EE517 LAB
Experiment 7

Analysis and design of fully differential telescopic OP-AMP circuits.

Submitted by,

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Contents

1 AIM

Analysis and design of fully differential telescopic OP-AMP circuits.

2 OBJECTIVE:

maximum output swing, maximum gain, higher bandwidth and lower power consumption with a suitable aspect ratio. Provided: Supply of 1.8V

3 Design Specifications:

1. The target design gain is greater than 60 dB.
2. The design should have a GBW greater than 200 MHz.
3. Power dissipation less than or equal to 10m W
4. Slew rate greater than equal to 50 V/µS

4 Differential Telescopic Op-Amp:

The telescopic amplifier is a single-stage amplifier that exhibits one dominant pole, so it typically has higher frequency capability and consumes less power than other topologies, Moreover, its speed is higher than most other types of amplifiers. The drawback of the telescopic amplifier is that the output swing is limited due to cascoded transistors. Although not suited for low voltage(2V) designs. the telescopic amplifier is an appropriate choice for a 3.3 V system In order to reduce the static error in the SC circuit due to a finite-gain op amp, the gain boosting is required to obtain higher dC gain. With the gain boosting, not only the dC gain is improved, but also the settling time is improved(shorten). So as a natural choice, gain boosted telescopic amplifier will be most preferable for high-speed and high-gain designs. Figure below shows the fully differential telescopic Op-Amp. The fully differential designs include the first and secondly switched current mirrors and the output which can be a circuit duo to boosting the gain and reaching the wide band, but this can cause the power consumption to increase. Biasing also can improve the gain with less dissipation, e.g. Wideband QFG dynamic biasing (QFG-DB) Op-amp, but it cannot to increase the output or input voltage. Some applications such as Fully Differential Difference Transconductance Amplifier (FDDTA), require low output, so the high gain is not important in their design. Because they are utilized as a low pass filter. The advantage of the fully differential design is that the differential mode signal path encompasses only the n-channel MOSFETs. Only NMOS transistors conduct time-varying currents, and PMOS transistors transmit a constant current. This increases the Op-Amp speed, so the mobility of the n-channel MOSFET is greater than that of the p-channel MOSFET. In my design, we use the telescopic Op-Amp of Figure. It is a combination of Common Gate-Common Source (CS-CG) that achieves higher gain due to double load of current source.

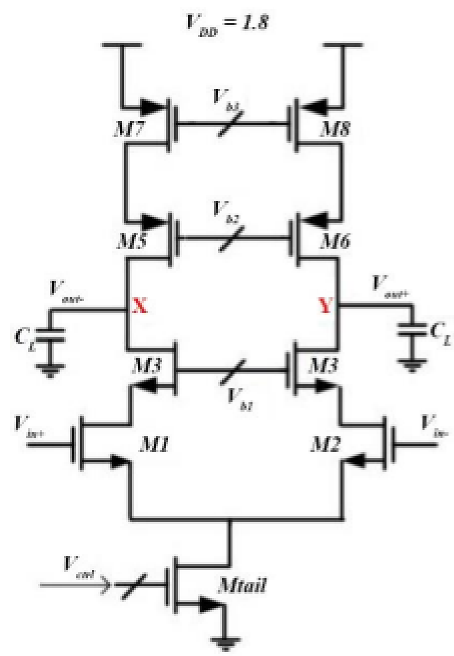

Figure 1: Differential telescopic amplifier

4.1 Telescopic op am calculations:

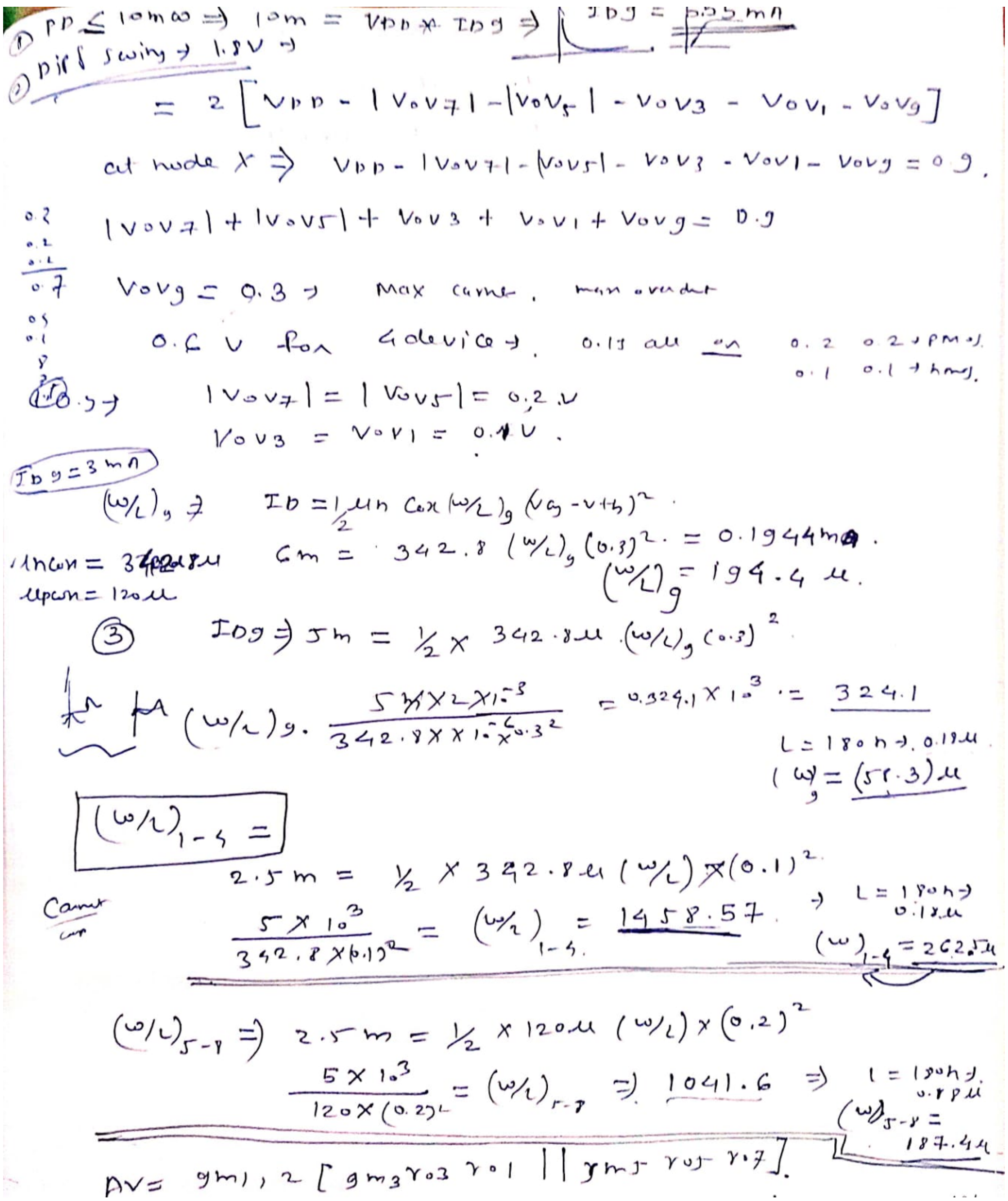

Figure 2: Telescopic op am calculations

5 DC Analysis:

For this, we have found the biasing voltages as 1.065v and 900mV for upper PMOS. And for lower NMOS we have varied vgs value from 0 to 1.8 for finding biasing value of NMOS.

5.1 Schematic of DC Analysis:

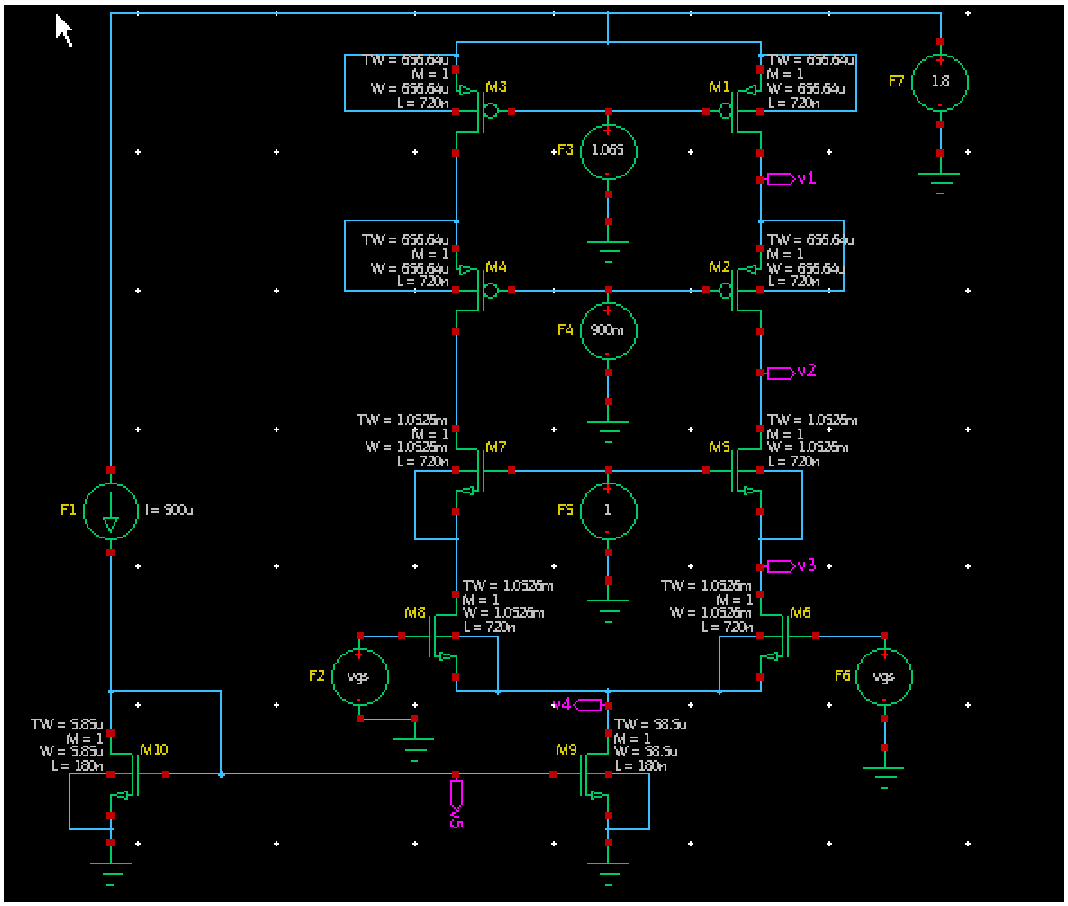

Figure 3: Circuit diagram for dc analysis

6 DC Analysis waveforms:

6.1 Schematic:

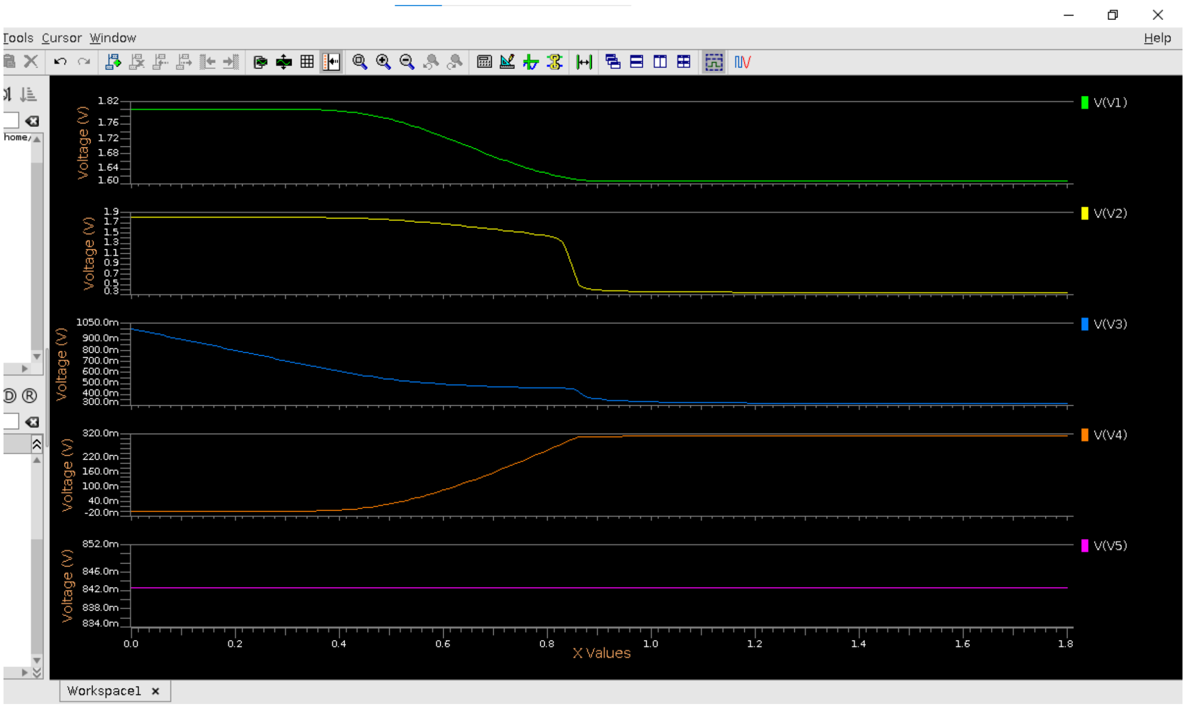

Figure 4: All voltage curves in DCv analysis

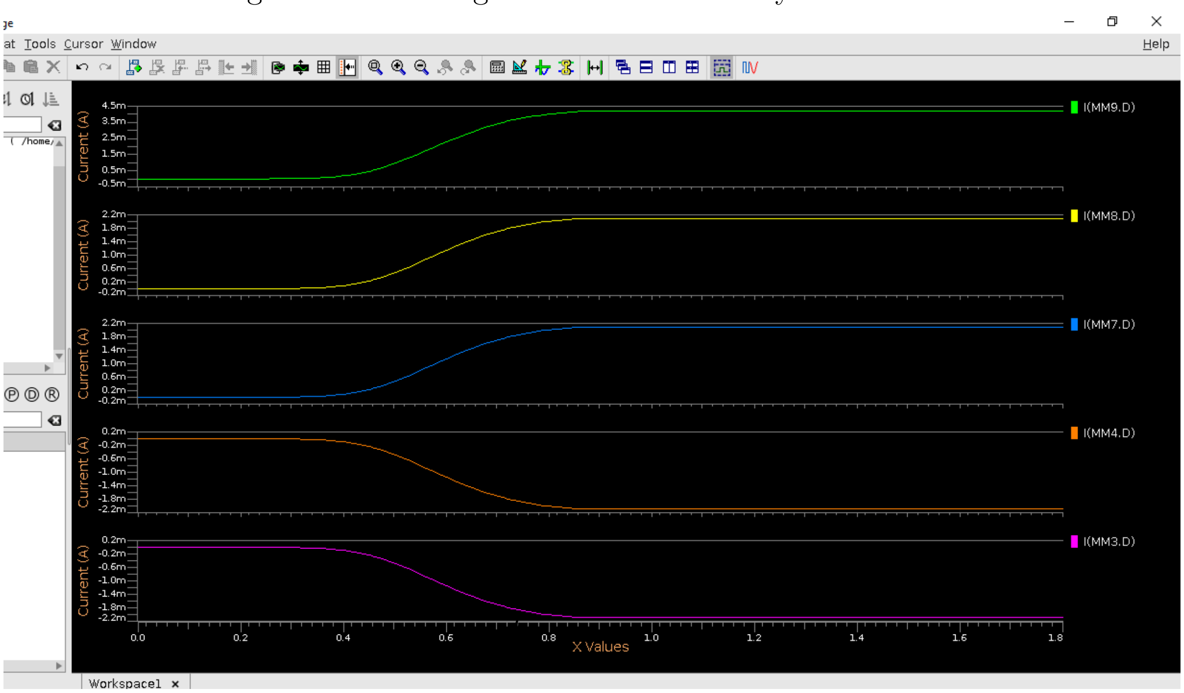

Figure 5: Current in each MOSFET to ensure saturation region

7 AC Analysis:

For this, we have kept frequency from 100 to 10 Gigahertz and got the waveforms for AC gain, bandwidth, CMRR and PSRR.

7.1 Schematic of AC analysis:

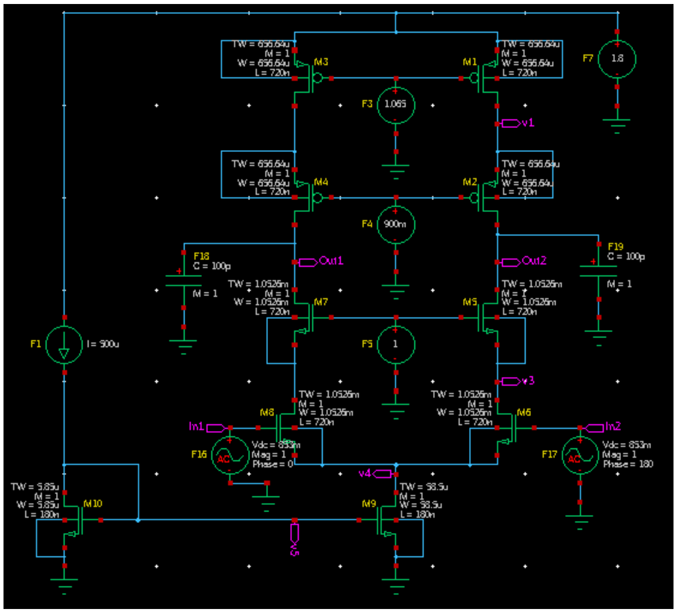

Figure 6: Circuit diagram for ac analysis

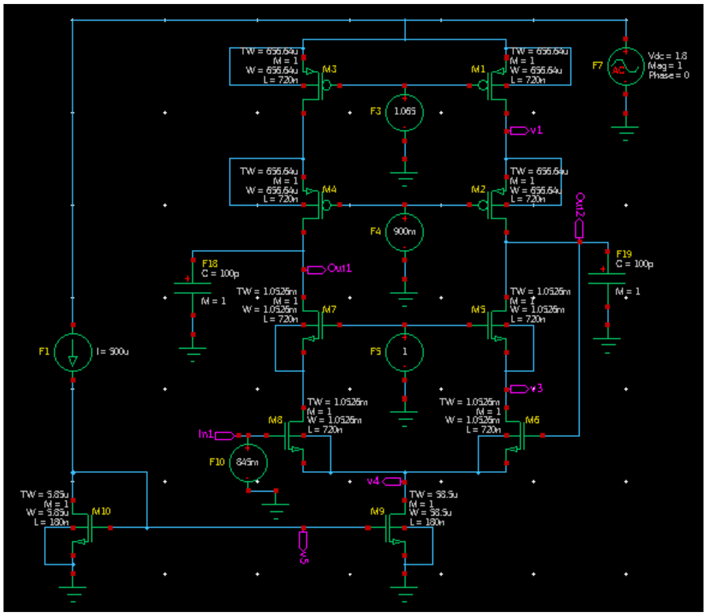

Figure 7: Circuit diagram for PSRR

7.2 AC Analysis gain and bandwidth waveforms:

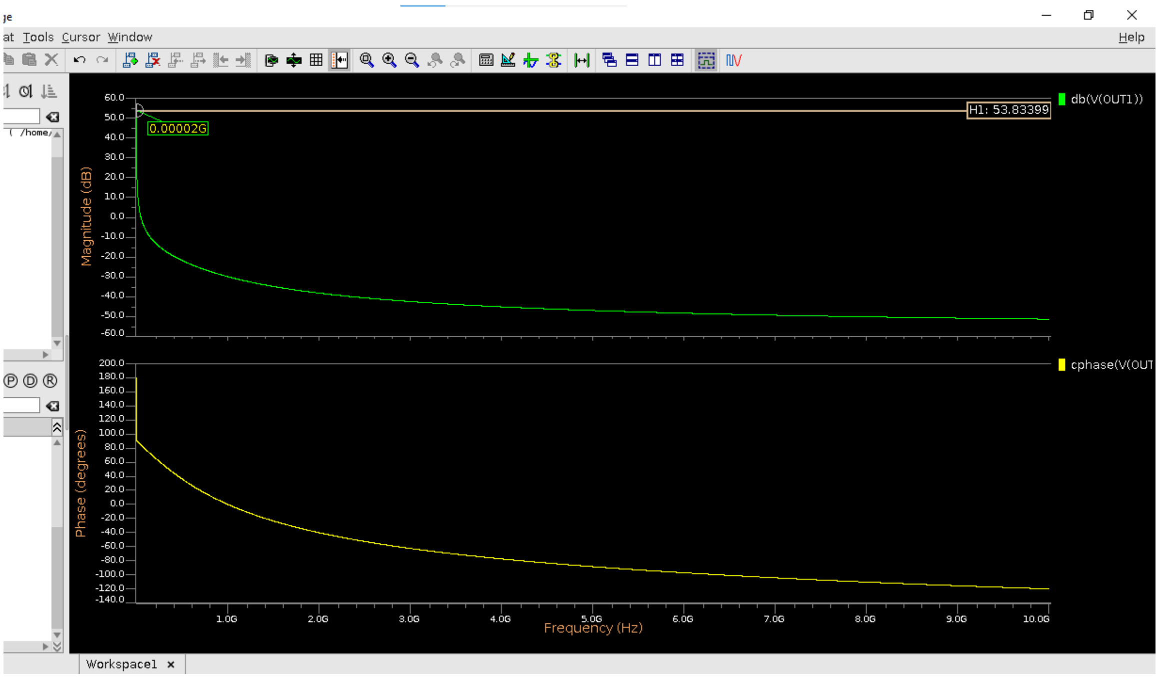

Figure 8: AC gain

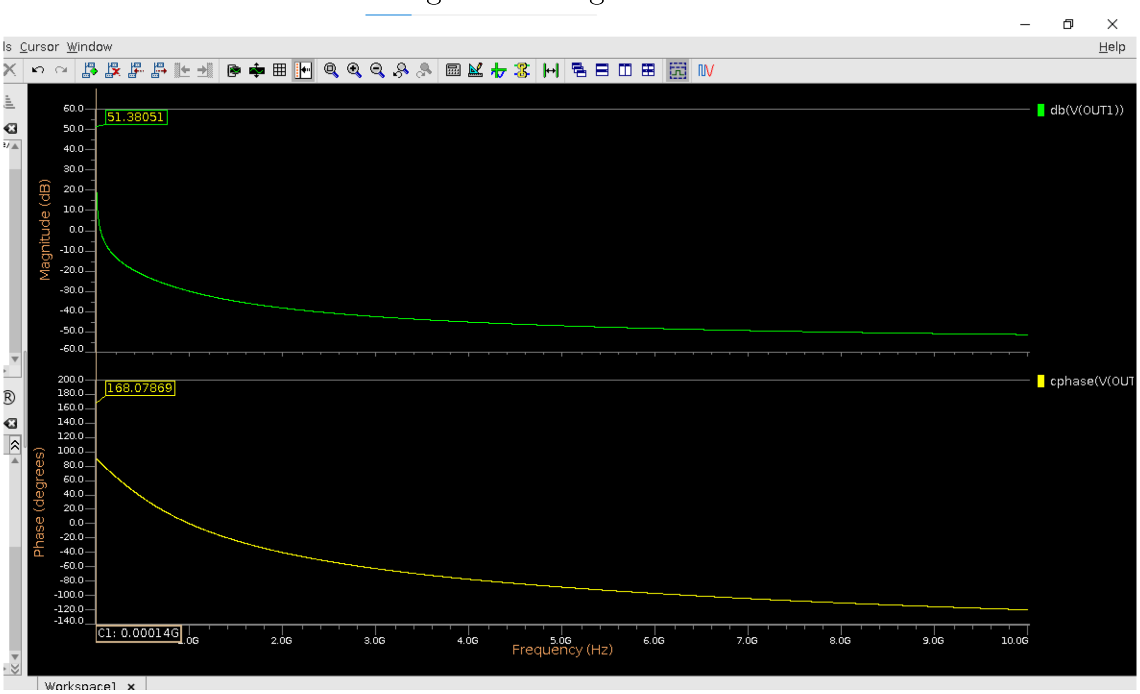

Figure 9: Bandwidth

7.3 AC Analysis phase margin waveform:

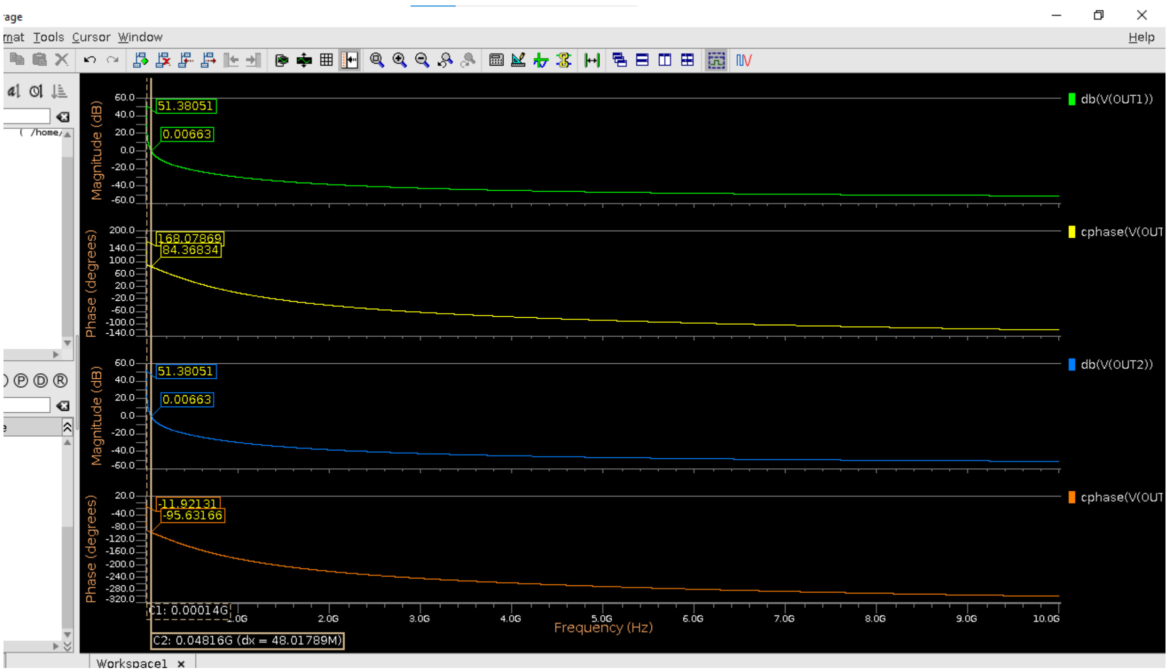

Figure 10: phase margin

7.4 AC Analysis CMRR and PSRR waveforms:

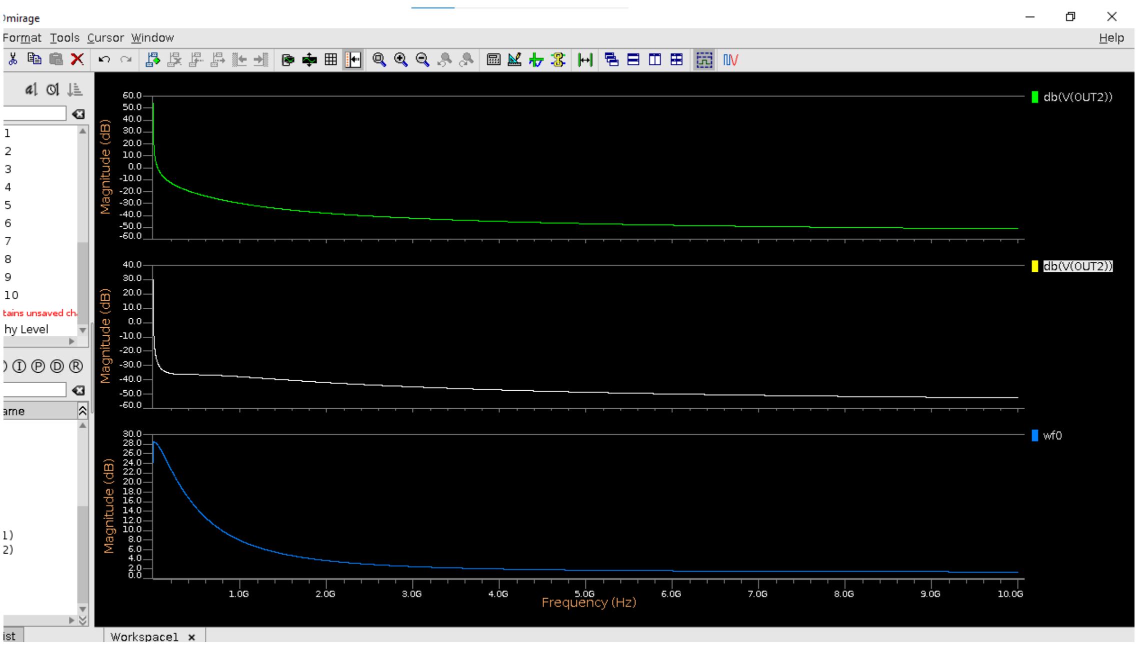

Figure 11: CMRR

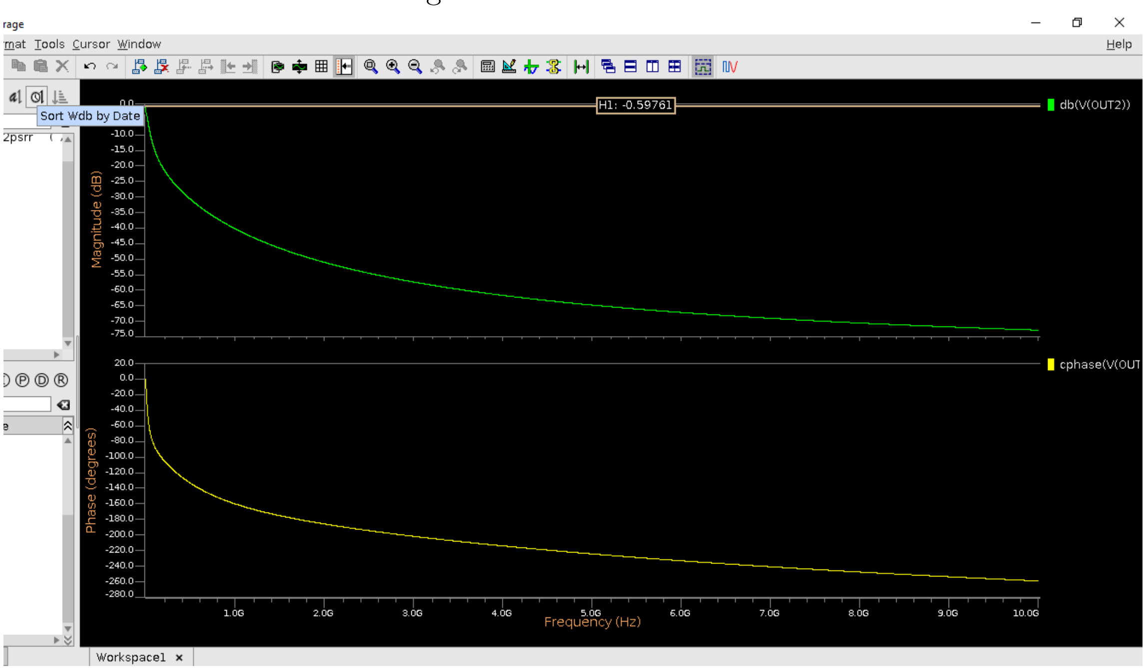

Figure 12: PSRR

7.5 ICMR and OCMR:

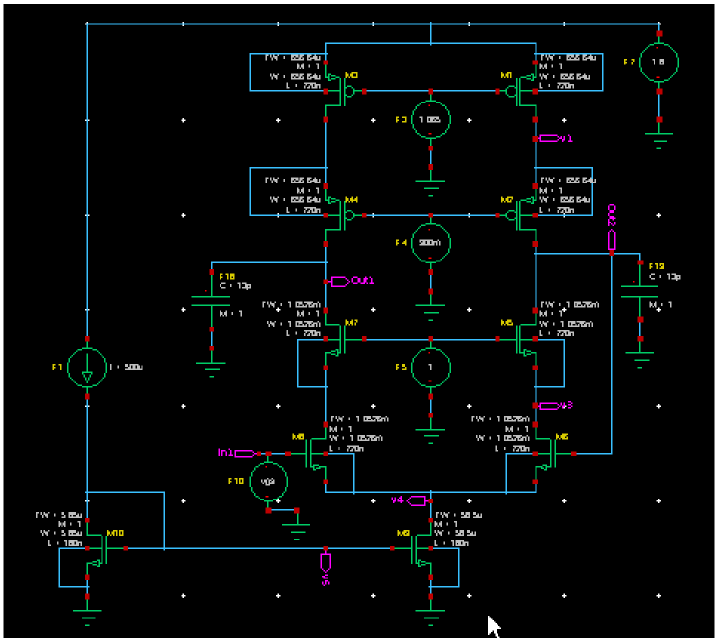

Figure 13: ICMR OCMR schematic

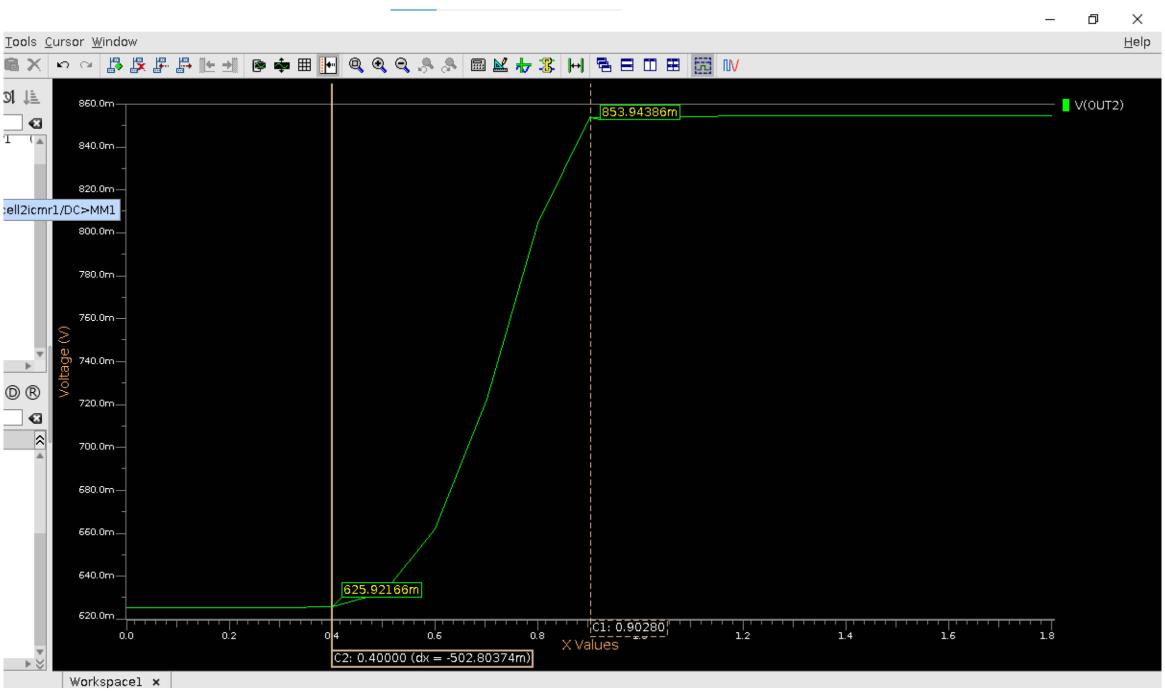

Figure 14: ICMR- OCMR wave

8 Transient Analysis:

Transient analysis is done to calculate slew rate.

8.1 Schematic:

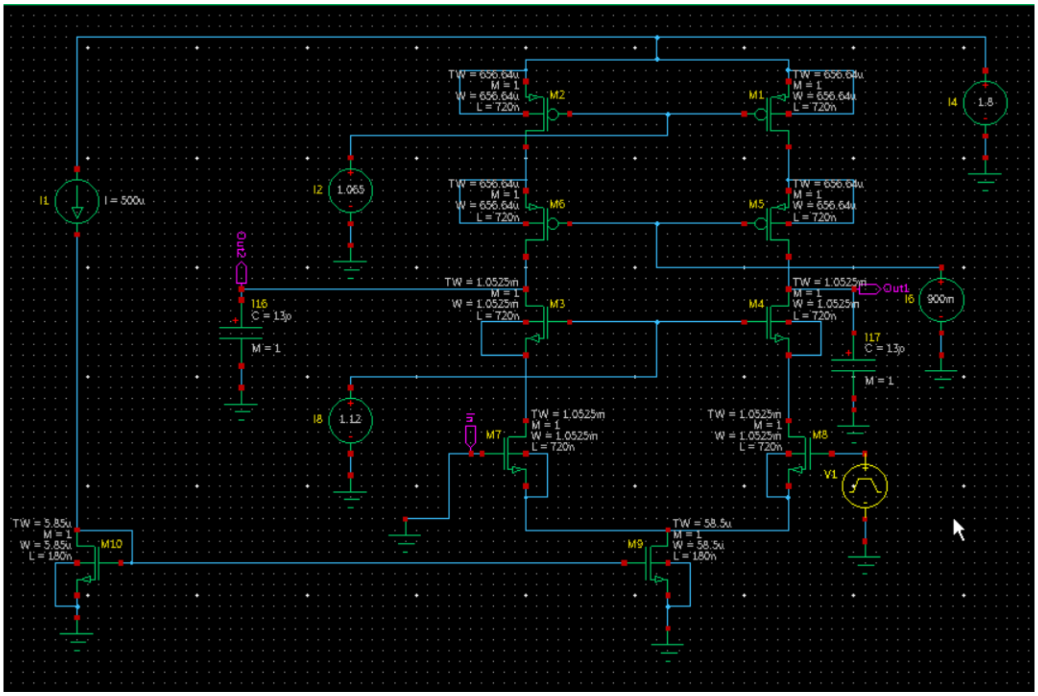

Figure 15: Circuit diagram for transient analysis

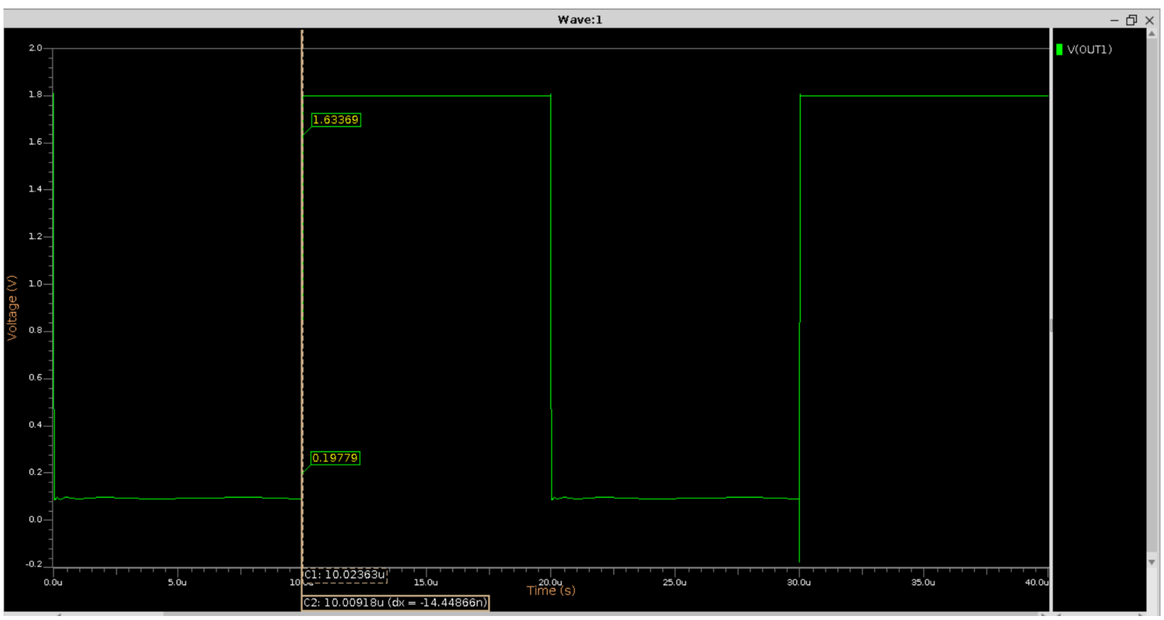

Figure 16: slew rate waveform

9 Calculations:

Circuit	Gain	BW	phasemarg	CMRR	PSRR	ICMR	OCMR	slewrate
Telescp Opamp	54.28	0.14M	84.36	28.7	-0.597	0.502	228.02	0.099

Table 1:

10 Conclusion:

- With the gain boosting, the dC gain is improved. So gain boosted telescopic amplifier will be most preferable for high-speed and high-gain designs.
- The drawback of the telescopic amplifier is that the output swing is limited due to cascoded transistors.