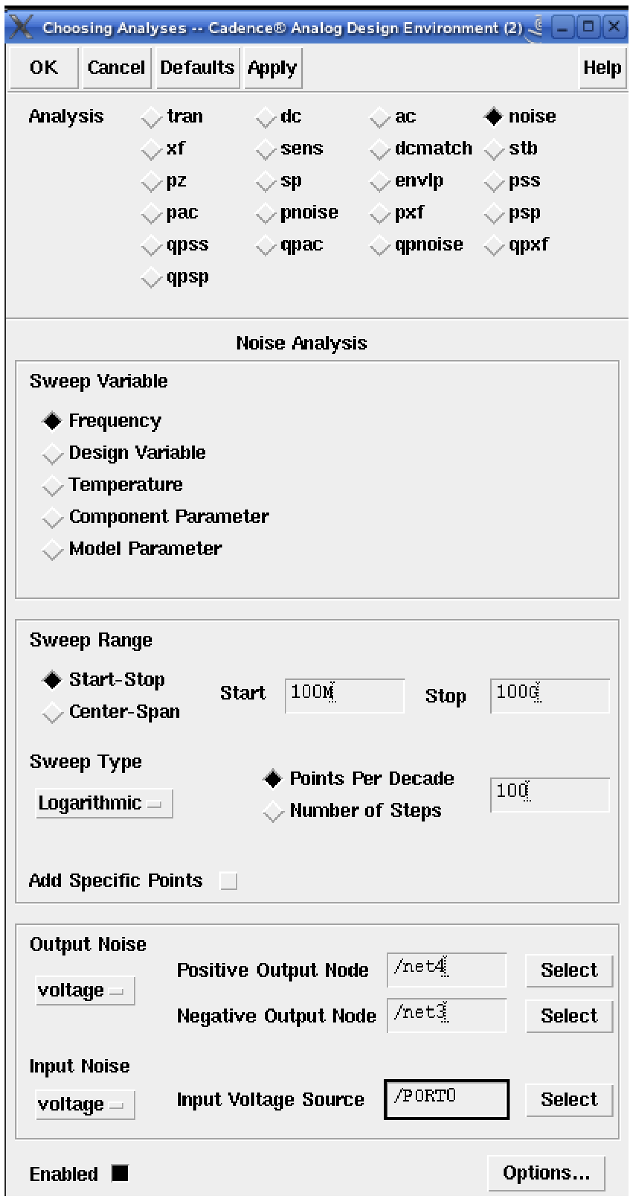



Figure 7: The noise analysis setup

| signal | OP("I0.M3" "??") | OP("I0.M5" "??") | OP("I0.M6" "??") | OP("I0.M0" "??") |
|---|---|---|---|---|
| betaeff | 152.169m | 152.169m | 317.012m | 31.6968m |
| cbb | 14.1671f | 14.1671f | 38.6198f | 3.86565f |
| cbd | 43.9535a | 43.9535a | 33.5063a | 2.13252a |
| cbg | -9.88887f | -9.88887f | -21.7144f | -2.16887f |
| cbs | -4.32222f | -4.32222f | -16.9389f | -1.69891f |
| cdb | -6.92121a | -6.92121a | -19.6438a | -4.09178a |
| cdd | 18.3155f | 18.3155f | 36.6262f | 3.66618f |
| cdg | -18.3449f | -18.3449f | -36.675f | -3.67487f |
| cds | 36.2751a | 36.2751a | 68.4437a | 12.7847a |
| cgb | -7.43434f | -7.43434f | -15.5338f | -1.53488f |
| cgd | -17.8413f | -17.8413f | -36.413f | -3.64246f |
| cgg | 86.9657f | 86.9657f | 175.336f | 17.5322f |
| cgs | -61.6901f | -61.6901f | -123.389f | -12.3549f |
| cjd | 18.8953f | 18.8953f | 44.7061f | 4.78904f |
| cjs | 25.7643f | 25.7643f | 67.0198f | 10.5896f |
| csb | -6.72587f | -6.72587f | -23.0663f | -2.32668f |
| csd | -518.225a | -518.225a | -246.725a | -25.8479a |
| csg | -58.7319f | -58.7319f | -116.946f | -11.6885f |
| css | 65.976f | 65.976f | 140.259f | 14.041f |
| gds | 661.066u | 661.066u | 931.349u | 106.196u |
| gm | 17.2657m | 17.2657m | 34.5142m | 3.31249m |
| gmbs | 2.85131m | 2.85131m | 9.73182m | 943.709u |
| gmoverid | 8.11562 | 8.11562 | 8.1116 | 8.28122 |
| ibulk | -81.416p | -81.416p | -807.071p | -54.9841f |
| id | 2.12746m | 2.12746m | 4.25492m | 400u |
| ids | 2.12746m | 2.12746m | 4.25492m | 400u |
| is | -2.12746m | -2.12746m | -4.25492m | -400u |
| pwr | 1.83323m | 1.83323m | 3.95268m | 268.082u |
| region | 2 | 2 | 2 | 2 |
| reversed | 0 | 0 | 0 | 0 |
| ron | 405.035 | 405.035 | 218.327 | 1.67551K |
| type | 0 | 0 | 0 | 0 |
| vbs | -928.966m | -928.966m | 0 | 0 |
| vds | 861.696m | 861.696m | 928.966m | 670.205m |
| vdsat | 136.884m | 136.884m | 128.391m | 128.065m |
| vgs | 871.034m | 871.034m | 670.205m | 670.205m |
| vth | 717.844m | 717.844m | 516.042m | 516.817m |

Figure 8: The DC operating points of all transistors

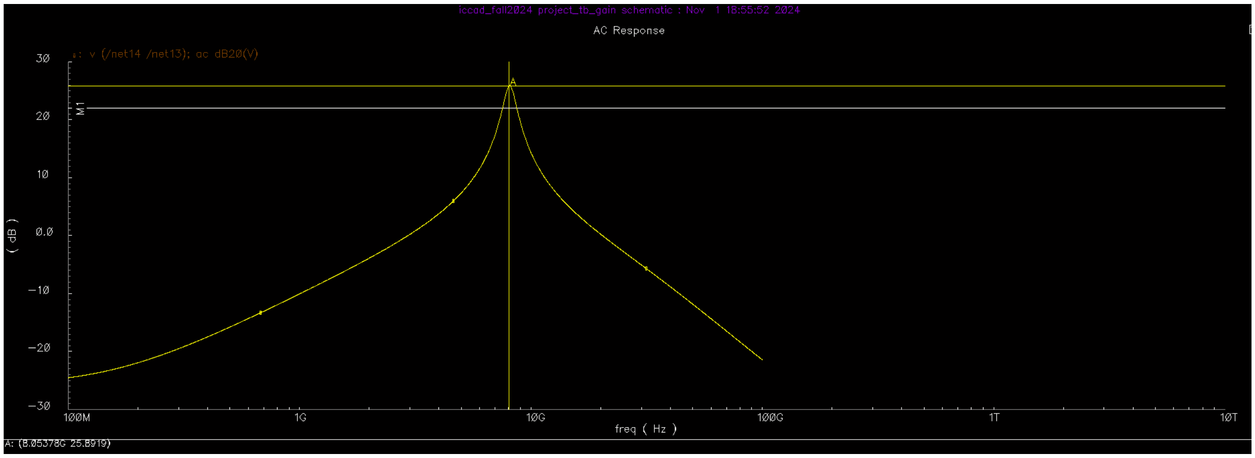
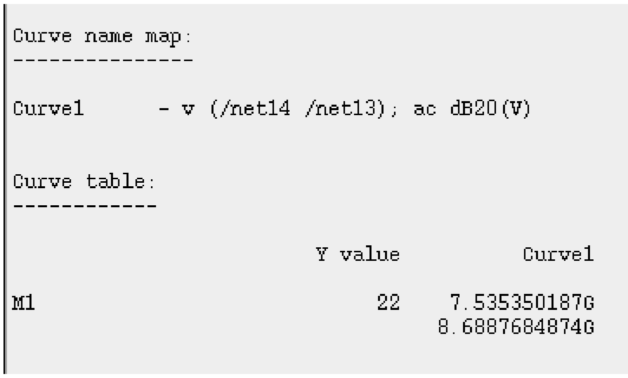



Figure 9: The gain plot


```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                         Y value        Curve1

M1                            22     7.535350187G
                                    8.68876848746
```

Figure 10: The bandwidth, using a horizontal marker

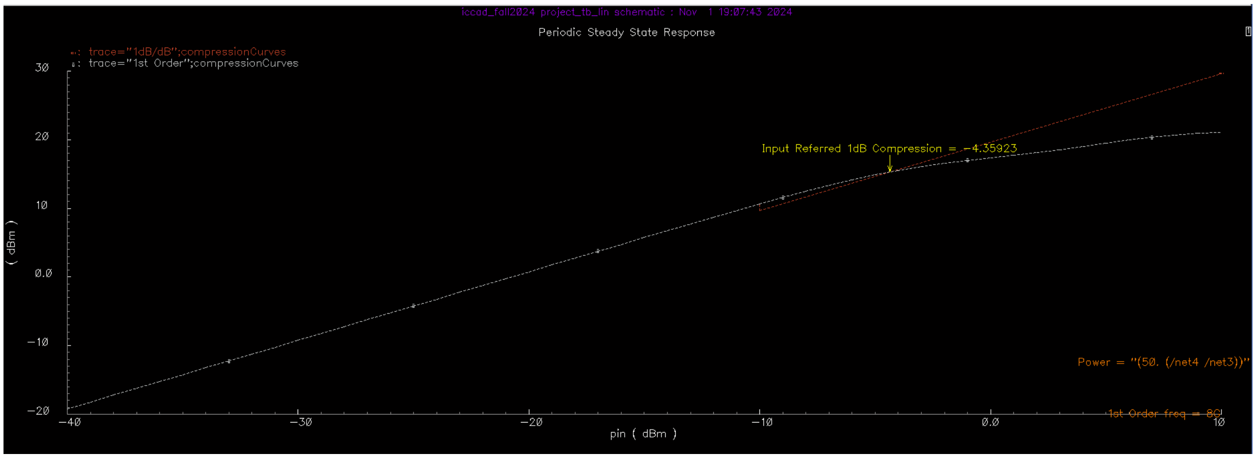



Figure 11: The 1dB compression point

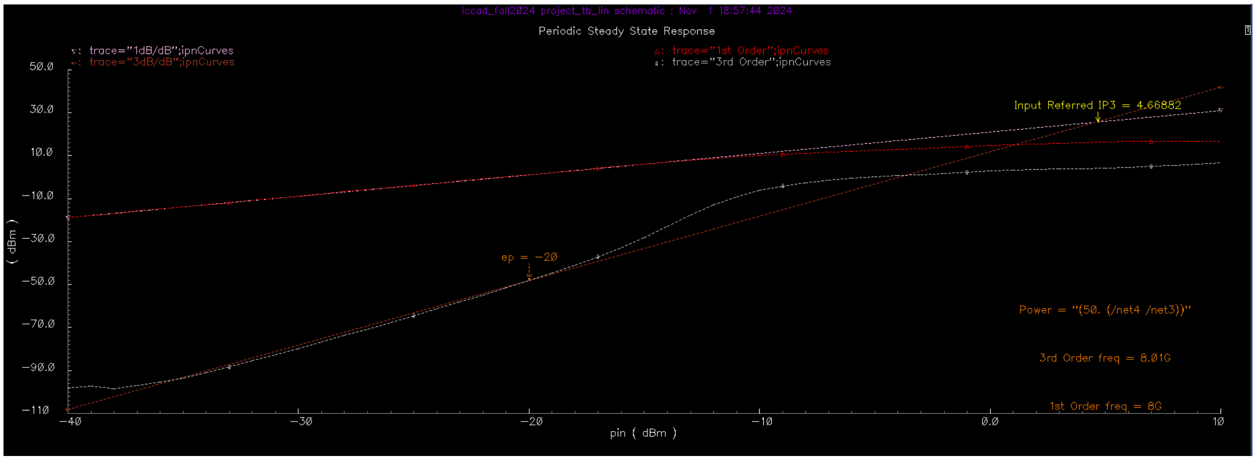



Figure 12: The IIP3 plot

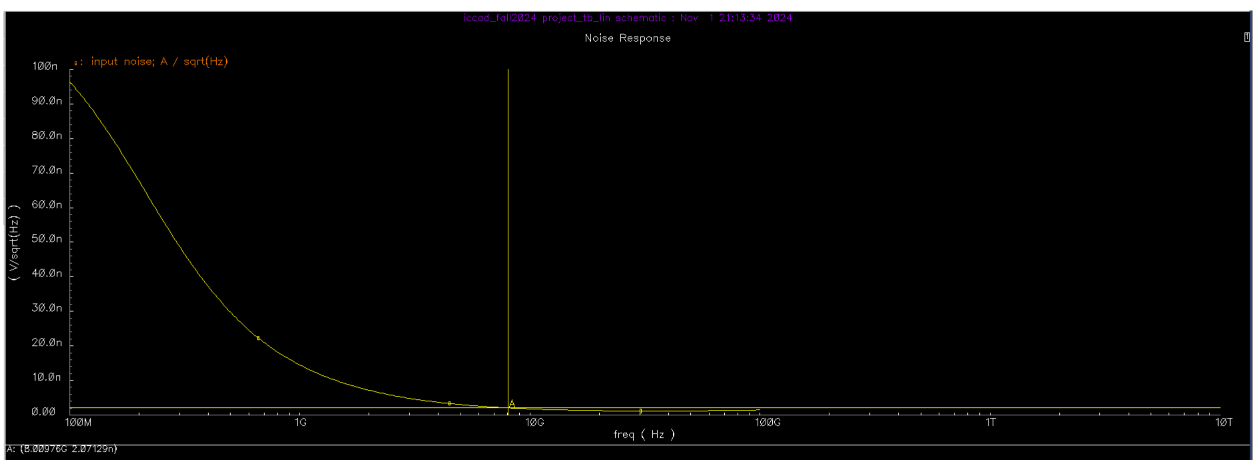



Figure 13: The input-referred noise plot

# 3 Simulation Results

The results for the TT corner at 27 degrees were shown in the last section. Here we will investigate every property at the TT, FF, and SS corners for temperatures of -40, 27, and 120 degrees.

## 3.1 TT

To change the temperature, I used `Analog Environment > Setup > Temperature...` and set the temperature to the desired value

### 3.1.1 -40°

The analysis results are shown in the following figures and in table 5.

| | |
|---|---|
| Power comsumption (mW) | 8.380 |
| Gain (@ 8GHz, dB) | 27.543 |
| Bandwidth (GHz) | 1.463 |
| 1dB compression point (dBm) | -6.004 |
| 3rd input intercept point (dBm) | -3.563 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.964 |

Table 5: The circuit properties at -40°

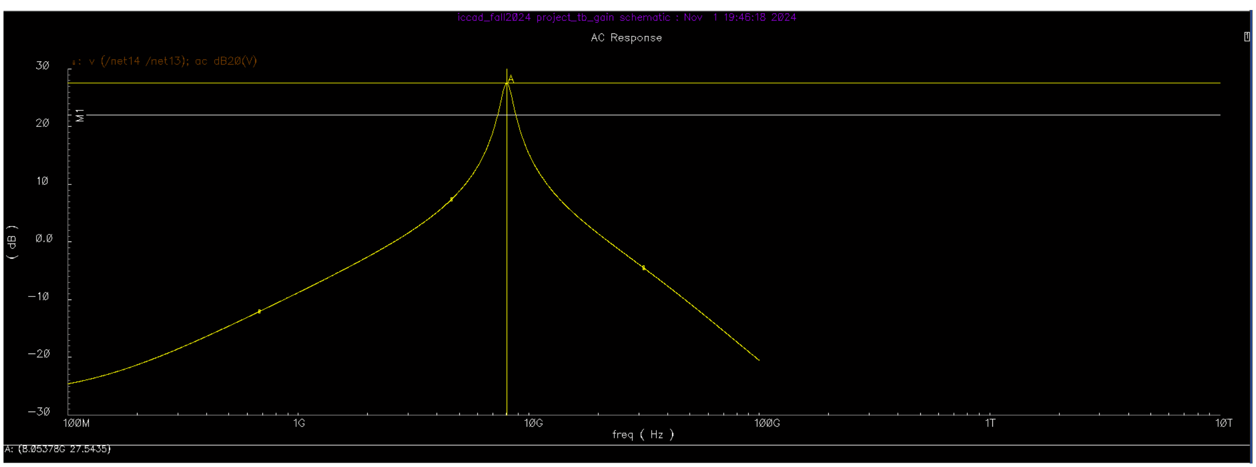



Figure 14: The gain plot

```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                         Y value          Curve1

M1                            22   7.32760367136
                                   8.79093909836
```

Figure 15: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") | OP("I0.M5" "??") | OP("I0.M6" "??") | OP("I0.M0" "??") |
|---|---|---|---|---|
| betaeff | 242.242m | 242.242m | 502.727m | 50.2666m |
| cbb | 14.1908f | 14.1908f | 38.5993f | 3.86327f |
| cbd | 44.6383a | 44.6383a | 34.8265a | 2.66512a |
| cbg | -9.92328f | -9.92328f | -21.7699f | -2.17479f |
| cbs | -4.31217f | -4.31217f | -16.8643f | -1.69114f |
| cdb | -6.20222a | -6.20222a | -18.6126a | -3.60428a |
| cdd | 18.3122f | 18.3122f | 36.6217f | 3.66456f |
| cdg | -18.3417f | -18.3417f | -36.6725f | -3.67337f |
| cds | 35.7046a | 35.7046a | 69.372a | 12.4195a |
| cgb | -7.63889f | -7.63889f | -15.844f | -1.56734f |
| cgd | -17.8395f | -17.8395f | -36.41f | -3.64178f |
| cgg | 87.1894f | 87.1894f | 175.77f | 17.5747f |
| cgs | -61.711f | -61.711f | -123.516f | -12.3656f |
| cjd | 18.5658f | 18.5658f | 43.6466f | 4.63356f |
| cjs | 25.1196f | 25.1196f | 63.3565f | 10.0055f |
| csb | -6.54572f | -6.54572f | -22.7367f | -2.29232f |
| csd | -517.278a | -517.278a | -246.562a | -25.4395a |
| csg | -58.9244f | -58.9244f | -117.328f | -11.7265f |
| css | 65.9874f | 65.9874f | 140.311f | 14.0443f |
| gds | 732.295u | 732.295u | 1.03179m | 111.438u |
| gm | 20.2802m | 20.2802m | 40.1873m | 3.87347m |
| gmbs | 3.25439m | 3.25439m | 11.1817m | 1.08818m |
| gmoverid | 9.52891 | 9.52891 | 9.44125 | 9.68368 |
| ibulk | -199.905p | -199.905p | -1.26856n | -269.671f |
| id | 2.12829m | 2.12829m | 4.25657m | 400u |
| ids | 2.12829m | 2.12829m | 4.25657m | 400u |
| is | -2.12829m | -2.12829m | -4.25657m | -400u |
| pwr | 1.85108m | 1.85108m | 3.9286m | 272.853u |
| region | 2 | 2 | 2 | 2 |
| reversed | 0 | 0 | 0 | 0 |
| ron | 408.663 | 408.663 | 216.83 | 1.70533K |
| type | 0 | 0 | 0 | 0 |
| vbs | -922.95m | -922.95m | 0 | 0 |
| vds | 869.751m | 869.751m | 922.95m | 682.132m |
| vdsat | 103.865m | 103.865m | 97.8347m | 97.5602m |
| vgs | 877.05m | 877.05m | 682.132m | 682.132m |
| vth | 754.956m | 754.956m | 559.542m | 560.263m |

Figure 16: The DC operating points of all transistors

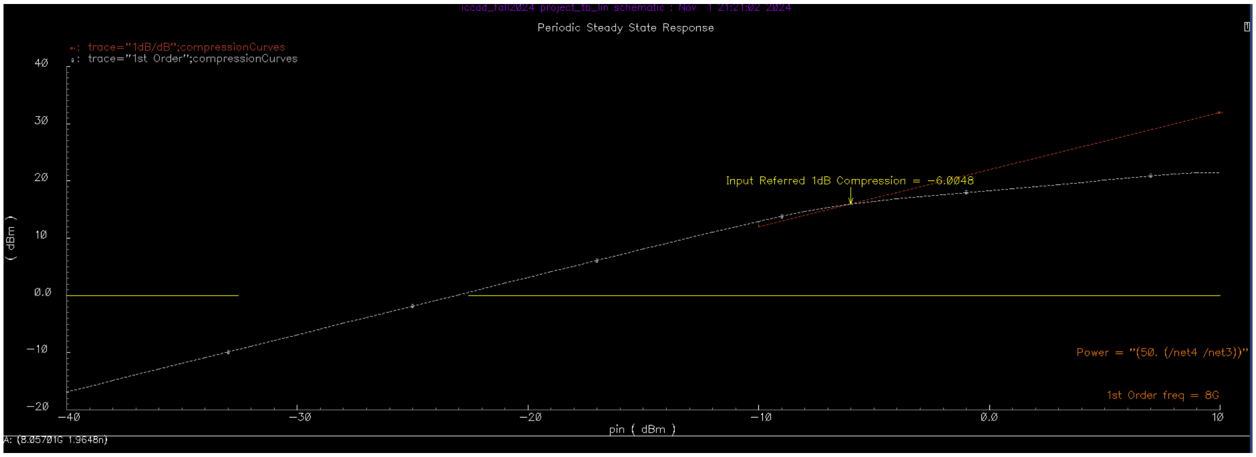



Figure 17: The 1dB compression point

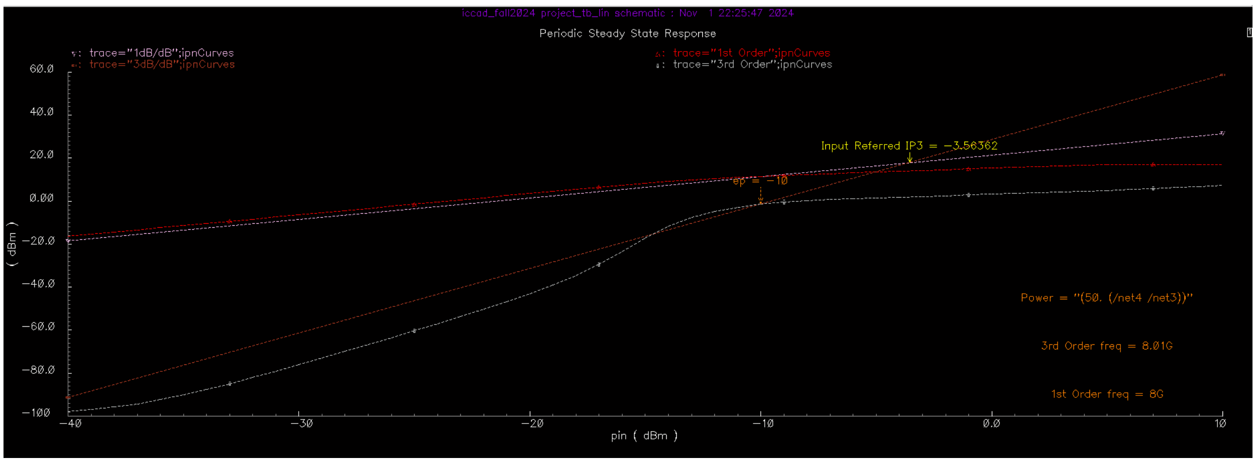



Figure 18: The IIP3 plot

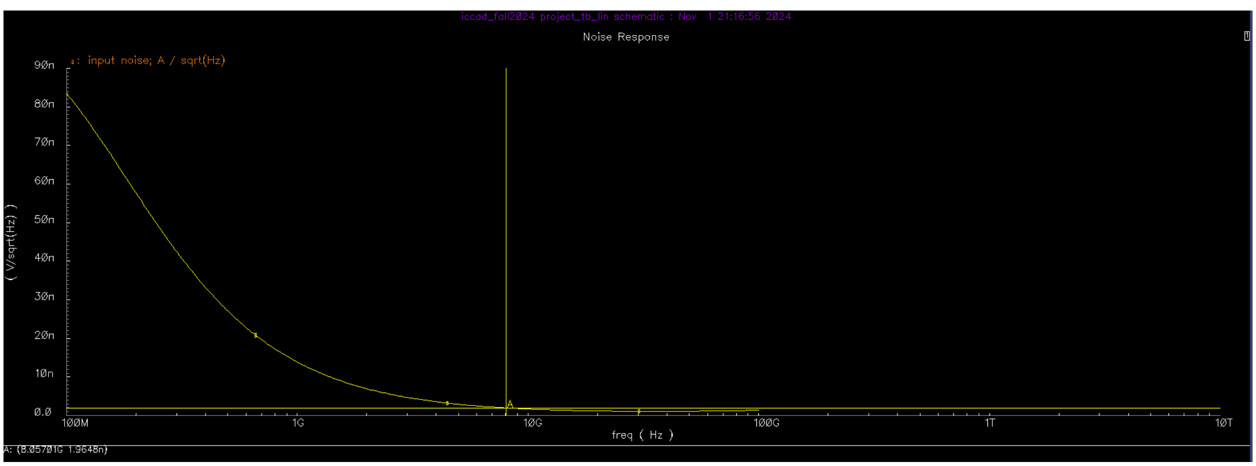



Figure 19: The input-referred noise

### 3.1.2 120°

The analysis results are shown in the following figures and in table 6.

| | |
|---|---|
| Power comsumption (mW) | 8.377 |
| Gain (@ 8GHz, dB) | 23.792 |
| Bandwidth (GHz) | 0.794 |
| 1dB compression point (dBm) | -2.411 |
| 3rd input intercept point (dBm) | 1.201 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 2.232 |

Table 6: The circuit properties at 120°

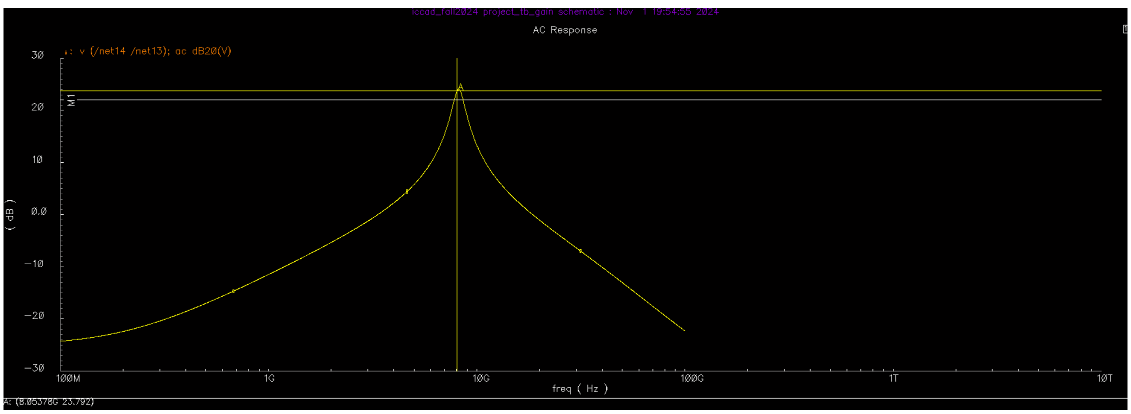
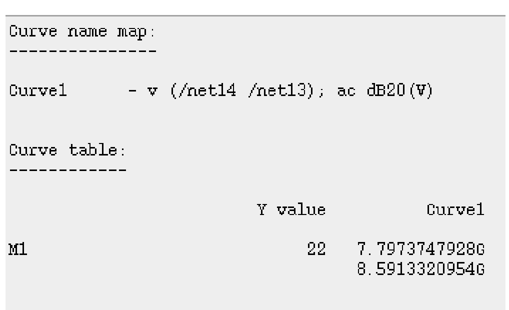



Figure 20: The gain plot



```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)

Curve table:
------------

                          Y value         Curve1

M1                             22    7.79737479280G
                                     8.59133209546G
```

Figure 21: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") |
|---|---|
| betaeff | 91.5292m |
| cbb | 14.146f |
| cbd | 42.3969a |
| cbg | -9.85569f |
| cbs | -4.33269f |
| cdb | -8.0975a |
| cdd | 18.3215f |
| cdg | -18.3501f |
| cds | 36.6926a |
| cgb | -7.12538f |
| cgd | -17.8442f |
| cgg | 86.8266f |
| cgs | -61.857f |
| cjd | 18.9894f |
| cjs | 26.2519f |
| csb | -7.01251f |
| csd | -519.709a |
| csg | -58.6208f |
| css | 66.153f |
| gds | 607.104u |
| gm | 14.4773m |
| gmbs | 2.48576m |
| gmoverid | 6.80461 |
| ibulk | -58.0854p |
| id | 2.12758m |
| ids | 2.12758m |
| is | -2.12758m |
| pwr | 1.82051m |
| region | 2 |
| reversed | 0 |
| ron | 402.181 |
| type | 0 |
| vbs | -932.155m |
| vds | 855.671m |
| vdsat | 184.233m |
| vgs | 867.845m |
| vth | 665.475m |

| signal | OP("I0.M5" "??") |
|---|---|
| betaeff | 91.5292m |
| cbb | 14.146f |
| cbd | 42.3969a |
| cbg | -9.85569f |
| cbs | -4.33269f |
| cdb | -8.0975a |
| cdd | 18.3215f |
| cdg | -18.3501f |
| cds | 36.6926a |
| cgb | -7.12538f |
| cgd | -17.8442f |
| cgg | 86.8266f |
| cgs | -61.857f |
| cjd | 18.9894f |
| cjs | 26.2519f |
| csb | -7.01251f |
| csd | -519.709a |
| csg | -58.6208f |
| css | 66.153f |
| gds | 607.104u |
| gm | 14.4773m |
| gmbs | 2.48576m |
| gmoverid | 6.80461 |
| ibulk | -58.0854p |
| id | 2.12758m |
| ids | 2.12758m |
| is | -2.12758m |
| pwr | 1.82051m |
| region | 2 |
| reversed | 0 |
| ron | 402.181 |
| type | 0 |
| vbs | -932.155m |
| vds | 855.671m |
| vdsat | 184.233m |
| vgs | 867.845m |
| vth | 665.475m |

| signal | OP("I0.M6" "??") |
|---|---|
| betaeff | 192.116m |
| cbb | 38.6256f |
| cbd | 30.9686a |
| cbg | -21.6434f |
| cbs | -17.0132f |
| cdb | -21.7294a |
| cdd | 36.6344f |
| cdg | -36.6808f |
| cds | 68.0822a |
| cgb | -14.9857f |
| cgd | -36.4168f |
| cgg | 175.092f |
| cgs | -123.689f |
| cjd | 45.4452f |
| cjs | 72.1042f |
| csb | -23.6182f |
| csd | -248.636a |
| csg | -116.767f |
| css | 140.634f |
| gds | 858.923u |
| gm | 29.2912m |
| gmbs | 8.38898m |
| gmoverid | 6.8837 |
| ibulk | -395.319p |
| id | 4.25515m |
| ids | 4.25515m |
| is | -4.25515m |
| pwr | 3.96646m |
| region | 2 |
| reversed | 0 |
| ron | 219.065 |
| type | 0 |
| vbs | 0 |
| vds | 932.155m |
| vdsat | 171.831m |
| vgs | 660.259m |
| vth | 455.677m |

| signal | OP("I0.M0" "??") |
|---|---|
| betaeff | 19.2085m |
| cbb | 3.86662f |
| cbd | 1.13849a |
| cbg | -2.16114f |
| cbs | -1.70662f |
| cdb | -4.88385a |
| cdd | 3.66917f |
| cdg | -3.67732f |
| cds | 13.0342a |
| cgb | -1.4788f |
| cgd | -3.64354f |
| cgg | 17.5093f |
| cgs | -12.387f |
| cjd | 4.92393f |
| cjs | 11.4005f |
| csb | -2.38294f |
| csd | -26.7638a |
| csg | -11.6708f |
| css | 14.0805f |
| gds | 105.018u |
| gm | 2.79422m |
| gmbs | 809.068u |
| gmoverid | 6.98554 |
| ibulk | -3.33425p |
| id | 400u |
| ids | 400u |
| is | -400u |
| pwr | 264.104u |
| region | 2 |
| reversed | 0 |
| ron | 1.65065K |
| type | 0 |
| vbs | 0 |
| vds | 660.259m |
| vdsat | 171.446m |
| vgs | 660.259m |
| vth | 456.491m |

Figure 22: The DC operating points of all transistors

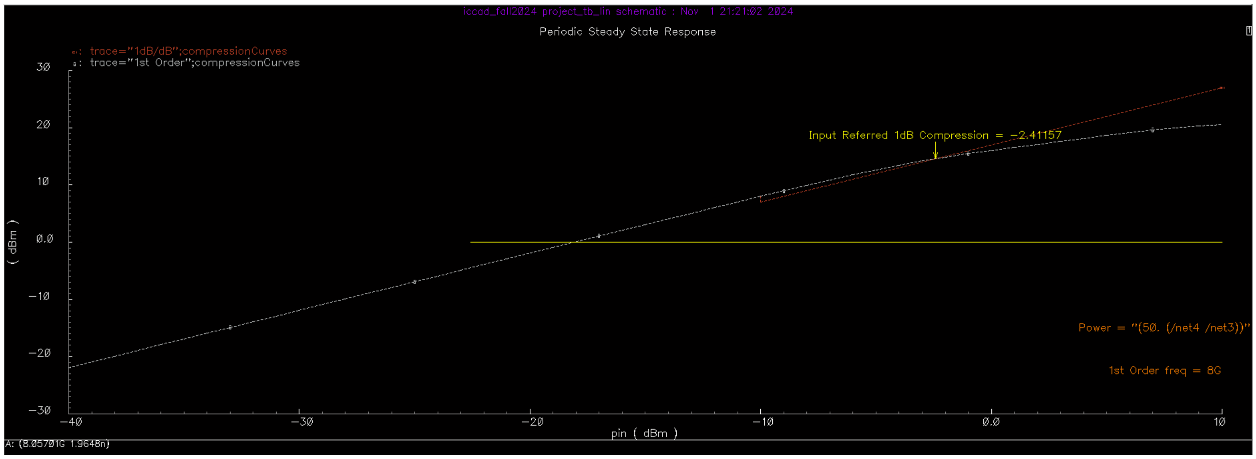



Figure 23: The 1dB compression point

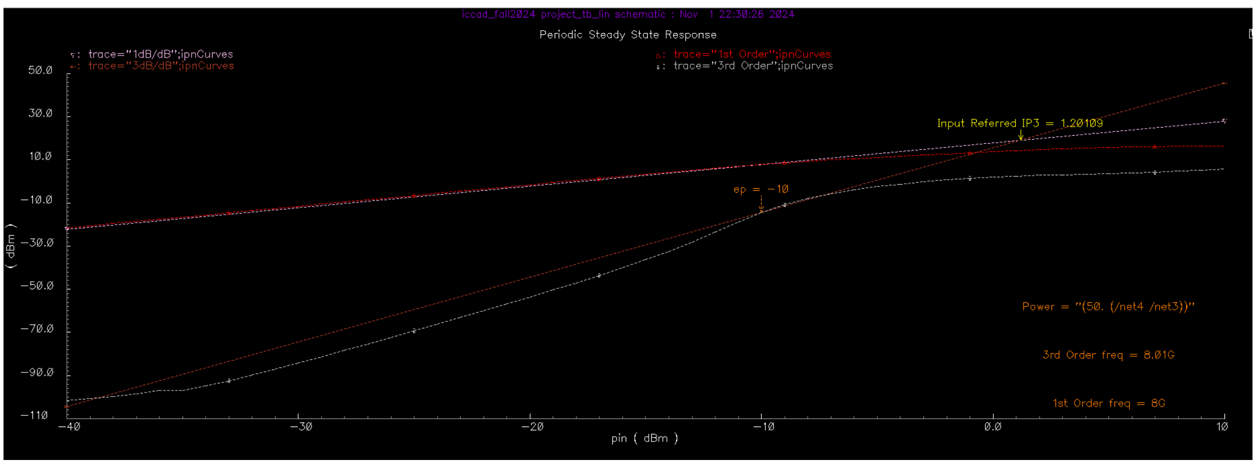



Figure 24: The IIP3 plot

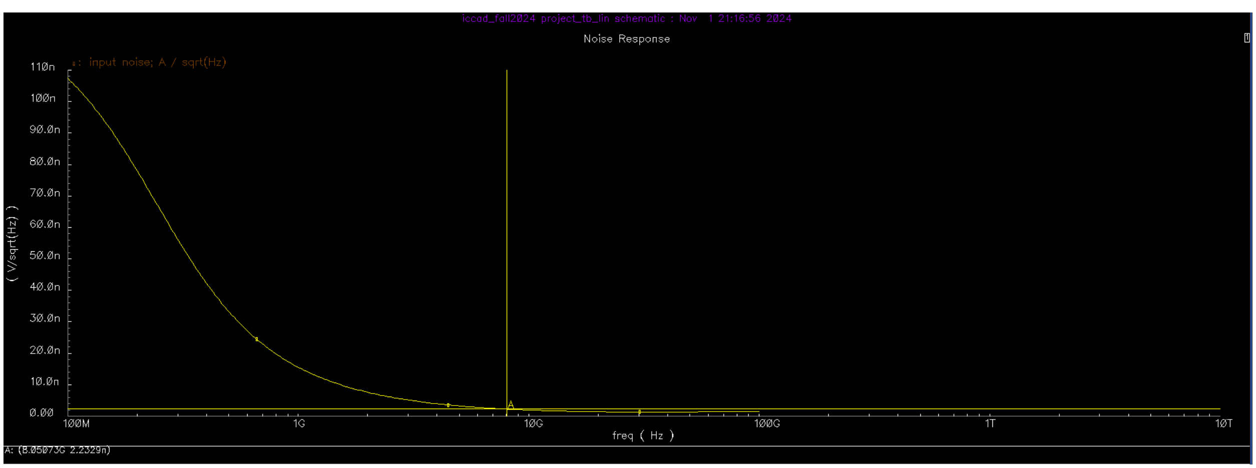



Figure 25: The input-referred noise

## 3.2 FF

To change the corner, I use `Analog Environment > Setup > Model Libraries...` and changed the corner of the transistor model, the MIM capacitor model, and the M model to FF.

### 3.2.1 -40°

The analysis results are shown in the following figures and in table 7.

| | |
|---|---|
| Power comsumption (mW) | 9.003 |
| Gain (@ 8GHz, dB) | 26.227 |
| Bandwidth (GHz) | 1.651 |
| 1dB compression point (dBm) | -1.160 |
| 3rd input intercept point (dBm) | -1.343 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.906 |

Table 7: The circuit properties at -40°

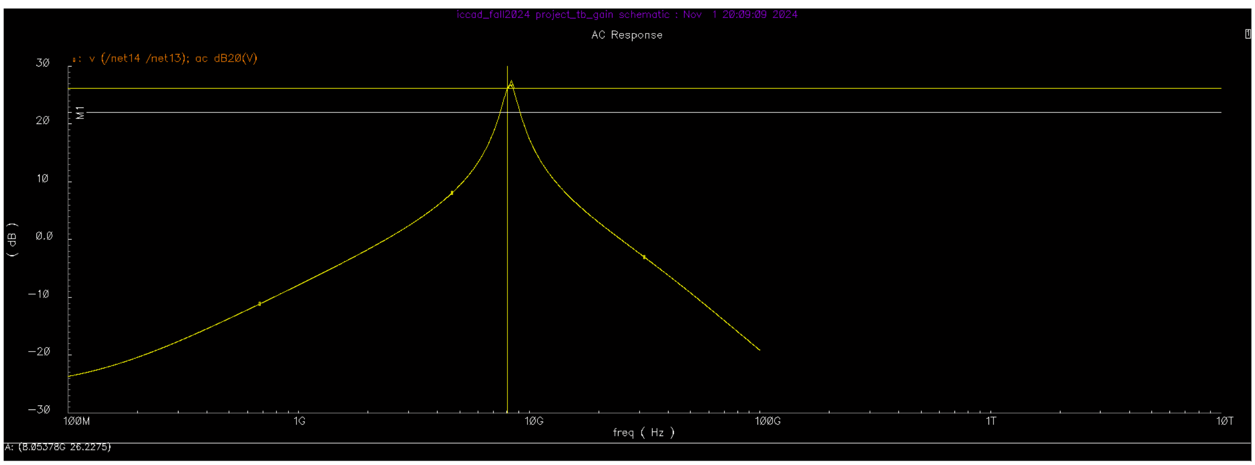



Figure 26: The gain plot

```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                          Y value          Curve1

M1                             22    7.47276040116
                                     9.12362341286
```

Figure 27: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") | OP("I0.M5" "??") | OP("I0.M6" "??") | OP("I0.M0" "??") |
|---|---|---|---|---|
| betaeff | 296.209m | 296.209m | 599.564m | 59.9246m |
| cbb | 13.5948f | 13.5948f | 37.3854f | 3.7413f |
| cbd | 74.2728a | 74.2728a | 138.422a | 12.5666a |
| cbg | -9.73662f | -9.73662f | -21.4588f | -2.142f |
| cbs | -3.93243f | -3.93243f | -16.065f | -1.61187f |
| cdb | -5.46399a | -5.46399a | -12.7015a | -3.7166a |
| cdd | 19.2678f | 19.2678f | 38.5232f | 3.85589f |
| cdg | -19.3033f | -19.3033f | -38.5654f | -3.86641f |
| cds | 41.0278a | 41.0278a | 54.9211a | 14.2358a |
| cgb | -8.94875f | -8.94875f | -18.2607f | -1.79898f |
| cgd | -18.4637f | -18.4637f | -37.8065f | -3.78204f |
| cgg | 87.8978f | 87.8978f | 177.183f | 17.6933f |
| cgs | -60.4853f | -60.4853f | -121.116f | -12.1123f |
| cjd | 17.6426f | 17.6426f | 40.669f | 4.48669f |
| cjs | 23.4238f | 23.4238f | 60.212f | 9.50755f |
| csb | -4.64056f | -4.64056f | -19.112f | -1.93861f |
| csd | -878.33a | -878.33a | -855.108a | -86.4134a |
| csg | -58.8578f | -58.8578f | -117.159f | -11.6849f |
| css | 64.3767f | 64.3767f | 137.126f | 13.7099f |
| gds | 1.06472m | 1.06472m | 1.49664m | 158.543u |
| gm | 22.5571m | 22.5571m | 44.9198m | 4.16144m |
| gmbs | 2.58625m | 2.58625m | 10.6772m | 1.00925m |
| gmoverid | 9.79913 | 9.79913 | 9.75693 | 10.4036 |
| ibulk | -31.8792p | -31.8792p | -6.37072n | -24.6915f |
| id | 2.30194m | 2.30194m | 4.60389m | 400u |
| ids | 2.30194m | 2.30194m | 4.60388m | 400u |
| is | -2.30194m | -2.30194m | -4.60388m | -400u |
| pwr | 1.79943m | 1.79943m | 4.6518m | 245.523u |
| region | 2 | 2 | 2 | 2 |
| reversed | 0 | 0 | 0 | 0 |
| ron | 339.582 | 339.582 | 219.468 | 1.53452K |
| type | 0 | 0 | 0 | 0 |
| vbs | -1.01041 | -1.01041 | 0 | 0 |
| vds | 781.699m | 781.699m | 1.01041 | 613.807m |
| vdsat | 97.5725m | 97.5725m | 91.4926m | 89.8858m |
| vgs | 789.593m | 789.593m | 613.807m | 613.807m |
| vth | 672.873m | 672.873m | 498.857m | 503.162m |

Figure 28: The DC operating points of all transistors

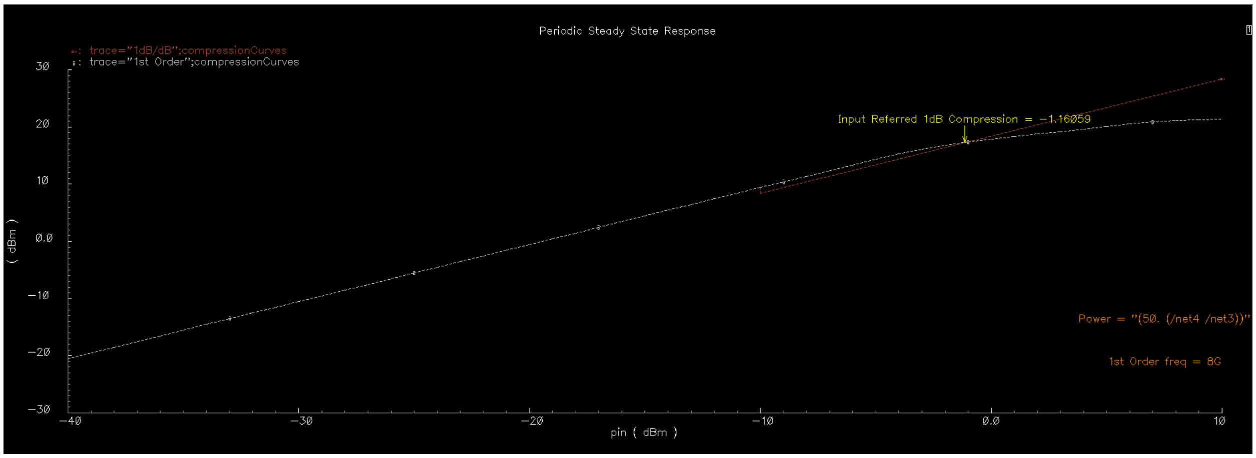



Figure 29: The 1dB compression point

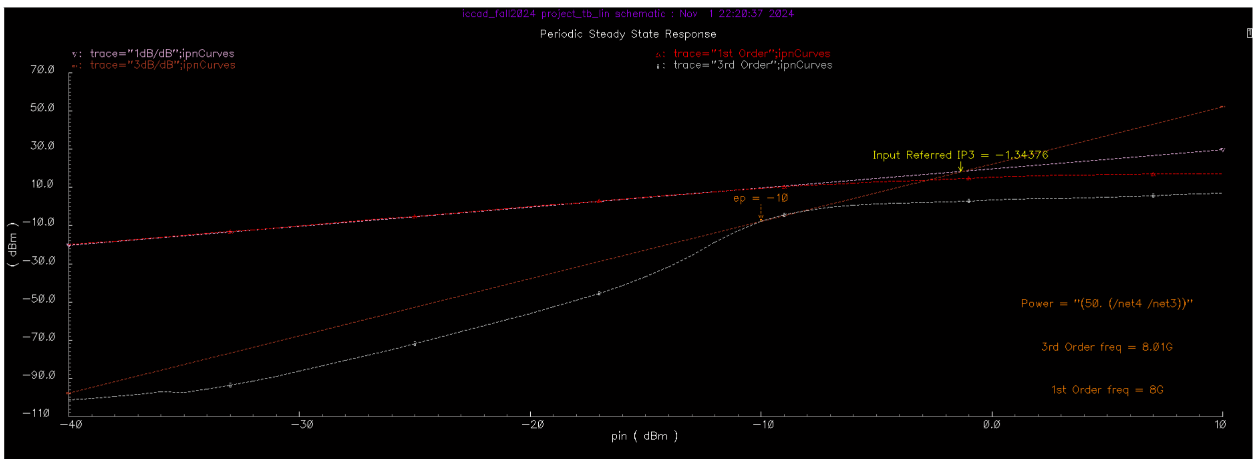



Figure 30: The IIP3 plot

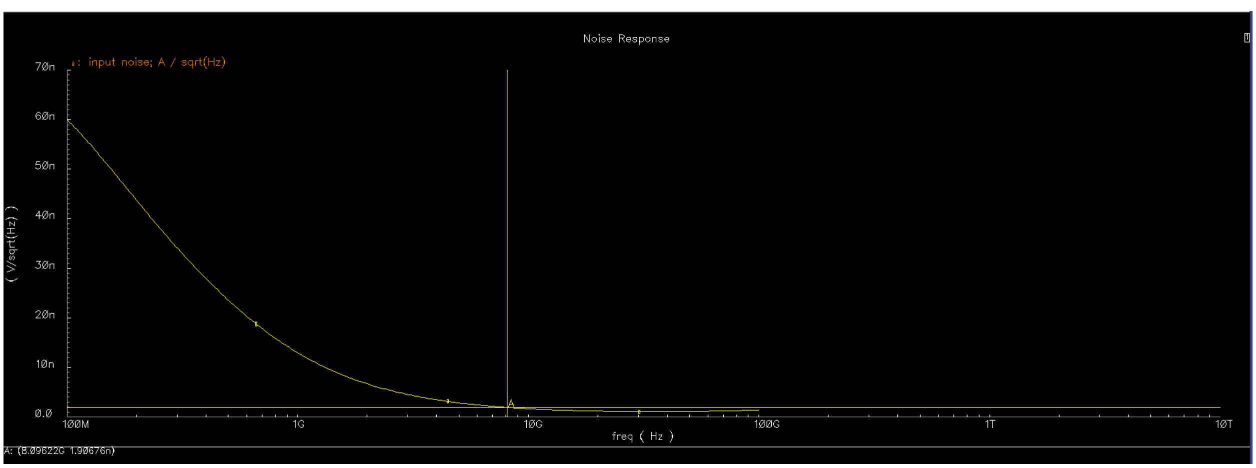



Figure 31: The input-referred noise

### 3.2.2 27°

The analysis results are shown in the following figures and in table 8.

| | |
|---|---|
| Power comsumption (mW) | 11.152 |
| Gain (@ 8GHz, dB) | 24.509 |
| Bandwidth (GHz) | 1.308 |
| 1dB compression point (dBm) | -0.485 |
| 3rd input intercept point (dBm) | 1.647 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 2.017 |

Table 8: The circuit properties at 27°

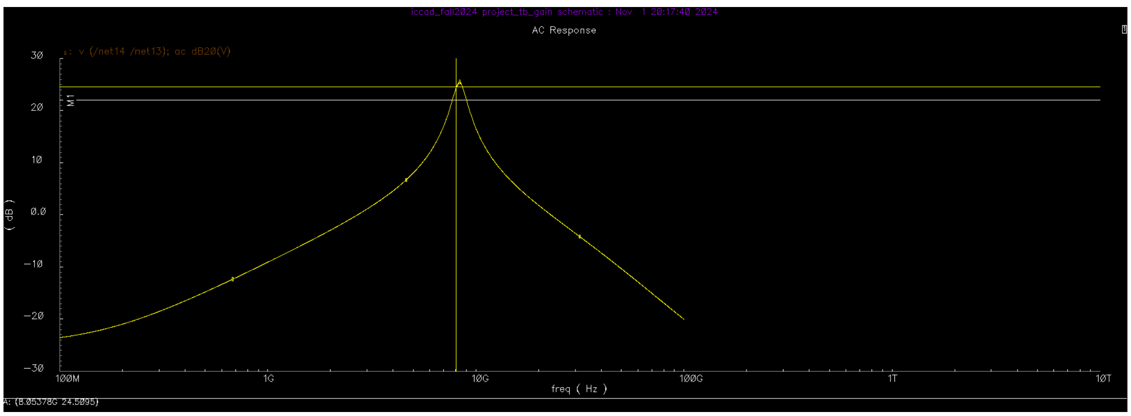
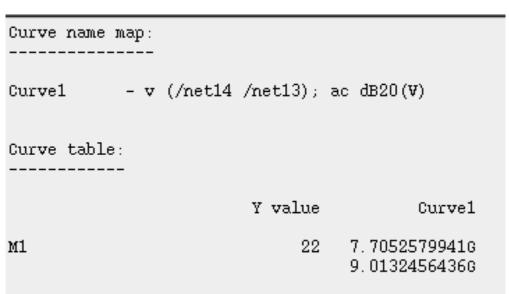



Figure 32: The gain plot



```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                          Y value          Curve1

M1                             22    7.70525799416
                                     9.01324564366
```

Figure 33: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") |
|---|---|
| betaeff | 186.563m |
| cbb | 13.5678f |
| cbd | 73.4129a |
| cbg | -9.69971f |
| cbs | -3.94148f |
| cdb | -6.20723a |
| cdd | 19.2721f |
| cdg | -19.3076f |
| cds | 41.7524a |
| cgb | -8.745f |
| cgd | -18.4676f |
| cgg | 87.646f |
| cgs | -60.4335f |
| cjd | 17.9556f |
| cjs | 23.9886f |
| csb | -4.81657f |
| csd | -877.94a |
| csg | -58.6387f |
| css | 64.3332f |
| gds | 961.23u |
| gm | 19.3505m |
| gmbs | 2.30229m |
| gmoverid | 8.4507 |
| ibulk | -10.4167p |
| id | 2.28981m |
| ids | 2.28981m |
| is | -2.28981m |
| pwr | 1.76689m |
| region | 2 |
| reversed | 0 |
| ron | 336.984 |
| type | 0 |
| vbs | -1.01832 |
| vds | 771.631m |
| vdsat | 128.22m |
| vgs | 781.681m |
| vth | 636.645m |

| signal | OP("I0.M5" "??") |
|---|---|
| betaeff | 186.563m |
| cbb | 13.5678f |
| cbd | 73.4129a |
| cbg | -9.69971f |
| cbs | -3.94148f |
| cdb | -6.20723a |
| cdd | 19.2721f |
| cdg | -19.3076f |
| cds | 41.7524a |
| cgb | -8.745f |
| cgd | -18.4676f |
| cgg | 87.646f |
| cgs | -60.4335f |
| cjd | 17.9556f |
| cjs | 23.9886f |
| csb | -4.81657f |
| csd | -877.94a |
| csg | -58.6387f |
| css | 64.3332f |
| gds | 961.23u |
| gm | 19.3505m |
| gmbs | 2.30229m |
| gmoverid | 8.4507 |
| ibulk | -10.4167p |
| id | 2.28981m |
| ids | 2.28981m |
| is | -2.28981m |
| pwr | 1.76689m |
| region | 2 |
| reversed | 0 |
| ron | 336.984 |
| type | 0 |
| vbs | -1.01832 |
| vds | 771.631m |
| vdsat | 128.22m |
| vgs | 781.681m |
| vth | 636.645m |

| signal | OP("I0.M6" "??") |
|---|---|
| betaeff | 379.944m |
| cbb | 37.4108f |
| cbd | 138.226a |
| cbg | -21.4053f |
| cbs | -16.1437f |
| cdb | -13.2658a |
| cdd | 38.526f |
| cdg | -38.5667f |
| cds | 53.945a |
| cgb | -17.9658f |
| cgd | -37.8134f |
| cgg | 176.708f |
| cgs | -120.929f |
| cjd | 41.5902f |
| cjs | 63.6931f |
| csb | -19.4318f |
| csd | -850.809a |
| csg | -116.736f |
| css | 137.018f |
| gds | 1.32492m |
| gm | 38.8077m |
| gmbs | 9.37579m |
| gmoverid | 8.47401 |
| ibulk | -4.68637n |
| id | 4.57963m |
| ids | 4.57962m |
| is | -4.57962m |
| pwr | 4.66352m |
| region | 2 |
| reversed | 0 |
| ron | 222.359 |
| type | 0 |
| vbs | 0 |
| vds | 1.01832 |
| vdsat | 119.712m |
| vgs | 599.178m |
| vth | 455.632m |

| signal | OP("I0.M0" "??") |
|---|---|
| betaeff | 37.9693m |
| cbb | 3.74405f |
| cbd | 11.9352a |
| cbg | -2.13637f |
| cbs | -1.61962f |
| cdb | -4.28416a |
| cdd | 3.85793f |
| cdg | -3.8684f |
| cds | 14.7553a |
| cgb | -1.76685f |
| cgd | -3.78326f |
| cgg | 17.6502f |
| cgs | -12.1001f |
| cjd | 4.64854f |
| cjs | 10.0626f |
| csb | -1.97292f |
| csd | -86.6068a |
| csg | -11.6455f |
| css | 13.705f |
| gds | 149.662u |
| gm | 3.57699m |
| gmbs | 882.509u |
| gmoverid | 8.94249 |
| ibulk | -3.43465f |
| id | 400u |
| ids | 400u |
| is | -400u |
| pwr | 239.671u |
| region | 2 |
| reversed | 0 |
| ron | 1.49794K |
| type | 0 |
| vbs | 0 |
| vds | 599.178m |
| vdsat | 117.835m |
| vgs | 599.178m |
| vth | 460.181m |

Figure 34: The DC operating points of all transistors

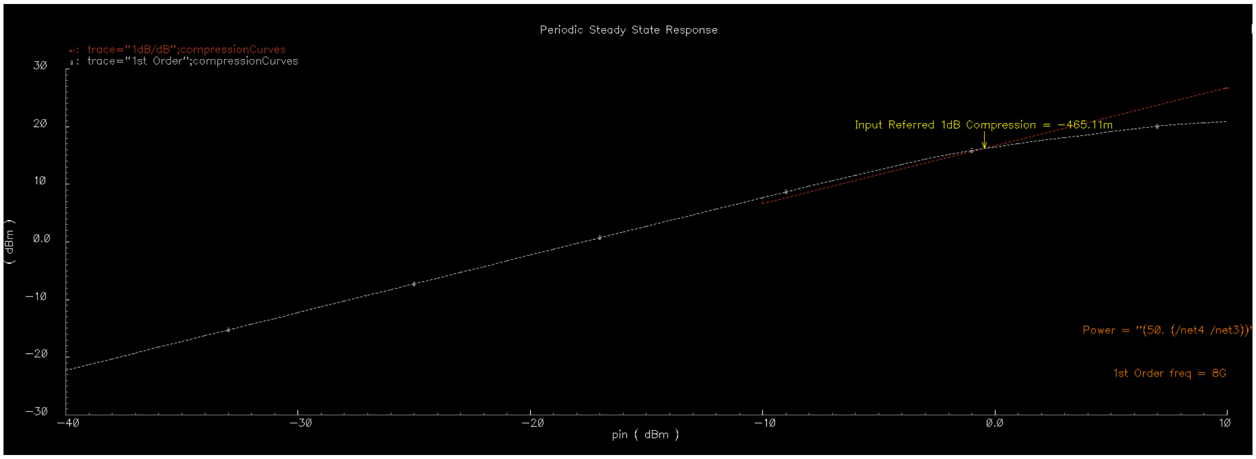



Figure 35: The 1dB compression point

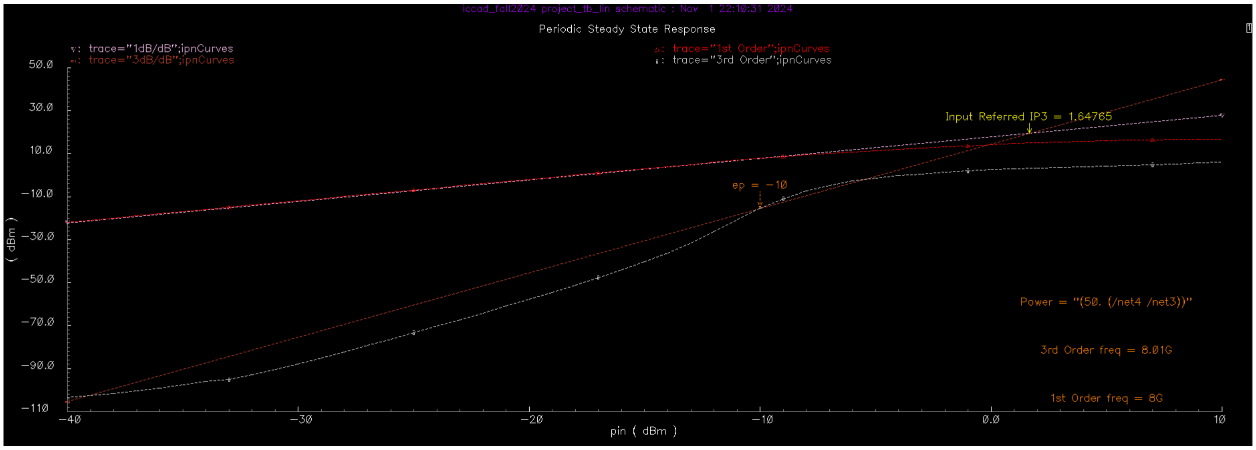



Figure 36: The IIP3 plot

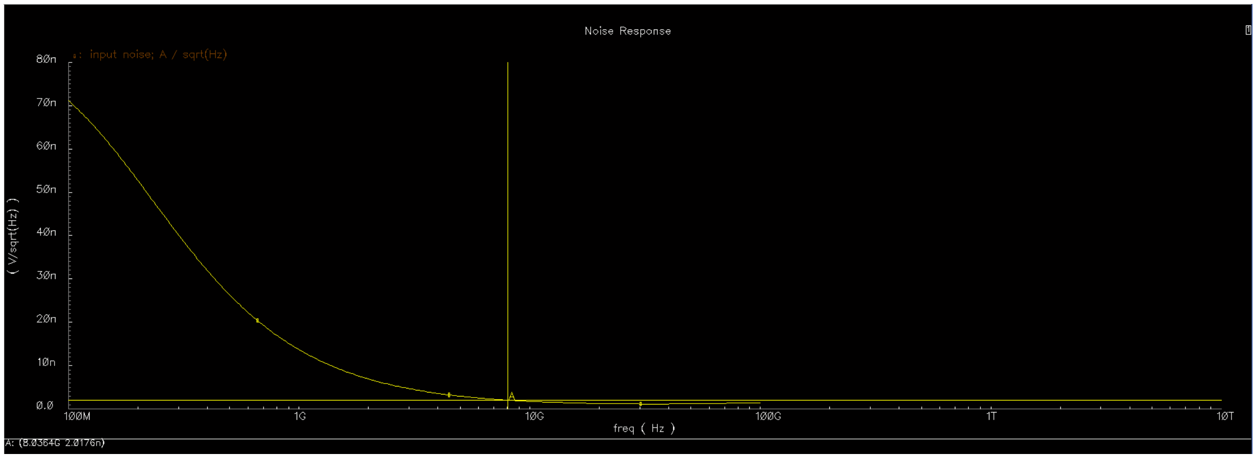



Figure 37: The input-referred noise

### 3.2.3 120°

The analysis results are shown in the following figures and in table 9.

| | |
|---|---|
| Power comsumption (mW) | 10.839 |
| Gain (@ 8GHz, dB) | 22.223 |
| Bandwidth (GHz) | 0.877 |
| 1dB compression point (dBm) | 0.425 |
| 3rd input intercept point (dBm) | 4.604 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 2.196 |

Table 9: The circuit properties at 120°

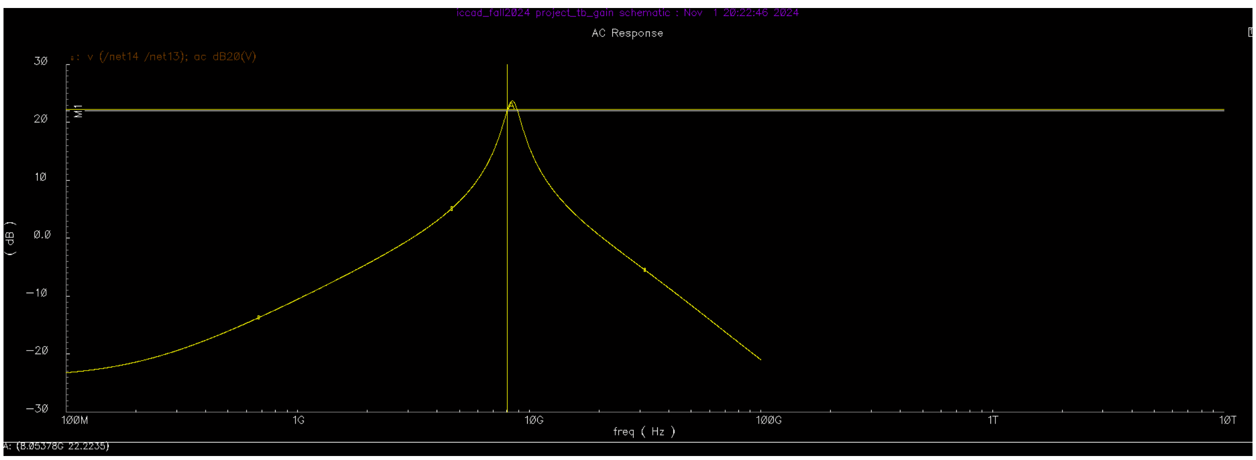



Figure 38: The gain plot

```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                              Y value          Curve1

M1                                 22    8.02069488896
                                         8.89786739496
```

Figure 39: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") | OP("I0.M5" "??") | OP("I0.M6" "??") | OP("I0.M0" "??") |
|---|---|---|---|---|
| betaeff | 108.934m | 108.934m | 224.421m | 22.4236m |
| cbb | 13.54f | 13.54f | 37.4258f | 3.74598f |
| cbd | 71.2006a | 71.2006a | 137.389a | 10.5741a |
| cbg | -9.66222f | -9.66222f | -21.3313f | -2.12786f |
| cbs | -3.94903f | -3.94903f | -16.2319f | -1.62869f |
| cdb | -7.54762a | -7.54762a | -14.5331a | -5.31382a |
| cdd | 19.2805f | 19.2805f | 38.5314f | 3.86217f |
| cdg | -19.3152f | -19.3152f | -38.5702f | -3.87201f |
| cds | 42.1959a | 42.1959a | 53.3346a | 15.1577a |
| cgb | -8.41826f | -8.41826f | -17.4056f | -1.70758f |
| cgd | -18.4721f | -18.4721f | -37.8197f | -3.785f |
| cgg | 87.4851f | 87.4851f | 176.418f | 17.6284f |
| cgs | -60.5947f | -60.5947f | -121.193f | -12.1358f |
| cjd | 18.0316f | 18.0316f | 42.1718f | 4.80636f |
| cjs | 24.3894f | 24.3894f | 68.8885f | 10.891f |
| csb | -5.11424f | -5.11424f | -20.0057f | -2.03308f |
| csd | -879.621a | -879.621a | -849.179a | -87.7428a |
| csg | -58.5077f | -58.5077f | -116.516f | -11.6285f |
| css | 64.5015f | 64.5015f | 137.371f | 13.7494f |
| gds | 877.515u | 877.515u | 1.17683m | 146.29u |
| gm | 16.1621m | 16.1621m | 32.8205m | 2.99926m |
| gmbs | 2.0343m | 2.0343m | 8.11994m | 758.335u |
| gmoverid | 7.08495 | 7.08495 | 7.19374 | 7.49815 |
| ibulk | -73.4332p | -73.4332p | -2.65439n | -6.56707p |
| id | 2.28119m | 2.28119m | 4.56238m | 400u |
| ids | 2.28119m | 2.28119m | 4.56237m | 400u |
| is | -2.28119m | -2.28119m | -4.56237m | -400u |
| pwr | 1.73975m | 1.73975m | 4.67219m | 233.704u |
| region | 2 | 2 | 2 | 2 |
| reversed | 0 | 0 | 0 | 0 |
| ron | 334.321 | 334.321 | 224.46 | 1.46065K |
| type | 0 | 0 | 0 | 0 |
| vbs | -1.02407 | -1.02407 | 0 | 0 |
| vds | 762.65m | 762.65m | 1.02407 | 584.259m |
| vdsat | 175.568m | 175.568m | 162.72m | 160.488m |
| vgs | 775.931m | 775.931m | 584.259m | 584.259m |
| vth | 581.81m | 581.81m | 391.182m | 395.957m |

Figure 40: The DC operating points of all transistors

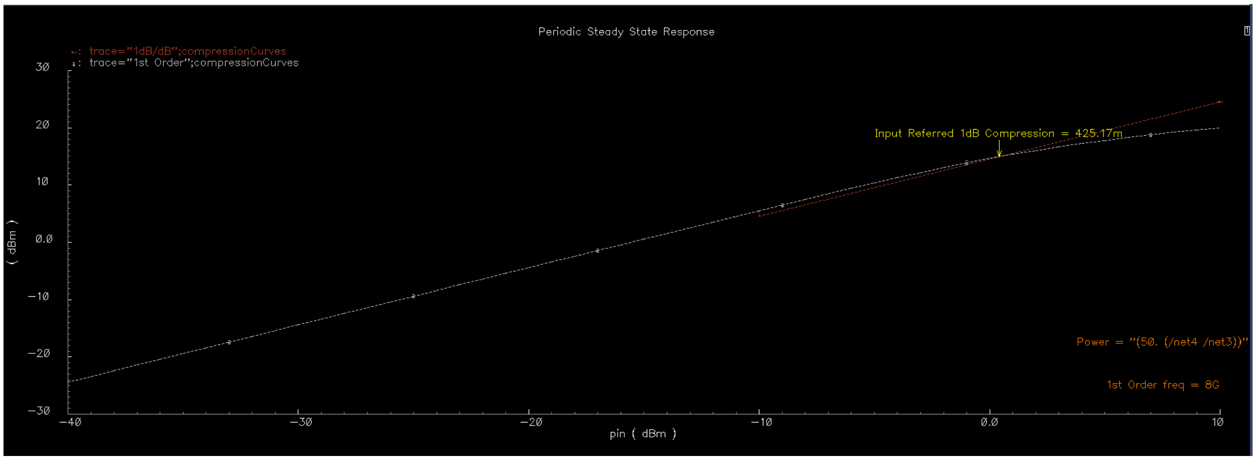



Figure 41: The 1dB compression point

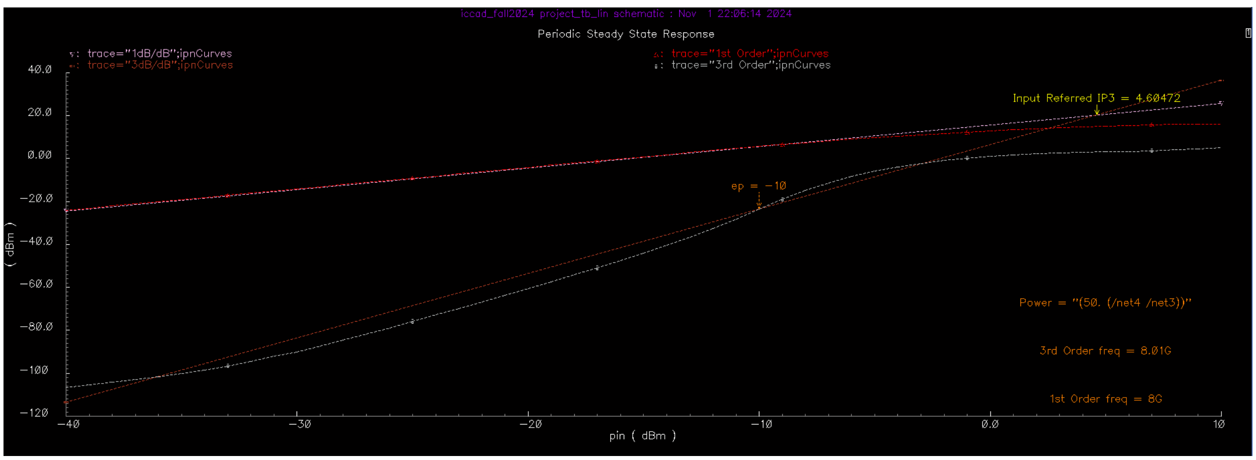



Figure 42: The IIP3 plot

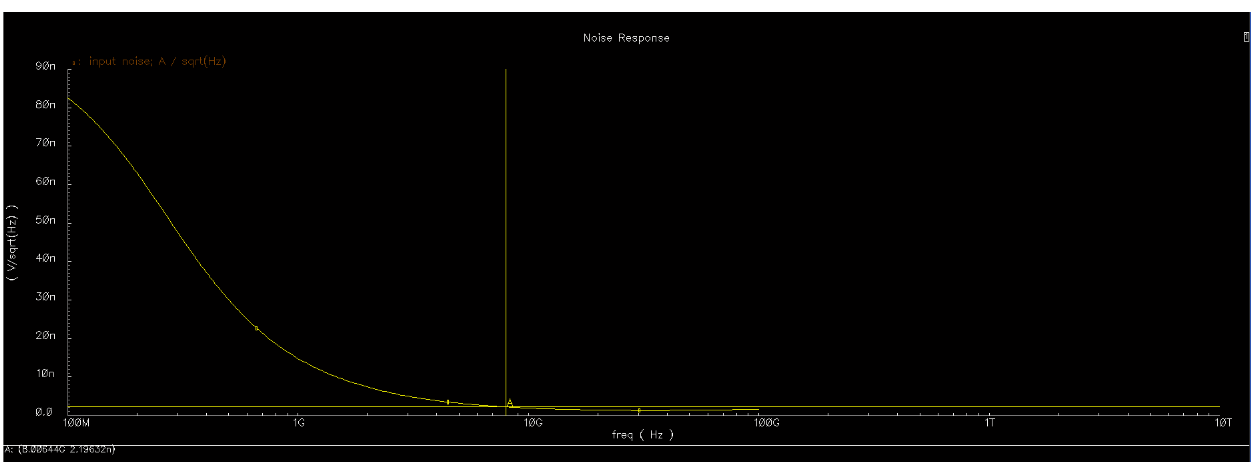



Figure 43: The input-referred noise

## 3.3 SS

### 3.3.1 -40°

The analysis results are shown in the following figures and in table 10.

| | |
|---|---|
| Power comsumption (mW) | 8.380 |
| Gain (@ 8GHz, dB) | 26.467 |
| Bandwidth (GHz) | 1.253 |
| 1dB compression point (dBm) | -7.744 |
| 3rd input intercept point (dBm) | -1.449 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.992 |

Table 10: The circuit properties at -40°

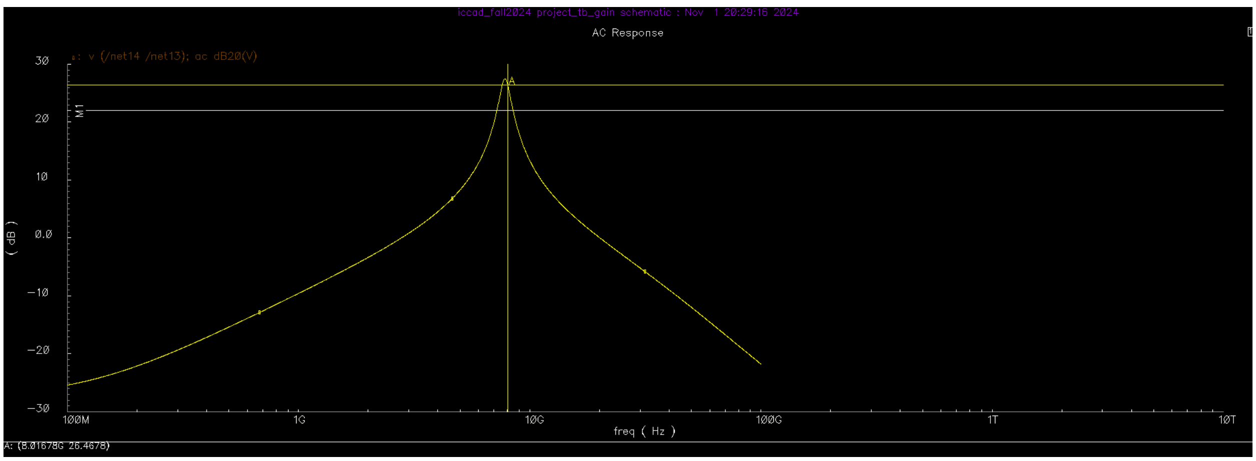
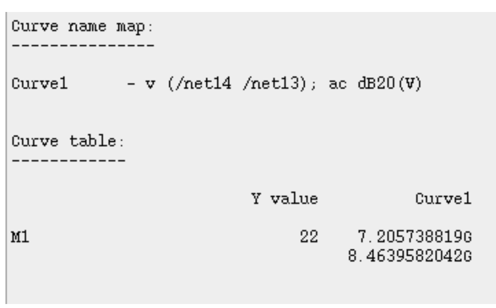



Figure 44: The gain plot



```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                          Y value          Curve1

M1                             22     7.2057388190
                                     8.46395820420
```

Figure 45: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") | OP("I0.M5" "??") | OP("I0.M6" "??") | OP("I0.M0" "??") |
|---|---|---|---|---|
| betaeff | 197.696m | 197.696m | 419.572m | 41.9548m |
| cbb | 14.8156f | 14.8156f | 39.898f | 3.99118f |
| cbd | 42.1271a | 42.1271a | 31.1189a | 2.73266a |
| cbg | -10.1132f | -10.1132f | -22.0729f | -2.20632f |
| cbs | -4.74453f | -4.74453f | -17.8563f | -1.78759f |
| cdb | -6.82882a | -6.82882a | -26.9635a | -3.55153a |
| cdd | 17.3613f | 17.3613f | 34.7303f | 3.47415f |
| cdg | -17.3869f | -17.3869f | -34.7916f | -3.48183f |
| cds | 32.4952a | 32.4952a | 88.2271a | 11.2322a |
| cgb | -6.31007f | -6.31007f | -13.4111f | -1.33424f |
| cgd | -16.9346f | -16.9346f | -34.5187f | -3.45224f |
| cgg | 86.5989f | 86.5989f | 174.573f | 17.4567f |
| cgs | -63.3542f | -63.3542f | -126.643f | -12.6703f |
| cjd | 19.4895f | 19.4895f | 46.6724f | 4.78364f |
| cjs | 26.8418f | 26.8418f | 66.4984f | 10.5031f |
| csb | -8.49866f | -8.49866f | -26.4599f | -2.65339f |
| csd | -468.818a | -468.818a | -242.799a | -24.6488a |
| csg | -59.0988f | -59.0988f | -117.709f | -11.7686f |
| css | 68.0663f | 68.0663f | 144.411f | 14.4466f |
| gds | 621.276u | 621.276u | 956.886u | 99.2742u |
| gm | 18.4592m | 18.4592m | 36.5177m | 3.60001m |
| gmbs | 3.78907m | 3.78907m | 11.5939m | 1.14673m |
| gmoverid | 9.0127 | 9.0127 | 8.9149 | 9.00004 |
| ibulk | -743.113p | -743.113p | -209.643p | -1.58585p |
| id | 2.04813m | 2.04813m | 4.09626m | 400u |
| ids | 2.04813m | 2.04813m | 4.09626m | 400u |
| is | -2.04813m | -2.04813m | -4.09626m | -400u |
| pwr | 1.94287m | 1.94287m | 3.45876m | 298.167u |
| region | 2 | 2 | 2 | 2 |
| reversed | 0 | 0 | 0 | 0 |
| ron | 463.158 | 463.158 | 206.132 | 1.86354K |
| type | 0 | 0 | 0 | 0 |
| vbs | -844.37m | -844.37m | 0 | 0 |
| vds | 948.606m | 948.606m | 844.37m | 745.418m |
| vdsat | 112.706m | 112.706m | 106.461m | 106.351m |
| vgs | 955.63m | 955.63m | 745.418m | 745.418m |
| vth | 822.617m | 822.617m | 610.195m | 610.476m |

Figure 46: The DC operating points of all transistors

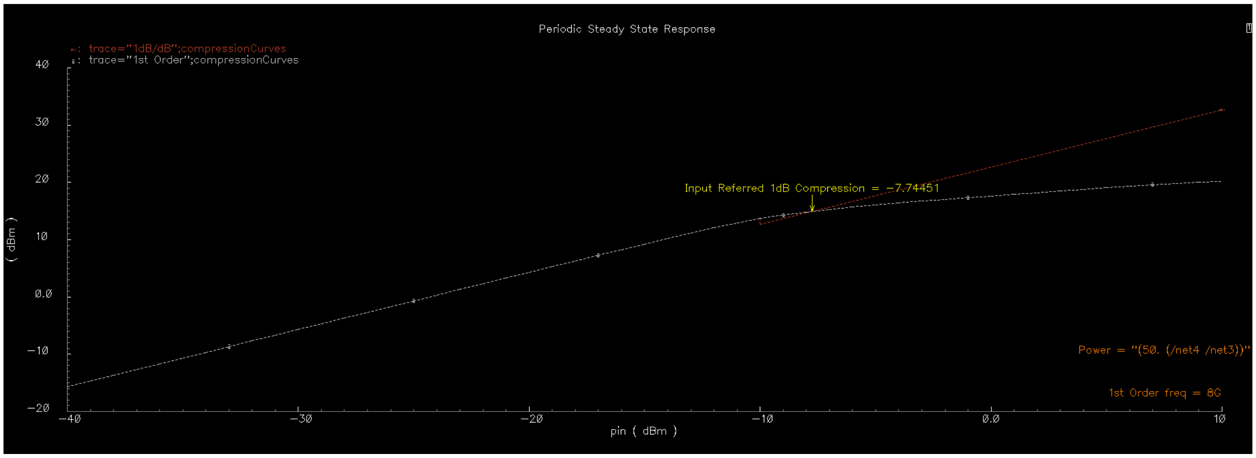



Figure 47: The 1dB compression point

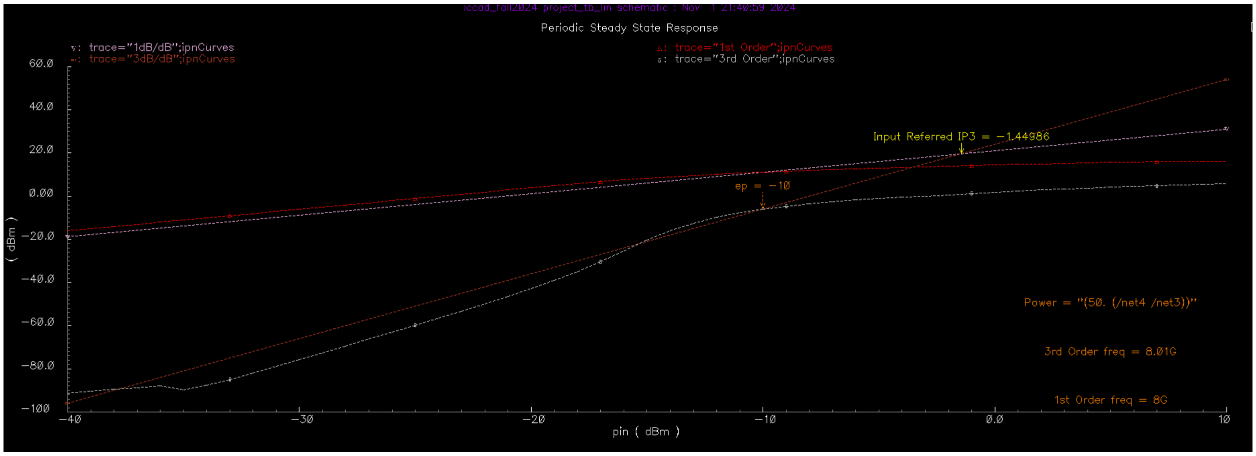



Figure 48: The IIP3 plot

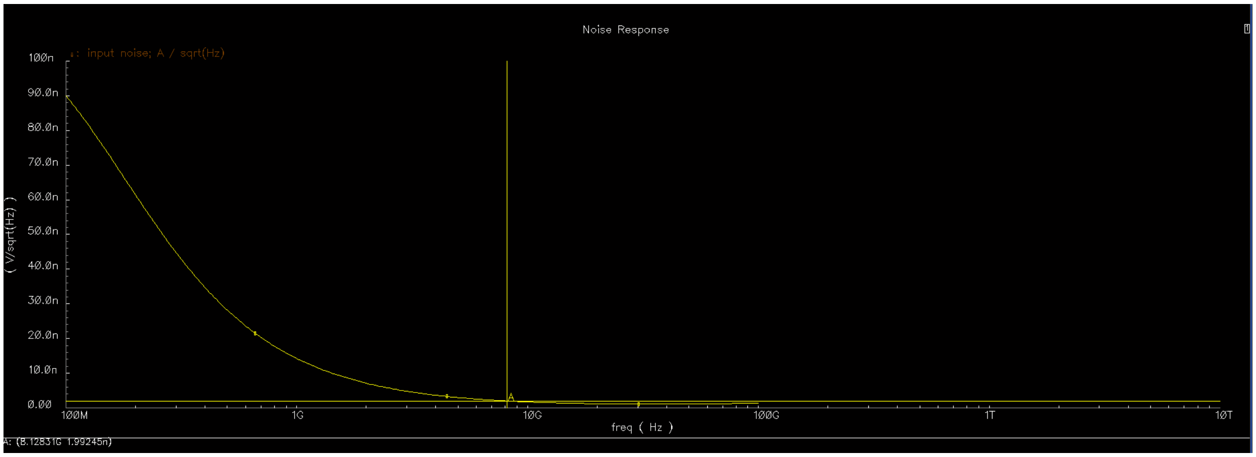



Figure 49: The input-referred noise

### 3.3.2 27°

The analysis results are shown in the following figures and in table 11.

| | |
|---|---|
| Power comsumption (mW) | 8.1 |
| Gain (@ 8GHz, dB) | 25.154 |
| Bandwidth (GHz) | 0.966 |
| 1dB compression point (dBm) | -6.582 |
| 3rd input intercept point (dBm) | -0.507 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 2.1 |

Table 11: The circuit properties at 27°

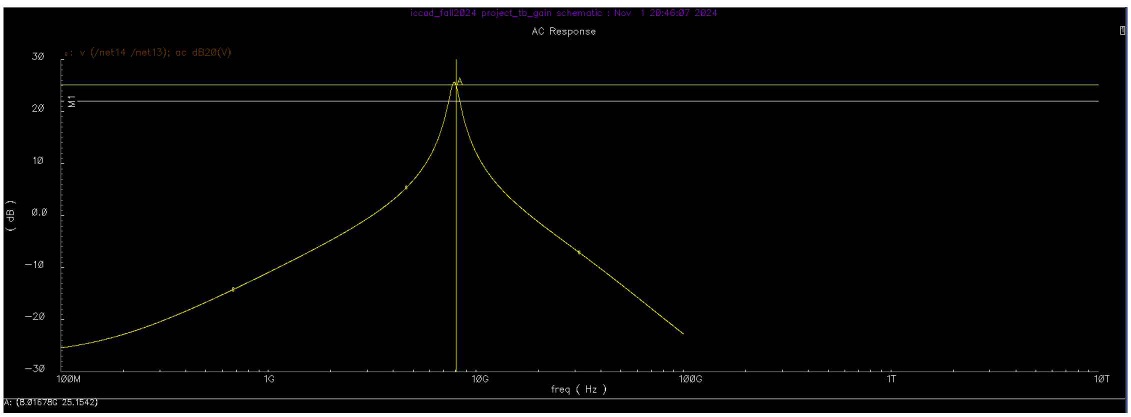
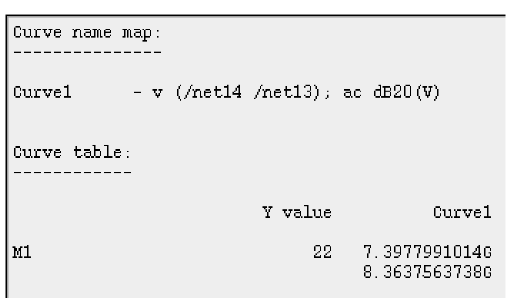



Figure 50: The gain plot



```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)

Curve table:
------------

                          Y value        Curve1

M1                             22    7.39779910140
                                     8.36375637380
```

Figure 51: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") |
|---|---|
| betaeff | 124.059m |
| cbb | 14.7976f |
| cbd | 41.5613a |
| cbg | -10.0796f |
| cbs | -4.75961f |
| cdb | -7.53739a |
| cdd | 17.3641f |
| cdg | -17.3895f |
| cds | 32.9475a |
| cgb | -6.10544f |
| cgd | -16.9367f |
| cgg | 86.3856f |
| cgs | -63.3434f |
| cjd | 19.8356f |
| cjs | 27.5767f |
| csb | -8.68466f |
| csd | -468.969a |
| csg | -58.9165f |
| css | 68.0701f |
| gds | 558.068u |
| gm | 15.6063m |
| gmbs | 3.28377m |
| gmoverid | 7.61092 |
| ibulk | -346.864p |
| id | 2.05051m |
| ids | 2.05051m |
| is | -2.05051m |
| pwr | 1.93353m |
| region | 2 |
| reversed | 0 |
| ron | 459.861 |
| type | 0 |
| vbs | -848.051m |
| vds | 942.949m |
| vdsat | 148.54m |
| vgs | 951.949m |
| vth | 784.505m |

| signal | OP("I0.M5" "??") |
|---|---|
| betaeff | 124.059m |
| cbb | 14.7976f |
| cbd | 41.5613a |
| cbg | -10.0796f |
| cbs | -4.75961f |
| cdb | -7.53739a |
| cdd | 17.3641f |
| cdg | -17.3895f |
| cds | 32.9475a |
| cgb | -6.10544f |
| cgd | -16.9367f |
| cgg | 86.3856f |
| cgs | -63.3434f |
| cjd | 19.8356f |
| cjs | 27.5767f |
| csb | -8.68466f |
| csd | -468.969a |
| csg | -58.9165f |
| css | 68.0701f |
| gds | 558.068u |
| gm | 15.6063m |
| gmbs | 3.28377m |
| gmoverid | 7.61092 |
| ibulk | -346.864p |
| id | 2.05051m |
| ids | 2.05051m |
| is | -2.05051m |
| pwr | 1.93353m |
| region | 2 |
| reversed | 0 |
| ron | 459.861 |
| type | 0 |
| vbs | -848.051m |
| vds | 942.949m |
| vdsat | 148.54m |
| vgs | 951.949m |
| vth | 784.505m |

| signal | OP("I0.M6" "??") |
|---|---|
| betaeff | 263.641m |
| cbb | 39.9134f |
| cbd | 28.8332a |
| cbg | -22.0124f |
| cbs | -17.9298f |
| cdb | -28.8943a |
| cdd | 34.7377f |
| cdg | -34.7965f |
| cds | 87.6078a |
| cgb | -13.0911f |
| cgd | -34.5226f |
| cgg | 174.149f |
| cgs | -126.535f |
| cjd | 47.8885f |
| cjs | 70.3437f |
| csb | -26.7934f |
| csd | -244.017a |
| csg | -117.34f |
| css | 144.377f |
| gds | 881.033u |
| gm | 31.1495m |
| gmbs | 10.0051m |
| gmoverid | 7.59554 |
| ibulk | -105.87p |
| id | 4.10102m |
| ids | 4.10102m |
| is | -4.10102m |
| pwr | 3.47788m |
| region | 2 |
| reversed | 0 |
| ron | 206.79 |
| type | 0 |
| vbs | 0 |
| vds | 848.051m |
| vdsat | 139.823m |
| vgs | 736.72m |
| vth | 566.388m |

| signal | OP("I0.M0" "??") |
|---|---|
| betaeff | 26.3624m |
| cbb | 3.99294f |
| cbd | 2.2936a |
| cbg | -2.20006f |
| cbs | -1.79518f |
| cdb | -3.98256a |
| cdd | 3.47551f |
| cdg | -3.48302f |
| cds | 11.4904a |
| cgb | -1.3013f |
| cgd | -3.45283f |
| cgg | 17.4146f |
| cgs | -12.6605f |
| cjd | 4.93308f |
| cjs | 11.1164f |
| csb | -2.68766f |
| csd | -24.978a |
| csg | -11.7316f |
| css | 14.4442f |
| gds | 93.9219u |
| gm | 3.06245m |
| gmbs | 987.33u |
| gmoverid | 7.65613 |
| ibulk | -425.191f |
| id | 400u |
| ids | 400u |
| is | -400u |
| pwr | 294.688u |
| region | 2 |
| reversed | 0 |
| ron | 1.8418K |
| type | 0 |
| vbs | 0 |
| vds | 736.72m |
| vdsat | 139.687m |
| vgs | 736.72m |
| vth | 566.704m |

Figure 52: The DC operating points of all transistors

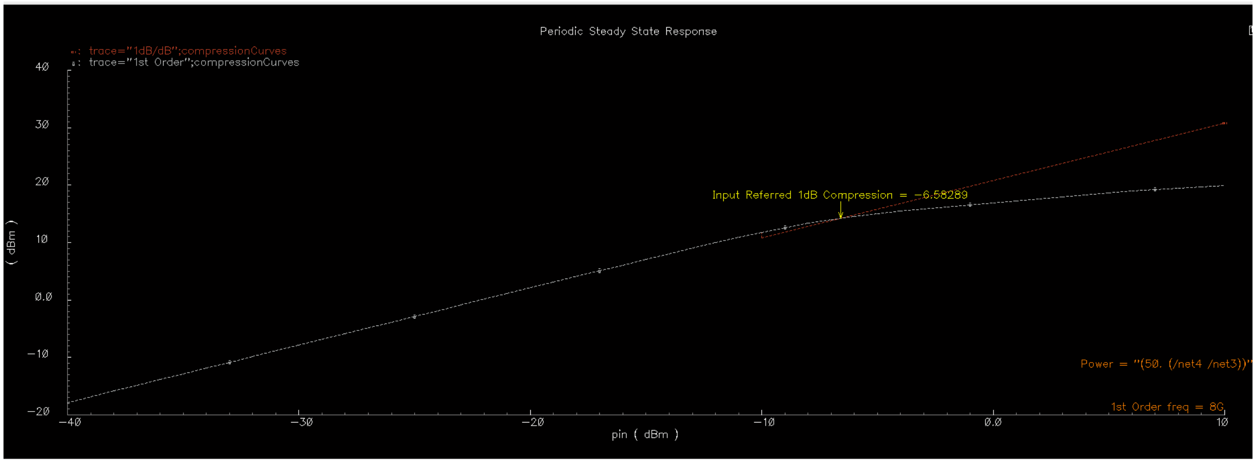



Figure 53: The 1dB compression point

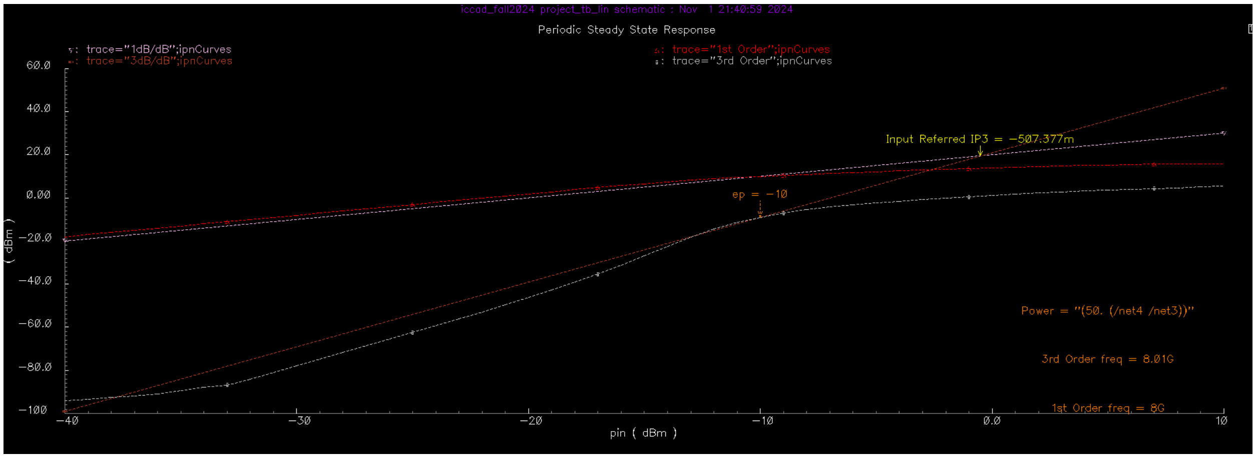



Figure 54: The IIP3 plot

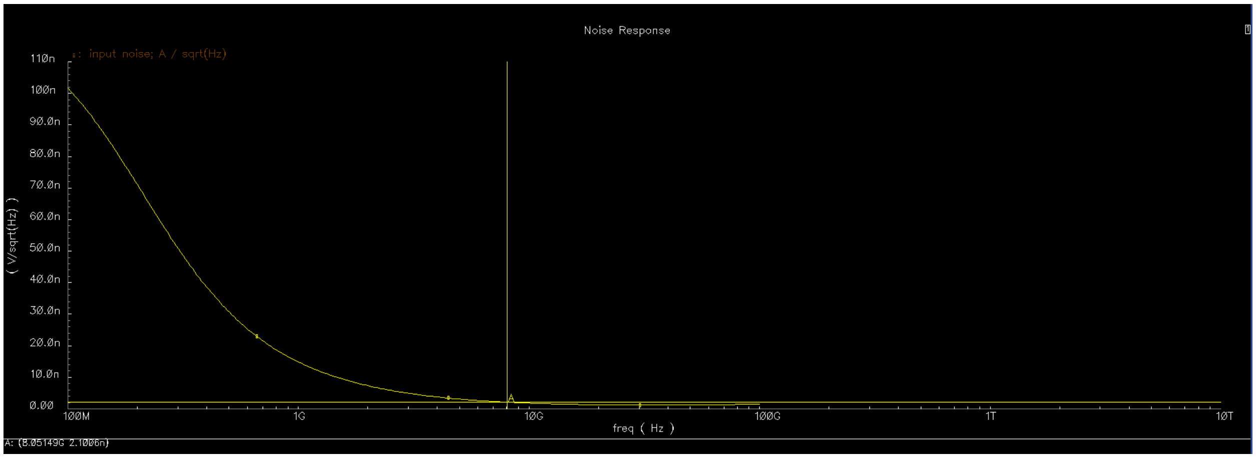



Figure 55: The input-referred noise

### 3.3.3 120°

The analysis results are shown in the following figures and in table 12.

| | |
|---|---|
| Power comsumption (mW) | 8.931 |
| Gain (@ 8GHz, dB) | 23.48 |
| Bandwidth (GHz) | 0.611 |
| 1dB compression point (dBm) | -5.041 |
| 3rd input intercept point (dBm) | 0.928 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 2.27 |

Table 12: The circuit properties at 120°

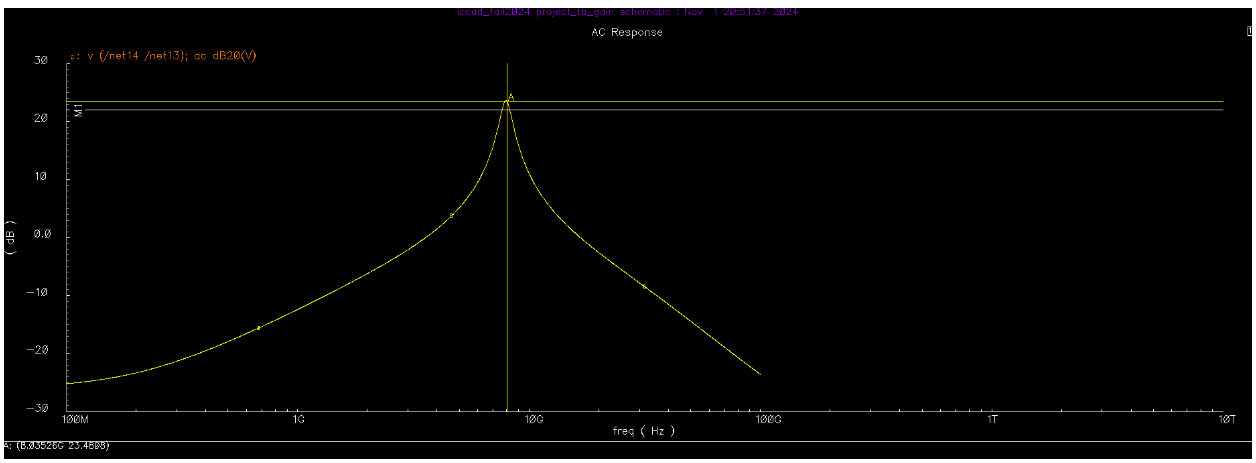



Figure 56: The gain plot

```
Curve name map:
---------------

Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                        Y value        Curve1

M1                           22    7.64864177246
                                   8.25935705446
```

Figure 57: The bandwidth, using a horizontal marker

| signal | OP("I0.M3" "??") |
|---|---|
| betaeff | 74.5036m |
| cbb | 14.7846f |
| cbd | 40.283a |
| cbg | -10.0476f |
| cbs | -4.77728f |
| cdb | -8.68012a |
| cdd | 17.3691f |
| cdg | -17.3937f |
| cds | 33.3042a |
| cgb | -5.79479f |
| cgd | -16.9404f |
| cgg | 86.2364f |
| cgs | -63.5013f |
| cjd | 19.9348f |
| cjs | 28.1734f |
| csb | -8.98111f |
| csd | -468.984a |
| csg | -58.7951f |
| css | 68.2452f |
| gds | 508.763u |
| gm | 12.9803m |
| gmbs | 2.81979m |
| gmoverid | 6.32868 |
| ibulk | -149.653p |
| id | 2.05103m |
| ids | 2.05103m |
| is | -2.05103m |
| pwr | 1.92771m |
| region | 2 |
| reversed | 0 |
| ron | 458.245 |
| type | 0 |
| vbs | -848.391m |
| vds | 939.874m |
| vdsat | 199.783m |
| vgs | 951.609m |
| vth | 730.581m |

| signal | OP("I0.M5" "??") |
|---|---|
| betaeff | 74.5036m |
| cbb | 14.7846f |
| cbd | 40.283a |
| cbg | -10.0476f |
| cbs | -4.77728f |
| cdb | -8.68012a |
| cdd | 17.3691f |
| cdg | -17.3937f |
| cds | 33.3042a |
| cgb | -5.79479f |
| cgd | -16.9404f |
| cgg | 86.2364f |
| cgs | -63.5013f |
| cjd | 19.9348f |
| cjs | 28.1734f |
| csb | -8.98111f |
| csd | -468.984a |
| csg | -58.7951f |
| css | 68.2452f |
| gds | 508.763u |
| gm | 12.9803m |
| gmbs | 2.81979m |
| gmoverid | 6.32868 |
| ibulk | -149.653p |
| id | 2.05103m |
| ids | 2.05103m |
| is | -2.05103m |
| pwr | 1.92771m |
| region | 2 |
| reversed | 0 |
| ron | 458.245 |
| type | 0 |
| vbs | -848.391m |
| vds | 939.874m |
| vdsat | 199.783m |
| vgs | 951.609m |
| vth | 730.581m |

| signal | OP("I0.M6" "??") |
|---|---|
| betaeff | 158.966m |
| cbb | 39.9093f |
| cbd | 24.4056a |
| cbg | -21.9388f |
| cbs | -17.9949f |
| cdb | -32.7215a |
| cdd | 34.7516f |
| cdg | -34.8067f |
| cds | 87.8147a |
| cgb | -12.5259f |
| cgd | -34.5282f |
| cgg | 173.888f |
| cgs | -126.834f |
| cjd | 48.8158f |
| cjs | 75.6808f |
| csb | -27.3507f |
| csd | -247.774a |
| csg | -117.143f |
| css | 144.741f |
| gds | 835.106u |
| gm | 26.1982m |
| gmbs | 8.51202m |
| gmoverid | 6.3866 |
| ibulk | -64.8883p |
| id | 4.10206m |
| ids | 4.10206m |
| is | -4.10206m |
| pwr | 3.48015m |
| region | 2 |
| reversed | 0 |
| ron | 206.821 |
| type | 0 |
| vbs | 0 |
| vds | 848.391m |
| vdsat | 187.336m |
| vgs | 731.528m |
| vth | 505.595m |

| signal | OP("I0.M0" "??") |
|---|---|
| betaeff | 15.8955m |
| cbb | 3.99271f |
| cbd | 1.49771a |
| cbg | -2.19241f |
| cbs | -1.80179f |
| cdb | -4.66498a |
| cdd | 3.47794f |
| cdg | -3.48492f |
| cds | 11.6367a |
| cgb | -1.24424f |
| cgd | -3.45374f |
| cgg | 17.3892f |
| cgs | -12.6912f |
| cjd | 5.05299f |
| cjs | 11.9676f |
| csb | -2.7438f |
| csd | -25.7023a |
| csg | -11.7119f |
| css | 14.4814f |
| gds | 91.8474u |
| gm | 2.56833m |
| gmbs | 837.812u |
| gmoverid | 6.42082 |
| ibulk | -3.39178p |
| id | 400u |
| ids | 400u |
| is | -400u |
| pwr | 292.611u |
| region | 2 |
| reversed | 0 |
| ron | 1.82882K |
| type | 0 |
| vbs | 0 |
| vds | 731.528m |
| vdsat | 187.176m |
| vgs | 731.528m |
| vth | 505.926m |

Figure 58: The DC operating points of all transistors

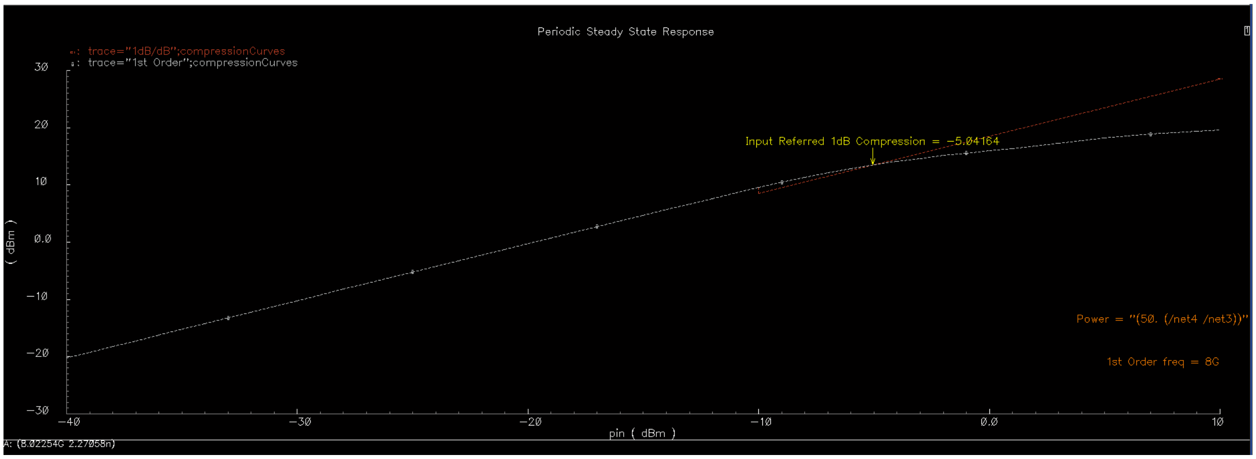



Figure 59: The 1dB compression point

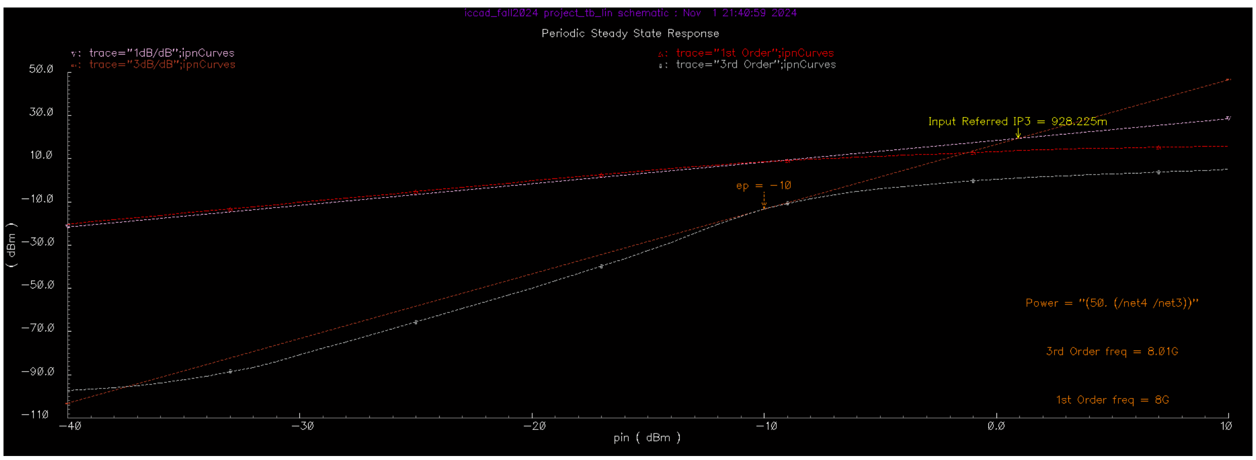



Figure 60: The IIP3 plot

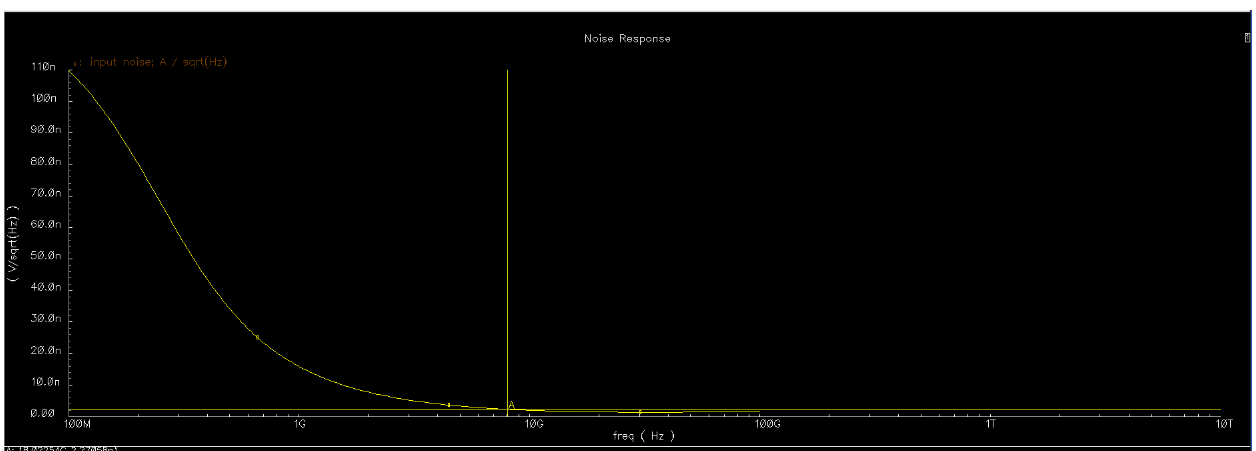



Figure 61: The input-referred noise

## 3.4 Final Results

| | TT (-40) | TT (27) | TT (120) | FF (-40) | FF (27) | FF (120) | SS (-40) | SS (27) | SS (120) |
|---|---|---|---|---|---|---|---|---|---|
| Power comsumption (mW) | 8.380 | 8.378 | 8.377 | 9.003 | 11.152 | 10.839 | 8.380 | 8.1 | 8.931 |
| Gain (@ 8GHz, dB) | 27.543 | 25.891 | 23.792 | 26.227 | 24.509 | 22.223 | 26.467 | 25.154 | 23.48 |
| Bandwidth (GHz) | 1.463 | 1.153 | 0.794 | 1.651 | 1.308 | 0.877 | 1.253 | 0.966 | 0.611 |
| 1dB compression point (dBm) | -6.004 | -4.359 | -2.411 | -1.160 | -0.485 | 0.425 | -7.744 | -6.582 | -5.041 |
| 3rd input intercept point (dBm) | -3.563 | 4.668 | 1.201 | -1.343 | 1.647 | 4.604 | -1.449 | -0.507 | 0.928 |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.964 | 2.071 | 2.232 | 1.906 | 2.017 | 2.196 | 1.992 | 2.1 | 2.27 |

Table 13: The circuit properties at all corners and temperatures

# 4 Layout

The first step was to lay the floor plan by putting down every element. As the amplifier is differential, keeping the design as symmetric as possible is important, so I put the components in a symmetric pattern, as shown in fig. 62. Then, I made the connections as short and sparse

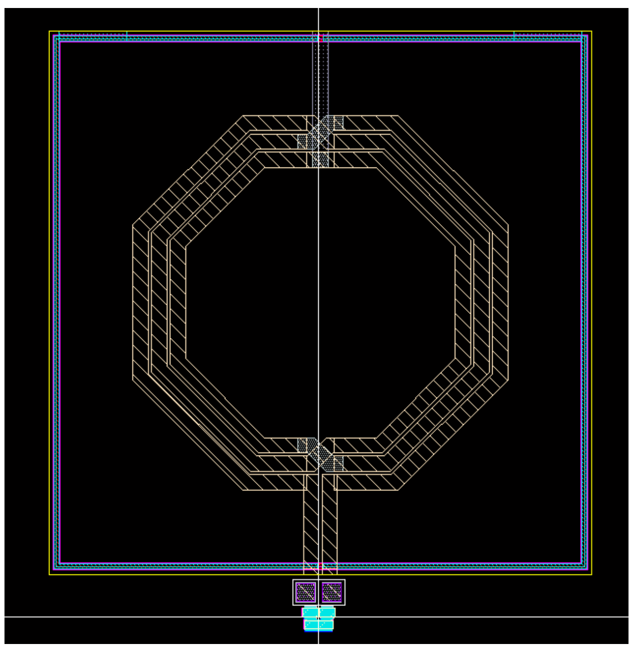


Figure 62: The floor plan

as possible. The following figures show every connection starting from the bottom of the circuit and moving to the top.

The bias transistors are shown in fig.63. The bulks are connected to the sources of both transistors which are connected on M1 and then brought to M2 to jump over the gate of the tail transistor and connected to the ground pin, GRND. The gates are also connected on both top and bottom, the two sides are connected to each other, and the bias current pin, IB. The drain of the current mirror transistor is directly connected to the top connection of the gate and the drains of the tail transistor are brought to M2 with VIAs and connected to the sources of the input transistors, as shown in fig. 64.

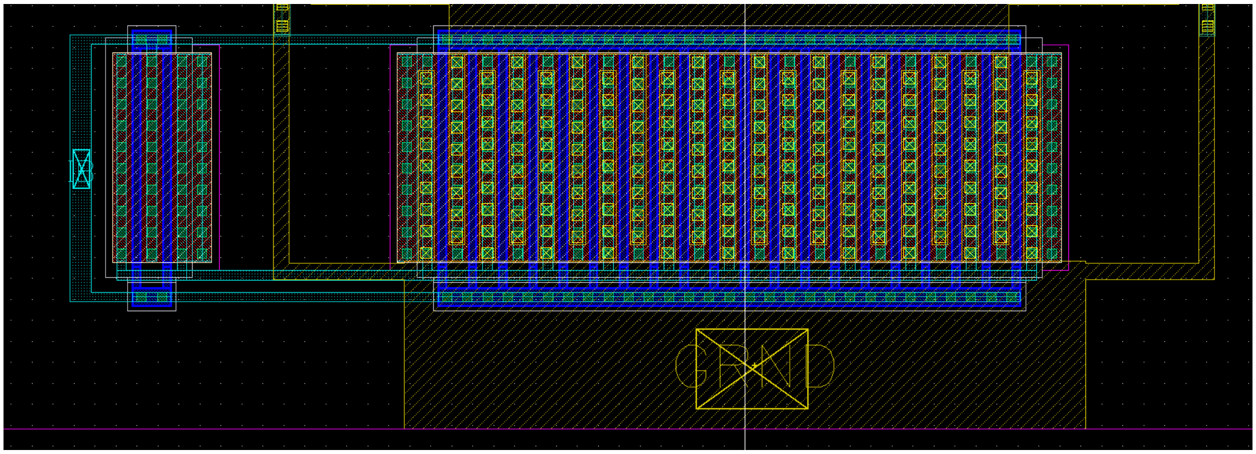



Figure 63: The bias circuit

The bulk connections of the input transistor are visible on both sides but detached from the sources. The bulk connection closer to the middle of both transistors is brought to M3 with VIAs to jump over the source connection, and then it is brought back to M2 to connect with the bulk connections on the outer edge and the GRND pin.

The gate connections of each transistor are connected on the outer edge and the input pins, IN1 and IN2, are placed there on M1. The drains of each transistor are connected and then brought to M6 with VIAs to connect to the top layer of the capacitors, as shown in fig. 65.

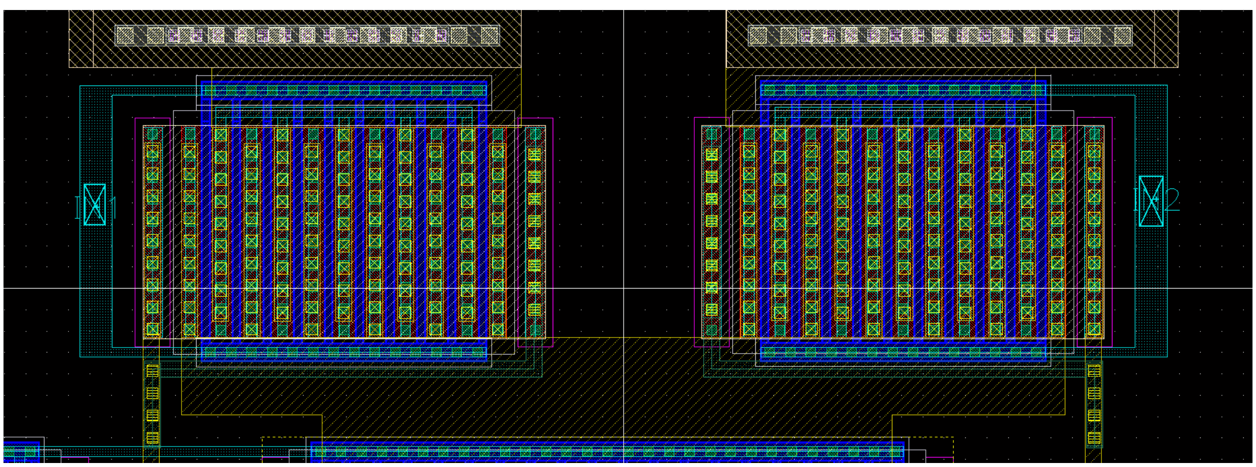


Figure 64: The input transistors

The top layer of the capacitors connects directly to the PLUS and MINUS terminals of the inductor and the output pins, OUT1 and OUT2, are placed on their connection. The bottom layer is dragged to the sides of the inductor and brought down to M4 with VIAs to connect to the center tap of the inductor, as shown in fig. 66. Fig. 67 shows the complete layout, while fig. 68 and fig. 69 show the results of the DRC and LVS runs.

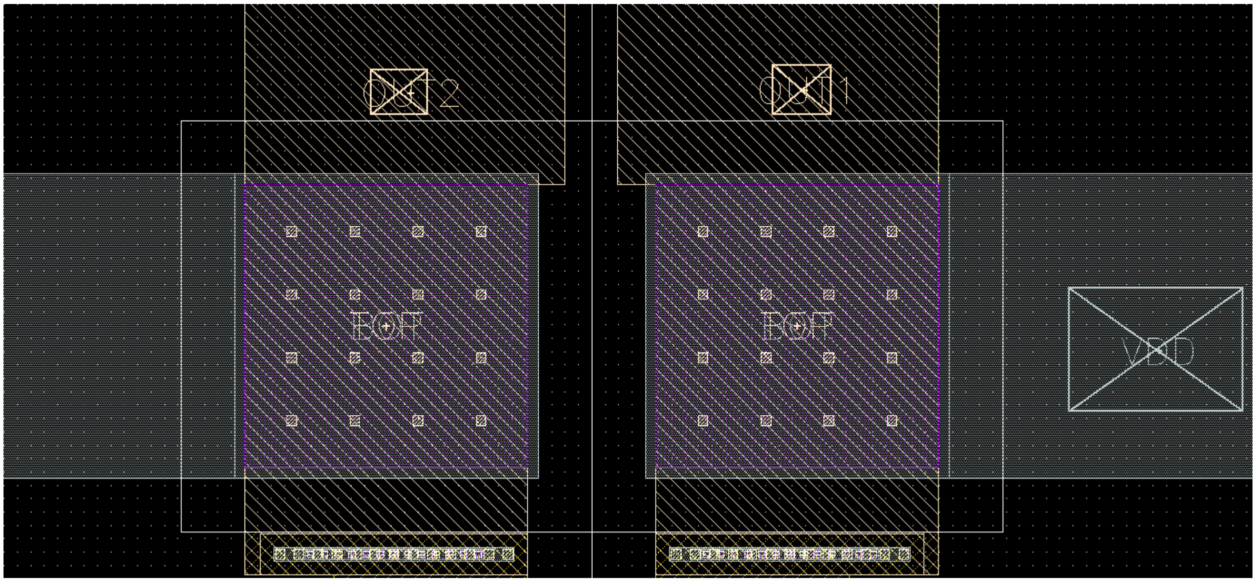



Figure 65: The capacitors

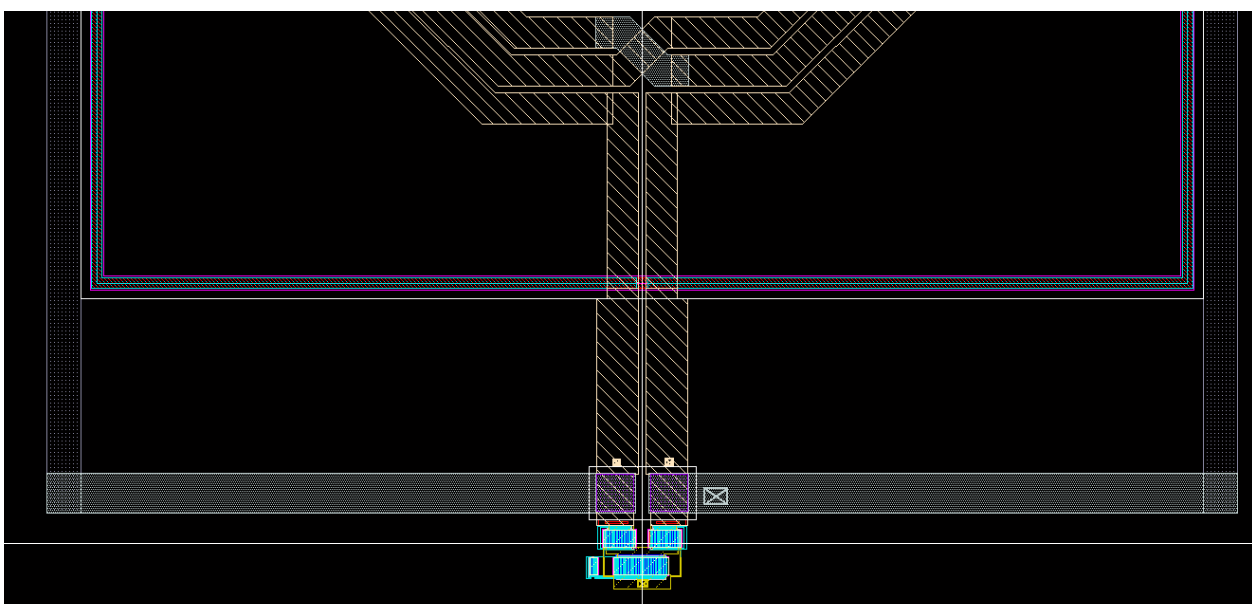


Figure 66: Overview of the capacitor connections

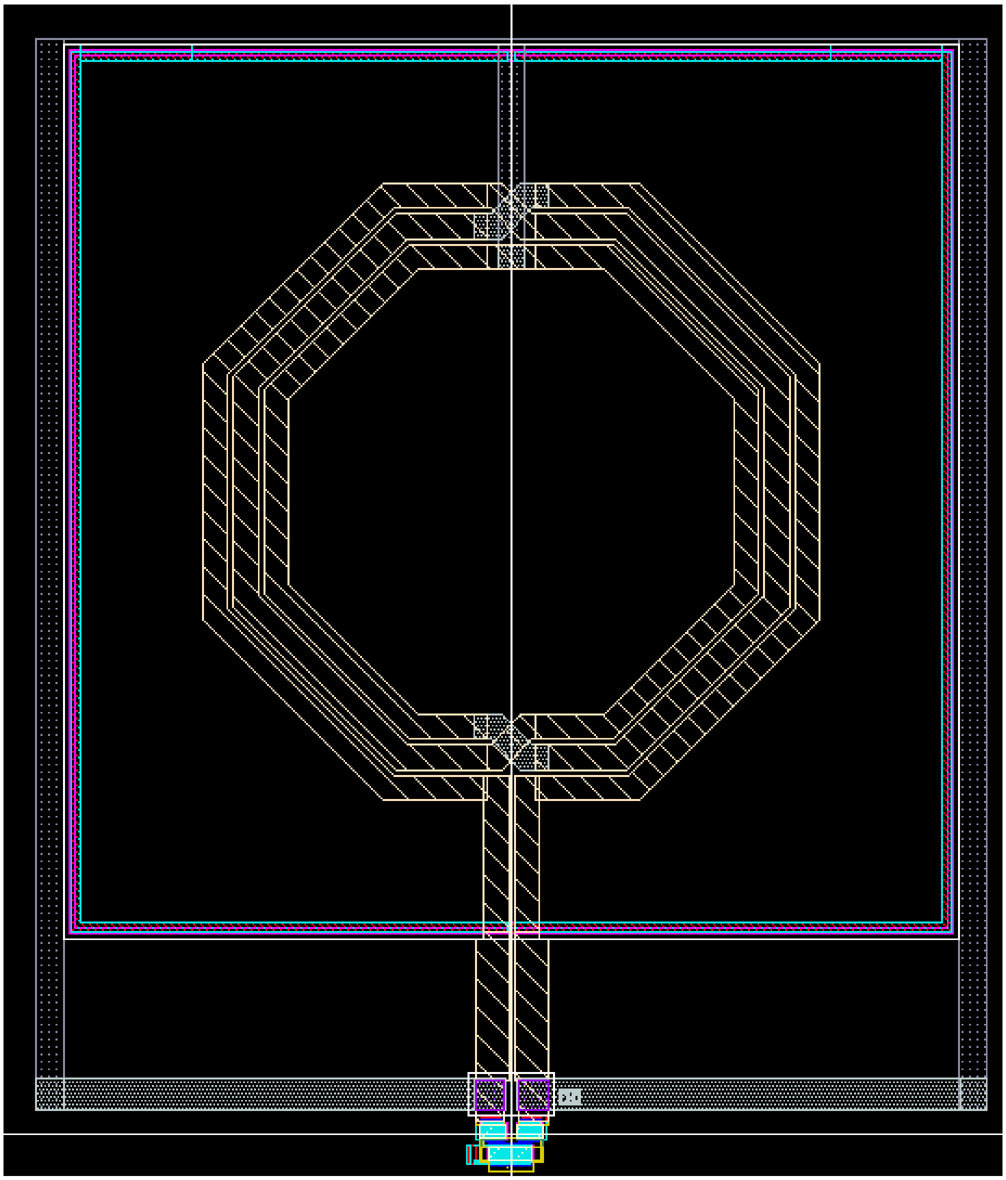


Figure 67: The layout

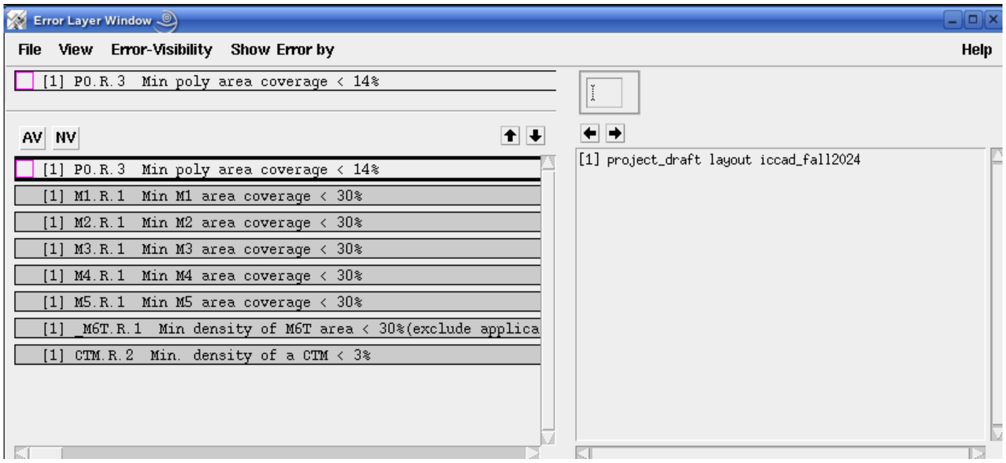



Figure 68: The DRC results

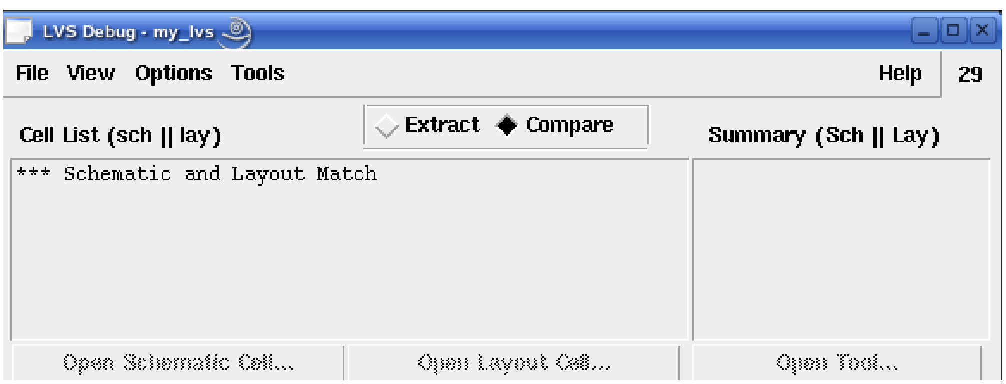



Figure 69: The LVS results

# 5 Parasitics

I ran the RCX three times: for R only, RC, and RLC. The settings each time were similar and only the name of the file and the extracted parameters in the Extraction tab were changed, a sample of which is shown in fig. 70. Also, fig. 71 shows a view of the RC parasitic file, zoomed in on the tail transistor to show the parasitics.

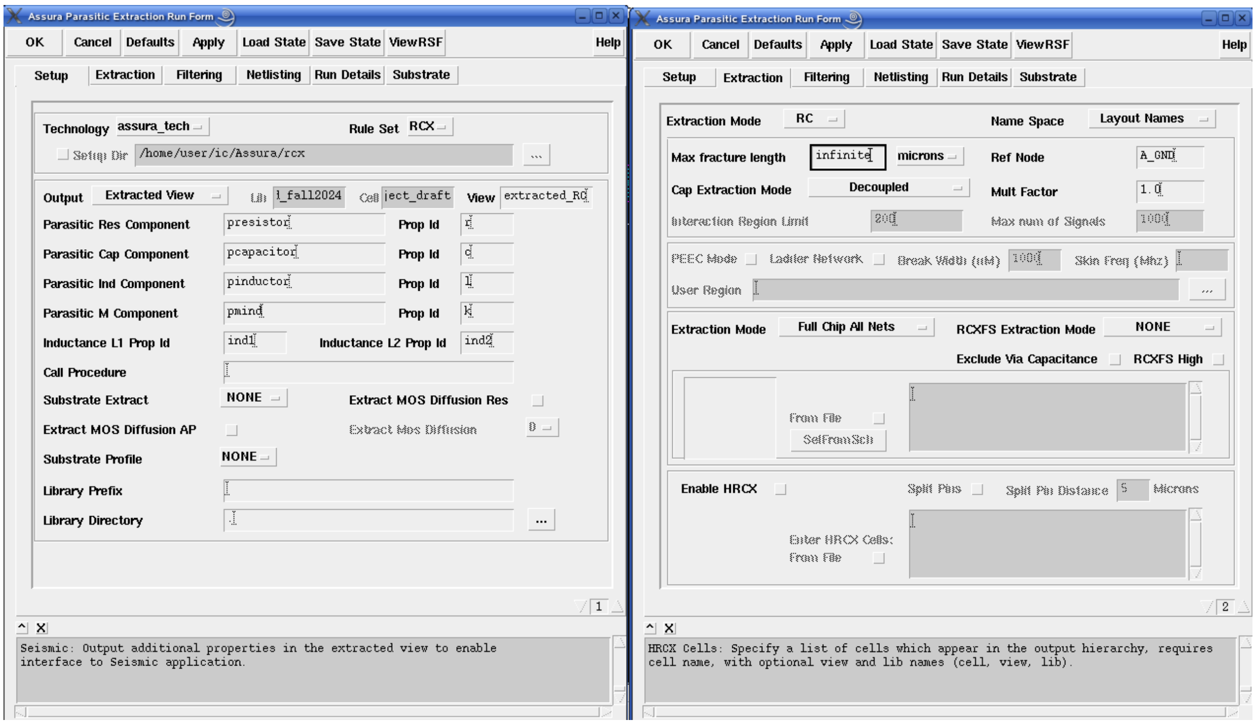



Figure 70: The RCX setup

Then, I made a config cell view of my test benches and ran the same analyses as the first section, for the TT corner at 27 degrees, the results of which are shown in the following subsections. The results for the AC and noise plots are drawn on the schematic results for ease of comparison, with the yellow line as the results from the parasitic view. Also, fig. 72 shows the hierarchy editor view of one of the test benches.

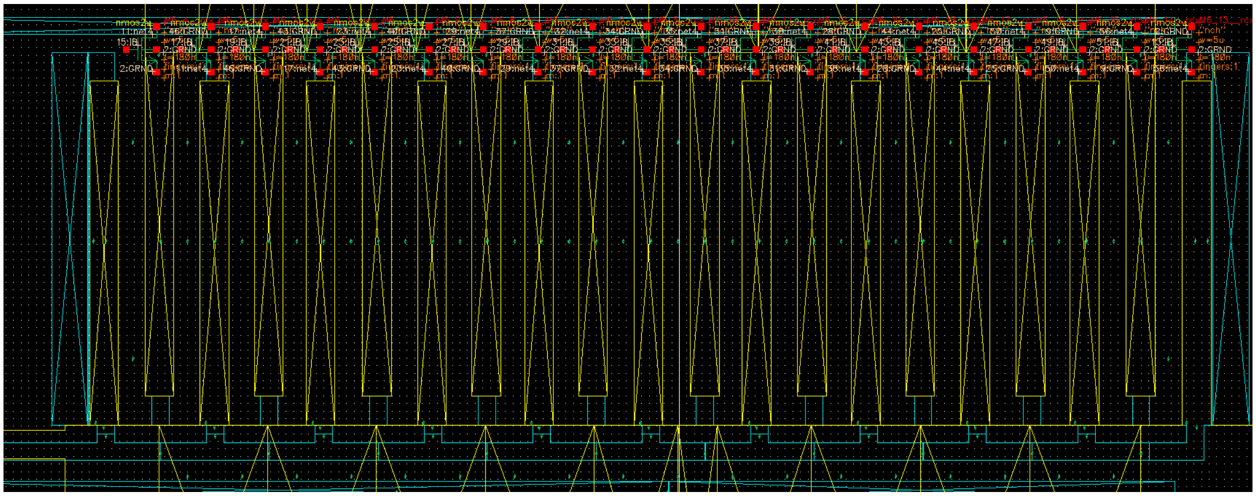


Figure 71: The parasitics

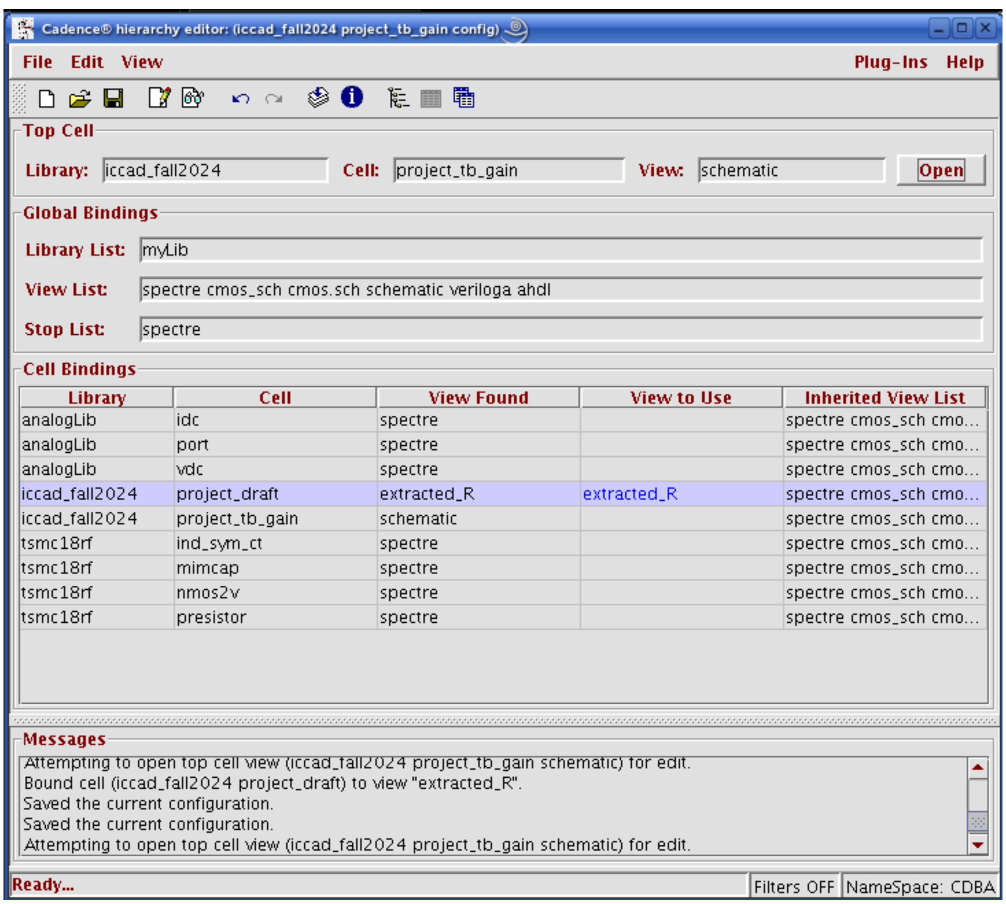



Figure 72: Hierarchy editor

## 5.1 R Only

The analysis results are shown in the following figures and in table 14. I could not run the PSS analysis to find IP3 because the error shown in fig. 77 occurred.

| | |
|---|---|
| Power comsumption (mW) | 8.368 |
| Gain (@ 8GHz, dB) | 22.821 |
| Bandwidth (GHz) | 0.63 |
| 1dB compression point (dBm) | -5.348 |
| 3rd input intercept point (dBm) | - |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.992 |

Table 14: The circuit properties for the R-only parasitic view

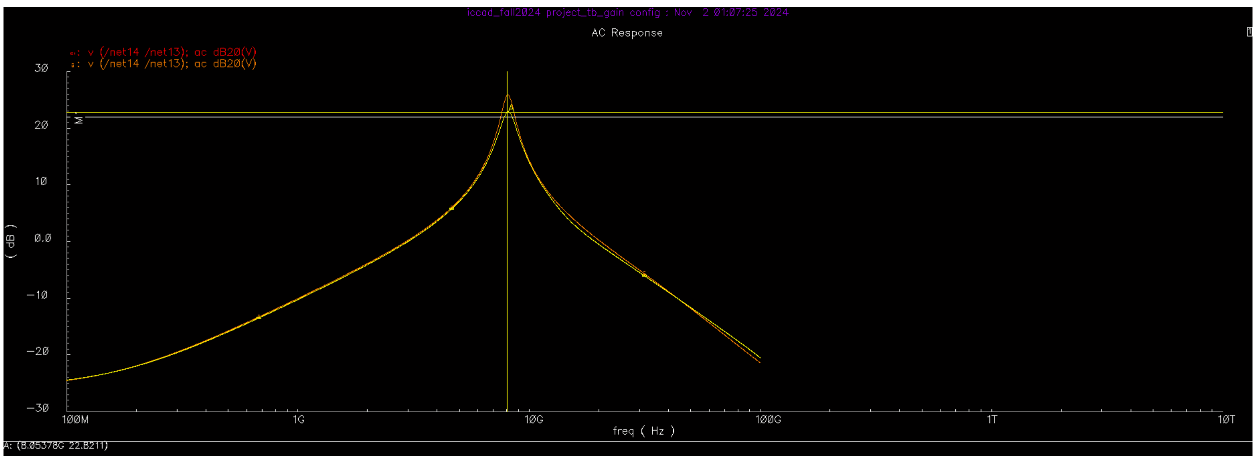



Figure 73: The gain plot

```
Curve name map:
---------------

Curve2      - v (/net14 /net13); ac dB20(V)
Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                         Y value         Curve2          Curve1

M1                            22    7.81347143636     7.5353501876
                                    8.44380199726     8.6887684874G
```

Figure 74: The bandwidth, using a horizontal marker

| signal | OP("VO" "??") |
|---|---|
| i | -4.64941m |
| pwr | -8.36894m |
| v | 1.8 |

Figure 75: The DC operating point of the supply voltage

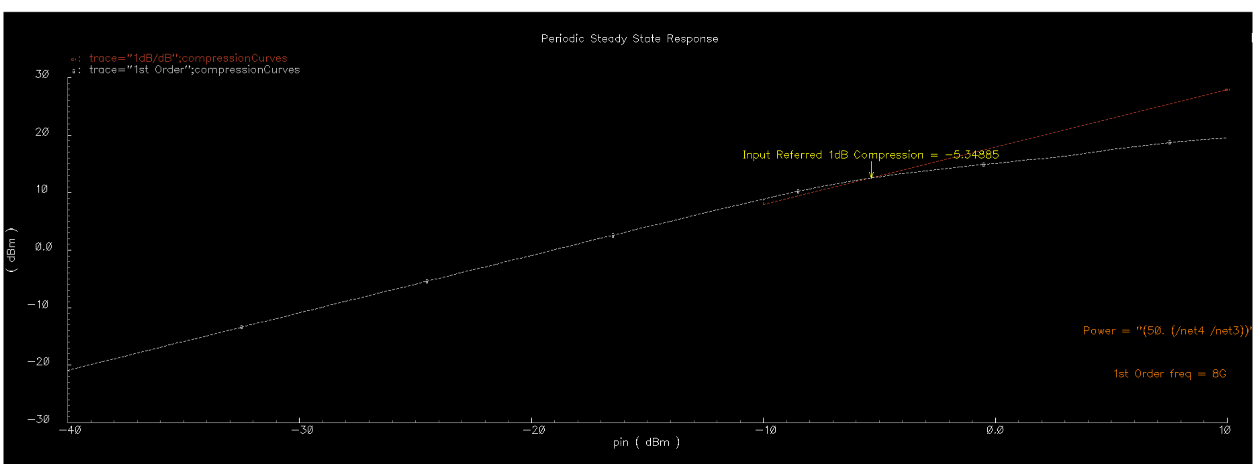
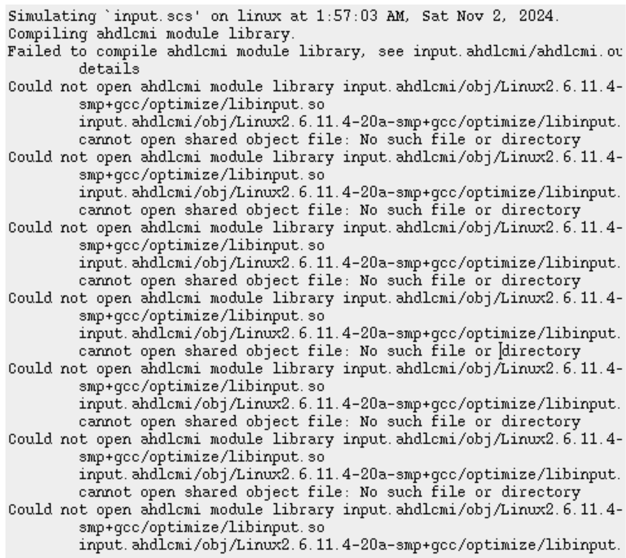



Figure 76: The 1dB compression point



```
Simulating `input.scs' on linux at 1:57:03 AM, Sat Nov 2, 2024.
Compiling ahdlcmi module library.
Failed to compile ahdlcmi module library, see input.ahdlcmi/ahdlcmi.ou
        details
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
```

Figure 77: The error shown after running PSS analysis for IIP3

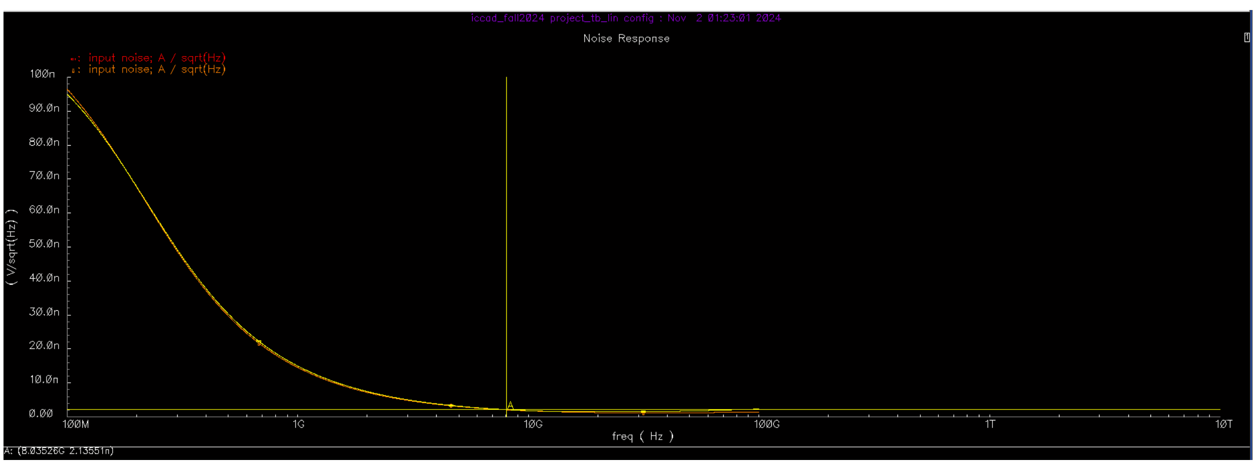



Figure 78: The input-referred noise

## 5.2 RC

The analysis results are shown in the following figures and in table 15. Again, I encountered the same error when running PSS for IP3.

| | |
|---|---|
| Power comsumption (mW) | 8.368 |
| Gain (@ 8GHz, dB) | 22.989 |
| Bandwidth (GHz) | 0.697 |
| 1dB compression point (dBm) | -8.001 |
| 3rd input intercept point (dBm) | - |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.86 |

Table 15: The circuit properties for the RC parasitic view

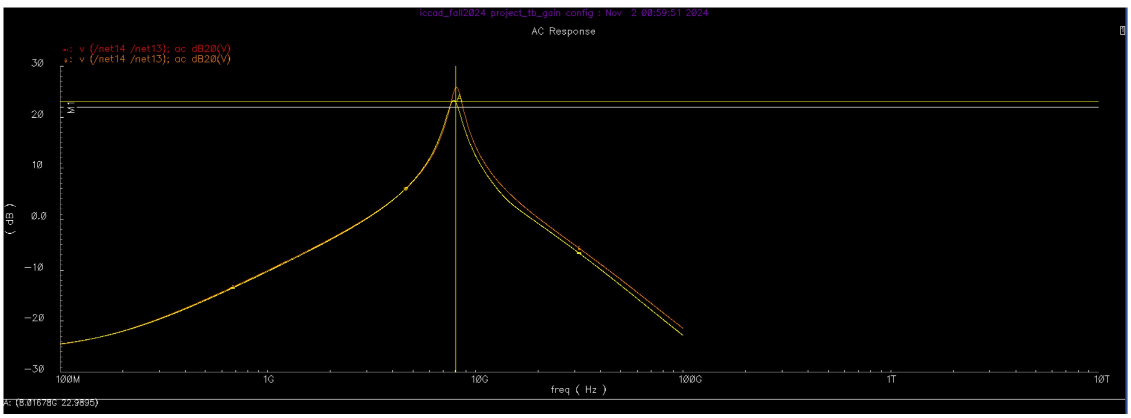



Figure 79: The gain plot

```
Curve name map:
---------------

Curve2      - v (/net14 /net13); ac dB20(V)
Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                         Y value         Curve2          Curve1

M1                            22    7.5140901873G    7.535350187G
                                    8.2111657435G   8.6887684874G
```

Figure 80: The bandwidth, using a horizontal marker

| signal | OP("V0" "??") |
|---|---|
| i | -4.64941m |
| pwr | -8.36894m |
| v | 1.8 |

Figure 81: The DC operating point of the supply voltage

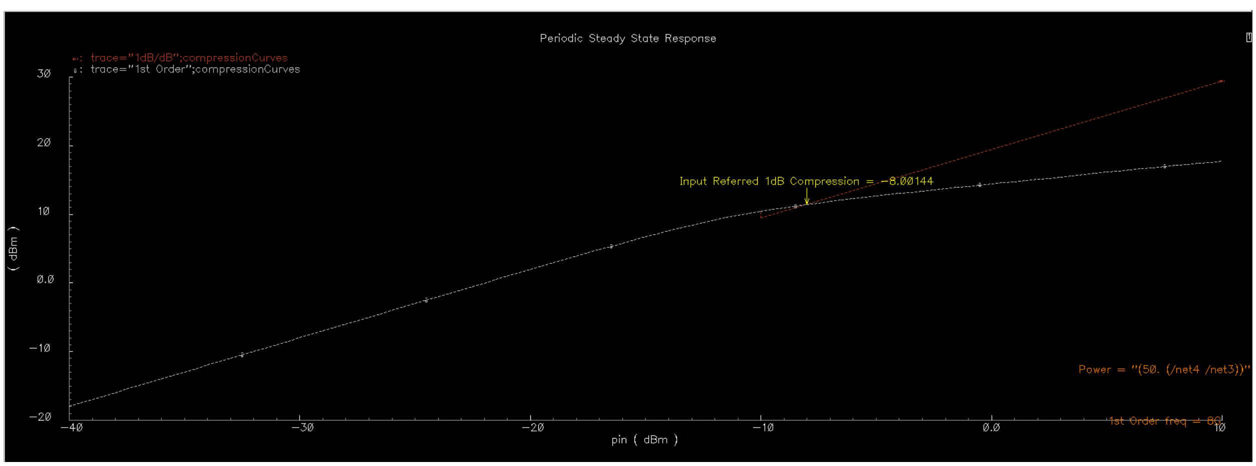



Figure 82: The 1dB compression point

```
Simulating `input.scs' on linux at 1:59:28 AM, Sat Nov 2, 2024.
Compiling ahdlcmi module library.
Failed to compile ahdlcmi module library, see input.ahdlcmi/ahdlcmi.ou
        details
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
```

Figure 83: The error shown after running PSS analysis for IIP3

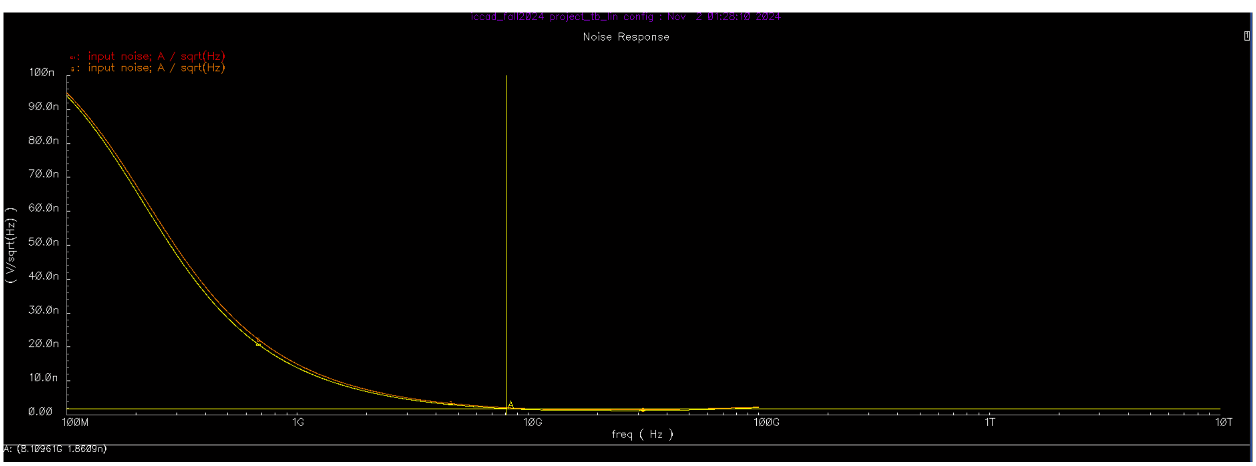



Figure 84: The input-referred noise

## 5.3 RLC

The analysis results are shown in the following figures and in table 16. Once again, I could not determine the IP3 due to the same error as the last ones.

| | |
|---|---|
| Power comsumption (mW) | 8.368 |
| Gain (@ 8GHz, dB) | 22.989 |
| Bandwidth (GHz) | 0.611 |
| 1dB compression point (dBm) | -8.001 |
| 3rd input intercept point (dBm) | - |
| Input-referred noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.86 |

Table 16: The circuit properties for the RLC parasitic view

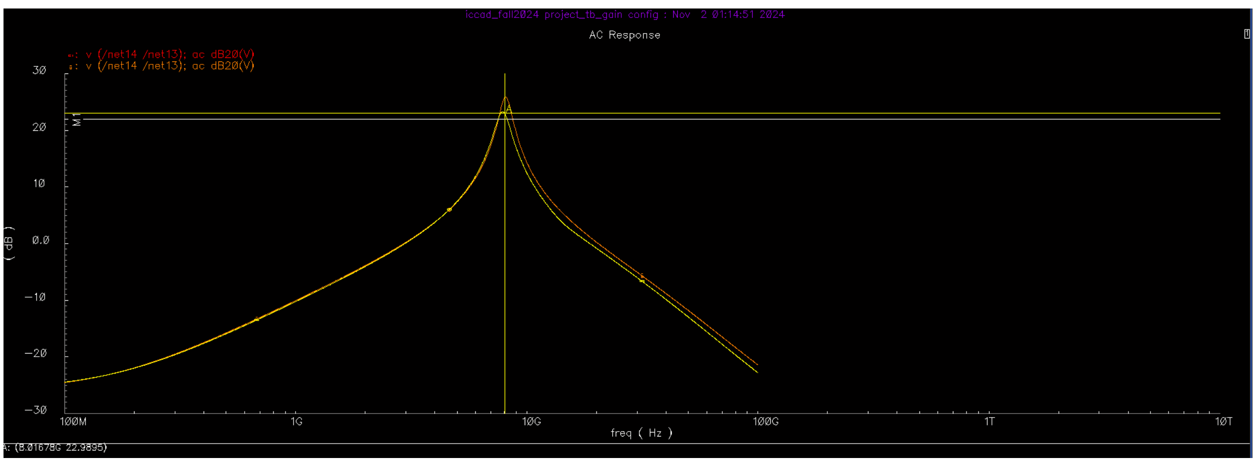



Figure 85: The gain plot

```
Curve name map:
---------------

Curve2      - v (/net14 /net13); ac dB20(V)
Curve1      - v (/net14 /net13); ac dB20(V)


Curve table:
------------

                          Y value         Curve2          Curve1

M1                             22    7.51409019296    7.5353501876
                                      8.2111657456   8.6887684874G
```

Figure 86: The bandwidth, using a horizontal marker

| signal | OP("VO" "??") |
|---|---|
| i | -4.64941m |
| pwr | -8.36894m |
| v | 1.8 |

Figure 87: The DC operating point of the supply voltage

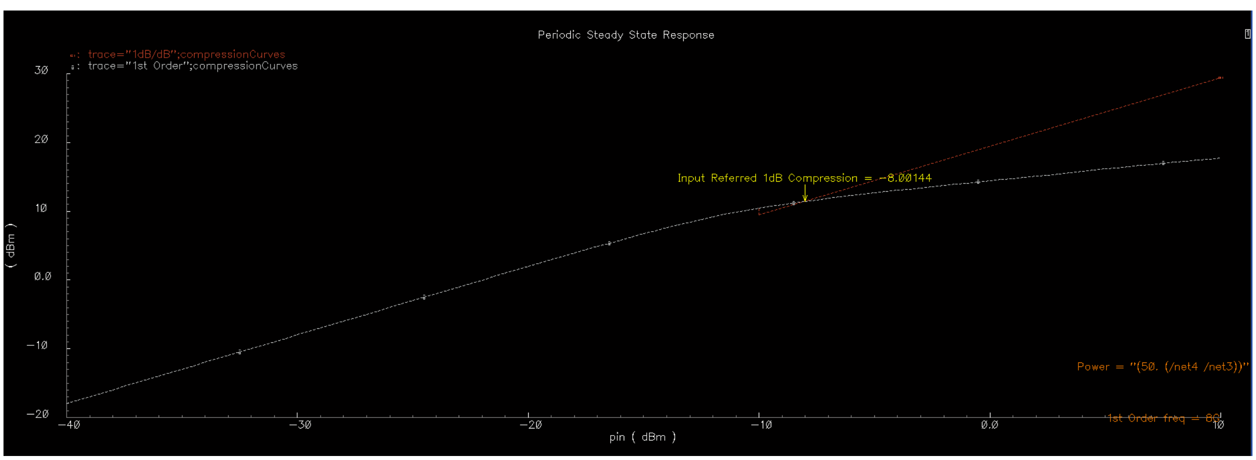
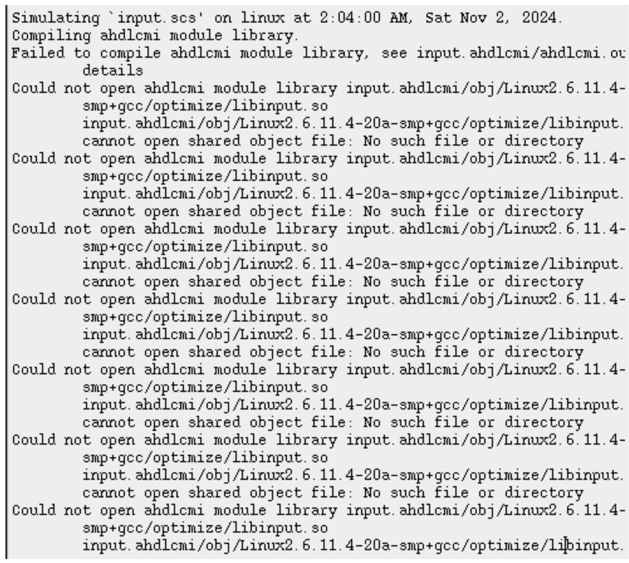



Figure 88: The 1dB compression point



```
Simulating `input.scs' on linux at 2:04:00 AM, Sat Nov 2, 2024.
Compiling ahdlcmi module library.
Failed to compile ahdlcmi module library, see input.ahdlcmi/ahdlcmi.ou
        details
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
        cannot open shared object file: No such file or directory
Could not open ahdlcmi module library input.ahdlcmi/obj/Linux2.6.11.4-
        smp+gcc/optimize/libinput.so
        input.ahdlcmi/obj/Linux2.6.11.4-20a-smp+gcc/optimize/libinput.
```

Figure 89: The error shown after running PSS analysis for IIP3

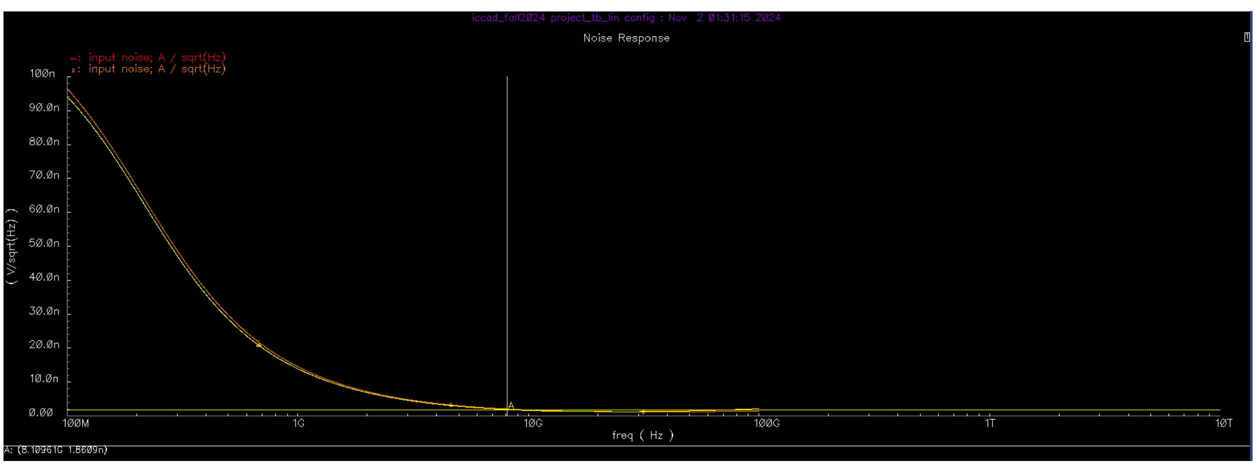



Figure 90: The input-referred noise

# 6 Final Comparison

The following table compares all the simulation results gathered from this project.

| | TT (-40) | TT (27) | TT (120) | FF (-40) | FF (27) | FF (120) | SS (-40) | SS (27) | SS (120) | R | RC | RLC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Power (mW) | 8.380 | 8.378 | 8.377 | 9.003 | 11.152 | 10.839 | 8.380 | 8.1 | 8.931 | 8.368 | 8.368 | 8.368 |
| Frequency (GHz) | 8.058 | 8.111 | 8.194 | 8.297 | 8.359 | 8.458 | 7.834 | 7.88 | 7.953 | 8.128 | 7.862 | 7.862 |
| Gain (@ 8GHz, dB) | 27.543 | 25.891 | 23.792 | 26.227 | 24.509 | 22.223 | 26.467 | 25.154 | 23.48 | 22.821 | 22.989 | 22.989 |
| Bandwidth (GHz) | 1.463 | 1.153 | 0.794 | 1.651 | 1.308 | 0.877 | 1.253 | 0.966 | 0.611 | 0.63 | 0.697 | 0.611 |
| $P_{1dB}$ (dBm) | -6.004 | -4.359 | -2.411 | -1.160 | -0.485 | 0.425 | -7.744 | -6.582 | -5.041 | -5.348 | -8.001 | -8.001 |
| IIP3(dBm) | -3.563 | 4.668 | 1.201 | -1.343 | 1.647 | 4.604 | -1.449 | -0.507 | 0.928 | - | - | - |
| noise (@ 8GHz, $\frac{nV}{\sqrt{Hz}}$) | 1.964 | 2.071 | 2.232 | 1.906 | 2.017 | 2.196 | 1.992 | 2.1 | 2.27 | 1.992 | 1.86 | 1.86 |

Table 17: The circuit properties at all corners and temperatures