FINAL PROJECT

BY

HERAMB SAWANT

ECE – 523

WINTER – 2020

SPECIFICATION

DRC PASSED
LVS PASSED

SPECIFICATIONS	-40 deg (FF)	27 deg (TT)	85 deg (SS)
Power Supply	1.7	1.8	1.9
Load at each output	3pF	3pF	3pF
Loop Gain (>65dB)	71 dB (fig 5)	75 dB (fig 6)	71 dB (fig 7)
Loop UGBW (>120 MHz)	191 MHz (fig 5)	163 MHz (fig 6)	124 MHz (fig 7)
Loop Phase Margin (>65 deg)	65 deg (fig 5)	62 deg (fig 6)	63 deg (fig 7)
CM accuracy (<0.05 V)	46 mV (fig 8)	43 mV (fig 9)	17 mV (fig 10)
Output swing (1V p-p)	2.76 V(p-p) (fig 11)	2.02 V(p-p) (fig 12)	2 V(p-p) (fig 13)
Power Consumption (<12mW)	20.4129 mW* (fig 14)	21.825 mW* (fig 15)	17.3627 mW* (fig 16)
CMFB Phase Margin (>60 deg)	70 deg (fig 17)	70 deg (fig 18)	78 deg (fig 19)

1 - SCHEMATICS

A – BIASING CIRCUIT

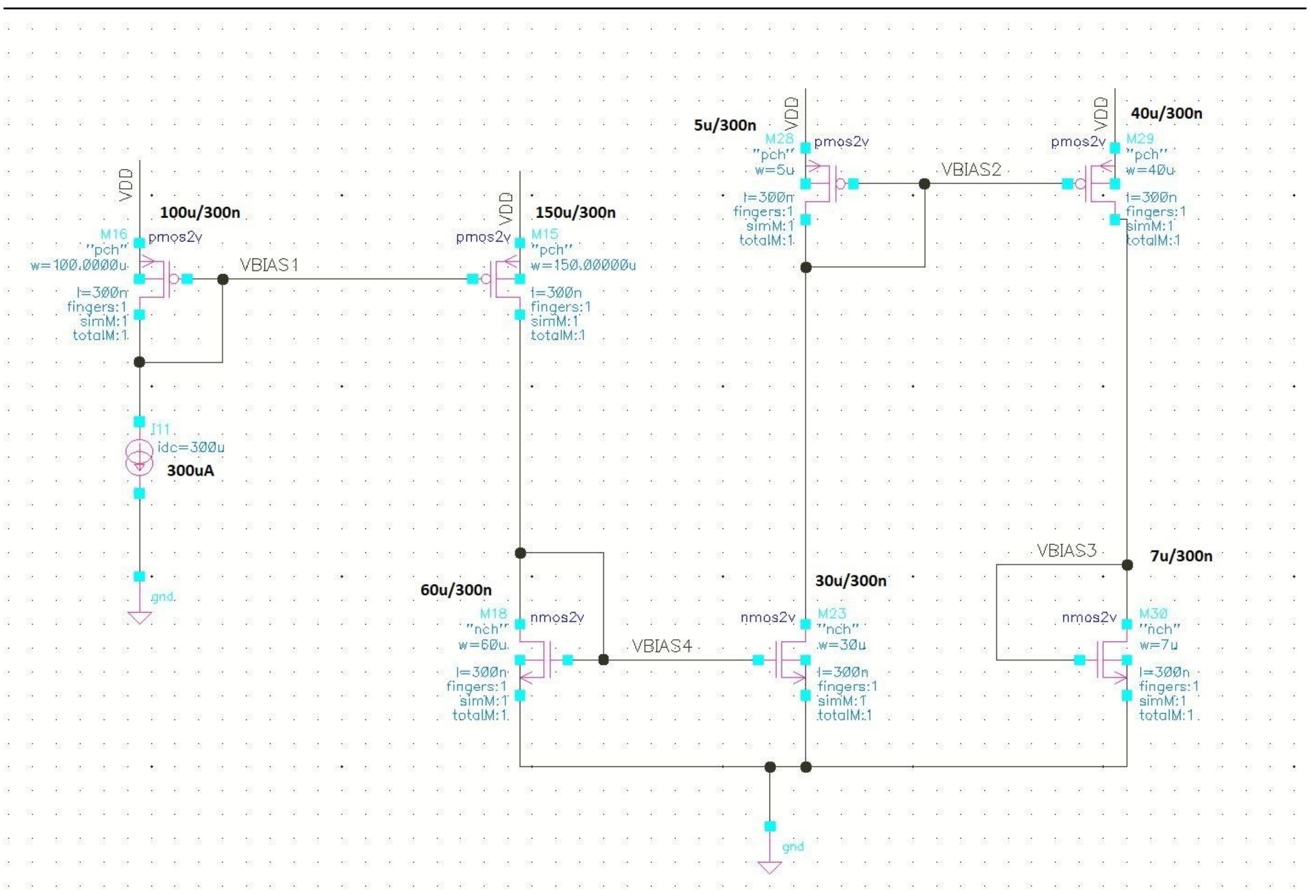

Figure 1 - BIASING CIRCUIT SCHEMATICS

B – TELESCOPIC 2-STAGE OP-AMP

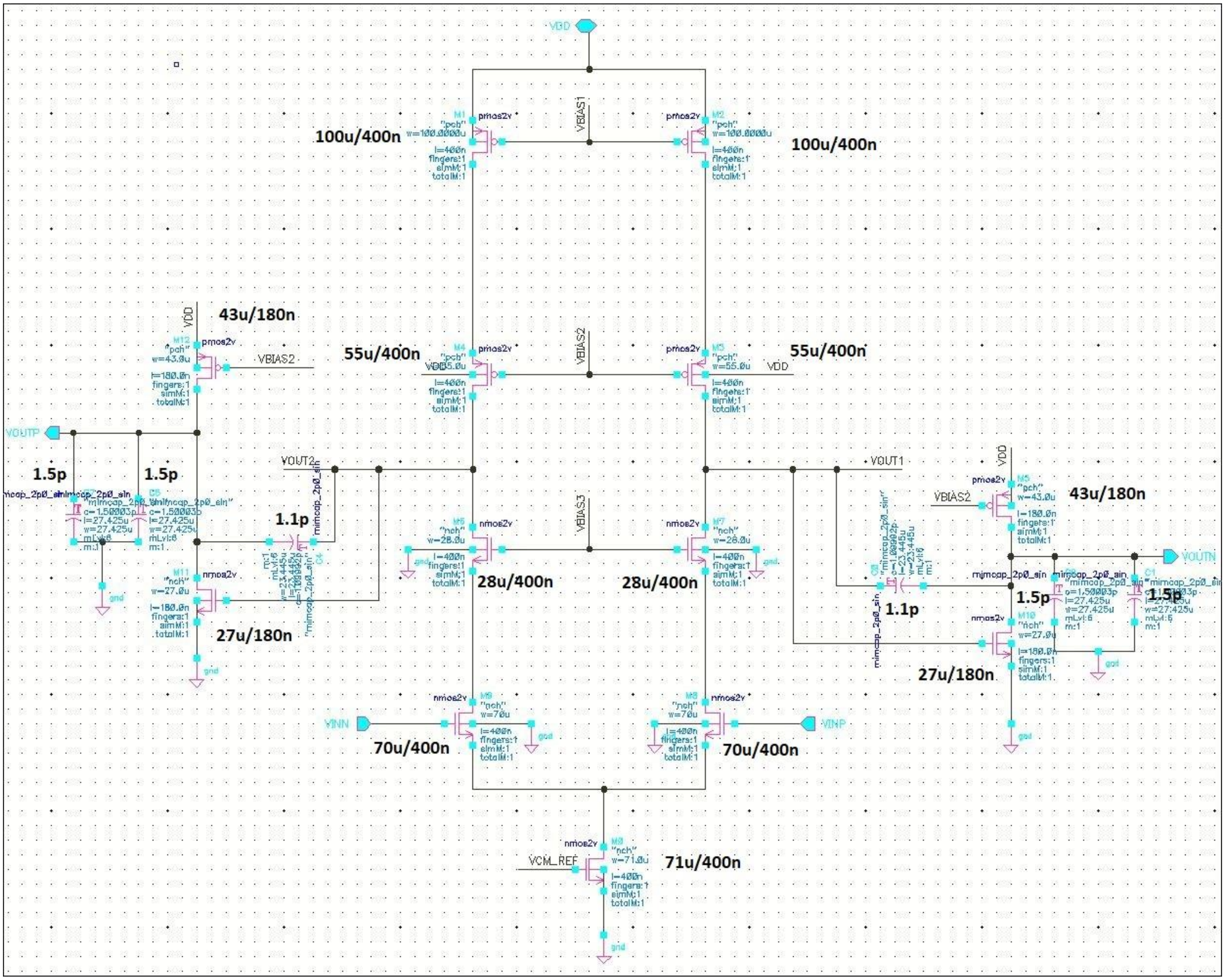

Figure 2 - Two stage telescopic opamp

C – CMFB CIRCUIT

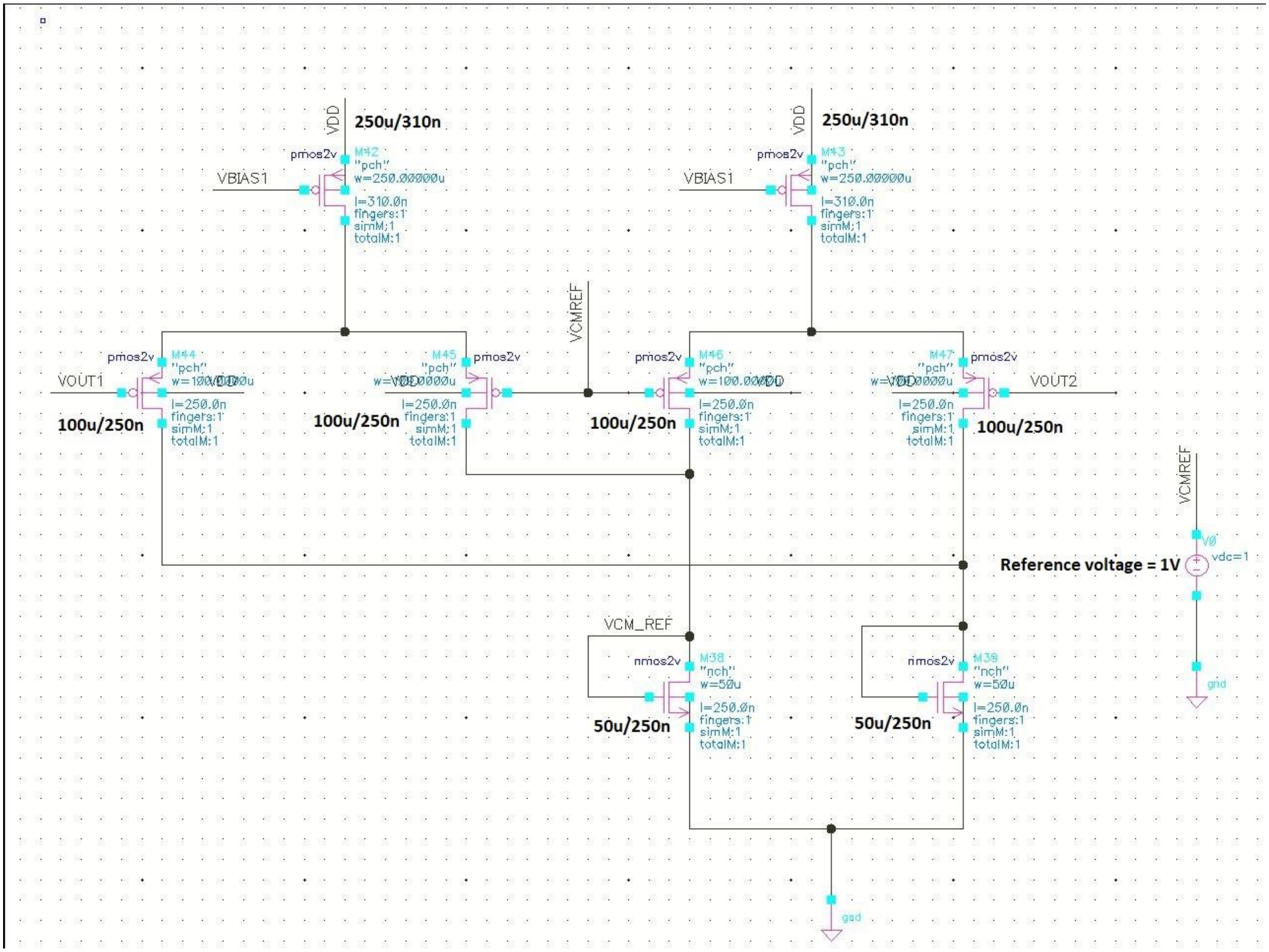

Figure 3 - Common Feedback Circuit

2 - LOOP GAIN, BANDWIDTH AND PHASE MARGIN

A – DIFFERENTIAL LOOP TESTBENCH

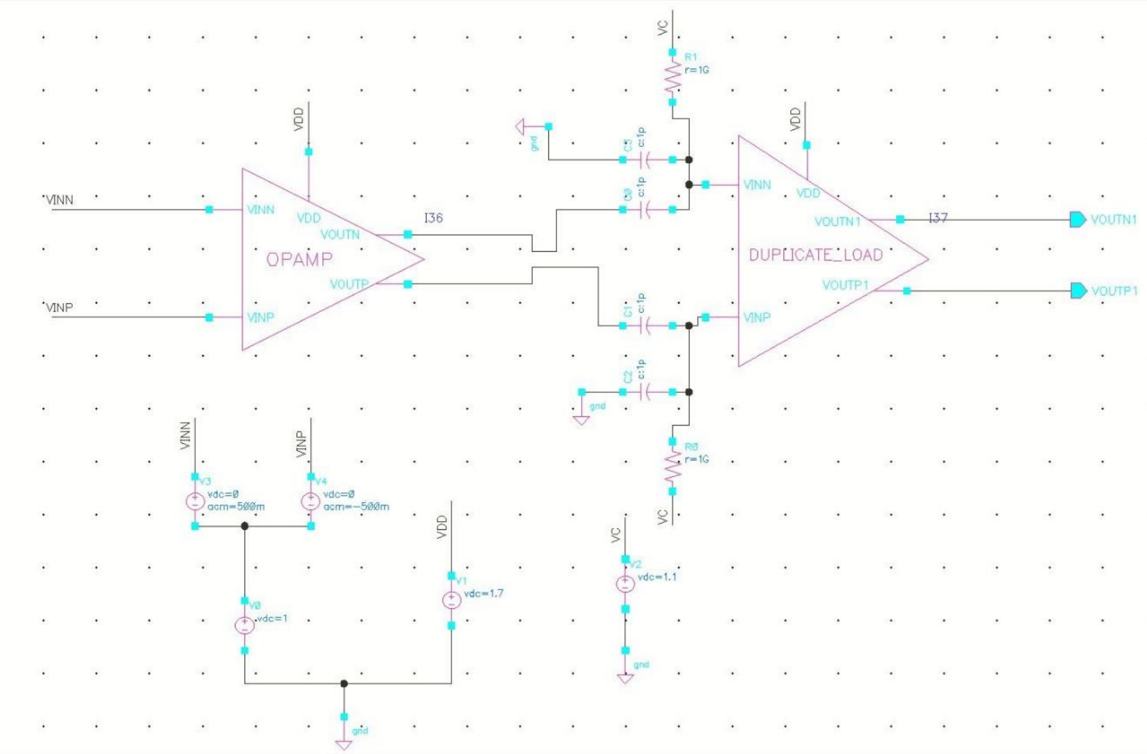

Figure 4 - Differential loop analysis testbench

B - -40 DEG (FF)

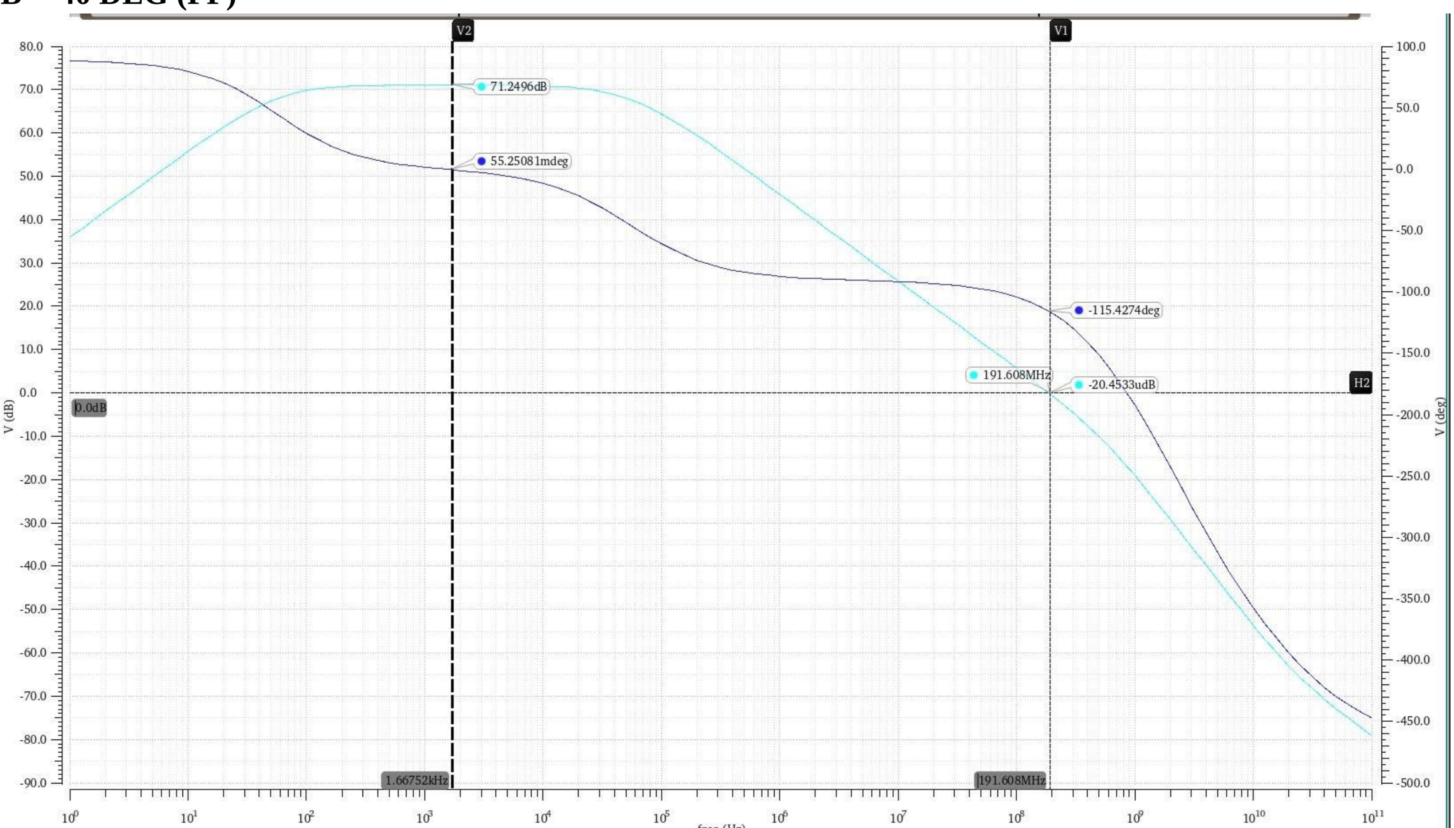

Figure 5 - Loop Gain, Bandwidth, Phase at -40 deg (FF)

C – 27 DEG (TT)

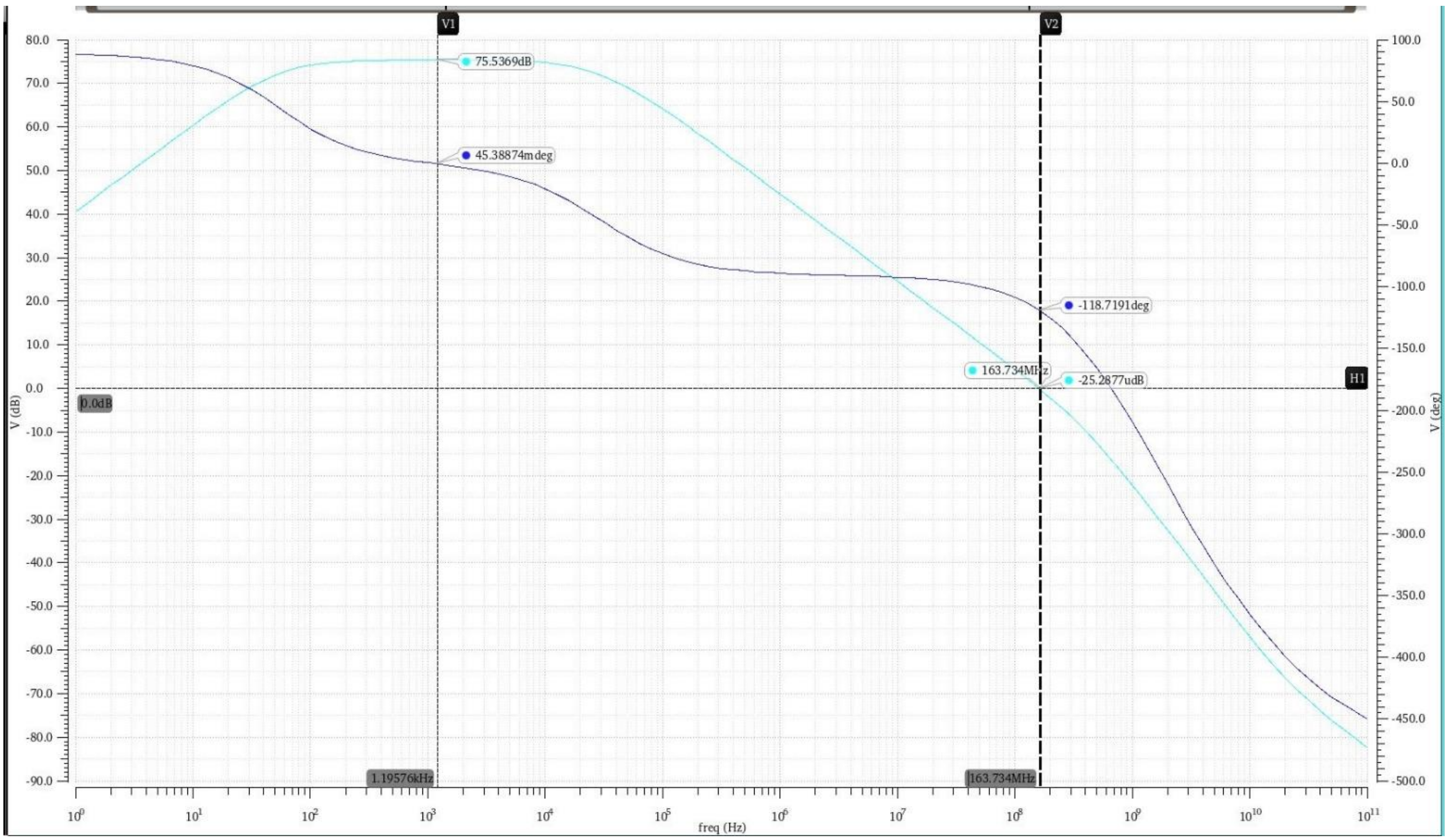

Figure 6 - Loop Gain, Bandwidth, Phase at 27 deg (TT)

D – 85 DEG (SS)

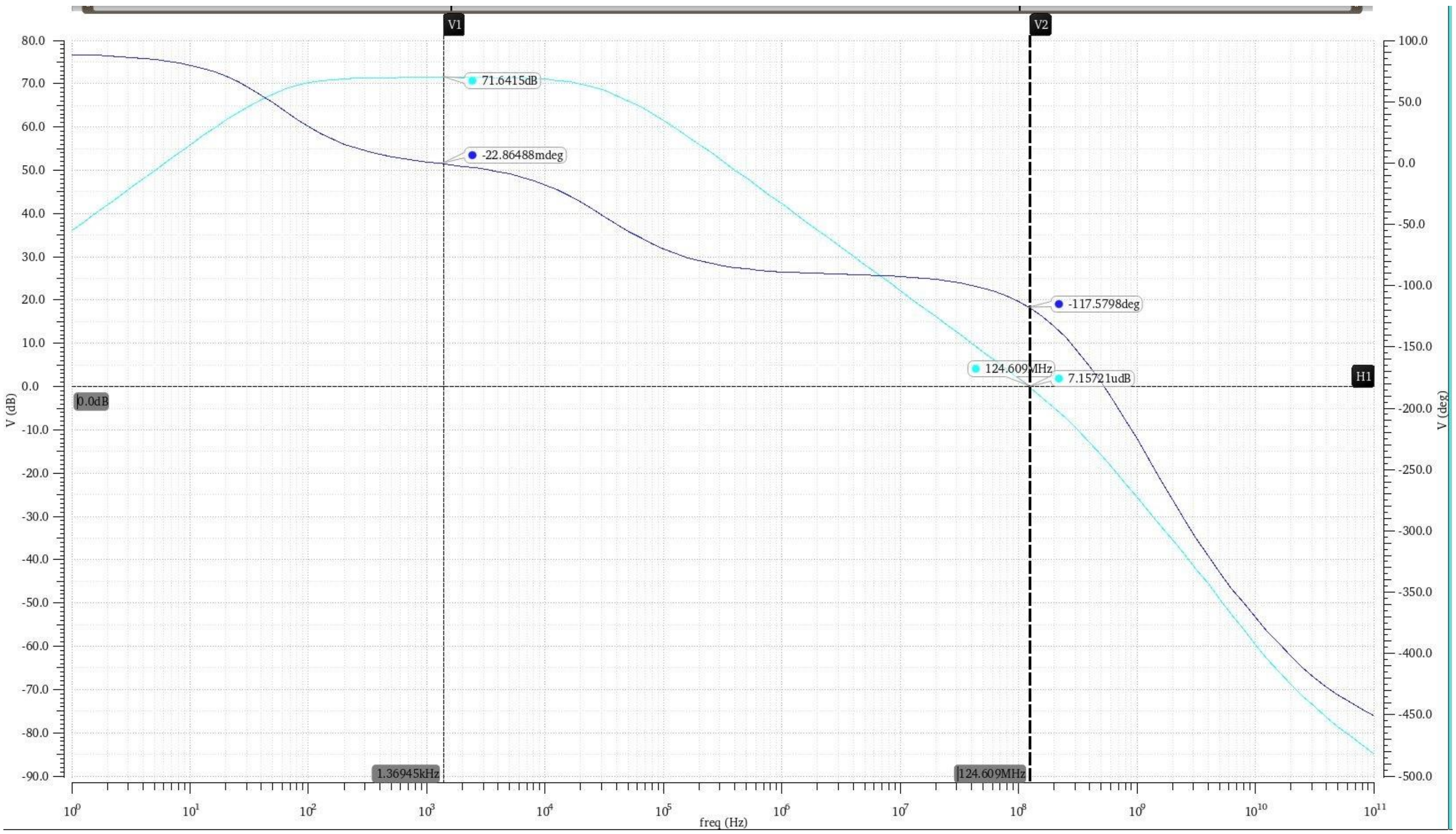

Figure 7 - Loop Gain, Bandwidth, Phase at 85 deg (SS)

3 – CM ACCURACY

A - -40 DEG (FF)

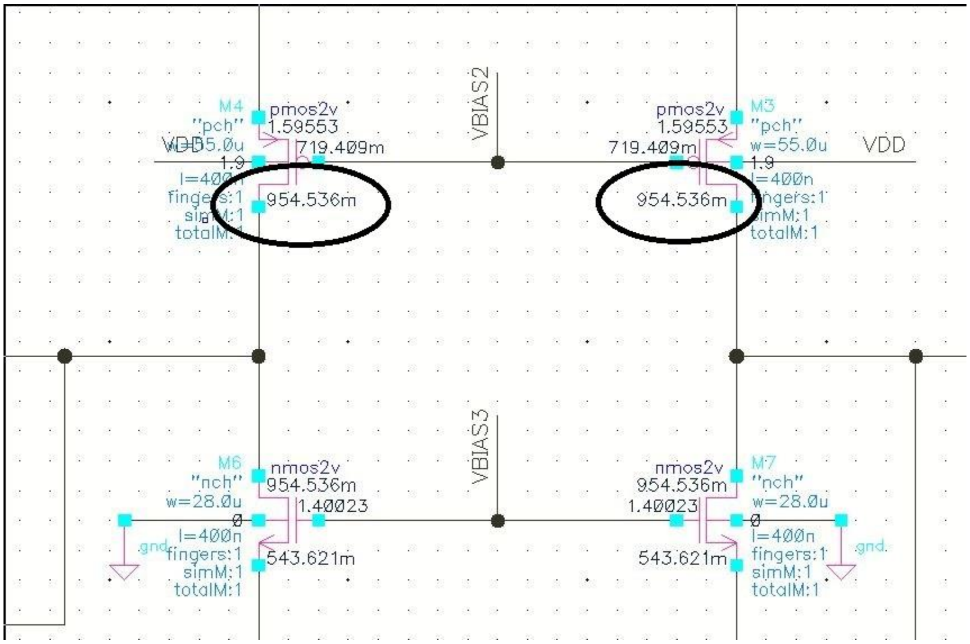

Figure 8 - Common mode accuracy at -40 deg (FF)

B – 27 DEG (TT)

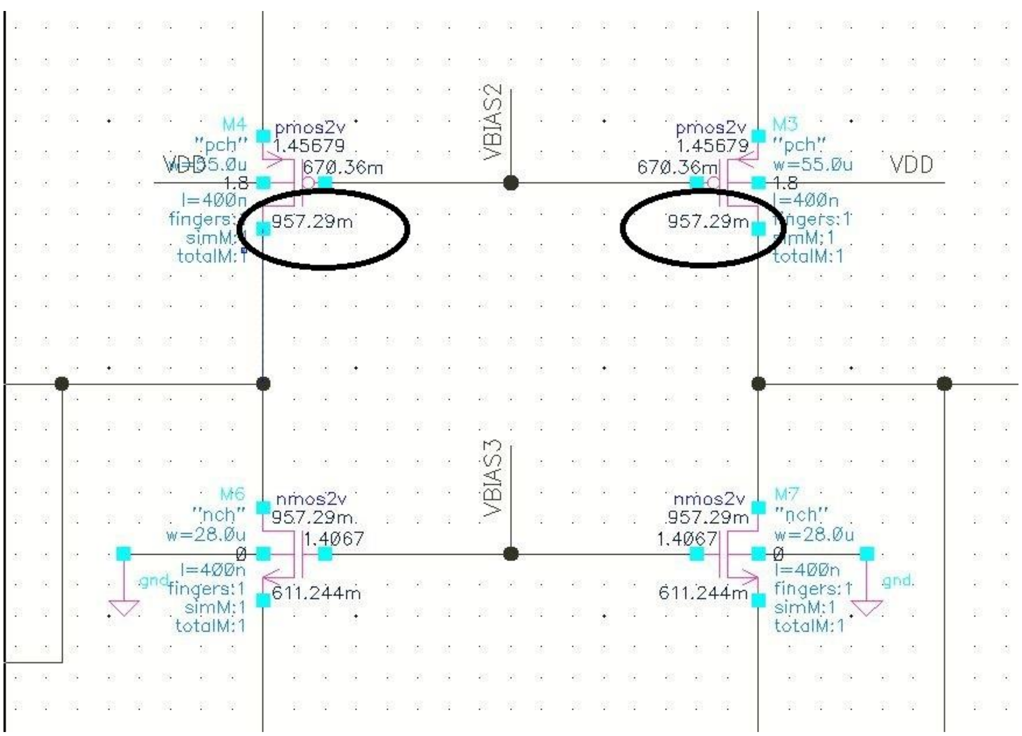

Figure 9 - Common mode accuracy at 27 deg (TT)

C – 85 DEG (SS)

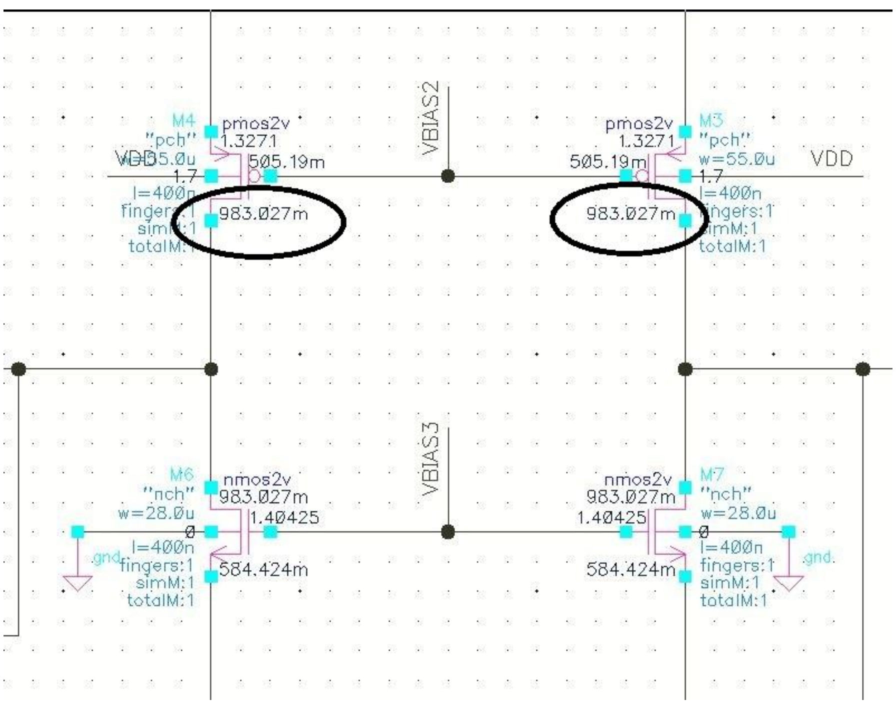

Figure 10 - Common mode accuracy at 85 deg (SS)

4 – OUTPUT SWING

A - -40 DEG (FF)

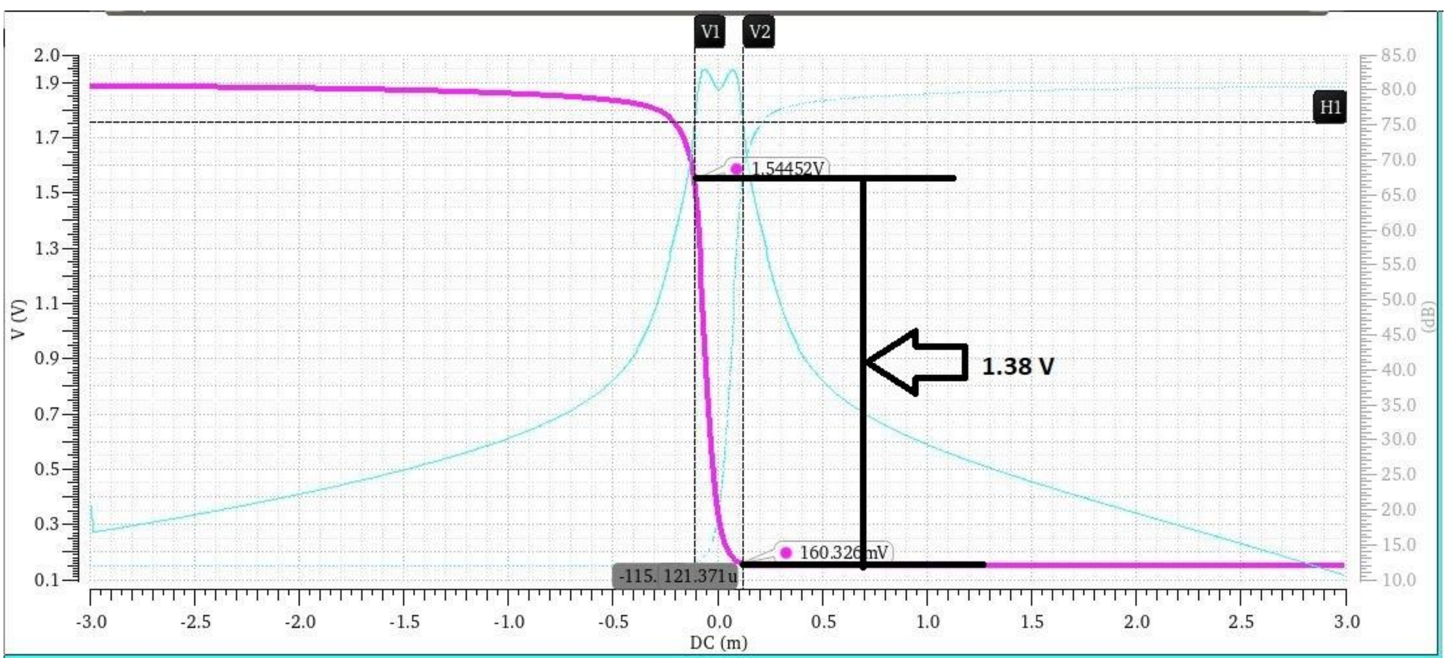

Figure 11 - Voltage swing at -40 deg (FF)

B – 27 DEG (TT)

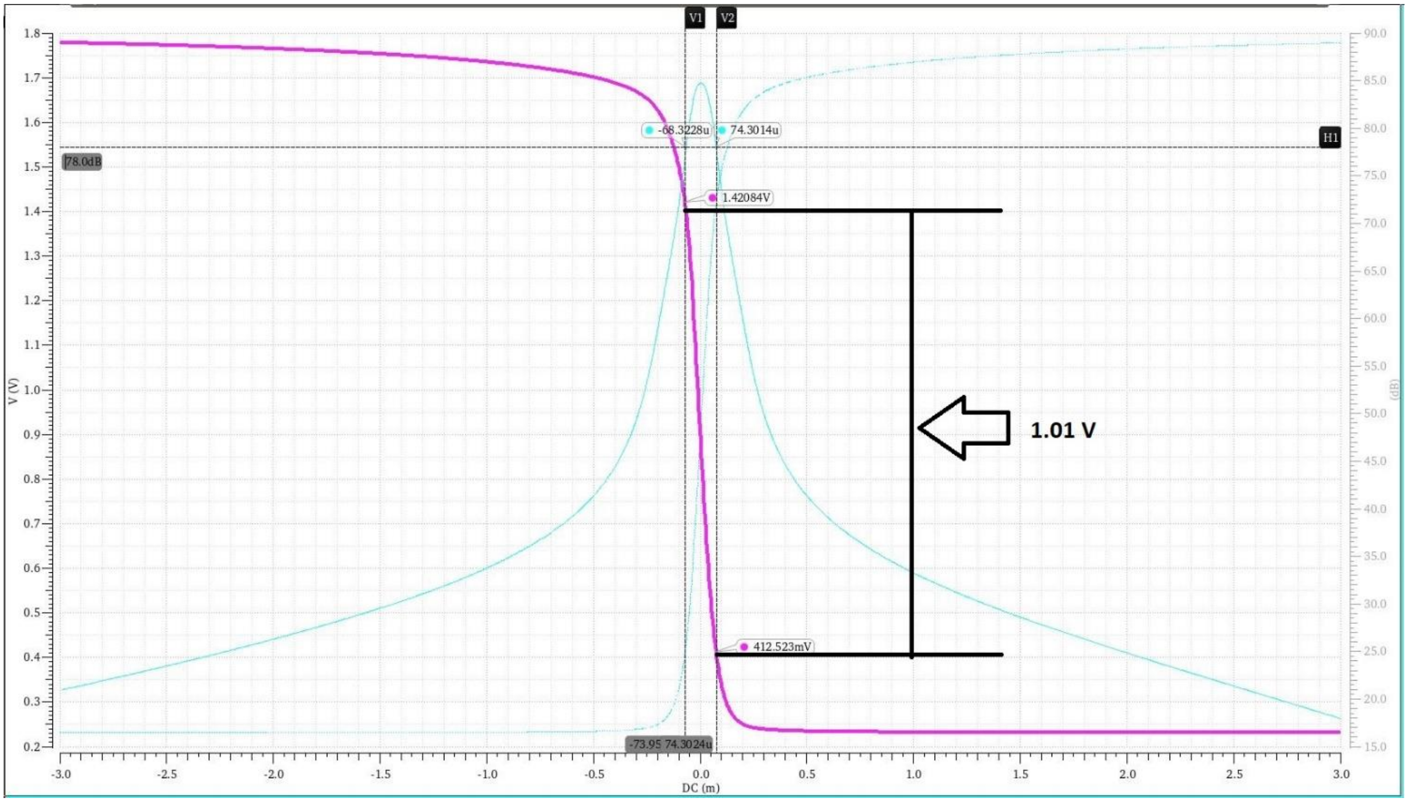

Figure 12 - Voltage swing at 27 deg (TT)

C – 85 DEG (SS)

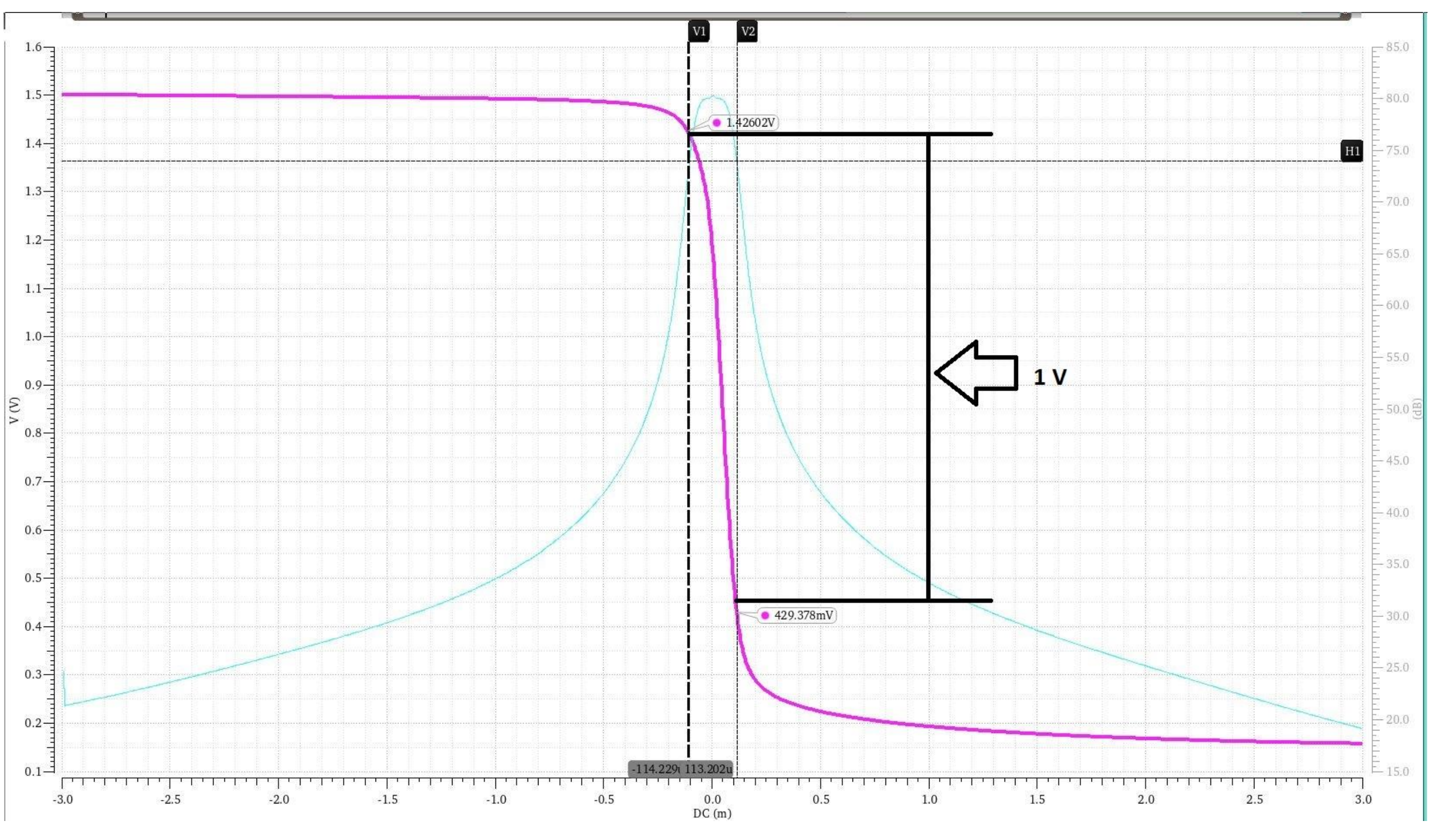

Figure 13 - Voltage swing at -40 deg (SS)

5 – POWER CONSUMPTION

A - -40 DEG (FF)

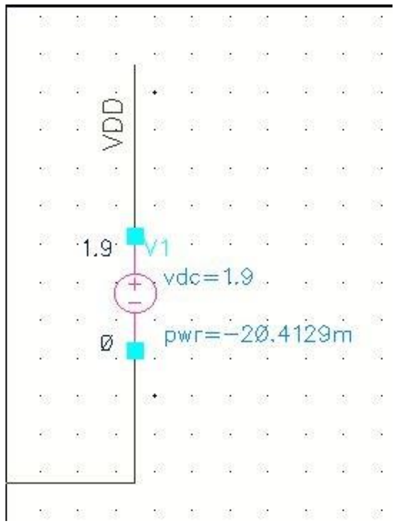

Figure 14 - Power consumption at -40 deg (FF)

B – 27 DEG (TT)

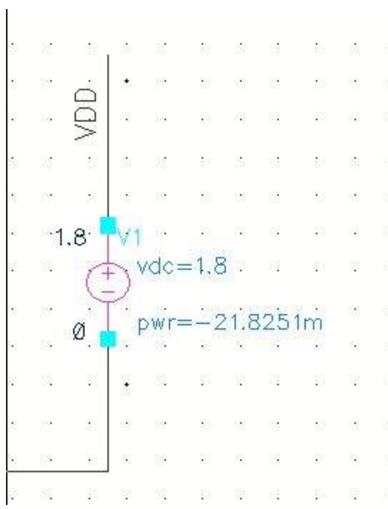

Figure 15 - Power consumption at 27 deg (TT)

C – 85 DEG (SS)

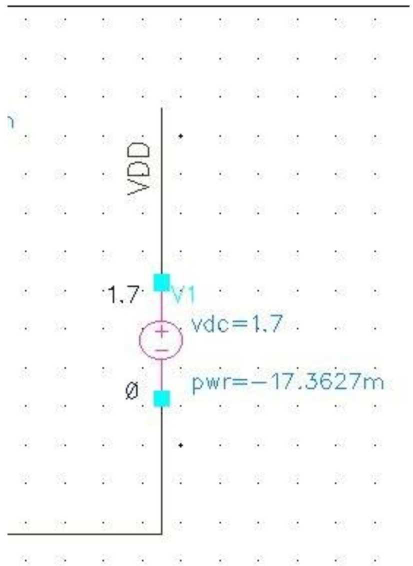

Figure 16 - Power consumption at 85 deg (SS)

6 – CMFB PHASE MARGIN

A - -40 DEG (FF)

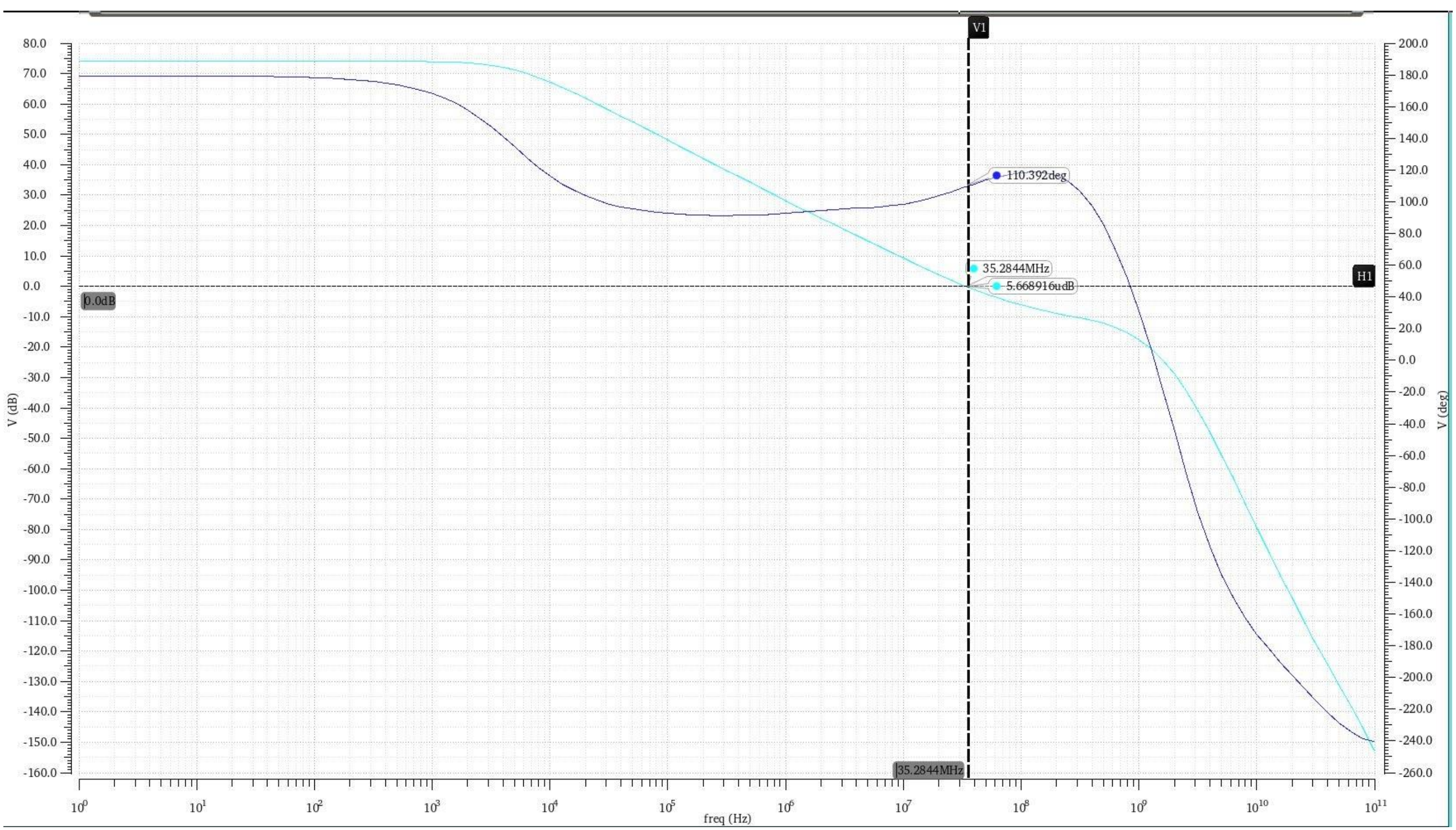

Figure 17 - CMFB phase margin at -40 deg (FF)

B – 27 DEG (TT)

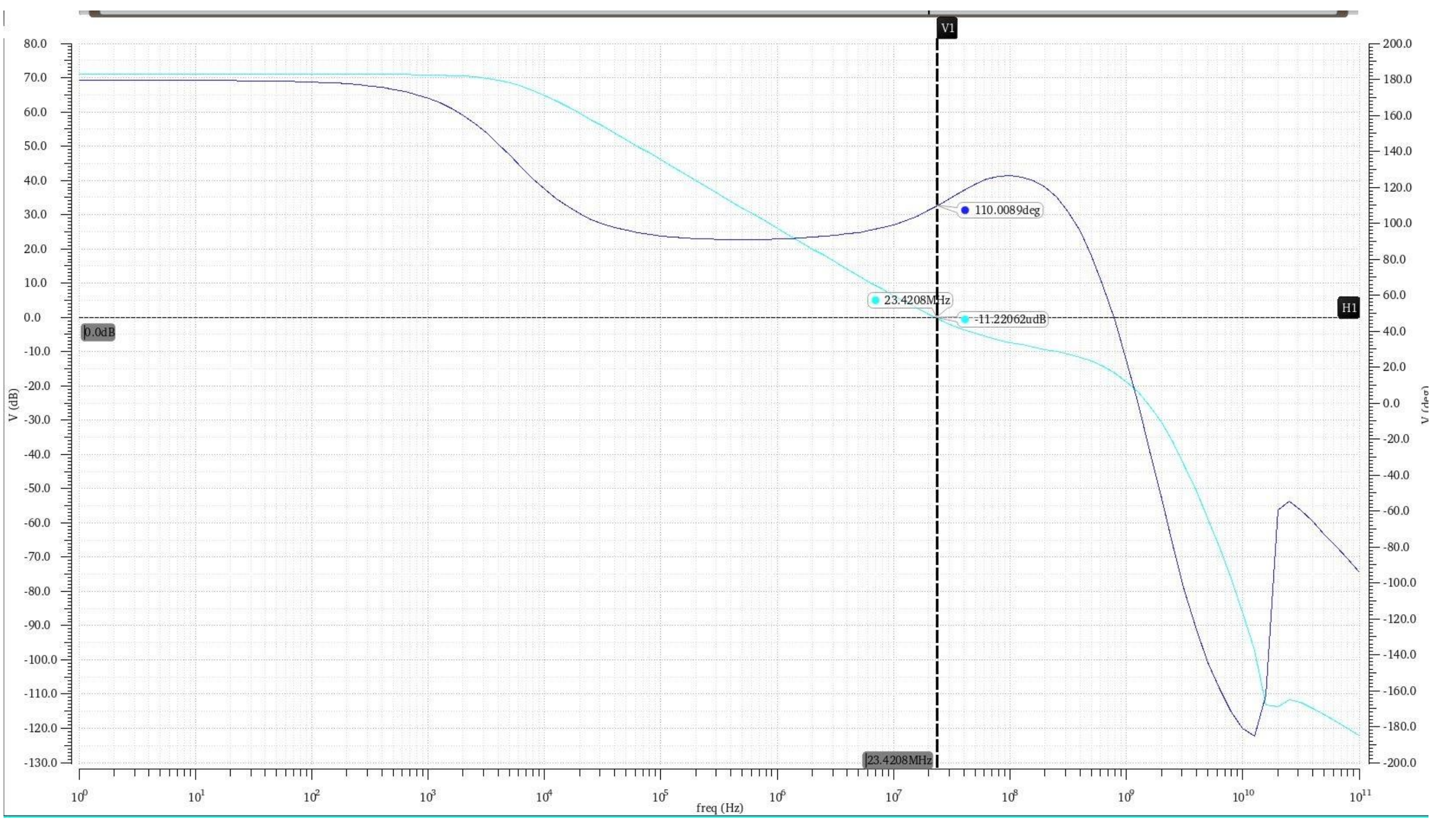

Figure 18 - CMFB phase margin at 27 deg (TT)

C – 85 DEG (SS)

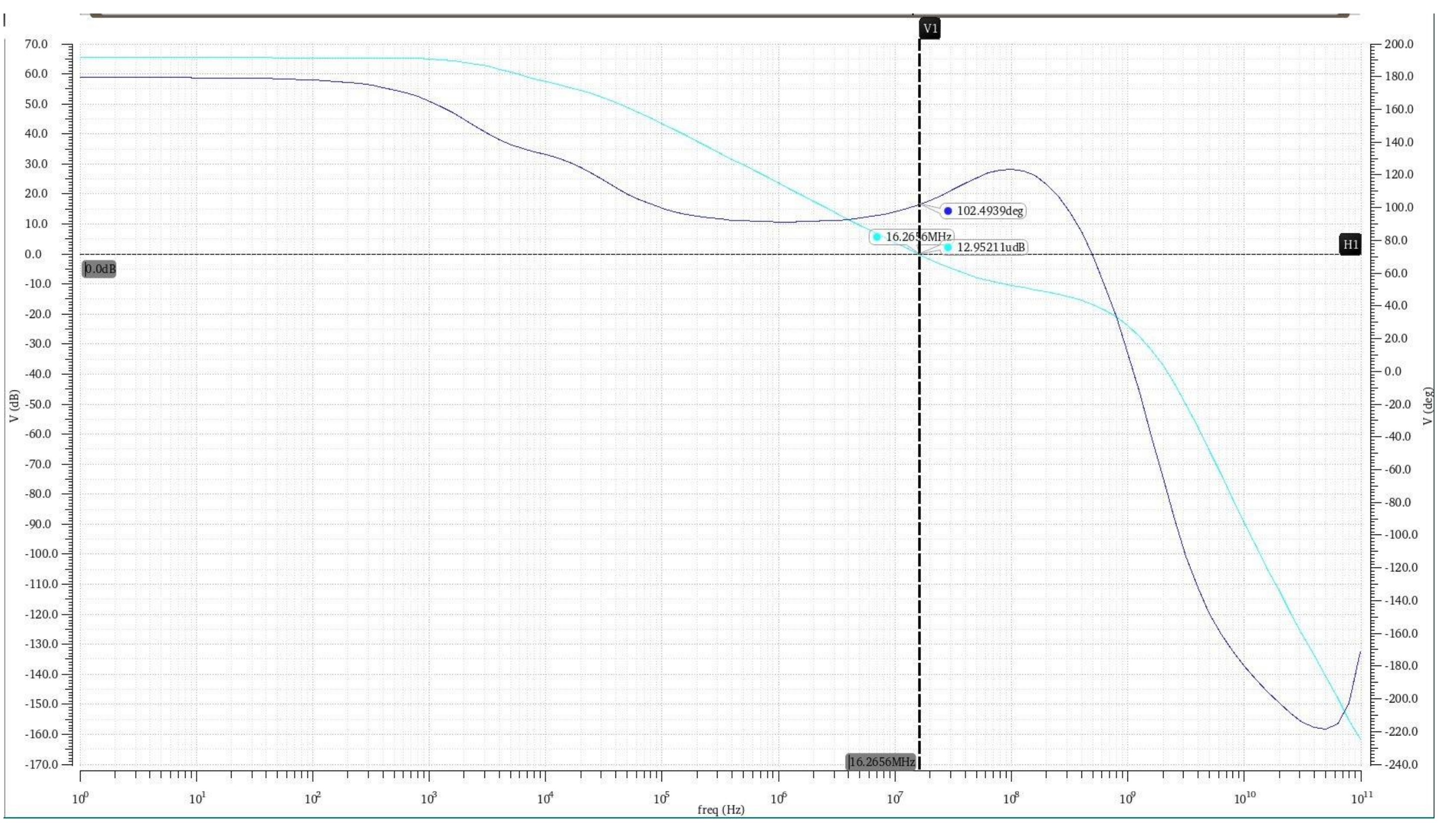

Figure 19 - CMFB phase margin at 85 deg (SS)

7 – LAYOUT

A – FULL CIRCUIT LAYOUT

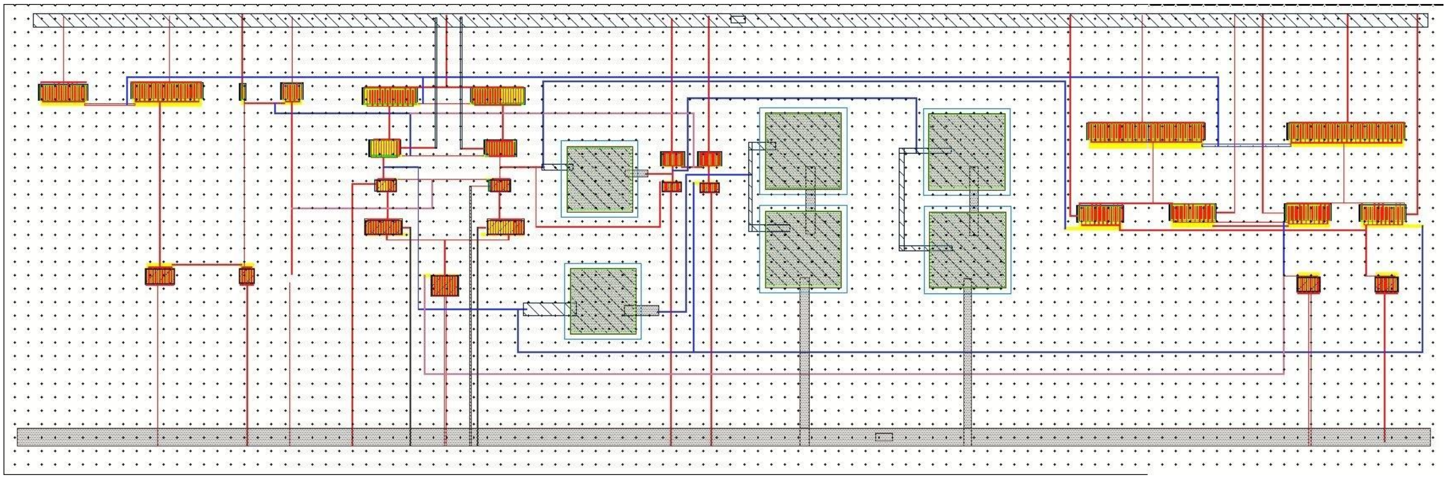

Figure 20 - Full circuit layout

B – DRC RESULT

DRC PASSED

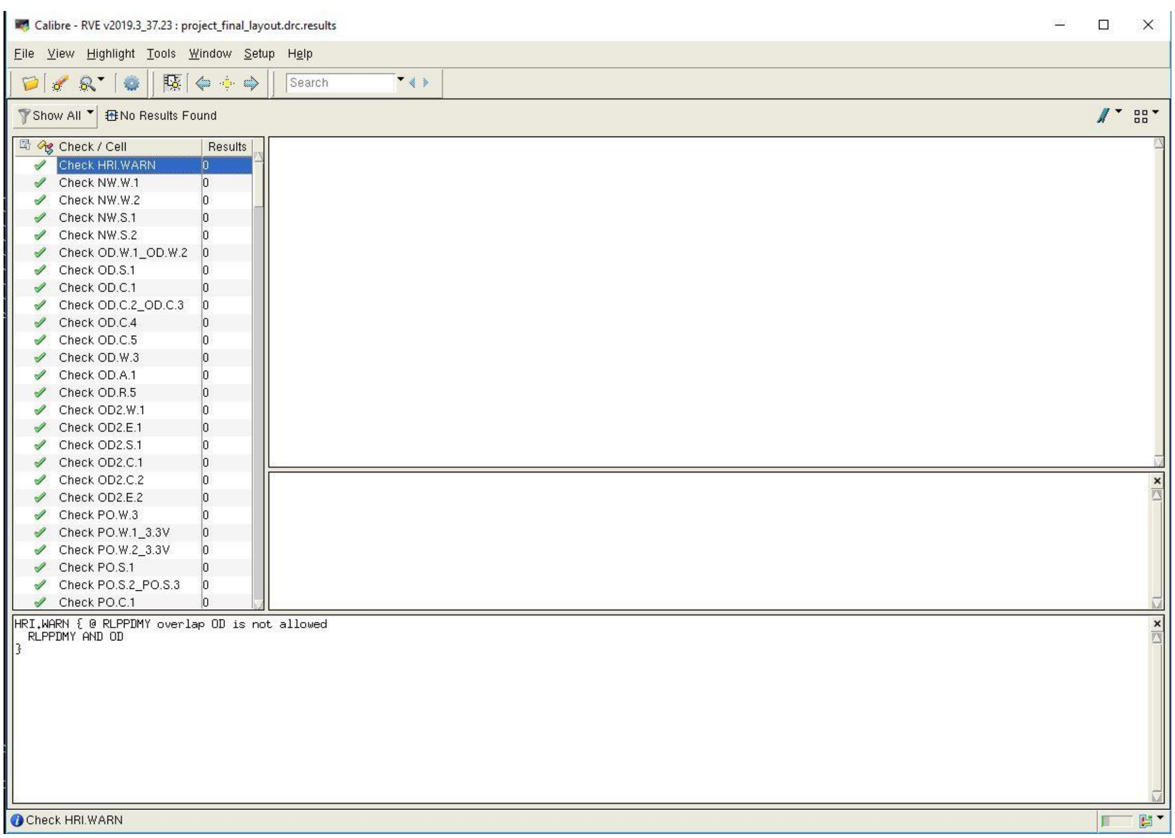

Figure 21 - DRC clean result

C - LVS RESULTS

LVS PASSED

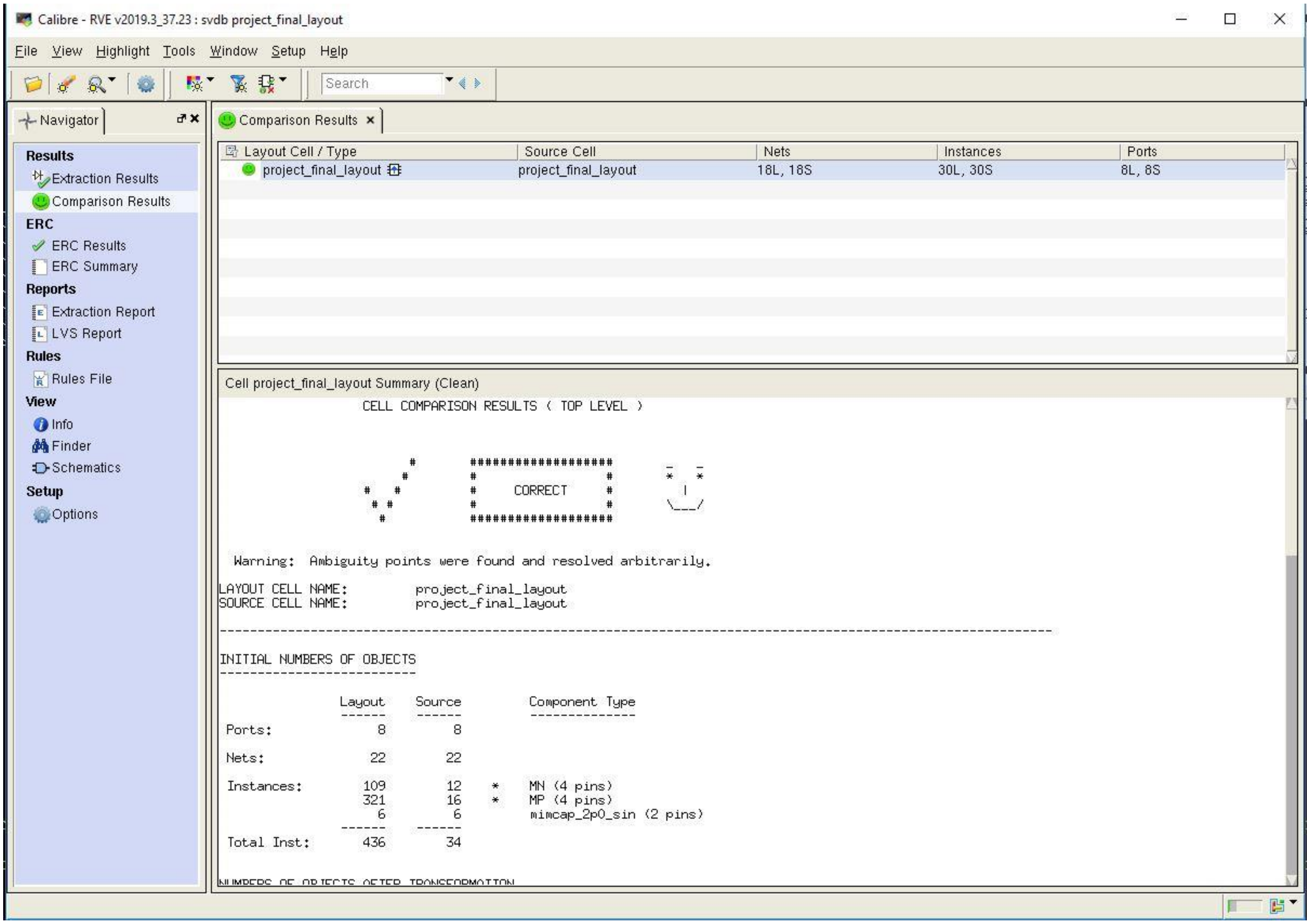

Figure 22 - LVS clear result

8 – TESTBENCHES

A – TESTBENCH FOR CM ACCURACY AND OUTPUT SWING

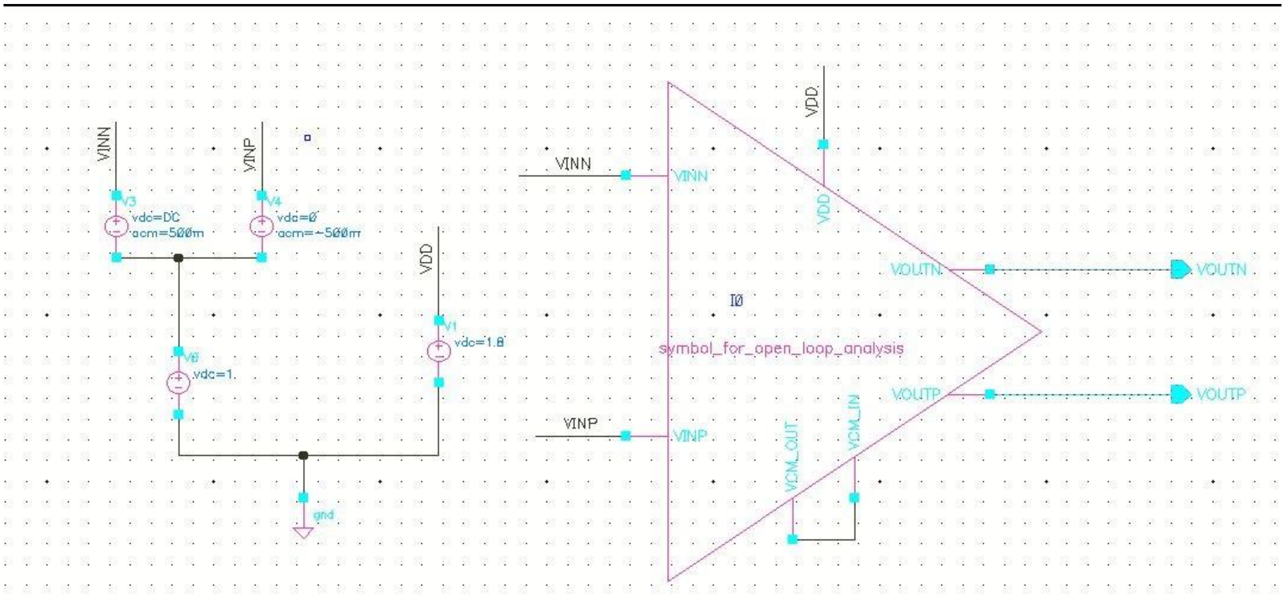

Figure 23 - TESTBENCH FOR CALCULATING CM ACCURACY AND OUTPUT VOLTAGE SWING

B – TESTBENCH FOR CM PHASE MARGIN

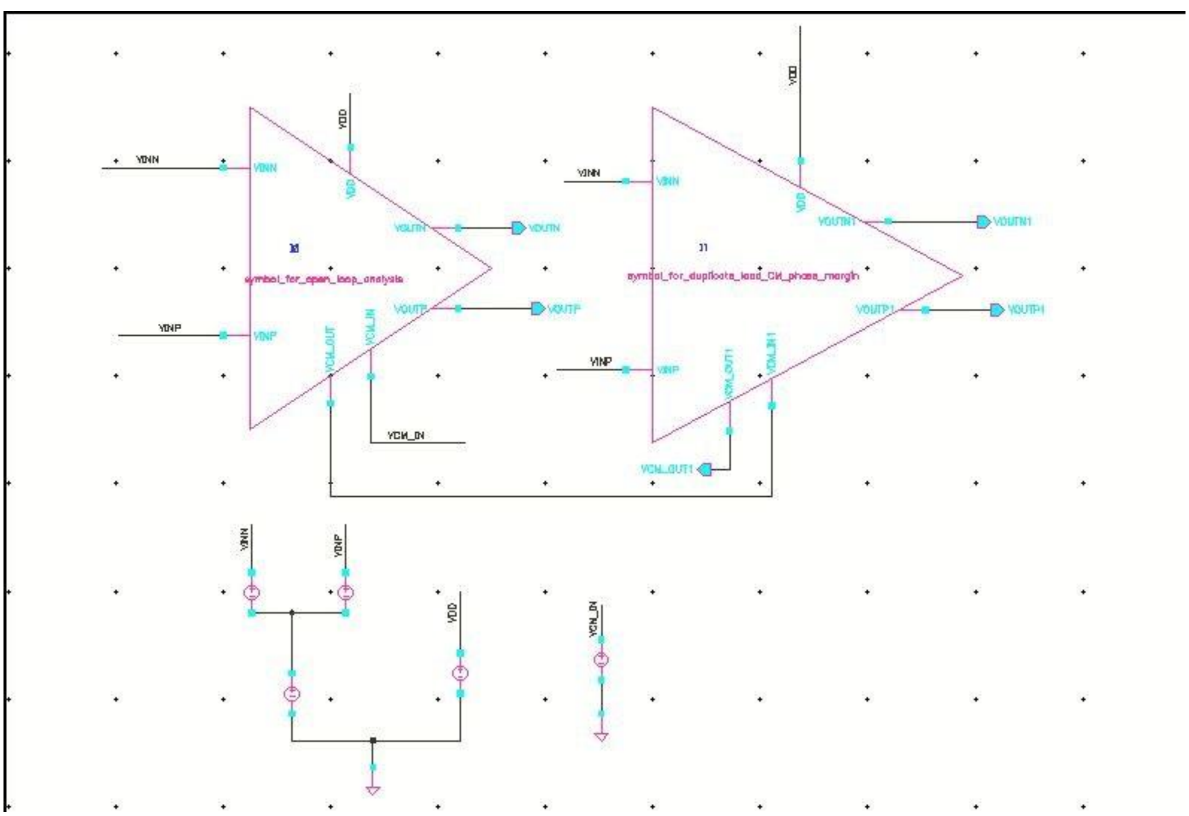

Figure 24 - TESTBENCH FOR CALCULATING CM PHASE MARGIN

9 – OSCILLATOR

A – SCHEMATICS

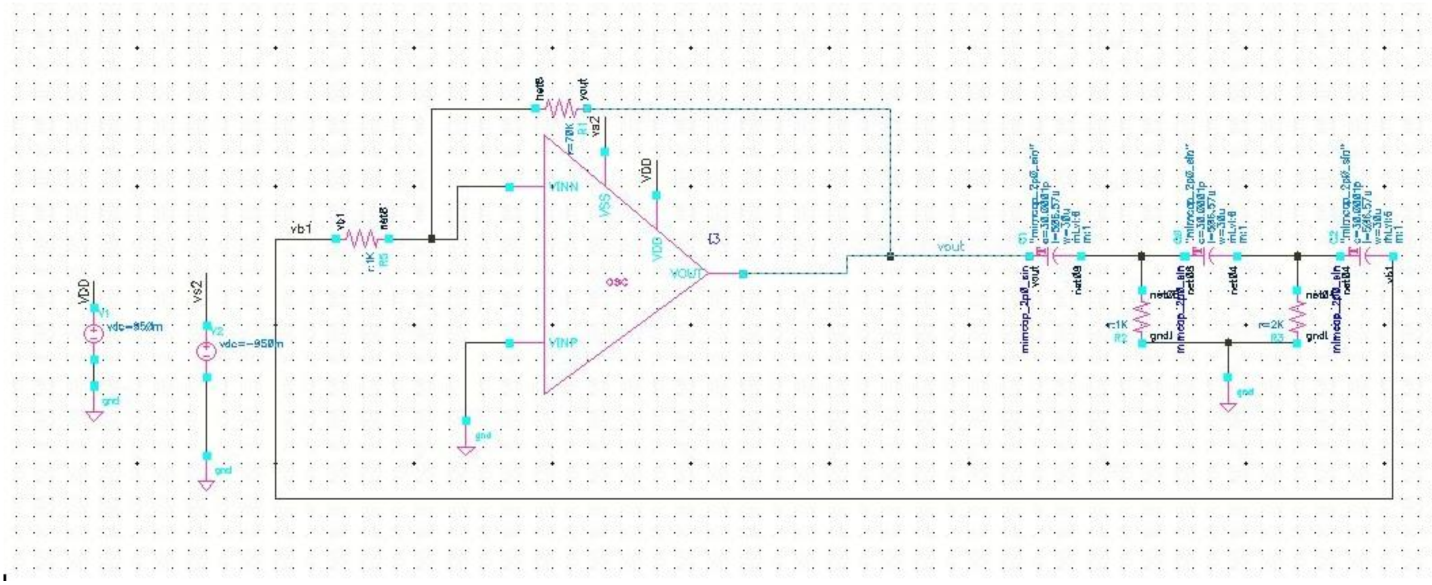

Figure 25 - OSCILLATOR TESTBENCH

I tried to implement RC phase shift oscillator using op amp. I converted my differential output op amp into single ended output op amp by diode connecting the output node to upper pmos. I have implemented 3 stage RC network where each network provide phase shift of 60 deg so in total it provides 180 deg phase shift. So, 180 deg phase shift from RC network and 180 deg phase shift from opamp in total gives 360 deg phase shift and it oscillates. Formula for frequency is as follows

f = $\frac{1}{2*\pi*R*C*\sqrt{2*N}}$ Where N = number of stages

B – OSCILLATOR OUTPUT AT -40 DEG(FF)

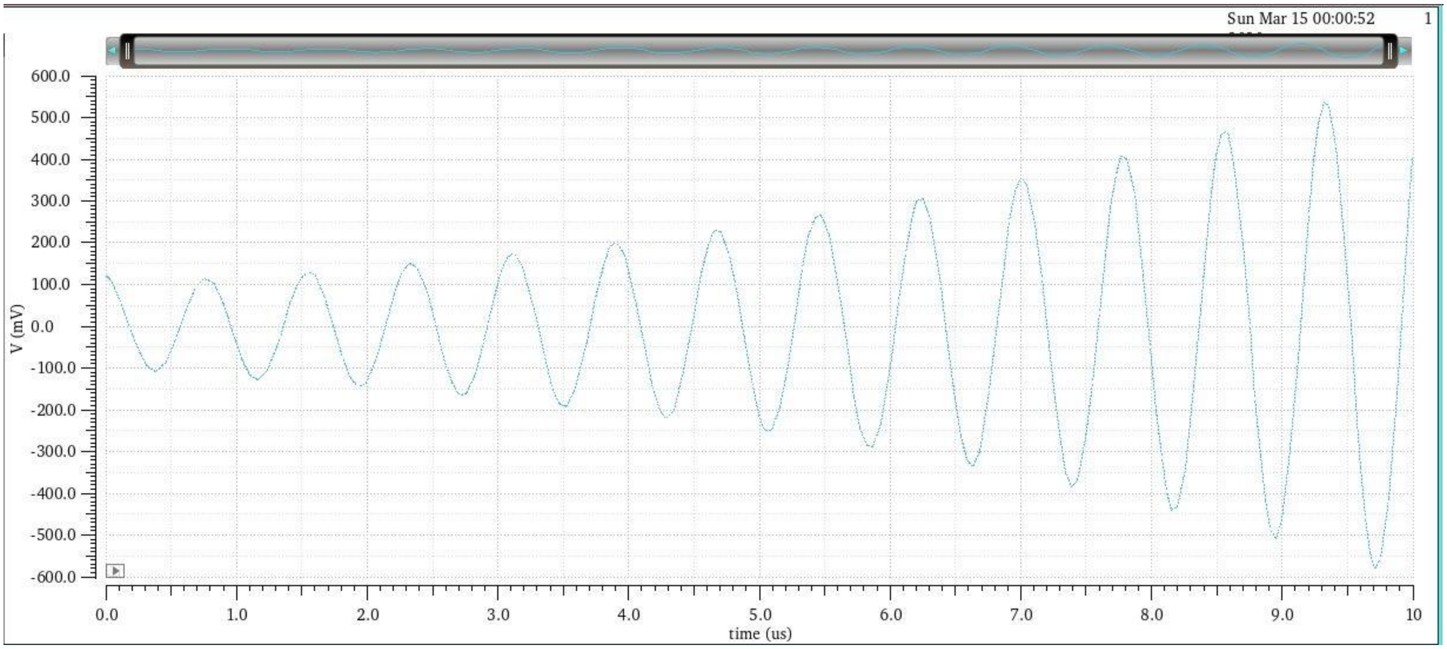

Figure 26 - OSCILLATOR OUTPUT AT -40 DEG(FF)

C – OSCILLATOR OUTPUT AT 27 DEG(TT)

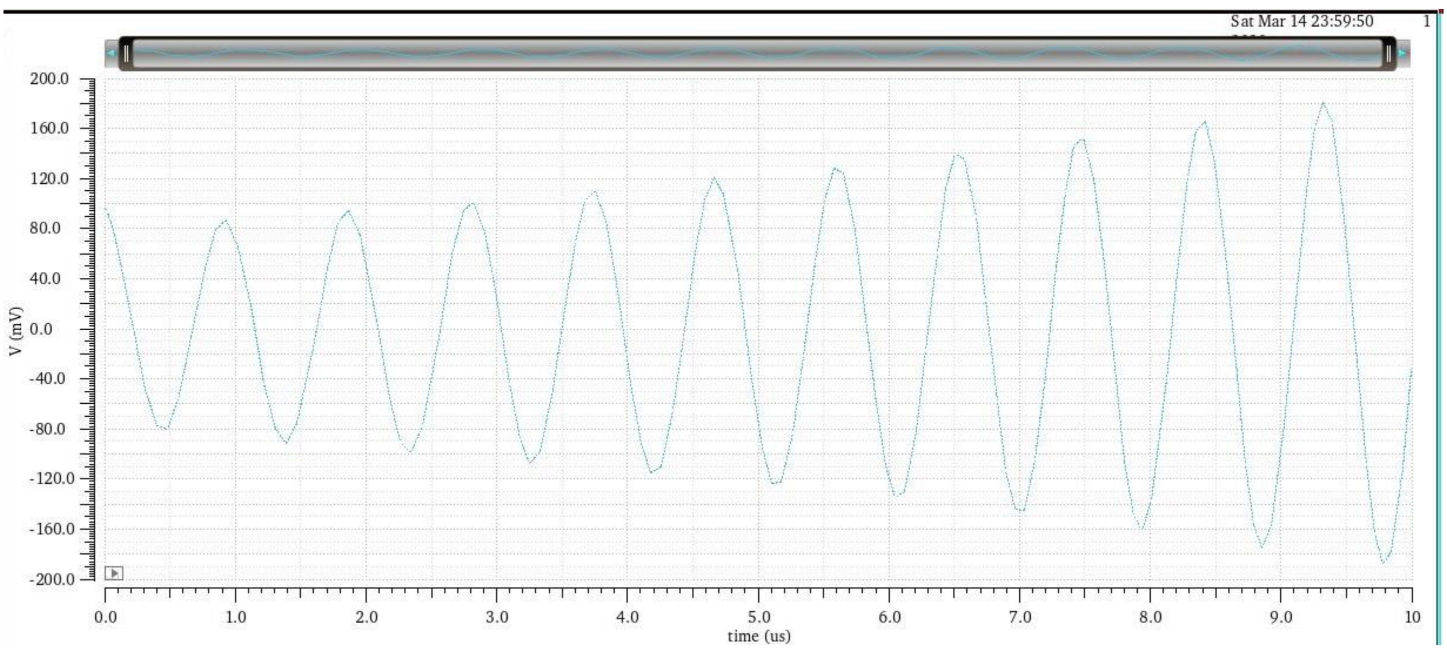

Figure 27 - OSCILLATOR OUTPUT AT 27 DEG (TT)

D – OSCILLATOR OUTPUT AT 85 DEG(SS)

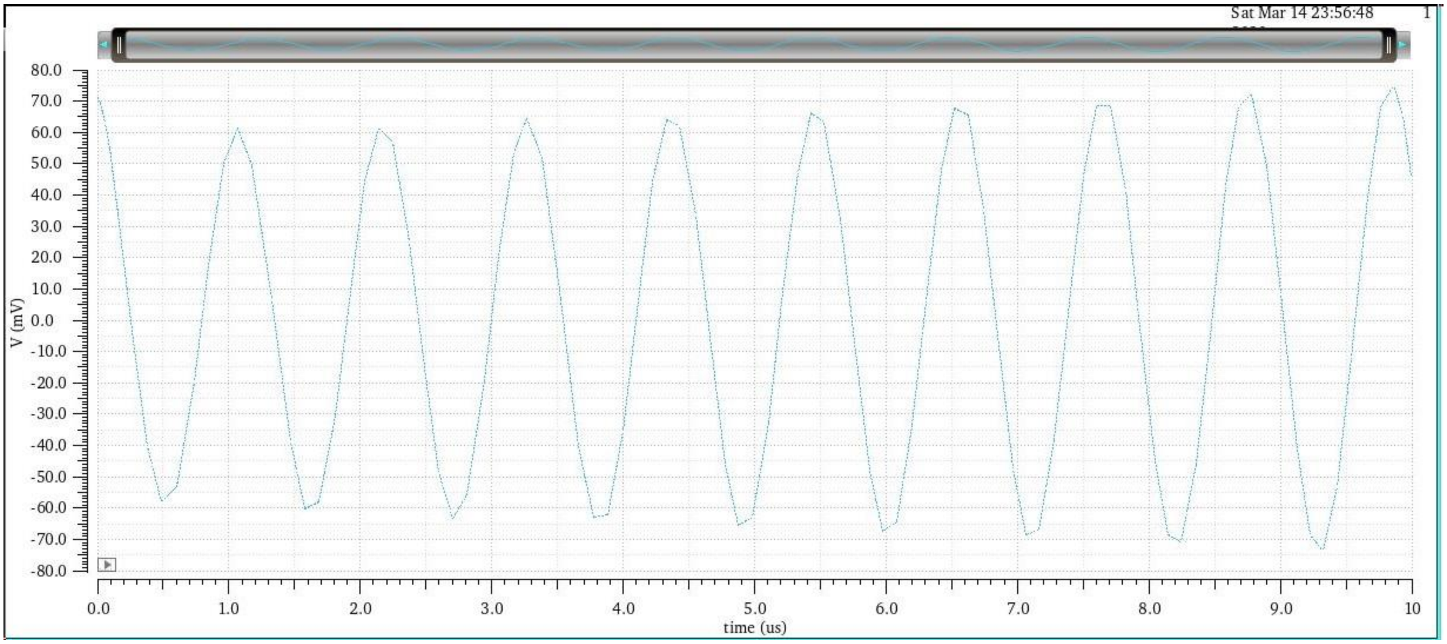

Figure 28 - OSCILLATOR OUTPUT AT 85 DEG (SS)